SGS Lakefield Research Limited
Environmental Services

Request for Laboratory Services and Chain of Custody Form

No 11806-007-17

P.O. Box 4300, 185 Concession St., Lakefield, ON. K0L 2H0, Phone (705) 652-2038, Fax (705) 652-6441

Report Results to:	**Name:** Barb Bowman
	Company: SGS Lakefield Research Ltd
	Address:
	City
	Province, Postal Code
	Telephone Number: 2148 **Fax:**
Send Invoice to:	Name: Rob Caldwell
	Company:
	Address:
	City
	Province, Postal Code
	Telephone Number: 2043 Fax:
Chain of Custody	**Sampled by:**
	Packed and Shipped by: **Date /Time:**
	Shipment Method and WB#: **Date /Time:**

LRL LIMS No.: Jan 10289
Received by (Date & Time):
Logged in by (Date): 01/20/11 SM
Lab Batch ID:

Project No.: 11806-007
Plant No.:
Quote No.:
Purchase Order No.:

TAT (Turnaround Time) * Some exceptions apply, please contact lab
Standard [X] RUSH [ ] Specify Date:
Time:

PLEASE CONTACT LAB PRIOR TO SUBMITTING RUSH PROJECTS

Sample condition upon receipt:

Temperature upon receipt: 18 °C >3

Please specify any guideline or regulation that these samples may apply(i.e. ODWS, PWQO, Reg 558, GCSO, MISA, MMER, CBWA).

Guideline: **Regulation:** **initial:**

Total, Dissolved and Rare Earth Metals : as per LIMS 11346-NOV10

LOW LEVEL RADIONUCLIDES
QUOTE T101028
SEND [redacted] 2L TO BECQUEREL

Analysis Requested (X) as Required

(Enter an "X" in the boxes to indicate which request(s) apply to each sample)

	Sample Matrix*	Sample Identifier	No. Bottles	Date Sampled	Time Sampled	pH, conductivity, acidity, alkalinity, EMF, TDS, TSS, TOC	Anions (Cl, F, NO2, NO3, PO4, SO4)	Ammonia	Thiosalts	Total Metals + Hg + Total Rare Earth Metals	Dissolved Metals + Hg + Dissolved Rare Earth Metals	Radionuclides (Ra226, RA228 +Pb210) - Becquerel quote T101028	
1		Jan 18/11 XPS PP Comp 1Tls Decant Day 60										X	
2		XPS Tap Water 14-JAN-11										X	
3		Ortech Tap Water				X	X	X	X	X	X	X	
4													
5													
6													
7													
8													
9													
10													

* Matrix Codes: GW-ground water, SW-surface water, RES-Residential Water, EFF-Effluent, PROC-Process Water, SOIL-Soil, SED-Sediment, SWAB-Swabs, FILT-Filters

* Regulated Water Codes: GRW-ground raw water, SRW-surface raw water, TDW-Treated Drinking Water, DDW-Distribution Drinking Water

Work Authorized by(Client or representative signature must accompany request): Date: Jan 20/11

Part No CofC-2(Email/Fax Copy)

SGS Lakefield Research Limited

Environmental Services

Request for Laboratory Services and Chain of Custody Form

No 11806-007-18

P.O. Box 4300, 185 Concession St., Lakefield, ON. K0L 2H0, Phone (705) 652-2038, Fax (705) 652-6441

Report Results to:	Name: Barb Bowman
	Company: SGS Lakefield Research Ltd
	Address:
	City
	Province, Postal Code
	Telephone Number: 2148 Fax:
Send Invoice to:	Name: Rob Caldwell
	Company:
	Address:
	City
	Province, Postal Code
	Telephone Number: 2043 Fax:
Chain of Custody	Sampled by:
	Packed and Shipped by: Date /Time:
	Shipment Method and WB#: Date /Time:

LRL LIMS No.:

Received by (Date & Time): FEB 14/11

Logged in by (Date):

Lab Batch ID:

Project No.: 11806-007

Plant No.:

Quote No.:

Purchase Order No.:

TAT (Turnaround Time) * Some exceptions apply, please contact lab

Standard X RUSH Specify Date:

Time:

PLEASE CONTACT LAB PRIOR TO SUBMITTING RUSH PROJECTS

Sample condition upon receipt: C2/M11 OR

Temperature upon receipt: 19 °C X2

Please specify any guideline or regulation that these samples may apply(I.e ODWS, PWQO, Reg 558, GCSO, MISA, MMER, CBWA).

Guideline: **Regulation:** **initial:**

Total, Dissolved and Rare Earth Metals : as per LIMS 11346-NOV10

Analysis Requested (X) as Required

(Enter an "X" in the boxes to indicate which request(s) apply to each sample)

	Sample Matrix*	Sample Identifier	No. Bottles	Date Sampled	Time Sampled	pH, conductivity, acidity, alkalinity, EMF, TDS, TSS, TOC	Anions (Cl, F, NO2, NO3, PO4, SO4)	Ammonia	Thiosalts	Total Metals + Hg + Total Rare Earth Metals	Dissolved Metals + Hg + Dissolved Rare Earth Metals	Radionuclides (Ra226, RA228 +Pb210) - Becquerel quote T101028	
1		Feb 14/11 XPS PP Comp 2 Tls Decant Day 61				X	X	X	X	X	X	X	
2													
3													
4													
5													
6													
7													
8													
9													
10													

* Matrix Codes: GW-ground water, SW-surface water, RES-Residential Water, EFF-Effluent, PROC-Process Water, SOIL-Soil, SED-Sediment, SWAB-Swabs, FILT-Filters

* Regulated Water Codes: GRW-ground raw water, SRW-surface raw water, TDW-Treated Drinking Water, DDW-Distribution Drinking Water

Work Authorized by(Client or representative signature must accompany request): **Date:** FEB14/11

Part No. CofC-2(Email/Fax Copy)

CHAIN OF CUSTODY RECORD

AQUATOX

AquaTox Work Order No:

Shipping Address: AquaTox Testing & Consulting Inc.
11B Nicholas Beaver Road, RR #3
Guelph, Ontario Canada N1H 6H9

Voice: (519) 763-4412 **Fax:** (519) 763-4419

P.O. Number:	Email invoice to Barb Bowman
Field Sampler Name (print):	Barb Bowman
Signature:	
Affiliation:	SGS Lakefield Research Ltd.
Sample Storage (prior to shipping):	ambient temperature in lab
Custody Relinquished by:	Barb Bowman
Date/Time Shipped:	2010-Nov 24 14:30

Client: SGS Lakefield Research Ltd.
185 Concession Street, Box 4300
Lakefield, ON
K0L 2H0

Phone: (705) 652-2148

Fax: (705) 652-6365

Contact: Barb Bowman

Sample Identification					Analyses Requested									Sample Method and Volume		
Date Collected (yyyy-mm-dd)	Time Collected (e.g. 14:30, 24 hr clock)	Sample Name	AquaTox Sample Number	Temp. on arrival	Rainbow Trout Single Concentration	Rainbow Trout LC50	*Daphnia magna* Single Concentration	*Daphnia magna* LC50	Fathead Minnow Survival & Growth	*Ceriodaphnia dubia* Survival & Reproduction	*Lemna minor* Growth	*Selenastrum capricornutum* Growth	Microtox	Grab	Composite	# of Containers and Volume (eg. 2 x 1L, 3 x 10L, etc.)
2010-11-24	11:30	Nov 24/10 XPS PP Comp 1Tls Decant Day 5				✓		✓						✓		1x20L + 1x10L

For Lab Use Only

Received By: _____

Date: _____

Time: _____

Storage Location: _____

Storage Temp.(°C) _____

Please list any special requests or instructions:

EPS 1/RM/13 and 14 Methods

SGS Project Reference Number - 11806-007

SGS Lakefield Research Sample Control Sheet for Mineralogy Samples

Mineralogy LIMS Number:
Date Prepared: DEC 21/10
Department: ENVIROMET
Project Number: 11806-007
Test Number:
Met. Project Manager

Date Required:
Sample Description: 2 ORES + 1 TLS
Number of samples: 3
***Mineralogy Proj Manager:** TASSOS
Quote/Proposal Number:

Quoted Price _____ [ ] *initialed by Project Manager* *Not to be exceeded without prior authorization*

Sample Description	Weight wt/g	Mineralogical Testing Information
XPS PP COMP 2 TLS		Request from client:
XPS PP ~~COMP~~ 2 HEAD		THESE SAMPLES ARE TO BE ADDED TO TASSO'S AVALON MINERALOGY PROJECT
XPS PP COMP 3 HEAD		
		AVALON SAMPLES

* Please fill in Mineralogy Proj. Manager to speed up login of samples.

Attach proposal/quote if possible.

SGS Lakefield Research Sample Control Sheet

Lims Number:
Date Prepared: Oct 25, 2010
Department: Met Ops
Project Number: 11806-007
Test Number (ID):

Analytical Quotation:

Turnaround Required: ASAP
Sample Type: solids
Number of Samples: 11
Technologist(s)/Operator(s): Kevin Bradley
Project Engineer:

↓ Sample Number	← Priority by Sample	Sample Identification Coding	Description	Weight g	Volume mL	Pulverize Sample	Determinations Required Elem.	Est.	Elem.	Est.	Elem.	Est.	Elem.	Est.	Elem.	Est.	Elem.	Est.	Elem.	Est.	Elem.	Est.	Size
		Priority by Element →																					
1		F33 Mozley Conc Comp					REE B		ICP Hg		Zr		Nb		Ga		Ta		Cl		F		Hf		
2		F36 Mozley Conc Comp					REE B		ICP Hg		Zr		Nb		Ga		Ta		Cl		F		Hf		
3		F37 Mozley Conc Comp					REE B		ICP Hg		Zr		Nb		Ga		Ta		Cl		F		Hf		
4		Master Tail					REE B		ICP Hg		Zr		Nb		Ga		Ta		Cl		F		Hf		
5		F25 Combined Tail					REE B		ICP Hg		Zr		Nb		Ga		Ta		Cl		F		Hf		
6		F28 Combined Tail					REE B		ICP Hg		Zr		Nb		Ga		Ta		Cl		F		Hf		
7		F29 Combined Tail					REE B		ICP Hg		Zr		Nb		Ga		Ta		Cl		F		Hf		
8		F30 Combined Tail					REE B		ICP Hg		Zr		Nb		Ga		Ta		Cl		F		Hf		
9		F33 Combined Tail					REE B		ICP Hg		Zr		Nb		Ga		Ta		Cl		F		Hf		
10		F36 Combined Tail					REE B		ICP Hg		Zr		Nb		Ga		Ta		Cl		F		Hf		
11		F37 Combined Tail					REE B		ICP Hg		Zr		Nb		Ga		Ta		Cl		F		Hf		

Prepared By:

solids

Avoid Contact - Use Rubber Gloves, Goggles, Ventilation
Refer to MSDS Sheets

Comments:

Samples labelled 11806-005
Charge project 11806-007
REE by ICP-MS, ICP scan by OES

Lakefield Research Sample Control Sheet for Pulp Samples

LIMS Number: Nov. 0228|
Date Prepared: NOV 5/10
Department: ENVIROMET
Project No.: 11806-007
Test No.:
Technician: B. BOWMAN

Date Required: ASAP
Sample Type: CONCENTRATES
Number of Samples: 2

Rej	Sample Description	Weight	Pulv	Analytical Requirements ICP AS PER 03108-OCT 10								Size
1	MASTER COMP B			X								
2	XPS PP COMP 1	CONC		X								
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												

Prepared by: _____ Date: _____ Time: _____

Comments: _____

_____

Lakefield Research Sample Control Sheet for Pulp Samples

LIMS Number:
Date Prepared: NOV 22/10
Department: ENVIROMET
Project No.: 11806-007
Test No.:
Technician: B BOWMAN

Date Required: ASAP
Sample Type: TLS
Number of Samples: 1

Rej	Sample Description	Weight	Pulv	Analytical Requirements (ICP)								Size
1	XPS PP COMP1	TLS		X								
2												
3	ANALYSES											
4	Ce											
5	Dy											
6	Er											
7	Eu											
8	Ga											
9	Gd											
10	Hf											
11	Ho											
12	La											
13	Lu											
14	Nb											
15	Nd											
16	Pr											
17	Sc											
18	Sm											
19	Ta											
20	Tb											
21	Th											
22	Tm											
23	Yb											
24	Zr											
25	Si											
26	F + Cl + P											

Prepared by: _____ Date: _____ Time: _____
Comments: _____

Lakefield Research Sample Control Sheet for Pulp Samples

LIMS Number:
Date Prepared: DEC 16/10
Department: ENVIROMET
Project No.: 11806-007
Test No.:
Technician: S. KUMAR

Date Required: ASAP
Sample Type: TLS
Number of Samples: 1

Rej	Sample Description	Weight	Pulv	Analytical Requirements: PRE ICP							Size
1	XPS PP COMP 2	TLS		X							
2											
3											
4											
5	AS PER										
6											
7	LIMS 03020-N0010										
8											
9											
10	EXCEPT										
11											
12	NO "P"	ANALYSIS									
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											

Prepared by: _____ Date: _____ Time: _____
Comments: _____

SGS

Lakefield Research Sample Control Sheet for Pulp Samples

LIMS Number:
Date Prepared: DEC 17/10
Department: ENVIROMET
Project No.: 11E06-007
Test No.:
Technician: B. BOWMAN

Date Required: ASAP
Sample Type: ORE
Number of Samples: 2

Rej	Sample Description	Weight	Pulv	Analytical Requirements: ICP								Size
1	XPS PP COMP 2	HEAD		X								
2	XPS PP COMP 3	HEAD		X								
3												
4												
5	AS PER											
6												
7	LIMS 02784-DEC10											
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												

Prepared by: _____ Date: _____ Time: _____

Comments: _____

_____

Lakefield Research Sample Control Sheet for Pulp Samples

LIMS Number:
Date Prepared: NOV 3/10
Department: ENVIROMET
Project No.: 11806-007
Test No.:
Technician: B. BOWMAN

Date Required: ASAP
Sample Type: TLS, CONC, ORE
Number of Samples: 16

Rej	Sample Description	Weight	Pulv	WASH SIEVE	Analytical Requirements	Size
1	MASTER COMP 3			X		
2	F25 COMB TLS			X		
3	F28 COMB TLS			X		
4	F29 COMB TLS			X		
5	MASTER CONC			X		
6	MASTER TLS BLEND			X		
7	AVALON HEADSAMPLE 1			X	SIEVES REQUIRED	
8	F33 MOZLEY CONC COMP			X		
9	F33 COMB TLS			X		
10	AVALON HEAD SAMPLE 2			X	3/8"	
11	F36 MOZLEY CONC COMP			X	#4	
12	F36 COMB TLS			X		
13	AVALON HEADSAMPLE 3			X	* #9 = 2.00 mm	
14	F37 MOZLEY CONC COMP			X	#20	
15	F37 COMB TLS			X	#35	
16	~~ABF~~			X	#65	
17	XPS PP COMP1 CONC			X	#100	
18					#200	
19						
20						
21						
22						
23						
24				*	MUST HAVE THIS SIEVE	
25						
26						

Prepared by: _____ Date: _____ Time: _____
Comments: _____

Lakefield Research Sample Control Sheet for Pulp Samples

LIMS Number:
Date Prepared: NOV 3/10
Department: ENVIROMET
Project No.: 11806-007
Test No.:
Technician: B. BOWMAN

Date Required: ASAP
Sample Type: TLS, CONC, ORE
Number of Samples: 16

Rej	Sample Description	Weight	Pulv	55 Analytical Requirements								Size
1	MASTER COMP 3			X								
2	F25 COMB TLS			X								
3	F28 COMB TLS			X								
4	F29 COMB TLS			X								
5	MASTER CONC BLEND			X								
6	MASTER TLS BLEND			X								
7	AVALON HEAD SAMPLE 1			X								
8	F33 MOZLEY CONC COMP			X								
9	F33 COMB TLS			X								
10	AVALON HEAD SAMPLE 2			X								
11	F36 MOZLEY CONC COMP			X								
12	F36 COMB TLS			X								
13	AVALON HEAD SAMPLE 3			X								
14	F37 MOZLEY CONC COMP			X								
15	F37 COMB TLS			X								
16	XPS PP COMP1 CONC			X								
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												

Prepared by: _____ Date: _____ Time: _____
Comments: _____

Lakefield Research Sample Control Sheet for Pulp Samples

LIMS Number:
Date Prepared: NOV 5/10
Department: ENVIROMET
Project No.: 11806-007
Test No.:
Technician: B. BOWMAN

Date Required: ASAP
Sample Type: ORES
Number of Samples:

Rej	Sample Description	Weight	Pulv	Analytical Requirements	Size
1	MASTER COMP 3			PULVERIZED	
2	AVALON HEAD SAMPLE 3				
3	AVALON HEAD SAMPLE 2				
4	AVALON HEAD SAMPLE 1				
5	MASTER COMP 3				
6				RETURN TO	
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
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21					
22					
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24					
25					
26					

RETURN TO SAR

Prepared by: Kevin Lorenda Date: Nov 5/10. Time: 1 30 pm.
Comments:

Lakefield Research Sample Control Sheet for Pulp Samples

LIMS Number:
Date Prepared: NOV 22/10
Department: ENVIROMET
Project No.: 11806-007
Test No.:
Technician: B BOWMAN

Date Required: ASAP
Sample Type: TLS
Number of Samples: 1

Rej	Sample Description	Weight	Pulv	Analytical Requirements (SG, WASH SIEVE)								Size
1	XPS PP COMP1	TLS		X	X							
2												
3												
4												
5												
6												
7												
8	SIEVES REQUIRED											
9												
10	#9 = 2.00 mm (*)											
11	#20											
12	#35											
13	#65											
14	#100											
15	#200											
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												

Prepared by: _____ Date: _____ Time: _____

Comments: _____

Lakefield Research Sample Control Sheet for Pulp Samples

LIMS Number:
Date Prepared: DEC 16/10
Department: ENVIROMET
Project No.: 11806-007
Test No.:
Technician: B. BOWMAN

Date Required: ASAP
Sample Type: TLS
Number of Samples: 1

Rej	Sample Description	Weight	Pulv	Analytical Requirements: SG w/ 1st sieve								Size
1	XPS PP COMP 2 TLS			X	X		2.82					
2												
3												
4												
5												
6	SIEVES	REQUIRED										
7												
8	#9 = 2.00 mm			(*)								
9	#20											
10	#35											
11	#65											
12	#100											
13	#200											
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												

Prepared by: _____ Date: _____ Time: _____

Comments: _____

_____

Lakefield Research Sample Control Sheet for Pulp Samples

LIMS Number:
Date Prepared: DEC 17/10
Department: ENVIROMET
Project No.: 11806-007
Test No.:
Technician: B. BOWMAN

Date Required: ASAP
Sample Type: ORE
Number of Samples: 2

Rej	Sample Description	Weight	Pulv	Analytical Requirements: WASH SIEVE								Size
1	XPS PP COMP 2	HEAD		X								
2	XPS PP COMP 3	HEAD		X								
3												
4												
5	SIEVES REQUIRED											
6												
7	1/2"											
8	3/8"											
9	#4											
10	#9 = 2.00 mm			(*) ← need this one								
11	#20											
12	#35											
13	#65											
14	#100											
15	#200											
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												

Prepared by: _____ Date: _____ Time: _____
Comments: _____

Lakefield Research Sample Control Sheet for Pulp Samples

LIMS Number:
Date Prepared: DEC 17/10
Department: ENVIROMET
Project No.: 11806-007
Test No.: ~~11806-007~~
Technician: S BOWMAN

Date Required: ASAP
Sample Type: ORE
Number of Samples: 2

Rej	Sample Description	Weight	Pulv	Analytical Requirements SG								Size
1	XPS PP COMP 2 HEAD			X		2.97						
2	XPS PP COMP 3 HEAD			X		2.91						
3												
4												
5												
6												
7												
8												
9												
10												
11												
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22												
23												
24												
25												
26												

Prepared by: _____ Date: _____ Time: _____
Comments: _____

Attachment 3

Avalon Rare Metals Inc.

FAILURE MODE AND EFFECTS ANALYSIS FOR THE THOR LAKE PROJECT, NORTHWEST TERRITORIES

Submitted To:
MACKENZIE VALLEY LAND AND WATER BOARD

September 2011

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DEFINITIONS

Accident	An accident is an unplanned event which leads to system or component failure. An accident could be a result of a specific initiating event or cause. Examples of accidents include extreme weather, human error and traffic accidents. Prevention measures could be implemented to decrease the likelihood of an accident and mitigating measures could be implemented to reduce the effects of an accident.
Component Failure	A component failure within the Thor Lake Project occurs when one or more parts or components of a system can no longer perform its function as required.
Detection (D)	Detection is sometimes termed effectiveness. It is a numerical subjective estimate of the effectiveness of the controls to prevent or detect the cause or failure mode before the failure reaches the customer. The assumption is that the cause has occurred.
Failure Cause	The physical or chemical processes, design defects, quality defects, part misapplication or other processes which are the basic reason for failure or which can initiate the physical process by which deterioration proceeds to failure. (Past)
Failure Effect	The consequence of a failure mode upon the operation, function or status of a system or equipment. (Future)
Failure Mode	The way in which a failure is observed, describes the way the failure occurs, and its impact on equipment operation. (Present)
Failure Scenario	A failure scenario is a specific sequence of events starting with an initiating event or cause which leads to system or component failure and corresponding impacts from that failure.
Initializing Event/ Cause	An initializing event or cause is the root of all failure scenarios and is the cause of system or component failure. An initiating event can lead to either an accident or malfunction and includes natural events, technological causes, or human error.
Malfunction	A malfunction is the failure of a system, component or sub-component (e.g., equipment) to function in a manner for which it was intended. A malfunction can result from an initiating event or cause as defined above.
Occurrence (O)	Occurrence or sometimes termed likelihood, is a numerical subjective estimate of the likelihood that the cause, if it occurs, will produce the failure mode and its particular effect.
Risk Priority Number (RPN)	Provides an alternate evaluation approach to Criticality Analysis. The risk priority number provides a qualitative numerical estimate of design risk. RPN is defined as the product of three independently assessed factors: Severity(S), Occurrence (O) and Detection (D). RPN = (S) * (O) * (D)

DEFINITIONS

Severity (S)	Severity is a numerical subjective estimate of how severe the Developer or public will perceive the effect of a failure. Considers the worst possible consequence of a failure classified by the degree of injury, property damage, system damage and loss that could occur.
System Failure	A system failure within the Giant Mine Remediation project is a major design or operating system that can no longer perform its function as required. System failures have the largest impact on the integrity of the project and are major remediation design elements. Each system has the potential to fail through a variety of initiating events or causes.

1.0 INTRODUCTION

The Thor Lake Project (TLP or the Project) is a proposed rare earth mine currently in the exploration phase. The Developer's Assessment Report (DAR) Thor Lake Project, Northwest Territories (Avalon 2011) is currently under review by the Mackenzie Valley Environmental Impact Review Board (MVEIRB). The DAR describes the life of the Project, including potential environmental and socio-economic effects, mitigation measures, and accidents and malfunctions. Section 9.0 of the DAR describes the potential accidents and malfunctions that could occur during the life of the Project.

1.1 PURPOSE AND SCOPE

As requested by the MVEIRB, Avalon has completed a Failure Mode and Effects Analysis (FMEA) or best practices risk assessment for the Project, based on the potential for events listed in Section 9.0 (Accidents and Malfunctions) of the DAR.

The original Terms of Reference (MVEIRB 2011a) for this item was as follows:

3.5 Accidents and malfunctions

6.. Conduct a best-practice risk assessment for the project, exploring the potential for events listed in points 1 through 5. Discuss systems, components, hazards and associated failure modes. The developer will assess likelihood and severity of each risk identified from the points 1-5 [in this section].

The deficiency identified by MVEIRB (2011b) is as follows:

- *A best practice risk assessment is required in this section particularly for the events listed in points 1-5 in this section. This information has not been provided in the DAR. Please provide a risk assessment for the project including likelihood and severity of each potential accident and malfunction event described in points 1 -5.*

2.0 RISK ASSESSMENT FRAMEWORK

2.1 RISK TIMELINE

For the purpose of this assessment, the risk timeline is defined as risks which occur during the construction, operations, and reclamation phases of the Thor Lake Project, an approximate period of 25 years. This timeline starts once the Project receives approval from MVEIRB and ends when reclamation and monitoring ceases. The duration of this timeline may vary depending on the total construction, operations and reclamation periods.

Risks are limited to what the assessment team can predict during that period of time. The longer terms risks would require re-evaluation should unforeseen events occur or new remediation technologies emerge.

2.2 ASSUMPTIONS

The following assumptions were used during the risk analysis.

2.2.1 Permits

It is assumed that all required permits and authorizations will be attained, without delay, prior to the start of the applicable Project phase, and that the conditions of these permits will be complied with.

2.2.2 Delays

Delays in the Project and the risks to the Project as a result of delays have not been assessed.

2.2.3 Worker Health and Safety

The health and safety of workers is not included in this assessment, as it is assumed that all tasks will be performed by appropriately trained staff in accordance with applicable regulations.

2.2.4 Mitigation Measures

Mitigation measures will be implemented fully, as described in the DAR.

2.3 POTENTIAL INITIATING EVENTS

MVEIRB (2011a) described several potential accident or malfunction scenarios that require risk analysis. These events include:

1. Predict the effects to water quality from a complete overturning of all barges during a typical Great Slave Lake transit of a barge-train fully-loaded with concentrate, at various points along the barge corridor between Thor Lake and the delivery point on the south shore of Great Slave Lake.

2. Describe and predict the potential impacts to the local water quality of Great Slave Lake from concentrate spillage at both barge loading/unloading sites, both in the short term and over the life of the mine.

3. Discuss what could leach from Avalon's frozen-concentrate transport container if left to thaw over a summer season or during a temporary shutdown of operations. Also discuss the likelihood of that happening over the course of a transport season and suggested mitigations to prevent any impacts.

4. Describe consequences of accidents, malfunctions, or "impacts of the environment on the development" that may affect water quality and quantity and the ability of the water management system to function. For both sites the following scenarios, at a minimum, will be considered:

    - extreme short-term precipitation events, snowpack buildup or other factors leading to flooding events;

- geologic instability or seismic activity causing slope failures at or near either project site, including impacts on the site workings, or of the tailings management facilities.
- failure of existing dams/containment structures, tailings management facilities at both sites;
- freezing effects on pipelines or other water transportation systems;
- interaction of water with improperly mixed or cured paste backfill;
- how mine water will be managed if the water treatment system malfunctions, with a focus on retention capacity timelines for water storage facilities and contingency water treatment plans;
- potential impacts to water from accidents in transport of processing chemicals and other dangerous goods;
- potential impacts to water from tailings spills or leaks; and
- potential impact to any valued components from any spill of any product.

5. Predict the effects to fish and fish habitat from the above situations and other potential impacts to water quality from accidents or malfunctions.

2.4 APPLICABLE SYSTEMS AND COMPONENTS AT THOR LAKE PROJECT

The following systems have been identified as the major systems and associated components/ subcomponents of the Thor Lake Project related to the specific potential initiating events identified by MVEIRB (2011a, 2011b) that require consideration.

1. Transportation System
    a. Barges
    b. Container
    c. Truck
    d. Fuel
2. Water Management System
    a. Water Storage
    b. Pipeline
    c. Tailings Management System
3. Tailings Management System
    a. Pipeline
    b. Dam
    c. Spillways
4. Underground System
    a. Backfill

5. Freeze System
    a. Frozen Concentrate
    b. Intentional Thaw
    c. Containers

2.5 RISK ASSESSMENT METHODS

The following sections describe the methods used to assess risk over the short and long term that have the potential to lead to system or component failure and consequential losses. These methods review the initiating events or causes identified by MVEIRB (2011a, 2011b) and identify the potential impacts of system or component failures. Failure scenarios for each system are then assessed for their overall risk priority by calculating the severity, occurrence, and detection of events based on their potential effects to the Project's operations.

To identify risk priority numbers, the Developer and its consultants used past experience and engineering judgment to rate each potential problem according to three rating scales: severity, occurrence and detection. Where appropriate, a description of possible mitigation measures is included and a reassessment of the residual risk is completed.

A systematic analysis was conducted to identify conditions and/or factors that relate to an initiating event and contribute to potential failures or negative effects. In this method, there is one initiating event with connecting accidents or malfunctions that lead to system or component failures.

The following steps outline the Failure Scenario Analysis process:

1. Define the event;
2. Identify the assumptions;
3. Understand the system and components;
4. Analyze the failure causes and effects;
5. Classify the failure effects by severity, occurrence and detection;
6. Identify failure scenario prevention and mitigation measures; and
7. Reanalyze the residual risks following implementation of mitigation measures.

As stated previously, the scope of the analysis was limited to the potential accident or malfunction scenarios defined by MVEIRB in the Terms of Reference (MVEIRB 2011a).

2.5.1 Risk Prediction

To predict the risk, the severity, occurrence and detection ratings were identified to calculate an overall risk priority number.

Severity is determined based on specific criteria that are ranked from 1 to 10 (Table 1), with the higher number representing the increasing seriousness or risk.

TABLE 1: SEVERITY SCALE

Rating	Description
1	No Effects (on system or operation)
2	Very Low or Very Minor (system or component operable at reduced performance)
3	Low or Minor (gradual operational degradation, affects very little)
4/5/6	Moderate (causes some loss of operational function)
7/8	High (causes a loss of primary operational function)
9/10	Very High or Catastrophic (system or component is inoperative, the failure may result in unsafe operation and possible injury)

Occurrence is calculated by identifying the cause of a failure mode and the number of time it occurs (Table 2). This is identified by comparing similar systems and components and the failure modes that have been documented for them.

TABLE 2: OCCURRENCE SCALE

Rating	Description
1	No known occurrences on similar systems and components
2/3	Low (relatively few failures)
4/5/6	Moderate (occasional failures)
7/8	High (repeated failures)
9/10	Very High (failure is almost inevitable)

Detection is derived by identifying how likely it is that a failure is detected once it occurs (Table 3); this determines the overall effectiveness of the system. Detection is based on several factors:

- Identifying testing, analysis, monitoring and other techniques used on similar systems to detect failures; and
- Understanding the current controls of the system that prevent failure modes from occurring, or that detect failure.

Detection ranks the ability of planned tests and inspections to remove defects or detect failure modes in time. The assigned detection number measures the risk that the failure will escape detection. A high detection number indicates that the chances are high that the failure will escape detection, or in other words, that the chances of detection are low.

TABLE 3: DETECTION SCALE	
Rating	**Description**
1	Certain (fault will be detected during test/ monitoring)
2	Almost Certain
3	High
4/5/6	Moderate
7/8	Low
9/10	Fault will pass undetected

2.5.2 Risk Evaluation

Risk priority numbers (RPNs) are threshold values for the evaluation of actions and are calculated using the following equation:

Risk Priority Number = Severity x Occurrence x Detection

RPNs are calculated for the set of systems and components identified within the scope of this report. The failure modes that have the highest RPN are typically given the highest priority for corrective action. Recommended actions and mitigation measures are identified following the calculation of RPNs.

2.5.3 Risk Reporting

Results from the analysis are documented in the Failure Mode Effects Analysis table (Table 4) that includes the following information:

- Process Step;
- Potential Failure Mode;
- Potential Failure Effects;
- Severity;
- Potential Causes;
- Occurrences;
- Current Controls;
- Detection;
- Risk Priority Number;
- Actions Recommended;
- Responsible Party(ies); and
- Residual Severity, Occurrence, Detection and Risk Priority Number.

3.0 RISK ASSESSMENT

Table 4 identifies the risks based on the scenarios provided by MVEIRB (2011a).

Table 4: Failure Mode and Effects Analysis

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Process Step	Potential Failure Mode	Potential (Operational) Failure Effects	Severity	Potential Causes	Occurrence	Current Controls	Detection	Risk Priority #	Actions Recommended	Responsible Party(ies)	Residual Severity	Residual Occurrence	Residual Detection	Residual Risk Priority #
Barging	Barge sinks	Concentrate spills into Great Slave Lake	2	High winds/ High waves	2	Barge constrained from travelling when high winds predicted	1	4	Barging operations restricted to fair weather.	Barging Contractor/ Avalon	2	1	1	2
Barging	Damage to fuel tank	Fuel spills into Great Slave Lake	3	Collision with tug, other barge, or dock	3	Design of fuel tanks to minimize potential for spill; barge constrained from travelling when high winds predicted.	2	18	Barging operations restricted to fair weather; immediate inspection for damage and reporting of spill; implementation of spill response procedures in accordance with Spill Contingency Plan	Barging Contractor/ Avalon	3	2	1	6
Storage of Concentrate in Containers	Damage to container on land during transit or during storage	Concentrate spills onto land	2	Truck rollover or collision	2	Proper loading and unloading; comply with traffic management/ speed limits	1	4	Proper loading and unloading; comply with traffic management/ speed limits	Trucking Contractor/ Avalon	2	2	1	4
Storage of Concentrate in Containers	Container leaks	Potential release of concentrate leachate from container onto land	2	Container integrity flaw	2	Maintain low moisture specification in concentrate (as per DAR); regular inspection of containers	3	12	Regular inspection of containers to confirm integrity	Trucking Contractor/ Avalon	2	2	2	8
Storage of Concentrate in Containers	Container leaks	Potential release of concentrate leachate from container onto land	2	Freeze/thaw cycles cause container to crack	2	Maintain low moisture specification in concentrate (as per DAR); regular inspection of containers	3	12	Regular inspection of containers to confirm integrity	Trucking Contractor/ Avalon	2	2	2	8
Tailings Storage	Tailings dam failure	Tailings are released into downstream waterbodies; temporary interruption to tailings management	5	Design/ construction flaw	3	Design/construct dam as per Canadian Dam Safety Guidelines	1	15	Regular inspection of dams and instrumentation installed to detect movements, deformation, etc.	Avalon	5	3	1	15
Tailings Storage	Tailings dam failure	Tailings are released into downstream waterbodies; temporary interruption to tailings management	5	Permafrost thaw	3	Excavate shallow permafrost to bedrock prior to dam construction	1	15	Regular inspection of dams and instrumentation installed to detect movements, deformation, etc.	Avalon	5	2	1	10
Tailings Transport (Pipeline)	Damage to pipeline or pipeline failure	Tailings are released into downstream waterbodies; temporary interruption to tailings management	4	Pipe integrity flaw	3	Design/ construct pipeline in accordance with northern mining practices	5	60	Regular inspection of pipeline to confirm integrity; use customized pipes for northern use	Avalon	4	3	2	24
Tailings Transport (Pipeline)	Damage to pipeline or pipeline failure	Tailings are released into downstream waterbodies; temporary interruption to tailings management	4	Pipeline design/ construction flaw	1	Design/ construct pipeline in accordance with northern mining practices	5	20	Regular inspection of pipeline to confirm integrity; use customized pipes for northern use	Avalon	4	3	2	24
Tailings Transport (Pipeline)	Damage to pipeline or pipeline failure	Tailings are released into downstream waterbodies; temporary interruption to tailings management	4	Freezing of pipeline	5	Design/ construct pipeline in accordance with northern mining practices	5	100	Regular inspection of pipeline to confirm integrity; use customized pipes for northern use	Avalon	4	3	2	24
Resource Extraction Optimization and Tailings Management	Interaction with improperly mixed or cured paste backfill	Temporary, minor increase in groundwater pH; delay in mining of pillars until safe to proceed	2	Poor mixing practices	3	Adequate characterization of tailings; conformance with engineering standards for producing backfill	2	12	Regular inspection of paste backfill prior to pumping to underground; regularly inspect the hardened backfill to confirm safety and integrity	Avalon/ Paste Backfill Contractor	2	2	2	8
Effects of Environment on Project	Barge sinks	Concentrate spills into Great Slave Lake	2	High winds	2	Barge constrained from travelling when high winds predicted	1	4	Barging operations restricted to fair weather.	Barging Contractor/ Avalon	2	1	1	2
Effects of Environment on Project	Tailings dam failure	Tailings are released into downstream waterbodies; temporary interruption to tailings management	5	Extreme precipitation	2	Design to northern conditions and conform with applicable standards, guidelines, and industry best management practices	1	10	Design to northern conditions and conform with applicable standards, guidelines, and industry best management practices. Regular inspection of dams and instrumentation installed to detect movements, deformation, etc.	Avalon	5	2	1	10
Effects of Environment on Project	Tailings dam failure	Tailings are released into downstream waterbodies; temporary interruption to tailings management	5	Climate change causing permafrost thaw	3	Excavate shallow permafrost to bedrock prior to dam construction	1	15	Regular inspection of dams and instrumentation installed to detect movements, deformation, etc.	Avalon	5	2	1	10
Effects of Environment on Project	Tailings dam and pipeline failure	Tailings are released into downstream waterbodies; temporary interruption to tailings management	5	Seismic event	0	Design to northern conditions and conform with applicable standards, guidelines, and industry best management practices	1	0	Regular inspection of dams and instrumentation installed to detect movements, deformation, etc.	Avalon	5	0	1	0

4.0 RISK ASSESSMENT RESULTS

According to the analysis, the process step with the highest potential for failure following implementation of mitigation measures is the tailings transport via the pipeline. The risks associated with pipeline transport, although generally low, would cause the greatest effect of these scenarios. As per the DAR, the effect of tailings released into downstream waterbodies would cause a minimal environmental effect; however, the effects to mining operations would be moderate should the pipeline failure cause delays in mine production. The potential effects will be minimized through implementation of mitigation measures, as discussed in the DAR.

5.0 CLOSURE

The Failure Mode and Effects Analysis was prepared by Avalon Rare Metals Inc. and EBA, A Tetra Tech Company. Participants included:

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