

Appendix G. Waste Characterisation

GRAEME CAMPBELL & ASSOCIATES PTY LTD

Specialists in Materials Characterisation

Integrated Geochemical and Physical Testing Service for Bedrocks, Regoliths and Soils
of Diverse Lithological, Alteration and Weathering Assemblages

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Testing Laboratory: Unit B, 15 Rose Street, Bridgetown, WA 6255

1813

COMPANY: Galena Mining Limited
ATTENTION: Troy Flannery
FROM: Graeme Campbell
SUBJECT: Abra Project: Geochemical Assessment of **Flotation-Tailings-Slurry** Sample – Implications for Tailings Management
NO. PAGES (including this page): 78 DATE: 17th July 2018

Troy,

The testwork results are presented in Tables 1-4, and shown on Figure 1.

Photographs of the as-submitted sample of the tailings-slurry, together with different testing procedures, are shown on Plates 1-5.

Details of the tailings-slurry sample supplied by ALS Metallurgy (Burnie) are presented in Attachment I.

Copies of the laboratory reports are presented in Attachment II.

1.0 TESTING

The tailings-slurry sample was subjected to '[static-testing](#)' [procedures](#) routinely employed for the geochemical assessment of process-tailings produced at hard-rock mines.

Sample preparation, [Acid-Neutralisation-Capacity \(ANC\)](#) determination, [Net-Acid-Generation \(NAG\)](#) testing, auto-titrations for pH-buffering properties, and direct measurement of [Oxygen-Consumption Rate \(OCR\)](#), were undertaken by Dr. Campbell in the GCA Testing Laboratory (Bridgetown).

Other testing and analyses were performed by Genalysis Laboratory Services Pty Ltd

(GLS) in Maddington, and SGS Australia Pty Ltd (SGS) in Newburn.

Mineralogical assessment was carried out by Dr. Roger Townend of Townend Mineralogical Laboratory Pty Ltd (TML) in Malaga.

2.0 TESTWORK OUTCOMES

2.1 Tailings-Solids

The tailings-solids sample was characterised by:

- 'trace/accessory-pyrite' (viz. Cr(II)-Reducible-S value of 0.48-0.54 %) in a gangue containing 'accessory-dolomite' (Table 1).
- at least 40-50 kg H₂SO₄/tonne of 'readily-available-alkalinity' forms associated with dolomite dissolution and circum-neutral-pH buffering (Table 1).¹
- contents of major/minor-elements either below, or close to, those typically recorded for soils, regoliths and bedrocks derived from unmineralised terrain (Table 2).

However, the **Ba** and **Pb** contents were 15.46 % and 0.48 %, respectively.

- barite and quartz as major components with minor hematite and subordinate dolomite, chlorite, albite, muscovite, magnetite and siderite (Table 3).

The sulphide-mineral suite was dominated by pyrite over galena and chalcopyrite.

The shape of the pH-buffering curve (Figure 1) reflects dolomite dissolution, and assaying of the test-solution corresponding to a pH-end-point near 4 indicates a net acid-consumption of 45 kg H₂SO₄/tonne. This value is similar to that above obtained in separate testing with dilute acetic-acid solution (Table 1).

The measured OCR_{300C} value of 1.67E-10 kg O₂/kg/s indicates that the **population of pyrite-grains in the tailings-solids includes varieties that are intrinsically reactive**. This assessment reflects both the Sulphide-S value of *ca.* 0.5 %, and the prevailing circum-neutral-pH.

*Summarising, the tailings-solids sample is classified as **Non-Acid Forming (NAF)**, and appreciably enriched in **Ba** – barite comprises almost one-third of the total-tailings.*

*The sample is also enriched in **Pb** chiefly associated with 'trace-galena' not recovered during flotation.*

¹ Refer footnote to Table 1 re. use of dilute acetic-acid solutions (pH 4-5) for estimating the 'pool' of 'readily-available-alkalinity' forms.

2.2 Tailings-Slurry-Water

The tailings-slurry-water sample had a pH value of 7-8, and an EC value of 430 $\mu\text{S}/\text{cm}$ (Table 4).²

The concentrations of a wide range of minor-elements in the tailings-slurry-water sample were either below, or close to, the respective detection-limits (viz. 0.000-0.01 mg/L range typically).

The Pb concentration of 0.086 mg/L (Table 4) is below the ANZECC (2000) guideline value of 0.1 mg/L for livestock drinking-water.³

ANZECC (2000) does not list a Ba guideline value for livestock drinking-water.

3.0 MANAGEMENT IMPLICATIONS

Based on the testwork outcomes of this study, it is concluded that the **flotation-tailings** stream to be produced for the Abra Project should be classified as **NAF**.

Though enriched in Pb, due to 'trace-galena' not recovered during flotation, the **abundance of barite**, corresponding to about one-third of the total-tailings mass, is the main geochemical feature to cater for in the design of the tailings-storage facility (TSF).

It is understood that tailings will be used in preparation of a stabilised paste-solids stream for use as backfill within the underground-workings (e.g. stope fill, etc.).

4.0 CLOSURE

I trust the above is useful to your current needs.

Regards,

Dr GD Campbell
Director

encl. Tables 1-4
Figure 1
Plates 1-5
Attachments I and II

² EC = Electrical-Conductivity.

³ Reference:

ANZECC, 2000, "Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 3, Primary Industries – Rationale and Background Information".

TABLES

Table 1: Acid-Base-Analysis and Net-Acid-Generation Results for Tailings-Solids Sample

GCA-SAMPLE NO.	TOTAL-S (%) BY VARIOUS DIGESTION / ASSAY METHODS			SO4-S (%) BY VARIOUS EXTRACTION METHODS			Cr(II)-Reducible-S (%)	TOTAL-C (%)	CO3-C (%)	ANC FORMS		NAG		NAG-pH	AFP CATEGORY		
	Combustion @ 1,800 oC	4-Acid Digest (HCl / HNO3 / HClO4 / HF)	Na2O2 Fusion / HCl Digest	HCl	Na2CO3	LiOH				Bulk (pH 1-2 @ 80 oC)	Reactive (pH 4-5 @ 20 oC)	pH=4.5	pH=7.0			NAG	
																(kg H2SO4/tonne)	
GCA11866	4.41 (4.35)	0.943 (0.940)	1.47	0.75 (0.75)	3.62 (3.59, 3.57, 3.53, 3.40, 3.30)	0.33 (0.33)	0.54 (0.52, 0.48, 0.52)	2.03 (2.02)	2.01 (2.00)	101 (89, 97, 94, 90, 93)	40-50	<0.5 (<0.5)	<0.5 (<0.5)	8.8 (9.0)	NAF		

Notes:

ANC = Acid-Neutralisation Capacity; NAG = Net-Acid Generation; AFP = Acid-Formation Potential; PNF = Non-Acid Forming

All values expressed on a dry-weight basis, except for NAG-pH

Values in parentheses represent duplicate determinations

Reactive-ANC corresponds to acid-consumption during overnight agitation of test-suspension at 20 oC using dilute acetic-acid/Na-acetate solution buffered at pH 4-5.

The larger SO4-S values for the Na2CO3-extraction method correspond to larger solution:solid ratios during testing to approach near-quantitative extraction of SO4.

If all of the Ba content of 15.46 % occurs as barite (BaSO4), then the barite-S value would be *ca. 3.6 %*.

Table 2: Multi-Element-Analysis Results for Tailings-Solids Sample

GCA-SAMPLE NO.	S	Ca	Mg	Na	K	Al	Fe	Si	As	Sb	Se	Mo	B	F	Ba	Pb	Cu	Zn	Cd	Hg	Ni	Cr	Co	Ag	Tl	Sr	Bi	P	Mn	Sn	V	Th	U
	%									mg/kg							mg/kg																
GCA11866	4.41	1.5	1.50	0.13	0.30	0.72	19.16	12.5	39.9	16.62	<0.01	5.9	<50	250	15.46	4,800	812	85	0.27	0.07	25	62	14.5	2.02	1.89	634.7	0.24	80	8,930	0.4	7	2.05	0.68
Average-Crustal Abundance (Bowen 1979)									1.5	0.2	0.05	1.5	10	950	500	14	50	75	0.11	0.05	80	100	20	0.07	0.6	370	0.05	1,000	950	2.2	160	12	2.4

Highlighted Assays:

signifies element content 10-100 times average-crustal abundance

signifies element content 100+ times average-crustal abundance

Reference: Bowen HJM, 1979, "Environmental Chemistry of the Elements", Academic Press, New York

Table 3: Mineralogical Results for Tailings-Solids Sample

GCA11866	
barite quartz	20-50 %
hematite	10-20 %
pyrite dolomite chlorite albite muscovite magnetite siderite	1-10 %
galena chalcopyrite	< 1 %

Notes:

major = 20-50 %; minor = 10-20 %; accessory = 1-10 %; trace = less than 1 %

The galena is usually very-fine grained (< 20 µm) and tends to be enclosed in the Fe-oxides

Table 4: Analysis Results for Tailings-Slurry-Water Sample

ELEMENT/ PARAMETER	GCA11866	ELEMENT/ PARAMETER	GCA11866
<i>Major-Parameters</i>		<i>Minor-Ions (mg/L)</i>	
pH	7.6	Fe	<0.01
pH (GCA)	8.21-	Cu	0.40
EC (µS/cm)	430	Ni	0.10
EC (GCA, µS/cm)	432	Zn	<0.01
		Co	0.1599
		Ag	0.00025
<i>Major-Ions (mg/L)</i>			
Na	29.9	As	0.0007
K	16.8	Sb	0.00563
Mg	12.36	Se	<0.0005
Ca	24.89	B	0.02
Cl	48	Mo	0.00577
SO4	112	F	0.5
HCO3 (as CaCO3)	75		
HCO3 (GCA, as CaCO3)	66	Mn	0.14
Si	0.85	Al	0.02
		Cd	<0.0005
<i>Nitrogen-Forms (mg/L)</i>		Pb	0.086
		Cr	<0.01
NH3-N	0.24	Hg	<0.0001
NO3-N	0.21	Bi	<0.000005
		P	<0.1
<i>Cyanide-Forms (mg/L)</i>		Ba	0.06244
		Sr	0.16843
CNtot	0.40	Tl	0.00021
CNwad	0.10	V	<0.01
CNfree	<0.01	Sn	0.0003
SCN	8	U	0.000092
		Th	<0.000005

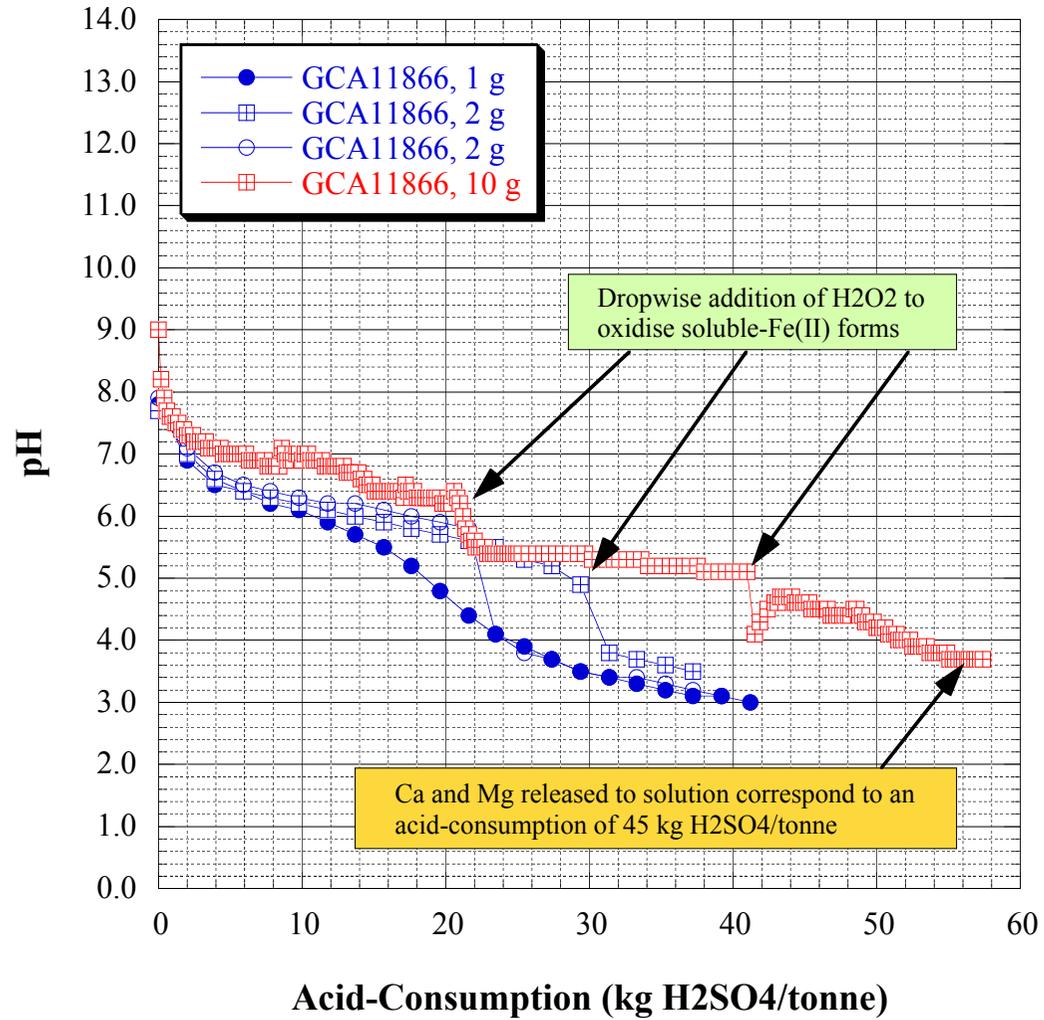
Notes:

EC = Electrical-Conductivity; CNtot = Total-Cyanide; CNwad = Weak-Acid-Dissociable Cyanide; CNfree = Free-Cyanide
SCN = thiocyanate

FIGURE

Figure 1

pH-Buffering Properties of Tailings-Solids Sample



PLATES



PLATE 1: [Slurry](#) sample (GCA11866) of [Flotation-Tailings](#) 'as-received' at GCA Testing Laboratory (Bridgetown)



PLATE 2: Sub-sampling [tailings-slurry-water](#) and [tailings-solids](#) for testing.



PLATE 3: Acid-Neutralisation-Capacity (ANC) testing.

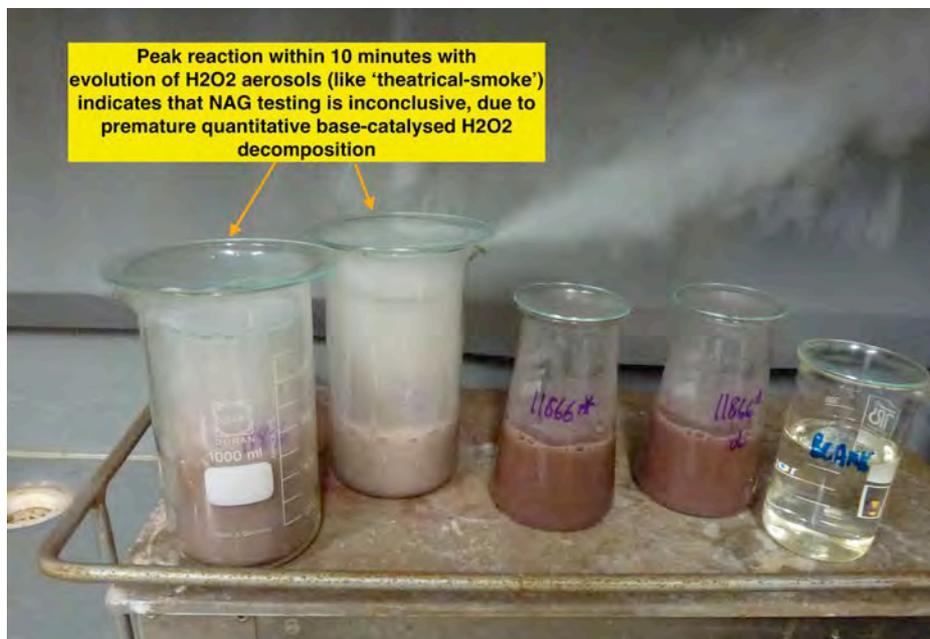


PLATE 4: Net-Acid-Generation (NAG) testing on pulps using 15 % H₂O₂ (@ pH 4.5).

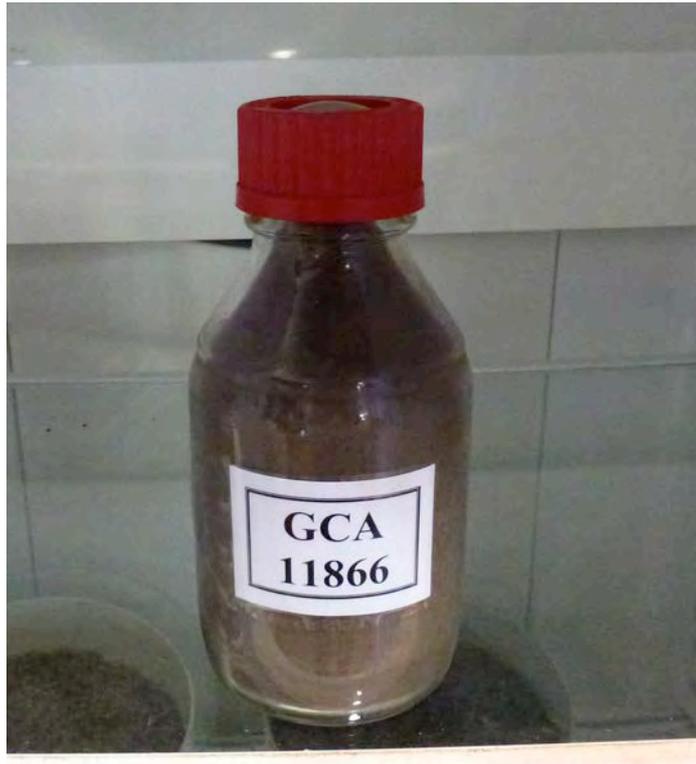


PLATE 5: [Oxygen-Consumption Cells \(OCCs\)](#) housed in an incubator at **30.0 (+/- 0.1) °C** for initial testing of intrinsic sulphide-mineral reactivity via measurement of [O₂-Consumption Rate \(OCR\)](#).

ATTACHMENT I

DETAILS OF TAILINGS-SLURRY SAMPLE



ALS Metallurgy

39 River Rd, BURNIE, Tasmania, 7320, Australia

Phone: 61 3 6431 6333, email: burnielab@alsglobal.com

FLOTATION ASSESSMENT
OF
ABRA RESOURCE CORE INTERVALS
FOR
GALENA MINING LTD

Summary Report T1098

J R Glen

May 2018

The results contained in this report relate only to the sample(s) submitted for testing.
ALS Metallurgy accepts no responsibility for the representivity of the sample(s) submitted.

FLOTATION ASSESSMENT OF
ABRA RESOURCE CORE INTERVALS FOR
GALENA MINING LTD

DATE

May, 2018

BRIEF

- Perform locked cycle galena flotation on three composites of Abra core.
- Generate tails pulp for a tails geochemistry study

SUMMARY

Three composites of Abra core were prepared for flotation testing. Samples were tested to generate a grind establishment and then batch floated to assess reagents and flotation parameters.

Flotation was then performed in locked cycle to assess final concentrate grade and recovery for the three composites.

Results indicate excellent lead separation with high grade concentrates (69-81%Pb) and recovery (94-96%) for the three composites.

A moderate grind size (p80=150um) and simple reagent scheme generated excellent results for these three composites.

Rougher and cleaner tails from these three tests were blended to generate a single tails pulp for geochemical testing. Flotation water from the tests was used.

MATERIAL TESTED

Three composites were generated from the following core intervals.

Composite Hole From (m) To (m)

Composite	Hole	From (m)	To (m)
Comp S1	AB70	378.0	378.8
		378.8	379.5
		379.5	380.0
		380.0	381.0
		381.0	382.0
		382.0	382.8
		382.8	384.0
		384.0	385.0
		385.0	386.0
		386.0	387.0
		387.0	388.0
		388.0	389.4
		389.4	390.4
		390.4	391.5
		391.5	392.5
		392.5	393.2
		393.2	394.3
		394.3	395.4
395.4	396.3		
396.3	397.2		
397.2	398.2		

Composite Hole From (m) To (m)

Composite	Hole	From (m)	To (m)
Comp S2	AB72	412.8	413.6
		413.6	414.2
		414.2	414.8
		414.8	415.5
		415.5	416.3
		416.3	417.3
		417.3	418.2
		418.2	418.9
		418.9	419.6
		419.6	420.3
		420.3	421.1
		421.1	421.4
		421.4	422.1
		422.1	422.8
		422.8	423.8
		423.8	424.8
		424.8	425.5
		425.5	426.2
426.2	426.8		
426.8	427.4		

		427.4	428.4
		428.4	429.3
		429.3	430.3
		430.3	431.0

Composite Hole From (m) To (m)

Composite	Hole	From (m)	To (m)
Comp S3	AB75	515.5	516.2
		516.2	516.9
		516.9	517.9
		517.9	518.4
		518.4	518.8
		518.8	519.4
		519.4	520.0
		520.0	520.7
		520.7	521.5
		521.5	522.0
		522.0	522.5
		522.5	523.2
		523.2	524.0
		524.0	524.5
		524.5	525.0
		525.0	526.0
		526.0	527.0
		527.0	528.0
		528.0	528.6
		528.6	529.2
529.2	530.0		
530.0	531.0		
531.0	532.1		
532.1	533.0		
533.0	534.0		
534.0	535.0		
535.0	536.0		
536.0	537.0		

TEST ROUTINES

SAMPLE PREPARATION: DRILL CORE

Samples were received as bagged damp half 45mm core. Samples were crushed in a single toggle lab jaw crusher to 100% passing 25mm. Crusher discharge was screened at 1.70mm and screen oversize stage rolls crushed to 100% passing 1.70mm. The combined crushed ore was rotary split to lots for cold storage.

GRIND ESTABLISHMENT

Samples of fine ore (100% passing 1.70mm) were assessed by batch grinding to establish a curve for discharge p80 versus grind time for the grind conditions required for further testing. The following grind conditions were used:

- 400mm long x 320mm diameter open ended mill steel mill.
- 6.0 kg of a graded (10 – 30mm diameter) steel ball charge.
- 1000gm of prepared ore at 66% solids.
- Grind times of 10, 20 and 30 minutes.

Grind discharges were fully removed, filtered, dried and prepared for sizing as detailed below. Discharge solids were also prepared for head analysis samples.

BASE METAL FLOTATION

Lead rougher and cleaner flotation tests were performed under the following conditions:

- Ore was dry jaw and rolls crushed to 100% passing 1.70mm.
- Grind at 66% solids in an open mild steel rod mill and charge to P₈₀ of 150µm.
- Flotation rougher performed in a 3.5L Agitair style laboratory cell.
- Dilute reagents were added and conditioned for two minutes prior to flotation.
- Lead rougher concentrates was then stirred mill to target P₈₀ of 40µm
- 1.5L cleaner floats were then performed to produce concentrates and tails.
- Air rate and time were recorded for each concentrate.
- Products were wet weighed, filtered and dried for weight and analysis.

FLOTATION REAGENTS USED

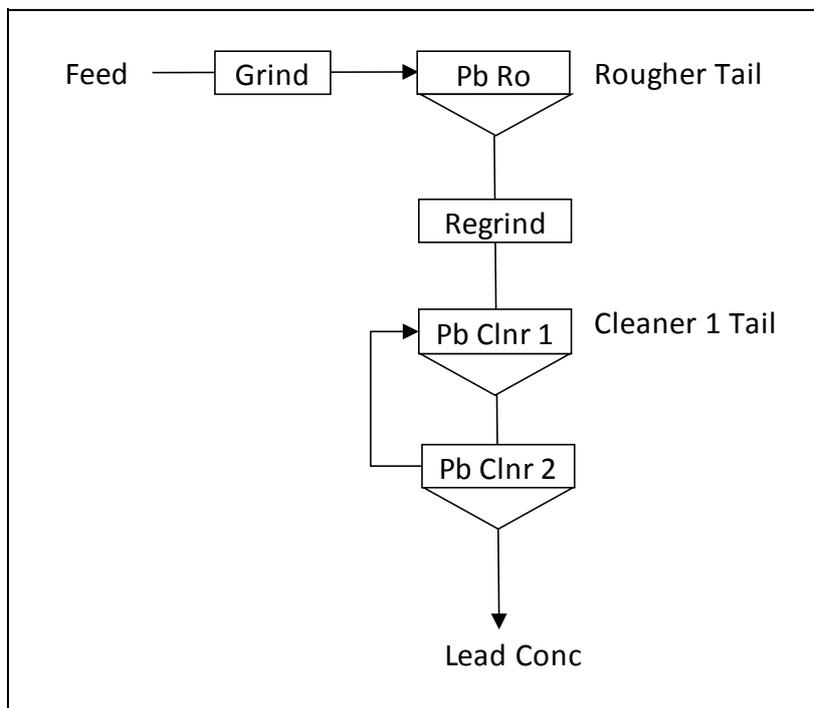
The following reagents were used in this test program:

- SEX, collector, Sodium Iso Butyl Xanthate, Orica.
- Lime, pH modifier, dry slaked lime.
- NaCN, depressant, Sodium Cyanide, Reagent Grade.
- MIBC, frother, methyl Iso Butyl Carbinol, Shell.

LOCKED CYCLE FLOTATION TESTING

A set of batch rougher/cleaner float tests is performed with the internal products produced, usually cleaner tails, added to the next test cycle. After a number of cycles the mass of internal products will stabilise to some equilibrium value. This effectively simulates a continuous flotation circuit. Results allow us to:

- Define the extent of circulating load build up.
- Determine if a stable equilibrium is established for the circuit and ore combination.
- Allow the influence of reagent build up to be seen.
- Determine the equilibrium value recovery and grade.



RESULTS

Test results are summarised in the following tables.

LC01 Stream and Analyses Analyses Distribution

Pb Rougher Tail	%Wt	82.788	
	0.02	%Cu	0.02 26.75
	0.43	%Pb	0.43 3.67
	0.37	%Zn	0.37 87.03
	32.23	%Fe	32.23 92.29
Pb Cleaner Tail	%Wt	5.948	
	0.09	%Cu	0.09 10.51
	2.84	%Pb	2.84 1.75
	0.11	%Zn	0.11 1.86
	30.99	%Fe	30.99 6.38
Pb Cleaner 2 Conc	%Wt	11.263	
	0.29	%Cu	0.29 62.74
	80.87	%Pb	80.87 94.58
	0.35	%Zn	0.35 11.11
	3.42	%Fe	3.42 1.33
Pb Cl2 Tail	%Wt	2.82	
	0.41	%Cu	0.41 22.42
	9.22	%Pb	9.22 2.70
	0.52	%Zn	0.52 4.13
	30.90	%Fe	30.90 3.01

LC02 Stream and Analyses

Analyses Distribution

Pb Rougher Tail		%Wt	79.604	
	0.04	%Cu	0.04	22.07
	0.25	%Pb	0.25	1.78
	0.01	%Zn	0.01	6.60
	5.66	%Fe	5.66	76.13
Pb Cleaner Tail		%Wt	6.354	
	0.47	%Cu	0.47	20.57
	4.03	%Pb	4.03	2.33
	0.10	%Zn	0.10	5.48
	13.03	%Fe	13.03	13.98
Pb Cleaner 2 Conc		%Wt	14.042	
	0.59	%Cu	0.59	57.37
	75.15	%Pb	75.15	95.89
	0.75	%Zn	0.75	87.91
	4.17	%Fe	4.17	9.89
Pb Cl2 Tail		%Wt	3.32	
	1.84	%Cu	1.84	42.41
	12.10	%Pb	12.10	3.65
	0.72	%Zn	0.72	19.83
	17.00	%Fe	17.00	9.53

LC03 Stream and Analyses

Analyses Distribution

Pb Rougher Tail	%Wt	81.090	
	0.09	%Cu	0.09 28.17
	0.37	%Pb	0.37 3.71
	0.02	%Zn	0.02 34.23
	34.00	%Fe	34.00 87.61
Pb Cleaner Tail	%Wt	7.871	
	0.52	%Cu	0.52 15.09
	2.29	%Pb	2.29 2.23
	0.05	%Zn	0.05 8.34
	39.02	%Fe	39.02 9.76
Pb Cleaner 2 Conc	%Wt	11.039	
	1.38	%Cu	1.38 56.74
	68.99	%Pb	68.99 94.06
	0.25	%Zn	0.25 57.43
	7.50	%Fe	7.50 2.63
Pb Cl2 Tail	%Wt	4.16	
	2.69	%Cu	2.69 41.68
	8.02	%Pb	8.02 4.12
	0.32	%Zn	0.32 28.12
	37.70	%Fe	37.70 4.99

DISCUSSION

Results indicate excellent lead separation with high grade concentrates (69-81%Pb) and recovery (94-96%) for the three composites.

A moderate grind size (p80=150um) and simple reagent scheme generated excellent results for these three composites.

Rougher and cleaner tails from these three tests were blended to generate a single tails pulp for geochemical testing. Flotation water from the tests was used.

ATTACHMENT II

LABORATORY REPORTS



Graeme Campbell and Assoc.

27-6-2018

PO Box 247

Bridgetown

WA 6255

Our reference 24289

Mineralogical (SEM/XRD/PLM) analysis of pulp GCA 11866

R Townend

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SAMPLE GCA 11866

POLISHED SECTION/XRD/SEM

Quartz	Major
Muscovite	Accessory
Chlorite	Accessory
Albite	Accessory
Hematite	Minor
Magnetite	Accessory
Pyrite	Accessory
Chalcopyrite	Trace
Galena	Trace
Barite	Major
Siderite	Accessory
Dolomite	Accessory

Siderite(SEM/EDS)

Wt%	
FeO	39-45
MnO	6
MgO	6-9
CaO	<1-2.6
ZnO	<1-1.9

The usually very fine galena tends to be enclosed in the iron oxides.

MINERALS TEST REPORT

CLIENT

CAMPBELL, GRAEME and ASSOCIATES

PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE : 143.0/1807962
NO. SAMPLES : 1
NO. ELEMENTS : 36
CLIENT ORDER NO. : GCA1813 (Job 1 of 1)
SAMPLE SUBMISSION NO. :
PROJECT : ABRA PROJECT
SAMPLE TYPE : Tailings
DATE RECEIVED : 30/05/2018
DATE REPORTED : 25/06/2018
DATE PRINTED : 25/06/2018

REPORT NOTES

TESTED BY

Intertek
15 Davison Street, Maddington 6109, Western Australia
PO Box 144, Gosnells 6990, Western Australia
Tel: +61 8 9251 8100
Email: min.aus.per@intertek.com

**Accredited for compliance with ISO/IEC 17025.
Company Accreditation Number 3244**



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.

Except where explicitly agreed in writing, all work and services performed by Intertek is subject to our standard Terms and Conditions which can be obtained at our website: intertek.com/terms/

JOB NO : 143.0/1807962

CLIENT REF : GCA1813

NOTES

NATA ENDORSED DOCUMENT

Company Accreditation Number 3244

Analysing Laboratory: Intertek Genalysis Perth

The contents of this report have been prepared in accordance with the terms of NATA accreditation and as such should only be reproduced in full.

The analysis results reported herein have been obtained using the following methods and conditions:

Project: Abra

The samples as listed were received as ex wet tailings solids.

Tailings-solids dried at 80 oC.

200-250 g were fine pulverised using zirconia-bowl.

The results have been determined according to Genalysis methods codes :

Digestions : MPL_W002 (4A/), MPL_W005 (SE1/), ENV_W012 (FC7/SIE), MPL_W013 (FP7/OE), MPL_W011 (FP1/) and MPL_W008 (HG1/CV)

Analytical Finishes: ICP_W004 (/OE), ICP_W003 (/MS) and AAS_W004 (/CV)

1.Total-C and Total-S were determined using an induction furnace

The samples are ignited in oxygen ~1700C and the CO₂ and SO₂ measured by infrared detectors

Genalysis method number MPL_W043.

2.C-Acinsol (acid insoluble carbon) by a C&S analyser after removal of carbonates

and soluble organic carbon using hot hydrochloric acid

Genalysis method number MPL_W046

NB S 4A/OE low due to presence of BaSO₄

The results included the assay of blanks and international reference standards:

MP-1b, AMIS0343, OREAS 927, AMIS0361 and MP-1b

Genalysis in house standards:

TOC-1a ,BaSO₄-0.1 ,OREAS 97.01 and HgSTD-8

The results are expressed as parts per million or percent by mass in the dried and prepared material.

Intertek Genalysis signatory

Ann Patricia EVERS

Chief Chemist

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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JOB NO : 143.0/1807962

CLIENT REF : GCA1813

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JOB NO : 143.0/1807962

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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	Ag	Al	As	B	Ba	Ba	Ba	Bi	C	C-Acinsol
UNITS	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	%
DETECTION LIMIT	0.01	0.01	0.5	50	0.1	10	10	0.01	0.01	0.01
DIGEST	4A/	FP1/	4A/	FP1/	4A/	FP1/	FP7/	4A/		C71/
ANALYTICAL FINISH	MS	OE	MS	OE	MS	OE	OE	MS	/CSA	CSA
SAMPLE NUMBERS										
0001 GCA11866	2.02	0.72	38.4	X	615.4	2.12%	15.46%	0.24	2.03	0.02

CHECKS										
0001 GCA11866									2.02	
0002 GCA11866	1.98	0.72	39.9	X	711.9			0.28		0.02

STANDARDS										
0001 BaSO4-0.1							5.87%			
0002 AMIS0343										
0003 HgSTD-8										
0004 MP-1b									0.03	
0005 OREAS 45d		7.89		X		331				
0006 OREAS 927	4.02		16.7		519.7			57.87		
0007 OREAS 97.01										
0008 TOC-1a										1.08

BLANKS										
0001 Control Blank	0.19	X	X	X	5.4	X		X		X
0002 Control Blank									X	



ELEMENTS	C-CO3	Ca	Cd	Co	Cr	Cu	F	Fe	Hg	K
UNITS	%	%	ppm	ppm	ppm	ppm	ppm	%	ppm	%
DETECTION LIMIT	0.01	0.1	0.02	0.1	50	1	50	0.01	0.01	0.05
DIGEST		FP1/	4A/	4A/	FP1/	4A/	FC7/	FP1/	HG1/	FP1/
ANALYTICAL FINISH	/CALC	OE	MS	MS	OE	OE	SIE	OE	CV	OE
SAMPLE NUMBERS										
0001 GCA11866	2.01	1.5	0.27	14.2	60	808	238	18.58	0.06	0.29

CHECKS										
0001 GCA11866	2.00									
0002 GCA11866		1.5	0.30	14.5	62	812	250	19.16	0.07	0.30

STANDARDS										
0001 BaSO4-0.1										
0002 AMIS0343							2230			
0003 HgSTD-8									3.08	
0004 MP-1b										
0005 OREAS 45d		0.2			570			14.04		0.38
0006 OREAS 927			1.04	29.2		1.08%				
0007 OREAS 97.01										
0008 TOC-1a										

BLANKS										
0001 Control Blank		X	X	X	X	X	X	X	0.01	X
0002 Control Blank										



ELEMENTS	Mg	Mn	Mo	Na	Ni	P	Pb	Pb	S	S
UNITS	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm
DETECTION LIMIT	0.01	1	0.1	20	1	10	0.5	50	0.01	50
DIGEST	FP1/	4A/	4A/	4A/	4A/	4A/	4A/	FP1/		4A/
ANALYTICAL FINISH	OE	OE	MS	OE	OE	OE	MS	OE	/CSA	OE
SAMPLE NUMBERS										
0001 GCA11866	1.50	8926	5.8	1239	24	80*	4707.2	4176	4.35	9395

CHECKS										
0001 GCA11866									4.41	
0002 GCA11866	1.46	8814	5.9	1232	25	77	4800.0			9427

STANDARDS										
0001 BaSO4-0.1										
0002 AMIS0343										
0003 HgSTD-8										
0004 MP-1b									13.49	
0005 OREAS 45d	0.24							X		
0006 OREAS 927		1096	1.2	1813	31	526	216.3			1.65%
0007 OREAS 97.01										
0008 TOC-1a										

BLANKS										
0001 Control Blank	X	1	X	22	X	X	X	X		X
0002 Control Blank									X	



ELEMENTS	S	Sb	Se	Si	Sn	Sr	Th	Tl	U	V
UNITS	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.05	0.05	0.01	0.1	0.1	0.05	0.01	0.02	0.01	1
DIGEST	FP1/	4A/	SE1/	FP1/	4A/	4A/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	OE	MS	MS	OE	MS	MS	MS	MS	MS	OE
SAMPLE NUMBERS										
0001 GCA11866	1.47	15.57	X	12.5	0.4	590.46	1.89	0.17	0.68	7

CHECKS										
0001 GCA11866										
0002 GCA11866		16.62		12.4	0.4	634.61	2.05	0.20	0.75	7

STANDARDS										
0001 BaSO4-0.1										
0002 AMIS0343										
0003 HgSTD-8										
0004 MP-1b										
0005 OREAS 45d	0.08			22.6						
0006 OREAS 927		1.70			20.8	29.20	14.06	0.68	2.60	71
0007 OREAS 97.01			0.64							
0008 TOC-1a										

BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	X
0002 Control Blank										



ELEMENTS	Zn
UNITS	ppm
DETECTION LIMIT	1
DIGEST	4A/
ANALYTICAL FINISH	OE
SAMPLE NUMBERS	
0001 GCA11866	161

CHECKS	
0001 GCA11866	
0002 GCA11866	149

STANDARDS	
0001 BaSO4-0.1	
0002 AMIS0343	
0003 HgSTD-8	
0004 MP-1b	
0005 OREAS 45d	
0006 OREAS 927	721
0007 OREAS 97.01	
0008 TOC-1a	

BLANKS	
0001 Control Blank	X
0002 Control Blank	



METHOD CODE DESCRIPTION

Method Code	Analysing Laboratory NATA Laboratory Accreditation	NATA Scope of Accreditation
/CALC	Intertek Genalysis Perth 3244 3237	No digestion or other pre-treatment undertaken. Results Determined by calculation from other reported data.
/CSA	Intertek Genalysis Perth 3244 3237	MPL_W043, CSA : MPL_W043 Induction Furnace Analysed by Infrared Spectrometry
4A/MS	Intertek Genalysis Perth 3244 3237	4A/ : MPL_W002, MS : ICP_W003 Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Tubes. Analysed by Inductively Coupled Plasma Mass Spectrometry.
4A/OE	Intertek Genalysis Perth 3244 3237	4A/ : MPL_W002, OE : ICP_W004 Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Tubes. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.
C71/CSA	Intertek Genalysis Perth 3244 3237	Digestion by hot acid(s) and Induction Furnace Analysed by Infrared Spectrometry
FC7/SIE	Intertek Genalysis Perth 3244 3237	ENV_W012, SIE : ENV_W012 Alkaline fusion (Nickel crucible) specific for Fluorine. Analysed by Specific Ion Electrode.
FP1/OE	Intertek Genalysis Perth 3244 3237	FP1/ : MPL_W011, OE : ICP_W004 Sodium peroxide fusion (Zirconia crucibles) and Hydrochloric acid to dissolve the melt. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.
FP7/OE	Intertek Genalysis Perth 3244 3237	Peroxide-Carbonate fusion specific for TOTAL Barium. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

METHOD CODE DESCRIPTION

Method Code	Analysing Laboratory NATA Laboratory Accreditation	NATA Scope of Accreditation
HG1/CV	Intertek Genalysis Perth 3244 3237	Low temperature Perchloric acid digest specific for Mercury. Analysed by Cold Vapour Generation Atomic Absorption Spectrometry.
SE1/MS	Intertek Genalysis Perth 3244 3237	Aqua-Regia digest followed by Precipitation and Concentration. Specific for Selenium. Analysed by Inductively Coupled Plasma Mass Spectrometry.

CLIENT DETAILS

LABORATORY DETAILS

Contact	Graeme Campbell	Manager	Ros Ma
Client	Graeme Campbell & Associates Pty Ltd	Laboratory	SGS Perth Environmental
Address	PO Box 247 Bridgetown WA 6255	Address	28 Reid Rd Perth Airport WA 6105
Telephone	0897 612 829	Telephone	(08) 9373 3500
Facsimile	0897 612 830	Facsimile	(08) 9373 3556
Email	gca@wn.com.au	Email	au.environmental.perth@sgs.com
Project	GCA Job No. 1813	SGS Reference	PE126467 R0
Order Number	GCA Job No. 1813	Date Received	13 Jun 2018
Samples	2	Date Reported	22 Jun 2018

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

SIGNATORIES

Michael McKay
Inorganics and ARD Supervisor

Murray O'Neill
Lab Technician-Nutrients Signatory

	Sample Number	PE126467.001	PE126467.002
	Sample Matrix	Soil	Water
	Sample Name	GCA 11866 Tailings-Solid	Tailings-Water (Raw)
Parameter	Units	LOR	

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 22/6/2018

Chromium Reducible Sulphur (Scr)	%	0.005	0.54	-
Chromium Reducible Sulphur (Scr)	moles H+/T	5	340	-
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	17	-

Nitrate Nitrogen and Nitrite Nitrogen (NOx) by FIA Method: AN258 Tested: 20/6/2018

Nitrate Nitrogen, NO ₃ as N	mg/L	0.05	-	0.21
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Ammonia Nitrogen by FIA Method: AN261 Tested: 20/6/2018

Ammonia Nitrogen, NH ₃ as N	mg/L	0.05	-	0.24
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MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Ammonia Nitrogen by FIA Method: ME-(AU)-[ENV]AN261

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Ammonia Nitrogen, NH ₃ as N	LB146987	mg/L	0.05	<0.05	0 - 2%	109 - 112%

Chromium Reducible Sulphur (CRS) Method: ME-(AU)-[ENV]AN217

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chromium Reducible Sulphur (Scr)	LB147217	%	0.005	<0.005	5%	100 - 101%
Chromium Reducible Sulphur (Scr)	LB147217	moles H+/T	5	<5		
Chromium Reducible Sulphur (Scr)	LB147217	kg H ₂ SO ₄ /T	0.25	<0.25		

Nitrate Nitrogen and Nitrite Nitrogen (NO_x) by FIA Method: ME-(AU)-[ENV]AN258

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrate Nitrogen, NO ₃ as N	LB146987	mg/L	0.05	<0.05	0 - 1%	NA

METHOD

METHODOLOGY SUMMARY

Nitrate and Nitrite by FIA: In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Without the cadmium reduction only the original nitrite is determined. Reference APHA 4500-NO3- F.

AN217

Dried pulped sample is mixed with acid and chromium metal in a rapid distillation unit to produce hydrogen sulfide (H₂S) which is collected and titrated with iodine (I₂(aq)) to measure SCR.

AN261

Ammonia by Continuous Flow Analyser: Ammonium in a basic medium forms ammonia gas, which is separated from the sample matrix by diffusion through a polypropylene membrane. The ammonia is reacted with phenol and hypochlorite to form indophenol blue at an intensity proportional to the ammonia concentration. The blue colour is intensified with sodium nitroprusside and the absorbance measured at 630 nm. The sensitivity of the automated method is 10-20 times that of the macro method. Reference APHA 4500-NH₃ H.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calculated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.

Note that in terms of units of radioactivity:

- a. 1 Bq is equivalent to 27 pCi
- b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : <http://www.sgs.com.au/~media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf>

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CLIENT DETAILS

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 Client Graeme Campbell & Associates Pty Ltd
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 WA 6255

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 Email gca@wn.com.au

Project **GCA Job No.1813 - Solid Triplicate**
 Order Number **GCA Job No. 1813**
 Samples 3

LABORATORY DETAILS

Manager Ros Ma
 Laboratory SGS Perth Environmental
 Address 28 Reid Rd
 Perth Airport WA 6105

Telephone (08) 9373 3500
 Facsimile (08) 9373 3556
 Email au.environmental.perth@sgs.com

SGS Reference **PE126467A R0**
 Date Received 29 Jun 2018
 Date Reported 17 Jul 2018

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

SIGNATORIES



Michael McKay
 Inorganics and ARD Supervisor

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name Tailings-Solid (Trip 1)	PE126467A.001 Soil GCA 11866 Tailings-Solid (Trip 1)	PE126467A.002 Soil GCA 11866 Tailings-Solid (Trip 2)
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Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 9/7/2018

Chromium Reducible Sulphur (Scr)	%	0.005	0.52	0.48
Chromium Reducible Sulphur (Scr)	moles H+/T	5	320	300
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	16	15

Sample Number	PE126467A.003		
Sample Matrix	Soil		
Sample Name	GCA 11866 Tailings-Solid (Trip 3)		
Parameter	Units	LOR	

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 9/7/2018

Chromium Reducible Sulphur (Scr)	%	0.005	0.52
Chromium Reducible Sulphur (Scr)	moles H+/T	5	330
Chromium Reducible Sulphur (Scr)	kg H2SO4/T	0.25	16

MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA', the results are less than the LOR and thus the RPD is not applicable.

Chromium Reducible Sulphur (CRS) Method: ME-(AU)-[ENV]AN217

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chromium Reducible Sulphur (Scr)	LB147828	%	0.005	<0.005	5%	100 - 101%
Chromium Reducible Sulphur (Scr)	LB147828	moles H+/T	5	<5		
Chromium Reducible Sulphur (Scr)	LB147828	kg H2SO4/T	0.25	<0.25		

METHOD

METHODOLOGY SUMMARY

AN217

Dried pulped sample is mixed with acid and chromium metal in a rapid distillation unit to produce hydrogen sulfide (H₂S) which is collected and titrated with iodine (I₂(aq)) to measure SCR.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calculated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the "Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

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Note that in terms of units of radioactivity:

- a. 1 Bq is equivalent to 27 pCi
- b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : <http://www.sgs.com.au/~media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf>

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Dr G Campbell
 CAMPBELL, GRAEME and ASSOCIATES PTY LTD
 PO Box 247
 BRIDGETOWN WA 6255

JOB INFORMATION

JOB CODE	143/17xxxxxx
No. of SAMPLES	1
CLIENT O/N	GCA 1813
PROJECT	Abra
STATE	Tailings
DATE RECEIVED	18/06/2018
DATE COMPLETED	17/07/2018

LEGEND

- X = Less than Detection Limit
- N/R = Sample Not Received
- * = Result Checked
- () = Result still to come
- I/S = Insufficient Sample for Analysis
- E6 = Result X 1,000,000
- UA = Unable to Assay
- > = Value beyond Limit of Method

The tailings-solids samples were received as ex pulp 1807962

Results of analysis on:

Element	Ba	S-SO4	S-SO4	S-SO4
Method	EDTA/OE	LiOH/OE	S71/OE	S72/GR
Detection	0.01	50	0.01	0.01
Units	%	ppm	%	%
Sample Name				
Control Blank		X	X	X
GCA11866	13.83	3320	0.75	3.3
GCA11866	13.53	3314	0.75	3.4
GCA11866-1.0g				3.57
GCA11866-1.0g				3.53
GCA11866-0.5g				3.62
GCA11866-0.5g				3.59
PD-1			4.15	4.1
BaSO4	56.63			

Notes

- S-SO4 was determined on the pulps by precipitation of BaSO4 after extraction with sodium carbonate according to Genalysis method number ENV_W039, after digestion with Na2CO3 (S72/GR) and by HCl digestion followed by determination of S in solution by OES.(S71/OE) Genalysis method codes: MPL_W045 and ICP_W004.The extraction with sodium carbonate is normally performed using 2 g of sample. The extraction was repeated using reduced weights 1g and 0.5 g as indicated.
- Also S-SO4 (LiOH) as per J.Prietzl and C. Hirsch, European journal of Soil Science 1998,49 669-681. 5g of sample was taken and extracted with 25ml 0.05M LiOH for 18hours at 22C. S in solution was read by ICPOES. Genalysis method code: ICP_W004.

The LiOH extraction procedure is not included in the NATA scope of accreditation.

BaSO₄ was measured by ETDA extraction. Ba measured in solution by ICPOES. Genalysis method codes: MPL_W014 and ICP_W004.

NATA ENDORSED DOCUMENT

Company Accreditation Number 3244

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Intertek Genalysis Signatory: Ann Evers

Ann Evers

Date: 17/07/2018

ACID-NEUTRALISATION-CAPACITY (ANC) TESTWORK:
BASED ON AMIRA (2002) WITH VARIATIONS TO CONSTRAIN DISSOLUTION OF
NON-CARBONATE-MINERALS UNRELATED TO CIRCUM-NEUTRAL BUFFERING

SAMPLE		HCl		milli moles H ⁺ Added	Digest- Slurry- Final- pH	NaOH		milli moles OH- Added	pH after H ₂ O ₂ Added	Vigour of 'Fizzling' from HCl Addition '(in-the-cold)'	BULK- ANC (kg H ₂ SO ₄ / tonne)
ID	WT (g)	Conc. (M)	Pipette Volume (mL)			Conc. (M)	Titre Volume (mL)				
GCA11866	2.75	0.50	20	10.00	1.6	0.10	43.30	4.330	2.5	weak-to-moderate	101
GCA1866 d	2.77	0.50	20	10.00	1.5	0.10	49.60	4.960	2.6		89
GCA11866-1	2.77	0.50	20	10.00	1.7	0.10	45.30	4.530	2.8		97
GCA11866-2	2.75	0.50	20	10.00	1.7	0.10	47.30	4.730	2.7		94
GCA11866-3	2.75	0.50	20	10.00	1.6	0.10	49.70	4.970	2.7		90
GCA11866-4	2.75	0.50	20	10.00	1.6	0.10	48.00	4.800	2.7		93
ANC Std	2.01	0.50	10	5.00	1.6	0.10	10.40	1.040	> 4.0		97
ANC Std d	2.02	0.50	10	5.00	1.6	0.10	10.10	1.010	> 4.0		97
0.5 M-HCl	-	0.50	5	2.50		0.10	25.20	2.52			100.8%
0.5 M-HCl (d)	-	0.50	5	2.50		0.10	25.25	2.53			101.0%

Notes:

1. Testing performed on tailings pulp (-75 µm nominal).
2. **ca. 20 mL** of high-purity-deionised-water (HPDW) added to all samples (including HCl-solution 'blanks') initially.
3. HCl solution added manually via volumetric glass pipette (A Class).
4. **HCl** and **NaOH** solutions certified reagents from Merck (viz. Titripur® reagents in hermetically-sealed Titripac® casks).
5. Sample weight, and volume and strength of HCl added, based on corresponding CO₃-C value(s).
6. During acid-digestion temperature of waterbath is **80 +/- 5 oC**, and digestion performed for **1.0 hr** with beakers swirled by hand 1-2 times during this reaction period. Digestion performed using 250 mL tall-form beakers covered with watchglasses.
7. After completion of acid-digestion step, the test-slurry is boiled for *ca.* 1 min to expel any dissolved CO₂(aq).
8. Following cooling to room-T, **digest-slurry-final-pH** is measured. HPDW is then added to bring test-slurry volume to *ca.* **125 mL** for titration with NaOH solution.
9. Titration with NaOH performed manually using 50 mL glass burette with slurry stirred using magnetic stirrer-bar. Fast titration with stopcock fully open until slurry-pH rises to approximate range 4.0-4.5 when titration stops for H₂O₂ addition.
10. Three drops of **30 % H₂O₂** (v/v) [adjusted to pH 4.5] added to slurry to oxidise **soluble-Fe(II)** forms ('latent-acidity') and precipitation of Fe(III)/Al-oxyhydroxides, etc. Minimum slurry-pH attained following H₂O₂ addition recorded. (Although three drops of peroxide is generally sufficient, several more drops were required for this testing, due to prominent siderite).
11. Following completion of H₂O₂ addition, titration with NaOH continues to a **pH=7** end-point. Titration with NaOH undertaken so that slurry-pH at end-point is within range 6.9-7.1 (i.e. pH 7.0 +/- 0.1) for *ca.* 30 seconds. [Related pH-end-point stability criteria for manual titration (cf. autotitration) option applies in ASTM E1915-13, and AS-4969.12-09].
12. ANC Standard is pulped mixture of quartz and AR CaCO₃ (CO₃-C = 1.21 %; ANC = 99 kg H₂SO₄/tonne).
13. Samples with 'magnetite' noted were characterised by heavy deposits clinging to magnetic-stirrer bar retrieved after completion of titration with NaOH solution.

The main variation to the AMIRA (2002) method is the initial 'applied HCl loading', as governed by the CO₃-C value.

Dr GD Campbell
30th June 2018

Laboratory Report

pH-BUFFERING TESTWORK (GCA11866)

Cumulative Volume of Acid Added (mL)	Cumulative Acid Consumption (kg H ₂ SO ₄ /tonne)	pH
0.00	0.0	7.7
0.40	2.0	7.0
0.80	3.9	6.6
1.20	5.9	6.4
1.60	7.8	6.3
2.00	9.8	6.2
2.40	11.8	6.1
2.80	13.7	6.0
3.20	15.7	5.9
3.60	17.6	5.8
4.00	19.6	5.7
4.40	21.6	5.6
4.80	23.5	5.5
5.20	25.5	5.3
5.60	27.4	5.2
6.00	29.4	4.9
6.40	31.4	3.8
6.80	33.3	3.7
7.20	35.3	3.6
7.60	37.2	3.5

Notes: Titration performed using Metrohm® 736 Titrino auto-titrator, and 0.05 M-H₂SO₄. Equilibration time between titrant additions is 15 minutes.

1.00 g of pulped (nominal -75 µm) sample initially dispersed in *ca.* 150 mL of deionised-water.

Test-suspension in contact with air in a CT-room @ 20 (+/1 1-2) oC, and continuously stirred.

Calibration of pH-Glass Electrode:

Immediately prior to titration: asymmetry potential = 1 mV (pH=7.00); slope-point = 174 V (pH=4.00);

97.6 % of Nernstian response.

After 6.00 mL of 0.05 M-H₂SO₄ had been added a few drops of 30 % H₂O₂(pH4.5) were added to oxidise soluble-Fe(II) forms, etc.

Dr GD Campbell 27th June 2018

Laboratory Report

pH-BUFFERING TESTWORK (GCA11866)

Cumulative Volume of Acid Added (mL)	Cumulative Acid Consumption (kg H ₂ SO ₄ /tonne)	pH
0.00	0.0	7.8
0.40	2.0	6.9
0.80	3.9	6.5
1.20	5.9	6.4
1.60	7.8	6.2
2.00	9.8	6.1
2.40	11.8	5.9
2.80	13.7	5.7
3.20	15.7	5.5
3.60	17.6	5.2
4.00	19.6	4.8
4.40	21.6	4.4
4.80	23.5	4.1
5.20	25.5	3.9
5.60	27.4	3.7
6.00	29.4	3.5
6.40	31.4	3.4
6.80	33.3	3.3
7.20	35.3	3.2
7.60	37.2	3.1
8.00	39.2	3.1
8.40	41.2	3.0

Notes: Titration performed using Metrohm® 736 Titrino auto-titrator, and 0.05 M-H₂SO₄. Equilibration time between titrant additions is 15 minutes.

1.00 g of pulped (nominal -75 µm) sample initially dispersed in *ca.* 150 mL of deionised-water.

Test-suspension in contact with air in a CT-room @ 20 (+/1 1-2) oC, and continuously stirred.

Calibration of pH-Glass Electrode:

Immediately prior to titration: asymmetry potential = 1 mV (pH=7.00); slope-point = 174 V (pH=4.00);

97.9 % of Nernstian response.

Dr GD Campbell 22nd June 2018

Laboratory Report

pH-BUFFERING TESTWORK (GCA11866)

Cumulative Volume of Acid Added (mL)	Cumulative Acid Consumption (kg H ₂ SO ₄ /tonne)	pH
0.00	0.0	7.9
0.40	2.0	7.1
0.80	3.9	6.7
1.20	5.9	6.5
1.60	7.8	6.4
2.00	9.8	6.3
2.40	11.8	6.2
2.80	13.7	6.2
3.20	15.7	6.1
3.60	17.6	6.0
4.00	19.6	5.9
4.40	21.6	5.8
4.80	23.5	4.1
5.20	25.5	3.8
5.60	27.4	3.7
6.00	29.4	3.5
6.40	31.4	3.4
6.80	33.3	3.4
7.20	35.3	3.3
7.60	37.2	3.2
8.00	39.2	3.1

Notes: Titration performed using Metrohm® 736 Titrino auto-titrator, and 0.05 M-H₂SO₄. Equilibration time between titrant additions is 15 minutes.

1.00 g of pulped (nominal -75 µm) sample initially dispersed in *ca.* 150 mL of deionised-water.

Test-suspension in contact with air in a CT-room @ 20 (+/1 1-2) oC, and continuously stirred.

Calibration of pH-Glass Electrode:

Immediately prior to titration: asymmetry potential = 0 mV (pH=7.00); slope-point = 173 V (pH=4.00);

97.7 % of Nernstian response.

After 4.40 mL of 0.05 M-H₂SO₄ had been added a few drops of 30 % H₂O₂(pH4.5) were added to oxidise soluble-Fe(II) forms, etc.

Dr GD Campbell 29th June 2018

Laboratory Report

pH-BUFFERING TESTWORK (GCA11841)

Cumulative Volume of Acid Added (mL)	Cumulative Acid Consumption (kg H2SO4/tonne)	pH	Cumulative Volume of Acid Added (mL)	Cumulative Acid Consumption (kg H2SO4/tonne)	pH
0.00	0.0	9.0	18.40	9.0	6.9
0.40	0.2	8.2	18.80	9.2	6.9
0.80	0.4	7.9	19.20	9.4	6.9
1.20	0.6	7.7	19.60	9.6	7.0
1.60	0.8	7.6	20.00	9.8	7.0
2.00	1.0	7.6	20.40	10.0	6.9
2.40	1.2	7.5	20.80	10.2	7.0
2.80	1.4	7.5	21.20	10.4	7.0
3.20	1.6	7.4	21.60	10.6	6.9
3.60	1.8	7.4	22.00	10.8	6.9
4.00	2.0	7.3	22.40	11.0	6.9
4.40	2.2	7.3	22.80	11.2	6.9
4.80	2.4	7.3	23.20	11.4	6.9
5.20	2.5	7.2	23.60	11.6	6.8
5.60	2.7	7.2	24.00	11.8	6.8
6.00	2.9	7.2	24.40	12.0	6.8
6.40	3.1	7.2	24.80	12.2	6.8
6.80	3.3	7.2	25.20	12.3	6.8
7.20	3.5	7.1	25.60	12.5	6.8
7.60	3.7	7.1	26.00	12.7	6.8
8.00	3.9	7.1	26.40	12.9	6.8
8.40	4.1	7.1	26.80	13.1	6.7
8.80	4.3	7.1	27.20	13.3	6.7
9.20	4.5	7.0	27.60	13.5	6.7
9.60	4.7	7.0	28.00	13.7	6.7
10.00	4.9	7.0	28.40	13.9	6.7
10.40	5.1	7.0	28.80	14.1	6.6
10.80	5.3	7.0	29.20	14.3	6.6
11.20	5.5	7.0	29.60	14.5	6.5
11.60	5.7	7.0	30.00	14.7	6.5
12.00	5.9	7.0	30.40	14.9	6.5
12.40	6.1	7.0	30.80	15.1	6.4
12.80	6.3	6.9	31.20	15.3	6.4
13.20	6.5	6.9	31.60	15.5	6.4
13.60	6.7	6.9	32.00	15.7	6.4
14.00	6.9	6.9	32.40	15.9	6.4
14.40	7.1	6.9	32.80	16.1	6.4
14.80	7.3	6.9	33.20	16.3	6.4
15.20	7.4	6.9	33.60	16.5	6.4
15.60	7.6	6.8	34.00	16.7	6.4
16.00	7.8	6.8	34.40	16.9	6.4
16.40	8.0	6.8	34.80	17.1	6.3
16.80	8.2	6.8	35.20	17.2	6.5
17.20	8.4	6.8	35.60	17.4	6.4
17.60	8.6	7.1	36.00	17.6	6.4
18.00	8.8	7.0	36.40	17.8	6.4

Cumulative Volume of Acid Added (mL)	Cumulative Acid Consumption (kg H2SO4/tonne)	pH	Cumulative Volume of Acid Added (mL)	Cumulative Acid Consumption (kg H2SO4/tonne)	pH
36.80	18.0	6.3	51.60	25.3	5.4
37.20	18.2	6.3	52.60	25.8	5.4
37.60	18.4	6.3	53.60	26.3	5.4
38.00	18.6	6.3	54.60	26.8	5.4
38.40	18.8	6.3	55.60	27.2	5.4
38.80	19.0	6.3	56.60	27.7	5.4
39.20	19.2	6.3	57.60	28.2	5.4
39.60	19.4	6.3	58.60	28.7	5.4
40.00	19.6	6.3	59.60	29.2	5.4
40.40	19.8	6.2	60.60	29.7	5.4
40.80	20.0	6.2	61.60	30.2	5.3
41.20	20.2	6.2	62.60	30.7	5.3
41.60	20.4	6.2	63.60	31.2	5.3
42.00	20.6	6.4	64.60	31.7	5.3
42.40	20.8	6.3	65.60	32.1	5.3
42.80	21.0	6.2	66.60	32.6	5.3
43.20	21.2	6.0	67.60	33.1	5.3
43.60	21.4	5.8	68.60	33.6	5.3
44.00	21.6	5.7	69.60	34.1	5.2
44.40	21.8	5.6	70.60	34.6	5.2
44.80	22.0	5.6	71.60	35.1	5.2
45.20	22.1	5.5	72.60	35.6	5.2
45.60	22.3	5.5	73.60	36.1	5.2
46.00	22.5	5.5	74.60	36.6	5.2
46.40	22.7	5.5	75.60	37.0	5.2
46.80	22.9	5.4	76.60	37.5	5.2
47.20	23.1	5.4	77.60	38.0	5.1
47.60	23.3	5.4	78.60	38.5	5.1
48.00	23.5	5.4	79.60	39.0	5.1
48.40	23.7	5.4	80.60	39.5	5.1
48.80	23.9	5.4	81.60	40.0	5.1
49.20	24.1	5.4	82.60	40.5	5.1
49.60	24.3	5.4	83.60	41.0	5.1
50.00	24.5	5.4	84.60	41.5	4.1
50.40	24.7	5.4	85.60	41.9	4.3
50.80	24.9	5.4	86.60	42.4	4.5
51.20	25.1	5.4	87.60	42.9	4.6

Cumulative Volume of Acid Added (mL)	Cumulative Acid Consumption (kg H2SO4/tonne)	pH	Cumulative Volume of Acid Added (mL)	Cumulative Acid Consumption (kg H2SO4/tonne)	pH
88.00	43.1	4.6	102.80	50.4	4.2
88.40	43.3	4.7	103.20	50.6	4.2
88.80	43.5	4.7	103.60	50.8	4.1
89.20	43.7	4.7	104.00	51.0	4.1
89.60	43.9	4.7	104.40	51.2	4.1
90.00	44.1	4.7	104.80	51.4	4.1
90.40	44.3	4.6	105.20	51.5	4.0
90.80	44.5	4.6	105.60	51.7	4.0
91.20	44.7	4.6	106.00	51.9	4.0
91.60	44.9	4.6	106.40	52.1	4.0
92.00	45.1	4.6	106.80	52.3	4.0
92.40	45.3	4.6	107.20	52.5	3.9
92.80	45.5	4.5	107.60	52.7	3.9
93.20	45.7	4.5	108.00	52.9	3.9
93.60	45.9	4.5	108.40	53.1	3.9
94.00	46.1	4.5	108.80	53.3	3.9
94.40	46.3	4.5	109.20	53.5	3.9
94.80	46.5	4.5	109.60	53.7	3.8
95.20	46.6	4.5	110.00	53.9	3.8
95.60	46.8	4.4	110.40	54.1	3.8
96.00	47.0	4.4	110.80	54.3	3.8
96.40	47.2	4.4	111.20	54.5	3.8
96.80	47.4	4.4	111.60	54.7	3.8
97.20	47.6	4.4	112.00	54.9	3.8
97.60	47.8	4.4	112.40	55.1	3.7
98.00	48.0	4.4	112.80	55.3	3.7
98.40	48.2	4.4	113.20	55.5	3.7
98.80	48.4	4.5	113.60	55.7	3.7
99.20	48.6	4.5	114.00	55.9	3.7
99.60	48.8	4.4	114.40	56.1	3.7
100.00	49.0	4.4	114.80	56.3	3.7
100.40	49.2	4.3	115.20	56.4	3.7
100.80	49.4	4.3	115.60	56.6	3.7
101.20	49.6	4.3	116.00	56.8	3.7
101.60	49.8	4.3	116.40	57.0	3.7
102.00	50.0	4.2	116.80	57.2	3.7
102.40	50.2	4.2	117.20	57.4	3.7

Notes: Titration performed using Metrohm® 736 Titrino auto-titrator, and 0.05 M-H2SO4. Equilibration time between titrant additions is 15 minutes.

10.0 g of pulped (nominal -75 µm) sample initially dispersed in ca. 150 mL of deionised-water.

Test-suspension in contact with air in a CT-room @ 20 (+/1 1-2) oC, and continuously stirred.

Calibration of pH-Glass Electrode:

Immediately prior to titration: asymmetry potential = 0 mV (pH=7.00); slope-point = 171 mV (pH=4.00); 97.8 % of Nernstian response.

Dr GD Campbell 2nd July 2018

Graeme Campbell & Associates Pty Ltd
Laboratory Report

NET-ACID-GENERATION (NAG) TESTWORK (SINGLE-ADDITION)

Sample_ ID	Sample Weight (g)	Comments	pH of Test-Suspension After O'Night Reaction [Before Boiling Steps]	Test-Suspension Values After 2nd-Boiling Step [Cu(II) Added Before Boiling]		Titre (mL) (0.1 M-NaOH)		NAG (kg H2SO4/tonne)		
				NAG-pH	NAG-EC (μ S/cm)	To pH 4.5	pH 4.5 to pH 7.0	To pH 4.5	pH 4.5 to pH 7.0	To pH 7.0
				GCA11866	4.97	intense reaction peak witin 10 mins	8.7	8.8	216	-
GCA11866 d	5.01	intense reaction peak witin 10 mins	9.3	9.0	225	-	-	<0.5	<0.5	<0.5
Blank			5.1	6.9	59	-	-	-	"<0.5"	"<0.5"

Notes: If needed, the pH of the 15 % (v/v) A.R. H2O2 solution is adjusted to pH 4.5 using dilute NaOH solution prior to commencing the NAG Tests. 250 mL of peroxide solution is added to sample in 500 mL conical Erlenmeyer beaker that is then covered with a watchglass. Following **reaction overnight**, the occurrence and vigour of reaction is judged according to degree of water condensation on the underside of the watchglass. The suspension-pH is measured, and the test-suspensions then boiled for *ca.* 1 hr. After allowing to cool, *ca.* 1 mL of **0.016 M-CuSO4** is added, and the 2nd-boiling step carried out for *ca.* 1 hr. The added Cu(II) catalyses the decomposition of any residual, unreacted H2O2 (AS 4969.12-2009). Following determination of supernatant-EC and suspension-pH, the test-suspensions are titrated manually with standardised NaOH solution to respective **pH4.5** and **pH7.0** end-points. After allowing for acidity due to addition of CuSO4, the NaOH titre recorded for the Blank corresponds to a "NAG-[pH7]" value less than 0.5 kg H2SO4/tonne for a sample weight of 3.00 gm. All testing performed on **pulps** (nominal -75 μ m).

Dr GD Campbell 10th June 2018

Determination of Oxygen-Consumption Rates (OCRs)

	GCA11866
<u>Test Specifications and Conditions</u>	
Moist-Solids (kg)	0.99
GWC (%)	4.2
Dry-Solids [DS] (kg)	0.95
Solids-SG	3.60
Dry-Solids Volume (L)	0.26
Pore-Fluid Volume (L)	0.04
Cell Volume (L)	0.61
Gas Volume [GV] (L)	0.31
GV/DS Ratio (L/kg)	0.32
Temperature (oC) [+/- 0.1]	30.0
<u>Measurement with Quantek 901</u>	
Reaction-Time (days)	2.17
Reaction-Time (hrs)	52.0
Measured O2-Conc. (%) [+/- 0.1]	13.6
O2-Consumption (%) [+/- 0.2]	7.3
O2-Consumption (mg O2)	29.7
OCR (kg O2/kg/s)	1.67E-10

Notes:

GWC = Gravimetric-Water Content; SG = Specific-Gravity.

SG value is estimated.

The relative-error for the OCR value is estimated to be *ca.* 10-20 %.

Dr GD Campbell

18th June 2018

NOTE:

The solution assays in the following GLS-report correspond to the following solid:solution ratios:

- 11866-(pH4-5;10g) 10g in 200 mL
- 11866-(pH4-5;5g) 5g in 200 mL

- 11866-ANC-5 2.75 g in 100 mL
- 11866-ANC-6 2.75 g in 100 mL

- 11866-autotit-200mL;1g 1.00 g in 200 mL
- 11866-autotit-250mL;10g 10.0 g in 250 mL

MINERALS TEST REPORT

CLIENT

CAMPBELL, GRAEME and ASSOCIATES

PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE : 143.0/1809811
NO. SAMPLES : 6
NO. ELEMENTS : 9
CLIENT ORDER NO. : GCA1813 (Job 1 of 1)
SAMPLE SUBMISSION NO. :
PROJECT : ABRA
SAMPLE TYPE : Solutions
DATE RECEIVED : 04/07/2018
DATE REPORTED : 10/07/2018
DATE PRINTED : 10/07/2018

REPORT NOTES

TESTED BY

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**Accredited for compliance with ISO/IEC 17025.
Company Accreditation Number 3244**



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JOB NO : 143.0/1809811

CLIENT REF : GCA1813

NOTES

NATA ENDORSED DOCUMENT

Company Accreditation Number 3244

Analysing Laboratory: Intertek Genalysis Perth

The contents of this report have been prepared in accordance with the terms of NATA accreditation and as such should only be reproduced in full.

The analysis results reported herein have been obtained using the following methods and conditions:

The 6 water samples, as listed in the report, were received on the 4th of July 2018.

From the clear, settled solution the results for Al, Ca, Fe-Sol, K, Mg, Mn, Na, S and Si were determined by ICP-OES (ICP_W004).

The assays included the determination of blanks and in-house reference standards. The results are expressed as milligram per litre in the sample as received.

Intertek Genalysis signatory
Huong ICP PHAM
ICP Chemist



Date: 10-Jul-2018

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JOB NO : 143.0/1809811

CLIENT REF : GCA1813



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	Al	Ca	Fe-Sol	K	Mg	Mn
UNITS	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
DETECTION LIMIT	0.01	0.01	0.01	0.1	0.01	0.01
DIGEST						
ANALYTICAL FINISH	/OE	/OE	/OE	/OE	/OE	/OE
SAMPLE NUMBERS						
0001 11866-(pH4-5;10g)	0.14	295.45	5.79	5.5	121.58	59.44
0002 11866-(pH4-5;5g)	0.33	240.40	11.24	3.7	98.37	49.44
0003 11866-ANC-5	15.92	384.77	782.16	3.6	314.34	221.32
0004 11866-ANC-6	15.79	376.49	789.72	3.5	307.04	223.29
0005 11866-autotit-200mL;1g	0.32	34.10	0.88	48.1	14.23	7.42
0006 11866-autotit-250mL;10g	2.39	417.22	1.77	375.9	189.92	99.01
CHECKS						
0001 11866-ANC-6	15.77	376.98	770.86	3.4	309.48	218.41
STANDARDS						
0001 UNI 1	24.32	24.86	242.65	24.4	24.32	9.85
BLANKS						
0001 Control Blank	X	X	X	X	X	X



ELEMENTS	Na	S	Si
UNITS	mg/l	mg/l	mg/l
DETECTION LIMIT	0.1	0.1	0.05
DIGEST			
ANALYTICAL FINISH	/OE	/OE	/OE
SAMPLE NUMBERS			
0001 11866-(pH4-5;10g)	165.6	3.6	3.67
0002 11866-(pH4-5;5g)	160.0	2.2	2.48
0003 11866-ANC-5	7.5	2.4	14.86
0004 11866-ANC-6	4.0	2.6	14.69
0005 11866-autotit-200mL;1g	1.2	63.8	0.80
0006 11866-autotit-250mL;10g	1.4	656.2	4.99
CHECKS			
0001 11866-ANC-6	3.9	2.6	14.68
STANDARDS			
0001 UNI 1	24.8	24.9	48.91
BLANKS			
0001 Control Blank	X	X	X



METHOD CODE DESCRIPTION

Method Code **Analysing Laboratory**

/OE Intertek Genalysis Perth
 Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

MINERALS TEST REPORT

CLIENT

CAMPBELL, GRAEME and ASSOCIATES

PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE : 143.0/1807961
NO. SAMPLES : 3
NO. ELEMENTS : 44
CLIENT ORDER NO. : GCA1813 (Job 1 of 1)
SAMPLE SUBMISSION NO. :
PROJECT : ABRA PROJECT
SAMPLE TYPE : Solutions
DATE RECEIVED : 30/05/2018
DATE REPORTED : 16/07/2018
DATE PRINTED : 16/07/2018

REPORT NOTES

TESTED BY

Intertek
15 Davison Street, Maddington 6109, Western Australia
PO Box 144, Gosnells 6990, Western Australia
Tel: +61 8 9251 8100
Email: min.aus.per@intertek.com

**Accredited for compliance with ISO/IEC 17025.
Company Accreditation Number 3244**



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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JOB NO : 143.0/1807961

CLIENT REF : GCA1813

NOTES

NATA ENDORSED DOCUMENT

Company Accreditation Number 3244

Analysing Laboratory: Intertek Genalysis Perth

The contents of this report have been prepared in accordance with the terms of NATA accreditation and as such should only be reproduced in full.

The analysis results reported herein have been obtained using the following methods and conditions:

Project: Abra

The solutions were analysed as received

The raw sample was analyzed for pH, EC, Cl, F, SCN and alkalinity

The HNO₃ dosed sample was analyzed for the requested suite by ICPOES and ICPMS

The NaOH dosed sample was analyzed for FreeCN, CN-WAD and Total CN

Genalysis method codes: ENV_W001 (pH), ENV_W002 (EC), ENV_W011 (F)

ENV_W004 (Cl), ENV_W006 (SCN),

(ICP_W004 (OE), (ICP_W003 (MS))

ENV_040 (CN-WAD), ENV_W041 (FreeCN), ENV_042 (CN-Tot)

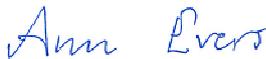
APHA method code: Alkalinity: 2320B

APHA code refers to "Standard methods for the examination of water and wastewater",
22nd Edition 2012

Intertek Genalysis signatory

Ann Patricia EVERS

Chief Chemist



Date: 26-Jun-2018

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JOB NO : 143.0/1807961

CLIENT REF : GCA1813



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
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	*	= Result Checked	>	= Value beyond Limit of Method
	DTF	= Result still to come	+	= Extra Sample Received Not Listed
	IS	= Insufficient Sample for Analysis		



ELEMENTS	Ag	Al	As	B	Ba	Bi
UNITS	ug/l	mg/l	ug/l	mg/l	ug/l	ug/l
DETECTION LIMIT	0.01	0.01	0.1	0.01	0.05	0.005
DIGEST						
ANALYTICAL FINISH	/MS	/OE	/MS	/OE	/MS	/MS
SAMPLE NUMBERS						
0001 GCA11866 RAW						
0002 GCA11866 HNO3	0.25	0.02	0.7	0.02	62.44	X
0003 GCA11866 NaOH						
CHECKS						
0001 GCA11866 RAW						
STANDARDS						
0001 GWS-2						
0002 TMDW	1.92		79.1		49.27	9.601
0003 TMDW		0.11		X		
BLANKS						
0001 Control Blank	0.01	X	X	X	X	X



ELEMENTS	CO3	Ca	Cd	Cl	Co	Cr
UNITS	mgCaCO3/L	mg/l	ug/l	mg/l	ug/l	mg/l
DETECTION LIMIT	1	0.01	0.5	2	0.1	0.01
DIGEST						
ANALYTICAL FINISH	/VOL	/OE	/MS	/COL	/MS	/OE
<hr/>						
0001 GCA11866 RAW	X			48		
0002 GCA11866 HNO3		24.89	X		159.9	X
0003 GCA11866 NaOH						
<hr/>						
CHECKS						
0001 GCA11866 RAW	X			46		
<hr/>						
STANDARDS						
0001 GWS-2						
0002 TMDW			9.6		24.8	
0003 TMDW		36.37				0.02
<hr/>						
BLANKS						
0001 Control Blank		X	X	X	X	X



ELEMENTS	Cu	EC	F	Fe-Sol	HCO3	Hg
UNITS	mg/l	uS/cm	mg/l	mg/l	mgCaCO3/L	ug/l
DETECTION LIMIT	0.01	10	0.1	0.01	2	0.1
DIGEST						
ANALYTICAL FINISH	/OE	/MTR	/SIE	/OE	/VOL	/MS
<hr/>						
SAMPLE NUMBERS						
0001 GCA11866 RAW		430	0.5		75	
0002 GCA11866 HNO3	0.40			X		X
0003 GCA11866 NaOH						
<hr/>						
CHECKS						
0001 GCA11866 RAW		429	0.5		75	
<hr/>						
STANDARDS						
0001 GWS-2					99	
0002 TMDW						X
0003 TMDW	0.02			0.09		
<hr/>						
BLANKS						
0001 Control Blank	X	X	X	X	3	X



ELEMENTS	K	Mg	Mn	Mo	Na	Ni
UNITS	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l
DETECTION LIMIT	0.1	0.01	0.01	0.05	0.1	0.01
DIGEST						
ANALYTICAL FINISH	/OE	/OE	/OE	/MS	/OE	/OE
<hr/>						
SAMPLE NUMBERS						
<hr/>						
0001 GCA11866 RAW						
0002 GCA11866 HNO3	16.8	12.36	0.14	5.77	29.9	0.10
0003 GCA11866 NaOH						
<hr/>						
CHECKS						
<hr/>						
0001 GCA11866 RAW						
<hr/>						
STANDARDS						
<hr/>						
0001 GWS-2						
0002 TMDW				99.74		
0003 TMDW	2.4	9.15	0.04		6.3	0.06
<hr/>						
BLANKS						
<hr/>						
0001 Control Blank	X	X	X	X	X	X
<hr/>						



ELEMENTS	OH	P	Pb	pH	S	Sb
UNITS	mgCaCO3/L	mg/l	ug/l	NONE	mg/l	ug/l
DETECTION LIMIT	1	0.1	2	0.1	0.1	0.01
DIGEST						
ANALYTICAL FINISH	/VOL	/OE	/MS	/MTR	/OE	/MS
<hr/>						
0001 GCA11866 RAW	X			7.6		
0002 GCA11866 HNO3		X	86		37.2	5.63
0003 GCA11866 NaOH						
<hr/>						
CHECKS						
0001 GCA11866 RAW	X			7.6		
<hr/>						
STANDARDS						
0001 GWS-2	X					
0002 TMDW			39			10.40
0003 TMDW		X			X	
<hr/>						
BLANKS						
0001 Control Blank	X	X	X		X	X



ELEMENTS	Se	Si	Sn	Sr	Th	Tl
UNITS	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l
DETECTION LIMIT	0.5	0.05	0.1	0.02	0.005	0.01
DIGEST						
ANALYTICAL FINISH	/MS	/OE	/MS	/MS	/MS	/MS
<hr/>						
SAMPLE NUMBERS						
<hr/>						
0001 GCA11866 RAW						
0002 GCA11866 HNO3	X	0.85	0.3	168.43	X	0.21
0003 GCA11866 NaOH						
<hr/>						
CHECKS						
<hr/>						
0001 GCA11866 RAW						
<hr/>						
STANDARDS						
<hr/>						
0001 GWS-2						
0002 TMDW	9.2		X	241.70	X	9.78
0003 TMDW		X				
<hr/>						
BLANKS						
<hr/>						
0001 Control Blank	X	X	X	X	X	X
<hr/>						



ELEMENTS	TotAlk	U	V	Zn	CN-Tot	CN-WAD
UNITS	mgCaCO3/L	ug/l	mg/l	mg/l	mg/l	mg/l
DETECTION LIMIT	5	0.005	0.01	0.01	0.01	0.01
DIGEST						
ANALYTICAL FINISH	/CALC	/MS	/OE	/OE	/COL	/COL
SAMPLE NUMBERS						
0001 GCA11866 RAW	75					
0002 GCA11866 HNO3		0.092	X	X		
0003 GCA11866 NaOH					0.40	0.10
CHECKS						
0001 GCA11866 RAW	75					
STANDARDS						
0001 GWS-2						
0002 TMDW		9.506				
0003 TMDW			0.03	0.07		
BLANKS						
0001 Control Blank	X	X	X	X	X	X



ELEMENTS	FreeCN	SCN
UNITS	mg/l	mg/l
DETECTION LIMIT	0.01	2
DIGEST		
ANALYTICAL FINISH	/COL	/COL
<hr/>		
0001 GCA11866 RAW		8
0002 GCA11866 HNO3		
0003 GCA11866 NaOH	X	
<hr/>		
CHECKS		
<hr/>		
0001 GCA11866 RAW		8
<hr/>		
STANDARDS		
<hr/>		
0001 GWS-2		
0002 TMDW		
0003 TMDW		
<hr/>		
BLANKS		
<hr/>		
0001 Control Blank	X	X
<hr/>		



METHOD CODE DESCRIPTION

Method Code

Analysing Laboratory

/CALC

Intertek Genalysis Perth
No digestion or other pre-treatment undertaken. Results Determined by calculation from other reported data.

/COL

Intertek Genalysis Perth
No digestion or other pre-treatment undertaken. Analysed by UV-Visible Spectrometry.

/MS

Intertek Genalysis Perth
No digestion or other pre-treatment undertaken. Analysed by Inductively Coupled Plasma Mass Spectrometry.

/MTR

Intertek Genalysis Perth
No digestion or other pre-treatment undertaken. Analysed with Electronic Meter Measurement

/OE

Intertek Genalysis Perth
Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

/SIE

Intertek Genalysis Perth
No digestion or other pre-treatment undertaken. Analysed by Specific Ion Electrode.

/VOL

Intertek Genalysis Perth
No digestion or other pre-treatment undertaken. Analysed by Volumetric Technique.

Document page break

CLIENT DETAILS

Contact **Paul Rokich**
Client **GALENA MINING LIMITED**
Address **PO BOX 2517
PERTH WA 6831**

Telephone **61 8 94810389**
Facsimile **(Not specified)**
Email **paul.rokich@gmail.com**

Project **AMD Testwork**
Order Number **SGS001**
Samples **18**

LABORATORY DETAILS

Manager **Ros Ma**
Laboratory **SGS Perth Environmental**
Address **28 Reid Rd
Perth Airport WA 6105**

Telephone **(08) 9373 3500**
Facsimile **(08) 9373 3556**
Email **au.environmental.perth@sgs.com**

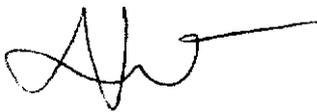
SGS Reference **PE131305 R0**
Date Received **19 Dec 2018**
Date Reported **07 Jan 2019**

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(898/20210).

Total Sulfur subcontracted to SGS Perth Minerals, 28 Reid Rd Perth Airport WA, NATA Accreditation Number 1936, WM190121

SIGNATORIES



Hue Thanh Ly
Metals Team Leader



Michael McKay
Inorganics and ARD Supervisor

Sample Number	PE131305.001	PE131305.002	PE131305.003	PE131305.004
Sample Matrix	Soil	Soil	Soil	Soil
Sample Name	G14635	G14636	G14047	G14048

Parameter Units LOR

Moisture Content Method: AN002 Tested: 4/1/2019

% Moisture	%ww	0.5	<0.5	<0.5	<0.5	<0.5

HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 20/12/2018

Acid Soluble Sulfur (SHCl)	%ww	0.005	0.080	0.067	0.058	0.058

Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: AN212 Tested: 24/12/2018

ANC as % CaCO ₃	% CaCO ₃	0.05	0.42	0.40	15	20
ANC as % CaMg(CO ₃) ₂	%ww	0.05	0.48	0.44	16	22
Acid Neutralisation Capacity/Neutralisation Potential	kg CaCO ₃ /T	0.5	4.2	4.0	150	200
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /T	0.5	4.2	3.9	140	200
Fizz Rating Reaction*	No unit	-	Moderate	Moderate	Strong	Strong
Titration - Green Colouration?*	No unit	-	None	None	None	None
Titration - Precipitate Formed?*	No unit	-	None	None	None	None
Initial Effervescence*	No unit	-	None	None	None	None
Effervescence on Warming*	No unit	-	None	None	None	None

Single Addition Net Acid Generation (NAG) Method: AN216 Tested: 20/12/2018

ECox (NAG Conductivity)	µS/cm	1	150	150	220	220
pHox (NAG pH)	No unit	-	8.5	8.3	9.2	9.1
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg H ₂ SO ₄ /tonne to pH 7	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg CaCO ₃ /tonne to pH 4.5	kg CaCO ₃ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg CaCO ₃ /tonne to pH 7	kg CaCO ₃ /T	0.5	<0.5	<0.5	<0.5	<0.5

Total Carbon/Sulphur in soil by LECO Method: CSA06V Tested: 27/12/2018

Sulphur*	%	0.005	1.88	1.43	3.48	2.3
Sulphur ppm*	ppm	50				

Sample Number	PE131305.005	PE131305.006	PE131305.007	PE131305.008
Sample Matrix	Soil	Soil	Soil	Soil
Sample Name	G16287	G16288	G13947	G13948

Parameter	Units	LOR				
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Moisture Content Method: AN002 Tested: 4/1/2019

% Moisture	%w/w	0.5	<0.5	<0.5	<0.5	<0.5
------------	------	-----	------	------	------	------

HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 20/12/2018

Acid Soluble Sulphur (SHCl)	%w/w	0.005	0.069	0.063	0.14	0.16
-----------------------------	------	-------	-------	-------	------	------

Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: AN212 Tested: 24/12/2018

ANC as % CaCO ₃	% CaCO ₃	0.05	15	15	1.3	0.95
ANC as % CaMg(CO ₃) ₂	%w/w	0.05	17	17	1.5	1.0
Acid Neutralisation Capacity/Neutralisation Potential	kg CaCO ₃ /T	0.5	150	160	13	9.5
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /T	0.5	150	160	13	9.3
Fizz Rating Reaction*	No unit	-	Strong	Strong	Moderate	Moderate
Titration - Green Colouration?*	No unit	-	None	None	None	None
Titration - Precipitate Formed?*	No unit	-	None	None	None	None
Initial Effervescence*	No unit	-	None	None	None	None
Effervescence on Warming*	No unit	-	None	None	None	None

Single Addition Net Acid Generation (NAG) Method: AN216 Tested: 20/12/2018

ECox (NAG Conductivity)	µS/cm	1	150	150	1300	960
pHox (NAG pH)	No unit	-	8.5	8.2	2.8	2.9
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	10	7.5
NAG as kg H ₂ SO ₄ /tonne to pH 7	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	12	10
NAG as kg CaCO ₃ /tonne to pH 4.5	kg CaCO ₃ /T	0.5	<0.5	<0.5	10	7.7
NAG as kg CaCO ₃ /tonne to pH 7	kg CaCO ₃ /T	0.5	<0.5	<0.5	13	10

Total Carbon/Sulphur in soil by LECO Method: CSA06V Tested: 27/12/2018

Sulphur*	%	0.005	4.61	4.57	10.6	10.6
Sulphur ppm*	ppm	50	-	-	-	-

Sample Number	PE131305.009	PE131305.010	PE131305.011	PE131305.012
Sample Matrix	Soil	Soil	Soil	Soil
Sample Name	G16298	G16307	G17157	G17158

Parameter
Units
LOR

Moisture Content Method: AN002 Tested: 4/1/2019

% Moisture	%w/w	0.5	<0.5	<0.5	<0.5	<0.5

HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 20/12/2018

Acid Soluble Sulfur (SHCl)	%w/w	0.005	0.065	0.083	0.12	0.14

Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: AN212 Tested: 24/12/2018

ANC as % CaCO ₃	% CaCO ₃	0.05	38	45	0.28	0.20
ANC as % CaMg(CO ₃) ₂	%w/w	0.05	43	48	0.28	0.22
Acid Neutralisation Capacity/Neutralisation Potential	kg CaCO ₃ /T	0.5	390	450	2.8	2.0
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /T	0.5	380	440	2.8	2.0
Fizz Rating Reaction*	No unit	-	Strong	Strong	Moderate	Moderate
Titration - Green Colouration?*	No unit	-	None	None	None	None
Titration - Precipitate Formed?*	No unit	-	None	None	None	None
Initial Effervescence*	No unit	-	None	None	None	None
Effervescence on Warming*	No unit	-	None	None	None	None

Single Addition Net Acid Generation (NAG) Method: AN216 Tested: 20/12/2018

ECox (NAG Conductivity)	µS/cm	1	170	230	240	260
pHox (NAG pH)	No unit	-	8.3	8.3	4.8	4.0
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	0.8
NAG as kg H ₂ SO ₄ /tonne to pH 7	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	3.5	3.5
NAG as kg CaCO ₃ /tonne to pH 4.5	kg CaCO ₃ /T	0.5	<0.5	<0.5	<0.5	0.8
NAG as kg CaCO ₃ /tonne to pH 7	kg CaCO ₃ /T	0.5	<0.5	<0.5	3.5	3.6

Total Carbon/Sulphur in soil by LECO Method: CSA06V Tested: 27/12/2018

Sulphur*	%	0.005	3.47	3.8	1.78	0.864
Sulphur ppm*	ppm	50	-	-	-	-

Sample Number	PE131305.013	PE131305.014	PE131305.015	PE131305.016
Sample Matrix	Soil	Soil	Soil	Soil
Sample Name	G14991	G14992	G16609	G16610

Parameter	Units	LOR				
-----------	-------	-----	--	--	--	--

Moisture Content Method: AN002 Tested: 4/1/2019

% Moisture	%ww	0.5	<0.5	<0.5	<0.5	<0.5

HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 20/12/2018

Acid Soluble Sulfur (SHC)	%ww	0.005	0.32	0.56	0.12	0.10

Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: AN212 Tested: 24/12/2018

ANC as % CaCO ₃	% CaCO ₃	0.05	9.3	9.7	13	9.7
ANC as % CaMg(CO ₃) ₂	%ww	0.05	10	11	14	11
Acid Neutralisation Capacity/Neutralisation Potential	kg CaCO ₃ /T	0.5	93	97	130	97
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /T	0.5	91	95	120	95
Fizz Rating Reaction*	No unit	-	Strong	Strong	Strong	Strong
Titration - Green Colouration?*	No unit	-	None	None	None	None
Titration - Precipitate Formed?*	No unit	-	None	None	None	None
Initial Effervescence*	No unit	-	None	None	None	None
Effervescence on Warming*	No unit	-	None	None	None	None

Single Addition Net Acid Generation (NAG) Method: AN216 Tested: 20/12/2018

ECox (NAG Conductivity)	µS/cm	1	230	310	200	380
pHox (NAG pH)	No unit	-	6.5	6.8	6.2	6.2
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg H ₂ SO ₄ /tonne to pH 7	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg CaCO ₃ /tonne to pH 4.5	kg CaCO ₃ /T	0.5	<0.5	<0.5	<0.5	<0.5
NAG as kg CaCO ₃ /tonne to pH 7	kg CaCO ₃ /T	0.5	<0.5	<0.5	<0.5	<0.5

Total Carbon/Sulphur in soil by LECO Method: CSA06V Tested: 27/12/2018

Sulphur*	%	0.005	4.55	6.01	4.49	6.56
Sulphur ppm*	ppm	50				

Sample Number	PE131305.017	PE131305.018
Sample Matrix	Soil	Soil
Sample Name	G17429	G17430

Parameter	Units	LOR
-----------	-------	-----

Moisture Content Method: AN002 Tested: 4/1/2019

% Moisture	%w/w	0.5	<0.5	<0.5
------------	------	-----	------	------

HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 20/12/2018

Acid Soluble Sulphur (SHC)	%w/w	0.005	0.093	0.46
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Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: AN212 Tested: 24/12/2018

ANC as % CaCO ₃	% CaCO ₃	0.05	2.3	2.8
ANC as % CaMg(CO ₃) ₂	%w/w	0.05	2.5	3.1
Acid Neutralisation Capacity/Neutralisation Potential	kg CaCO ₃ /T	0.5	23	28
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /T	0.5	23	28
Fizz Rating Reaction*	No unit	-	Strong	Strong
Titration - Green Colouration?*	No unit	-	None	None
Titration - Precipitate Formed?*	No unit	-	None	None
Initial Effervescence*	No unit	-	None	None
Effervescence on Warming*	No unit	-	None	None

Single Addition Net Acid Generation (NAG) Method: AN216 Tested: 20/12/2018

ECox (NAG Conductivity)	µS/cm	1	270	320
pHox (NAG pH)	No unit	-	5.9	6.6
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5
NAG as kg H ₂ SO ₄ /tonne to pH 7	kg H ₂ SO ₄ /T	0.5	<0.5	<0.5
NAG as kg CaCO ₃ /tonne to pH 4.5	kg CaCO ₃ /T	0.5	<0.5	<0.5
NAG as kg CaCO ₃ /tonne to pH 7	kg CaCO ₃ /T	0.5	<0.5	<0.5

Total Carbon/Sulphur in soil by LECO Method: CSA06V Tested: 27/12/2018

Sulphur*	%	0.005	1.85	4.04
Sulphur ppm*	ppm	50	-	-

MB blank results are compared to the Limit of Reporting

LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared to the amount of analyte spiked into the sample.

DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula: *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA', the results are less than the LOR and thus the RPD is not applicable.

Acid Neutralising Capacity or Neutralisation Potential(ANC/NP) Method: ME-(AU)-(ENV)AN212

Parameter	QC	Units	LOR	MB	DUP %RPD	LCS
	Reference					
ANC as % CaCO ₃	LB154463	% CaCO ₃	0.05	<0.05		
ANC as % CaMg(CO ₃) ₂	LB154463	%w/w	0.05	<0.05		
Acid Neutralisation Capacity/Neutralisation Potential	LB154463	kg CaCO ₃ /T	0.5	<0.5	1 - 6%	NA
Acid Neutralisation Capacity/Neutralisation Potential kg H ₂ SO ₄ /t	LB154463	kg H ₂ SO ₄ /T	0.5	<0.5	1 - 6%	NA
Fizz Raging Reaction*	LB154463	No unit	-	None		
Titration - Green Colouration?*	LB154463	No unit	-	None		
Titration - Precipitate Formed?*	LB154463	No unit	-	None		
Initial Effervescence*	LB154463	No unit	-	None		
Effervescence on Warming*	LB154463	No unit	-	None		

HCl Extractable S, Ca and Mg in Soil ICP OES Method: ME-(AU)-(ENV)AN014

Parameter	QC	Units	LOR	MB	DUP %RPD	LCS
	Reference					
Acid Soluble Sulfur (SHCl)	LB154384	%w/w	0.005	<0.005	3 - 4%	119%

Moisture Content Method: ME-(AU)-(ENV)AN002

Parameter	QC	Units	LOR	DUP %RPD
	Reference			
% Moisture	LB154654	%w/w	0.5	0%

Single Addition Net Acid Generation (NAG) Method: ME-(AU)-(ENV)AN216

Parameter	QC	Units	LOR	MB	DUP %RPD	LCS
	Reference					
ECox (NAG Conductivity)	LB154365	µS/cm	1	98		
pHox (NAG pH)	LB154365	No unit	-	5.6	1%	100%
NAG as kg H ₂ SO ₄ /tonne to pH 4.5	LB154365	kg H ₂ SO ₄ /T	0.5	<0.5	0%	114%
NAG as kg H ₂ SO ₄ /tonne to pH 7	LB154365	kg H ₂ SO ₄ /T	0.5	<0.5	0%	112%
NAG as kg CaCO ₃ /tonne to pH 4.5	LB154365	kg CaCO ₃ /T	0.5	<0.5	0%	114%
NAG as kg CaCO ₃ /tonne to pH 7	LB154365	kg CaCO ₃ /T	0.5	<0.5	0%	112%

METHOD

METHODOLOGY SUMMARY

AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN014	This method is for the determination of soluble sulfate (SO ₄ -S) by extraction with hydrochloric acid. Sulphides should not react and would normally be expelled. Sulfur is determined by ICP.
AN212	Samples are initially evaluated to determine the strength of reagents needed using a 'fizz' test. Samples are then subjected to an excess of hydrochloric acid followed by alkaline back titration to pH 7. Results are expressed in kg H ₂ SO ₄ /tonne or Kg CaCO ₃ /tonne after correction for moisture content if applicable.
AN216	Pulverised sub-sample of a waste rock or an as received sample of filter cake, soil or sludge is subjected to an oxidising digest with 15% hydrogen peroxide adjusted to pH 4.5. The pH and EC of the NAG suspension is recorded at various stages in the digest. The acid produced (if any) is titrated using standardised NaOH to pH 7.0. NAG results are reported to 0.5 kg H ₂ SO ₄ /tonne.
CSA06V	The sulfur is oxidised to sulfur trioxide gas and carbon to carbon dioxide gas in a tube furnace using oxygen to aid the oxidation process. The evolved sulfur trioxide and carbon dioxide is measured by an infra red cell. The infra red cell output is calibrated against the value of a known standard sample to provide the total sulfur and total carbon value of the unknown sample.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calculated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.

Note that in terms of units of radioactivity:

- a. 1 Bq is equivalent to 27 pCi
- b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : <http://www.sgs.com.au/-/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf>

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Appendix H. Mine Closure Plan

See separate pdf document

Appendix I. Water Resources Reports

ABRA LEAD-SILVER PROJECT

POTENTIAL WATER SOURCES

REPORT FOR
GALENA MINING LTD

JUNE 2018



Rockwater
HYDROGEOLOGICAL AND ENVIRONMENTAL CONSULTANTS

Report No 496-0/18/01



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REVISION	AUTHOR	REVIEW	AUTHORISED	ISSUED
0	PHW	JRP		28/6/18



1. INTRODUCTION

Galena Mining Ltd is conducting a pre-feasibility study for mining its Abra lead-silver deposit, located 200 km north of Meekatharra (Fig. 1) in the Jillawarra sub-basin of the Proterozoic Edmund Basin.

A water supply of about 25 L/s will be required for camp use, dust suppression and processing ore. This report covers the first stage of an investigation to locate and prove-up a suitable water source, preferably within about 10 km of the project site.

1.1. CLIMATE

The project site has a semi-arid to sub-tropical climate. The nearest Bureau of Meteorology (BoM) station is Tangadee (Stn. 007179), located 45 km east-north-east of Abra.

Table 1: Average Rainfall (Tangadee) and Dam Evaporation (Newman) (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall	49.7	55.6	39.5	23.7	19.2	20.2	15.2	6.2	2.8	4.6	11.0	21.6	269.1
Dam Evap.	290	232	216	182	109	108	125	121	166	237	267	293	2,346

Rainfall at Tangadee (1960 to 2018) averages 269 mm per annum, with on average, 71 % falling in the months December to April mainly due to thunderstorms or the remnants of cyclones. The highest daily fall was 192 mm on 12 March 1965.

Average dam evaporation at Newman, to the north-east (Luke, Burke and O'Brien, 1988) exceeds average rainfall in all months of the year (Table 1), and by a factor of nine overall.

Temperatures recorded at Three Rivers, 78 km to the south-east (BoM station 007080) indicate monthly mean minimum temperatures ranging from 4.7 °C in July to 24.1 °C in January; and mean maximum temperatures ranging from 21 °C in July to 39.3 °C in January.

2. GEOLOGY

Geological descriptions of the Abra deposit provided by Galena Mining include the following:

The Abra polymetallic deposit is hosted in siliciclastic metasedimentary rocks of the Irregully and Kiangi Creek Formations of the Mesoproterozoic Edmund Group, part of the Bangemall Supergroup.

Five main lithological units have been identified. From the top to the base of the deposit they are named as follows:

- Kiangi Creek interbedded sediments;
- Kiangi Creek lower conglomerate;
- Upper Irregully dolomitic unit;
- Irregully chloritic sediment;
- Irregully fine sediment.

The Kiangi Creek interbedded sediments unit is defined by micaceous interbedded sandstone and minor siltstone, with lenticular quartz sandstone beds along an east-west strike direction.



The Kiangi Creek Lower Conglomerate forms the top horizon of the Abra Pb-Ag-Zn mineralisation within the apron of the Abra polymetallic deposit, and it is characterized by granular to pebbly clast-supported polymictic conglomerate and coarse to granular quartz sandstone. It has strong hydrothermal alteration with alteration minerals including jaspilite, barite, dolomite and haematite. Its minimum depth is about 250 m.

The Upper Irregularly Dolomitic Unit forms the upper part of the Irregularly Formation at the Abra Deposit, and comprises dolomitic mudstone, banded dolomite, and minor lenses of conglomerate and sandstone. It contains the most significant Pb-Ag mineralisation of the deposit. Hydrothermal alteration has resulted in jaspilite-barite-haematite in the upper parts and magnetite, haematite and silica towards the base.

The Irregularly Chloritic Sediment forms part of the upper Irregularly Formation and is characterised by chlorite and silica-altered fine grained sediments and minor sandstone. It has undergone intense hydrothermal alteration, veining and brecciation, and includes the core of the Abra Pb-Ag-Zn mineralisation as well as the lower Cu-Au mineralised zones.

The Irregularly Fine Sediment forms the base of Abra Deposit. It consists of well laminated siltstone and shale with some layers of fine dolomitic sediments.

The hydrothermal nature of the Abra deposit indicates emplacement during significant faulting events. The deposit is located along the east-west striking Quartzite Well Fault that is thought to be an eastern extension of the Lyons River Fault, where that fault is intersected by another northerly-trending fault (Cutten, Thorne and Sheppard, 2010). The deposit is located within the southern limb of an east-west trending open anticline, near the fold axial plane. It takes the form of a funnel-shaped brecciated zone, overlain by vertically zoned strata-bound mineralisation. The eastern boundary of the deposit plunges to the east, and the western boundary to the west.

The depth of weathering is variable, but saprolite (clay) generally extends down to about 50 m depth or less; saprock is generally 50 to 100 m deep and grades down to transition zone rocks which are oxidised along joints and fractures.

3. HYDROGEOLOGY

3.1. PREVIOUS STUDIES

Geopeko drilled at least 22 holes (JHP1 to JHP22) in 1990 to depths of 28 m to 76 m for the purpose of obtaining water samples and drill cuttings. They recorded lithologies, depths water cut, and static water levels; and pH, electrical conductivity and temperature of water from the holes. Lithological samples were analysed for zinc and lead. Many of the holes ended in clay (completely weathered rock) and so would have been above any potential aquifer zones. Most of these holes/bores remain, and can be used for groundwater level and quality measurements.

AQ2 (2017) conducted a data review and site reconnaissance as part of a pre-feasibility study for the project. Groundwater-level measurements indicated a northerly direction of flow and a possible high-permeability zone centred near the ore body. Groundwater salinities ranged from 380 to 540 mg/L TDS, and pH 6.0 to 6.8 (slightly acidic). Saprock in the transition zone was expected to be of low to high



permeability. Rocks hosting the ore body were expected to be of low permeability; and along the main east-west fault there were some broken zones that may have high permeability, although these zones were thin and did not appear to be continuous. A field testing programme was recommended.

AQ2 (2018) conducted 16 packer tests on three cored drillholes; and micro pumping tests on five drillholes. The packer tests included one in a saprock/transition zone; 10 in the Upper West Creek (Kiangi Creek) formation; and five in the Lower West Creek (Irregully) formation. There were none in the fault zone. The results all indicated very low permeabilities: 0.00041 m/d (transition zone); 0.000023 to 0.00033 m/d (Upper West Creek; and 0.0000077 to 0.000063 m/d (Upper West Creek). The micro pumping tests indicated low permeabilities for the saprock /transition zone ranging from 0.033 to 0.3 m/d, although some of the open intervals tested were not recorded (e.g. for AB71) and so the holes may have collapsed above deeper, more-permeable zones. Test-pumping rates were also not reported.

Salinities ranged from 430 to 510 mg/L TDS; pH 8.0 to 8.1 (alkaline); and the water was of sodium/calcium bicarbonate type, which with the low salinity indicates good recharge conditions.

3.2. AVAILABLE DATA

In addition to the data and reports described above, the following data were available for this assessment:

1. Pumps United airlifted or pumped a number of open drillholes and bores to obtain an indication of potential water yields. Galena Mining provided geological logs for the holes tested;
2. Data on bores in the project area were obtained from the Department of Water and Environmental Regulation (DWER) Water Information Reporting (WIR) database;
3. Photos of core from three typical diamond drillholes in the Abra deposit were provided by Galena Mining, as well as a geological section through the deposit; and
4. The 1:100,000 Calyie geological map was scrutinised for rock types and structures that could form potential aquifers.

3.3. HYDROGEOLOGICAL ASSESSMENT

3.3.1. AQUIFER CHARACTERISTICS

The packer tests and micro pumping tests conducted by AQ2 (2018) on holes AB54, 70, 71, 74, 76, 78, and 80 (Fig. 2a) suggested that rocks of the Abra deposit are of low permeability, although AQ2 did note that some fracture zones were untested. These results are not definitive, as packer test permeabilities can be reduced by factors such as clay smearing on drillhole walls; and the very low pumping rates during the micro pumping tests cannot produce significant water-level drawdowns.

The results of the testing by Pumps United are summarised in Table 2.

The JHP-series bores are shallow regional bores which all had low or no yields. They intersect mainly clay and weathered rock, and have slotted casing intervals that are above transition zone rocks which might have been permeable.

Eight holes in and around the Abra, Genie and Hyperion Deposits (Fig. 2b) were tested.



Table 2: Results of Pumps United Tests

Bore/Hole	mE	mN	Dip	Azimuth	Diam (mm)	Depth (m)	How Tested	Yield (L/s)
AB10	660870	7273022	-85				Pumped	7
ABRC001	660542	7274491	90		100	250 (40)	Airlift	0
EP1	660519	7274257	90	0		180	Airlift	6
Ethel Creek Bore	668210	7275089	-90		120	80	Pumped	3.7
GE1	663919	7273082	-85	0	100	70	Airlift	0
HY1	658539	7272958	-80		100	605.6	Airlift	8
HY2	658740	7272975	68.5	67		93	Airlift	0.5
JHP13	662710	7275124	90	0	100	28	Airlift	0
JHP16	660489	7274490	90	0	100	44	Airlift	0.5
JHP17	659849	7273662	90	0		70	Airlift	0
JHP18	660963	7273643	90	0		58	Airlift	0
JHP2	658450	7272550	90			70	Airlift	Minor
JHP20	659856	7272881	90	0	100	52	Airlift	0
JHP21	660507	7272760	90	0	100	28	Airlift	0
JHP22	659910	7272564	90	0	100	34	Airlift	Minor
JHP3	658801	7273948	90	0	100	70	Airlift	0
JHP4	658900	7274400				60	Airlift	0
JHP5	659763	7275752	90	0	100	40	Airlift	0
NARCO13	663139	7276311	-60	180	150	119	Pumped	<1
NARCO18	662739	7274804	-60	180	150	114		ND
AB8	660203	7272819				154	Airlift	Uncert.

Of these three (AB10, EP1 and HY1) had significant yields, and another (AB8) had intermittent surges of moderate water flows where the compressed air may have been lost to fractures/joints in the rocks.

Inspection of core photos for drillholes AB71, AB75 and AB79 in the Abra deposit (Fig. 2a) indicated common, apparently open joints that might have moderate to high permeability, as well as some ferruginous and minor vuggy zones. These and the high percentage of drillholes yielding water, and the low salinities of the groundwater (Section 3.3.3) suggest that most or all of the required water supply might be able to be obtained from the Hyperion, Abra and possibly Genie mineralised zones (Fig. 2b). Controlled pumping tests will be needed to confirm this.

3.3.2. GROUNDWATER LEVELS, FLOW DIRECTIONS

Groundwater levels measured by AQ2 (2017) and Pumps United in 2018 indicate that the water table in the Abra area ranges from about 16 m to 54 m deep (depending on ground elevation). Those reduced to m AHD (Fig. 3) indicate that the groundwater is flowing northwards (in the direction of surface drainages) under a hydraulic gradient averaging about 0.0027.

3.3.3. GROUNDWATER QUALITY

Groundwater electrical conductivity (EC) recorded on the Geopeko geological logs, and those measured by AQ2 (2017) and by Pumps United (2018), were used to estimate salinity (Table 3).



Table 3: Field EC and pH Measurements

Bore	EC (uS/cm)	Temp	TDS (mg/L)	pH
AB10	853	28	420	10.5
Ethel Creek Bore	650	29.2	310	6.2
EP1	402		190	10.7
JHP1	580		380	6.0
JHP10	700		460	6.8
JHP13	700	28	340	6.2
JHP14	750		500	6.8
JHP15	700		460	6.8
JHP16	820	27	420	6.8
JHP2	750	28	370	
JHP2	750		495	6.8
JHP3	790	28	390	6.8
JHP4	750	29	360	6.8
JHP5	800	28	400	6.8
JHP7	700		460	6.4

These measurements indicate that the groundwater is fresh with salinities ranging from 200 to 500 mg/L TDS. The water is slightly acidic (pH 6.0 to 6.8) – the two high values measured by Pumps United are probably erroneous.

AQ2 (2018) had water samples taken from four drillholes in the Abra deposit on 8 December 2017 analysed for major ions and pH – the results of those analyses are given in Table 4.

Table 4: Results of Chemical Analyses, 2017

Analyte	Units	AB71	AB74	AB76	AB78
pH	pH Units	8.0	8.0	8.0	8.1
Conductivity @ 25 C	uS/cm	760	750	750	730
Total Dissolved Solids	mg/L	510	490	470	430
Total Alkalinity as CaCO ₃	mg/L	220	200	240	240
Carbonate Alkalinity as CO ₃	mg/L	<1	<1	<1	<1
Bicarbonate Alkalinity as HCO ₃	mg/L	270	250	290	290
Chloride	mg/L	64	65	64	70
Sulphate	mg/L	49	54	48	32
Calcium	mg/L	48	47	46	38
Potassium	mg/L	8.1	8.8	9.2	12
Magnesium	mg/L	34	33	34	33
Sodium	mg/L	40	40	41	45

They indicate that the water is of calcium/sodium bicarbonate type, and slightly alkaline with higher pH than the field samples (dissolved carbon dioxide may have been lost from the samples in transit to the laboratory).



Pumps United collected water samples from five of the bores/holes tested in 2018 (AB7, AB10, EP1, Ethel Creek, and HY1), and submitted them to ALS Environmental for chemical analysis. The results are given in Table 5.

Table 5: Results of Chemical Analyses, 2018

	Sample Date:		13/05/2018	13/05/2018	17/05/2018	11/05/2018	10/05/2018
	Bore:		AB10	AB7	EP1	Ethel River B	HY1
Analyte	Unit	Limit of Reporting					
pH Value	pH Unit	0.01	8.29	7.93	8.36	8.21	8.4
Electrical Conductivity @ 25°C	µS/cm	1	864	772	678	1040	1160
Total Dissolved Solids @180°C	mg/L	10	462	408	391	578	669
Suspended Solids	mg/L	5	13	<5	819	105	41
Turbidity	NTU	0.1	8.6	0.2	562	64.6	27.7
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	1	<1	<1	3	<1	9
Bicarbonate Alkalinity as CaCO3	mg/L	1	310	263	165	263	244
Total Alkalinity as CaCO3	mg/L	1	310	263	168	263	254
Acidity as CaCO3	mg/L	1	<1	11	<1	4	<1
Sulphate as SO4	mg/L	1	44	48	39	61	121
Chloride	mg/L	1	69	65	58	147	142
Calcium	mg/L	1	42	46	38	56	60
Magnesium	mg/L	1	31	35	28	43	50
Sodium	mg/L	1	75	50	34	65	76
Potassium	mg/L	1	9	9	8	18	11
Aluminium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	mg/L	0.001	0.061	0.006	<0.001	<0.001	0.001
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	0.253	0.41	<0.001	<0.001	0.16
Nickel	mg/L	0.001	<0.001	0.004	<0.001	<0.001	<0.001
Selenium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Iron	mg/L	0.05	0.11	<0.05	<0.05	<0.05	<0.05
Hexavalent Chromium	mg/L	0.001	<0.001	<0.001	<0.001	0.001	<0.001
Ferrous Iron	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ammonia as N	mg/L	0.01	0.13	0.02	0.02	0.02	0.04
Nitrite as N	mg/L	0.01	0.1	0.02	<0.01	<0.01	0.06
Nitrate as N	mg/L	0.01	4.46	2.69	13.4	4.7	14.6
Nitrite + Nitrate as N	mg/L	0.01	4.56	2.71	13.4	4.7	14.7
Total Kjeldahl Nitrogen as N	mg/L	0.1	0.6	0.3	1.7	0.7	2
Total Nitrogen as N	mg/L	0.1	5.2	3	15.1	5.4	16.7
Total Phosphorus as P	mg/L	0.01	0.06	<0.02	<0.05	0.04	<0.05
Reactive Phosphorus as P	mg/L	0.01	0.04	0.01	0.02	<0.01	<0.01
Sulphide as S2-	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1

These results again show that the water is slightly alkaline (pH 7.9 to 8.4) and of a calcium/sodium bicarbonate type. Metals are mostly below Limits of Reporting. Total nitrogen ranges from 3 to 16.7 mg/L; and phosphorus concentrations are low.



3.3.4. IMPACTS OF GROUNDWATER EXTRACTION

Bores, wells and springs in the Abra area recorded in the WIR database are shown in Figure 4.

There are only two sites within 15 km of Abra: Bedford bore (and adjacent ESR well No. 14A); and Chalk Spring in the Ethel River. The recorded details for these are summarised in Table 6.

Table 6: Bore, Well and Spring, WIR Database

Site Ref	Name	Easting	Northing	TD (m)	Yield (kL/d)	WL (mbtc)	TDS (mg/L)	Remarks
70610640	Bedford B	656662	7278867	16.5	8	3.7	520, 1255	Bore in dolomite. Well in shale
70610685	Chalk Spring	667355	7277611	16.9		4	925	Pool. Calcrete, shale & mudstone

There is no possibility that pumping from bores at Abra would have any impact on these features. Also, there are no other known groundwater dependent vegetation or ecosystems that could be impacted.

3.4. POTENTIAL ADDITIONAL WATER SOURCES

Initial indications are that groundwater in the Proterozoic felsic volcanoclastic rocks and metasediments at and near the Abra, Genie and Hyperion deposits might be the source of much or all of the water needed for the Abra project.

If an additional source or sources of water are required, the following are potential targets within about 10 km of the project site:

- Ethel Creek Bore, which Pumps United pumped at 3.7 L/s. This is believed to be a Government bore, located about 8 km east of Abra. Approval to use the bore might be needed, and environmental impacts of extraction would need to be assessed.
- Other areas of fractured and jointed rocks in and around the three deposits. These could be defined, and tested for groundwater yields.
- Calcrete associated with the Ethel River, near and north and south of Ethel Creek Bore (Fig.2b); and north of Abra. There could be potential environmental impacts developing this aquifer near Ethel River.
- Dolomite and sandstone of the Irregularly Formation: an outcrop is mapped 7.5 km east of Abra.
- Alluvium and possible palaeochannel sediments in a tributary which extends south from the above outcrop.
- Faulted Discovery Formation and Devil Creek Formation (chert, dolomite and sandstone) about 3 km south of Abra.

4. CONCLUSIONS AND RECOMMENDATIONS

Eight holes in and around the Abra, Genie and Hyperion Deposits were subjected to short-term pumping or airlift tests by Pumps United.



Of these three (AB10, EP1 and HY1) had significant yields, and another (AB8) had intermittent surges of moderate water flows – the surging may have been caused by compressed air being lost to fractures/joints in the rocks.

These results suggest that most or all of the required water supply might be obtainable from the Hyperion, Abra and possibly Genie mineralised zones and adjoining rocks. This is supported by observation of open joints and some ferruginous and minor vuggy zones in diamond core, and the low salinity of the groundwater,

There are only two water-source sites recorded in the DWER WIR database within 15 km of the Abra deposit: Bedford bore (and adjacent ESR well No. 14A); and Chalk Spring in the Ethel River. There is no possibility of pumping from bores at Abra or Hyperion having any impact on these features. Also, there are no other known groundwater dependent vegetation or ecosystems that could be impacted by pumping from these locations.

The groundwater in the Abra area flows northwards (in the direction of surface drainages) under a hydraulic gradient averaging about 0.0027. The water is slightly alkaline (pH 7.9 to 8.4) and of a calcium/sodium bicarbonate type. Metals are mostly below Limits of Reporting. Total nitrogen ranges from 3 to 16.7 mg/L; and phosphorus concentrations are low.

Potential targets for groundwater supplies – additional to the mineral deposits noted above –within 10 km of the project site include:

- Ethel Creek Bore, which Pumps United pumped at 3.7 L/s.
- Other areas of fractured and jointed rocks in and around the three mineral deposits.
- Calcrete associated with the Ethel River, near Ethel Creek Bore; and north of Abra.
- Dolomite and sandstone of the Irregularly Formation: an outcrop is mapped 7.5 km east of Abra.
- Alluvium and possible palaeochannel sediments in a tributary which extends south from the above outcrop.
- Faulted Discovery Formation and Devil Creek Formation (chert, dolomite and sandstone) about 3 km south of Abra.

It is recommended that test-production bores be constructed where testing has indicated good flows of groundwater, and the bores test-pumped to determine long-term yields. Depending on the results, groundwater exploration drilling could be conducted in the other prospective areas nearby.

Dated: 27 June 2018

Rockwater Pty Ltd



**P H Wharton
Principal**

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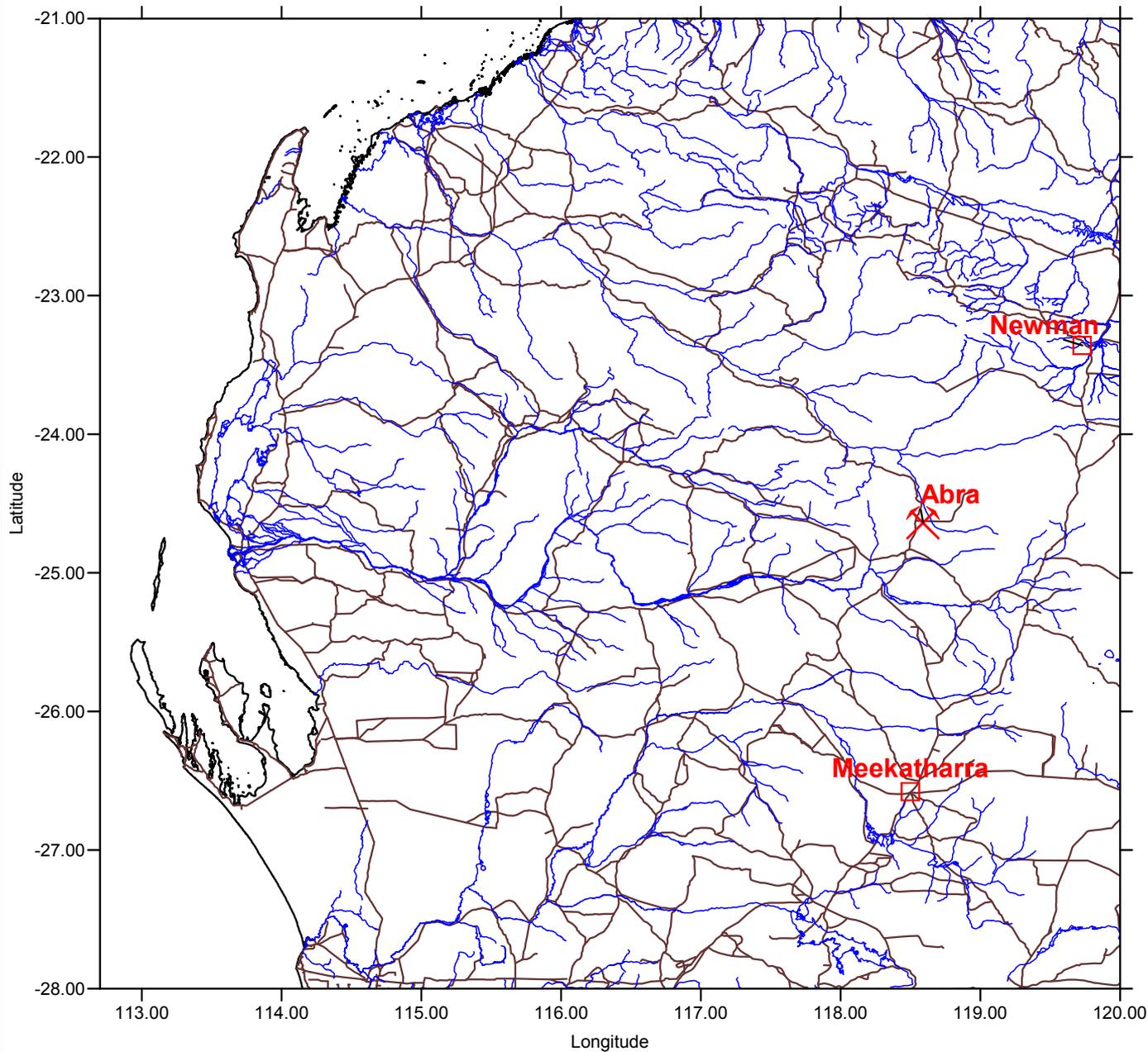
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FIGURES



Figure 1



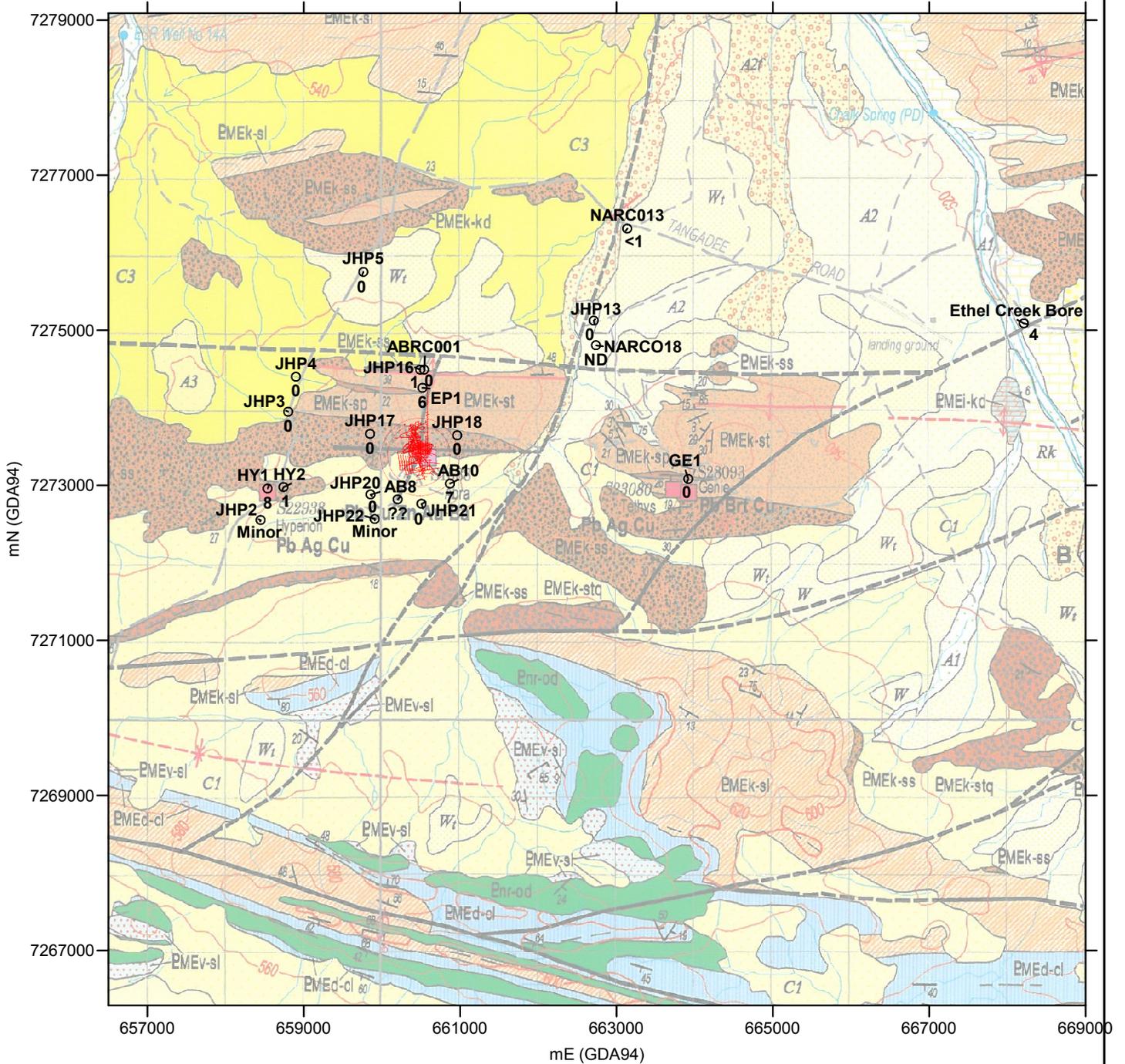
General Locality.srf

CLIENT: Galena Mining
PROJECT: Water Sources
DATE: June 2018
Dwg. No: 496-0/18/01-1

PROJECT LOCATION



FIGURE 2b



JHP4 Bore
 ○ Flow (L/s)
 8

PEV - sl Devil Creek Fm
 PMEd - cl Discovery Fm
 PMEk - ss Kiangi Creek Fm (sandstone & siltstone)
 PMEk - st Kiangi Creek Fm (qtz sandstone & siltstone)
 PMEI - kd Irregully Fm

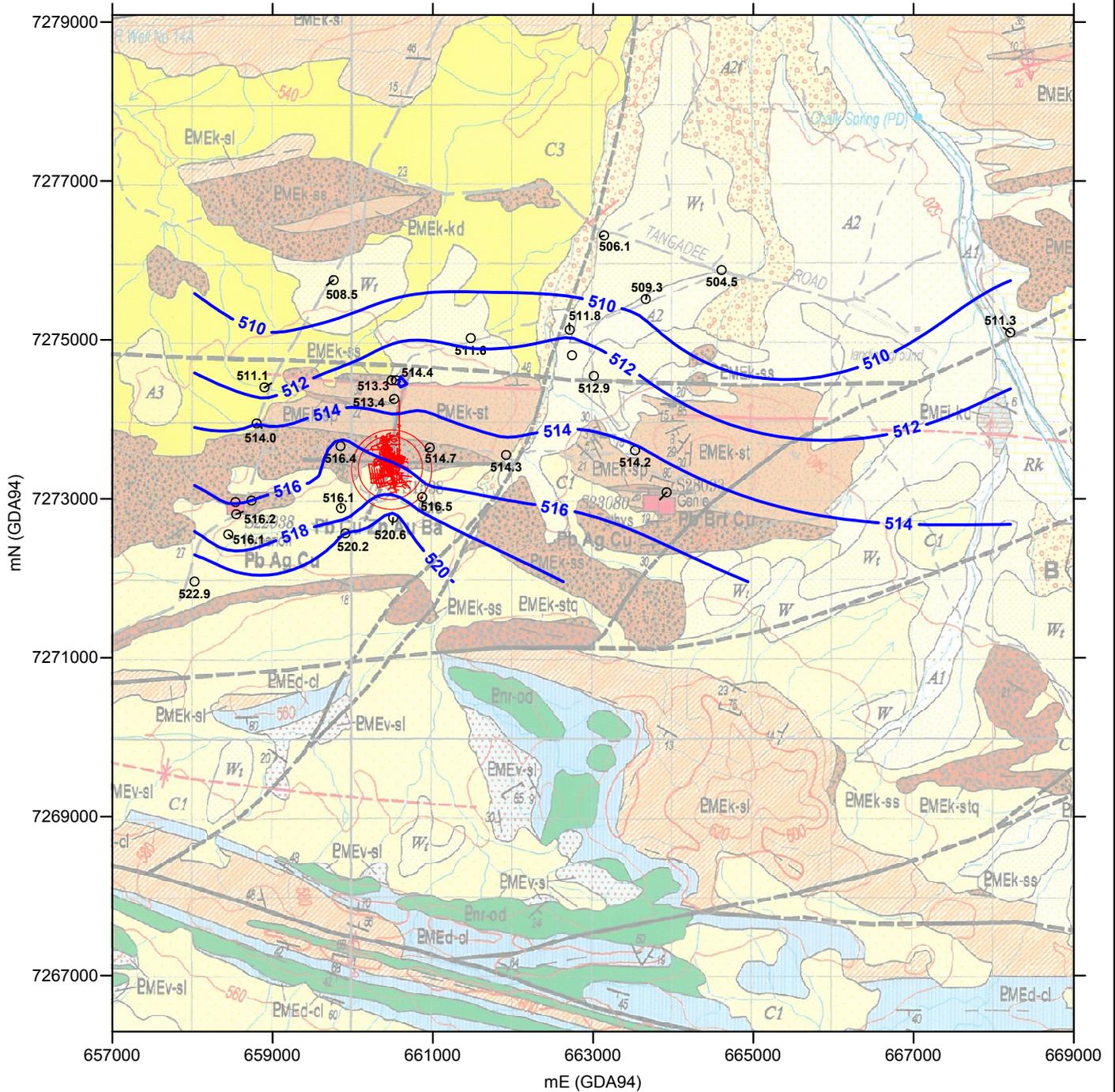
water flows.srf

Base Map: Calyie 1:100 000 Geological Series

CLIENT: Galena Mining
 PROJECT: Abra
 DATE: June 2018
 Dwg No: 496-0/18/1-2b

BORES AND HOLES TESTED, AND FLOWS (L/S),
 REGIONAL

FIGURE 3



rwls.srf

Base Map: Calyie 1:100 000 Geological Series

CLIENT: Galena Mining
 PROJECT: Abra
 DATE: June 2018
 Dwg No: 496-0/18/1-3

REDUCED GROUNDWATER LEVELS (m AHD)
 MEASURED AT VARIOUS TIMES