

MEMORANDUM

Recipient: Phil Scott – Preston Consulting

From: Josh Pearce - MWM

Date: 13 March 2020

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Document Title: Arrowsmith Acid Base Accounting Analysis

Mine Waste Management Pty Ltd (MWM) was engaged by Preston Consulting Pty Ltd to complete an acid base accounting (ABA) analysis of five composited samples from VRX Silica Pty Ltd's (VRX) proposed Arrowsmith Silica Sands Project. This memorandum details the findings of the ABA analysis results provided.

BACKGROUND

The proposed Arrowsmith North Silica Sands project is located approximately 280 km north of Perth in the Geraldton Sandplain bioregion of Western Australia (Figure 1; Preston Consulting, 2020). The high-grade silica sand will be mined via extraction and mechanical upgrading. Mining will occur in 2.25 ha sections to an approximate depth of 8-15 m. Mined sand will be pumped to a processing plant where it is upgraded to commercial grade sand. Mined areas will be revegetated progressively by direct vegetation transfer. Clay tailings will be pumped back to the mine face and respread or recombined with sand as part of the progressive rehabilitation procedure.

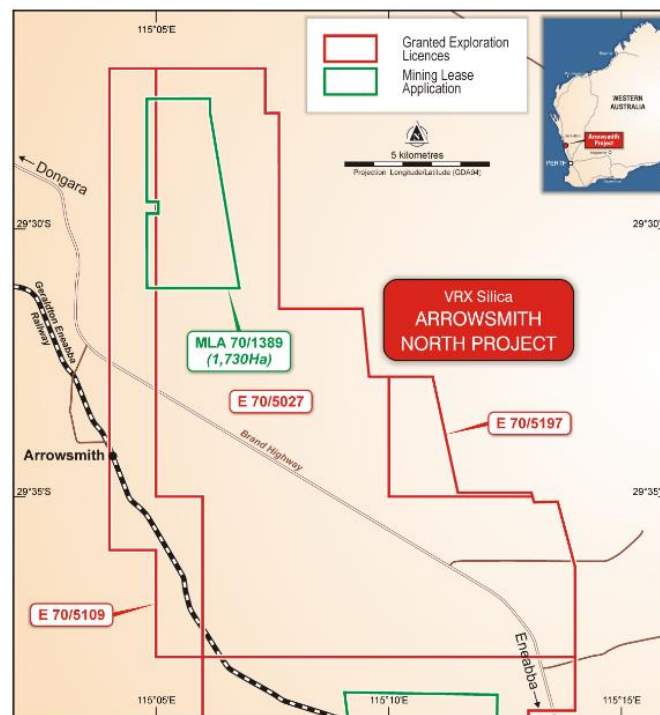


Figure 1: Regional setting and tenure of the proposed North Project. Most northern aspect of the Central Project mining lease boundary at bottom of figure.

SAMPLE DETAILS

Results of five composite samples were provided to MWM for analysis (Attachment A). These composites were made from a total of 15 primary samples (Table 1) collected from three drill holes across five cross-sections, spanning two mining leases (Figure 2). Sample depths for primary samples were not provided.

Table 1: Primary and composite sample details.

PRIMARY SAMPLE ID	SAMPLE TYPE	COMPOSITE SAMPLE ID	PROJECT AREA (MINING LEASE)
CB09996A	Pulp		
CB09977A	Pulp	ANARD Comp01	North Project (M70/1389)
CB10044A	Pulp		
CB10458A	Pulp		
CB10486A	Pulp	ANARD Comp02	North Project (M70/1389)
CB10515A	Pulp		
CB10782A	Pulp		
CB10811A	Pulp	ANARD Comp03	North Project (M70/1389)
CB10831A	Pulp		
CB11237A	Pulp		
CB11250A	Pulp	ACARD Comp01	Central Project (M70/1392)
CB11267A	Pulp		
CB11277A	Pulp		
CB11287A	Pulp	ACARD Comp02	Central Project (M70/1392)
CB11301A	Pulp		

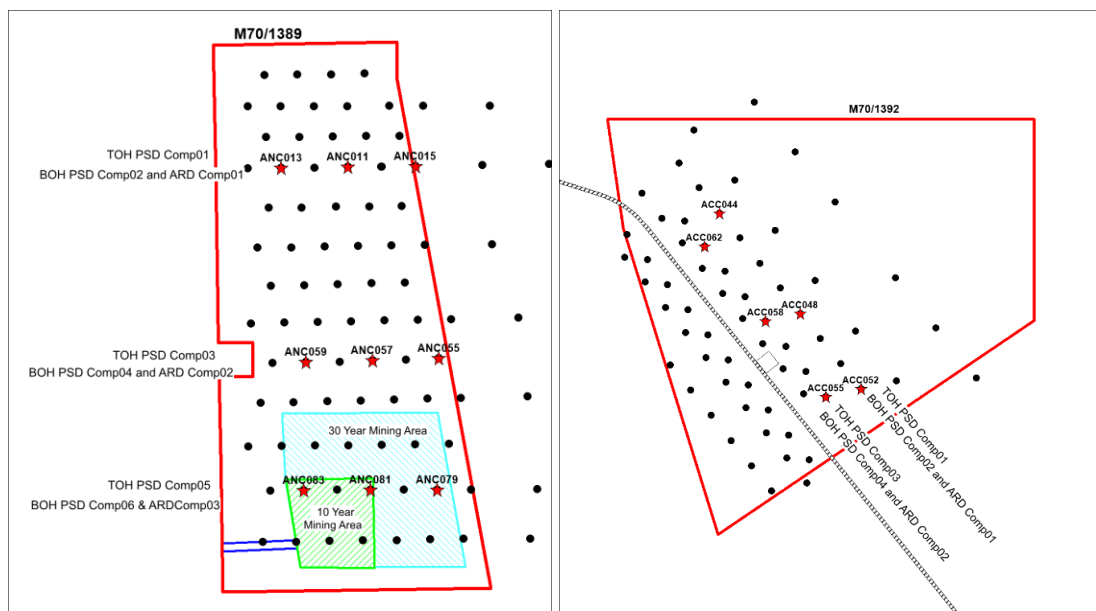


Figure 2: Location of drill holes from which primary samples were collected. Left Plate = North Project; Right Plate = Central Project.

LABORATORY METHODS

Each of the five composite samples were analysed for:

- Rinse pH/EC (1:5 solid to deionised water ratio);
- Total sulfur (TS) and total carbon (TC) (induction furnace, e.g. LECO);
- Acid neutralising capacity (ANC) (volumetric titration based on AMIRA 2002 method); and
- Net acid generation (NAG) testing (AMIRA, 2002).

ACID BASE ACCOUNTING METHOD

Acid base accounting (ABA) was conducted to predict the acid generation characteristics of geological waste material through determination of the acid neutralising capacity (ANC) and the maximum potential acidity (MPA). Although analysis of pH using distilled water is not a standard ABA test, it was completed to aid in the interpretation of the ABA data as ancillary information.

The net acid production potential (NAPP) is a measure of the samples overall acid generating capacity and was calculated by subtracting the ANC of the sample from the MPA. A negative NAPP indicates that the sample has a net neutralising capacity and a positive NAPP indicates that the sample has a net acid generating capacity. NAPP, MPA, and ANC are expressed in kg H₂SO₄/tonne equivalent.

ANC was determined by acid digestion (using HCl) of the sample followed by back-titration (using NaOH) to determine the quantity of acid consumed by neutralising minerals within the rock sample. MPA was based on total wt% sulfur multiplied by the stoichiometric conversion factor 30.6. This conversion factor is determined from the stoichiometry of pyrite oxidation. NAPP was calculated from the below equation (all units are in kg H₂SO₄/tonne):

Equation: $NAPP = MPA - ANC$

Thus, potentially acid forming (PAF) rocks have a positive NAPP and non-acid forming (NAF) rocks have a negative NAPP. The addition of net acid generation (NAG) testing data often facilitates further refinement of the ABA approach through the application of the AMIRA Classification System (AMIRA, 2002). Acid generation potential guidelines for evaluating acid forming potential of mine wastes presented by AMIRA are summarised in Table 2. (AMIRA, 2002). The AMIRA guidelines are commonly used in Australasia.

Table 2: AMIRA acid generating classification system.

CLASSIFICATION	CRITERIA	COMMENTS
Potentially Acid Forming (PAF)	NAPP > 0 NAG pH < 4.5	Sample always has a significant sulfur content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material.
Non-Acid Forming (NAF)	NAPP < 0 NAG pH ≥ 4.5	Sample may, or may not, have a significant sulfur content but the ANC availability is more than adequate to neutralise the acid that theoretically could be produced.
Uncertain (UC)	NAPP > 0 NAG pH ≥ 4.5 NAPP < 0 NAG pH < 4.5	An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results. Uncertain samples are generally given a tentative classification that is shown in brackets e.g. UC (NAF).

RESULTS

Results of the ABA analysis and AMD classification are given in Table 3. Key findings include:

- Samples are devoid of both acid generating and neutralising potential as demonstrated by total sulfur values less than reporting limit for all samples and ANC equal to or less than 1 kg H₂SO₄/t in all samples.
- When combining NAPP and NAG pH results as per the AMIRA classification system, all samples are classified as non-acid forming (NAF). Although a NAPP value was not calculated for ANARD Comp01 due to both TS and ANC being below the limit of reporting, this sample represents a low risk of generating acidity and can be considered NAF.
- Rinse pH and electrical conductivity (EC) results demonstrate slightly acidic (5.5-6.5) fresh leachates (e.g. negligible salinity).

Table 3: ABA results and AMIRA acid generation classifications.

COMPOSITE ID	pH _{1.5}	EC _{1.5}	TS	TC	MPA	ANC	NAPP	NAG pH	AMIRA CLASS.
	-	µS/cm	wt%			(kg H ₂ SO ₄ /t)		-	
ANARD Comp01	5.9	22	<0.01	0.05	<0.3	<1	N/A	5.2	NAF
ANARD Comp02	6.2	28	<0.01	0.03	<0.3	1	-1	5.4	NAF
ANARD Comp03	6.2	45	<0.01	0.05	<0.3	1	-1	5.5	NAF
ACARD Comp01	5.7	27	<0.01	0.03	<0.3	1	-1	5.5	NAF
ACARD Comp02	5.7	25	<0.01	0.01	<0.3	1	-1	5.3	NAF

**AMIRA acid generation classifications.*

Half the limit of reporting was used for MPA and NAPP calculations. Where both MPA and ANC are below the limit of reporting, NAPP was not calculated.

CONCLUSIONS

The five Arrowsmith composite samples analysed all represent a low acidic drainage risk. The observed lack of acid generation and neutralisation capacity is in line with expectations for material collected from a silica sand deposit. Rinse EC results suggest a low risk of generating saline drainage.

CLOSING REMARKS

We thank Preston Consulting for the opportunity to provide this memorandum. Please do not hesitate to contact Josh Pearce at +61 409 882 823 or josh.pearce@minewaste.com.au should you wish to discuss our memorandum in greater detail.

Attachments: Attachment A – Laboratory Certificates

REFERENCES

AMIRA, 2002. ARD Test Handbook - Project P387A Prediction and Kinetic Control of Acid Mine Drainage. AMIRA International Limited. Melbourne, Australia.

Preston Consulting, 2020 Arrowsmith PD - The Proposal (UNPUBLISHED). Preston Consulting Pty Ltd, East Perth, WA.

ATTACHMENT A – LABORATORY CERTIFICATES

MINERALS TEST REPORT

CLIENT	BRUCE MALUISH VRX SILICA PO Box 1925 WEST PERTH, W.A. 6872 AUSTRALIA
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JOB INFORMATION	JOB CODE : 1602.0/2001851 NO. SAMPLES : 20 NO. ELEMENTS : 14 CLIENT ORDER NO. : Arrowsmith ARD and PSD (Job 1 of 1) SAMPLE SUBMISSION NO. : Arrowsmith ARD and PSD PROJECT : ARROWSMITH SAMPLE TYPE : Ex-Pulp DATE RECEIVED : 04/02/2020 DATE TESTED : 07/02/2020 - 13/02/2020 DATE REPORTED : 13/02/2020 DATE PRINTED : 13/02/2020
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REPORT NOTES

TESTED BY

Intertek
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 PO Box 144, Gosnells 6990, Western Australia
 Tel: +61 8 9251 8100
 Email: min.aus.per@intertek.com

APPROVED SIGNATURE FOR

Craig RITCHIE
 Operations Manager - Perth

This report relates specifically to the sample(s) tested that were drawn and/or provided by the client or their nominated third party to Intertek. The reported result(s) provide no warranty or verification on the sample(s) representing any specific goods and/or shipment. This report was prepared solely for the use of the client named in this report. Intertek accepts no responsibility for any loss, damage or liability suffered by a third party as a result of any reliance upon or use of this report. The results provided are not intended for commercial settlement purposes.

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SIGNIFICANT FIGURES

It is common practice to report data derived from analytical instrumentation to a maximum of two or three significant figures. Some data reported herein may show more figures than this. The reporting of more than two or three figures in no way implies that figures beyond the least significant digit have significance.

For more information on the uncertainty on individual reported values, please contact the laboratory.

SAMPLE STORAGE

All solid samples (assay pulps, bulk pulps and residues) will be stored for 60 days without charge. Following this, samples will be stored at a daily rate until clients' written advice regarding return, collection or disposal is received. If storage information is not supplied on the submission, or arranged with the laboratory in writing, the default will be to store the samples with the applicable charges. Storage is charged at \$4.00 per m³ per day, expenses related to the return or disposal of samples will be charged at cost. Current disposal cost is charged at \$150.00 per m³.

Samples received as liquids, waters or solutions will be held for 60 days free of charge then disposed of, unless written advice for return or collection is received.

LEGEND				
	X	= Less than Detection Limit	NA	= Not Analysed
	SNR	= Sample Not Received	UA	= Unable to Assay
	*	= Result Checked	>	= Value beyond Limit of Method
	DTF	= Result still to come	+	= Extra Sample Received Not Listed
	IS	= Insufficient Sample for Analysis		



ELEMENTS	ANC	C	ColourChange	EC	Final-pH	Fizz-Rate
UNITS	kgH2SO4/t	%	NONE	uS/cm	NONE	NONE
DETECTION LIMIT	1	0.01	0	0.01	0.1	1
DIGEST	ANCx/		ANCx/	Ws/	ANCx/	ANCx/
ANALYTICAL FINISH	VOL	/CSA	QUAL	MTR	MTR	QUAL
SAMPLE NUMBERS						
0001 ANARD Comp01	X	0.05	No	22.00	1.7	X
0002 ANARD Comp02	X	0.03	No	28.00	1.7	X
0003 ANARD Comp03	X	0.05	No	45.00	1.7	X
0004 ACARD Comp01	X	0.03	No	27.00	1.7	X
0005 ACARD Comp02	X	0.01	No	25.00	1.7	X
CHECKS						
0001 ACARD Comp01	X	0.03	No		1.7	X
0002 ACARD Comp02						
0003 ANARD Comp03				47.00		
STANDARDS						
0001 ANC-3	97				1.9	
0002 NAG Std 3						
0003 GWS-3				322.00		
0004 OREAS 24b		0.18				
BLANKS						
0001 Control Blank	X	X			1.6	
0002 Control Blank						
0003 Control Blank				1.00		



ELEMENTS	MPA	NAG	NAGpH	NAG(4.5)	NAPP	pH
UNITS	kgH2SO4/t	kgH2SO4/t	NONE	kgH2SO4/t	kgH2SO4/t	NONE
DETECTION LIMIT	1	1	0.1	1	1	0.1
DIGEST		NAGx/	NAGx/	NAGx/		Ws/
ANALYTICAL FINISH	/CALC	VOL	MTR	VOL	/CALC	MTR
SAMPLE NUMBERS						
0001 ANARD Comp01	X	4	5.2	X	X	5.9
0002 ANARD Comp02	X	5	5.4	X	X	6.2
0003 ANARD Comp03	X	5	5.5	X	X	6.2
0004 ACARD Comp01	X	4	5.5	X	X	5.7
0005 ACARD Comp02	X	5	5.3	X	X	5.7
CHECKS						
0001 ACARD Comp01	X				X	
0002 ACARD Comp02		5	5.2	X		
0003 ANARD Comp03						6.1
STANDARDS						
0001 ANC-3						
0002 NAG Std 3		24	2.5	21		
0003 GWS-3						9.1
0004 OREAS 24b						
BLANKS						
0001 Control Blank	X				X	
0002 Control Blank		6	5.3	X		
0003 Control Blank						5.6



ELEMENTS	pH Drop	S
UNITS	NONE	%
DETECTION LIMIT	0.1	0.01
DIGEST	ANCx/	
ANALYTICAL FINISH	MTR	/CSA
SAMPLE NUMBERS		
0001 ANARD Comp01	X	X
0002 ANARD Comp02	X	X
0003 ANARD Comp03	X	X
0004 ACARD Comp01	X	X
0005 ACARD Comp02	X	X
CHECKS		
0001 ACARD Comp01	X	X
0002 ACARD Comp02		
0003 ANARD Comp03		
STANDARDS		
0001 ANC-3		
0002 NAG Std 3		
0003 GWS-3		
0004 OREAS 24b		0.20
BLANKS		
0001 Control Blank		X
0002 Control Blank		
0003 Control Blank		

**METHOD CODE DESCRIPTION**

Method Code Date Tested	Analysing Laboratory NATA Laboratory Accreditation	NATA Scope of Accreditation
/CALC 06/02/20 10:57	Intertek Genalysis Perth 3244 3237	No digestion or other pre-treatment undertaken. Results Determined by calculation from other reported data.
/CSA 13/02/20 11:42	Intertek Genalysis Perth 3244 3237	ENV_W061, CSA : ENV_W061 Induction Furnace Analysed by Infrared Spectrometry
ANCx/MTR 07/02/20 08:11	Intertek Genalysis Perth 3244 3237	Acid Neutralizing Capacity Digestion Procedure. Analysed with Electronic Meter Measurement
ANCx/QUAL 07/02/20 08:11	Intertek Genalysis Perth 3244 3237	Acid Neutralizing Capacity Digestion Procedure. Analysed by Qualitative Inspection
ANCx/VOL 07/02/20 08:11	Intertek Genalysis Perth 3244 3237	Acid Neutralizing Capacity Digestion Procedure. Analysed by Volumetric Technique.
NAGx/MTR 07/02/20 08:32	Intertek Genalysis Perth 3244 3237	Net Acid Generation Extraction of samples with H2O2 Analysed with Electronic Meter Measurement
NAGx/VOL 07/02/20 08:32	Intertek Genalysis Perth 3244 3237	Net Acid Generation Extraction of samples with H2O2 Analysed by Volumetric Technique.
Ws/MTR 06/02/20 11:00	Intertek Genalysis Perth 3244 3237	Water Extraction using a sample:water ratio of 1:5 or to client request. Analysed with Electronic Meter Measurement

METHOD CODE DESCRIPTION

Method Code Date Tested	Analysing Laboratory NATA Laboratory Accreditation	NATA Scope of Accreditation
WT01	Intertek Genalysis Perth 3244 3237 Reporting weights of samples	
