WORK PLAN FOR THE RIO ALGOM MINING AMBROSIA LAKE MILL SITE:

DISPOSAL CELLS 1 and 2 DAMS AND TAILINGS CHARACTERIZATION

Radioactive Material License Number SUA-1473 McKinley County, New Mexico

Prepared for:

Rio Algom Mining LLC
P.O. Box 218
Grants, NM 87020

Prepared by:

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

6000 Uptown Boulevard NE, Suite 220
Albuquerque, New Mexico 87110

February 9, 2018

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INTERA

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ACRONYMS AND ABBREVIATIONS

AMEC	AMEC-Foster Wheeler
ATT	Advanced Terra Testing
Cells 1 and 2	reclaimed tailings disposal Cells 1 and 2 at the Ambrosia Lake Mine Tailings Storage Facility in New Mexico
CDA	Canadian Dam Association
cm/sec	centimeters per second
cm/sec/cm^2	centimeters per second per square centimeter
CPT/CPTu	piezocone penetration test
DBS &A	Daniel B. Stephens & Associates
DSR	Dam Safety Review
INTERA	INTERA Incorporated
HSA	hollow-stem auger
HELP	Hydrologic Evaluation of Landfill Performance model
IDW	Investigation-Derived Waste
MSW	Municipal Solid Waste
NRC	US Nuclear Regulatory Commission
PVC	polyvinyl chloride
RAML	Rio Algom Mining LLC
Site	Rio Algom Mining LLC, Ambrosia Lake Facility, McKinley County, New Mexico
SMS	Soil Measurement Systems
SOW	Scope of Work
Work Plan	Work Plan for the Rio Algom Mining Ambrosia Lake Site, Disposal Cells 1 and 2 Tailings Characterization (Site).

1.0 INTRODUCTION

This *Work Plan for the Rio Algom Mining Ambrosia Lake Mill Site: Disposal Cells 1 and 2 Dams and Tailings Characterization* ("Work Plan") is for conducting specialized field testing, laboratory sample analyses, data management and analyses, modeling, and reporting, associated with the geotechnical and water balance performance assessments of reclaimed tailings disposal Cells 1 and 2 (Cells 1 and 2) at the Ambrosia Lake Mill Site in New Mexico ("Site"). The execution of work as proposed herein would ultimately provide (1) supplemental geotechnical testing information required to complete a corporate Dam Safety Review (DSR) of the Site, and (2) key constraints on the source-term data for future groundwater solute fate and transport modeling at the Site. **Figure 1** shows the locations of Cells 1 and 2 at the Site.

The Site is currently regulated under Nuclear Regulatory Commission (NRC) Materials License SUA-1473 Amendment 61.

2.0 BACKGROUND

This section provides a brief background of work being conducted at the Site related to the activities proposed in this Work Plan.

2.1 Dam Safety Review

Rio Algom Mining LLC (RAML) is the current licensee for the Site. RAML's parent company, BHP, has been conducting Dam Safety Reviews (DSRs) at a number of its world-wide facilities, and has decided to expand the scope to cover all operating and reclaimed facilities in their portfolio. The Ambrosia Lake Site was included in this requirement. The information obtained during this investigation will supplement previous work at the site to characterize geotechnical Site conditions for design and operation and may prove very useful for any data gaps identified for the forthcoming Construction Completion Report (CCR).

BHP has adopted the Canadian Dam Association (CDA) Dam Safety Guidelines as their corporate guidance for the design and management of all tailings and water management dams. The CDA guidelines define a DSR as 'a systematic review and evaluation of all aspects of design, construction, maintenance, operation, processes, and systems affecting a dam's safety, including the dam safety management system. The review encompasses all components of a dam system under evaluation (including dam, spillway, foundation, abutments and tailraces)' (CDA, 2013). The guidelines contain minimum qualifications for review engineers, suggested frequencies for undertaking DSRs, and suggested scope and content of the review.

At the direction of BHP, AMEC-Foster Wheeler (AMEC) undertook a preliminary DSR for the tailings dams associated with Cells 1 and 2. The preliminary results of AMEC's DSR indicated that the dams were generally considered to be in a safe condition but that there was no current data on the physical characteristics of the tailings within the cells (i.e., degree of saturation & liquefaction potential). AMEC recommended a field program be undertaken to improve confidence in the stability of the dams and better understand the potential for the tailings to flow in an unlikely hypothetical dam failure scenario.

The recommended investigation would consist of conducting piezocone penetration test (CPTu) soundings, Standard Penetration Test (SPT) borings, and piezometer installation in Cells 1 and 2. Although not a part of this, AMEC would use the data from the Investigation to conduct slope stability and liquifaction analyses to address the knowledge gaps and finalize the DSR. The information obtained during this investigation may prove very useful for any data gaps identified for the CCR.

2.2 Groundwater Solute Fate and Transport Modeling

Also at the direction of, and under contract with RAML, INTERA Inc. (INTERA) has been in the process of developing a comprehensive hydrogeological assessment of the Site to facilitate closure of NRC license and state permit requirements to allow for Site transfer to the Department of Energy (DOE). In support of this overall assessment, INTERA proposes herein to characterize the final cover and underlying tailings in Cells 1 and 2 and to conduct a water balance performance assessment of the final cover and tailings profile. As part of the field characterization effort to provide this information, representative samples of the tailings solids and tailings pore water in Cells 1 and 2 will be collected to represent the solids and fluid chemistry, respectively, or the "source term" chemistry. Collectively, the water balance performance assessment and source term chemistry will be used as an upper-boundary input to comprehensive geochemical and solute transport modeling of the aquifer system at the Site.

While the geotechnical and tailings characterization described above support two distinct objectives, the field work and data gathering are synergistic in many ways, and the soil borings, material samples, and laboratory analyses can be shared at some locations to provide the required information for both objectives. Additionally, the single field program proposed herein will help to minimize equipment and personnel mobilizations, and related issues associated with site health and safety, decontamination/management of investigation derived wastes, and other important procedures and tasks associated with the execution of the work.

3.0 SCOPE OF WORK

The Scope of Work (SOW) for this Work Plan includes the following primary elements:

- Field Investigation and Testing for Geotechnical and Tailings Profile Characterization
- Geotechnical Laboratory Testing of Cover and Tailings Solids
- Supporting Plans and Documents
- Geotechnical Investigation Report
- Water Balance Assessment
- Tailings Pore Fluid and Solids Geochemistry Source Term Assessment
- Cells 1 and 2 Water Balance and Source Term Report

These primary work elements are key to successful completion of the DSR and fate and transport modeling for the Ambrosia Lake site as discussed in Sections 2.1 and 2.2, respectively.

The field investigation and laboratory analysis programs are detailed below in Sections 3.1 and 3.2 respectively. Section 3.3 describes ancillary planning and documents required to conduct the field investigation and testing.

3.1 Field Investigation and Testing

INTERA proposes to complete the geotechnical and tailings profile investigations and testing described in the following sections. **Figure 2** shows the locations of proposed testing at the Site.

3.1.1 Geotechnical Investigation

The geotechnical investigation (GI) will consist of conducting piezocone penetration test (CPTu) soundings, Standard Penetration Test (SPT) borings and piezometer installation in Cell 1 and 2 tailings impoundments. The purpose of the GI is to obtain subsurface information necessary to complete a geotechnical risk assessment, including slope stability analysis and liquefaction analyses. The results of the analyses are intended to confirm the stability of the dams and susceptibility to liquefaction of the tailings impoundments.

For the GI, a total of nine (9) hollow stem auger (HSA) borings (GBH-01 through 09) are proposed at the approximate locations shown on Figure 2. Seven (7) of the borings (GBH-01 and 02; and 04 through 08) will be advanced through the full tailings profile, and a few feet into subgrade materials underlying the tailings. Three (3) of the borings (GBH-04, 06, and 07) will be converted to 2-inch diameter open pipe piezometers with an extensive screen length (completed within the tailings column), and three (3) will be converted to vibrating wire piezometers (VWP) with three fully grouted VWPs in each. Two (2) of the borings (GBH-03 and 09) will be advanced to an anticipated depth of thirty to forty feet, or refusal below grade at the toe of the dam (outside of the tailings storage facility

footprint). Boring GBH-03 will be converted to a 2-inch diameter open pipe piezometer with an extensive screen length. During drilling, standard penetration tests (SPT) will be conducted at minimum five-foot intervals, or at other intervals as determined during drilling. Material samples will be collected for laboratory analysis as described in detail in Section 3.2.

All piezometer installations are proposed to remain in-place for long-term monitoring of piezometric conditions. Abandonment of boreholes not converted to piezometers shall be done using cement-grout pumped into the borehole from the bottom up, to a level approximately 12 inches below surrounding grade. The remaining 12 inches of the boring will be filled with cover materials representing the pre-existing final cover, inclusive of rock cover. Abandonment of borings and completion of piezometers shall be done to preclude preferential migration pathways to underlying foundational materials.

A CPT program will be implemented using a truck-mounted CPT unit. A total of twenty-four (24) CPT probe holes, designated as CPT-01 through CPT-24 (see **Figure 2**), will be advanced in the Cell 1 (total of 17) and Cell 2 (total of 7) tailings impoundment areas. The CPTu soundings will be advanced through the tailings to the bottom of the impoundments, or to refusal, whichever is encountered first.

The CPT's will be performed in general agreement with ASTM D 5778 standard using a 60° apex cone that will be advanced at the rate of 20 millimeters per second. The 60° apex cone used has a 10.18 cm^2 tip area and a friction sleeve area of 113 cm^2. The electronic piezocone penetrometer produces a computerized log of tip resistance, sleeve friction resistance, and induced pore pressure behind the cone tip for every ten (10) centimeters of penetration. During a cone penetration test measured parameters are affected by soil particle sizes, mineralogy, soil fabric, age, stress state, etc. Because CPT provides a continuous stratigraphic profile of the subsurface and a repeatable index of the soil behavior of the in-situ material in the immediate area of the probe, the recorded data can be used to infer soil types, the 'flowability' of a material, and other engineering parameters.

Pore pressure dissipation tests will be conducted in each test sounding (24 total) to obtain transmissivity information if free water is encountered in the tailings impoundments.

Shear wave velocity measurements (21 total, 3 tests in each of the 7 CPTs in tailings) will be made in selected piezocone test soundings to generate a shear wave velocity profile in each of the seven holes. Shear wave velocity provides additional information regarding liquefaction susceptibility.

All GI borings and CPTu locations will be surveyed in the field using a hand-held GPS unit to determine their approximate location. Following completion of the data acquisition phase, all final locations will be surveyed using more accurate methods to obtain final coordinates and elevations. Tailings brought to the surface during drilling will be containerized and handled as Investigation

Derived Waste (IDW) in conformance with the project-specific Waste Management Plan as described in Section 3.3.

3.1.2 Tailings Profile Investigation

The tailings profile investigation (TPI) will utilize some of the same auger borings proposed for the GI (Section 3.1.1), plus additional borings for the specific purpose of characterizing the final cover and underlying tailings profile for Cells 1 and 2. Data collected from the TPI will be used to assess the water balance of closed Cells 1 and 2 using the methodologies described in Section 3.5 of this Work Plan. Information obtained for the TPI may also prove useful for any data gaps identified for the CCR.

Figure 2 illustrates the proposed boreholes (TPBH-01 through 07) to be used for characterization of the final cover and tailings profiles for Cells 1 and 2. A total of four TPI boreholes are proposed for Cell 1, and three TPI boreholes are proposed for Cell 2.

If feasible, GI borehole GBH-05 will also double as one of the TPI boreholes (TPBH-03) on Cell 1, depending upon the degree of saturation of the tailings at that location. GBH-05 is proposed for completion as a piezometer. If the tailings are saturated at that location, pore fluids will be sampled from the piezometer in addition to collection of cover and tailing samples during drilling for laboratory analysis as described further herein. If the tailings profile at the GBH-05 location is unsaturated, then a TPI borehole will be drilled at the TPBH-03(a) location shown on **Figure 2** in lieu of the GBH-05 location. TPI boring TPBH-07 is located immediately south of Cell 2 to characterize the former Pond 2 sediment profile at that location. While the Pond 2 sediments at the proposed TPBH-07 location do not have the final cap profile as Cell 2, both the geotechnical and pore fluid data collected at this location will be useful for the overall groundwater assessment at the Site. Any TPI boreholes completed as piezometers will be constructed in a manner similar to the GI piezometers as described in Section 3.1.1.

Each of the TPI boreholes will be drilled through the existing final cover to the base of the tailings and into natural materials, or until auger refusal, whichever comes first. The TPI boreholes will ideally terminate in subgrade of natural materials a few feet beneath the base of the tailings profile.

During drilling of the TPI boreholes, drive samples will be collected continuously through the cover, then at minimum 5-foot depth intervals to total boring depth using a 24-inch long (maximum) split-spoon California sampler with 2.4-inch outside diameter stainless steel sample sleeves. Drive sample blow counts will be recorded for future conversion to standard penetration blow counts. Material samples will be collected for laboratory analysis as described in detail in Sections 3.2 and 3.6.

Each of the TPI borings will be completed as either a piezometer or will be equipped with a suction lysimeter sampler to collect samples of pore water representative of the tailings profile. If the

tailings are saturated, the boring(s) will be completed as a monitoring point using 2-inch or 3-inch polyvinyl chloride (PVC) casing and screen for collection of tailing pore water chemistry.

Additional sample(s) of pore water will be collected through the augers at shallow depths in the boring(s) if intermediate perched zones exist within the tailings.

If the tailings are unsaturated, one suction lysimeter will be installed at depth in the boring(s) (near the base of the tailing) to collect a representative sample of pore water. The lysimeters will be Soil Measurement Systems (SMS), stainless steel dual-chamber, 540-milliliter capacity.

All piezometer and lysimeter installations are proposed to remain in-place for long-term monitoring of piezometric and pore water conditions. Abandonment of boreholes not converted to piezometers shall be done using cement-bentonite grout pumped into the borehole from the bottom up, to a level approximately 12 inches below surrounding grade. The remaining 12 inches of the boring will be filled with cover materials representing the pre-existing final cover, inclusive of rock cover. Abandonment of borings and completion of piezometers and lysimeters shall be done to preclude preferential migration pathways to underlying foundational materials.

All TPI borings will be surveyed in the field using a hand-held GPS unit to determine their approximate location. Following completion of the data acquisition phase, all final locations will be surveyed using more accurate methods to obtain final coordinates and elevations. Tailings brought to the surface during drilling will be containerized and handled as Investigation Derived Waste (IDW) in conformance with the project-specific Waste Management Plan as described in Section 3.3.

3.2 Laboratory Testing of Cover and Tailings Solids

Laboratory testing of solid material samples specific to the GI and TPI is described in detail in this section.

3.2.1 Geotechnical Investigation

AMEC will provide an accredited mobile laboratory at the Site to test samples from the GI borings. Selected samples will be analyzed for the following:

- Particle Size Analysis and USCS (ASTM) Classification – ASTM D422, ASTM D2487
- Gravimetric Moisture Content – D2216
- Atterberg Limits – D4318
- Dry Bulk Density and Calculated Porosity - ASTM D7263
- Volumetric Moisture Content - D2216, D7263
- Specific Gravity – D854

3.2.2 Tailings Profile Investigation

Cover samples collected from the TPI borings will be prepared, catalogued, and shipped to the Daniel B. Stephens & Associates, Inc. (DBS&A) in Albuquerque, New Mexico for analysis. Selected cover samples will be analyzed for the following:

- Particle Size Analysis and USCS (ASTM) Classification – ASTM D422, ASTM D2487
- Gravimetric Moisture Content – D2216
- Atterberg Limits – D4318
- Dry Bulk Density and Calculated Porosity - ASTM D7263
- Volumetric Moisture Content - D2216, D7263
- Specific Gravity – D854
- Saturated and Unsaturated Hydraulic Properties
    - Saturated Hydraulic Conductivity – Constant Head (ASTM D2434), Falling Head (Klute and Dirkson), Hanging Column and Pressure Plate (ASTM D6836)
    - Moisture Retention Characteristics and Calculated Unsaturated Hydraulic Conductivity – ASTM D6836 and van Genuchten

Tailing samples collected from the TPI borings will be prepared, catalogued, and shipped or driven to the Advanced Terra Testing laboratory in Lakewood, Colorado.

3.3 Supporting Plans, Documents, and Preparation for Field Work

Prior to conducting any field work or testing at the Site as described in the previous sections of this Work Plan, several supporting documents will be developed and approved. Additionally, this section describes the preparation and training required to conduct work at the Site.

To comply with license, RAML, and INTERA safety requirements, and the material handling requirements of Section 11e.(2) of the Atomic Energy Act (AEA) for handling and management of IDW; preparation for field data collection will include the following:

- Development of a site-specific health and safety plan (SSHASP);
- Development of an Investigation Derived Waste Management Plan (IDWMP);
- Radiation Safety Training for each member of the on-site Investigation team; and
- Development of a Radiation Work Permit (RWP).

INTERA's SSHASP for Tailings Impoundment Characterization at the Site will specify roles and responsibilities, a comprehensive plan for Site safety, Site hazards, and Site health and safety

procedures. The IDWMP will provide a description of the IDW expected to be generated, mobilization of waste management equipment to the Site, on-site management of solid and liquid IDW, characterization of solid and liquid IDW for disposal, transportation of IDW to the waste disposal facility, and demobilization of waste management equipment. Radiation Safety Training will be administered by Environmental Restoration Group, Inc. (ERG) of Albuquerque, New Mexico.

RAML and INTERA will engage qualified contractors to perform the proposed drilling and CPT work at the Site. In conformance with RAML requirements, and to minimize the risk of potential hazards during drilling, the drill rig, CPT rig, and related equipment will be inspected and approved by INTERA and RAML prior to beginning the work. Additionally, prior to drilling and CPT advancement, Job Risk Assessment (JRA) Worksheets will be completed, which identified each of the job steps in the processes, potential hazards and consequences, controls to protect against identified hazards, and the person responsible for ensuring the proper control(s) is/are in place. Each of the contractors will be required to develop a Decontamination Plan which will describe, in detail, the procedures for decontamination of equipment that comes into contact with tailing. The Decontamination Plan will include specific procedures for containing wash water. Both the SSHASP and IDWMP will include specific sections for meshing with the specific procedures identified in the Decontamination Plan.

ERG will develop a RWP for the specific work proposed in this Work Plan. The RWP will include the following:

- Date and location(s) of the work
- Work description summary
- Site radiological conditions and required project levels of radioactivity
- Dosimetry requirements
- Protective clothing and respiratory protection requirements
- ALARA review
- Air monitoring
- Any special requirements

Finally, a Field Implementation Plan (FIP) will be developed which will provide detail, on a day-to-day basis, for implementing the work proposed in this Work Plan. INTERA will be responsible for the development of the SSHASP, IDWMP, and FIP with input from AMEC and ERG. All plans will be reviewed and approved by RAML.

3.4 Geotechnical Investigation Report

Following completion of the field work and laboratory testing as proposed herein, a Geotechnical Investigation Report (GIR) will be produced to present a summary of the work conducted in the field, the data collected, and analysis of the data. The GIR will serve as a single reference for the information required for the DSR (Sections 2.1 and 3.1.1) and the Water Balance Assessment (Section 3.5) of Cells 1 and 2 at the Site. It is anticipated that the sections of the GIR will include:

- Introduction
- Data Collection
- Data Analysis
- Geotechnical and Hydrological Characteristics of the Closed Tailing Impoundments

In addition to supporting graphics and table summaries, the GIR appendices will include:

- Selected Photographs
- Drilling, Sampling, and CPT Equipment and Procedures
- Soil Boring Logs and piezometer completion logs
- CPT Data
- Laboratory Data Reports
    - AMEC Mobile Laboratory
    - Daniel B. Stephens & Associates, Inc. Laboratory Report for Cover Samples
    - Advanced Terra Testing Laboratory Report for Tailing Samples

Depending upon the timing of the GIR and collection and analysis of liquid samples representative of tailings pore water, the GIR may, or may not, include this information. More information related to collection and analysis of tailings pore water samples is included in Section 3.6 of this Work Plan.

3.5 Water Balance Assessment

Figure 3 shows a generalized conceptual model of the water balance of a closed tailing impoundment, like Cells 1 and 2 at the Site. The profile in **Figure 3** shows a final cover like that at the Site, and an underlying thickness of tailing. At the base of the tailing, slimes are represented just above native materials. The purpose of the field testing proposed in this Work Plan is to characterize the components of the profile such that impoundment profiles of Cells 1 and 2 are accurately represented. The layering and geometry of the final covers are relatively well-known, but will be better defined once the covers have been further investigated as described herein. The tailing profile is likely complicated and layered, as materials would typically range in texture from sands to silts/clays.

Once the tailing impoundments are enclosed with a final cover, the process of moisture re-distribution largely controls the quantity of leachate that exits the base of the impoundments (and is therefore available to mix with underlying groundwater). This time distribution of leachate flux is referred to as a transient drainage curve (Coons, 1993) as illustrated in **Figure 3**. Typically—especially for waste impoundments where the tailings are slurried in place—initial flux rates are high, the tailings drain, and moisture is re-distributed within the impoundment. Over time the flux rate becomes less until the long-term flux is equal to the infiltration/percolation-limiting process within the closed impoundment.

For closed impoundments in arid to semi-arid climates (like those at the Site), long-term flux is typically limited by the net percolation rate of precipitation through the final cover. Alternatively, there may be rate-limiting layer(s) within the tailings, or beneath the tailings, of low permeability (clays, slimes) that physically impede the downward percolation of leachate to groundwater.

Performance analyses from other semi-arid waste impoundments suggest that the final cover will ultimately limit the long-term flux from the impoundments since it is unlikely that there are layers within the tailing with saturated hydraulic conductivities equal to or less than these flux values; however, in the future, when the tailing leachate flux rates reach these low values, the flux rates will be higher and dictated by the drainage of moisture with the tailings.

INTERA has used models at closed waste impoundment sites to assess the long-term water balance into and through the impoundments. For Cells 1 and 2, INTERA proposes to use the Hydrologic Evaluation of Landfill Performance (HELP) model, or UNSAT-H.

HELP was developed by Paul Schroeder for the U.S. Army Engineer Waterways Experiment Station in Vicksburg, Mississippi, to evaluate movement of water across, into, through, and out of landfills. HELP has become a requirement for obtaining operating permits for municipal solid waste (MSW) landfills in the United States. HELP has been effective in assessment of groundwater recharge rates in the arid and semi-arid southwestern US (Stephens and Coons, 1994), and the use of the model for predicting infiltration of water through earthen covers has compared favorably with UNSAT-H (Coons et al., 2000).

While HELP was originally developed for use in design and evaluation of MSW landfills, HELP treats solid waste as a porous medium with soil-like properties within the layered sequence. As such, any impoundment designed and constructed to contain regulated soil-like materials (such as Cells 1 and 2) can effectively be evaluated using HELP.

HELP is a quasi-two-dimensional hydrologic model that requires the following input data:

- Weather (precipitation, solar radiation, temperature, and evapotranspiration parameters)

- Soil (porosity, field capacity and wilting point moisture contents, and saturated hydraulic conductivity)
- Design (surface slope, engineered features such as liners, collection systems, etc.)

HELP uses numerical solution techniques that account for the effects of surface storage, snowmelt, runoff, infiltration, evapotranspiration, vegetative growth, soil moisture storage, lateral subsurface drainage, unsaturated vertical drainage; or leakage through soil, geomembranes, and composite liners.

Alternatively, INTERA would use UNSAT-H to evaluate the long-term water balance performance of Cells 1 and 2.

The UNSAT-H model was developed at Pacific Northwest National Laboratory (PNNL) to assess the water dynamics of arid sites and, in particular, estimate recharge fluxes for scenarios pertinent to waste disposal facilities. The two major objectives of UNSAT-H are to estimate deep drainage rates which can then be used in contaminant transport analyses, and assist in assessing barrier (final cover) design and performance (Fayer, 2000).

Input for the water balance modeling will be considered as follows:

- Boundary Conditions: Because of the geometry of Cells 1 and 2, modeling would be conducted only in one dimension (vertically) and representative of the top slopes of the disposal cells. As such, the model would consider only upper and lower boundary conditions. The upper boundary is atmospheric, and will impose meteorological conditions specific to the site (see below). The lower boundary would be the base of the tailings profile. Additionally, a unit gradient is conservatively considered for the lower boundary of the model unless specific site conditions necessitate the use of a more complex lower boundary condition.
- Meteorological Data: Site-specific historical meteorological data for the average precipitation year consisting of precipitation, solar radiation, relative humidity, air temperature, and wind speed will be used in the model. The average precipitation year will be based on daily meteorological data compiled to represent 12 months of average precipitation and climate conditions.
- Soil Properties: Soil properties used in the model include saturated hydraulic conductivity and unsaturated characteristic information from soil moisture characteristic curves (SMCCs). UNSAT-H has the advantage of permitting the SMCC and unsaturated hydraulic conductivity function as data, or using a polynomial fit to the data.
- Vegetation Properties: Vegetation properties required for input include leaf area index (LAI), parameters describing how availability of water in the root zone affects transpiration, the rate at which roots extend into the cover soil and the maximum depth of

root penetration, the distribution of root density with depth, and the percent cover on the surface. Vegetation properties for application of UNSAT-H at the Site will consider the thin rock cover over the top slope of Cells 1 and 2, and the limitation of vegetation growing deeply into the cover profiles.

- Geometry: Because only the top slopes of Cells 1 and 2 will be considered, one-dimensional modeling will accurately represent water balance conditions of the cover. In general, 1-D models tend to be more conservative (with higher infiltration rates) than 2-D models as lateral and transverse advective and diffusive fluxes are not accounted for in 1-D modeling, leading to potentially higher vertical infiltration rates. As such, our experience is that for covers with shallow slopes, 1-D infiltration modeling is a computationally efficient and robust approach for water balance modeling for engineered cover systems.

INTERA has experience using both HELP and UNSAT-H to evaluate the long-term water balance performance of closed waste repositories, and feel either approach would yield appropriate information for evaluating long-term flux of tailing fluids into underlying groundwater at the Site. The HELP model typically yields infiltration/percolation rates that are somewhat more conservative (higher) than UNSAT-H. The proposed data collection and testing program described in this Work Plan will provide the necessary data to conduct a water balance assessment using either model.

3.6 Tailings Pore Fluid and Solids Geochemistry Source Term Assessment

As described in Section 3.1, the TPI borings will be completed as either piezometers or lysimeters to facilitate collection of tailings pore fluids. **Table 1** is a summary of the proposed analytical list for pore fluid samples.

In addition to analysis of pore fluid samples from Cells 1 and 2, selected tailings samples will be sent to ACZ Laboratories, Inc. (Steamboat Springs, CO) and will undergo a total hydrofluoric-nitric acid digestion using method EPA M3052. The analytes, analysis, and preservation methods to be performed on the tailings digests are summarized in **Table 2**. Subsamples of the tailings will also be sent to Hazen Research (Golden, CO) for quantitative bulk X-ray diffraction (XRD) analysis.

Data characterizing the mineralogy and bulk chemistry of the tailings solids will not be used directly to determine source concentrations, but will be useful in developing a conceptual understanding of processes that control those source concentrations (which may entail future geochemical equilibrium modeling). As such, the laboratory analysis of the tailing solids would not be used to define the source term itself (that will come from the laboratory analysis of the

tailings pore water samples), but will be useful in supporting development of the overall conceptual site model.

3.7 Cells 1 and 2 Water Balance and Source Term Report

A report (Report) will be produced that provides the results of the water balance and source-term assessment of Cells 1 and 2. The Report will use the GIR described in Section 3.4 as a reference for input data, and it will include a complete description of the cover and tailings profile modeling and geochemical assessment of the tailings pore fluids and solids. The Report will include descriptive text, supporting graphics and tabular summaries, and appendices to support the Report's conclusions.

4.0 REFERENCES

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FIGURES

NOTES: **1) Pond 2 Limits estimated from 1985 image of site.**
2) Imagery shows construction of Cell 2 final cap in 2016.

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS INTERA INCORPORATED 6000 Uptown Boulevard, Suite 220 Albuquerque, NM 87110 Phone 505-246-1600 www.intera.com	*Rio Algom Mining, LLC* *Ambrosia Lake Facility*		
	FIGURE 1. Site Features		
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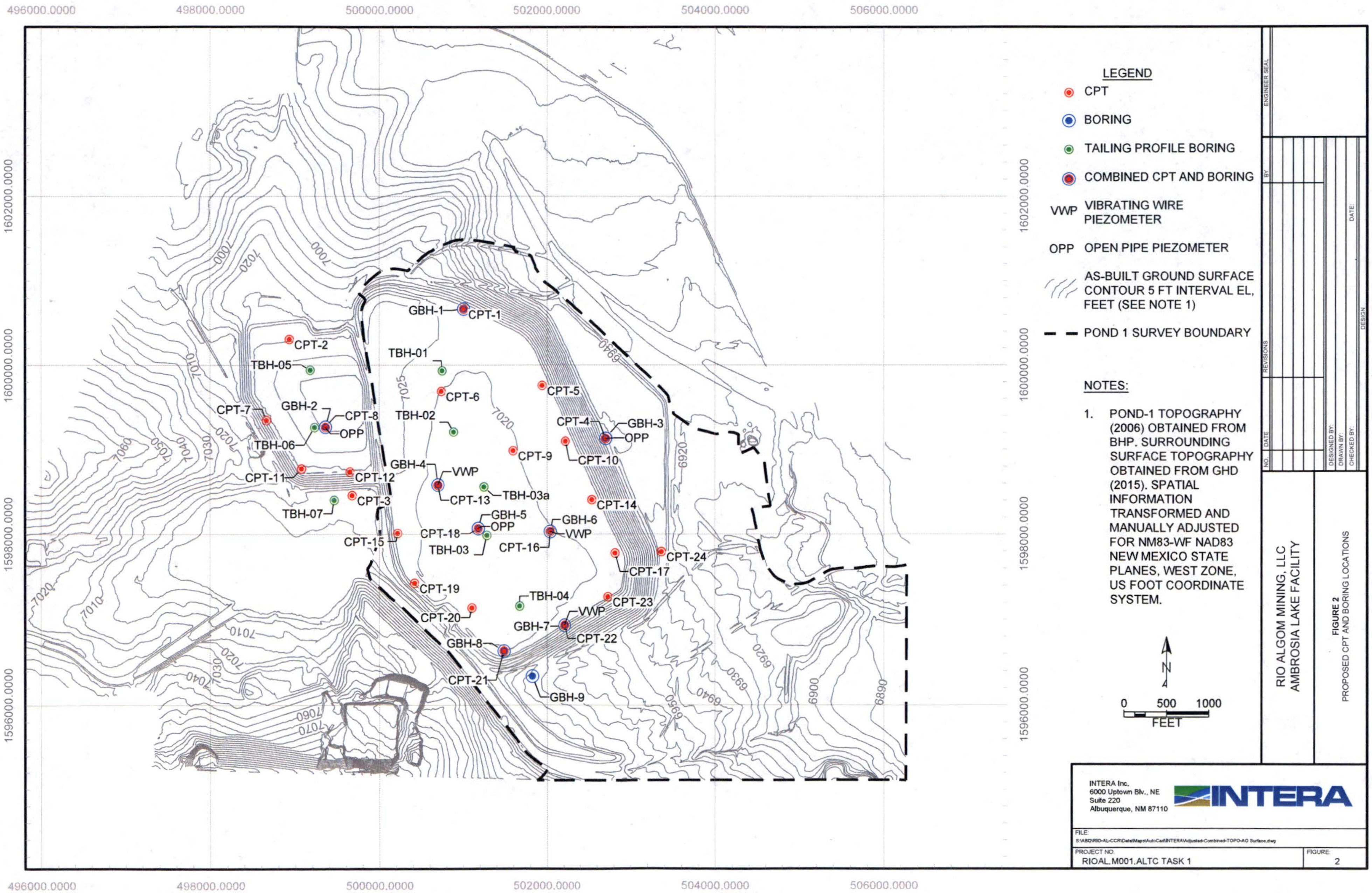

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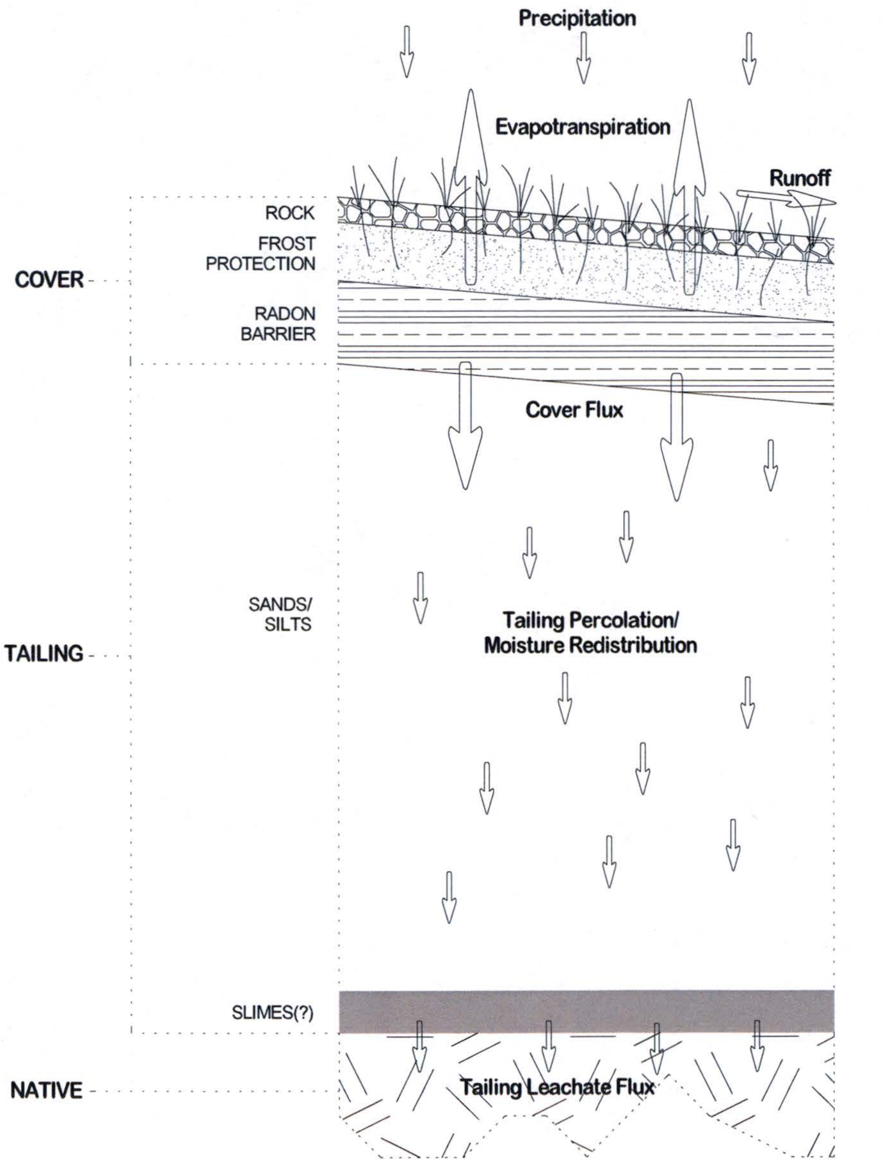
CPT-8
OPP
TBH-02
CPT-4
GBH-3
OPP
TBH-06
CPT-9
CPT-10
GBH-4
VWP
CPT-11
CPT-12
CPT-13
TBH-03a
CPT-3
CPT-14
TBH-07
GBH-5
GBH-6
CPT-18
OPP
VWP
CPT-15
TBH-03
CPT-16
CPT-24
CPT-17
CPT-19
TBH-04
CPT-23
CPT-20
VWP
GBH-7
CPT-22
GBH-8
CPT-21
GBH-9
7000
7020
7025
7010
7030
7040
7050
7060
6940
6920
6900
6890
LEGEND
CPT
BORING
TAILING PROFILE BORING
COMBINED CPT AND BORING
VWP VIBRATING WIRE PIEZOMETER
OPP OPEN PIPE PIEZOMETER
AS-BUILT GROUND SURFACE CONTOUR 5 FT INTERVAL EL, FEET (SEE NOTE 1)
POND 1 SURVEY BOUNDARY
NOTES:
1. POND-1 TOPOGRAPHY (2006) OBTAINED FROM BHP. SURROUNDING SURFACE TOPOGRAPHY OBTAINED FROM GHD (2015). SPATIAL INFORMATION TRANSFORMED AND MANUALLY ADJUSTED FOR NM83-WF NAD83 NEW MEXICO STATE PLANES, WEST ZONE, US FOOT COORDINATE SYSTEM.
N
0 500 1000
FEET
ENGINEER SEAL
NO. DATE REVISIONS BY
DATE:
DESIGN
DESIGNED BY:
DRAWN BY:
CHECKED BY:
RIO ALGOM MINING, LLC
AMBROSIA LAKE FACILITY
FIGURE 2
PROPOSED CPT AND BORING LOCATIONS
INTERA Inc.
6000 Uptown Blv., NE
Suite 220
Albuquerque, NM 87110
INTERA
FILE:
S:\ABQ\RIO-AL-CCR\Data\Maps\AutoCad\INTERA\Adjusted-Combined-TOPO-AO Surface.dwg
PROJECT NO:
RIOAL.M001.ALTC TASK 1
FIGURE:
2



GENERALIZED CLOSED IMPOUNDMENT PROFILE

SIMPLIFIED CLOSED IMPOUNDMENT WATER BALANCE

COVER:

Steady-state (dynamic equilibrium) **Cover Flux** water balance is a function of:

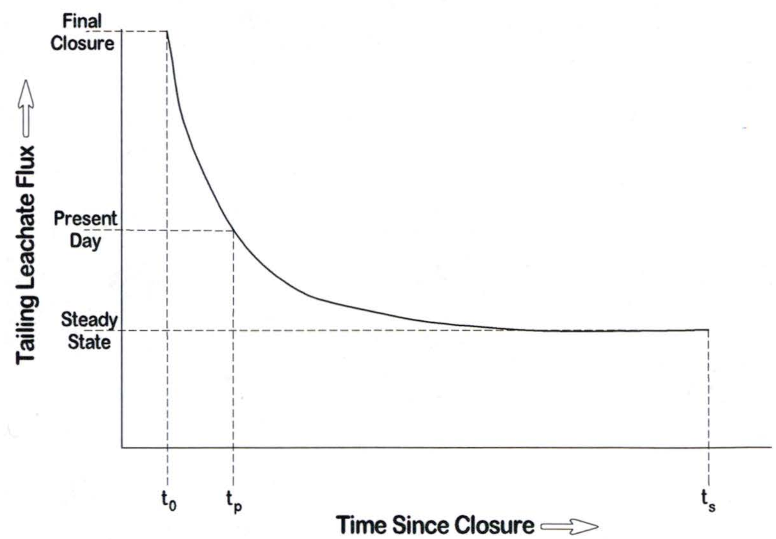
PRECIPITATION - EVAPOTRANSPIRATION - RUNOFF (+/-) CHANGE IN COVER STORAGE

IMPOUNDMENT:

Steady-state (dynamic equilibrium) **Tailing Leachate Flux** water balance is a function of:

COVER FLUX (+/-) CHANGE IN TAILING STORAGE

GENERALIZED TRANISENT DRAINAGE CURVE



INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

INTERA INCORPORATED
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Albuquerque, NM 87110

Phone 505-246-1600
www.intera.com

Rio Algom Mining, LLC Ambrosia Lake Facility

Figure 3. Closed Tailing Impoundment Water Balance Conceptual Model

Date	Drawn By	File	Revision
15 DEC 17	LMC	S:\Projects\RIO-AL-EoR\NRC-Scope-of-Work\WorkPlan\WB-PROFILE.cad	0
Scale None			Page No 1

TABLES

Rio Algom Mining, LLC Ambrosia Lake Facility
Table 1. Analytical List for Tailing Fluid Samples

Analyte	Dissolved or Total?	Media	EPA Method	Units	MDL	Preservative	Filtered?	Container	Holding Time
Chloride	Dissolved	Aqueous	M300.0 IC	mg/L	0.5	None/ 6° C	Yes	250-ml HDPE	28 days
Bromide	Dissolved	Aqueous	M300.0 IC	mg/L	0.05				28 days
Fluoride	Dissolved	Aqueous	M300.0 IC	mg/L	0.05				28 days
Sulfate	Dissolved	Aqueous	M300.0 IC	mg/L	0.5				28 days
Nitrate+Nitrite as N	Dissolved	Aqueous	M 353.2 Automated Colorimetric	mg/L	0.02				28 days
TDS	Dissolved	Aqueous	SM 2540 C	mg/L	10				7 days
Total Alkalinity	Total	Aqueous	SM2320B - Titration	mg/L	2	None/ 6° C	No	500-mL HDPE	14 days
Carbonate	Total	Aqueous	SM2320B - Titration	mg/L	2				
Bicarbonate	Total	Aqueous	SM2320B - Titration	mg/L	2				
Hydroxide	Total	Aqueous	SM2320B - Titration	mg/L	2				
Acidity	Total	Aqueous	SM2310B - Titration	mg/L	10				
Cyanide	Total	Aqeous	M335.4	mg/L	0.2	NaOH/ 6° C	No	250-ml HDPE	14 days
TKN	Dissolved	Aqueous	M351.2 - TKN by Block Digester	mg/L	0.1	H_2SO_4/ 6° C	No	250-ml HDPE	28 days
Radium-226	Dissolved	Aqueous	M903.1	pCi/L	0.4	HNO3/ 6° C	Yes	2-L HDPE cube	180 days
Radium-228	Dissolved	Aqueous	M9320	pCi/L	1.5	HNO3/ 6° C	Yes	2-L HDPE cube	180 days
Thorium-230	Dissolved	Aqueous	ESM4108/4506 TOPO Extraction	pCi/L	0.3	HNO3/ 6° C	Yes	500-mL HDPE	180 days
Pb-210	Dissolved	Aqueous	Eichrom OTW01	pCi/L	4	HNO3/ 6° C	Yes	500-mL HDPE	180 days
Gross Alpha	Dissolved	Aqueous	900.0/9310	pCi/L	2	HNO3/ 6° C	Yes	100-mL HDPE	180 days
Aluminum	Dissolved	Aqueous	M200.7 ICP	mg/L	0.03	HNO_3/ 6° C	Yes	250-mL HDPE, precleaned	180 days
Arsenic	Dissolved	Aqueous	M200.8 ICP-MS	mg/L	0.0005				
Barium	Dissolved	Aqueous	M200.7 ICP	mg/L	0.003				
Boron	Dissolved	Aqueous	M200.8 ICP-MS	mg/L	0.0005				
Cadmium	Dissolved	Aqueous	M200.7 ICP	mg/L	0.005				
Calcium	Dissolved	Aqueous	M200.7 ICP	mg/L	0.2				
Chromium	Dissolved	Aqueous	M200.7 ICP	mg/L	0.01				
Cobalt	Dissolved	Aqueous	M200.7 ICP	mg/L	0.01				
Copper	Dissolved	Aqueous	M200.7 ICP	mg/L	0.01				
Iron	Dissolved	Aqueous	M200.7 ICP	mg/L	0.02				
Lead	Dissolved	Aqueous	M200.8 ICP-MS	mg/L	0.0001				
Magnesium	Dissolved	Aqueous	M200.7 ICP	mg/L	0.2				
Manganese	Dissolved	Aqueous	M200.7 ICP	mg/L	0.005				
Molybdenum	Dissolved	Aqueous	M200.7 ICP	mg/L	0.01				
Nickel	Dissolved	Aqueous	M200.7 ICP	mg/L	0.01				
Potassium	Dissolved	Aqueous	M200.7 ICP	mg/L	0.3				
Selenium	Dissolved	Aqueous	M200.8 ICP-MS	mg/L	0.0001				
Silicon	Dissolved	Aqueous	M200.7 ICP	mg/L	0.1				
Silver	Dissolved	Aqueous	M200.7 ICP	mg/L	0.01				
Sodium	Dissolved	Aqueous	M200.7 ICP	mg/L	0.3				
Strontium	Dissolved	Aqueous	M200.7 ICP	mg/L	0.005				
Sulfur	Dissolved	Aqueous	M200.7 ICP	mg/L	0.25				
Titanium	Dissolved	Aqueous	M200.7 ICP	mg/L	0.005				
Uranium	Dissolved	Aqueous	M200.8 ICP-MS	mg/L	0.0001				
Vanadium	Dissolved	Aqueous	M200.8 ICP-MS	mg/L	0.0002				
Zinc	Dissolved	Aqueous	M200.7 ICP	mg/L	0.01				

Notes:

EPA = U.S. Environmental Protection Agency
H_2SO_4 = Sulfuric Acid
HDPE = high-density polyethylene
HNO_3 = Nitric Acid
ICP = Inductively coupled plasma
MDL = Method detection limit

mg/L = milligrams per liter
MS = mass spectrometry
pCi/L = picocuries per liter
TDS = Total dissolved solids
TKN = Total Kjeldahl Nitrogen

INTERA

Rio Algom Mining, LLC Ambrosia Lake Facility
Table 2. Analytical List for Tailing Solid Samples

Analyte	Dissolved or Total?	Media	EPA Method	Units	MDL	Preservative	Filtered?	Container	Holding Time
Aluminum	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	3	None	NA	1 liter material, double bagged in 1 gallon ziploc-type freezer bags	180 Days
Arsenic	Dissolved	Soil - EPA M3052	M200.8 ICP-MS	mg/L	0.1				
Barium	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	0.3				
Boron	Dissolved	Soil - EPA M3052	M200.8 ICP-MS	mg/L	0.25				
Cadmium	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	0.5				
Calcium	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	10				
Chromium	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	1				
Cobalt	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	1				
Copper	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	1				
Iron	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	2				
Lead	Dissolved	Soil - EPA M3052	M200.8 ICP-MS	mg/L	0.05				
Magnesium	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	20				
Manganese	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	0.5				
Molybdenum	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	2				
Nickel	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	0.8				
Potassium	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	20				
Selenium	Dissolved	Soil - EPA M3052	M200.8 ICP-MS	mg/L	0.05				
Silicon	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	10				
Silver	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	1				
Sodium	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	20				
Strontium	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	0.5				
Sulfur	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	0.25				
Titanium	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	0.5				
Uranium	Dissolved	Soil - EPA M3052	M200.8 ICP-MS	mg/L	0.05				
Vanadium	Dissolved	Soil - EPA M3052	M200.8 ICP-MS	mg/L	0.1				
Zinc	Dissolved	Soil - EPA M3052	M200.7 ICP	mg/L	1				
Radium-226	Dissolved	Soil - EPA M3052	M903.1	pCi/L	0.4				
Radium-228	Dissolved	Soil - EPA M3052	M9320	pCi/L	1.5				
Thorium-230	Dissolved	Soil - EPA M3052	ESM4108/4506 TOPO Extraction	pCi/L	0.3				
Pb-210	Dissolved	Soil - EPA M3052	Eichrom OTW01	pCi/L	4				
Gross Alpha	Dissolved	Soil - EPA M3052	900.0/9310	pCi/g	1				

Notes:
Soil MDL's are different from aqueous MDL's due to the concentrations produced by SPLP extraction.
ICP = Inducltively coupled plasma
MS = mass spectrometry
mg/L = milligrams per liter
MDL = Method detection limit
pCi/L = picocuries per liter