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APPENDIX F

SGS GEOCHEMISTRY / MINERALOGY REPORT

Appendix F.1 An Investigation into Environmental Characterization of Ore, Concentrate, and Tailings from the Nechalacho Rare Earth Element Project – Phase 2.

Appendix F.1

An Investigation into Environmental Characterization of Ore, Concentrate, and Tailings from the Nechalacho Rare Earth Element Project – Phase 2.

An Investigation into

ENVIRONMENTAL CHARACTERISATION OF ORE, CONCENTRATE AND TAILINGS FROM THE NECHALACHO RARE EARTH ELEMENT PROJECT – PHASE 2

prepared for

AVALON RARE METALS INC.

Project 11806-007 – **Interim Report**
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Executive Summary

SGS was contracted by Avalon Rare Metals Inc. (Avalon) to complete environmental characterisation of ore, concentrate and tailings from the Thor Lake Nechalacho project in the Northwest Territories. The purpose of the environmental test program was to assess the geochemical, acid rock drainage (ARD), contaminant release potential and geotechnical characteristics associated with the Avalon products. Environmental tests were conducted on head, tailings and concentrate samples from the locked cycle test (LCT) flotation project (SGS Project Reference No. 12390-001) and from the Xstrata Process Centre (XPS) pilot plants. Solution samples from the hydrometallurgical test program (SGS Project Reference No. 11806-005), a Thor Lake water sample shipped to SGS facilities by Avalon and tap water samples shipped to SGS facilities from XPS and Ortech were also included in the environmental test program. For completeness, summary results of the modal analyses from the mineralogical examinations completed on these samples are also included in this report (SGS Mineralogy Reference No's. MI5004-SEP10, MI5006-SEP10, MI5001-NOV10, MI5042-NOV10 and MI5041-DEC10).

Results of the modal analyses completed during the mineralogical examinations (QEMSCAN®) determined that the Thor Lake head (*Head 1, Head 2, Head 3, PPX Head* and *PP2 Head)* and tailings samples (*F25 Tls, F28 Tls, F29 Tls, F30 Tls, F33 Tls, F36, Tls, F37 Tls, PP1 Tls* and *PP2 Tls*) were comprised primarily of gangue minerals including plagioclase, biotite, quartz, K-feldspar, Fe-oxides and muscovites/clays. Minor to trace amounts of zircon and rare earth element (REE) minerals were also evident. While only trace levels of neutralising carbonates were reported in the tailings samples; increased carbonate concentrations were reported in the head samples. Only trace levels of sulphide minerals were reported in the head and tailings samples.

As expected, the concentrate samples (*F25 Conc, F33 Conc, F36 Conc, F37 Conc* and *PP1 Conc*) typically reported considerably lesser levels of gangue minerals and significantly increased amounts of zircon and REE minerals (columbite (Fe), fergusonite, bastnaesite, synchysite, allanite and monazite). While the concentrates also reported significantly increased levels of carbonate minerals, again only trace levels of sulphide minerals were observed.

Whole rock analyses inductively coupled plasma-optical emission spectroscopy/mass spectroscopy (ICP-OES/MS) elemental analyses confirmed the primarily silicate composition of the Nechalacho samples. With the exception of the *MC3* ore composite, the high loss on ignition (LOI) values determined for the head and concentrate samples suggests significant amounts of volatile species (e.g. sulphides, hydroxides and carbonates) are present in these samples. The low LOI values reported for the tailing samples, however; indicate that little of these species remain in the tailings.

Radionuclide analysis of the Thor Lake solids samples typically reported increased levels of radionuclides in the concentrates in comparison to the heads, while again lower levels of radionuclides were evident in the tailings.

Analysis of the Thor Lake head, tailings and concentrate shake flask extraction leachates, aged pilot plant tailings decant solutions and simulated hydromet solutions (before and after radium treatment) reported all parameters controlled by the Canadian Metal Mining Effluent Regulations (MMER), including ^{226}Ra, at concentrations well within the designated limits. Acute lethality testing of the initial pilot plant tailings decant solution *(PP1 Tls Decant Day 5)* resulted in the non-lethal designations for both rainbow trout and *Daphnia magna*.

Samples of the Thor Lake water and XPS and Ortech tap waters were also subjected to analysis for comparative purposes. Although results of the radionuclide analyses completed on the tap water samples were not available at the time of issue of this report, it is expected that these samples will also reported within all the specified limits.

Modified acid base accounting (ABA) test results for the heads and concentrates indicated that these samples are potentially acid neutralising (PAN). Similarly, although ABA test results for the tailings suggested some minor uncertainty, the very low sulphide concentrations reported coupled with the significant carbonate (CO_3) NP/AP ratios, indicate that these samples are highly unlikely to generate acidity. The alkaline final pH values reported after aggressive oxidation of these samples during net acid generation (NAG) testing confirmed the non-acid forming nature of these samples

After seven weeks of humidity cell testing, the cumulative sulphide and related CO_3 NP depletion rates determined for 7 of the 8 humidity cell test samples (*F33 Tls, F36 Tls, F37 Tls, Master Tls, PP1 Tls, Master Conc* and *PP1 Conc*) suggest that the sulphide minerals in these samples are depleting at significantly faster rates than the carbonate minerals. However, at this time, the leachates from 5 of these test cells (*F36 Tls, F37 Tls, Master Tls, PP1 Tls* and *PP1 Conc*) are showing decreasing pH and alkalinity concentrations. In contrast, the other 2 test cells (*F33 Tls* and *Master Conc*) are showing increasing pH trends and alkalinity concentrations. Analyses of the humidity cell leachates are reported all MMER controlled parameters well within their respective limits in all test cells. Humidity cell testing has only recently been initiated on the *PP2 Tls* sample; therefore, projections cannot yet be made.

Particle size distribution analyses indicated that the head samples were comprised primarily of sand sized grains. Only minor fractions of the samples were classified as fines. In comparison, the concentrates and tailings and tailings showed a much finer particle size distribution with the majority of the samples being classified as fines.

Although liquid limits were determined for the *Master Tls, PP1 Tls* and *PP2 Tls* samples, all three samples were found to be non-plastic. This behaviour is typical of cohesionless inorganic silt or rock flour type samples.

Introduction

SGS was contracted by Avalon Rare Metals Inc. (Avalon) to complete environmental characterisation of ore, concentrate and tailings from the Thor Lake Nechalacho project in the Northwest Territories. Environmental tests were conducted on products (heads, concentrates and tailings) from the locked cycle test (LCT) flotation program (SGS Project Reference No. 12390-001) and from the Xstrata Process Centre (XPS) pilot plants. Solution samples from the hydrometallurgical test program (SGS Project Reference No. 11806-005), a Thor Lake water sample shipped to SGS facilities by Avalon and tap water samples shipped to SGS facilities from XPS and Ortech were also included in the environmental test program. For completeness, summary results of the modal analyses from the mineralogical examinations completed on these samples are also included in this report (SGS Mineralogy Reference No's. MI5004-SEP10, MI5006-SEP10, MI5001-NOV10, MI5042-NOV10 and MI5041-DEC10).

The test program was designed in consultation with Mr. Bill Mercer (Avalon) and Mr. John Goode (Consulting Metallurgist for Avalon). The purpose of the environmental test program was to assess the geochemical, acid rock drainage (ARD), contaminant release potential and geotechnical characteristics associated with the Avalon products.

The following report provides a summary of the environmental testwork completed to February 10, 2011 and the results thereof.

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Scope of Work

The scope of test work completed on the ore, concentrate, tailings and solution samples included:

- Modal analysis (mineralogical examination) - only the modal analyses are included in this report, complete mineralogy results will be covered in separate stand alone mineralogical reports - (SGS Mineralogy Reference No's. MI5004-SEP10, MI5006-SEP10, MI5001-NOV10, MI5042-NOV10 and MI5041-DEC10)).
- Quantitative X-ray diffraction (XRD) analyses.
- Borate fusion X-ray fluorescence (XRF) whole rock analyses.
- Radionuclide analyses of the sample solids.
- Inductively coupled plasma-optical emission spectroscopy/mass spectroscopy (ICP-OES/MS) strong acid digest elemental analyses.
- Shake flask extraction testing (SFE).
- Modified acid base accounting (ABA).
- Net acid generation (NAG) testing.
- Analysis of the lake water, tap water and fresh hydromet filtrate solutions.
- Analysis of the fresh and aged pilot plant tailings decant solutions.
- LC_{50} acute lethality testing of *Daphnia magna* and rainbow trout – tailings decant solutions.
- Particle size distribution (PSD) by sieve and hydrometer (ASTM D 422-63 (2007)).
- Particle size distribution by Malvern laser.
- Atterberg limits (ASTM D 4318-05).
- Standard and drained settling tests - pending.
- Standard Proctor (ASTM D 698-07e1) - pending.
- Hydraulic conductivity testing (ASTM D 5084) at standard Proctor effort - pending.

For ease of reference, the individual scope of testwork completed on the Avalon samples is summarised in Table 1.

Table 1: Scope of Work

Sample Identifier	Modal Analyses	XRD Analyses	Whole Rock Analyses	Radionuclide Analyses - Solids	ICP	Shake Flask Extractions	Ageing Test	Toxicity Testing LC_{50} DM + RT	Solution Analyses	Modified ABA	NAG	Humidity Cell	SG	PSD (sieve + hydrometer)	Malvern Laser PSD	Atterberg Limits	Standard + Drained Settling Tests	Standard Proctor	Hydraulic Conductivity
Master Comp 3			X	X	X	X				X	X		X	X					
Avalon Head Sample 1	X		X	X	X	X				X	X		X	X					
Avalon Head Sample 2	X		X	X	X	X				X	X		X	X					
Avalon Head Sample 3	X		X	X	X	X				X	X		X	X					
XPS PP Comp 2 Head	X		X	X	X	X				X	X		X	X					
XPS PP Comp 3 Head	X		X	X	X	X				X	X		X	X					
F25 Comb Tls	X		X	X	X	X				X	X		X	X					
F28 Comb Tls	X		X	X	X	X				X	X		X	X					
F29 Comb Tls	X		X	X	X	X				X	X		X	X					
F30 Comb Tls				X	X														
F33 Comb Tls	X		X	X	X	X				X	X	X	X	X					
F36 Comb Tls	X		X	X	X	X				X	X	X	X	X					
F37 Comb Tls	X		X	X	X	X				X	X	X	X	X					
Master Tls			X	X	X	X				X	X	X	X	X		X			X
XPS PP Comp 1 Tls	X		X	X	X	X	X	X		X	X	X	X	X		X	X	X	X
XPS PP Comp 2 Tls	X		X	X	X	X	X			X	X	X	X	X		X	X	X	X
Ro Tls Decant (red water solids)		X			X										X				
F25 Mozley Conc	X				X														
F28 Conc Blend				X	X														
F29 Conc Blend				X	X														
F30 Conc Blend				X	X														
F33 Mozley Conc Comp	X		X	X	X	X				X	X		X	X					
F36 Mozley Conc Comp	X		X	X	X	X				X	X		X	X					
F37 Mozley Conc Comp	X		X	X	X	X				X	X		X	X					
Master Conc			X	X	X	X				X	X	X	X	X					
XPS PP Comp 1 Conc	X		X	X	X	X				X	X	X	X	X					
Thor Lake Water #4									X										
Thor Lake Water #7									X										
XPS Tap Water 14-JAN-11									X										
Ortech Tap Water									X										
CH-WT1 PLS+Wash									X										
RAR-1 Filtrate									X										

Sample Descriptions, Preparation and Test Methods

The following sections provide brief overviews of the samples received, sample preparation and test methods included in the environmental characterisation program.

1. Sample Descriptions

Descriptions of the various head, concentrates and tailings samples received are summarised in Table 2. The solution samples received are shown in Table 3.

Table 2: Thor Lake Nechalacho Samples Received

Received Sample ID	Reporting Sample ID	Description
Heads		
Master Comp 3	MC3 Head	F25, F28, F29 + F30 Head
Avalon Head Sample 1	Head 1	F33 Head
Avalon Head Sample 2	Head 2	F36 Head
Avalon Head Sample 3	Head 3	F37 Head
XPS PP Comp 2 Head	PPX Head	XPS MPPX – not used
XPS PP Comp 3 Head	PP2 Head	XPS MPP Run 2 Head
Tailings		
F25 Comb Tls	F25 Tls	MC3 Tails
F28 Comb Tls	F28 Tls	MC3 Tails
F29 Comb Tls	F29 Tls	MC3 Tails
F30 Comb Tls	F30 Tls	MC3 Tails
F33 Comb Tls	F33 Tls	Head 1 Tails
F36 Comb Tls	F36 Tls	Head 2 Tails
F37 Comb Tls	F37 Tls	Head 3 Tails
Master Tls	Master Tls	Combined F25, F28, F29 + F30 Tails
XPS PP Comp 1 Tls	PP1 Tls	XPS MPP Run 1 Tails
XPS PP Comp 2 Tls	PP2 Tls	XPS MPP Run 2 Tls (XPS Comp 3 used for MPP2 as per J. Goode)
Concentrates		
F25 Mozley Conc	F25 Conc	MC3 Concentrate
F28 Conc Blend	F28 Conc	MC3 Concentrate
F29 Conc Blend	F29 Conc	MC3 Concentrate
F30 Conc Blend	F30 Conc	MC3 Concentrate
F33 Mozley Conc Comp	F33 Conc	Head 1 Concentrate
F36 Mozley Conc Comp	F36 Conc	Head 2 Concentrate
F37 Mozley Conc Comp	F37 Conc	Head 3 Concentrate
Master Conc	Master Conc	Combined F25, F28, F29 + F30 Concentrates
XPS PP Comp 1 Conc	PP1 Conc	XPS MPP Run 1 Concentrate

Table 3: Solution Samples Received

Received Sample ID	Origin of Sample
Thor Lake Water #4	N/A
Thor Lake Water #7	N/A
XPS Tap Water 14-JAN-11	XPS tap water
Ortech Tap Water	Ortech tap water
CH-WT1 PLS+Wash	simulated end product from the hydromet program
RAR-1 Filtrate	simulated end product from the hydromet program after Ra removal by addition of $BaCl2+Fe^{2}(SO_4)_3+5H_2O$, pH adjusted to 7, expected to go to tailings pond
Avalon Ro Tls (Red Water)	Solution blended with PP1 Tls
XPS Comp 2 Tls Decant Water (Final Tls Decant)	Solution blended with PP2 Tls

2. Sample Preparation

Upon receipt, the XPS pilot plant tailings samples (*PP1 Tls* and *PP2 Tls*), which were received as very thick pulps, were recombined with enough of their respective solutions to generate slurries that were approximately 30% solids. The reconstituted pilot plant tailings and as-received *PP1 Conc* sample were subsequently mixed for 1 hour at 200 rpm to ensure all solids were thoroughly recombined prior to the extraction and filtration of the solids on #1 Whatman filter papers. Representative portions of the resultant filter cake solids and of the head, tailings and concentrate samples from project 12390-001, which were received as dry solids, were prepared for the proposed geochemical and geotechnical testwork and analyses according to SGS Standard Operating Procedures and the individual test method protocols. The remainder of the tailings pulps were allowed to settle (5 days) prior to the majority of the supernatant being decanted. An aliquots of these day 5 solutions were preserved and submitted for analysis, while the reminder of the decanted solutions were reserved for solution ageing test analyses which were subsequently completed on days 60 and 61.

3. Project Status

At the time of report preparation, the humidity cell tests currently in progress on the *F33 Tls, F36 Tls, F37 Tls, Master Tls, PP1 Tls, Master Conc* and *PP1 Conc* samples were in the 9th week of testing, while the humidity cell test in progress on the *PP2 Tls* sample was in the 4rd week of testing. This report includes all results available to February 10, 2011.

4. Test Methods

The following sections provide a brief overview of the test methods included in the environmental characterisation program.

4.1. Modal Analysis

QEMSCAN provided the modal estimate of the main mineral species within the samples included in this report.

4.2. Qualitative X-ray Diffraction Analyses

A representative portion of the *Ro Tls Decant* (red water solids) sample was submitted for qualitative XRD analyses in order to identify the bulk mineralogy, crystalline species present and the relative proportions of the mineral phases. In this method, x-rays are used to bombard a powdered sample. The x-rays, which penetrate a very thin layer of the sample, are diffracted by lattice planes of minerals. These unique diffraction patterns were used to semi-quantitatively identify the minerals contained within the sample.

4.3. X-ray Fluorescence Whole Rock Analyses

Whole rock analyses were completed on the samples using an XRF method in order to determine the elemental concentrations of the major rock forming constituents. This method quantifies major elements present and reports them as oxides to permit a mass balance assessment against the component of a sample that is amenable to oxidization (loss on ignition).

4.4. Radionuclide Analyses

Representative test charges of the Nechalacho sample solids were analysed for radionuclide content. Radionuclide analyses, which were subcontracted to Becquerel, included ^{226}Ra, ^{228}Ra and ^{210}Pb.

4.5. ICP-OES/MS Strong Acid Digest Elemental Analyses

The samples were digested using an acid mixture of HNO_3, HF, $HClO_4$, and HCl to obtain a near total digest of the parameters being analysed. ICP-OES/MS trace metal scans were performed to provide quantitative analyses of the elemental components of the sample material. Analyses requested included: Cl, F, Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Si, Sn, Sr, Th, Ti, Tl, U, V, Y, Zn and Zr. The rare earth elements of Ce, Dy, Er, Eu, Ga, Gd, Hf, Ho, La, Lu, Nb, Nd, Pr, Sc, Sm, Ta, Tb, Tm and Yb were also included in the analytical suite. Mercury analyses were completed by cold vapour atomic absorption spectroscopy (CVAAS).

4.6. Shake Flask Extraction Testing

The shake flask extraction is used to determine the mobility of contaminants under the chemical environment dictated by the samples intrinsic properties. Deionised (DI) water leachant was added to the samples at a 3:1 liquid to solid ratio. The samples were rotated end over end at 29 ± 2 rpm for a period of 24 hours prior to being filtered through a 0.45 µm cellulose acetate membrane filter. The resultant filtrates were submitted for radionuclide and dissolved metals analyses utilising the aforementioned analytical suite of parameters.

4.7. Solution Analyses – Lake Water, Tap Water and Hydromet Solutions

ICP-OES/MS elemental analyses were completed as per the aforementioned suite of parameters on the Thor Lake water, XPS and Ortech tap waters and simulated final hydromet filtrate solutions (before and after radium removal by the addition of $BaCl_2$ and $Fe^2(SO_4)_3$*$5H_2O$) to provide quantitative analysis of the total and/or dissolved elemental components and to aid in the identification of elements present at potential environmentally significant concentrations.

4.8. Analysis of the Fresh and Aged Pilot Plant Tailings Decant Solutions

The tailings supernatants, which were initially decanted from the settled tailings slurries, were aged and analysed after defined time periods. The objective of this testing was to identify changes in the sample supernatant over time, and quantify elemental concentrations that may report to surface or ground water systems in a tailings pond setting. Both the fresh and aged solutions were collected and submitted for chemical analysis of the following parameters: pH, TOC, alkalinity, acidity, conductivity, EMF, TDS, TSS, anions (Cl, F, SO_4, NO_2, NO_3 and PO_4), thiosalts and ammonia (NH_3 and NH_4). Total and dissolved metal analyses and radionuclide analyses were also completed as per the previously noted suite of parameters.

4.9. LC_{50} Acute Lethality Testing of *Daphnia Magna* and Rainbow Trout

Acute lethality testing was completed to determine the concentration of the PP1 tailings decant solution in which 50% of *Daphnia magna* exposed would die after 48 hours (the LC_{50}). Rainbow trout LC_{50} testing similarly determined the concentration of effluent at which 50% of the trout exposed would die after 96 hours. The test organisms (*Daphnia magna* or rainbow trout) were exposed to the full-strength filtrate solution and at least four geometrically more dilute (for example, 50%, 25%, 12.5%, and 6.3%) concentrations of the effluent. The LC_{50} values were then statistically estimated. Control tests of the dilution water were run parallel to the tests. Testwork was conducted according to the *Daphnia magna* Acute Lethality Toxicity Test Protocol EPS 1/RM/14 and the Acute Lethality of Liquid Effluents to Fish EPS 1/RM/13 protocols from Environment Canada. These tests were subcontracted to Aquatox Testing and Consulting Inc.

4.10. Modified Acid Base Accounting

The modified ABA test provided quantification of the total sulphur, sulphide sulphur, and sulphate concentrations present and the potential acid generation (AP) related to the oxidation of the sulphide sulphur concentration. The test method determined the neutralisation potential (NP) of the samples by initiating a reaction with excess acid and then identified the quantity of acid neutralized by the samples

NP by back-titrating to pH 8.3 with NaOH. The balance between the AP and NP assists in defining the potential of the sample to generate acid drainage. In addition, quantification of the extent of carbonate mineral content permitted calculation of the theoretical carbonate NP.

4.11. Net Acid Generation Testing

NAG tests were conducted to determine the balance between the acid consuming and acid producing components of the Thor Lake products. The NAG test initiated a reaction between the sample and concentrated hydrogen peroxide in order to force complete oxidation and reaction of the acidity produced with the neutralising minerals present within the sample. After the reaction ceased, the pH of the solution was measured (NAG pH). The acid remaining after the reaction was titrated with standardized NaOH to pH 4.5 and the net acid generated by the reaction was calculated and expressed in units of kg H_2SO_4 equivalent per tonne. The $NAG_{4.5}$ value is indicative of the contribution from free acid, Al and Fe. Titration from pH 4.5 to pH 7.0 can provide additional information for sample characterisation as, under certain conditions, the $NAG_{7.0}$ is indicative of the presence of metallic ions that consume alkalinity over this pH range, such as Cu and Zn.

4.12. Humidity Cell Testing – ASTM D 5744-96 (2001)

The humidity cell test is used to predict the potential for acidic leachate generation and the primary rates of reaction under aerobic weathering conditions. Following the standard ASTM D5744-96 (2001) method, humidity cell tests were initiated on the tailings and concentrate samples at the as-received particle size in test cells with dimensions of 20.3 cm (8”) ID by 10.2 cm (4”) height. A perforated disk was located approximately 12.5 mm (1/2”) above the cell bottom to support the solid sample. A filter media was placed on the perforated disk to transmit air and to allow leachate to drain and collect in the cell bottom. A valve located at the bottom of the cell allowed leachate to pass into the collection vessel.

A 1000 g dry equivalent weight of sample was loaded into the cell. The first leach, designated as the Week 0 leach, initiated the humidity cell test and established the initial characteristics of the leachate. The first leach was performed by flooding the sample with 1000 mL of DI water for one hour, followed by the collection of leachate for analyses.

Subsequent steps of the humidity cell test involved three stages over a 7-day cycle: (1) dry air (which entered from the side of the test cell and flowed across the sample) continued for 3 days; (2) humid air was passed through the cell in the same manner as the dry air for 3 days; and (3) on the last day of the cycle, DI water was added through the top of the cell and allowed to flood the cell for one hour prior to the leachate being collected. Weekly leachate samples from the humidity cell tests were submitted for general analyses including: pH, acidity, alkalinity, conductivity and sulphate. ICP-OES/MS trace metal scans were initially performed on a weekly basis (Weeks 0 through 5) with subsequent metal scans completed every five weeks thereafter. Radionuclide analyses were completed on the initial Week 0 leachates with subsequent radionuclide analyses conducted on Weeks 5, 10, 15 and 20.

4.13. Particle Size Distribution Analyses (ASTM D 422-63 (2007))

The Micromeritics Model 1305 multivolume gas pycnometer measures the volume of powdery, granular, porous and irregularly shaped solids in the solids using Boyle's Law. The test used a known weight of solids to quantitatively determine the specific gravity of the solids.

Standard screen sieve sizes (Tyler) were used to determine the particle sizes of the solid tailings particles. The weights of the percent retained and passing on each respective screen size were determined. The test determined the particle size distribution of the plus 200 mesh fraction of the products being investigated.

The particle size distribution for the minus 200 mesh fraction of the products was established using the hydrometer (sedimentation) method. A 50 g (dry equivalent) sample was placed into solution (dispersing agent) with 1 L of distilled water in a standardized glass cylinder. The solution was agitated, and the particles were permitted to settle out of suspension. As settling occurred over time, the average specific gravity of the mixture decreased, causing the height of the suspended hydrometer to drop. Reading of the hydrometer at specific time intervals provided (though established relationships) the weight of the soil remaining in suspension, and the size of the particles that had settled out of solution. The percent finer weight was calculated based on the hydrometer readings, using Stokes Law for spheres falling freely in a fluid of known properties.

4.14. Malvern Laser Particle Size Distribution Analyses

The particle size distribution of the Ro Tls Decant (red water solids) was established using the Malvern laser. In this analysis the as-received red water slurry was slowly added to a stirred beaker of distilled water which feeds the analyzer. The analyzer indicated the optimum concentration of solids for analysis, at which point addition of the slurry was ceased. The system pumped the diluted slurry past a lens and laser system, which determined the particle size distribution based on the diffraction of light.

4.15. Atterberg Limits (ASTM D 4318-05)

Testing was completed to determine the liquid limit (LL), plastic limit (PL), and plasticity index (PI) of the minus 0.425 mm (-40 mesh) fraction of the tailings solids. The liquid limit was determined by performing a number of trials in which a moist sample was spread in a brass cup and divided by a grooving tool. The sample was then allowed to flow together, closing the groove, as a result of the impacts from the repeated dropping of the cup in a standardized mechanical device. The plastic limit was determined by rolling a portion of the test sample into a 3-mm diameter thread until the water content of the sample was reduced to the point where the thread crumbled and the sample could no longer be rolled. The plasticity index was then calculated based on the liquid and plastic limit results.

4.16. Standard and Drained Settling Tests

Standard and drained settling tests were conducted to determine if the tailings would settle adequately without flocculant or rakes and to provide an estimate of the settled terminal density. Two litres of pulp were prepared to the desired density and poured into a two litre graduated cylinder (standard settling test). The slurry was then vigorously agitated. A stopwatch was started immediately at the cessation of agitation, and the height of the liquid-solid interface (or mud line) was recorded at given time intervals for a period of 24 hours. The settled pulp and bulk densities were then calculated.

The drained settling test was conducted in the same manner as the standard settling test. This test also utilised two litres of pulp which was poured into a rigid-wall permeameter cell fitted with porous stone and drainage port in the bottom of the permeameter. The height of the liquid-solid interface and drainage volume were recorded at given time intervals and the settled pulp and bulk densities were calculated.

4.17. Standard Proctor (ASTM D 698-07e1)

The objective of this testing was to determine the compaction characteristics of the tailings produced under the standard compaction effort of 600 kN-m/m^3. This test determined the maximum wet and dry densities for the tailings compacted with standard effort and the optimum moisture content that will facilitate compaction to this density.

4.18. Hydraulic Conductivity Testing (ASTM D 5084)

The hydraulic conductivity of the tailings samples were determined by the falling head method using a flexible wall permeameter. The sample was compacted into the standard Proctor mould a moisture content of 38% using the standard compaction effort of 600 kN-m/m^3 and subsequently frozen. The consolidated frozen sample was then removed from the Proctor mould, inserted into a latex membrane, sealed into the flexible wall permeameter and allowed to thaw prior to back pressure saturation under a confining pressure of 2 psi. Once fully saturated, three trials were performed under up-flow conditions. Changes in gradient over time were monitored and the hydraulic conductivity was determined based on Darcy's Law. Corrections for the viscosity of water at ambient temperatures were made and results were expressed as a result at 20°C in units of m/s.

Testwork Summary

Summary results of the Thor Lake environmental testwork are shown in the following sections. Complete analytical test results are included in Appendix A. Analytical certificates of analysis are provided in Appendix B.

1. Modal Analysis

Tables 4 through 7 provide summary results of the modal analyses completed during the mineralogical examination of the Nechalacho samples.

Table 4: Quantitative Modal Abundance – Heads

Mineral Mass	**Head 1**	**Head 2**	**Head 3**	**PPX Head**	**PP2 Head**
Sample Origin	F25, 28, 29 + 30	F33	F36	F37	
	(%)	(%)	(%)	(%)	(%)
	MI5006-OCT10	MI5006-OCT10	MI5006-OCT10	MI5041-OCT10	MI5041-OCT10
Columbite (Fe)	0.2	0.2	0.6	0.4	0.5
Fergusonite	0.2	0.3	0.3	0.2	0.1
Bastnasite	0.9	1.4	1.2	1.2	0.8
Synchysite	1.0	1.0	0.7	0.5	1.8
Allanite	0.8	1.1	1.4	2.1	1.0
Monazite	0.8	0.4	0.6	0.4	0.3
Other REE	0.0	0.0	0.0	0.0	0.0
Zircon	7.1	8.1	9.0	9.0	8.0
Apatite	0.0	0.0	0.0	0.1	0.0
Quartz	12.9	17.5	14.4	21.7	18.0
Plagioclase	18.8	15.2	19.2	17.6	16.1
K-Feldspar	16.4	11.7	11.8	12.2	14.2
Biotite	17.0	17.1	18.2	19.2	21.6
Muscovites/Clays	6.6	4.5	5.0	3.8	4.5
Chlorite	0.4	0.3	0.6	0.3	0.2
Amphibole	0.4	1.2	0.7	0.2	0.5
Other Silicates	0.5	0.8	0.6	0.5	0.7
Calcite	1.4	1.6	1.4	1.1	0.9
Dolomite	0.8	2.0	0.7	0.2	0.7
Ankerite	2.8	3.6	2.9	1.1	2.5
Other Carbonates	0.0	0.0	0.0	0.0	0.0
Fluorite	0.8	0.6	0.5	0.5	0.2
Fe-Oxides	9.7	11.1	10.0	7.4	7.1
Sulphides	0.1	0.1	0.1	0.1	0.0
Other	0.2	0.1	0.2	0.1	0.0
Total	100.0	100.0	100.0	100.0	100.0

Table 5: Quantitative Modal Abundance – Tailings

Mineral Mass	F25 Tls (%) MI5001-OCT10	F28 Tls (%) MI5001-OCT10	F29 Tls (%) MI5001-OCT10	F30 Tls (%) MI5001-OCT10
Columbite (Fe)	0.2	0.3	0.4	0.4
Fergusonite	0.1	0.3	0.3	0.3
Bastnasite	0.1	0.1	0.1	0.1
Synchysite	0.1	0.2	0.2	0.2
Allanite	0.5	0.8	0.4	0.7
Monazite	0.1	0.2	0.1	0.1
Other REE	0.0	0.0	0.0	0.0
Zircon	2.2	4.0	3.8	4.2
Apatite	0.0	0.0	0.0	0.0
Quartz	18.0	17.4	18.2	18.0
Plagioclase	16.3	14.0	16.0	14.7
K-Feldspar	12.8	11.4	15.2	13.6
Biotite	16.9	16.3	12.8	16.2
Muscovites/Clays	23.2	23.4	22.3	20.9
Chlorite	0.1	0.0	0.0	0.1
Amphibole	0.1	0.1	0.1	0.0
Other Silicates	0.1	0.2	0.1	0.2
Calcite	0.1	0.2	0.2	0.3
Dolomite	0.0	0.0	0.1	0.1
Ankerite	0.6	0.9	0.8	1.2
Other Carbonates	0.0	0.0	0.0	0.0
Fluorite	0.0	0.0	0.0	0.0
Fe-Oxides	8.3	10.1	8.7	8.4
Sulphides	0.0	0.0	0.1	0.0
Other	0.1	0.1	0.1	0.1
Total	100.0	100.0	100.0	100.0

Table 6: Quantitative Modal Abundance – Tailings

Mineral Mass	F33 Tls (%) MI5001-OCT10	F36 Tls (%) MI5001-OCT10	F37 Tls (%) MI5001-OCT10	PP1 Tls (%) MI5042-NOV10	PP2 Tls (%) MI5041-OCT10
Columbite (Fe)	0.2	0.2	0.2	0.4	0.4
Fergusonite	0.1	0.1	0.1	0.2	0.2
Bastnasite	0.1	0.1	0.1	0.1	0.1
Synchysite	0.1	0.2	0.1	0.1	0.1
Allanite	0.6	0.8	0.8	0.2	0.4
Monazite	0.0	0.1	0.1	0.1	0.1
Other REE	0.0	0.0	0.0	0.0	0.0
Zircon	1.8	3.4	2.1	3.8	3.5
Apatite	0.0	0.0	0.0	0.0	0.0
Quartz	15.5	20.4	17.5	14.0	16.8
Plagioclase	17.6	14.9	18.3	21.7	19.3
K-Feldspar	14.4	12.4	13.2	16.8	14.2
Biotite	15.0	15.8	15.6	20.3	15.5
Muscovites/Clays	24.0	19.5	19.9	15.6	22.6
Chlorite	0.1	0.1	0.1	0.1	0.1
Amphibole	0.1	0.2	0.1	0.1	0.1
Other Silicates	0.1	0.2	0.2	0.1	0.1
Calcite	0.2	0.2	0.3	0.1	0.1
Dolomite	0.1	0.2	0.1	0.0	0.0
Ankerite	0.6	0.8	0.7	0.4	0.3
Other Carbonates	0.0	0.0	0.0	0.0	0.0
Fluorite	0.0	0.0	0.0	0.0	0.0
Fe-Oxides	9.4	10.4	10.5	5.9	6.1
Sulphides	0.0	0.0	0.0	0.1	0.1
Other	0.0	0.2	0.1	0.1	0.1
Total	100.0	100.0	100.0	100.0	100.0

Table 7: Quantitative Modal Abundance – Concentrates

Mineral Mass	F25 Conc (%) MI5004-OCT10	F33 Conc (%) MI5001-OCT10	F36 Conc (%) MI5001-OCT10	F37 Conc (%) MI5001-OCT10	PP1 Conc (%) MI5001-OCT10
Columbite (Fe)	1.3	3.1	2.0	2.3	1.5
Fergusonite	1.4	1.7	1.4	1.9	2.3
Bastnasite	4.2	2.8	3.0	4.0	3.5
Synchysite	4.6	3.4	2.3	2.8	5.3
Allanite	2.5	2.3	3.1	2.6	3.7
Monazite	1.2	1.5	1.3	1.8	2.4
Other REE	0.1	0.0	0.0	0.1	0.1
Zircon	38.4	33.3	30.3	35.9	28.8
Apatite	0.3	0.4	0.5	0.3	0.0
Quartz	8.5	7.2	8.8	5.8	5.6
Plagioclase	2.0	2.2	1.7	1.9	2.2
K-Feldspar	1.2	1.3	0.6	0.9	2.1
Biotite	6.8	17.2	14.0	18.6	9.8
Muscovites/Clays	1.2	2.3	2.0	2.4	2.0
Chlorite	0.7	0.5	0.2	0.5	0.6
Amphibole	0.3	0.2	0.8	0.2	0.2
Other Silicates	0.8	0.3	0.5	0.2	0.3
Calcite	2.4	1.5	1.7	1.5	2.3
Dolomite	1.2	1.3	3.0	1.0	1.9
Ankerite	8.1	8.1	9.0	6.9	13.6
Other Carbonates	0.0	0.0	0.0	0.0	0.0
Fluorite	2.2	1.6	0.8	0.9	1.0
Fe-Oxides	10.2	7.6	12.3	6.9	9.9
Sulphides	0.4	0.2	0.2	0.3	0.5
Other	0.2	0.1	0.3	0.3	0.1
Total	100.0	100.0	100.0	100.0	100.0

2. Qualitative X-ray Diffraction Analyses

Summary results of the XRD analyses completed on the *Ro Tls Decant* (red water) solids are presented in Table 8. The complete XRD test report is included in Appendix C.

Table 8: XRD Summary Results

Sample	Crystalline Mineral Assemblage (relative proportions based on peak height)			
	Major (>30% Wt)	Moderate (10% -30% Wt)	Minor (2% -10% Wt)	Trace (<2% Wt)
Ro Tls Decant (red water solids)	-	potassium feldspar, plagioclase	Quartz, mica, hematite, zircon, ferrocolumbite, monetite	*allanite, *monazite, *bastnaestite, *palygorskite, *montmorillonite

**Tentative identification due to low concentrations, diffraction line overlap or poor crystallinity.*

3. X-ray Fluorescence Whole Rock Analyses

Results of the XRF whole rock analyses are presented in Tables 9 through 11.

Table 9: XRF Whole Rock Analyses Results – Heads

Parameter	**Unit**	**MC3**	**Head 1**	**Head 2**	**Head 3**	**PPX Head**	**PP2 Head**
Sample Origin		F25, 28, 29 + 30	F33	F36	F37		
SiO_2	%	54.0	54.7	53.6	53.9	54.2	53.8
Al_2O_3	%	10.8	11.3	9.15	10.6	9.42	10.8
Fe_2O_3	%	12.7	11.5	13.3	12.4	13.5	12.6
MgO	%	2.83	2.68	3.34	2.77	3.35	2.79
CaO	%	2.60	2.59	3.08	2.68	2.99	2.58
Na_2O	%	2.94	2.93	2.39	2.88	2.43	2.78
K_2O	%	4.89	5.24	4.44	4.81	4.48	4.86
TiO_2	%	0.05	0.05	0.05	0.04	0.05	0.04
P_2O_5	%	0.11	0.08	0.05	0.12	0.06	0.12
MnO	%	0.19	0.22	0.40	0.19	0.40	0.20
Cr_2O_3	%	< 0.01	< 0.01	< 0.01	< 0.01	0.11	< 0.01
V_2O_5	%	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01
LOI	%	1.14	3.42	4.54	3.42	4.25	3.68
Sum	%	92.2	94.7	94.3	93.9	95.2	94.3
Nb_2O_5	%	0.43	0.39	0.46	0.50	0.46	0.44
ZrO_2	%	3.65	3.14	3.73	3.75	3.57	3.58

Table 10: XRF Whole Rock Analyses Results – Tailings

Parameter	**Unit**	**F25 Tls**	**F28 Tls**	**F29 Tls**	**F33 Tls**	**F36 Tls**	**F37 Tls**	**PP1 Tls**	**PP2 Tls**	**Master Tls**
SiO_2	%	59.2	63.6	61.5	60.2	60.2	59.8	60.2	61.9	60.9
Al_2O_3	%	11.6	12.0	11.5	12.7	10.9	12.0	13.2	12.8	11.5
Fe_2O_3	%	11.2	9.66	11.5	11.8	12.8	13.0	10.7	10.0	12.0
MgO	%	2.01	1.47	1.67	1.85	2.23	1.82	2.43	1.93	1.86
CaO	%	0.89	0.91	1.08	0.98	1.15	1.00	0.85	0.75	1.11
Na_2O	%	3.23	3.37	3.23	3.49	2.95	3.38	3.35	3.71	3.28
K_2O	%	5.51	5.53	5.35	5.78	5.10	5.35	6.05	5.65	5.42
TiO_2	%	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.04	0.03
P_2O_5	%	0.04	0.04	0.03	0.03	0.01	0.03	0.04	0.04	0.05
MnO	%	0.12	0.11	0.12	0.12	0.16	0.09	0.09	0.08	0.14
Cr_2O_3	%	0.08	0.09	0.10	0.10	0.10	0.10	< 0.01	< 0.01	0.10
V_2O_5	%	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01
LOI	%	1.82	1.67	1.81	1.74	1.96	1.61	1.54	1.50	1.86
Sum	%	95.6	98.4	97.9	98.8	97.6	98.2	98.5	98.4	98.2
Nb_2O_5	%	0.14	0.16	0.19	0.15	0.18	0.16	0.18	0.22	0.20
ZrO_2	%	0.95	1.01	1.60	0.92	1.55	0.97	1.52	1.45	1.38

Table 11: XRF Whole Rock Analyses Results – Concentrates

Parameter	**Unit**	**F33 Conc**	**F36 Conc**	**F37 Conc**	**Master Conc**	**PP1 Conc**
SiO_2	%	30.6	30.1	29.9	25.8	26.5
Al_2O_3	%	4.13	3.14	4.17	2.92	3.59
Fe_2O_3	%	13.8	17.7	13.7	16.6	13.1
MgO	%	3.62	4.31	3.60	3.08	3.64
CaO	%	8.45	8.50	7.39	9.03	12.1
Na_2O	%	0.56	0.80	0.58	0.41	0.58
K_2O	%	1.93	1.46	1.88	1.32	1.49
TiO_2	%	0.14	0.14	0.18	0.11	0.09
P_2O_5	%	0.80	0.44	0.80	0.66	0.61
MnO	%	0.57	0.98	0.47	0.65	0.84
Cr_2O_3	%	< 0.01	< 0.01	0.02	< 0.01	< 0.01
V_2O_5	%	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
LOI	%	9.62	10.8	8.78	10.8	12.4
Sum	%	74.2	78.3	71.5	71.3	74.9
Nb_2O_5	%	1.69	1.54	1.80	1.88	1.53
ZrO_2	%	16.0	13.0	18.0	17.3	13.5

4. Radionuclide Analyses

Tables 12 through 14 provide results of the radionuclide analyses conducted on the Nechalcho solids.

Table 12: Radionuclide Analyses Results – Heads

Parameter	Unit	MC3	Head 1	Head 2	Head 3	PPX Head	PP2 Head
Sample Origin		F25, 28, 29 + 30	F33	F36	F37		
^{226}Ra	Bq/g	0.32	0.28	0.30	0.36	0.2	0.4
^{210}Pb	Bq/g	0.20	0.16	0.19	0.19	0.2	0.3
^{228}Ra	Bq/g	0.38	0.31	0.28	0.38	0.3	0.4

Table 13: Radionuclide Analyses Results – Tailings

Parameter	Unit	F25 Tls	F28 Tls	F29 Tls	F30 Tls	F33 Tls	F36 Tls	F37 Tls	Master Tls	PP1 Tls	PP2 Tls
^{226}Ra	Bq/g	0.11	0.13	0.16	0.2	0.15	0.15	0.14	0.12	0.17	0.2
^{210}Pb	Bq/g	0.11	0.10	0.13	< 0.3	0.12	0.12	0.10	0.15	0.13	0.2
^{228}Ra	Bq/g	0.12	0.11	0.16	0.1	0.09	0.10	0.11	0.13	0.13	0.2

Table 14: Radionuclide Analyses Results – Concentrates

Parameter	Unit	F25 Conc	F28 Conc	F29 Conc	F30 Conc	F33 Conc	F36 Conc	F37 Conc	Master Conc	PP1 Conc
^{226}Ra	Bq/g	No	1.2	1.2	1.6	1.4	1.2	1.5	1.4	1.2
^{210}Pb	Bq/g	Sample	0.3	0.2	0.3	0.25	0.33	0.30	0.28	0.28
^{228}Ra	Bq/g	Available	1.7	1.6	2.1	1.9	1.2	1.8	1.9	1.8

5. ICP-OES/MS Strong Acid Digest Elemental Analyses

ICP-OES/MS strong acid digest elemental analyses results for the Nechalacho samples (including the solids collected from the *Ro Tls Decant*) are summarised in Tables 15 through 17. Complete results of the elemental analyses are presented in Appendix C.

Table 15: Strong Acid Digest ICP-OES/MS Elemental Analyses Results – Heads

Parameter	Unit	MC3	Head 1	Head 2	Head 3	PPX Head	PP2 Head
Sample Origin		F25, 28, 29 + 30	F33	F36	F37		
F	%	1.04	1.11	0.89	1.05	0.69	0.91
Hg	µg/g	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Al	µg/g	56000	59000	47000	58000	62000	73000
As	g/t	13	4.8	7.4	4.2	4.4	3.4
Ca	µg/g	18000	17000	21000	19000	22000	19000
Cu	g/t	3.6	4.7	7.9	3.8	2.0	1.7
Fe	µg/g	87000	78000	90000	90000	100000	94000
K	µg/g	39000	41000	35000	40000	43000	47000
Mg	µg/g	17000	16000	20000	18000	22000	19000
Na	µg/g	20000	19000	16000	20000	18000	22000
Ni	g/t	16	13	12	14	6.0	6.7
Pb	g/t	17	14	15	18	10	11
Se	g/t	7.6	6.0	7.2	7.4	13	12
Si	%	27.2	23.8	24.7	22.3	24.2	23.8
Th	g/t	110	91	73	110	61	80
U	g/t	22	19	17	23	12	15
Zn	g/t	140	140	160	130	100	64
Ce	g/t	5700	4300	5200	5100	5700	5600
La	g/t	2500	2100	2500	2500	2500	2700
Nb	%	0.24	0.22	0.26	0.28	0.30	0.30
Nd	g/t	2600	2300	2700	2700	3200	3000
Zr	%	2.4	1.9	2.5	2.4	2.68	2.70

Table 16: Strong Acid Digest ICP-OES/MS Elemental Analyses Results – Tailings

Parameter	Unit	F25 Tls	F28 Tls	F29 Tls	F30 Tls	F33 Tls	F36 Tls	F37 Tls	Master Tls	PP1 Tls	Ro Tls Decant	PP2 Tls
F	%	0.54	0.65	0.49	0.58	0.47	0.52	0.54	0.55	0.57	---	0.50
Hg	µg/g	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	---	< 0.1
Al	µg/g	65000	64000	60000	73000	68000	55000	63000	62000	67000	74300	86000
As	g/t	3.1	2.5	4.2	4.5	3.0	4.0	2.8	4.4	49	<30	1.8
Ca	µg/g	6400	6300	7300	9000	6500	7600	6900	7700	5800	12500	5500
Cu	g/t	19	14	17	15	21	23	22	18	5.4	27.8	3.0
Fe	µg/g	81000	68000	80000	82000	82000	87000	89000	83000	72000	89900	75000
K	µg/g	46000	44000	42000	43000	46000	39000	42000	43000	47000	56200	54000
Mg	µg/g	13000	9400	10000	12000	12000	13000	11000	12000	14000	28500	13000
Na	µg/g	23000	24000	21000	22000	24000	20000	24000	22000	22000	15500	27000
Ni	g/t	330	270	320	290	340	340	320	330	17	76	8.5
Pb	g/t	8.9	9.2	10	11	9.0	9.4	8.6	9.9	8.1	30	7.0
Se	g/t	1.9	2.6	3.8	5.3	1.8	2.4	2.4	3.2	2.9	<30	2.6
Si	%	26.2	25.2	25.5	22.4	26.1	26.0	25.9	26.3	24.8	---	27.0
Th	g/t	31	31	44	66	29	31	34	40	39	---	39
U	g/t	7.7	8.1	11	11	8.9	9.1	10	9.9	12	<20	9.7
Zn	g/t	74	55	61	77	75	97	71	68	77	174	44
Ce	g/t	1600	2600	1900	2400	1500	1800	1800	1900	1260	---	1500
La	g/t	680	1100	870	1100	660	800	800	850	547	---	600
Nb	%	0.09	0.14	0.13	0.14	0.10	0.11	0.09	0.10	0.12	---	0.14
Nd	g/t	780	1300	970	1200	730	910	880	970	654	---	900
Zr	%	0.74	1.07	1.07	1.20	0.69	1.17	0.73	0.88	1.13	---	1.12

Table 17: Strong Acid Digest ICP-OES/MS Elemental Analyses Results – Concentrates

Parameter	Unit	F25 Conc	F28 Conc	F29 Conc	F30 Conc	F33 Conc	F36 Conc	F37 Conc	Master Conc	PP1 Conc
F	%	2.15	2.66	3.10	2.74	2.96	1.98	2.41	2.80	3.21
Hg	µg/g	< 0.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Al	µg/g	15000	20000	19000	15000	21000	16000	22000	15000	18000
As	g/t	160	81	62	100	27	26	20	77	16
Ca	µg/g	61000	60000	71000	59000	56000	56000	50000	61000	81000
Cu	g/t	< 50	17	12	22	21	13	17	16	45
Fe	µg/g	113000	110000	110000	120000	94000	120000	96000	110000	89000
K	µg/g	9900	13000	13000	9900	17000	13000	17000	12000	13000
Mg	µg/g	17000	21000	22000	18000	22000	26000	22000	19000	22000
Na	µg/g	3500	3100	2500	2000	3600	5000	4200	2500	3600
Ni	g/t	91	87	79	89	77	44	48	86	100
Pb	g/t	< 200	48	52	62	52	54	64	63	55
Se	g/t	< 30	32	32	43	25	25	26	31	24
Si	%	13.2	12.7	11.5	10.9	11.5	13.8	11.5	12.0	12.6
Th	g/t	530	45	85	90	210	53	210	3.5	2.2
U	g/t	110	70	66	87	84	65	89	87	67
Zn	g/t	270	260	260	290	260	300	320	270	230
Ce	g/t	26000	24000	26000	30000	23000	22000	24000	27000	26000
La	g/t	11000	11000	12000	13000	10000	9300	10000	12000	11000
Lu	g/t	110	99	93	110	85	87	90	100	77
Nb	%	1.38	1.24	1.11	1.43	1.18	1.01	1.02	1.28	0.82
Nd	g/t	13000	12000	13000	15000	12000	11000	12000	14000	13000
Zr	%	13.5	12.0	10.5	14.1	11.5	9.39	10.6	12.6	8.4

6. Shake Flask Extraction

Results of the 3:1 liquid to solid ratio shake flask extractions are summarised in Tables 18 through 21.

Table 18: Shake Flask Extraction Results – Heads

Parameter	Unit	*MMER	MC3	Head 1	Head 2	Head 3	PPX Head	PP2 Head
Sample Origin			F25, 28, 29 + 30	F33	F36	F37		
Initial pH	units		9.90	9.82	9.87	9.86	9.97	9.86
Final pH	units		9.56	9.50	9.61	9.54	9.46	9.51
Radionuclide Analyses								
^{226}Ra	Bq/L	0.37	< 0.01	< 0.01	< 0.01	< 0.01	***	***
^{228}Ra	Bq/L		< 0.3	< 0.1	< 0.4	< 0.3	***	***
^{210}Pb	Bq/L		0.3	0.1	< 0.1	0.2	***	***
General and Metals Analyses								
pH	units	6.0-9.5	9.27	9.21	8.96	9.33	8.50	8.92
F	mg/L		12.0	12.2	10.3	11.8	0.98	11.0
Cl	mg/L		11	11	11	10	12	11
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
As	mg/L	0.50	0.0010	0.0010	0.0011	0.0010	0.0013	0.0008
Ca	mg/L		8.09	7.30	7.25	7.99	7.12	6.44
Cu	mg/L	0.30	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0013	0.0009
Fe	mg/L		0.015	0.018	0.010	0.003	0.012	0.014
K	mg/L		27.9	24.4	24.2	28.3	24.0	20.2
Mg	mg/L		3.52	3.00	3.38	3.57	3.31	2.83
Na	mg/L		21.8	25.1	21.8	22.0	22.2	16.8
Ni	mg/L	0.50	0.0004	0.0004	0.0004	0.0003	0.0003	0.0003
Pb	mg/L	0.20	< 0.00002	< 0.00002	< 0.00002	< 0.00002	0.00047	0.00072
Se	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	mg/L		3.36	3.50	4.28	3.46	4.42	2.67
Th	mg/L		0.00223	0.000577	0.000365	0.000066	0.000489	0.000300
U	mg/L		0.000143	0.000327	0.000169	0.000462	0.000160	0.000165
Zn	mg/L	0.50	0.001	0.002	0.002	0.001	0.006	0.003

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Table 19: Shake Flask Extraction Results – Tailings

Parameter	Unit	*MMER	F25 Tls	F28 Tls	F29 Tls	F33 Tls
Initial pH	units		8.30	8.59	8.62	8.86
Final pH	units		8.44	8.66	8.66	8.91
Radionuclide Analyses						
^{226}Ra	Bq/L	0.37	< 0.01	< 0.01	< 0.01	< 0.01
^{228}Ra	Bq/L		< 0.2	< 0.1	< 0.3	< 0.1
^{210}Pb	Bq/L		0.2	< 0.1	< 0.1	< 0.1
General and Metals Analyses						
pH	units	6.0-9.5	7.91	7.87	7.81	7.90
F	mg/L		1.29	1.23	1.39	2.40
Cl	mg/L		1.4	1.7	1.9	2.6
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001
As	mg/L	0.50	0.0024	0.0027	0.0031	0.0079
Ca	mg/L		13.1	12.8	13.0	13.1
Cu	mg/L	0.30	0.0042	0.0020	0.0029	0.0049
Fe	mg/L		0.304	0.081	0.123	0.041
K	mg/L		2.33	3.44	3.47	7.79
Mg	mg/L		2.41	2.20	2.10	2.46
Na	mg/L		6.70	6.75	9.29	9.95
Ni	mg/L	0.50	0.0023	0.0012	0.0016	0.0019
Se	mg/L		< 0.001	< 0.001	< 0.001	< 0.001
Si	mg/L		7.72	6.44	6.17	5.74
Th	mg/L		0.00280	0.000702	0.00186	0.000354
U	mg/L		0.00132	0.00119	0.00131	0.00410
Zn	mg/L	0.50	0.008	0.006	0.006	0.004

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Table 20: Shake Flask Extraction Results – Tailings

Parameter	Unit	*MMER	F36 Tls	F37 Tls	Master Tls	PP1 Tls	PP2 Tls
Initial pH	units		8.84	8.92	8.52	9.28	9.08
Final pH	units		8.84	8.95	8.59	8.81	8.82
Radionuclide Analyses							
^{226}Ra	Bq/L	0.37	< 0.01	< 0.01	< 0.01	< 0.01	***
^{228}Ra	Bq/L		< 0.1	< 0.1	< 0.1	< 0.3	***
^{210}Pb	Bq/L		< 0.1	< 0.1	< 0.1	< 0.1	***
General and Metals Analyses							
pH	units	6.0-9.5	8.02	8.09	7.81	7.95	8.12
F	mg/L		2.33	2.71	1.40	1.83	4.43
Cl	mg/L		3.3	3.6	1.8	3.6	5.0
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
As	mg/L	0.50	0.0081	0.0066	0.0032	0.0199	0.0060
Ca	mg/L		13.8	14.1	13.3	21.0	14.5
Cu	mg/L	0.30	0.0063	0.0056	0.0028	0.0010	0.0008
Fe	mg/L		0.079	0.056	0.198	0.041	0.072
K	mg/L		8.52	7.96	2.69	8.76	12.8
Mg	mg/L		2.70	2.50	2.30	3.20	5.31
Na	mg/L		10.3	10.9	9.18	13.4	17.4
Ni	mg/L	0.50	0.0020	0.0015	0.0018	0.0059	0.0015
Se	mg/L		< 0.001	0.001	< 0.001	< 0.001	< 0.001
Si	mg/L		5.85	5.58	7.56	4.72	3.35
Th	mg/L		0.000577	0.000420	0.002330	0.000832	0.000377
U	mg/L		0.00429	0.00514	0.00136	0.00535	0.00535
Zn	mg/L	0.50	0.008	0.010	0.011	0.003	0.010

**Department of Justice Canada. 2002. Metal Mining Effluent Regulations, Fisheries Act SOR-2002-222.*

Table 21: Shake Flask Extraction Results – Concentrates

Parameter	Unit	*MMER	F33 Conc	F36 Conc	F37 Conc	Master Conc	PP1 Conc
Initial pH	units		8.92	8.68	8.87	9.10	8.90
Final pH	units		8.93	8.75	8.89	9.02	8.80
Radionuclide Analyses							
^{226}Ra	Bq/L	0.37	< 0.01	0.01	< 0.01	< 0.01	< 0.01
^{228}Ra	Bq/L		< 0.1	< 0.1	< 0.1	< 0.1	< 0.3
^{210}Pb	Bq/L		< 0.1	0.1	< 0.1	< 0.1	< 0.1
General and Metals Analyses							
pH	units	6.0-9.5	7.93	7.61	7.61	7.71	7.78
F	mg/L		0.97	0.90	0.90	1.31	1.08
Cl	mg/L		1.1	1.1	1.0	1.3	2.0
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
As	mg/L	0.50	0.0113	0.0107	0.0093	0.0047	0.0019
Ca	mg/L		7.20	8.18	7.46	10.1	10.4
Cu	mg/L	0.30	0.0020	0.0008	0.0006	0.0020	0.0006
Fe	mg/L		0.083	0.070	0.031	0.104	0.014
K	mg/L		1.57	4.52	2.75	0.872	1.73
Mg	mg/L		0.855	1.12	0.929	0.914	1.53
Na	mg/L		8.53	7.14	8.13	7.79	4.56
Ni	mg/L	0.50	0.0005	0.0004	< 0.0001	< 0.0001	0.0004
Se	mg/L		< 0.001	< 0.001	< 0.001	0.001	< 0.001
Si	mg/L		3.50	3.29	3.40	3.31	2.65
Th	mg/L		0.000248	0.000169	0.000089	0.000514	0.000039
U	mg/L		0.000180	0.000078	0.000103	0.00105	0.00154
Zn	mg/L	0.50	0.008	0.006	0.005	0.004	0.004

**Department of Justice Canada. 2002. Metal Mining Effluent Regulations, Fisheries Act SOR-2002-222.*

7. Solution Analyses – Lake Water, Tap Water and Hydromet Solutions

Results of the lake and tap water analyses are summarised in Table 22. Summary results of the analyses completed on the simulated end product from the hydromet test program both before and after radium removal are provided in Table 23.

Table 22: Solution Analysis Results – Lake and Tap Waters

Parameter	Unit	*MMER	Thor Lake Water # 4		Thor Lake Water # 7		XPS Tap Water 14-JAN-11		Ortech Tap Water	
Radionuclide Analyses										
^{226}Ra	Bq/L	0.37	< 0.01	---	< 0.01	---	***	---	***	---
^{228}Ra	Bq/L		< 0.2	---	< 0.2	---	***	---	---	---
^{210}Pb	Bq/L		< 0.1	---	< 0.1	---	***	---	---	---
General Analyses										
pH	units	6.0-9.5	8.19	---	8.26	---	7.62	---	7.96	---
Alkalinity	mg/L as $CaCO_3$		144	---	142	---	51	---	89	---
EMF	mV		303	---	281	---	686	---	576	---
Conductivity	µS/cm		277	---	280	---	311	---	308	---
TDS	mg/L		186	---	180	---	200	---	186	---
TSS	mg/L	15.00	< 2	---	2	---	< 2	---	< 2	---
Cl	mg/L		3.8	---	3.8	---	48	---	29	---
SO_4	mg/L		0.4	---	0.4	---	20	---	27	---
F	mg/L		1.01	---	1.02	---	0.06	---	0.34	---
TOC	mg/L		12.2	---	13.0	---	2.3	---	1.6	---
Metals Analyses			**Total**	**Diss**	**Total**	**Diss**	**Total**	**Diss**	**Total**	**Diss**
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
As	mg/L	0.50	0.0009	0.0008	0.0008	0.0009	0.0015	0.0017	0.0007	0.0008
Ca	mg/L		32.1	30.5	31.3	30.2	25.6	30.2	35.4	35.4
Cu	mg/L	0.30	< 0.0005	0.0006	< 0.0005	< 0.0005	0.0342	0.0335	0.0025	0.0030
Fe	mg/L		0.019	< 0.002	0.013	0.008	0.008	0.002	0.006	0.003
K	mg/L		1.87	1.81	1.82	1.76	1.37	1.62	1.82	1.83
Mg	mg/L		17.5	16.4	17.1	16.3	5.57	6.60	9.37	9.43
Na	mg/L		5.94	5.55	5.83	5.49	20.3	23.5	16.1	16.2
Ni	mg/L	0.50	0.0006	0.0007	0.0006	0.0008	0.0009	0.0011	0.0008	0.0008
Pb	mg/L	0.20	0.00006	0.00007	0.00007	0.00008	0.00016	0.00005	0.00095	0.00085
Se	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	mg/L		3.12	2.95	3.03	2.92	7.15	8.40	0.47	0.49
Th	mg/L		0.000115	0.000022	0.000079	0.000023	0.000026	0.000006	0.000027	0.000004
U	mg/L		0.000402	0.000338	0.000373	0.000350	0.000322	0.000345	0.000310	0.000289
Zn	mg/L	0.50	< 0.002	< 0.002	< 0.002	< 0.002	0.204	0.241	0.007	0.006

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Table 23: Solution Analysis Results – Hydromet Solutions

Parameter	Unit	*MMER	CH-WT1 PLS +Wash Simulated Hydromet Tls Filtrate	RAR-1 Filtrate Hydromet Tls after Ra Removal
Radionuclide Analyses				
^{226}Ra	Bq/L	0.37	0.10	< 0.01
^{228}Ra	Bq/L		< 0.2	< 0.4
^{210}Pb	Bq/L		< 0.1	0.1
General Analyses				
pH	units	6.0-9.5	7.73	7.46
Alkalinity	mg/L as $CaCO_3$		118	82
EMF	mV		214	---
Conductivity	µS/cm		13400	13300
TDS	mg/L		16800	---
TSS	mg/L	15.00	---	---
Cl	mg/L		55	---
SO_4	mg/L		11000	12000
F	mg/L		1.82	---
TOC	mg/L		53.9	---
NH_3+NH_4	as N mg/L		91.7	---
Metals Analyses			**Diss**	**Diss**
Hg	mg/L		< 0.0001	< 0.0001
As	mg/L	0.50	0.0022	0.0024
Ca	mg/L		393	387
Cu	mg/L	0.30	0.0226	0.0470
Fe	mg/L		0.150	0.138
K	mg/L		86.8	87.8
Li	mg/L		2.18	2.22
Mg	mg/L		1530	1550
Mn	mg/L		6.15	6.33
Na	mg/L		1580	1470
Ni	mg/L	0.50	0.0701	0.0726
Pb	mg/L	0.20	0.00052	0.00075
Se	mg/L		0.005	0.008
Si	mg/L		2.47	2.55
Sr	mg/L		11.2	11.0
Th	mg/L		0.002945	0.000690
U	mg/L		0.0239	0.0167
Zn	mg/L	0.50	< 0.002	0.030

**Department of Justice Canada. 2002. Metal Mining Effluent Regulations, Fisheries Act SOR-2002-222.*

8. Analysis of the Fresh and Aged Tailings Decant Solutions

Tables 24 and 25 provide summary results of the ICP-OES/MS analyses completed on the fresh and aged tailings decant solutions.

Table 24: ICP-OES/MS Fresh and Aged Decant Solution Results – PP1 Tls

Parameter	Unit	*MMER	PP1 Tls Decant Day 5		PP1 Tls Decant Day 60	
Radionuclide Analyses						
^{226}Ra	Bq/L	0.37	< 0.01	---	***	---
^{228}Ra	Bq/L		0.3	---	***	---
^{210}Pb	Bq/L		< 0.1	---	***	---
General Analyses						
pH	units	6.0-9.5	8.20	---	8.16	---
Alkalinity	mg/L as $CaCO_3$		119	---	126	---
EMF	mV		284	---	207	---
Conductivity	µS/cm		617	---	662	---
TDS	mg/L		400	---	406	---
TSS	mg/L	15.00	14	---	< 2	---
Cl	mg/L		44	---	44	---
SO_4	mg/L		100	---	110	---
F	mg/L		4.43	---	4.46	---
TOC	mg/L		12.2	---	7.2	---
Metals Analyses			**Total**	**Diss**	**Total**	**Diss**
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001
As	mg/L	0.50	0.0022	0.0025	0.0019	0.0019
Ca	mg/L		43.7	40.0	41.2	40.9
Cu	mg/L	0.30	0.0023	0.0024	0.0012	0.0027
Fe	mg/L		0.570	0.025	0.025	< 0.002
K	mg/L		28.8	27.0	26.4	26.4
Mg	mg/L		9.14	8.15	8.56	8.43
Mn	mg/L		0.0788	0.0488	0.00808	0.00140
Na	mg/L		70.4	66.0	66.5	66.5
Ni	mg/L	0.50	0.0070	0.0066	0.0048	0.0046
Pb	mg/L	0.20	0.00060	0.00033	0.00051	0.00011
Se	mg/L		< 0.001	0.001	< 0.001	< 0.001
Si	mg/L		8.10	6.24	6.31	6.23
Th	mg/L		0.000694	0.000082	0.000385	0.000084
U	mg/L		0.00880	0.00836	0.00865	0.00863
Y	mg/L		0.00877	0.000376	0.000174	0.000091
Zn	mg/L	0.50	0.007	0.004	0.003	< 0.002

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Table 25: ICP-OES/MS Fresh and Aged Decant Solution Results – PP2 Tls

Parameter	Unit	*MMER	PP2 Tls Decant Day 5		PP 2 Tls Decant Day 61	
Radionuclide Analyses						
^{226}Ra	Bq/L	0.37	< 0.01	---	***	***
^{228}Ra	Bq/L		< 0.4	---	***	***
^{210}Pb	Bq/L		0.1	---	***	***
General Analyses						
pH	units	6.0-9.5	8.41	---	***	***
Alkalinity	mg/L as $CaCO_3$		148	---	***	***
EMF	mV		178	---	***	***
Conductivity	µS/cm		603	---	***	***
TDS	mg/L		354	---	***	***
TSS	mg/L	15.00	2	---	***	***
Cl	mg/L		63	---	***	***
SO_4	mg/L		29	---	***	***
F	mg/L		9.53	---	***	***
TOC	mg/L		17.1	---	***	***
Metals Analyses			**Total**	**Diss**	**Total**	**Diss**
Hg	mg/L		< 0.0001	< 0.0001	***	***
As	mg/L	0.50	0.0047	0.0048	***	***
Ca	mg/L		21.8	22.1	***	***
Cu	mg/L	0.30	0.0007	0.0027	***	***
Fe	mg/L		0.706	0.020	***	***
K	mg/L		37.0	36.8	***	***
Mg	mg/L		12.3	12.3	***	***
Mn	mg/L		0.0317	0.0240	***	***
Na	mg/L		74.5	74.8	***	***
Ni	mg/L	0.50	0.0068	0.0065	***	***
Pb	mg/L	0.20	0.00026	0.00011	***	***
Se	mg/L		< 0.001	< 0.001	***	***
Si	mg/L		8.19	4.70	***	***
Th	mg/L		0.00140	0.000193	***	***
U	mg/L		0.00784	0.00742	***	***
Y	mg/L		0.00436	0.000464	***	***
Zn	mg/L	0.50	0.002	0.003	***	***

**Department of Justice Canada. 2002. Metal Mining Effluent Regulations, Fisheries Act SOR-2002-222.*

9. LC_{50} Acute Lethality Testing of *Daphnia Magna* and Rainbow Trout

Summary results of the LC_{50} acute lethality tests are presented in Table 26. Complete toxicity test reports are provided in Appendix D.

Table 26: LC_{50} Acute Lethality Test Results

Sample Identifier	Unit	LC_{50} Acute Lethality of Effluents to Daphnia Magna 48-h LC_{50}	LC_{50} Acute Lethality of Effluents to Rainbow Trout 96-h LC_{50}
PP1 Tls Decant Day 5	%	> 100%	> 100%

10. Modified Acid Base Accounting and Net Acid Generation Testing

Summary results of the ABA and NAG tests completed on the Nechalacho samples are provided in 27 through 29. Detailed test results are shown in Appendix A.

Table 27: Modified Acid Base Accounting and Net Acid Generation Test Results – Heads

Parameter	Unit	MC3 F25, 28, 29 + 30	Head 1 F33	Head 2 F36	Head 3 F37	PPX Head	PP2 Head
Paste pH	units	9.12	9.54	9.58	9.57	9.59	9.51
Fizz Rate	---	3	3	3	3	3	3
NP[1]	t $CaCO_3$/1000 t	44.2	42.4	67.4	45.1	67.6	47.7
AP	t $CaCO_3$/1000 t	0.31	0.31	0.31	0.31	0.31	0.31
Net NP	t $CaCO_3$/1000 t	43.9	42.1	67.1	44.8	67.3	47.4
NP/AP	ratio	143	137	217	145	218	154
S	%	0.021	0.016	0.023	0.019	< 0.005	< 0.005
SO_4	%	0.02	0.02	0.02	0.02	< 0.01	< 0.01
Sulphide	%	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
C	%	0.690	0.655	0.992	0.713	0.930	0.680
Carbonate	%	1.97	1.98	3.30	2.26	3.21	2.08
CO_3 NP[2]	t $CaCO_3$/1000 t	32.7	32.9	54.8	37.5	53.3	34.5
CO_3 Net NP	t $CaCO_3$/1000 t	32.4	32.6	54.5	37.2	53.0	34.2
CO_3 NP/AP	ratio	105	106	177	121	172	111
Classification	based on ABA NP[1]	PAN	PAN	PAN	PAN	PAN	PAN
Classification	based on CO_3 NP[2]	PAN	PAN	PAN	PAN	PAN	PAN
Final pH	units	10.88	10.65	10.63	10.90	10.76	10.84
NAG@pH4.5	kg H_2SO_4/t	0	0	0	0	0	0
NAG@pH7.0	kg H_2SO_4/t	0	0	0	0	0	0

[1] measured in ABA test
[2] theoretical, based on CO_3 content alone.
Green highlighting indicates Net NP values less than 20.
Orange highlighting indicates NP/AP ratios less than 3.
PAG - Potentially Acid Generating based on interpretation of ABA test data alone.
PAN - Potentially Acid Neutralising based on interpretation of ABA test data alone.
uncertain - acid generation potential is uncertain based on interpretation of ABA test data alone.

Table 28: Modified Acid Base Accounting and Net Acid Generation Test Results – Tailings

Parameter	Unit	F25 Tls	F28 Tls	F29 Tls	F33 Tls	F36 Tls	F37 Tls	Master Tls	PP1 Tls	PP2 Tls
Paste pH	units	9.40	9.40	8.90	9.37	9.38	9.41	9.30	9.32	8.92
Fizz Rate	---	2	2	2	2	2	2	2	1	2
NP[1]	t $CaCO_3$/1000 t	19.2	20.0	22.8	20.3	25.8	21.3	22.4	18.3	16.7
AP	t $CaCO_3$/1000 t	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Net NP	t $CaCO_3$/1000 t	18.9	19.7	22.5	20.0	25.5	21.0	22.1	18.0	16.4
NP/AP	ratio	61.9	64.5	73.5	65.5	83.2	68.7	72.3	59.0	53.9
S	%	0.007	< 0.005	0.006	0.008	0.006	0.006	0.006	0.007	< 0.005
SO_4	%	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sulphide	%	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
C	%	0.344	0.321	0.377	0.312	0.406	0.316	0.405	0.214	0.196
Carbonate	%	0.608	0.599	0.699	0.604	0.903	0.622	0.810	0.515	0.469
CO_3 NP[2]	t $CaCO_3$/1000 t	10.1	9.9	11.6	10.0	15.0	10.3	13.4	8.5	7.8
CO_3 Net NP	t $CaCO_3$/1000 t	9.8	9.6	11.3	9.7	14.7	10.0	13.1	8.2	7.5
CO_3 NP/AP	ratio	32.6	32.1	37.4	32.3	48.4	33.3	43.4	27.577	25.114
Classification	based on ABA NP[1]	uncertain	uncertain	PAN	uncertain	PAN	PAN	PAN	uncertain	uncertain
Classification	based on CO_3 NP[2]	uncertain	uncertain	uncertain	uncertain	uncertain	uncertain	uncertain	uncertain	uncertain
Sample weight	g	1.50	1.49	1.52	1.54	1.53	1.51	1.50	1.49	1.55
Final pH	units	10.39	10.41	10.50	10.39	10.42	10.51	10.40	9.76	10.21
NAG@pH4.5	kg H_2SO_4/t	0	0	0	0	0	0	0	0	0
NAG@pH7.0	kg H_2SO_4/t	0	0	0	0	0	0	0	0	0

[1] measured in ABA test
[2] theoretical, based on CO_3 content alone.
Green highlighting indicates Net NP values less than 20.
Orange highlighting indicates NP/AP ratios less than 3.
PAG - Potentially Acid Generating based on interpretation of ABA test data alone.
PAN - Potentially Acid Neutralising based on interpretation of ABA test data alone.
uncertain - acid generation potential is uncertain based on interpretation of ABA test data alone.

Table 29: Modified Acid Base Accounting and Net Acid Generation Test Results – Concentrates

Parameter	Unit	F33 Conc	F36 Conc	F37 Conc	Master Conc	PP1 Conc
Paste pH	units	9.10	9.21	9.17	9.29	8.96
Fizz Rate	---	3	3	3	3	3
NP[1]	t $CaCO_3$/1000 t	110	172	106	139	188
AP	t $CaCO_3$/1000 t	2.94	1.89	4.05	3.26	2.62
Net NP	t $CaCO_3$/1000 t	107	170	102	136	186
NP/AP	ratio	37.4	91.0	26.2	42.8	71.9
S	%	0.116	0.078	0.135	0.118	0.098
SO_4	%	0.02	0.02	< 0.01	0.01	0.01
Sulphide	%	0.09	0.06	0.13	0.10	0.08
C	%	2.02	2.64	1.93	2.86	3.08
Carbonate	%	5.36	8.50	4.81	7.03	9.59
CO_3 NP[2]	t $CaCO_3$/1000 t	89.0	141	79.8	117	159
CO_3 Net NP	t $CaCO_3$/1000 t	86.0	139	75.8	113	157
CO_3 NP/AP	ratio	30.3	74.7	19.7	35.8	60.8
Classification	based on ABA NP[1]	PAN	PAN	PAN	PAN	PAN
Classification	based on CO_3 NP[2]	PAN	PAN	PAN	PAN	PAN
Final pH	units	10.50	10.34	10.84	10.61	9.40
NAG@pH4.5	kg H_2SO_4/t	0	0	0	0	0
NAG@pH7.0	kg H_2SO_4/t	0	0	0	0	0

[1] measured in ABA test
[2] theoretical, based on CO_3 content alone.
Green highlighting indicates Net NP values less than 20.
Orange highlighting indicates NP/AP ratios less than 3.
PAG - Potentially Acid Generating based on interpretation of ABA test data alone.
PAN - Potentially Acid Neutralising based on interpretation of ABA test data alone.

11. Humidity Cell Testing – ASTM D 544-96 (2001)

Results of pH, conductivity, acidity, alkalinity and sulphate analyses, and sulphate production, NP consumption and cumulative depletion rates calculated for the *F33 Tls, F36 Tls, F37 Tls, Master Tls, PP 1 Tls, PP2 Tls, Master Conc* and *PP1 Conc* humidity cell test leachates are summarised in Tables 30, 32, 34, 36, 38, 40, 42 and 44, respectively . Summary results of the dissolved metal concentrations in the *F33 Tls, F36 Tls, F37 Tls, Master Tls, PP 1 Tls, PP2 Tls, Master Conc* and *PP1 Conc* leachates, as compared to the Canadian Metal Mining Effluent Regulation (MMER) limits, are presented in Tables 31, 33, 35, 37, 39, 41, 43 and 45, respectively. Complete humidity cell test reports are provided in Appendix E. Humidity cell certificates of analysis are included in Appendix F.

Table 30: Humidity Cell Test – Weekly Leachate Results and Cumulative Depletion Rates – F33 TIs

Week	pH	Acidity	Alkalinity	Conductivity	SO_4	SO_4 Prod Rate	Cum $S^=$ Depl	NP Consumption	Cum NP Depl	Cum CO_3 NP Depl
No.	units	$CaCO_3$ eq. mg/L	$CaCO_3$ eq.mg/L	µS/cm	mg/L	g/t/wk	%	$CaCO_3$, g/t/wk	%	%
0	7.37	<2	15	41	2.0	1.7	0.72	1.80	0.01	0.02
1	7.51	<2	16	45	2.9	2.6	1.80	2.69	0.02	0.04
2	7.51	<2	13	41	2.8	2.6	2.89	2.74	0.04	0.07
3	7.52	<2	12	33	1.6	1.4	3.47	1.45	0.04	0.09
4	7.68	<2	16	44	2.6	2.3	4.45	2.44	0.05	0.11
5	7.62	<2	26	54	1.7	1.4	5.02	1.42	0.06	0.13
6	8.21	<2	91	276	17	14.7	11.16	15.35	0.14	0.28
7	7.96	<2	73	155	0.8	0.7	11.44	0.72	0.14	0.29

Table 31: Humidity Cell Test – Dissolved Metals Concentrations – F33 TIs

Parameter	Units	*MMER	0	1	2	3	4	5	6	7
^{226}Ra	Bq/L	0.37	< 0.01	---	---	---	---	< 0.01	---	---
^{228}Ra	Bq/L		0.4	---	---	---	---	< 0.4	---	---
^{210}Pb	Bq/L		< 0.1	---	---	---	---	0.2	---	---
pH	units	6.0-9.5	7.37	7.51	7.51	7.52	7.68	7.62	8.21	7.96
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	---	---
As	mg/L	0.50	0.0006	0.0005	0.0006	0.0007	0.0008	0.0006	---	---
Ca	mg/L		3.34	3.92	3.49	3.51	3.68	4.83	---	---
Cu	mg/L	0.30	0.0005	0.0007	0.0012	< 0.0005	< 0.0005	0.0006	---	---
Fe	mg/L		0.016	0.007	0.004	0.006	0.009	0.027	---	---
K	mg/L		1.50	1.94	1.85	1.45	1.65	1.29	---	---
Mg	mg/L		0.490	0.818	0.720	0.481	0.587	0.584	---	---
Na	mg/L		2.20	3.19	2.88	1.78	2.30	1.86	---	---
Ni	mg/L	0.50	0.0008	0.0010	0.0012	0.0004	0.0005	0.0004	---	---
Pb	mg/L	0.20	0.00005	< 0.00002	< 0.00002	0.00002	< 0.00002	0.00032	---	---
Se	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	---	---
Th	mg/L		0.000128	0.000005	< 0.000004	0.000026	0.000012	0.000035	---	---
U	mg/L		0.00168	0.00262	0.00221	0.000958	0.00132	0.000869	---	---
Zn	mg/L	0.50	0.003	< 0.001	0.001	< 0.001	< 0.001	< 0.001	---	---

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Table 32: Humidity Cell Test – Weekly Leachate Results and Cumulative Depletion Rates – F36 Tls

Week	pH	Acidity	Alkalinity	Conductivity	SO_4	SO_4 Prod Rate	Cum $S^=$ Depl	NP Consumption	Cum NP Depl	Cum CO_3 NP Depl
No.	units	$CaCO_3$ eq. mg/L	$CaCO_3$ eq. mg/L	µS/cm	mg/L	g/t/wk	%	$CaCO_3$, g/t/wk	%	%
0	7.47	<2	21	55	2.4	2.1	0.70	2.20	0.01	0.01
1	7.82	<2	40	94	4.9	4.8	2.29	4.96	0.03	0.05
2	7.99	<2	37	94	4.9	4.8	3.88	4.97	0.05	0.08
3	7.56	2	13	39	2.0	1.9	4.51	1.97	0.05	0.09
4	7.40	<2	14	40	2.4	2.2	5.26	2.33	0.06	0.11
5	6.94	<2	9	26	1.3	1.2	5.65	1.23	0.07	0.12
6	6.91	<2	7	20	1.1	1.0	5.99	1.05	0.07	0.12
7	7.33	< 2	13	39	2.5	2.3	6.77	2.44	0.08	0.14

Table 33: Humidity Cell Test – Dissolved Metals Concentrations – F36 Tls

Parameter	Units	*MMER	0	1	2	3	4	5	6	7
^{226}Ra	Bq/L	0.37	< 0.01	---	---	---	---	0.04	---	---
^{228}Ra	Bq/L		< 0.7	---	---	---	---	0.3	---	---
^{210}Pb	Bq/L		< 0.1	---	---	---	---	< 0.1	---	---
pH	units	6.0-9.5	7.47	7.82	7.99	7.56	7.40	6.94	6.91	7.33
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	---	---
As	mg/L	0.50	0.0006	0.0006	0.0009	0.0005	0.0005	0.0003	---	---
Ca	mg/L		4.45	9.32	9.78	3.18	3.72	2.21	---	---
Cu	mg/L	0.30	0.0007	0.0010	0.0011	< 0.0005	< 0.0005	< 0.0005	---	---
Fe	mg/L		0.010	0.007	0.007	< 0.002	0.003	0.008	---	---
K	mg/L		2.06	3.45	3.81	1.80	1.99	1.09	---	---
Mg	mg/L		0.787	1.81	1.86	0.644	0.743	0.413	---	---
Na	mg/L		3.07	5.48	5.60	2.21	2.60	1.41	---	---
Ni	mg/L	0.50	0.0010	0.0020	0.0019	0.0006	0.0007	0.0004	---	---
Pb	mg/L	0.20	0.00003	< 0.00002	< 0.00002	0.00002	< 0.00002	0.00027	---	---
Se	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	---	---
Th	mg/L		0.000109	0.000004	< 0.000004	0.000012	< 0.000004	0.000013	---	---
U	mg/L		0.00272	0.00652	0.00626	0.00197	0.00217	0.000864	---	---
Zn	mg/L	0.50	< 0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	---	---

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Table 34: Humidity Cell Test – Weekly Leachate Results and Cumulative Depletion Rates – F37 Tls

Week No.	pH units	Acidity $CaCO_3$ eq. mg/L	Alkalinity $CaCO_3$ eq. mg/L	Conductivity µS/cm	SO_4 mg/L	SO_4 Prod Rate g/t/wk	Cumulative $S^=$ %	NP Consumption $CaCO_3$, g/t/wk	Cum NP Depl %	Cum CO_3 NP Depl %
0	7.80	<2	28	69	2.7	2.3	0.75	2.36	0.01	0.02
1	7.68	<2	24	59	3.2	3.1	1.80	3.27	0.03	0.05
2	7.60	<2	15	44	2.4	2.4	2.59	2.46	0.04	0.08
3	7.54	<2	12	37	2.1	2.0	3.24	2.03	0.05	0.10
4	7.35	<2	11	35	2.0	1.9	3.87	1.98	0.06	0.12
5	7.19	<2	12	32	1.3	1.2	4.26	1.22	0.06	0.13
6	7.13	<2	8	25	1.3	1.2	4.68	1.29	0.07	0.14
7	7.30	<2	11	32	2.0	1.9	5.30	1.93	0.08	0.16

Table 35: Humidity Cell Test – Dissolved Metals Concentrations – F37 Tls

Parameter	Units	*MMER	0	1	2	3	4	5	6	7
^{226}Ra	Bq/L	0.37	< 0.01	---	---	---	---	0.03	---	---
^{228}Ra	Bq/L		< 0.5	---	---	---	---	< 0.2	---	---
^{210}Pb	Bq/L		< 0.1	---	---	---	---	0.1	---	---
pH	units	6.0-9.5	7.80	7.68	7.60	7.54	7.35	7.19	7.13	7.30
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	---	---
As	mg/L	0.50	0.0009	0.0007	0.0005	0.0005	0.0004	0.0003	---	---
Ca	mg/L		18.5	5.49	4.18	3.03	3.30	3.40	---	---
Cu	mg/L	0.30	0.0010	0.0009	0.0007	0.0006	< 0.0005	< 0.0005	---	---
Fe	mg/L		< 0.002	0.009	0.004	< 0.002	< 0.002	0.010	---	---
K	mg/L		4.69	2.34	1.88	1.56	1.48	1.03	---	---
Mg	mg/L		5.30	0.928	0.699	0.496	0.524	0.419	---	---
Na	mg/L		16.9	3.95	2.90	2.21	2.14	1.58	---	---
Ni	mg/L	0.50	0.0010	0.0009	0.0007	0.0005	0.0005	0.0003	---	---
Pb	mg/L	0.20	0.00004	< 0.00002	0.00003	< 0.00002	< 0.00002	0.00061	---	---
Se	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	---	---
Th	mg/L		0.000092	< 0.000004	< 0.000004	0.000011	< 0.000004	0.000013	---	---
U	mg/L		0.00369	0.00386	0.00235	0.00149	0.00143	0.000769	---	---
Zn	mg/L	0.50	0.001	< 0.001	0.002	0.002	< 0.001	< 0.001	---	---

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Table 36: Humidity Cell Test – Weekly Leachate Results and Cumulative Depletion Rates – Master Tls

Week	pH	Acidity	Alkalinity	Conductivity	SO_4	SO_4 Prod Rate	Cum $S^=$ Depl	NP Consumption	Cum NP Depl	Cum CO_3 NP Depl
No.	units	$CaCO_3$ eq. mg/L	$CaCO_3$ eq. mg/L	µS/cm	mg/L	g/t/wk	%	$CaCO_3$, g/t/wk	%	%
0	7.67	<2	29	75	3.0	2.5	0.83	2.59	0.01	0.02
1	7.53	<2	25	65	3.0	2.7	1.73	2.80	0.02	0.04
2	8.15	<2	62	153	9.2	8.4	4.52	8.72	0.06	0.11
3	7.49	<2	12	33	1.0	0.9	4.83	0.98	0.07	0.11
4	7.16	<2	9	22	0.7	0.6	5.04	0.66	0.07	0.12
5	6.87	<2	7	18	0.5	0.4	5.19	0.45	0.07	0.12
6	6.84	<2	6	15	0.6	0.5	5.36	0.55	0.07	0.13
7	7.11	<2	8	22	0.9	0.8	5.63	0.83	0.08	0.13

Table 37: Humidity Cell Test – Dissolved Metals Concentrations – Master Tls

Parameter	Units	*MMER	0	1	2	3	4	5	6	7
^{226}Ra	Bq/L	0.37	< 0.01	---	---	---	---	< 0.01	---	---
^{228}Ra	Bq/L		0.5	---	---	---	---	< 0.1	---	---
^{210}Pb	Bq/L		< 0.1	---	---	---	---	0.1	---	---
pH	units	6.0-9.5	7.67	7.53	8.15	7.49	7.16	6.87	6.84	7.11
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	---	---
As	mg/L	0.50	0.0005	0.0003	0.0009	< 0.0002	< 0.0002	< 0.0002	---	---
Ca	mg/L		6.83	6.81	21.4	4.10	2.80	2.01	---	---
Cu	mg/L	0.30	0.0009	0.0007	0.0027	< 0.0005	< 0.0005	< 0.0005	---	---
Fe	mg/L		0.004	0.004	0.005	< 0.002	0.007	0.009	---	---
K	mg/L		1.61	1.20	2.84	0.607	0.466	0.310	---	---
Mg	mg/L		1.24	1.05	3.16	0.483	0.362	0.248	---	---
Na	mg/L		4.42	3.41	9.19	1.22	0.89	0.64	---	---
Ni	mg/L	0.50	0.0011	0.0010	0.0040	0.0007	0.0004	0.0002	---	---
Pb	mg/L	0.20	0.00005	< 0.00002	0.00004	< 0.00002	< 0.00002	0.00037	---	---
Se	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	---	---
Th	mg/L		0.000172	< 0.000004	< 0.000004	0.000024	< 0.000004	0.000008	---	---
U	mg/L		0.00474	0.00426	0.0116	0.00129	0.000815	0.000903	---	---
Zn	mg/L	0.50	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001	---	---

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Table 38: Humidity Cell Test – Weekly Leachate Results and Cumulative Depletion Rates – PP1 Tls

Week	pH	Acidity	Alkalinity	Conductivity	SO_4	SO_4 Prod Rate	Cum $S^=$ Depl	NP Consumption	Cum NP Depl	Cum CO_3 NP Depl
No.	units	$CaCO_3$ eq. mg/L	$CaCO_3$ eq. mg/L	µS/cm	mg/L	g/t/wk	%	$CaCO_3$, g/t/wk	%	%
0	7.72	<2	27	95	11	9.1	3.02	9.43	0.05	0.11
1	7.79	<2	25	79	11	10.8	6.60	11.21	0.11	0.24
2	7.63	<2	15	55	6.5	6.3	8.72	6.60	0.15	0.32
3	7.56	<2	13	44	5.0	4.8	10.32	5.01	0.18	0.38
4	7.19	<2	10	36	4.5	4.3	11.75	4.47	0.20	0.43
5	6.94	<2	8	30	3.6	3.3	12.84	3.42	0.22	0.47
6	6.89	<2	7	26	3.1	3.0	13.84	3.10	0.24	0.51
7	7.19	<2	9	31	4.1	3.8	15.11	3.99	0.26	0.56

Table 39: Humidity Cell Test – Dissolved Metals Concentrations – PP1 Tls

Parameter	Units	*MMER	0	1	2	3	4	5	6	7
^{226}Ra	Bq/L	0.37	0.01	---	---	---	---	0.07	---	---
^{228}Ra	Bq/L		< 0.6	---	---	---	---	< 0.1	---	---
^{210}Pb	Bq/L		< 0.1	---	---	---	---	0.1	---	---
pH	units	6.0-9.5	7.72	7.79	7.63	7.56	7.19	6.94	6.89	7.19
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	---	---
As	mg/L	0.50	0.0005	0.0003	0.0004	< 0.0002	< 0.0002	< 0.0002	---	---
Ca	mg/L		6.85	7.61	5.47	4.05	3.30	2.92	---	---
Cu	mg/L	0.30	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	---	---
Fe	mg/L		0.038	0.037	0.016	0.010	0.004	0.017	---	---
K	mg/L		4.22	3.71	2.30	2.18	1.86	1.49	---	---
Mg	mg/L		1.17	1.31	0.840	0.627	0.553	0.469	---	---
Na	mg/L		5.35	5.55	3.16	2.25	1.98	1.72	---	---
Ni	mg/L	0.50	0.0008	0.0005	0.0004	0.0003	0.0002	0.0002	---	---
Pb	mg/L	0.20	0.00009	0.00002	< 0.00002	< 0.00002	< 0.00002	0.00061	---	---
Se	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	---	---
Th	mg/L		0.000088	0.000017	< 0.000004	0.000025	< 0.000004	0.000013	---	---
U	mg/L		0.00215	0.00208	0.00121	0.000901	0.000669	0.000592	---	---
Zn	mg/L	0.50	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	---	---

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Table 40: Humidity Cell Test – Weekly Leachate Results and Cumulative Depletion Rates – PP2 Tls

Week	pH	Acidity	Alkalinity	Conductivity	SO_4	SO_4 Prod Rate	Cum $S^=$ Depl	NP Consumption	Cum NP Depl	Cum CO_3 NP Depl
No.	units	$CaCO_3$ eq. mg/L	$CaCO_3$ eq. mg/L	µmhos/cm	mg/L	g/t/wk	%	$CaCO_3$, g/t/wk	%	%
0	7.69	<2	34	85	2.5	2.1	0.71	2.23	0.01	0.03
1	7.88	<2	25	65	2.4	2.4	1.50	2.46	0.03	0.06
2	7.93	<2	36	103	5.4	5.3	3.26	5.51	0.06	0.13

Table 41: Humidity Cell Test – Dissolved Metals Concentrations – PP2 Tls

Parameter	Units	*MMER	0	1	2
^{226}Ra	Bq/L	0.37	< 0.01	---	---
^{228}Ra	Bq/L		< 0.1	---	---
^{210}Pb	Bq/L		0.1	---	---
pH	units	6.0-9.5	7.69	7.20	7.93
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001
As	mg/L	0.50	0.0004	0.0005	0.0009
Ca	mg/L		4.38	3.95	5.15
Cu	mg/L	0.30	0.0012	< 0.0005	< 0.0005
Fe	mg/L		0.055	0.040	0.021
K	mg/L		5.92	4.42	8.19
Mg	mg/L		1.03	1.10	1.80
Na	mg/L		5.66	4.82	8.82
Ni	mg/L	0.50	0.0008	0.0004	0.0062
Pb	mg/L	0.20	0.00057	0.00003	0.00003
Se	mg/L		< 0.001	< 0.001	< 0.001
Th	mg/L		0.000079	0.000066	0.000008
U	mg/L		0.000852	0.000875	0.00155
Zn	mg/L	0.50	0.006	< 0.001	< 0.001

**Department of Justice Canada. 2002. Metal Mining Effluent Regulations, Fisheries Act SOR-2002-222.*

Table 42: Humidity Cell Test – Weekly Leachate Results and Cumulative Depletion Rates – Master Conc

Week	**pH**	**Acidity**	**Alkalinity**	**Conductivity**	**SO_4**	**SO_4 Prod Rate**	**Cum $S^=$ Depl**	**NP Consumption**	**Cum NP Depl**	**Cum CO_3 NP Depl**
No.	units	$CaCO_3$ eq. mg/L	$CaCO_3$ eq. mg/L	µS/cm	mg/L	g/t/wk	%	$CaCO_3$, g/t/wk	%	%
0	7.22	<2	11	33	2.0	1.8	0.06	1.83	0.00	0.00
1	7.64	<2	21	55	1.9	1.8	0.12	1.89	0.00	0.00
2	7.56	<2	13	47	2.5	2.1	0.19	2.22	0.00	0.01
3	7.44	<2	12	39	1.6	1.4	0.24	1.48	0.01	0.01
4	7.69	<2	27	50	2.7	2.6	0.32	2.73	0.01	0.01
5	7.86	<2	59	160	11	9.1	0.63	9.45	0.01	0.02
6	7.84	<2	51	111	1.5	1.3	0.67	1.31	0.02	0.02
7	8.05	<2	58	112	1.7	1.4	0.72	1.48	0.02	0.02

Table 43: Humidity Cell Test – Dissolved Metals Concentrations – Master Conc

Parameter	**Units**	***MMER**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
^{226}Ra	Bq/L	0.37	0.05	---	---	---	---	0.11	---	---
^{228}Ra	Bq/L		< 0.5	---	---	---	---	< 0.2	---	---
^{210}Pb	Bq/L		< 0.1	---	---	---	---	0.2	---	---
pH	units	6.0-9.5	7.22	7.64	7.56	7.44	7.69	7.86	7.84	8.05
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	---	---
As	mg/L	0.50	0.0002	0.0002	0.0005	0.0004	0.0005	0.0059	---	---
Ca	mg/L		3.01	2.82	3.41	2.97	5.04	22.1	---	---
Cu	mg/L	0.30	0.0006	< 0.0005	< 0.0005	0.0007	0.0006	0.0030	---	---
Fe	mg/L		0.007	0.008	0.010	0.005	0.003	0.046	---	---
K	mg/L		0.255	0.210	0.199	0.162	0.306	1.28	---	---
Mg	mg/L		0.233	0.263	0.298	0.224	0.443	2.23	---	---
Na	mg/L		2.15	2.04	2.18	1.56	2.78	18.4	---	---
Ni	mg/L	0.50	0.0002	0.0002	0.0002	0.0005	0.0002	0.0008	---	---
Pb	mg/L	0.20	0.00009	0.00003	0.00004	0.00006	< 0.00002	0.00046	---	---
Se	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	---	---
Th	mg/L		0.000222	< 0.000004	< 0.000004	0.000033	0.000010	0.000067	---	---
U	mg/L		0.00226	0.00248	0.00331	0.00232	0.00476	0.01860	---	---
Zn	mg/L	0.50	< 0.001	< 0.001	< 0.001	0.002	0.002	0.001	---	---

**Department of Justice Canada. 2002. Metal Mining Effluent Regulations, Fisheries Act SOR-2002-222.*

Table 44: Humidity Cell Test – Weekly Leachate Results and Cumulative Depletion Rates – PP1 Conc

Week	**pH**	**Acidity**	**Alkalinity**	**Conductivity**	**SO_4**	**SO_4 Prod Rate**	**Cum $S^=$ Depl**	**NP Consumption**	**Cum NP Depl**	**Cum CO_3 NP Depl**
No.	units	$CaCO_3$ eq. mg/L	$CaCO_3$ eq. mg/L	µS/cm	mg/L	g/t/wk	%	$CaCO_3$, g/t/wk	%	%
0	8.01	<2	80	264	22	19.1	0.80	19.91	0.01	0.01
1	8.11	<2	58	126	1.9	1.8	0.87	1.85	0.01	0.01
2	8.13	<2	44	96	1.8	1.7	0.94	1.76	0.01	0.01
3	8.13	<2	46	97	1.7	1.6	1.01	1.71	0.01	0.02
4	8.01	<2	42	91	2.0	2.0	1.09	2.07	0.01	0.02
5	7.77	<2	44	96	2.2	2.0	1.18	2.10	0.02	0.02
6	7.26	<2	13	30	0.5	0.5	1.20	0.48	0.02	0.02
7	7.33	<2	12	26	0.4	0.4	1.21	0.40	0.02	0.02

Table 45: Humidity Cell Test – Dissolved Metals Concentrations – PP1 Conc

Parameter	**Units**	***MMER**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
^{226}Ra	Bq/L	0.37	< 0.01	---	---	---	---	< 0.01	---	---
^{228}Ra	Bq/L		< 0.3	---	---	---	---	0.4	---	---
^{210}Pb	Bq/L		< 0.1	---	---	---	---	< 0.1	---	---
pH	units	6.0-9.5	8.01	8.11	8.13	8.13	8.01	7.77	7.26	7.33
Hg	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	---	---
As	mg/L	0.50	0.0033	0.0028	0.0027	0.0026	0.0022	0.0021	---	---
Ca	mg/L		5.43	11.1	12.5	12.1	12.0	16.3	---	---
Cu	mg/L	0.30	0.0019	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	---	---
Fe	mg/L		0.011	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	---	---
K	mg/L		2.56	2.32	2.50	2.44	2.32	2.47	---	---
Mg	mg/L		0.968	2.38	2.42	2.05	1.87	2.41	---	---
Na	mg/L		4.05	4.02	2.45	1.54	1.14	1.13	---	---
Ni	mg/L	0.50	0.0095	0.0034	0.0026	0.0018	0.0015	0.0017	---	---
Pb	mg/L	0.20	0.00006	< 0.00002	< 0.00002	0.00003	< 0.00002	0.00012	---	---
Se	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	---	---
Th	mg/L		0.000088	< 0.000004	< 0.000004	0.000008	< 0.000004	0.000005	---	---
U	mg/L		0.0147	0.00599	0.00505	0.00460	0.00447	0.00454	---	---
Zn	mg/L	0.50	0.003	0.002	< 0.001	0.001	< 0.001	< 0.001	---	---

**Department of Justice Canada. 2002. Metal Mining Effluent Regulations, Fisheries Act SOR-2002-222.*

12. Particle Size Distribution Analyses (ASTM D 422-63 (2007)) and Malvern Laser

Specific gravity results for the Nechalacho samples are provided in Table 46. Summary results of the PSD (sieve and hydrometer analyses) completed on the samples are presented in Tables 47 through 50. Results of the Malvern PSD analyses are shown in Table 51. Complete PSD test reports are shown in Appendix G.

Table 46: Specific Gravity Determinations

Sample Identifier (Heads)	Specific Gravity	Sample Identifier (Tails)	Specific Gravity	Sample Identifier (Concentrates)	Specific Gravity
MC3 (F25, 28, 29 + 30)	2.92	F25 Tls	2.81	Master Conc	3.67
Head 1 (F33)	2.89	F28 Tls	2.76	F33 Conc	3.54
Head 2 (F36)	2.96	F29 Tls	2.82	F36 Conc	3.49
Head 3 (F37)	2.93	F33 Tls	2.82	F37 Conc	3.53
PPX Head	2.97	F36 Tls	2.86	PP1 Conc	3.47
PP2 Head	2.91	F37 Tls	2.86	---	---
---	---	Master Tls	2.83	---	---
---	---	PP1 Tls	2.84	---	---
---	---	PP2 Tls	2.82	---	---

Table 47: Particle Size Distribution Results (ASTM D 422-63 (2007)) – Heads

MC3 F25, 28, 29 +30		**Head 1** F33		**Head 2** F36		**Head 3** F37		**PPX Head**		**PP2 Head**	
Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %
4.750	100.0	4.750	100.0	4.750	100.0	4.750	100.0	4.750	99.9	4.750	100.0
2.000	74.1	2.000	61.5	2.000	68.2	2.000	66.7	2.000	63.6	2.000	70.5
0.850	43.6	0.850	32.2	0.850	41.1	0.850	37.6	0.850	32.9	0.850	37.8
0.425	30.9	0.425	23.1	0.425	29.0	0.425	26.8	0.425	24.8	0.425	29.3
0.212	23.2	0.212	17.9	0.212	21.3	0.212	20.5	0.212	17.1	0.212	21.0
0.150	19.1	0.150	15.2	0.150	18.4	0.150	17.2	0.150	15.2	0.150	18.8
0.075	16.4	0.075	13.4	0.075	15.2	0.075	13.8	0.075	12.1	0.075	15.2
0.045	13.8	0.046	9.9	0.045	8.0	0.045	11.6	0.044	11.8	0.045	13.4
0.032	11.3	0.033	8.9	0.032	6.3	0.032	9.9	0.032	9.6	0.032	11.6
0.023	10.0	0.023	8.3	0.023	5.7	0.023	9.4	0.023	9.1	0.023	10.5
0.016	8.8	0.016	7.3	0.016	5.7	0.016	7.7	0.016	8.6	0.016	9.3
0.012	8.8	0.012	5.7	0.012	5.1	0.012	6.6	0.012	7.0	0.012	8.1
0.008	7.5	0.009	5.2	0.008	4.5	0.008	6.6	0.008	6.4	0.008	7.0
0.006	6.3	0.006	4.7	0.006	3.4	0.006	5.5	0.006	5.4	0.006	5.8
0.004	5.0	0.004	4.2	0.004	2.3	0.004	5.0	0.004	5.4	0.004	4.7
0.001	2.5	0.001	2.6	0.001	1.1	0.001	2.2	0.001	3.2	0.001	3.5

Table 48: Particle Size Distribution Results (ASTM D 422-63 (2007)) – Tailings

F25 Tls		F28 Tls		F29 Tls		F33 Tls	
Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %
4.750	100.0	4.750	100.0	4.750	100.0	4.750	100.0
2.000	100.0	2.000	100.0	2.000	100.0	2.000	100.0
0.850	100.0	0.850	100.0	0.850	100.0	0.850	100.0
0.425	100.0	0.425	99.9	0.425	100.0	0.425	99.9
0.212	99.9	0.212	99.8	0.212	99.9	0.212	99.9
0.150	99.9	0.150	99.7	0.150	99.9	0.150	99.8
0.075	98.8	0.075	97.2	0.075	97.9	0.075	98.5
0.038	62.2	0.038	67.8	0.043	39.0	0.038	66.7
0.029	49.8	0.029	53.1	0.031	32.5	0.029	52.8
0.021	42.6	0.022	41.2	0.023	26.0	0.021	44.5
0.016	32.9	0.016	33.0	0.016	22.3	0.015	36.1
0.012	25.8	0.012	26.6	0.012	18.6	0.011	29.6
0.008	19.5	0.008	21.1	0.008	16.7	0.008	23.2
0.006	16.0	0.006	16.5	0.006	13.0	0.006	17.6
0.004	11.5	0.004	12.8	0.004	11.1	0.004	13.0
0.001	3.6	0.001	5.5	0.001	4.6	0.001	5.6

Table 49: Particle Size Distribution Results (ASTM D 422-63 (2007)) – Tailings

F36 Tls		F37 Tls		Master Tls		PP1 Tls		PP2 Tls	
Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %
4.750	100.0	4.750	100.0	4.750	100.0	4.750	100.0	4.750	100.0
2.000	100.0	2.000	100.0	2.000	100.0	2.000	100.0	2.000	100.0
0.850	100.0	0.850	100.0	0.850	100.0	0.850	100.0	0.850	100.0
0.425	100.0	0.425	100.0	0.425	100.0	0.425	100.0	0.425	100.0
0.212	100.0	0.212	100.0	0.212	100.0	0.212	100.0	0.212	100.0
0.150	100.0	0.150	100.0	0.150	99.8	0.150	100.0	0.150	100.0
0.075	98.1	0.075	98.3	0.075	98.2	0.075	99.1	0.075	99.4
0.039	59.6	0.037	64.7	0.039	61.9	0.040	60.7	0.039	56.9
0.029	46.0	0.028	50.4	0.029	49.2	0.029	50.0	0.029	46.5
0.021	37.0	0.021	41.4	0.021	40.1	0.021	43.8	0.021	39.6
0.016	29.8	0.015	32.4	0.016	32.8	0.015	37.5	0.016	32.8
0.012	23.5	0.011	27.0	0.012	27.3	0.012	32.1	0.012	27.6
0.008	19.0	0.008	21.6	0.008	21.9	0.008	26.8	0.008	24.1
0.006	15.3	0.006	16.2	0.006	16.4	0.006	22.3	0.006	19.0
0.004	11.7	0.004	12.6	0.004	12.7	0.004	17.9	0.004	16.4
0.001	3.6	0.001	5.4	0.001	4.6	0.001	7.1	0.001	6.9

Table 50: Particle Size Distribution Results (ASTM D 422-63 (2007)) – Concentrates

Master Conc		F33 Conc		F36 Conc		F37 Conc		PP1 Conc	
Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %	Particle Size (mm)	Weight Passing %
4.750	100.0	4.750	100.0	4.750	100.0	4.750	100.0	4.750	100.0
2.000	100.0	2.000	100.0	2.000	100.0	2.000	100.0	2.000	100.0
0.850	100.0	0.850	100.0	0.850	100.0	0.850	100.0	0.850	100.0
0.425	100.0	0.425	100.0	0.425	100.0	0.425	100.0	0.425	100.0
0.212	100.0	0.212	100.0	0.212	100.0	0.212	100.0	0.212	100.0
0.150	100.0	0.150	99.9	0.150	99.9	0.150	100.0	0.150	100.0
0.075	99.3	0.075	99.0	0.075	99.0	0.075	99.6	0.075	99.3
0.032	48.7	0.033	50.7	0.033	56.2	0.032	58.4	0.033	51.5
0.025	34.1	0.025	36.0	0.025	40.1	0.024	42.6	0.026	35.4
0.018	22.7	0.019	24.5	0.019	28.9	0.018	31.5	0.019	27.3
0.013	13.0	0.014	14.7	0.014	17.6	0.014	18.9	0.014	16.1
0.010	5.7	0.010	8.2	0.010	9.6	0.010	10.3	0.010	10.5
0.007	2.4	0.007	3.3	0.007	4.8	0.007	5.5	0.007	5.6
0.005	1.6	0.005	1.6	0.005	3.2	0.005	3.2	0.005	3.2
0.004	0.8	0.004	0.8	0.004	1.6	0.004	1.6	0.004	2.4
0.001	0.8	0.001	0.8	0.001	1.6	0.001	1.6	0.001	1.6

Table 51: Malvern Particle Size Distribution Results – Red Water

Size µm	Volume Under %	Size µm	Volume Under %	Size µm	Volume Under %
0.138	1.19	0.832	50.93	5.012	95.79
0.158	5.44	0.955	54.12	5.754	96.30
0.182	11.83	1.096	57.63	6.607	96.71
0.209	18.95	1.259	61.75	7.586	97.11
0.240	25.35	1.445	66.51	8.710	97.55
0.275	30.09	1.660	71.65	10.000	98.02
0.316	33.05	1.905	76.82	11.482	98.51
0.363	34.89	2.188	81.67	13.183	98.98
0.417	36.52	2.512	85.91	15.136	99.38
0.479	38.56	2.884	89.35	17.378	99.71
0.550	41.25	3.311	91.96	19.953	99.89
0.631	44.37	3.802	93.80	22.909	99.97
0.724	47.70	4.365	95.02	26.303	100.00

13. Atterberg Limits (ASTM D 4318-05)

Results of the Atterberg limit tests completed on the *Master Tls, PP1 Tls* and *PP2 Tls* samples are summarised in Table 52. Test reports are included in Appendix F.

Table 52: Atterberg Limit Test Results

Parameter	Master Tls	PP1 Tls	PP2 Tls
Liquid Limit (LL)	24	22	21
Plastic Limit (PL)	*NP	NP	*NP
Plasticity Index (PI)	*NP	NP	*NP

**NP= Not plastic*

14. Standard and Drained Settling Tests (Pending)

Summary results of the standard and drained settling tests completed on the XPS PP samples *(PP1 Tls* and *PP2 Tls*) are shown in Table 53. Complete test reports are provided in Appendix F.

Table 53: Standard and Drained Settling Test Results (Pending)

Parameter	Unit	Standard Settling Test PP1 Tls	Drained Settling Test PP1 Tls	Standard Settling Test PP2 Tls	Drained Settling Test PP2 Tls
Dry solid SG		***	***	***	***
Feed pulp density	g/L	***	***	***	***
Feed percent solids	%	***	***	***	***
Total settling time	min	***	***	***	***
Final mudline	mL	***	***	***	***
Final percent solids	%	***	***	***	***
Final settled density	g/L	***	***	***	***

15. Standard Proctor (ASTM D 698-07e1) – Pending

Table 54 shows summary results of the standard Proctor tests completed on the XPS PP samples *(PP1 Tls* and *PP2 Tls*). Complete test reports are provided in Appendix F.

Table 54: Standard Proctor Test Results (Pendng)

Parameter	Unit	PP1 Tls	PP2 Tls
Max. Wet Density	g/cm^3	***	***
Max. Dry Density	g/cm^3	***	***
Optimum Moisture Content	%	***	***

16. Hydraulic Conductivity Testing (Pending)

Summary results of the hydraulic conductivity tests completed on the compacted tailings solids (*Master Tl, PP1 Tls* and *PP2 Tls*) are provided in Table 55. Complete test reports are included in Appendix F.

Table 55: Hydraulic Conductivity Test Results (Pending)

Discussion

Results of the modal analyses completed during the mineralogical examination (QEMSCAN®) determined that the Thor Lake head samples tested (*Head 1, Head 2, Head 3, PPX Head* and *PP2 Head*) were comprised primarily of gangue minerals including plagioclase, biotite, quartz, K-feldspar, Fe-oxides and muscovites/clays. Minor amounts of zircon (7.1 to 9.0%) and trace levels (≤2%) of rare earth element (REE) minerals including columbite (Fe), fergusonite, bastnaesite, synchysite, allanite and monazite were also evident in the head samples. Minor to moderate concentrations of neutralising carbonates (2.5 to 7.2%) were observed. Ankerite was the dominant carbonate mineral, typically followed by calcite and dolomite. Only trace levels of sulphide minerals (≤0.1%) were reported in the head samples.

As expected, modal analyses of the Thor Lake tailings samples (*F25 Tls, F28 Tls, F29 Tls, F30 Tls, F33 Tls, F36, Tls, F37 Tls, PP1 Tls* and *PP2 Tls*) reported increased amounts of gangue minerals (plagioclase, biotite, quartz, K-feldspar and muscovites/clays) and lesser levels of zircon (1.8 to 4.2%) and REE (<0.5%) minerals than the head samples from which they were derived. Only trace levels of carbonate (0.9 to 1.6%) and sulphide (≤0.1%) minerals were observed in the tailings samples.

The concentrate samples (*F25 Conc, F33 Conc, F36 Conc, F37 Conc* and *PP1 Conc*) typically reported considerably lesser levels of gangue minerals (plagioclase, biotite, quartz, K-feldspar, Fe-oxides and muscovites/clays) than the ore samples. Major amounts of zircon (30 to 39%) and significantly increased levels of REE minerals (1.2 to 5.3%) were evident in the concentrates. Increased levels of carbonate minerals (10 to 18%) were also observed in the concentrates. Again only trace levels of sulphide minerals (0.2 to 0.5%) were reported. Results of the modal analyses are illustrated graphically in Figure1 below.

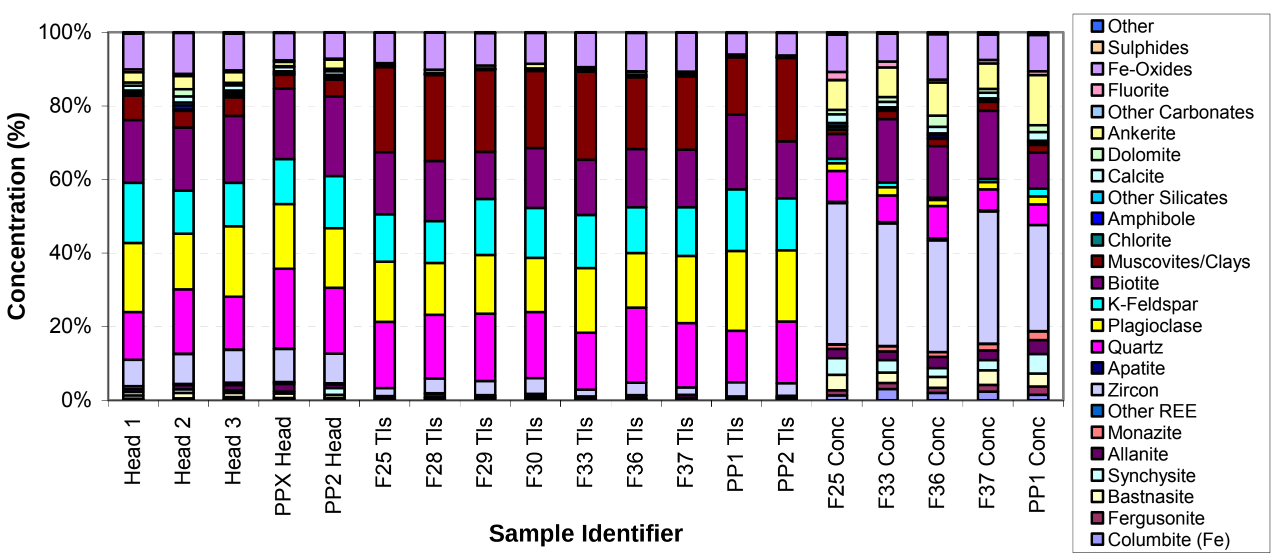


Figure 1: Modal Abundance Results

Because the *Ro Tls Decant* (solution from the XPS PP1 that was separated from the tailings solids at the Xstrata facility) contained large amounts of extremely fine suspended particulate matter ("red water") in solution, to better understand the system the suspended particle content of the sample was submitted for qualitative XRD, basic ICP metals and Malvern particle size distribution analyses. It should be noted that, once the red water (*Ro Tls Decant*) was blended with the tailings, the "red water" clarified and slowly settled out of solution (over a 3-4 day period). Qualitative XRD analyses conducted on the *Ro Tls Decant* solids determined that this sample was comprised predominantly of potassium feldspar and plagioclase with minor amounts of quartz, mica, hematite, zircon, ferrocolumbite and monetite.

Whole rock analyses confirmed that the head and tailings samples tested were comprised primarily of SiO_2 (54 to 64 %) with moderate amounts of Fe_2O_3 (10 to 14%) and Al_2O_3 (9.2 to 13%) and minor amounts of K_2O (4.4 to 6.1%) and Na_2O (2.4 to 3.7%). Minor concentrations of ZrO_2 (3.1 to 3.8%) and trace concentration of Nb_2O_5 (0.4 to 0.5%) were also evident in the head samples. As expected, only trace levels of ZrO_2 and Nb_2O were reported in the tailings samples. The lesser levels of MgO (1.5 to 2.4%) and CaO (0.8 to 1.2%) observed in the tailings samples in comparison to the ore composite samples (MgO 2.7 to 3.4% and CaO 2.6 to 3.1%) were consistent with the modal analysis for these samples.

In comparison to the aforementioned samples, whole rock analyses of the concentrates indicated significantly lesser concentrations of SiO_2 (20 to 31%), Al_2O_3 (9.2 to 13%), K_2O (1.3 to 1.9%) and Na_2O (<1%) and significantly increased concentrations of Fe_2O_3 (13 to 18%), CaO (7.4 to 12%), MgO (3.1 to 4.3%), ZrO_2 (13 to 18%) and Nb_2O_5 (1.5 to 1.9%). Again the increased CaO and MgO contents reported for the concentrates are consistent with the modal analysis for these samples.

With the exception of the *MC3* head sample, the high loss on ignition (LOI) values (3.5 to 12%) determined for the head and concentrate samples suggests significant amounts of volatile species (e.g. sulphides, hydroxides and carbonates) are present in these samples. The low LOI values (≤2.0%) reported for the tailings samples, however; indicate that little of these species remain in the tailings. The poor recovery sums reported for the whole rock analyses, especially for the concentrate and head samples, are expected to result directly from the considerable REE content of the samples. Comparative results of the whole rock analyses are shown in Figure 2.

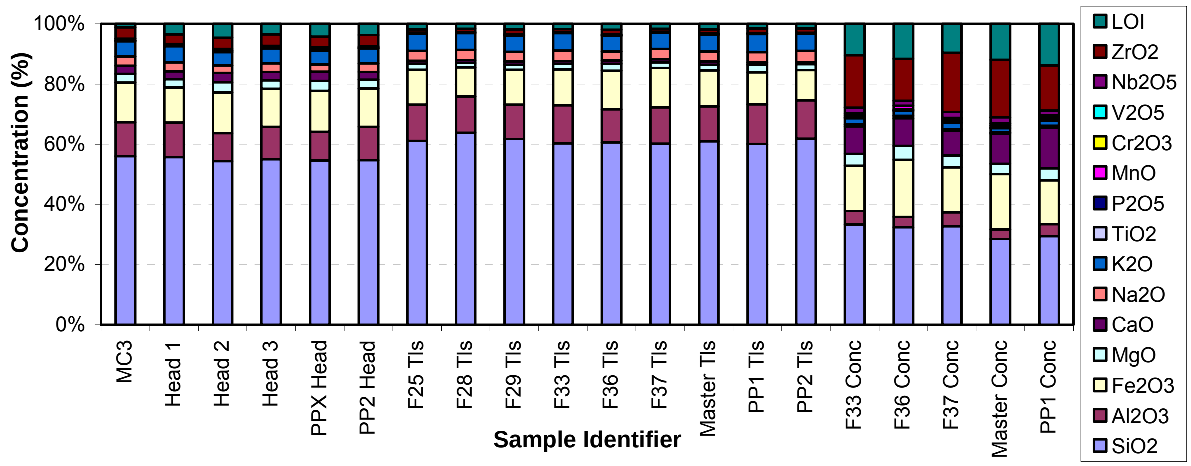


Figure 2: XRF Whole Rock Results

As expected, radionuclide analysis of the Thor Lake solids typically reported increased levels of radionuclides in the concentrate samples in comparison to the ore samples, while tailings showed lower levels of radionuclides. Results of the radionuclide analyses are illustrated in Figure 3

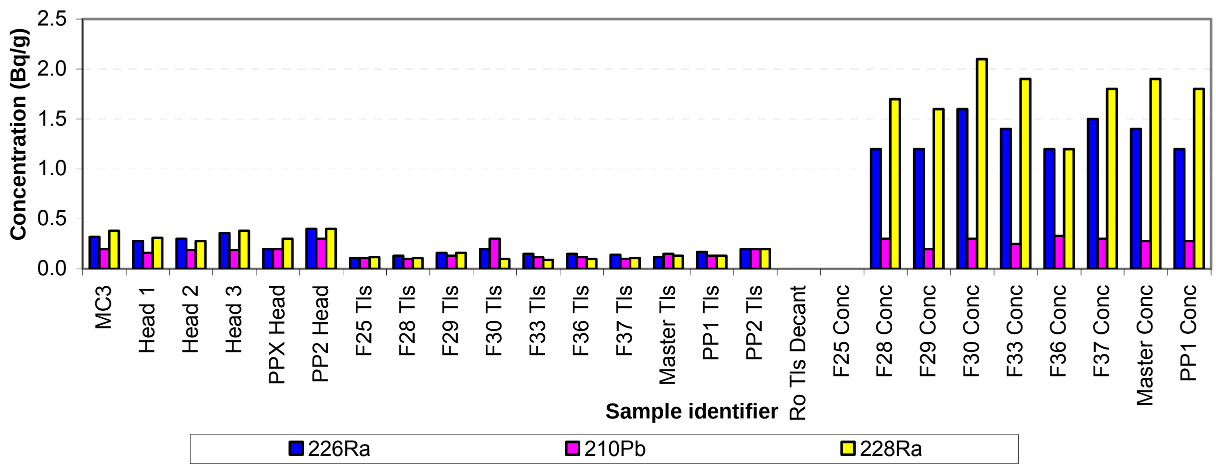


Figure 3: Radionuclide Analysis Results

ICP-OES/MS strong acid digest elemental analysis of the Thor Lake samples typically reported significant amounts of Si, Al, Ca, F, Fe, K, Mg and Na. Noteworthy levels of Ce, La, Nb, Nd and Zr were also evident in the concentrates and, in the case of Zr, in the heads.

As expected, the concentrates typically reported lesser concentrations of Si (11 to 14%) and Al (1.5 to 2.2%) and increased levels of Ca, Zr, Ce, La, Nb and Nd. In comparison, the head and tailings samples generally reported increased levels of Si (22 to 27%) and Al (4.7 to 8.6%) and considerably lesser concentrations of Ca, Zr, Ce, La, Nb and Nd. The *Ro Tls Decant* sample ("red water" solids) typically reported increased levels of Ba, Ca, Cu, Li, Mn, Pb, Y and Zn (one order of magnitude) and double the amount of Mg observed in the other tailings samples.

It should be noted that, as per instructions from John Goode and Avalon, ICP analyses were initially submitted to the minerals analytical department through the hydromet department, rather than being submitted to environmental analytical. Because minerals deals with the increased metal concentrations typical of metallurgical process samples, the final detection limits achieved for numerous parameters (e.g. Hg, Ag, Bi, Cd, Co, Cu, Pb, Sb, Se, Sn and Tl) were unsuitable for the environmental test program. To achieve the environmental detection limits required the samples were resubmitted for environmental ICP analyses. Due to a lack of sample mass, the environmental ICP reassay analyses could not be completed on the *F25 Conc* and *Ro Tls Decant* samples. Comparative results of the ICP elemental analyses and of the zirconium and REE analyses are provided in Figures 4 and 5, respectively. The significant components of the samples are illustrated in Figures 6 through 8.

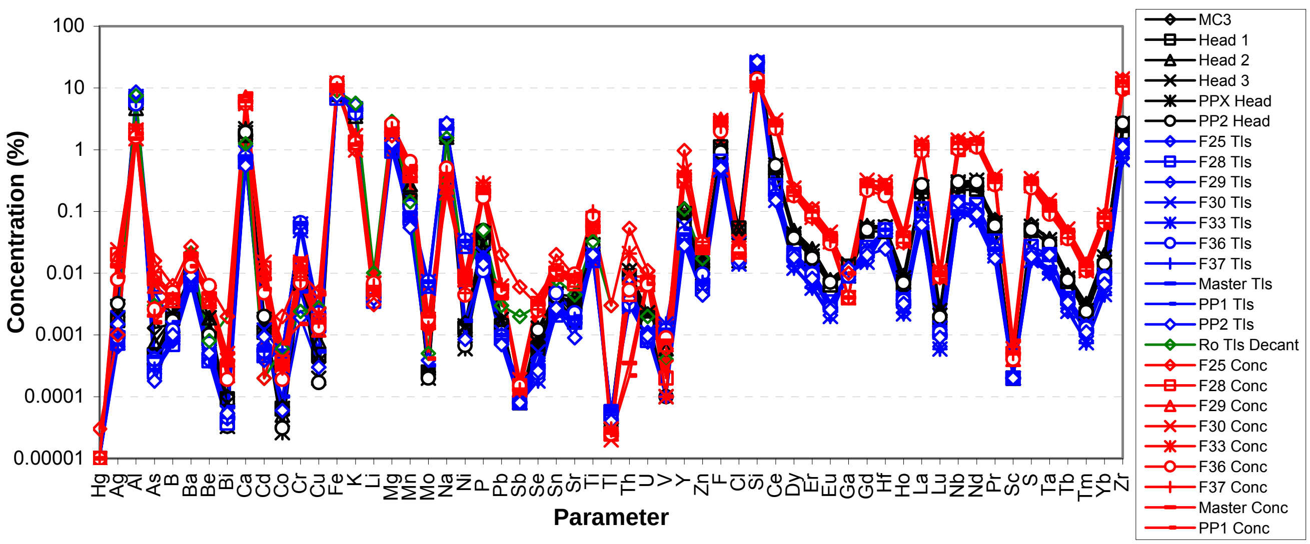


Figure 4: ICP-OES/MS Elemental Analyses Results

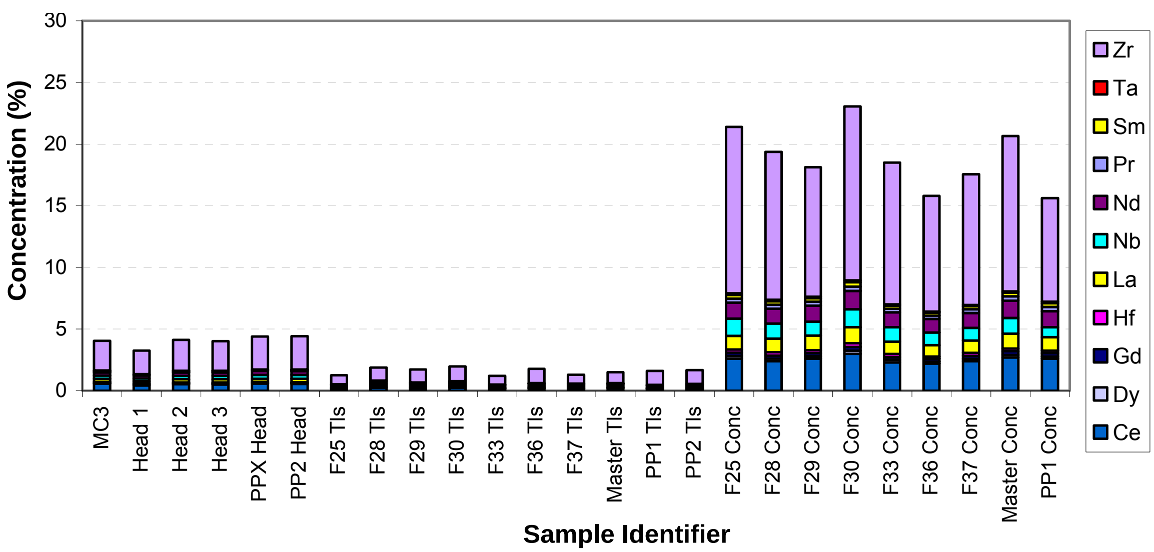


Figure 5: Comparison of Zirconium and REE Significant Components

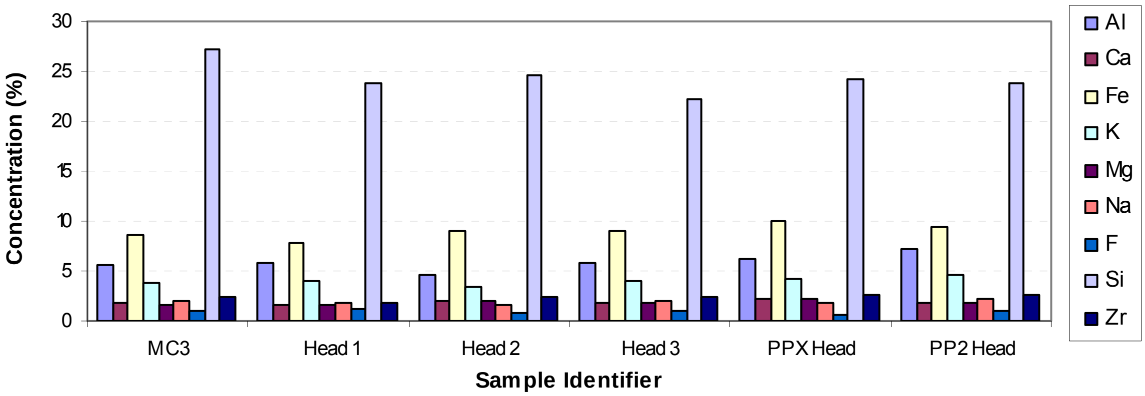


Figure 6: Comparison of the ICP Elemental Significant Components – Heads

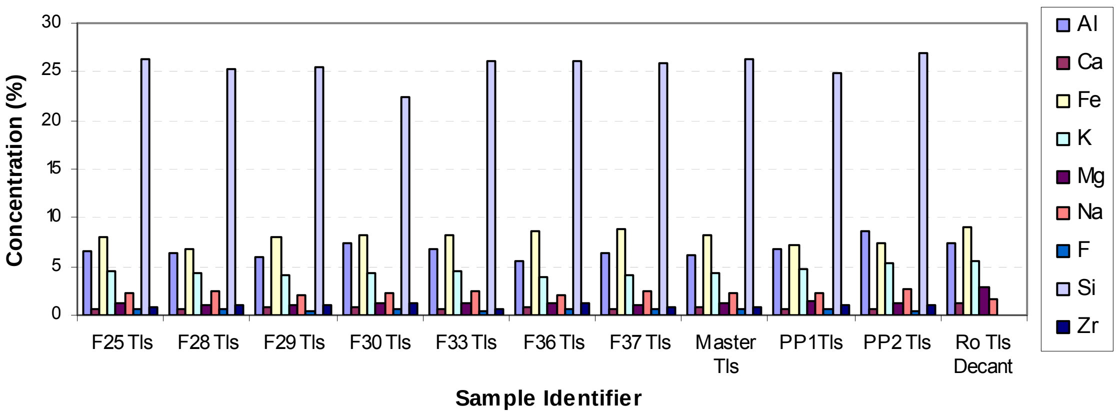


Figure 7: Comparison of the ICP Elemental Significant Components – Tailings

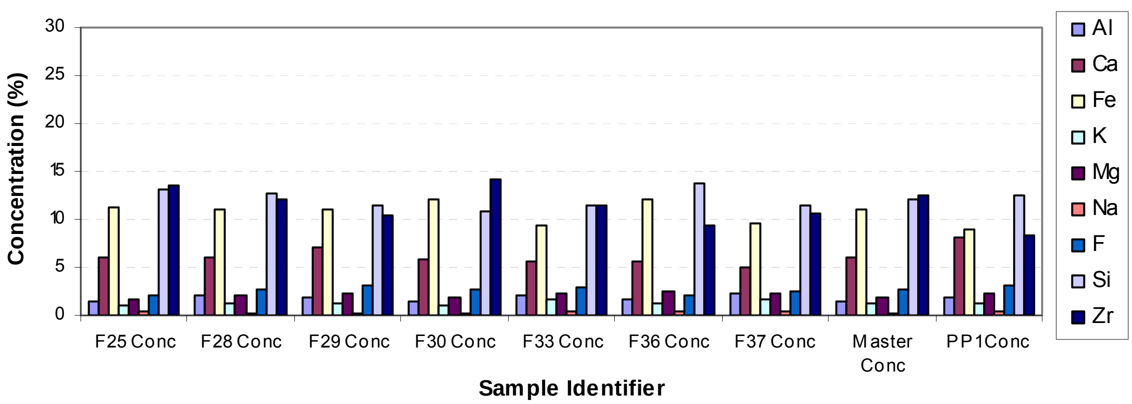


Figure 8: Comparison of the ICP Elemental Significant Components – Concentrates

Analysis of the Thor Lake shake flask extraction leachates reported all controlled parameters at concentrations well within the Canadian Metal Mining Regulation (MMER) limits. Radionuclide levels (^{226}Ra, ^{228}Ra and ^{210}Pb) of the shake flask leachates typically remained below the analytical detection limits.

Although the head samples (*MC3, Head 1, Head 2, Head 3, PPX Head* and *PP2 Head*) reported alkaline initial and final slurry pH values in excess of the MMER upper limit (9.5), separation of the DI leachant from the solids resulted in alkaline final pH values within the specified limits. Near neutral to slightly alkaline final pH values (7.61 to 8.12) were reported for the concentrate and tailings samples. Significant amounts of Cl (1.0 to 12 mg/L), F (0.90 to 12 mg/L), Ca (6.4 to21 mg/L), K (0.87 to 28 mg/L), Mg (0.96 to 5.3 mg/L), Na (4.6 to 25 mg/L) and Si (2.7 to 7.7 mg/L) were evident in all of the Thor Lake leachates.

The head samples typically reported concentrations of Cl, F and K one order of magnitude greater than those determined for the concentrate and tailings samples. Increased levels of Na (one order of magnitude) were also evident in the head and the *F36, F37, PP1* and *PP2* tailings leachates. Increased Ca was observed in the tailings samples. Figure 9 graphically illustrates the results of the shake flask extractions.

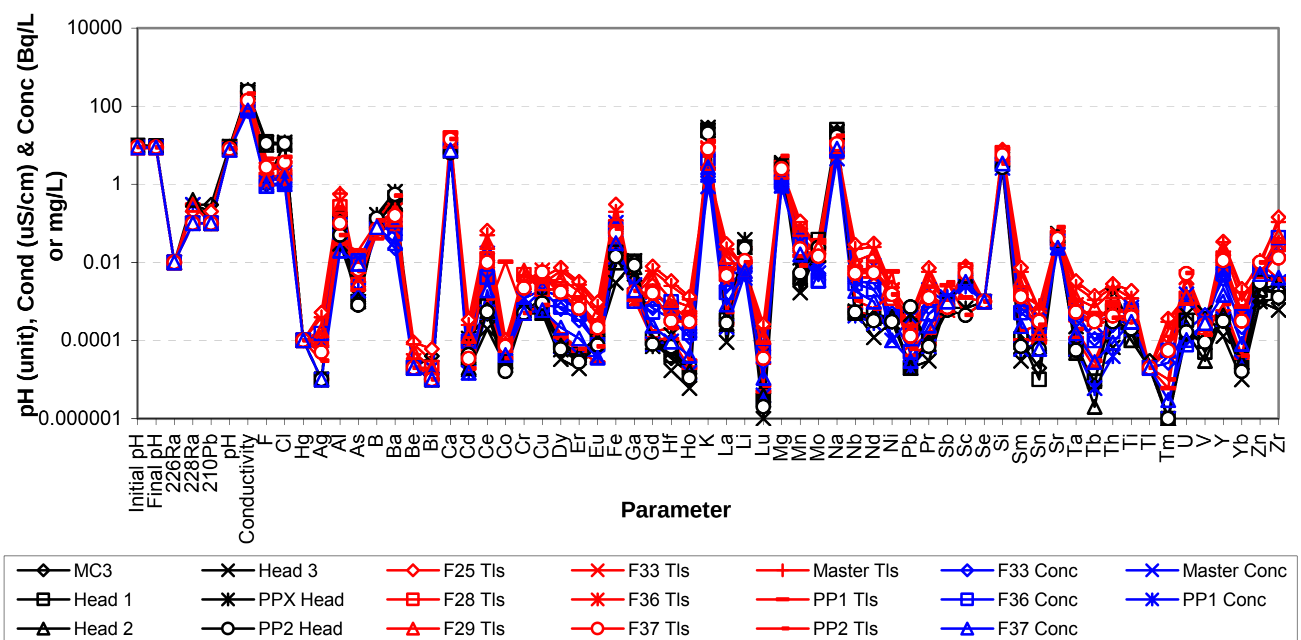


Figure 9: Shake Flask Extraction Test Results

As expected, analysis of the *Thor Lake water* (*#4* and *#7*), *XPS Tap Water* and *Ortech Tap Water* samples reported all MMER controlled parameters within the specified limits. Near neutral to moderately alkaline pH values (≥7.62) and significant levels of TDS and corresponding conductivity measurements were observed in both the lake and tap water solutions. Radionuclide levels in the lake water samples were below the analytical detection limits. Results of the radionuclide analyses completed on the tap water samples were not available at the time of issue of this report.

Increased levels of alkalinity, F, TOC and Mg (one order of magnitude) were observed in the *Thor Lake Water* samples, while increased levels of Cl, Na (one order of magnitude) and SO_4 (2 orders of magnitude were evident in the tap water samples (XPS and Ortech). The *XPS Tap Water* sample also reported an unusually high level of Zn for a tap water sample (two orders of magnitude higher than the lake water and *Ortech Tap Water* samples).

Overall the both the lake water and tap water solutions showed significant levels of alkalinity (51 to 44 mg/L), TOC (1.6 to 13 mg/L), Cl (3.8 to 48 mg/L), Ca (26 to 35 mg/L), K (1.4 to 1.9 mg/L), Mg (5.6 to 18 mg/L), Na (2.6 to 24 mg/L). While significant concentrations of Si (2.9 to 8.4 mg/L) were observed in the lake water and *XPS Tap Water* samples, only low level Si was evident in the *Ortech Tap Water* sample.

Analysis of the simulated hydromet filtrate solutions (*CH-WT1 PLS* and *RAR-1*) again reported all parameters controlled by the MMER within the designated limits. Near neutral pH values (≥7.46) and very high levels of TDS and corresponding conductivity measurements were observed in both the initial solution (*CH-WT1 PLS+WASH*) and in the solution after radium removal by addition of $BaCl_2$ and $Fe^2(SO_4)_3$*$5H_2O$ (*RAR-1 Filtrate*). With the exception of ^{226}Ra in the *CH-WT1 PLS* solution, radionuclide analyses completed on the hydromet filtrate solution typically remained were below the analytical detection limits.

In general the both the hydromet filtrate solutions showed very high levels of SO_4 (11,000 to 12,000 mg/L), Ca (387 to 393 mg/L), Mg (1530 to 1550 mg/L), Na (1470 to 1580 mg/L). Significant levels of alkalinity (82 to 118 mg/L), K (87 to 88 mg/L), Li (2.2 mg/L for both samples), Mn (6.2 to 6.3 mg/L), Si (2.5 to 2.6 mg/L) and Sr (11 mg/L for both samples) were also observed. Increased levels of Cl (55 mg/L), F (1.8 mg/L), TOC (54 mg/L) and ammonia (92 mg/L) were also reported in the *CH-WT1 PLS* filtrate solution. The cause of the increased zirconium and REE concentrations observed in the hydromet solution after radium removal (*RAR-1 Filtrate*) is unknown.

Results of the lake and tap water analyses and of the hydromet solution analyses are illustrated in Figures 10 and 11, respectively.

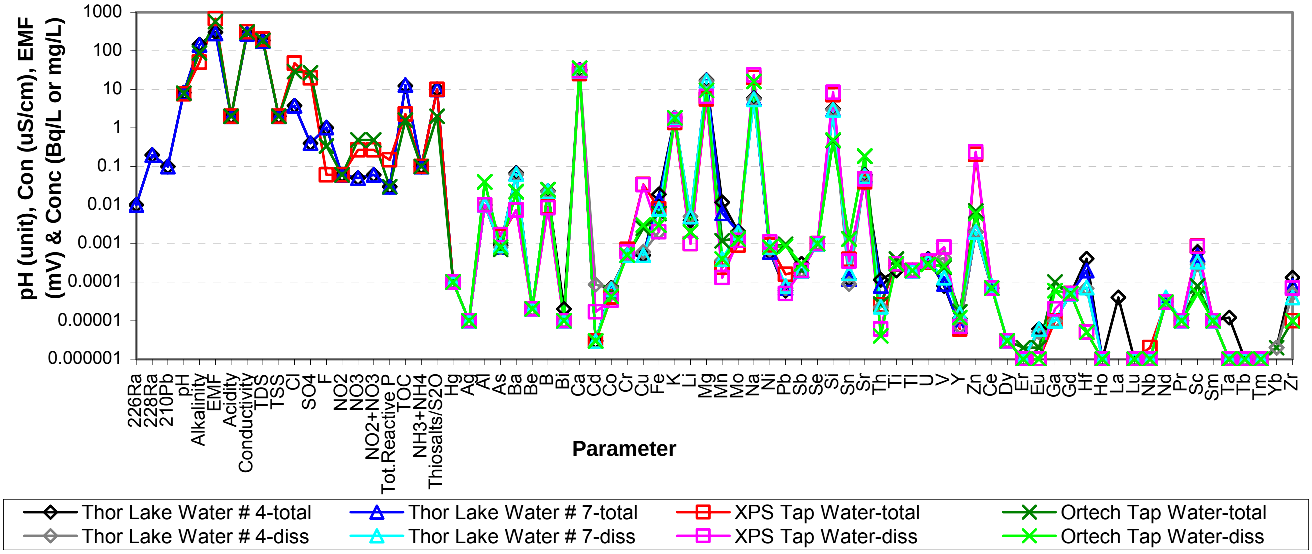


Figure 10: Thor Lake Water and XPS & OrtechTap Water Solution Analyses

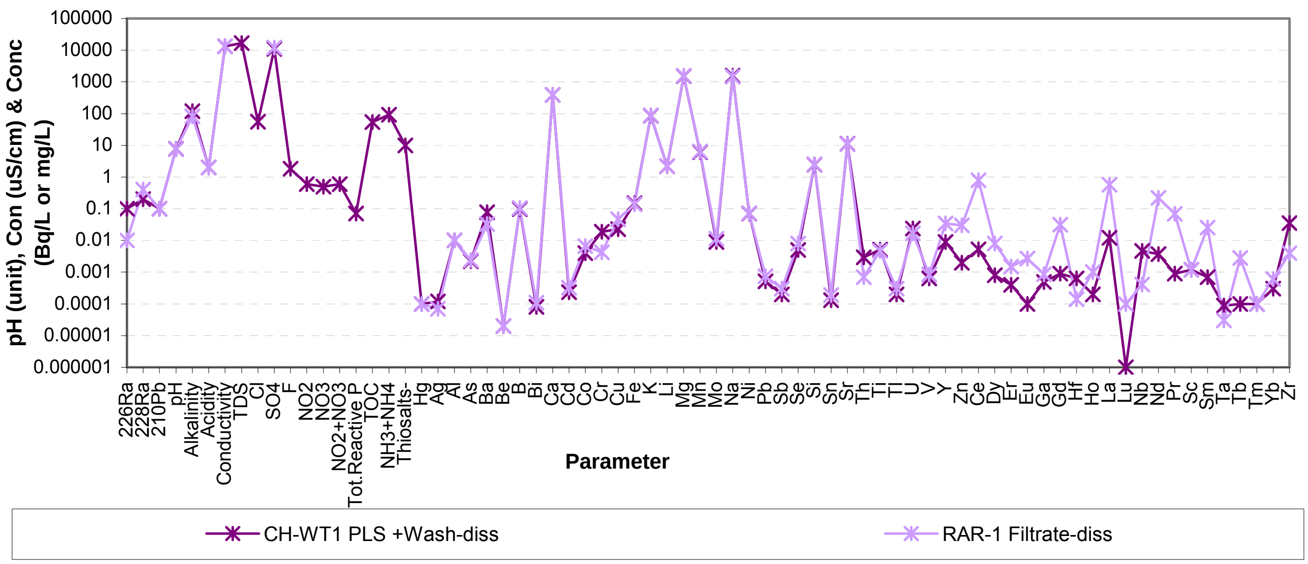


Figure 11: Hydromet Filtrate Solution Analyses

Because of the high level of suspended solids in the fresh *PP1* and *PP2* tailings pulps, these samples were allowed to settle for 5 days prior to decantation of the tailings solution. Analysis of the fresh and aged tailings solutions (*PP1 Tls Decant Day 5* and *Day 60* and *PP2 Tls Decant Day 5*) reported all controlled parameter at concentrations well within the designated MMER limits. Moderately alkaline pH values (≥8.16) and high levels of TDS and corresponding conductivity measurements were observed in both the fresh and aged solutions. Radionuclide levels in the solutions typically remained at, or below the analytical detection limits. Significantly lesser levels of SO_4 (one order of magnitude) were evident in the *PP2 Tls Day 5* solution in comparison to the *PP1 Tls Day 5* solution. Over the 60 day ageing test period one order of magnitude decreases were observed in the concentrations of Mn and Y in the *PP1 Tls* solutions.

Overall the fresh and aged *PP1* and *PP2* tailings solutions showed significant levels of alkalinity (119 to 148 mg/L), TOC (7.2 to 17 mg/L), F (4.4 to 9.3 mg/L), Cl (44 to 63 mg/L), SO_4 (29 to 110 mg/L), Ca (22 to 44 mg/L), K (26 to 37 mg/L), Mg (8.2 to 12 mg/L), Na (66 to 75 mg/L) and Si (4.7 to 8.2 mg/L). Dissolved metals analyses indicated that the majority of the Al, Fe and REE metals in solution in the Day 5 decants were due to suspended solids.

LC_{50} acute lethality testing of the *PP1 Tls Decant Day 5* solution resulted in non-lethal designations for both *Daphnia magna* and rainbow trout. Both the daphnia and the trout tests reported 100% survival rates in the full strength effluent (100% effluent concentration) resulting in LC_{50} values of >100%. Results of the fresh and aged solution analyses are illustrated graphically in Figure 12.

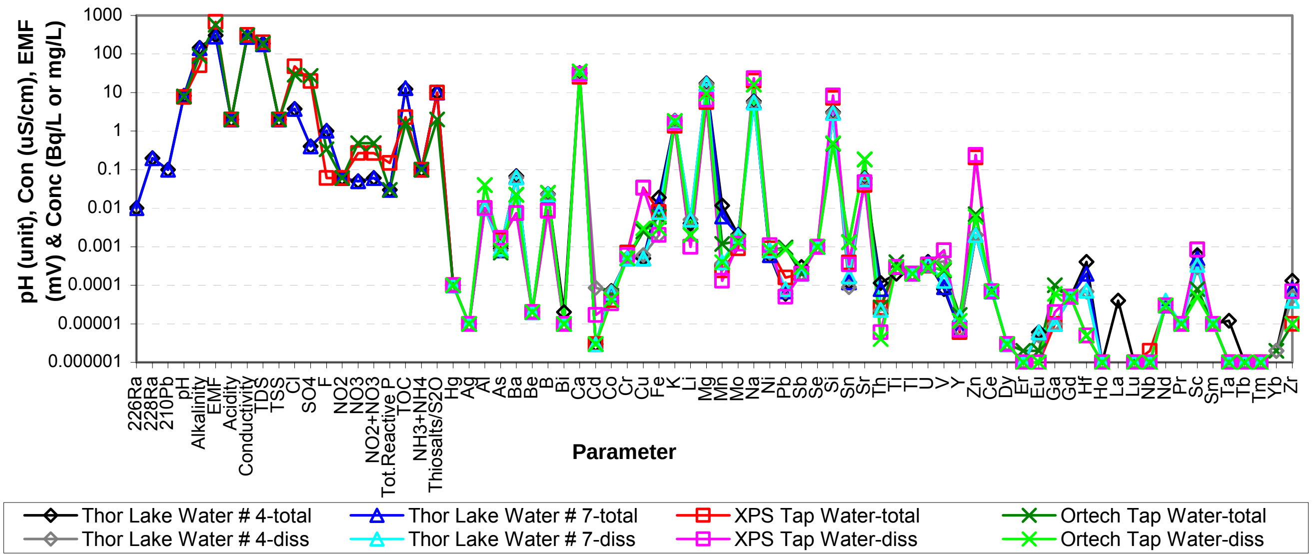


Figure 12: ICP-OES/MS Fresh and Aged Tailings Decant Solution Analyses

ABA test results for the head (*MC3, Head 1, Head 2, Head 3, PPX Head* and *PP2 Head*) and concentrate samples (*Master Conc, F33 Conc, F36 Conc, F37 Conc* and *PP1 Conc*) reported alkaline paste pH values (>8.96) and fizz rates (3) suggesting the presence of available reactive alkaline minerals. Determination of the carbonate (CO_3) content of these samples also indicated that ≥72% of the total NP reported for these samples is related to fast reacting carbonate minerals. The resultant CO_3 NP values (32.7 to 159 t $CaCO_3$/1000 t), coupled with the relatively low sulphide contents (<0.01 to 0.10%) and significant CO_3 NP/AP ratios (19.7 to 172), clearly illustrate the neutralisation capacity of these samples and indicate the potential for acid neutralisation. The non-acid forming nature of these samples was corroborated by the NAG test results which reported no net acidity generated and alkaline final pH values (≥9.40) after aggressive oxidation of the samples.

The tailings samples (*F25 Tls, F28 Tls, F29 Tls, Master Tls, F33 Tls, F36 Tls, F37 Tls, PP1 Tls* and *PP2 Tls*) samples reported lesser total NP values than the head and concentrate samples. Carbonate analyses also indicated that much of this total NP (40% to 53%) was from less reactive sources. Since carbonate minerals are typically the only minerals that can react at fast enough rates to counteract acidities released by sulphide mineral oxidation; the resultant CO_3 Net NP values >20 t $CaCO_3$/1000 t (7.5 to 14.7 t $CaCO_3$/1000 t) reported for the tailings samples indicate increased uncertainty with regards to the availability and reactivity of this NP. Nonetheless, the very low sulphide contents (<0.01%) and considerable CO_3 NP/AP ratios (25 to 48) indicate that these samples are highly unlikely to generate acidity. The alkaline final pH values (≥9.76) reported after aggressive oxidation of the tailings samples during NAG testing confirmed the highly unlikely acid generation potential determined by the ABA test method. Results of the total and CO_3 NP versus AP and of the total and CO_3 NP/AP ratios versus sulphide are presented in Figure 13.

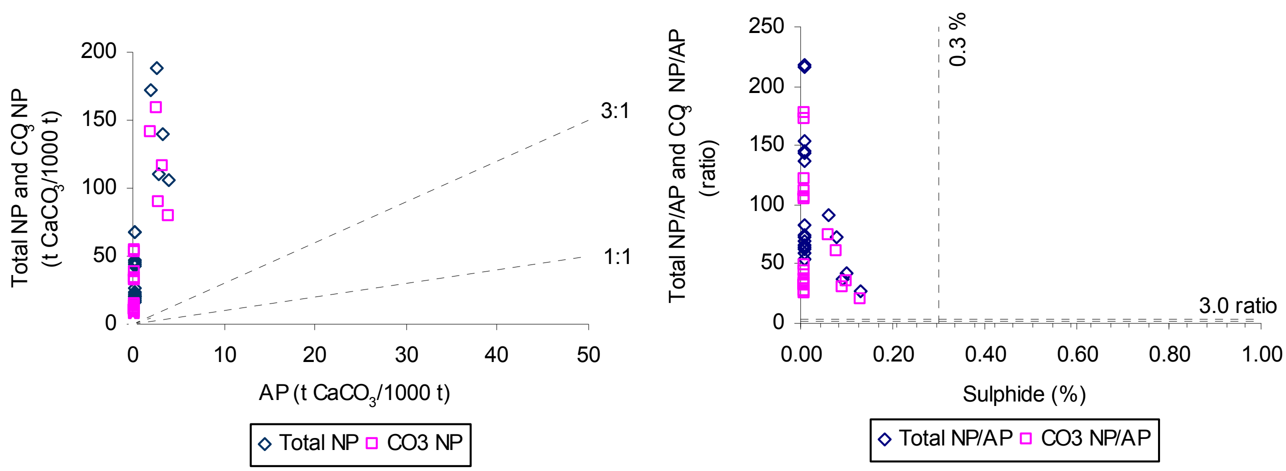


Figure 13: Modified Acid Base Accounting Results

Note: Samples reporting NP to AP ratios greater than 3 are considered indicative of a low potential for acid generation (non-acid generating), while samples reporting NP to AP ratios of less than 3 but greater than 1indicate an uncertain potential for acid generation. Samples reporting NP to AP ratios less than 1 indicate a potential for acid generation.

Although the *F36 Tls, F37 Tls, Master Tls, PP1 Tls* and *PP1 Conc* humidity cell leachates are currently reporting near neutral pH values, decreasing pH and alkalinity levels are evident in the leachates. In contrast to the aforementioned samples, increasing pH values and alkalinity concentrations are apparent in the *F33 Tls, Master Conc* and *PP2 Tls* humidity cell leachates. Nonetheless, all the Thor Lake tailings and concentrate samples are releasing only minimal concentrations of SO_4. ICP-OES/MS analyses of the humidity cell leachates are reported all MMER controlled parameters well within their respective limits in all test cells. Comparisons of the weekly pH values, conductivity levels and SO_4 concentrations reported in the *F36 Tls, F37 Tls, Master Tls, PP1 Tls* and *PP1 Conc* leachates are illustrated in Figure14. Results for the *F33 Tls, Master Conc* and *PPI Tls* leachates are shown in Figure 15.

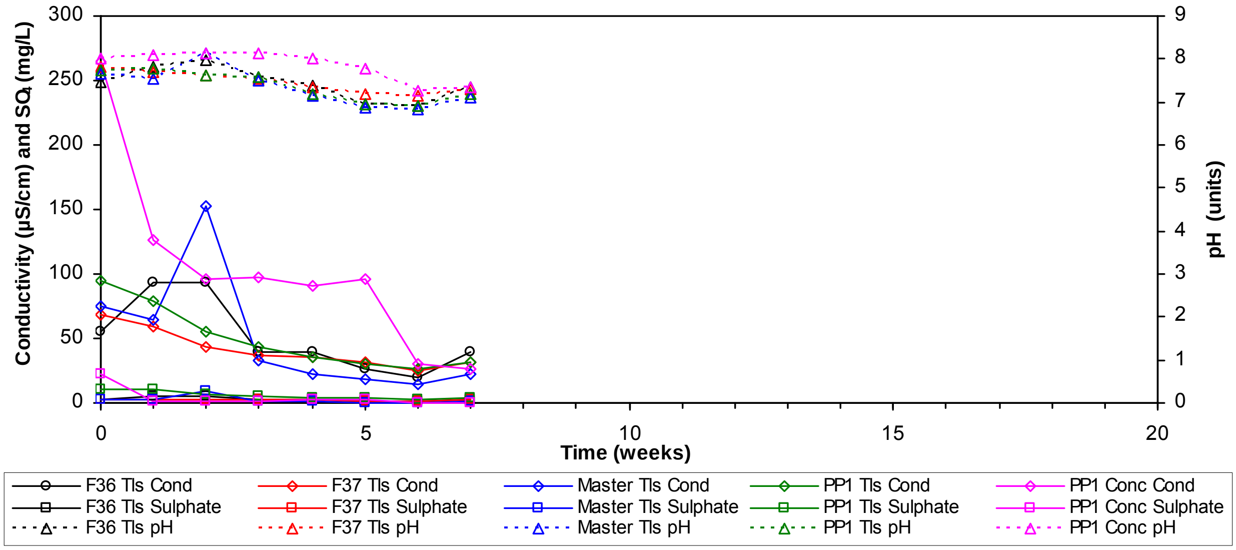


Figure 14: Humidity Cell Test – pH Values, Conductivity and Sulphate Concentrations – F36 Tls, F37 Tls, Master Tls, PP1 Tls and PP1 Conc

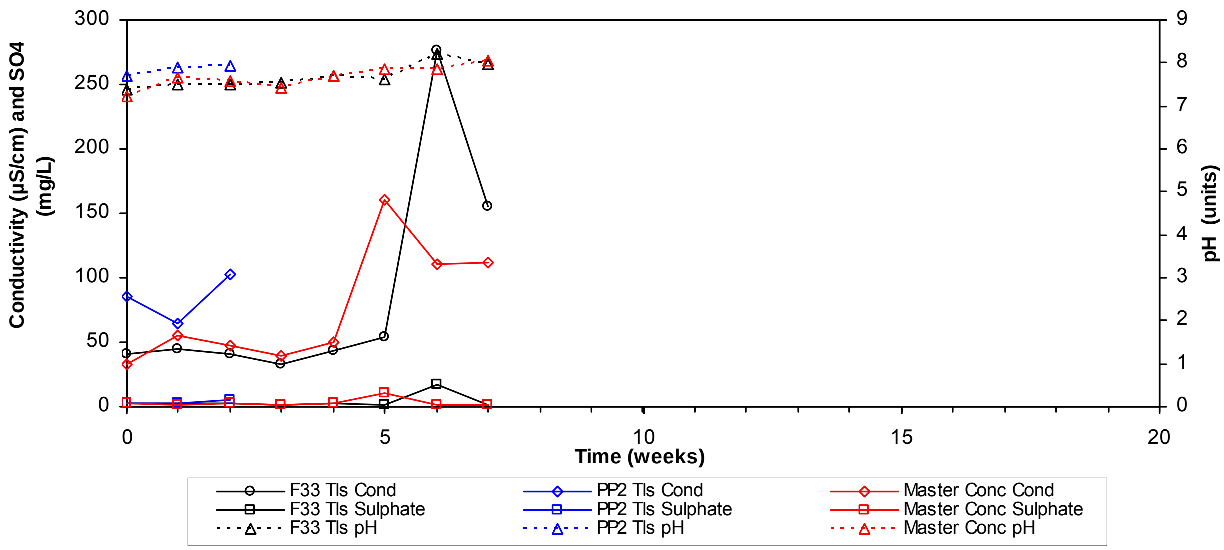
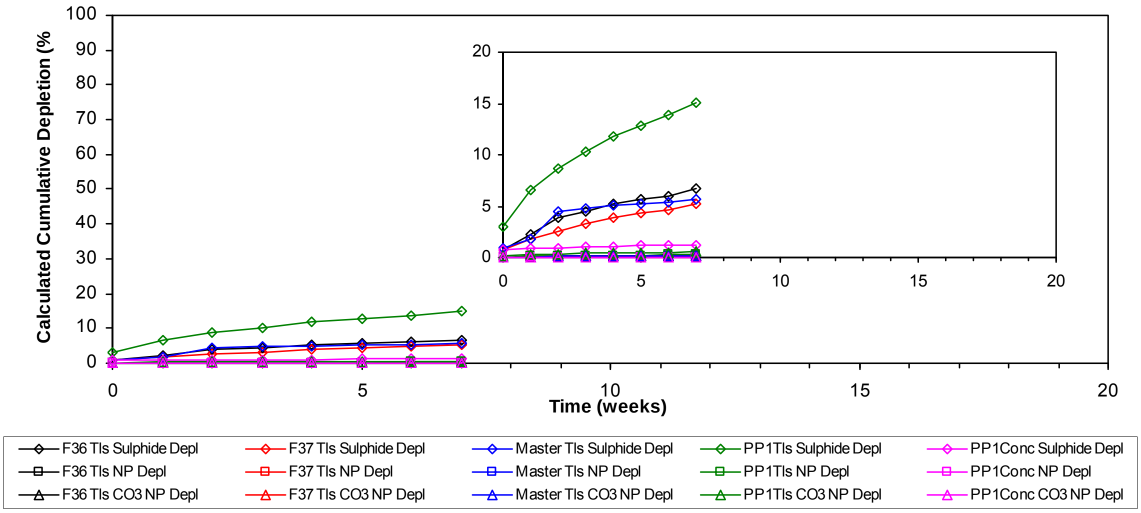


Figure 15: Humidity Cell Test – pH Values, Conductivity and Sulphate Concentrations – F33 Tls, PP2 Tls and Master Conc

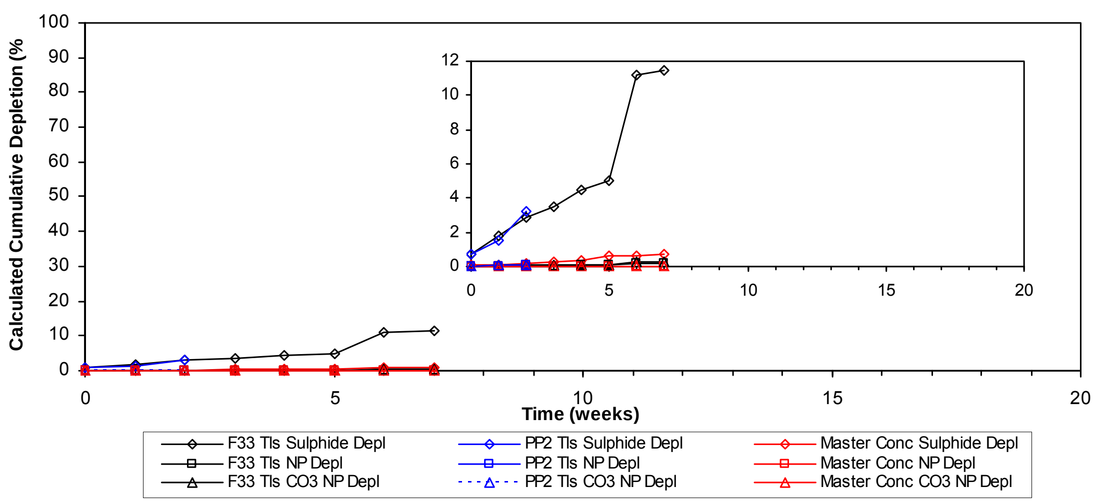
After seven weeks of leaching, the cumulative sulphide depletion rates (0.72 to 15.1%) and related CO_3 NP depletions (0.02 to 0.56%) determined for the *F33 Tls, F36 Tls, F37 Tls, Master Tls, PP1 Tls, Master Conc* and *PP1 Conc* samples suggest that the sulphide minerals in these samples are depleting at significantly faster rates than the carbonate minerals. This would imply that, if the current depletion rates continue, these samples may be expected to retain excess CO_3 NP carbonate available upon exhaustion of the sulphide content contained within the samples.

Humidity cell testing has only recently been initiated on the *PP2 Tls* sample; therefore, depletion projections cannot yet be made. Preliminary depletion rates for the *F36 Tls, F37 Tls, Master Tls, PP1 Tls* and *PP1 Conc* samples are shown in Figure 16 below. Preliminary depletion rates for the *F33 Tls, Master Conc* and *PP2 Tls* samples are illustrated in Figure 17.



Note: Inset graph y-axis reduced to 10% for ease of viewing.

Figure 16: Humidity Cell Test – Depletion Rates – F36 Tls, F37 Tls, Master Tls, PP1 Tls and PP1 Conc



Note: Inset graph y-axis reduced to 10% for ease of viewing.

Figure 17: Humidity Cell Test – Depletion Rates – F33 Tls, PP2 Tls and Master Conc

Specific gravities of 2.91 to 2.97 were determined for the head sample solids (*MC3, Head 1, Head 2, Head 3, PP2 Head* and *PP2 Head)*. As expected, the ASTM D 422 particle size distribution analyses (sieve and hydrometer) completed on the crushed head samples classified these samples as primarily sand sized material (≥85%). Of this sand sized material, the majority would be classified as coarse to medium grained sand. Only 12 to 15% of the head samples fractured into fine grained particles (<200 mesh or 0.075 mm) with only 2 to 5% of this fine grained material reporting as clay size particles (<0.002 mm).

Lesser specific gravities (2.76 to 2.86) were determined for the tailing samples (*F25 Tls, F28 Tls, F29 Tls, Master Tls, F33 Tls, F36 Tls, F37 Tls, PP1 Tls* and *PP2 Tls*). In comparison to the head samples, sieve and hydrometer analyses completed on the tailings samples reported very fine particle size distribution characteristics with approximately 98% of the samples passing the 200 mesh sieve (0.075 mm). Of this fine grained material, approximately 88% comprised of silt size grains. The remaining approximately 10% of the tailings samples fell into the clay size range.

As would be expected, the concentrate samples (*Master Conc, F33 Conc, F36 Conc, F37 Conc* and *PP1 Conc*) reported increased specific gravities (3.47 to 3.67). PSD analyses completed on the concentrates also showed a very finer particle size distribution with only approximately 1% of the samples being classified as fine sand sized material and approximately 99% of the samples passing the 200 mesh sieve (0.075 mm). This fine grained material was typically comprised of silt size grains (~97%) with only a minor fraction falling into the clay size range (~2%).

Malvern laser particle size analysis completed on the Ro Tls Decant (red water) reported a much finer particle size distribution than the tailings samples. In comparison tot the tailings, the 100% of the "red water" solids fell into the clay/silt size range. Of this extremely fine grained material, approximately 18% was comprised of silt size grains while the remaining 82% of the sample was comprised of clay sized grain (<0.002 mm). Comparative results of the particle size analyses are presented graphically in Figures 18 and 19.

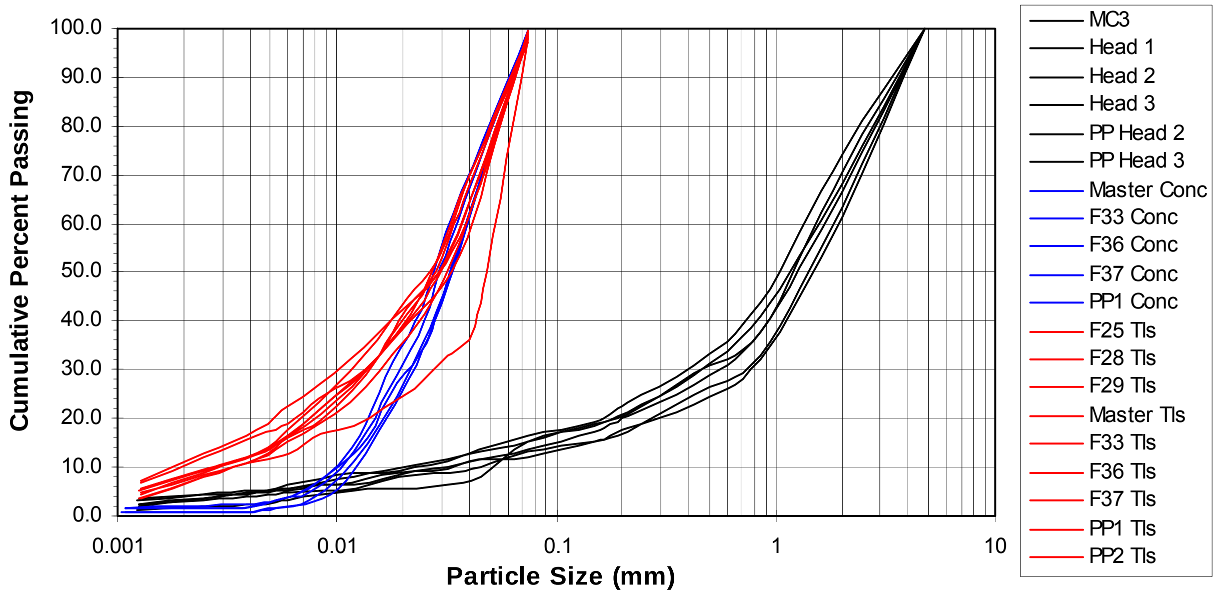


Figure 18: Particle Size Distribution Results

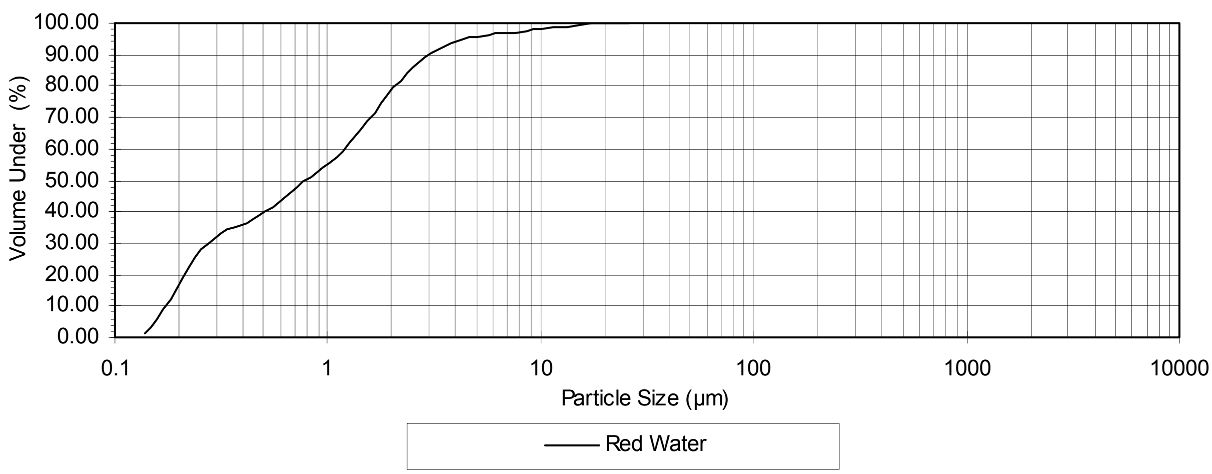


Figure 19: Malvern Particle Size Distribution Results – Red Water

Atterberg limits testing reported liquid limits (LL) of 21 to 24 for the *Master Tls, PP1 Tls* and *PP2 Tls* samples. However, the ASTM D 4318-05 method states that, if the sample cannot be rolled into a 1/8″ thread at any moisture content, which was the case with the Avalon tailings, it is to be determined as non-plastic. The Avalon tailings samples were therefore determined to be non-plastic. This behaviour is typical of cohesionless inorganic silt or rock flour type samples.

Conclusions

This report has been provided to Avalon to summarise results of the testwork completed on the Thor Lake Nechalacho samples. In conclusion:

- Modal analyses determined that the Thor Lake samples tested were predominantly comprised of gangue silicate minerals with minor to moderate amounts of Fe-oxides.
- While only trace levels of neutralising carbonates were reported in the tailings samples; increased carbonate concentrations were reported in the head and concentrate samples.
- Only trace levels of sulphide minerals were reported in the head and tailings samples.
- Whole rock and ICP-OES/MS elemental analyses confirmed the primarily silicate composition of the samples.
- The high loss on ignition values determined for the head and concentrate samples suggested the presence of significant amounts of volatile species, while the low LOI values reported for the tailing samples indicate that little of these species remain in the tailings.
- The low whole rock recoveries reported for the concentrate and head samples, are expected to result directly from the considerable REE content of the samples.
- The Nechalacho head, tailings and concentrate sample solids typically reported only low levels of radionuclides.
- Analysis of the shake flask extraction leachates, aged pilot plant tailings decant solutions and simulated hydromet solutions (before and after radium treatment) reported all controlled parameters, including ^{226}Ra, at concentrations well within the MMER limits.
- Toxicity testing determined that the *PP1 Tls Decant Day 5* solution was non-lethal to both *Daphnia magna* and rainbow trout.
- Modified ABA testing indicated, and NAG testing confirmed, that the Thor Lake head, tailings and concentrate samples tested were either potentially acid neutralising or highly unlikely to generate acidity.
- After 7 weeks of humidity cell testing, cumulative depletion rates calculated for 7 of the 8 humidity cell test samples (*F33 Tls, F36 Tls, F37 Tls, Master Tls, PP1 Tls, Master Conc* and *PP1 Conc*) suggest that the sulphide minerals in these samples are depleting at significantly faster rates than the carbonate minerals.
- The leachates from 5 of these humidity test cells (*F36 Tls, F37 Tls, Master Tls, PP1 Tls* and *PP1 Conc*); however, are showing decreasing pH and alkalinity levels.
- Particle size distribution analyses indicated that the head samples were comprised primarily of sand sized grains, while the tailings and concentrate samples were comprised primarily of fines (silt and clay sized material).
- Atterberg limit testing indicated that the tailings samples tested (*Master Tls, PP1 Tls* and *PP2 Tls*) were non-plastic.

References

Department of Justice Canada. 2002. *Metal Mining Effluent Regulations, Fisheries Act SOR-2002-222.* Updated 2004. Available Online: http://laws.justice.gc.ca/en/F-14/SOR-2002-222/119716.html