# Appendix 1: Physical and Analytical Methodology

## 1A.1 Physical Chemistry

### 1A.1.1 pH

A Radiometer-Copenhagen: TTA80 instrument equipped with a combined glass-calomel electrode was used to measure the pH of porewaters and column leachates. The electrode was calibrated using pH 7 and pH 4 buffer solutions.

### 1A.1.2 Electrical Conductivity (EC)

A Radiometer-Copenhagen CDM 83 Conductivity Meter was used for EC measurements. The meter is equipped with 3 platinum electrodes. The cell constant was calibrated with standard KCl solutions of varying concentrations (0.01, 0.1 and 1.0 N) that were selected in accordance with the expected conductivity of the porewater or leachate sample.

### 1A.1.3 Redox Potential

Redox Potential (Eh) was measured with an IONODE combined platinum/silver – silver chloride electrode connected to a HANNA HI 8521 pH/Eh meter. All readings were adjusted to the standard hydrogen electrode reference. The electrode was calibrated with Zobell's solution. This solution is prepared by first mixing 1/300 M potassium ferricyanide in 0.1 M potassium chloride (solution 1). A second solution comprising 1/300 M potassium ferrocyanide in 0.1 M potassium chloride is also prepared separately then combined with solution 1 in equal volumes before calibration.

The potential of platinum against a calomel reference should be + 186 mV at 25°C and + 186 ± 10 mV against 1 M potassium chloride/silver-silver chloride.

## 1A.2 Mineralogy

### 1A.2.1 X-ray Powder Diffraction

Finely ground powders of samples were lightly pressed into aluminium sample holders to achieve random orientation of the mineral particles for XRD analysis. Measurements were made using a Philips PW1800 microprocessor-controlled diffractometer with Co K alpha radiation, variable divergence slit and a graphite monochromator. The diffraction patterns were acquired in steps of 0.05° 2θ with a 1 second count time per step. Data were logged to permanent files on an IBM - compatible PC and subsequently analysed using a software package XPLOT developed by Raven and Self (1988).

### 1A.2.2 Scanning Electron Microscopy

Selected tailings solids were carbon coated and examined in a Cambridge Stereoscan 250 Scanning Electron Microscope (SEM) operating at 20 kV. The elemental composition of particles identified with the SEM were determined with a Link energy-dispersive X-ray (EDX) microanalyser.

### 1A.2.3 Quantitative Electron Microscopy – SEM

QEMSEM is an automatic system for the rapid determination and quantification of mineral matter. Specifically the method provides quantitative data on the petrographic, mineralogical and chemical composition of all phases present including particle size and shape, grain size and textural associations. The instrument comprises of a Leo SEM equipped with 4 light element Gresham X-ray detectors. The instrument uses image analysis to interpret back scattered electron and energy dispersive x-ray signals collected at a pre-determined stepping rate. These are then converted into colour coded digital images. The images are stored on a computer and statistically analysed to obtain mineralogical, chemical and textural parameters. The instrument can process 100,000 pixels/hour with a spatial resolution of up to 0.3 µm.

Sample preparation included desliming at 20 µm, with the plus 20 µm fraction being sized to 45 and 106 µm. The minus 20 µm fraction was cyclosized to obtain both the plus and minus 10 µm fractions. Acetone instead of water was used in the cyclosizer to prevent the leaching of salts and other soluble metals.

## 1A.3 Water and Solids Chemistry

### 1A.3.1 Inductively Coupled Plasma Atomic Emission and Mass Spectrometry

The dissolved major and trace metals (including U) for all porewaters and leachates were analysed by inductively coupled plasma atomic emission spectrometry (ICPAES) and ICP – mass spectrometry (ICPMS). Analytical detection limits for ICPAES are summarised in Table 1A.1. ICPMS detection limits are generally < 1 µg/L.

**Table 1A.1: Analytical detection limits for ICPAES**

| Element | Detection Limit (mg/L) |
|---|---|
| Al | 0.005 |
| B | 0.005 |
| Ba | 0.005 |
| Be | 0.002 |
| Ca | 0.05 |
| Cd | 0.01 |
| Co | 0.01 |
| Cr | 0.005 |
| Cu | 0.005 |
| Fe | 0.02 |
| K | 0.20 |
| Li | 0.005 |
| Mg | 0.01 |
| Mn | 0.002 |
| Mo | 0.01 |
| Na | 0.20 |
| Ni | 0.01 |
| P | 0.05 |
| Pb | 0.02 |
| S | 0.02 |
| Si | 0.10 |
| Sr | 0.002 |
| Ti | 0.005 |
| V | 0.005 |
| Zn | 0.05 |

Porewaters and column leachates were filtered through a 0.45 µm membrane filter and the filtrate acidified to pH < 2 with nitric acid. Prior to ICPAES or MS analysis, the filtrates were subjected to acid digestion in accordance with US EPA methods 3005/3010 (1996). This method destroys colloidal complexes and provides a total dissolved metal concentration.

### 1A.3.2 Ion Chromatography

The unacidified filtrates generated from porewaters and column leachates were analyzed for $Cl^-$, $NO_3^-$, $NO_2^-$ and $NH_4^+$ by a DioneX 4500I series ion chromatograph.

### 1A.3.3 Radium Determination

The analysis of $^{226}Ra$ by alpha spectrometry involved co-precipitation of radium (and $^{133}Ba$) with colloidal barium sulfate on a < 0.2 µm filter membrane. The activity of $^{226}Ra$ was determined by counting the alpha particles with an Ortec 676A Alpha-King spectrometer coupled to a multi-channel analyser and emulation software (Maestro II). The gravimetric yield or recovery of precipitated radium was inferred by the yield tracer $^{133}Ba$, which was counted by gamma spectrometry.

Other radionuclides ($^{230}Th$ and $^{210}Pb$) were also determined in porewaters however these data were not evaluated as part of this research project. Thorium-230 was determined by alpha spectrometry and lead-210 by beta spectrometry.

### 1A.3.4 X-Ray Fluorescence Major and Trace Elemental Analysis

The 'grab' weight method was employed in the preparation of the samples for major and trace element analysis. This involved accurately weighing approximately 1 g of each of the finely ground oven dried (105°C) powders into glass vials with approximately 0.3 g $NaNO_3$. The mixture was transferred to a Pt-Au crucible and preoxidised in an oven set to 750°C for 15 minutes. The preoxidised material was then fused into a homogeneous glass over an oxy-propane flame at a temperature of approximately 1050°C and the molten material was poured into a 32 mm diameter Pt-Au mould heated to a similar temperature. The melt was then cooled by air jets for approximately 30 seconds. The resulting glass disks were analysed on a Philips PW1480 XRF system using a control program developed by Philips. Table 1A.2 summarises the analytical detection limits.

**Table 1A.2: XRF detection limits (mg/kg)**

| Component | < 200 (mg/kg) | > 200 (mg/kg) | Component | < 200 (mg/kg) | > 200 (mg/kg) |
|---|---|---|---|---|---|
| $SiO_2$ (%) | - | 0.24 | Ni (ppm) | 5.00 | 6.00 |
| $Al_2O_3$ (%) | - | 0.15 | Rb (ppm) | 4.00 | 5.00 |
| $Fe_2O_3$ (%) | - | 0.07 | Ba (ppm) | 14.00 | 40.00 |
| MgO (%) | - | 0.07 | V (ppm) | 4.00 | 7.00 |
| CaO (%) | - | 0.06 | Cr (ppm) | 7.00 | 10.00 |
| $Na_2O$ (%) | - | 0.06 | La (ppm) | 18.00 | 21.00 |
| $K_2O$ (%) | - | 0.03 | Ce (ppm) | 9.00 | 17.0 |
| $TiO_2$ (%) | - | 0.02 | Pb (ppm) | 6.00 | 6.00 |
| $P_2O_5$ (%) | - | 0.004 | Y (ppm) | 3.00 | 4.00 |
| MnO (%) | - | 0.005 | Co (ppm) | 3.00 | 3.00 |
| Ga (ppm) | 3.00 | 3.00 | Cu (ppm) | 11.00 | 11.00 |
| U (ppm) | 5.00 | 7.00 | Sr (ppm) | 3.00 | 7.00 |
| Th (ppm) | 5.00 | 7.00 | Zr (ppm) | 9.00 | 11.00 |
| $SO_3$ (%) | 0.003 (1%) | 0.05 (30%) | Zn (ppm) | 6.00 | 7.00 |

Error Determination for Fusion Analysis

The errors quoted below for each component are the standard deviations based on standard rock compositions. Trace element errors are quoted for < 200 ppm and > 200 ppm.

## 1A.4 Geotechnical Properties

### 1A.4.1 Particle Size Distribution

Method no. 11.1 from the CSIRO-Division of Soils was used to perform this analysis. The procedure outlined below does not include the pre-treatments for organic matter or highly calcareous materials as the samples tested did not require these treatments.

**Reagents**

Dispersant solution: weigh 200 g sodium tripolyphosphate and 20 g sodium carbonate into a beaker and add approx. 1.6 L water, stir and then make up to 2 L.

**Apparatus**

Shaking bottles and machine

Sedimentation cylinder

Glass vials

Sand vials

25 mL pipette and pipetus (holder and pump)

Glass siphon and U-tube

Sand washing beakers

Sand sieve

**Procedure**

Weigh 10 g soil into a 250 mL shaking bottle, add 10 mL dispersant and half fill the bottle with water. Place bottles in an end-over-end shaker for 64 hrs. After shaking, transfer the dispersed material into 500 mL sedimentation cylinders in a 20°C constant temperature room. Make up to 500 mL with water and allow to equilibrate.

**Determination of Silt and Clay Particle (< 20µm) fraction**

Prepare the pipetus by inserting a 25 mL pipette and switch on. Prepare and pre-weigh a 30 mL glass vial. Paddle the cylinder for 30 seconds vigorously at first to dislodge the soil pad at the bottom, then continuously up and down with the upward stroke reaching no higher than the 400 mL mark. Insert the pipette carefully into the cylinder and hold it so the 104 mm graduation is level with the surface of the suspension. At time 5 minutes draw up 25 mL of solution. Dispense the sample into the glass vial A. When all samples have been removed, clean the pipette, paddle the blank cylinder, sample 25 mL and dispense into a Blank vial. Place the vials into an oven at 105°C.

**Determination of Clay Particles (< 2µm)**

Using the pipetus, place the pipette at the 75 mm graduation mark level with the top of the soil suspension in the cylinder and take a 25 mL sample 6 hours after paddling the cylinder for silt and clay. Dispense the sample into a glass vial Q and place in 105°C oven.

**Determination of Coarse and Fine Sand (> 20µm)**

Pour or siphon off the remaining soil suspension from the 1st batch and use a wash bottle to transfer the remaining residue to 600 mL tall beakers. Place a 0-50°C thermometer into the beaker and fill with tap water. The settling time is temperature dependent so temperature measurements must be made e.g. at 16°C the settling time is 5 min 20 sec. After the required time has passed, siphon off the top 100 mm of suspension. Repeat this timed washing until all the supernatant liquid is clear at the time when it should be siphoned off. With a smaller siphon, take off half of the remaining supernatant. Transfer the remainder of sample into the sieve and collection system. Place the retained contents into a pre-weighed polycarbonate Vial C and transfer the fine sand from the base into F vial. With the small siphon remove most of the supernatant in the vials and when all are complete, place in an oven at 80°C and leave until dry.

**Calculations**

After all sub-samples are oven dried, record their weights.

For 10 g soil in 500 mL sedimentation cylinder taking 25 mL aliquot:

Wt clay fraction = (wt of Q vial + fraction) – wt Q vial

% clay = (wt clay fraction – wt blank) x 200

wt silt + clay fraction = (wt of A vial + fraction) – wt A vial

% silt = (wt silt + clay fraction – wt clay fraction) x 200

wt fine sand = (wt of F vial + fraction) – wt F vial

% fine sand = wt fine sand x 10

wt coarse sand = (wt of C vial + fraction) – wt C vial

% coarse sand = wt coarse sand x 10

### 1A.4.2 Gravimetric Water Content

Tailings were sub-sampled directly after exposure or extrusion. The sub-sample was weighed ($W_w$) and placed in an oven at 105°C for 24 hrs. The sample was then re-weighed after equilibrating in a desiccator for 24 hours ($W_d$). The water content expressed as a percentage of the oven dry weight was then calculated using the formula:

$$w = [(W_w - W_d) / W_d] \times 100$$

### 1A.4.3 Bulk Density Determinations

The following procedure was used to determine the Wet and Dry Bulk densities of the tailing samples:

Undisturbed samples of know volume were removed from the sample cores or directly from laboratory column experiments. Sub-samples were also taken to determine the water content, immediately after extrusion or exposure. The Dry and Wet Bulk densities were then calculated using the following formulae:

Dry Bulk Density ($\gamma_d$)

$\gamma_d = 100 \text{ x } \rho_s / (100 + (w \text{ x } \rho_{s)}$

Wet Bulk Density ($\gamma_w$)

$\gamma_w = \gamma_d /(100 + w) / 100$

where:

$\rho_s$ = particle density

w = gravimetric water content expressed as a percentage of oven dry weight

### 1A.4.4 Void Ratio and Porosity Determinations

The void ratio and porosity values were calculated using the following formulae:

Void Ratio (E)

$E = w \text{ x } \rho_s / 100$

Porosity (N)

$N = e / (1 + e)$

# Appendix 2: Tailings Core Mineralogy, Geochemistry and Porewater Chemistry

**Table 2A.1: Modal percentages of mineral assemblages as a function of grain size for selected tailings samples**

| **Site 4 (11.38-11.39m)** | | | | | | |
|---|---|---|---|---|---|---|
| **Mineral % wt/wt** | **+106 (µm)** | **+45 (µm)** | **+20 (µm)** | **+10 (µm)** | **-10 (µm)** | **[(1)]HEAD** |
| Gypsum | 1.1 | 7.8 | 10.5 | 12.2 | 13.0 | 10.3 |
| Chalcopyrite | 0.0 | 0.0 | 0.0 | 0.6 | 0.5 | 0.3 |
| Galena | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Jarosite | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Barite | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pyrite | 0.0 | 0.0 | 0.0 | 1.4 | 1.2 | 0.7 |
| Fe-Sphalerite | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fe-Oxide | 2.3 | 2.6 | 3.3 | 3.5 | 1.8 | 3.5 |
| Ilmenite | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Rutile | 1.0 | 0.3 | 0.7 | 0.9 | 0.8 | 0.7 |
| Quartz | 51.8 | 44.9 | 40.8 | 25.1 | 19.6 | 33.1 |
| Chlorite | 30.0 | 30.7 | 31.3 | 34.0 | 36.8 | 33.1 |
| Mica | 12.0 | 10.9 | 10.4 | 13.1 | 14.6 | 12.4 |
| Al-Silicates | 1.4 | 2.4 | 2.7 | 5.8 | 6.6 | 4.3 |
| Zircon | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| U-Phases | 0.006 | 0.006 | 0.009 | 0.02 | 0.023 | 0.0 |
| Rhodochrosite | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Pyrolusite | 0.2 | 0.2 | 0.3 | 0.9 | 1.3 | 0.7 |
| Calcite | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| Mg-Phases | 0.2 | 0.2 | 0.2 | 1.5 | 1.0 | 0.7 |
| Apatite | 0.1 | 0.1 | 0.2 | 0.5 | 0.0 | 0.2 |
| Other | <0.1 | <0.1 | <0.1 | 0.5 | 0.1 | 0.2 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |
| **Site 5 (7.1-7.11m)** | | | | | | |
| **Mineral % wt/wt** | **+106 (µm)** | **+45 (µm)** | **+20 (µm)** | **+10 (µm)** | **-10 (µm)** | **[(1)]HEAD** |
| Gypsum | [(2)]ns | 1.5 | 5.9 | 14.1 | 15.0 | 9.4 |
| Chalcopyrite | ns | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Galena | ns | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Jarosite | ns | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Barite | ns | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pyrite | ns | 0.0 | 0.0 | 1.3 | 0.0 | 0.6 |
| Fe-Sphalerite | ns | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fe-Oxide | ns | 3.7 | 4.2 | 5.3 | 7.9 | 4.9 |
| Ilmenite | ns | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Rutile | ns | 0.6 | 0.9 | 0.9 | 0.5 | 0.8 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Quartz | ns | 48.5 | 43.1 | 22.7 | 19.2 | 32.7 |
| Chlorite | ns | 35.6 | 35.3 | 42.1 | 43.0 | 39.3 |
| Mica | ns | 6.9 | 6.7 | 9.2 | 9.7 | 8.2 |
| Al-Silicates | ns | 2.8 | 2.9 | 3.9 | 4.2 | 3.5 |
| Zircon | ns | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| U-Phases | ns | 0.015 | 0.012 | 0.028 | 0.034 | 0.0 |
| Rhodochrosite | ns | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Pyrolusite | ns | 0.2 | 0.2 | 0.5 | 0.6 | 0.4 |
| Calcite | ns | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| Mg-Phases | ns | <0.2 | <0.2 | <0.2 | <0.2 | 0.0 |
| Apatite | ns | 0.2 | 0.9 | 0.0 | 0.0 | 0.2 |
| Other | ns | <0.2 | <0.2 | <0.2 | <0.2 | 0.0 |
| Total | ns | 100 | 100 | 100 | 100 | 100 |
| **Site 5 (10.34-10.38)** | | | | | | |
| **Mineral % wt/wt** | **+106 (µm)** | **+45 (µm)** | **+20 (µm)** | **+10 (µm)** | **-10 (µm)** | **(1)HEAD** |
| Gypsum | 1.5 | 1.4 | 5.1 | 14.2 | 15.2 | 8.2 |
| Chalcopyrite | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Galena | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Jarosite | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Barite | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pyrite | 0.0 | 0.0 | 0.0 | 1.2 | 1.3 | 0.6 |
| Fe-Sphalerite | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fe-Oxide | 3.8 | 5.2 | 6.7 | 9.5 | 9.3 | 7.2 |
| Ilmenite | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Rutile | 0.2 | 1.6 | <0.1 | <0.1 | <0.1 | 0.4 |
| Quartz | 42.1 | 42.2 | 38.7 | 19.4 | 19.4 | 31.0 |
| Chlorite | 32.8 | 35.5 | 36.4 | 38.9 | 38.4 | 36.8 |
| Mica | 15.2 | 10.2 | 9.9 | 11.2 | 10.8 | 11.1 |
| Al-Silicates | 2.1 | 2.8 | 3.7 | 4.3 | 4.5 | 4.0 |
| Zircon | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| U-Phases | 0.015 | 0.011 | 0.01 | 0.027 | 0.028 | 0.0 |
| Rhodochrosite | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Pyrolusite | 0.2 | 0.2 | 0.2 | 0.5 | 0.5 | 0.3 |
| Calcite | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| Mg-Phases | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.1 |
| Apatite | 0.2 | 0.0 | -0.4 | 0.0 | 0.0 | 0.0 |
| Other | <0.1 | <0.1 | <0.1 | 0.2 | 0.3 | 0.1 |
| Total | 98 | 99 | 100 | 100 | 100 | 100 |
| **Site 5 (11.12-11.15m)** | | | | | | |
| **Mineral % wt/wt** | **+106 (µm)** | **+45 (µm)** | **+20 (µm)** | **+10 (µm)** | **-10 (µm)** | **(1)HEAD** |
| Gypsum | (2)ns | 2.3 | 6.3 | 11.7 | 13.4 | 9.7 |
| Chalcopyrite | ns | 0.0 | 0.0 | 1.4 | 0.9 | 0.8 |
| Galena | ns | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Jarosite | ns | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Barite | ns | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pyrite | ns | 0.0 | 0.0 | 0.9 | 0.6 | 0.5 |
| Fe-Sphalerite | ns | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fe-Oxide | ns | 2.9 | 3.5 | 4.3 | 4.5 | 4.0 |
| Ilmenite | ns | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Rutile | ns | 3.4 | 2.5 | 1.7 | 1.5 | 2.1 |
| Quartz | ns | 47.6 | 44.6 | 24.8 | 23.8 | 31.6 |
| Chlorite | ns | 30.8 | 31.2 | 38.2 | 37.1 | 35.5 |
| Mica | ns | 11.9 | 11.3 | 13.0 | 13.3 | 12.6 |
| Al-Silicates | ns | 2.1 | 2.9 | 3.8 | 4.5 | 3.3 |
| Zircon | ns | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| U-Phases | ns | 0.008 | 0.007 | 0.018 | 0.018 | 0.0 |
| Rhodochrosite | ns | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Pyrolusite | ns | 0.3 | 0.3 | 0.7 | 0.7 | 0.6 |
| Calcite | ns | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| Mg-Phases | ns | 0.3 | <0.1 | 1.1 | 2.3 | 1.1 |
| Apatite | ns | 0.2 | 0.0 | 1.0 | 0.0 | 0.4 |
| Other | ns | 0.2 | <0.1 | 0.9 | 1.5 | 0.8 |
| Total | ns | 102 | 102 | 103 | 104 | 103 |
| **Site 6 (5.38-5.5m)** | | | | | | |
| **Mineral % wt/wt** | **+106 (µm)** | **+45 (µm)** | **+20 (µm)** | **+10 (µm)** | **-10 (µm)** | **[(1)]HEAD** |
| Gypsum | 0.2 | 1.5 | 4.5 | 2.2 | 2.9 | 1.3 |
| Chalcopyrite | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Galena | 0.2 | 0.0 | 0.0 | 1.6 | 1.7 | 0.2 |
| Jarosite | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Barite | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pyrite | 0.0 | 0.0 | 0.0 | 2.0 | 2.2 | 0.2 |
| Fe-Sphalerite | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fe-Oxide | 3.2 | 4.7 | 7.3 | 8.0 | 8.3 | 4.6 |
| Ilmenite | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Rutile | 0.8 | 0.6 | 0.7 | 0.5 | 0.8 | 0.7 |
| Quartz | 51.8 | 48.9 | 44.7 | 24.7 | 23.9 | 47.8 |
| Chlorite | 33.7 | 34.6 | 33.6 | 47.2 | 46.1 | 35.1 |
| Mica | 7.7 | 6.9 | 6.9 | 9.7 | 9.3 | 7.4 |
| Al-Silicates | 1.5 | 2.5 | 3.4 | 4.6 | 5.1 | 3.8 |
| Zircon | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| U-Phases | 0.0023 | 0.021 | 0.021 | 0.036 | 0.036 | 0.0 |
| Rhodochrosite | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Pyrolusite | 0.2 | 0.2 | 0.3 | 0.5 | 0.4 | 0.2 |
| Calcite | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| Mg-Phases | 0.8 | 1.2 | 1.8 | 3.0 | 3.3 | 1.2 |
| Apatite | 0.5 | 0.5 | 0.1 | 0.0 | 0.0 | 0.4 |
| Other | 0.5 | 0.6 | 0.4 | 0.4 | 0.8 | 0.5 |
| Total | 101 | 102 | 104 | 104 | 105 | 103 |

| Site 6 (12.36-12.4m) | | | | | | |
|---|---|---|---|---|---|---|
| **Mineral % wt/wt** | **+106 (µm)** | **+45 (µm)** | **+20 (µm)** | **+10 (µm)** | **-10 (µm)** | **[(1)]HEAD** |
| Gypsum | ns | ns | 0.5 | 5.8 | 6.9 | 7.0 |
| Chalcopyrite | ns | ns | 0.0 | 0.5 | 0.5 | 0.5 |
| Galena | ns | ns | 0.0 | 0.0 | 0.0 | 0.0 |
| Jarosite | ns | ns | 0.0 | 0.0 | 0.0 | 0.0 |
| Barite | ns | ns | 0.0 | 0.0 | 0.0 | 0.0 |
| Pyrite | ns | ns | 0.0 | 0.6 | 0.6 | 0.5 |
| Fe-Sphalerite | ns | ns | 0.0 | 0.0 | 0.0 | 0.0 |
| Fe-Oxide | ns | ns | 2.6 | 3.8 | 3.6 | 3.6 |
| Ilmenite | ns | ns | 0.0 | <0.1 | <0.1 | 0.0 |
| Rutile | ns | ns | 0.8 | 1.1 | 0.8 | 1.0 |
| Quartz | ns | ns | 39.6 | 30.1 | 30.1 | 31.6 |
| Chlorite | ns | ns | 24.3 | 32.2 | 32.1 | 31.4 |
| Mica | ns | ns | 17.3 | 20.5 | 19.7 | 19.9 |
| Al-Silicates | ns | ns | 3.1 | 3.9 | 4.2 | 3.5 |
| Zircon | ns | ns | <0.2 | <0.2 | <0.2 | <0.2 |
| U-Phases | ns | ns | 0.01 | 0.021 | 0.02 | 0.0 |
| Rhodochrosite | ns | ns | <0.1 | <0.1 | <0.1 | <0.1 |
| Pyrolusite | ns | ns | 0.2 | 0.7 | 0.4 | 0.5 |
| Calcite | ns | ns | <0.2 | <0.2 | <0.2 | <0.2 |
| Mg-Phases | ns | ns | 2.1 | 2.1 | 2.8 | 2.3 |
| Apatite | ns | ns | <0.2 | 0.4 | 0.3 | 0.3 |
| Other | ns | ns | 0.9 | 1.8 | 2.1 | 1.7 |
| Total | ns | ns | 91 | 103 | 104 | 104 |

[1]HEAD: Whole sample
[2]ns: Not sufficient sample for analysis

**Table 2A.2: Bulk phase geochemistry of tailings solids**

| **Core Sample** | | **Major Elements (% wt/wt)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Site 3** | **RL (m) Midpoint** | **$SiO_2$** | **$Al_2O_3$** | **$Fe_2O_3$** | **MnO** | **MgO** | **CaO** | **$K_2O$** | **$SO_3$** |
| 4-4.5 | 39.5 | 53.8 | 12.0 | 8.2 | 0.16 | 10.0 | 3.10 | 0.68 | 4.7 |
| 5-5.5 | 38.5 | 61.6 | 12.0 | 7.1 | 0.17 | 11.0 | 0.75 | 0.87 | 0.72 |
| 6-6.5 | 37.5 | 56.1 | 14.0 | 9.3 | 0.30 | 12.0 | 0.72 | 1.01 | 1.3 |
| 7-7.5 | 36.5 | 52.0 | 14.0 | 8.2 | 0.24 | 10.0 | 2.90 | 1.23 | 4.0 |
| 8-8.5 | 35.6 | 63.0 | 12.0 | 6.6 | 0.33 | 8.9 | 1.50 | 1.16 | 2.2 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 9-9.5 | 34.6 | 69.0 | 11.0 | 4.3 | 0.27 | 7.9 | 1.50 | 1.23 | 2.0 |
| **Site 4** | **RL (m) Midpoint** | **$SiO_2$** | **$Al_2O_3$** | **$Fe_2O_3$** | **MnO** | **MgO** | **CaO** | **$K_2O$** | **$SO_3$** |
| 7-7.5 | 37.6 | 54.0 | 13.0 | 9.5 | 0.32 | 12.0 | 0.71 | 0.97 | 2.3 |
| 8-8.5 | 36.4 | 52.0 | 15.0 | 7.7 | 0.28 | 11.0 | 1.10 | 1.57 | 3.2 |
| 9-9.5 | 35.2 | 56.0 | 12.0 | 6.0 | 0.25 | 10.0 | 2.60 | 1.14 | 4.8 |
| 10-10.5 | 34.0 | 50.0 | 14.0 | 6.3 | 0.39 | 9.4 | 3.10 | 1.61 | 6.5 |
| 11-11.5 | 32.8 | 47.0 | 14.0 | 6.4 | 0.59 | 8.6 | 4.40 | 1.49 | 8.0 |
| 12-12.5 | 31.7 | 50.0 | 16.0 | 6.5 | 0.21 | 9.4 | 3.20 | 1.93 | 5.3 |
| 13-13.5 | 30.5 | 52.0 | 16.0 | 6.4 | 0.25 | 8.9 | 3.00 | 1.69 | 4.8 |
| 14-14.5 | 29.3 | 53.0 | 15.0 | 6.8 | 0.37 | 8.4 | 2.70 | 1.65 | 4.2 |
| **Site 5** | **RL (m) Midpoint** | **$SiO_2$** | **$Al_2O_3$** | **$Fe_2O_3$** | **MnO** | **MgO** | **CaO** | **$K_2O$** | **$SO_3$** |
| 2-2.5 | 40.6 | 48.0 | 13.0 | 11.0 | 0.36 | 11.0 | 3.00 | 0.78 | 5.3 |
| 3-3.5 | 39.8 | 41.0 | 10.0 | 8.0 | 0.49 | 8.5 | 2.90 | 0.76 | 5.2 |
| 4-4.5 | 38.9 | 48.0 | 13.0 | 11.0 | 0.31 | 11.0 | 2.90 | 0.84 | 5.3 |
| 5-5.5 | 38.0 | 52.0 | 14.0 | 8.5 | 0.28 | 11.0 | 1.30 | 1.18 | 4.0 |
| 6-6.5 | 37.1 | 56.0 | 12.0 | 6.7 | 0.26 | 10.0 | 2.60 | 1.10 | 4.5 |
| 7-7.5 | 36.2 | 53.0 | 11.0 | 6.4 | 0.23 | 9.9 | 2.10 | 0.10 | 3.6 |
| 8-8.5 | 35.2 | 60.0 | 12.0 | 6.7 | 0.28 | 10.0 | 1.80 | 0.10 | 3.1 |
| 9-9.5 | 34.4 | 58.0 | 12.0 | 7.8 | 0.44 | 9.7 | 2.00 | 1.12 | 4.2 |
| 10-10.5 | 33.4 | 56.0 | 13.0 | 7.0 | 0.35 | 10.0 | 2.40 | 1.23 | 4.5 |
| 11-11.5 | 32.5 | 61.0 | 12.0 | 5.5 | 0.32 | 8.9 | 2.30 | 1.22 | 3.8 |
| 12-12.5 | 31.6 | 58.0 | 13.0 | 4.9 | 0.36 | 7.8 | 1.90 | 1.68 | 3.3 |
| 13-13.5 | 30.7 | 60.0 | 13.0 | 5.2 | 0.23 | 7.9 | 2.10 | 1.31 | 3.4 |
| **Site 6** | **RL (m) Midpoint** | **$SiO_2$** | **$Al_2O_3$** | **$Fe_2O_3$** | **MnO** | **MgO** | **CaO** | **$K_2O$** | **$SO_3$** |
| 4-4.5 | 38.6 | 56.0 | 12.0 | 8.2 | 0.22 | 9.4 | 2.30 | 0.95 | 4.1 |
| 5-5.5 | 37.8 | 64.0 | 11.0 | 7.2 | 0.21 | 10.0 | 0.60 | 0.78 | 1.1 |
| 6-6.5 | 36.9 | 65.0 | 11.0 | 6.9 | 0.14 | 11.0 | 0.63 | 0.66 | 0.77 |
| 7-7.5 | 36.0 | 58.0 | 13.0 | 8.2 | 0.19 | 11.0 | 0.64 | 1.13 | 1.8 |
| 8-8.5 | 35.2 | 51.0 | 14.0 | 8.0 | 0.25 | 11.0 | 1.90 | 1.48 | 4.1 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 9-9.5 | 34.2 | 53.0 | 14.0 | 6.8 | 0.27 | 9.5 | 3.10 | 1.46 | 5.7 |
| 10-10.5 | 33.4 | 61.0 | 12.0 | 6.6 | 0.46 | 9.1 | 2.10 | 1.15 | 3.6 |
| 11-11.5 | 32.6 | 52.0 | 16.0 | 6.2 | 0.23 | 9.2 | 2.50 | 1.86 | 4.4 |
| 12-12.5 | 31.5 | 58.0 | 14.0 | 5.4 | 0.27 | 8.2 | 2.30 | 1.78 | 3.7 |
| 12.5-13 | 30.8 | 56.0 | 15.0 | 5.5 | 0.24 | 8.2 | 2.60 | 1.81 | 4.5 |
| **Site 9** | **RL (m) Midpoint** | **$SiO_2$** | **$Al_2O_3$** | **$Fe_2O_3$** | **MnO** | **MgO** | **CaO** | **$K_2O$** | **$SO_3$** |
| 6-6.5 | 38.3 | 53.0 | 13.0 | 7.0 | 0.32 | 11.0 | 2.20 | 1.25 | 4.9 |
| 7-7.5 | 37.2 | 58.0 | 13.0 | 5.7 | 0.23 | 9.5 | 2.10 | 1.40 | 4.2 |
| 8-8.5 | 36.1 | 56.0 | 12.0 | 7.8 | 0.31 | 9.99 | 2.40 | 1.11 | 4.3 |
| 9-9.5 | 34.9 | 56.0 | 12.0 | 6.8 | 0.30 | 10.0 | 2.16 | 1.05 | 4.1 |
| 10-10.5 | 33.8 | 51.0 | 13.0 | 10.0 | 0.50 | 11.0 | 2.20 | 1.11 | 4.9 |
| 11-11.5 | 32.6 | 50.0 | 15.0 | 7.0 | 0.34 | 9.6 | 2.90 | 1.79 | 5.5 |
| 12-12.5 | 31.5 | 55.0 | 14.0 | 6.9 | 0.30 | 10.0 | 2.50 | 1.33 | 4.2 |
| 13-13.5 | 30.3 | 62.0 | 13.0 | 4.7 | 0.24 | 8.4 | 2.30 | 1.51 | 3.4 |

**Table 2A.3: Multi-element composition of tailings solids**

| **Core Sample** | | **Trace Elements (mg/kg)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Site 3** | **RL (m) Midpoint** | **Ba** | **Zn** | **Pb** | **Cu** | **Sr** | **Th** | **U** | **Co** | **Ni** |
| 4-4.5 | 37.5 | 70 | 73 | 645 | 188 | 19 | 115 | 548 | 24 | 64 |
| 5-5.5 | 38.5 | 77 | 75 | 811 | 85 | 24 | 94 | 360 | 25 | 72 |
| 6-6.5 | 37.5 | 180 | 79 | 989 | 102 | 25 | 98 | 386 | 28 | 80 |
| 7-7.5 | 36.5 | 268 | 65 | 967 | 240 | 30 | 109 | 416 | 25 | 71 |
| 8-8.5 | 35.6 | 144 | 47 | 814 | 149 | 69 | 98 | 358 | 21 | 59 |
| 9-9.5 | 34.6 | 115 | 43 | 511 | 168 | 52 | 94 | 298 | 18 | 55 |
| **Site 4** | **RL (m) Midpoint** | **Ba** | **Zn** | **Pb** | **Cu** | **Sr** | **Th** | **U** | **Co** | **Ni** |
| 7-7.5 | 37.6 | 176 | 63 | 938 | 117 | 23 | 105 | 430 | 29 | 72 |
| 8-8.5 | 36.4 | 226 | 65 | 1164 | 306 | 25 | 107 | 383 | 29 | 72 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 9-9.5 | 35.2 | 143 | 61 | 473 | 232 | 15 | 94 | 295 | 28 | 58 |
| 10-10.5 | 34.0 | 186 | 59 | 800 | 304 | 29 | 118 | 373 | 22 | 65 |
| 11-11.5 | 32.8 | 182 | 83 | 760 | 369 | 40 | 111 | 440 | 29 | 71 |
| 12-12.5 | 31.7 | 398 | 54 | 1333 | 308 | 96 | 102 | 382 | 34 | 69 |
| 13-13.5 | 30.5 | 314 | 56 | 1123 | 306 | 34 | 108 | 395 | 31 | 73 |
| 14-14.5 | 29.3 | 291 | 53 | 1021 | 409 | 35 | 112 | 435 | 28 | 72 |
| **Site 5** | **RL (m) Midpoint** | **Ba** | **Zn** | **Pb** | **Cu** | **Sr** | **Th** | **U** | **Co** | **Ni** |
| 2-2.5 | 40.6 | 188 | 80 | 737 | 279 | 14 | 82 | 542 | 28 | 66 |
| 3-3.5 | 39.8 | 222 | 65 | 721 | 383 | 21 | 120 | 717 | 31 | 60 |
| 4-4.5 | 38.9 | 223 | 88 | 772 | 304 | 19 | 102 | 578 | 29 | 97 |
| 5-5.5 | 38.0 | 209 | 65 | 984 | 257 | 29 | 107 | 444 | 28 | 73 |
| 6-6.5 | 37.1 | 206 | 59 | 807 | 288 | 78 | 88 | 336 | 25 | 58 |
| 7-7.5 | 36.2 | 128 | 40 | 636 | 165 | 75 | 98 | 342 | 21 | 54 |
| 8-8.5 | 35.2 | 172 | 52 | 760 | 262 | 65 | 92 | 432 | 26 | 63 |
| 9-9.5 | 34.4 | 146 | 38 | 921 | 174 | 77 | 113 | 432 | 24 | 107 |
| 10-10.5 | 33.4 | 199 | 59 | 1125 | 288 | 100 | 101 | 403 | 28 | 63 |
| 11-11.5 | 32.5 | 155 | 43 | 596 | 200 | 96 | 87 | 260 | 22 | 56 |
| 12-12.5 | 31.6 | 193 | 39 | 846 | 296 | 71 | 91 | 285 | 18 | 56 |
| 13-13.5 | 30.7 | 193 | 39 | 644 | 256 | 25 | 107 | 334 | 23 | 63 |
| **Site 6** | **RL (m) Midpoint** | **Ba** | **Zn** | **Pb** | **Cu** | **Sr** | **Th** | **U** | **Co** | **Ni** |
| 4-4.5 | 38.6 | 171 | 63 | 763 | 281 | 20 | 98 | 507 | 24 | 61 |
| 5-5.5 | 37.8 | 124 | 55 | 889 | 127 | 23 | 94 | 451 | 24 | 61 |
| 6-6.5 | 36.9 | 78 | 50 | 512 | 89 | 16 | 79 | 421 | 21 | 57 |
| 7-7.5 | 36.0 | 166 | 64 | 770 | 201 | 18 | 94 | 349 | 24 | 61 |
| 8-8.5 | 35.2 | 245 | 69 | 1203 | 254 | 20 | 103 | 359 | 29 | 65 |
| 9-9.5 | 34.2 | 227 | 74 | 1050 | 342 | 60 | 121 | 388 | 31 | 74 |
| 10-10.5 | 33.4 | 164 | 56 | 865 | 214 | 87 | 101 | 356 | 27 | 58 |
| 11-11.5 | 32.6 | 301 | 47 | 939 | 320 | 110 | 112 | 426 | 26 | 75 |
| 12-12.5 | 31.5 | 278 | 51 | 1215 | 321 | 34 | 92 | 348 | 22 | 64 |
| 12.5-13 | 30.8 | 242 | 45 | 1383 | 338 | 52 | 111 | 414 | 23 | 69 |

| Site 9 | RL (m) Midpoint | Ba | Zn | Pb | Cu | Sr | Th | U | Co | Ni |
|---|---|---|---|---|---|---|---|---|---|---|
| 6-6.5 | 38.3 | 202 | 71 | 793 | 264 | 21 | 105 | 338 | 24 | 66 |
| 7-7.5 | 37.2 | 141 | 51 | 765 | 346 | 54 | 111 | 341 | 21 | 58 |
| 8-8.5 | 36.1 | 162 | 43 | 913 | 220 | 98 | 99 | 448 | 20 | 57 |
| 9-9.5 | 34.9 | 121 | 46 | 678 | 253 | 70 | 108 | 407 | 22 | 53 |
| 10-10.5 | 33.8 | 263 | 52 | 970 | 194 | 91 | 101 | 459 | 33 | 59 |
| 11-11.5 | 32.6 | 302 | 59 | 1487 | 279 | 127 | 112 | 421 | 28 | 72 |
| 12-12.5 | 31.5 | 263 | 63 | 819 | 272 | 38 | 113 | 314 | 28 | 72 |
| 13-13.5 | 30.3 | 236 | 35 | 950 | 268 | 23 | 100 | 282 | 23 | 64 |

## Table 2A.4: Porewater pH, Eh and Multi-element Composition as determined by ICP-AES (mg/L)

| Sample | RL (m) midpoint | pH | Eh (mV) | EC (mS/cm) | Al | B | Ca | Cr | Fe | K | Li | Mg | Mn | Na | P | S | Si | Sr | Ti | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Site 3** | | | | | | | | | | | | | | | | | | | | | |
| 5-5.5 | 38.5 | 7.95 | 340 | 13.3 | 0.010 | 0.065 | 412 | <0.005 | 22 | 85 | 0.017 | 2257 | 14 | 94 | <0.05 | 3894 | 1.7 | 0.426 | <0.005 | <0.005 | 0.05 |
| 6-6.5 | 37.5 | 7.26 | 394 | 10.4 | <0.005 | 0.654 | 349 | 0.007 | 18 | 89 | 0.018 | 1160 | 125 | 96 | <0.05 | 2600 | 3.4 | 0.315 | <0.005 | <0.005 | 0.13 |
| 7-7.5 | 36.5 | 7.24 | 379 | 5.2 | 0.006 | 0.464 | 444 | <0.005 | 6 | 43 | 0.058 | 142 | 36 | 69 | <0.05 | 1077 | 6.1 | 2.32 | <0.005 | <0.005 | 0.08 |
| 8-8.5 | 35.6 | 8.4 | 321 | 4 | 0.013 | 0.153 | 417 | <0.005 | 0.01 | 77 | 0.008 | 37 | 4.2 | 69 | 0.07 | 737 | 1.2 | 3.97 | <0.005 | <0.005 | <0.03 |
| 9-9.5 | 34.6 | 9.45 | 276 | 3 | 0.034 | 0.112 | 523 | <0.005 | 0.01 | 163 | 0.006 | 0.98 | 0.17 | 72 | 0.24 | 627 | 5.4 | 4.50 | <0.005 | 0.013 | <0.03 |
| **Site 4** | | | | | | | | | | | | | | | | | | | | | |
| 7-7.5 | 37.6 | 6.85 | 183 | 26.5 | 0.019 | 0.755 | 442 | 0.020 | 23 | 114 | 0.041 | 6776 | 456 | 101 | <0.05 | 10365 | 5.7 | 0.343 | <0.005 | <0.005 | 2.5 |
| 8-8.5 | 36.4 | 6.78 | 194 | 20.4 | 0.023 | 0.695 | 407 | 0.022 | 56 | 124 | 0.114 | 4384 | 433 | 113 | <0.05 | 7250 | 6.3 | 0.592 | <0.005 | <0.005 | 0.49 |
| 9-9.5 | 35.2 | 6.53 | 202 | 26.7 | 0.006 | 0.719 | 446 | 0.035 | 33 | 159 | 0.182 | 6472 | 760 | 176 | <0.05 | 10451 | 8.7 | 1.17 | <0.005 | <0.005 | 0.77 |
| 10-10.5 | 34 | 6.58 | 241 | 24.6 | 0.019 | 0.762 | 425 | 0.036 | 13 | 153 | 0.213 | 5206 | 772 | 166 | <0.05 | 8864 | 10 | 1.67 | <0.005 | <0.005 | 1.6 |
| 11-11.5 | 32.8 | 6.66 | 131 | 17.7 | 0.034 | 0.868 | 423 | 0.027 | 7 | 120 | 0.190 | 3010 | 542 | 116 | <0.05 | 5622 | 9.1 | 3.34 | <0.005 | <0.005 | 0.51 |
| 12-12.5 | 31.7 | 6.85 | 103 | 10.1 | 0.038 | 0.526 | 398 | 0.019 | 4 | 61 | 0.074 | 1540 | 369 | 52 | <0.05 | 3037 | 9.9 | 0.887 | <0.005 | <0.005 | 0.54 |
| 13-13.5 | 30.5 | 7.57 | 321 | 8.1 | 0.029 | 0.461 | 456 | 0.015 | 0.01 | 42 | 0.023 | 1371 | 259 | 41 | 0.51 | 2577 | 11 | 0.546 | <0.005 | <0.005 | 0.13 |
| 14-14.5 | 29.3 | 7.56 | 309 | 7.3 | <0.005 | 0.396 | 452 | 0.005 | 0.01 | 37 | 0.057 | 1064 | 91 | 38 | 0.09 | 2030 | 7.8 | 0.689 | <0.005 | <0.005 | 0.07 |
| **Site 5** | | | | | | | | | | | | | | | | | | | | | |
| 2-2.5 | 40.6 | 6.52 | 241 | 20.8 | 0.005 | 1.81 | 432 | 0.058 | 4.4 | 59 | 0.123 | 4553 | 1367 | 55 | <0.05 | 7873 | 16 | 0.550 | <0.005 | <0.005 | 1.4 |
| 3-3.5 | 39.8 | 6.32 | 228 | 22.3 | <0.005 | 0.694 | 448 | 0.053 | 98 | 59 | 0.083 | 5170 | 1175 | 60 | <0.05 | 8746 | 7.4 | 0.318 | <0.005 | <0.005 | 0.42 |
| 4-4.5 | 38.9 | 6.77 | 326 | 19.8 | <0.005 | 1.79 | 414 | 0.058 | 35 | 60 | 0.127 | 4418 | 1310 | 58 | <0.05 | 7643 | 16 | 0.554 | <0.005 | <0.005 | 1.3 |
| 5-5.5 | 38 | 6.9 | 346 | 29.6 | <0.005 | 0.724 | 454 | 0.032 | 0.01 | 138 | 0.126 | 7424 | 744 | 199 | <0.05 | 11614 | 5.5 | 2.89 | <0.005 | <0.005 | 0.59 |
| 6-6.5 | 37.1 | 7.48 | 315 | 22.3 | <0.005 | 0.928 | 419 | 0.015 | 0.01 | 189 | 0.105 | 3315 | 289 | 247 | <0.05 | 6973 | 4.6 | 6.8 | <0.005 | <0.005 | 0.15 |
| 7-7.5 | 36.2 | 7.27 | 391 | 17.7 | 0.009 | 0.746 | 413 | 0.013 | 0.01 | 152 | 0.095 | 2620 | 269 | 203 | <0.05 | 5529 | 4.6 | 6.8 | <0.005 | <0.005 | 0.14 |
| 8-8.5 | 35.2 | 7.46 | 335 | 25.1 | 0.008 | 0.546 | 403 | 0.011 | 0.01 | 157 | 0.110 | 4765 | 224 | 223 | <0.05 | 8369 | 2.5 | 7.6 | <0.005 | <0.005 | 0.19 |
| 9-9.5 | 34.4 | 7.2 | 381 | 29.1 | <0.005 | 0.824 | 417 | 0.037 | 0.01 | 193 | 0.114 | 6032 | 860 | 249 | 0.36 | 11002 | 4.3 | 7.3 | <0.005 | <0.005 | 0.37 |
| 10-10.5 | 33.4 | 7.22 | 369 | 16 | <0.005 | 0.776 | 402 | 0.022 | 0.01 | 157 | 0.189 | 2212 | 438 | 166 | 0.14 | 4848 | 5.8 | 5.7 | <0.005 | <0.005 | 0.39 |
| 11-11.5 | 32.5 | 8 | 336 | 15 | 0.005 | 0.407 | 409 | 0.007 | 0.01 | 128 | 0.095 | 2630 | 167 | 129 | <0.05 | 4828 | 1.7 | 9.4 | <0.005 | <0.005 | 0.06 |
| 12-12.5 | 31.6 | 7.3 | 246 | 11.8 | 0.012 | 0.548 | 409 | 0.021 | 0.02 | 70 | 0.071 | 1950 | 415 | 69 | <0.05 | 3696 | 8.2 | 3.78 | <0.005 | <0.005 | 0.23 |
| 13-13.5 | 30.7 | 7.54 | 323 | 6.3 | 0.006 | 0.351 | 455 | <0.005 | 0.02 | 47 | 0.037 | 945 | 39 | 46 | 0.09 | 1926 | 7.4 | 0.935 | <0.005 | <0.005 | 0.07 |

**Table 2A.4 (cont.) - Porewater pH, Eh and Multi-element Composition as determined by ICP-AES (mg/L)**

| Sample | RL (m) midpoint | pH | Eh (mv) | EC (ms/cm) | Al | B | Ca | Cr | Fe | K | Li | Mg | Mn | Na | P | S | Si | Sr | Ti | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Site 6** | | | | | | | | | | | | | | | | | | | | | |
| 4-4.5 | 38.6 | 6.66 | 158 | 18.7 | 0.019 | 0.612 | 421 | 0.016 | 15 | 53 | 0.106 | 3990 | 322 | 43 | <0.05 | 6309 | 7.2 | 0.430 | <0.005 | <0.005 | 0.67 |
| 5-5.5 | 37.8 | 7.6 | 301 | 19 | 0.012 | 0.050 | 417 | <0.005 | 10 | 55 | 0.015 | 4357 | 20 | 46 | 0.21 | 6489 | 2.8 | 0.673 | <0.005 | <0.005 | 0.10 |
| 6-6.5 | 36.9 | 7.85 | 346 | 23.2 | <0.005 | 0.035 | 443 | <0.005 | 19 | 75 | 0.049 | 5806 | 21 | 73 | <0.05 | 8663 | 1.8 | 0.563 | <0.005 | <0.005 | <0.03 |
| 7-7.5 | 36 | 6.95 | 169 | 22.2 | 0.006 | 0.384 | 419 | 0.012 | 3 | 103 | 0.026 | 4848 | 310 | 107 | <0.05 | 7804 | 5.2 | 0.333 | <0.005 | <0.005 | 0.27 |
| 8-8.5 | 35.2 | 6.85 | 303 | 23.1 | 0.074 | 0.695 | 416 | 0.026 | 0.49 | 137 | 0.118 | 4518 | 611 | 154 | <0.05 | 7878 | 7.0 | 0.792 | <0.005 | <0.005 | 0.26 |
| 9-9.5 | 34.2 | 7.2 | 418 | 21.8 | 0.010 | 0.711 | 402 | 0.018 | 0.01 | 163 | 0.226 | 3661 | 446 | 189 | <0.05 | 6939 | 5.2 | 5.3 | <0.005 | <0.005 | 1.1 |
| 10-10.5 | 33.4 | 7.4 | 378 | 15.8 | <0.005 | 0.584 | 394 | 0.017 | 0.01 | 119 | 0.209 | 2351 | 360 | 113 | <0.05 | 4689 | 3.7 | 6.5 | <0.005 | <0.005 | 0.10 |
| 11-11.5 | 32.6 | 6.74 | 397 | 11.5 | 0.007 | 0.471 | 400 | 0.013 | 0.01 | 73 | 0.097 | 1650 | 267 | 62 | <0.05 | 3278 | 7.8 | 2.23 | <0.005 | <0.005 | 0.26 |
| 12-12.5 | 31.5 | 7.24 | 376 | 9.5 | 0.005 | 0.501 | 420 | 0.009 | 0.01 | 52 | 0.088 | 1521 | 222 | 45 | 0.05 | 2880 | 8.3 | 1.51 | <0.005 | <0.005 | 0.20 |
| 12.5-13 | 30.8 | 7 | 358 | 8.8 | 0.008 | 0.467 | 385 | 0.012 | 0.01 | 42 | 0.085 | 1346 | 305 | 40 | 0.44 | 2588 | 9.0 | 0.893 | <0.005 | <0.005 | 0.31 |
| **Site 9** | | | | | | | | | | | | | | | | | | | | | |
| 6-6.5 | 38.3 | 6.72 | 196 | 26.3 | <0.005 | 0.766 | 414 | 0.032 | 13 | 137 | 0.153 | 5572 | 771 | 143 | <0.05 | 9288 | 5.9 | 0.720 | <0.005 | <0.005 | 0.20 |
| 7-7.5 | 37.2 | 7.05 | 362 | 24.8 | 0.006 | 0.786 | 404 | 0.023 | 25 | 147 | 0.112 | 4785 | 505 | 204 | <0.05 | 8305 | 4.7 | 6.0 | <0.005 | <0.005 | 0.15 |
| 8-8.5 | 36.1 | 7.18 | 346 | 23.3 | <0.005 | 0.966 | 420 | 0.024 | 8 | 162 | 0.151 | 3875 | 538 | 208 | 0.25 | 7390 | 5.7 | 6.9 | <0.005 | <0.005 | 0.15 |
| 9-9.5 | 34.9 | 7 | 209 | 27 | <0.005 | 0.762 | 419 | 0.031 | 1 | 161 | 0.133 | 5021 | 848 | 214 | 0.46 | 9393 | 5.4 | 6.9 | <0.005 | <0.005 | 0.23 |
| 10-10.5 | 33.8 | 6.77 | 351 | 28.4 | <0.005 | 1.12 | 429 | 0.059 | <0.01 | 169 | 0.133 | 5235 | 1538 | 192 | <0.05 | 10167 | 5.2 | 6.3 | <0.005 | <0.005 | 0.47 |
| 11-11.5 | 32.6 | 6.95 | 174 | 17.8 | 0.007 | 0.799 | 406 | 0.037 | 4 | 111 | 0.173 | 2838 | 812 | 104 | 0.23 | 5683 | 8.4 | 4.04 | <0.005 | <0.005 | 0.74 |
| 12-12.5 | 31.5 | 7.35 | 162 | 11.5 | 0.005 | 0.495 | 419 | 0.005 | <0.01 | 64 | 0.055 | 1790 | 87 | 58 | 0.60 | 3199 | 7.2 | 1.09 | <0.005 | <0.005 | 0.09 |
| 13-13.5 | 30.3 | 7.54 | 371 | 9.1 | <0.005 | 0.513 | 471 | <0.005 | <0.01 | 41 | 0.035 | 1325 | 53 | 43 | 1.8 | 2401 | 8.9 | 0.639 | <0.005 | <0.005 | 0.08 |

## Table 2A.5 - Porewater Trace Metals and Radionuclides

| Sample | RL (m) midpoint | Ba (µg/L) | Ni (µg/L) | Cu (µg/L) | Co (µg/L) | Ga (µg/L) | Ge (µg/L) | Rb (µg/L) | Y (µg/L) | Mo (µg/L) | Cd (µg/L) | Sb (µg/L) | Cs (µg/L) | La (µg/L) | Gd (µg/L) | Pb (µg/L) | Bi (µg/L) | U (µg/L) | $^{226}$Ra (Bq/L) | $^{230}$Th (Bq/L) | $^{210}$Pb (Bq/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Site 3** | | | | | | | | | | | | | | | | | | | | | |
| 5-5.5 | 38.5 | 5 | 45 | 59 | 20 | 1 | 2 | 283 | <1 | 120 | 3 | 1 | 42 | <1 | <1 | 2 | <1 | 209 | 9.4 | 0.4 | 1 |
| 6-6.5 | 37.5 | 5 | 57 | 19 | 15 | 10 | 2 | 253 | <1 | 130 | 4 | <1 | 31 | <1 | <1 | 2 | <1 | 158 | 2.1 | 0.5 | 1 |
| 7-7.5 | 36.5 | 9 | 31 | 48 | 8 | 2 | <1 | 150 | <1 | 40 | 1 | <1 | 14 | <1 | <1 | <1 | <1 | 291 | 6 | 0.1 | 1 |
| 8-8.5 | 35.6 | 7 | 10 | 34 | 2 | <1 | <1 | 92 | <1 | 480 | 3 | <1 | 11 | <1 | <1 | <1 | <1 | 86 | 1.8 | 0.1 | 1 |
| 9-9.5 | 34.6 | 15 | 2 | 34 | 3 | <1 | <1 | 99 | <1 | 450 | 1 | <1 | 4 | <1 | <1 | <1 | <1 | 6 | 6.5 | 0.3 | 0.5 |
| **Site 4** | | | | | | | | | | | | | | | | | | | | | |
| 7-7.5 | 37.6 | 5 | 50 | 8 | 32 | 55 | 9 | 447 | 13 | 80 | 9 | 2 | 57 | <1 | 2 | 3 | <1 | 707 | 3.7 | 1.1 | 0.5 |
| 8-8.5 | 36.4 | 78 | 280 | <5 | 107 | 53 | 4 | 397 | <1 | 170 | 45 | 2 | 43 | <1 | <1 | 4 | <1 | 343 | 3.3 | 0.035 | 0.9 |
| 9-9.5 | 35.2 | 5 | 290 | <5 | 79 | 107 | 16 | 629 | 33 | 20 | 2 | <1 | 57 | 5 | 4 | <1 | <1 | 136 | 3.7 | 0.9 | 0.3 |
| 10-10.5 | 34 | 12 | 130 | 16 | 20 | 81 | 7 | 536 | 23 | 60 | 120 | <1 | 52 | 4 | 2 | 46 | <1 | 122 | 2.9 | 1.7 | 0.9 |
| 11-11.5 | 32.8 | 5 | 40 | 15 | 12 | 53 | 18 | 376 | 11 | 70 | 11 | <1 | 36 | 2 | <1 | 5 | <1 | 51 | 3.1 | 0.3 | 2 |
| 12-12.5 | 31.7 | 15 | 8 | 5 | 5 | 38 | 8 | 187 | 2 | 30 | 10 | <1 | 15 | <1 | <1 | <1 | <1 | 89 | 7 | 2.9 | 0.8 |
| 13-13.5 | 30.5 | 5 | 3 | 5 | 2 | 28 | 2 | 113 | 1 | 110 | 12 | <1 | 9 | <1 | <1 | <1 | <1 | 367 | 2.8 | 0.8 | 2 |
| 14-14.5 | 29.3 | 5 | 3 | 7 | 2 | 12 | 2 | 99 | <1 | 230 | 13 | <1 | 9 | <1 | <1 | 5 | <1 | 230 | 0.9 | 0.7 | 1 |
| **Site 5** | | | | | | | | | | | | | | | | | | | | | |
| 2-2.5 | 40.6 | 11 | 110 | 14 | 194 | 172 | 14 | 250 | 51 | 10 | 13 | <1 | 30 | 3 | 9 | 4 | <1 | 50 | 4.5 | 0.31 | 2 |
| 3-3.5 | 39.8 | 5 | 20 | <5 | 134 | 128 | 33 | 306 | 71 | 10 | 6 | <1 | 35 | 1 | 12 | 2 | <1 | 24 | 4.7 | 0.04 | 0.3 |
| 4-4.5 | 38.9 | 43 | 140 | 31 | 178 | 161 | 5 | 237 | 33 | 10 | 21 | <1 | 28 | 3 | 5 | 42 | <1 | 14 | 3.5 | 0.8 | 0.8 |
| 5-5.5 | 38 | <5 | 50 | 10 | 14 | 106 | 5 | 619 | 18 | 80 | 4 | <1 | 76 | 2 | 4 | 1 | <1 | 268 | 3.1 | 0.2 | 2 |
| 6-6.5 | 37.1 | <5 | 20 | 157 | 8 | 58 | 3 | 930 | 3 | 150 | 7 | <1 | 99 | <1 | <1 | 10 | <1 | 342 | 2.7 | 0.2 | 0.05 |
| 7-7.5 | 36.2 | <5 | 2 | 36 | 4 | 40 | 4 | 650 | 4 | 290 | 4 | <1 | 75 | <1 | <1 | 2 | <1 | 282 | 5.2 | 0.003 | 0.1 |
| 8-8.5 | 35.2 | <5 | 2 | 83 | 6 | 45 | 3 | 814 | 2 | 110 | 11 | <1 | 104 | <1 | <1 | 9 | <1 | 642 | 4.7 | 0.7 | 0.8 |
| 9-9.5 | 34.4 | <5 | 2 | 22 | 6 | 142 | 4 | 904 | 4 | 90 | 9 | <1 | 99 | <1 | <1 | 13 | <1 | 64 | 5.8 | 1 | 0.1 |
| 10-10.5 | 33.4 | 15 | 2 | 32 | 6 | 58 | 2 | 522 | 4 | 120 | 6 | <1 | 54 | <1 | <1 | 1 | <1 | 59 | 6.5 | 0.13 | 0.2 |
| 11-11.5 | 32.5 | 5 | 2 | 18 | 3 | 23 | 2 | 445 | <1 | 180 | 5 | <1 | 44 | <1 | <1 | 2 | <1 | 58 | 3.1 | 0.17 | 0.2 |
| 12-12.5 | 31.6 | 11 | 2 | <5 | 7 | 59 | 2 | 218 | 2 | 100 | 3 | <1 | 23 | <1 | <1 | 2 | <1 | 232 | 2.7 | 1.6 | 2 |
| 13-13.5 | 30.7 | 12 | 2 | 35 | 1 | 1 | <1 | 82 | <1 | 140 | 2 | <1 | 7 | <1 | <1 | 3 | <1 | 240 | 4.6 | 1.2 | 0.7 |

**Table 2A.5 (cont.): Porewater Trace Metals and Radionuclides**

| Sample | RL (m) midpoint | Ba (µg/L) | Ni (µg/L) | Cu (µg/L) | Co (µg/L) | Ga (µg/L) | Ge (µg/L) | Rb (µg/L) | Y (µg/L) | Mo (µg/L) | Cd (µg/L) | Sb (µg/L) | Cs (µg/L) | La (µg/L) | Gd (µg/L) | Pb (µg/L) | Bi (µg/L) | U (µg/L) | $^{226}$Ra (Bq/L) | $^{230}$Th (Bq/L) | $^{210}$Pb (Bq/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Site 6** | | | | | | | | | | | | | | | | | | | | | |
| 4-4.5 | 38.6 | 7 | 39 | 22 | 28 | 41 | 7 | 251 | 3 | 110 | 3 | 1 | 34 | <1 | <1 | 3 | <1 | 551 | 5.3 | 0.2 | 0.9 |
| 5-5.5 | 37.8 | 7 | 38 | 139 | 115 | 2 | 2 | 243 | 3 | 220 | 4 | 2 | 33 | <1 | <1 | 5 | <1 | 560 | 6.9 | 0.008 | 1 |
| 6-6.5 | 36.9 | 5 | 37 | 12 | 85 | 2 | 1 | 356 | <1 | 340 | 3 | 1 | 43 | <1 | <1 | 4 | <1 | 590 | 2.9 | 0.2 | 1 |
| 7-7.5 | 36 | 24 | 36 | 29 | 33 | 31 | 2 | 359 | 3 | 200 | 4 | 1 | 48 | <1 | <1 | 4 | <1 | 900 | 14 | 0.24 | 1 |
| 8-8.5 | 35.2 | <5 | 35 | 19 | 15 | 48 | 3 | 396 | 5 | 110 | 6 | 2 | 43 | <1 | <1 | 16 | <1 | 141 | 3.6 | 1.1 | 2 |
| 9-9.5 | 34.2 | <5 | 34 | 1182 | 5 | 36 | 3 | 512 | 3 | 50 | 5 | <1 | 54 | <1 | <1 | 6 | <1 | 398 | 7.8 | 0.3 | 0.7 |
| 10-10.5 | 33.4 | <5 | 33 | 28 | 3 | 25 | 1 | 403 | 1 | 130 | 2 | <1 | 41 | <1 | <1 | 3 | <1 | 123 | 4.3 | 0.07 | 0.6 |
| 11-11.5 | 32.6 | <5 | 33 | 263 | 2 | 17 | <1 | 192 | 2 | 40 | 3 | <1 | 18 | <1 | <1 | <1 | <1 | 75 | 4.2 | 0.17 | 0.7 |
| 12-12.5 | 31.5 | <5 | 32 | 49 | 2 | 14 | 1 | 124 | 2 | 110 | 3 | <1 | 12 | <1 | <1 | 3 | <1 | 780 | 4.5 | 0.026 | 0.4 |
| 12.5-13 | 30.8 | 6 | 31 | 114 | 1 | 20 | 1 | 106 | 1 | 30 | 4 | <1 | 11 | <1 | <1 | 3 | <1 | 26 | 4.1 | 0.028 | 1 |
| **Site 9** | | | | | | | | | | | | | | | | | | | | | |
| 6-6.5 | 38.3 | <5 | 38 | 9 | 18 | 63 | 6 | 445 | 8 | 120 | 2 | <1 | 47 | 1 | <1 | 4 | <1 | 159 | 5.5 | 0.2 | 1 |
| 7-7.5 | 37.2 | <5 | 37 | <5 | 24 | 46 | 3 | 572 | 4 | 150 | 3 | <1 | 67 | <1 | <1 | 4 | <1 | 111 | 2.8 | 0.32 | 0.9 |
| 8-8.5 | 36.1 | <5 | 36 | 246 | 12 | 47 | 4 | 646 | 3 | 200 | 3 | 1 | 76 | <1 | <1 | 5 | <1 | 127 | 5.8 | 0.23 | 0.2 |
| 9-9.5 | 34.9 | <5 | 35 | 8 | 4 | 73 | 3 | 644 | 5 | 120 | 3 | <1 | 83 | <1 | <1 | 3 | 1 | 50 | 3.6 | 0.08 | 1 |
| 10-10.5 | 33.8 | <5 | 34 | 152 | 3 | 115 | 2 | 726 | 5 | 30 | 3 | <1 | 81 | <1 | <1 | 5 | 3 | 23 | 3.7 | 0.27 | 1 |
| 11-11.5 | 32.6 | <5 | 33 | <5 | 2 | 56 | 3 | 325 | 5 | 30 | 2 | <1 | 35 | <1 | <1 | 2 | <1 | 29 | 2.4 | 0.8 | 3 |
| 12-12.5 | 31.5 | <5 | 32 | <5 | 3 | 8 | 1 | 167 | 1 | 30 | 3 | 1 | 14 | <1 | <1 | 3 | <1 | 240 | 1.8 | 0.4 | 3 |
| 13-13.5 | 30.3 | <5 | 30 | 154 | 3 | 4 | <1 | 114 | 2 | 10 | 1 | <1 | 9 | <1 | <1 | 4 | <1 | 262 | 2.3 | 0.23 | 1 |

**Table 2A.6 Porewater Ammonia, Nitrate and Chloride concentrations for selected cores**

| Sample | RL (m) midpoint | $NH_4^+$ (mg/L) | $NO_3^-$ (mg/L) | $Cl^-$ (mg/L) |
|---|---|---|---|---|
| **Site 3** | | | | |
| 5-5.5 | 38.5 | 279 | 0.45 | 588 |
| 7-7.5 | 36.5 | 206 | 0.78 | 40 |
| 9-9.5 | 34.6 | 66 | 7.33 | 60 |
| **Site 4** | | | | |
| 7-7.5 | 37.6 | 404 | 1.67 | 60 |
| 8-8.5 | 36.4 | 441 | 1.67 | 78 |
| 9-9.5 | 35.2 | 625 | 1.23 | 80 |
| 10-10.5 | 34 | 588 | 1.23 | 138 |
| 14-14.5 | 29.3 | 147 | 0.78 | 31 |
| **Site 5** | | | | |
| 2-2.5 | 40.6 | 331 | 1.11 | 55 |
| 3-3.5 | 39.8 | 360 | 0.78 | 51 |
| 5-5.5 | 38 | 551 | 1.44 | 102 |
| 6-6.5 | 37.1 | 721 | 0.45 | 262 |
| 13-13.5 | 30.7 | 147 | 0.67 | 33 |
| **Site 6** | | | | |
| 5-5.5 | 37.8 | 103 | 0.22 | 116 |
| 6-6.5 | 36.9 | 294 | 0.22 | 122 |
| 12-12.5 | 31.5 | 169 | 0.67 | 53 |
| **Site 9** | | | | |
| 6-6.5 | 38.3 | 500 | 1.11 | 78 |
| 7-7.5 | 37.2 | 603 | 1.67 | 107 |
| 8-8.5 | 36.1 | 633 | 1.78 | 93 |
| 10-10.5 | 33.8 | 691 | 2.67 | 78 |
| 13-13.5 | 30.3 | 147 | 0.56 | 31 |

# Appendix 3: Mineralogy and Geochemistry of Tailings Before and After Kinetic Column Leaching

**Table 3A.1: Bulk phase geochemistry of fresh and aged tailings prior to leaching**

| Tailings Type | Major Elements (% wt/wt) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $SiO_2$ | MgO | $Al_2O_3$ | $SO_3$ | $Fe_2O_3$ | $K_2O$ | CaO | $Na_2O$ | $TiO_2$ | $P_2O_5$ | MnO |
| **Fresh** | 58 | 11 | 12 | 7.1 | 4.3 | 1.3 | 1.3 | 1.3 | 0.40 | 0.20 | 0.20 |
| **Aged** | 60 | 9.4 | 10 | 13 | 6.0 | 0.95 | 1.6 | 0.60 | 0.40 | 0.40 | 0.23 |

**Table 3A.2: Trace element composition of fresh and aged tailings prior to leaching**

| Tailings Type | Trace Metals (mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Co | Ni | Cu | Zn | Sr | Ba | Pb | U | Mo |
| **Fresh** | 147 | 58 | 290 | 78 | 14 | 140 | 600 | 683 | 11 |
| **Aged** | 132 | 61 | 230 | 75 | 18 | 156 | 755 | 410 | 14 |

**Table 3A.3: Modal percentages of mineral assemblages as a function of grain size for fresh and aged saturated tailings – after leaching**

| Mineral | % Mineral per sample | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh Saturated Tailings | | | | | Aged Saturated Tailings | | | | |
| | +106 (µm) | +45 (µm) | +20 (µm) | +10 (µm) | -10 (µm) | +106 (µm) | +45 (µm) | +20 (µm) | +10 (µm) | -10 (µm) |
| **S-phases** | | | | | | | | | | |
| Gypsum | 0.1 | 4.4 | 12.9 | 10.4 | 7.6 | 0.6 | 8.3 | 13.4 | 11.6 | 9.8 |
| Chalcopyrite | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.1 | 0.1 | 0.1 | 0.2 | 0.4 |
| Pyrite | 0.2 | 0.3 | 0.4 | 0.3 | 0.4 | 0.1 | 0.0 | 0.3 | 0.3 | 0.4 |
| Sphalerite | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Galena | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Jarosite | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Barite | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **Silicates** | | | | | | | | | | |
| Chlorite | 43.3 | 46.2 | 38.1 | 29.2 | 31.3 | 37.5 | 34.4 | 32.4 | 37.2 | 35.1 |
| Quartz | 37.6 | 33.0 | 28.6 | 43.1 | 41.6 | 42.4 | 43.3 | 34.6 | 32.0 | 33.9 |
| Muscovite | 12.8 | 8.0 | 7.0 | 7.5 | 9.9 | 13.8 | 6.1 | 7.2 | 7.0 | 8.0 |
| Mica | 3.5 | 2.3 | 1.7 | 1.7 | 2.2 | 1.9 | 1.5 | 1.3 | 1.1 | 1.1 |
| Al-Silicates | 1.2 | 2.1 | 3.2 | 3.9 | 4.5 | 0.8 | 1.5 | 2.7 | 3.6 | 4.1 |
| **Other** | | | | | | | | | | |
| U Phases | 0.002 | 0.011 | 0.028 | 0.024 | 0.019 | 0.002 | 0.018 | 0.03 | 0.027 | 0.025 |
| Mn Ox/Carb | 0.3 | 2.1 | 5.2 | 4.4 | 3.5 | 0.4 | 3.2 | 5.5 | 5.0 | 4.5 |
| Calcite | 0.01 | 0.01 | 0.20 | 0.40 | 0.60 | 0.10 | 0.15 | 0.60 | 0.60 | 0.50 |
| Mg-Phases | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| FeOxide | 0.9 | 0.4 | 1.7 | 1.0 | 1.6 | 0.7 | 0.3 | 2.1 | 2.0 | 2.9 |
| Other* | 0.3 | 0.5 | 0.5 | 0.5 | 0.3 | 0.1 | 0.5 | 0.4 | 0.2 | 0.2 |
| **Total** | **101** | **100** | **100** | **103** | **104** | **99** | **99** | **101** | **101** | **101** |

*Other includes Rutile, Ilmenite and Apatite

**Table 3A.4: Bulk phase geochemistry of fresh and aged tailings at the cessation of leaching**

| | **Major Elements (% wt/wt)** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **$SiO_2$** | **MgO** | **$Al_2O_3$** | **$SO_3$** | **$Fe_2O_3$** | **$K_2O$** | **CaO** | **$Na_2O$** | **$TiO_2$** | **$P_2O_5$** | **MnO** |
| **Fresh** | | | | | | | | | | | |
| **Upper 1** | 54.35 | 10.36 | 13.00 | 5.61 | 4.64 | 1.48 | 1.21 | 0.81 | 0.42 | 0.21 | 0.06 |
| **Upper 2** | 54.35 | 10.31 | 12.60 | 3.87 | 4.43 | 1.40 | 0.66 | 0.47 | 0.38 | 0.21 | 0.06 |
| **Ave Upper** | **54.35** | **10.34** | **12.80** | **4.74** | **4.54** | **1.44** | **0.94** | **0.64** | **0.40** | **0.21** | **0.06** |
| **Lower top** | 55.00 | 8.78 | 13.30 | 7.85 | 7.06 | 2.01 | 2.34 | 0.61 | 0.43 | 0.30 | 0.09 |
| **Lower mid** | 54.89 | 8.74 | 13.20 | 8.35 | 7.09 | 2.00 | 2.49 | 0.43 | 0.43 | 0.34 | 0.10 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Lower base** | 57.54 | 9.08 | 12.62 | 5.23 | 6.79 | 1.87 | 1.54 | 0.66 | 0.43 | 0.27 | 0.06 |
| **Ave Lower** | **55.81** | **8.87** | **13.04** | **7.14** | **6.98** | **1.96** | **2.12** | **0.57** | **0.43** | **0.30** | **0.08** |
| **Aged** | | | | | | | | | | | |
| **Upper 1** | 54.61 | 9.76 | 12.90 | 7.62 | 8.20 | 1.25 | 2.41 | 0.58 | 0.53 | 0.48 | 0.14 |
| **Upper 2** | 55.08 | 9.58 | 13.08 | 6.68 | 7.80 | 1.24 | 2.13 | 0.62 | 0.53 | 0.45 | 0.11 |
| **Ave Upper** | **54.85** | **9.67** | **12.99** | **7.15** | **8.00** | **1.25** | **2.27** | **0.60** | **0.53** | **0.47** | **0.12** |
| **Lower top** | 50.29 | 9.20 | 13.30 | 11.00 | 11.20 | 1.33 | 3.66 | 0.69 | 0.52 | 0.46 | 0.22 |
| **Lower mid** | 49.56 | 9.25 | 13.86 | 13.00 | 11.60 | 1.35 | 4.45 | 0.50 | 0.52 | 0.43 | 0.25 |
| **Lower base** | 52.75 | 9.20 | 11.50 | 6.87 | 10.10 | 1.17 | 2.08 | 0.58 | 0.53 | 0.43 | 0.16 |
| **Ave Lower** | **50.87** | **9.22** | **12.89** | **10.29** | **10.97** | **1.28** | **3.40** | **0.59** | **0.52** | **0.44** | **0.21** |

**Table 3A.5: Multi-element composition of fresh and aged tailings at the cessation of leaching**

| | **Trace Metals (mg/kg)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Pb** | **U** | **Cu** | **Co** | **Ba** | **Zn** | **Ni** | **Sr** | **Mo** |
| **Fresh** | | | | | | | | | |
| **Upper 1** | 630 | 282 | 250 | 169 | 145 | 91 | 80 | 14 | 18 |
| **Upper 2** | 559 | 240 | 280 | 163 | 133 | 84 | 74 | 13 | 15 |
| **Ave Upper** | **594** | **261** | **265** | **166** | **139** | **87.5** | **77** | **13.5** | **16.5** |
| **Lower top** | 610 | 400 | 509 | 220 | 144 | 71 | 85 | 17 | 10 |
| **Lower mid** | 592 | 400 | 470 | 260 | 142 | 70 | 98 | 17 | 11 |
| **Lower base** | 442 | 410 | 450 | 235 | 114 | 65 | 92 | 15 | 11 |
| **Ave Lower** | **548** | **403** | **476** | **238** | **133** | **69** | **92** | **16** | **11** |
| **Aged** | | | | | | | | | |
| **Upper 1** | 761 | 600 | 242 | 120 | 164 | 70 | 58 | 22 | 13 |
| **Upper 2** | 713 | 610 | 214 | 135 | 158 | 70 | 76 | 20 | 13 |
| **Ave Upper** | **737** | **605** | **228** | **128** | **161** | **70** | **67** | **21** | **13** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Lower top** | 857 | 750 | 350 | 180 | 205 | 77 | 95 | 24 | 12 |
| **Lower mid** | 1011 | 740 | 380 | 220 | 227 | 84 | 110 | 27 | 12 |
| **Lower base** | 541 | 670 | 290 | 200 | 137 | 69 | 98 | 17 | 13 |
| **Ave Lower** | **803** | **720** | **340** | **200** | **190** | **77** | **101** | **23** | **12** |

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