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SUBJECT: Medcalf Project: Geochemical Characterisation of Slurry Samples of **Deslimed-Tailings** and **Gravity-Reject-Tailings** and Implications for Tailings Management

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Geoffrey,

The testwork results obtained in this study are presented in **Tables 1-6**.

Photographs of the samples received for testing, and various testing procedures, are shown on **Plates 1-8**.

Details of the metallurgical testwork programme employed to generate the tailings slurry samples tested herein, are presented in **Attachment I**. Relevant background information for the Project's processing route is also presented in this Attachment.

Copies of the laboratory reports are presented in **Attachment II**.

The slurry samples tested in this study correspond to:

- **Deslimed-Tailings (D-Tailings)**

  Bulk Cyclone OF
  GCA11903

- **Gravity-Reject-Tailings (GR-Tailings)**

  CUF P_{100} 0.5mm Bulk RC100 OF
  GCA11904

For each tailings sample, the corresponding tailings-solids and tailings-slurry-water, were tested.

1.0 TESTWORK OUTCOMES

It will be shown that, geochemically, the D-Tailings and GR-Tailings samples are essentially identical, reflecting simply a physical (i.e. sizing/density-based) fractionation and differentiation when beneficiating the ore-blends.

1.1 Tailings-Slurry-Waters

The slurry-waters for the D-Tailings and GR-Tailings samples were neutral, and of 'potable-salinity' (**Table 1**) reflective of both a low salt content of the ore-blends, and the use of Perth tap-water in the metallurgical testwork programme (**Attachment I**).[1]

The concentrations of a wide range of minor-elements were typically below, or close to, the respective detection-limits (invariably 1 µg/L). Such tightly constrained solubilities applied to Cu, Ag, Bi, and V that were variously enriched in the corresponding tailings-solids samples (**Table 3**).

A V concentration of 78 µg/L was recorded for the D-Tailings-slurry-water, and a Mn concentration of 420 µg/L was recorded for the GR-Tailings-slurry-water (**Table 1**).

Both tailings-slurry-water samples had NO_3-N concentrations of 5-6 mg/L.

1.2 Tailings-Solids

1.2.1 Acid-Base Chemistry

Although devoid of reactive-carbonates (e.g. calcites), the solids of both the D-Tailings and GR-Tailings samples are equally devoid of sulphides (e.g. pyrites), as evident from Cr(II)-Reducible-S values below the detection-limit of 0.005 % (**Table 2**).

The D-Tailings-Solids and GR-Tailings-Solids samples are both classified as Non-Acid Forming (NAF).

1.2.2 Multi-Element Composition and Mineralogy

Each tailings-solids sample was characterised by major/minor-element contents below, or close to, those typically recorded for soils, regoliths and bedrocks derived from non-mineralised terrain (**Table 3**).

Although each tailings-solids sample was enriched in Cu, Ag, Bi, and V, the degree of enrichment was not marked.[2]

Both tailings-solids samples comprised mostly hematite, goethite, and kaolin with sub-ordinate anatase, rutile, and quartz (**Table 4**). The GR-Tailings-Solids sample also contained halloysite as a minor component.

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[1] Though site-groundwaters are (hyper)saline, make-up-water for the mill needs to be of low salinity for processing reasons.

[2] The indicated element enrichments in **Table 3** fall within the range recorded for strongly ferruginous tailings-solids produced at hard-rock mines for a wide range of commodities throughout the WA mining industry (Campbell, unpublished results since the late-1980s).

1.2.3 Stability of Bound-Element Forms: Batch-Reactor Extractions Using Dilute Acetic-Acid-Based Solutions Buffered at pH 5

As a measure of the strength with which elements are chemically bound to the surfaces of the Fe/Al/Ti/Si oxyhydroxides (viz. 'resistates') and kaolinites in the D-Tailings and GR-Tailings, the tailings-solids samples were subjected to extraction testing at pH 5 using dilute acetic-acid-based solutions – refer footnotes to **Table 5** for testing details.

Despite imposition of mildly-acidic conditions, the concentrations of elements in the pH-extracts were typically:

(a) below the detection-limits (invariably 1 µg/L)

(b) within the range 10-100 µg/L

The 'weak response' to imposition of pH 5 attests to the stability of element forms bound to the surfaces of 'sesquioxides' (i.e. predominance of strong 'inner-sphere' complexes of the high-affinity / poorly-reversible type involving surface hydroxyl groups [e.g. –Fe-OH, –Al-OH, etc.]).[3]

In terms of the 'pools' of weakly-bound elements forms, the elements (e.g. Cu, Ni, Zn, and Co) conforming to (b) would be characterised by potentially 'leachable-pools' within the sub-mg/kg (dry-solids basis) range only.

Exceptions to the above were:

- Mn with pH5-extract concentrations of 200-720 µg/L
- B with pH5-extract concentrations of 160-220 µg/L

The pH5-extract-Mn concentrations reflect the often observed weaker interaction of Mn(II) forms with the surfaces of oxyhydroxides. The 'pool' size for such weakly-bound-Mn forms is within the 1-10 mg/kg (dry-solids basis), and thus modest.

The pH5-extract-B concentrations are biased 'on-the-high-side', since the pH5-Feed solution had a B concentration of 89 µg/L.

1.2.4 Stability of Bound-Element Forms: Weathering Testing Under Unsaturated-Moisture Regime at 30 °C

In addition to the pH5-extraction testwork above, weathering testing at 30 °C was undertaken on the D-Tailings-Solids and GR-Tailings-Solids samples, as described in the footnotes to **Table 6**, and shown on **Plates 7-8**.

In total, the weathering testing was undertaken over *ca.* 3 months with elution of solutes from the weathered-solids conducted on two occasions (viz. after an ageing period of *ca.* 6 weeks, and after an additional ageing period of *ca.* 8 weeks).[4] Throughout weathering the tailings-solids were progressively dewatered to near residual-moistures/suctions, and following remoistening with high-purity-deionised-water (HPDW), allowed to again dewater. These alternating cycles of drying and remoistening were conducted several

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[3] It is implicit that elements incorporated into the crystal structures of the various 'resistate-minerals' are totally 'fixed' geochemically.

[4] A 'Pre-Rinse' treatment was also undertaken before commencing weathering.

times between addition of excess HPDW for elution of solutes accrued during weathering.

The leachate-analysis results presented in **Table 6** indicate that weathering of the tailings-solids samples was characterised by:

- a neutral-to-alkaline pH regime
- negligible liberation / release of minor-elements (i.e. concentration of minor-elements typically below, or close to, the respective detection-limits [0.1-1 µg/L range generally])

The stability of bound-element forms in the D-Tailings and GR-Tailings samples indicated by the weathering testing is consistent with that for the pH5-extraction testing above.

2.0 IMPLICATIONS FOR TAILINGS MANAGEMENT

2.1 Geology, Ore Beneficiation and Groundwater Contexts

Interpretation of the above 'wet-chemistry' findings in terms of decision-making for tailings management reflects the following important contexts for the Project:

(a) **Ore-Zone Geology**

The Medcalf Deposit owes it very existence to the 'loss-by-weathering', over geological time, of the various primary-silicates with associated 'base-cations' (Ca, Mg, K, and Na), and minor-element suites, characterising the lithochemistry of the original 'source-rocks'.

All that remains within the Oxide-Zone to be mined for Ti/V-minerals are therefore 'resistates' (i.e. minerals so resistant to hydrolysis / dissolution during weathering that they have persisted to the present day, and have been 'concentrated-up', in relative terms of abundance, as other 'more-weatherable' minerals have been lost from the geologic-profile).

The tailings-mineral assemblage therefore comprises inert 'resistates' (i.e. the same minerals as in ore *in* situ, save for appreciably less amounts of the Ti/V-minerals recovered as concentrates).

(b) **Ore Beneficiation**

The Medcalf mill will simply beneficiate the ore-blends via comminution, washing, and gravity-separation circuits with much in common with the numerous WA iron-ore mines where ore-feeds are likewise beneficiated to produce concentrates.

Within the Medcalf mill, the processing circuits will not be subject to wholesale unit addition of acids / alkalies with ensuing mineral dissolution / precipitation reactions. Furthermore, the make-up-water for the mill has to be of low salinity, due to the need for tight control of salt content in the various concentrates.

The chemistry of the tailings-waters within the tailings-storage facility (TSF) is therefore controlled by weak interactions between (potable) make-up-water, and the inert 'resistate-minerals' in the ores. Without any major influence from reagent chemistry, the quality of the tailings-waters is therefore very similar to that of potable-water.

(c) **Site Groundwaters**

The hydrogeology beneath the site of the TSF comprises an unconfined fractured bedrock with the water-level located around 30-40 m bgl. The groundwater is saline-to-hypersaline.

The contexts addressed in (a) to (c) translate into the D-Tailings and GR-Tailings streams both comprising tailings-solids made up of inert 'resistate-minerals', and tailings-waters of potable chemistry, and naturally (hyper)saline groundwaters beneath the TSF site.

Taken together, environmental risks from any slow solute generation and leaching associated with tailings management for the Project are, in practical terms, non-existent.

2.2 Design of Tailings-Storage Facility

2.2.1 Seepage Control

Given the above discussion, there is little environmental benefit to be gained from implementing seepage-control measures that strive to tightly constrain the rate of seepage from the TSF (e.g. 'impermeable' liners).

That is, the tailings-bed-profile within the TSF should should be one that is 'free-draining' without specific, engineered, seepage-control measures.

2.2.2 Decommissioning

At decommissioning, the outer-slopes of the TSF will need to be physically stabilised via cladding with inert rock, and then topsoiled as part of overall site rehabilitation. The blocky Upper-Mottled-Zone stream excavated from the Vesuvius, Fuji, Egmont, and Pinatubo Pits is a candidate mining stream for such TSF cladding (GCA 2020).[5]

In terms of the upper-surface of the tailings-bed at TSF decommissioning, placement of a rock/soil-cover to prevent 'tailings-dusting', and promote revegetation will be needed. Given the geochemically-benign nature of the tailings-solids, a thin (300 mm nominal) veneer of the rock/soil-cover should suffice: the Upper-Mottled-Zone stream would again likely be the best mining stream to employ for the rock/soil-cover.

In the case of deeper-rooting vegetation with root-zones established within the tailings-profile, uptake of minor-elements detrimental to plant growth and ecological functioning should not be a concern, due to the 'resistate-type-mineralogy' of the tailings-solids.

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[5] Reference: Graeme Campbell and Associates Pty Ltd, 2020, "Medcalf Project: Characterisation of Mine-Waste Samples from Vesuvius, Fuji, Egmont, and Pinatubo Pits – Implications for Mine-Waste Management", unpublished report prepared for Audalia Resources Limited.

3.0 CLOSING

The inert nature of the **D-Tailings** and **GR-Tailings** streams is one that is conducive to relative simplicity in terms of tailings management (e.g. no need for engineered seepage-control measures, and minimal rehabilitation demands). This reflects the nature of the geology and ore-treatment for the Medcalf Project (i.e. simple beneficiation of 'resistate-enriched' ores).

Apart from being of a fine-size grading, and thus texturally akin to a 'heavy-clay-soil', the tailings-bed profile in the decommissioned-TSF will be inert, and thus have no impact on the sub-surface and surrounding environs from any recharge episodes during 'wet-spells'.

I trust the above is useful to you.

Regards,

Dr GD Campbell
Director

encl. Tables 1-6
Plates 1-8
Attachments I-II

TABLES

Table 1: Assay Results for Tailings-Slurry-Water Samples

ELEMENT/ PARAMETER	**Deslimed-Tailings (GCA11903)**	**Gravity-Rejects-Tailings (GCA11904)**	**ELEMENT/ PARAMETER**	**Deslimed-Tailings (GCA11903)**	**Gravity-Rejects-Tailings (GCA11904)**
Major-Parameters			***Minor-Ions (µg/L)***		
pH	7.5	7.1	As	5	2
pH (GCA)	7.5	7.0	Sb	<1	<1
EC (µS/cm)	1,000	710	Se	1	2
EC (GCA, µS/cm)	1,090	750	B	350	300
TDS-(grav.) [mg/L]	600	410	Mo	0.5	0.6
Major-Ions (mg/L)			Ag	<1	<1
			Fe	<5	<5
Na	180	110	Cu	4	5
K	6.8	5.2	Ni	23	7
Mg	10	15	Zn	33	50
Ca	15	10	Co	<1	1
Cl	230	160	Mn	35	420
SO4	89	57	Al	27	26
HCO3 (as CaCO3)	31	21	Cd	0.9	0.3
HCO3 (GCA, as CaCO3)	27	18	Pb	<1	<1
F	0.4	0.3	Cr	<1	<1
Si	13	10	Hg	<0.05	<0.05
			Bi	<1	<1
Nitrogen-Forms (mg/L)			P	<50	51
			Ba	27	25
NH3-N	5.1	5.7	Sr	74	69
NO3-N	0.15	<0.05	Ti	<1	<1
			Tl	<1	<1
			V	78	1
			Sn	<1	<1
			U	<1	<1
			Th	<1	<1

Notes:
EC = Electrical-Conductivity
TDS-(grav.) = Total-Dissolved-Solids-(gravimetric)

Table 2: Acid-Base-Analysis and Net-Acid-Generation Results for Tailings-Solids Samples

GCA-SAMPLE NO.	TAILINGS-TYPE	TOTAL-S (%)	Cr(II)-RED.-S (%)	TOTAL-C (%)	BULK-ANC	NAG pH=4.5	NAG pH=7.0	NAG-pH	AFP CATEGORY
					kg H2SO4/tonne				
GCA11903	Deslimed-Tailings	0.07	<0.005	0.19	1 (2)	<0.5	<0.5	5.8	**NAF**
GCA11904	Gravity-Reject-Tailings	0.04	<0.005	0.17	1 (1)	<0.5 (<0.5)	<0.5 (1.0)	5.8 (5.1)	**NAF**

Notes:
ANC = Acid-Neutralisation Capacity; NAG = Net-Acid Generation; AFP = Acid-Formation Potential; NAF = Non-Acid Forming
All values expressed on a dry-weight basis, except for NAG-pH.
Values in parentheses represent duplicate determinations.

Table 3: Multi-Element-Analysis Results for Tailings-Solids Samples

SAMPLE_ ID	TAILINGS- TYPE	S	Ca	Mg	K	Na	Al	Fe	Ti	Si	As	Sb	Se	Mo	B	F
		%									mg/kg					
GCA11903	Deslimed-Tailings	0.07	0.025	0.23	0.063	0.086	11.5	24.1	2.64	14.0	2	0.1	0.19	4.3	35	80
GCA11904	Gravity-Reject-Tailings	0.04	0.019	0.22	0.026	0.035	6.71	36.0	5.39	7.3	2	0.2	0.20	5.3	<20	60
		Average-Crustal Abundance (Bowen 1979)									1.5	0.2	0.05	1.5	10	950

		Cu	Zn	Cd	Pb	Hg	Ni	Cr	Co	Mn	Ag	Bi	P	Sr	Ba	Sn	V	Tl	Th	U
		mg/kg																		
GCA11903	Deslimed-Tailings	920	142	<0.1	7	0.03	453	390	127	976	1.17	1.3	65	5.4	17	2.8	2,170	0.2	1.92	0.58
GCA11904	Gravity-Reject-Tailings	867	204	0.1	8	0.02	437	405	148	1,470	0.73	1.9	65	4.0	16	3.7	2,910	0.1	1.90	0.61
Average-Crustal Abundance (Bowen 1979)		50	75	0.11	14	0.05	80	100	20	950	0.07	0.05	1,000	370	500	2.2	160	0.6	12	2.4

▨	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 4: Mineralogical Results for Tailings-Solids Samples

Deslimed-Tailings (GCA11903)		Gravity-Reject-Tailings (GCA11904)	
hematite kaolin	20-50 %	hematite kaolin	20-50 %
goethite	10-20 %	goethite halloysite	10-20 %
anatase rutile quartz	1-10 %	anatase rutile quartz ilmenite	1-10 %
ilmenite	< 1 %		

Notes:

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

The hematite in both samples contained *ca.* 1 % as V2O5 together with detectable Ti based on micro-assaying during assessment via scanning-electron microscopy (SEM).

Table 5: Analysis Results for Extractions of Tailings-Solids Samples Under Mildly-Acidic (pH 5) Conditions

ELEMENT/ PARAMETER	Deslimed-Tailings (GCA11903)	Gravity-Rejects-Tailings (GCA11904)	ELEMENT/ PARAMETER	Deslimed-Tailings (GCA11903)	Gravity-Rejects-Tailings (GCA11904)
Major-Parameters			***Minor-Ions (µg/L)***		
pH	5.1	5.1	As	<1	1
pH (GCA)	5.0	5.1	Sb	<1	<1
EC (µS/cm)	610	600	Se	<1	<1
EC (GCA, µS/cm)	680	620	B	220	160
			Mo	<0.5	<0.5
Major-Ions (mg/L)					
			Ag	<1	<1
K	4.4	2.8	Fe	7	<5
Mg	8.1	6.9	Cu	17	33
Ca	2.2	3.3	Ni	16	34
			Zn	26	73
F	<0.1	<0.1	Co	16	29
Si	12	8.7	Mn	200	720
			Al	19	12
			Cd	<0.1	<0.1
			Pb	<1	<1
			Cr	<1	<1
			Hg	<0.05	<0.05
			Bi	<1	<1
			P	<50	<50
			Ba	24	55
			Sr	23	30
			Ti	<1	<1
			Tl	<1	<1
			V	<1	<1
			Sn	<1	<1
			U	<1	<1
			Th	<1	<1

Notes:
EC = Electrical-Conductivity

Testing Details:
Each tailings-solids sample was first oven-dried at 80 oC in a forced-fan convective oven, and then crushed to nominal -5 mm.
The **-2 mm** fraction obtained via dry-sieving was then subjected to extraction using an acetic-acid-based solution at room-T (i.e. 20-22 oC).
Specifically, a pH5-Hac/NaAc buffer solution was used, and the test slurries had a solid:solution ratio of **10:1 (w/v)**. Test slurries
continually agitated for **24 hrs** via bottle-rolling. [Acetate]-total = **0.01 M** (i.e. very dilute solution of a very feebly complexing buffer).
(Tendency to form any acetato solution complexes is further suppressed by the acidic pH regime imposed).
Since the 'acid-demand' of the tested solids slightly exceeded the buffering capacity of the HAc/NaAc system, graded amounts of
0.1 M-HNO_3 were added to the test-slurries after *ca.* 1 hr following commencing testing (i.e. 'early-time' reaction / equilibration).
When expressed in units of kg H_2SO_4/tonne, the 'acid-demand' for both tailings-solids samples was *ca.* 0.5-1 kg H_2SO_4/tonne.
These 'acid-demands' are similar to the corresponding Bulk-ANC values (**Table 2**).

Table 6: Leachate-Analysis Results for Weathering Testing of Tailings-Solids Samples

Gravity-Reject-Tailings (GCA11904)

PARAMETER / ELEMENT	WEATHERING-CYCLES @ 30 oC		
	"0" (= 'Pre-Rinse')	1 (*ca.* 6 weeks)	2 (*ca.* 8 weeks)
pH, Salinity & Alkalinity			
pH	7.7	7.2	7.3
pH (GCA)	7.7	7.5	7.4
EC (µS/cm)	840	370	230
EC (GCA, µS/cm)	824	378	259
HCO3 (mg/L CaCO3)	33	9	13
Major-Ion Chemistry			
Ca (mg/L)	5.4	2.0	1.4
Mg (mg/L)	13	4.8	3.1
K (mg/L)	5.2	2.9	2.3
Na (mg/L)	120	55	35
Cl (mg/L)	170	53	23
SO4 (mg/L)	70	62	48
F (mg/L)	0.2	0.3	0.4
Al (mg/L)	0.02	0.01	0.01
Fe (mg/L)	<0.01	<0.01	0.01
Si (mg/L)	7.1	11	10
Minor-Element Chemistry			
As (µg/L)	4	6	11
Sb (µg/L)	<1	<1	<1
B (µg/L)	270	380	350
Mo (µg/L)	<0.5	0.8	1.1
Se (µg/L)	3	3	2
P (µg/L)	<50	<50	<50
Cu (µg/L)	19	2	2
Zn (µg/L)	10	<5	6
Cd (µg/L)	<0.1	<0.1	<0.1
Pb (µg/L)	<1	<1	<1
Ni (µg/L)	6	3	5
Cr (µg/L)	1	<1	<1
Cr(VI) (µg/L)	<1	<1	<1
Co (µg/L)	1	1	1
Hg (µg/L)	<0.05	<0.05	<0.05
Mn (µg/L)	190	130	77
Sn (µg/L)	<1	<1	<1
Ag (µg/L)	<1	<1	<1
Ba (µg/L)	31	7.6	4.6
Sr (µg/L)	47	16	10
Bi (µg/L)	<1	<1	<1
Ti (µg/L)	<1	<1	<1
Tl (µg/L)	<1	<1	<1
Th (µg/L)	<1	<1	<1
U (µg/L)	<1	<1	<1
V (µg/L)	1	2	3
Leachate Wt (kg)	0.41	0.62	0.57

Note:

EC = Electrical-Conductivity

1.00 kg (dry-solids equivalent) of tailings-solids; dry-tailings-solids initially passed through 4.75 mm stainless-steel sieve.

For the 'Pre-Rinse' (= "Cycle-0"), and Cycle-1, and Cycle-2, 1.00 kg of high-purity-deionised-water (HPDW) used for flushing. For all Cycles, cessation of drainage typically occurred after *ca.* 1 week.

Flushed tailings dewatered in incubator @ 30 oC to approaching residual-moistures/ suctions. HPDW then misted onto heavily-cracked-tailings' to remoisten, followed by dewatering. These steps repeated a few times over the course of *ca.* 6 weeks for Cycle-1, and *ca.* 8 weeks for Cycle-2.

Table 6 (Cont'd): Leachate-Analysis Results for Weathering Testing of Tailings-Solids Samples

Deslimed-Tailings (GCA11903)

PARAMETER / ELEMENT	WEATHERING-CYCLES @ 30 oC		
	"0" **(= 'Pre-Rinse')**	**1** **(*ca.* 6 weeks)**	**2** **(*ca.* 8 weeks)**
pH, Salinity & Alkalinity			
pH	7.9	7.2	7.3
pH (GCA)	7.9	7.5	7.7
EC (µS/cm)	1,900	300	340
EC (GCA, µS/cm)	1,710	380	364
HCO3 (mg/L CaCO3)	59	37	is
Major-Ion Chemistry			
Ca (mg/L)	13	0.64	0.84
Mg (mg/L)	30	1.5	2.0
K (mg/L)	10	3.1	3.2
Na (mg/L)	280	48	54
Cl (mg/L)	370	44	40
SO4 (mg/L)	200	46	61
F (mg/L)	0.4	0.7	0.6
Al (mg/L)	0.01	0.09	0.11
Fe (mg/L)	<0.01	0.04	0.08
Si (mg/L)	15	15	13
Minor-Element Chemistry			
As (µg/L)	5	28	96
Sb (µg/L)	<1	<1	2
B (µg/L)	580	500	450
Mo (µg/L)	1.9	2.0	1.9
Se (µg/L)	2	<1	<1
P (µg/L)	<50	<50	<50
Cu (µg/L)	10	20	3
Zn (µg/L)	<5	<5	5
Cd (µg/L)	<0.1	<0.1	<0.1
Pb (µg/L)	<1	<1	<1
Ni (µg/L)	6	5	17
Cr (µg/L)	<1	<1	<1
Cr(VI) (µg/L)	<1	<1	<1
Co (µg/L)	<1	1	4
Hg (µg/L)	<0.05	<0.05	is
Mn (µg/L)	25	14	20
Sn (µg/L)	<1	<1	<1
Ag (µg/L)	<1	<1	<1
Ba (µg/L)	20	2.0	2.1
Sr (µg/L)	86	4	6
Bi (µg/L)	<1	<1	<1
Ti (µg/L)	<1	<1	2
Tl (µg/L)	<1	<1	<1
Th (µg/L)	<1	<1	<1
U (µg/L)	<1	<1	<1
V (µg/L)	4	11	10
Leachate Wt (kg)	0.37	0.10	0.080

Note:
EC = Electrical-Conductivity; is = insufficient sample
1.00 kg (dry-solids equivalent) of tailings-solids; dry-tailings-solids initially passed through 4.75 mm stainless-steel sieve.
For the 'Pre-Rinse' (= "Cycle-0"), 1.00 kg of high-purity-deionised-water (HPDW) used for flushing. Cessation of drainage occurred after *ca.* 2 weeks.
Flushed tailings dewatered in incubator @ 30 oC to approaching residual-moistures/ suctions. HPDW then misted onto 'heavily-cracked-tailings' to remoisten, followed by dewatering. These steps repeated a few times over the course of *ca.* 6 weeks for Cycle-1, and *ca.* 8 weeks for Cycle-2.

For Cycle-1 and Cycle-2 it was not possible to flush the tailings-solids, since the 'tailings-mass' simply did **not drain under gravity** (cf. "Cycle-0") where sieved dry-tailings did drain when flushed initially.
In place of the usual flushing procedure, a compromise needed to be made whereby *ca.* 0.70 kg of HPDW was added to the tailings-solids (near residual-moisture), and the resulting sticky 'paste/sludge' worked-up by hand-mixing (wearing nitrile, disposable laboratory-gloves). After thorough hand-mixing, portions of the sticky 'wet-tailings' were placed in 50mL, polypropylene centrifuge-tubes, and centrifuged for up to 1 hr @ *ca.* 1,000 G. The centrifugates were then decanted, and vacuum-filtered (0.45µm-membrane), etc. Only small volumes of 'leachates' were generated for assaying using this approach. Following centrifugation for Cycle-1, the sticky 'tailings-plugs' in the centrifuge-tubes were dug-out, and retuned to the humidity-cell (column) to resume weathering.

PLATES

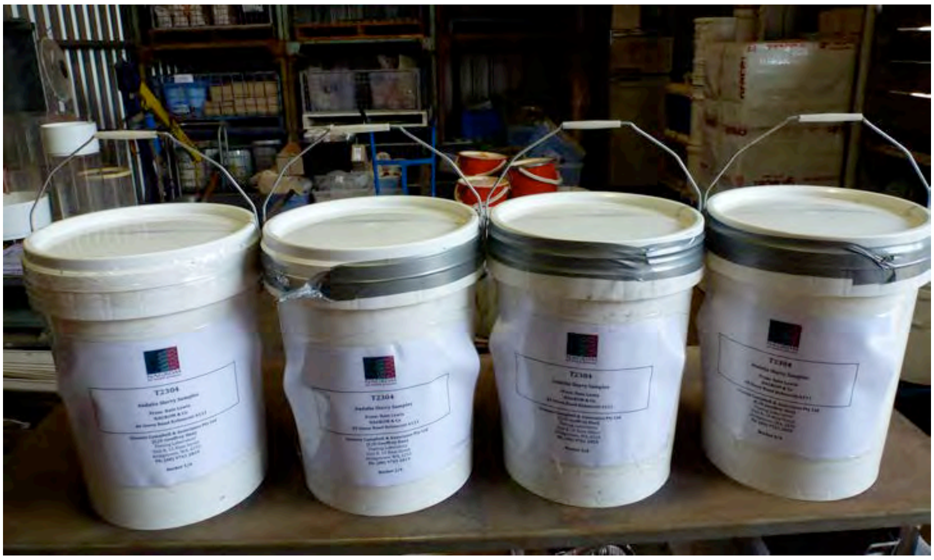

PLATE 1: 20 L drums containing tailings samples 'as-received' at GCA Testing Laboratory (Bridgetown) as supplied by Nagrom (Kewdale)

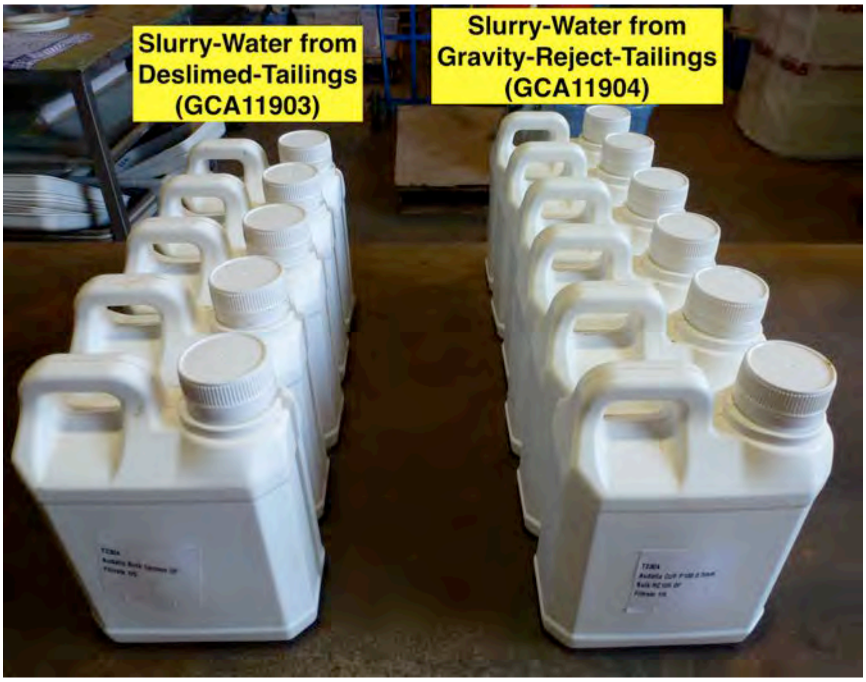

PLATE 2: Bulk samples of **Tailings-Slurry-Waters**.

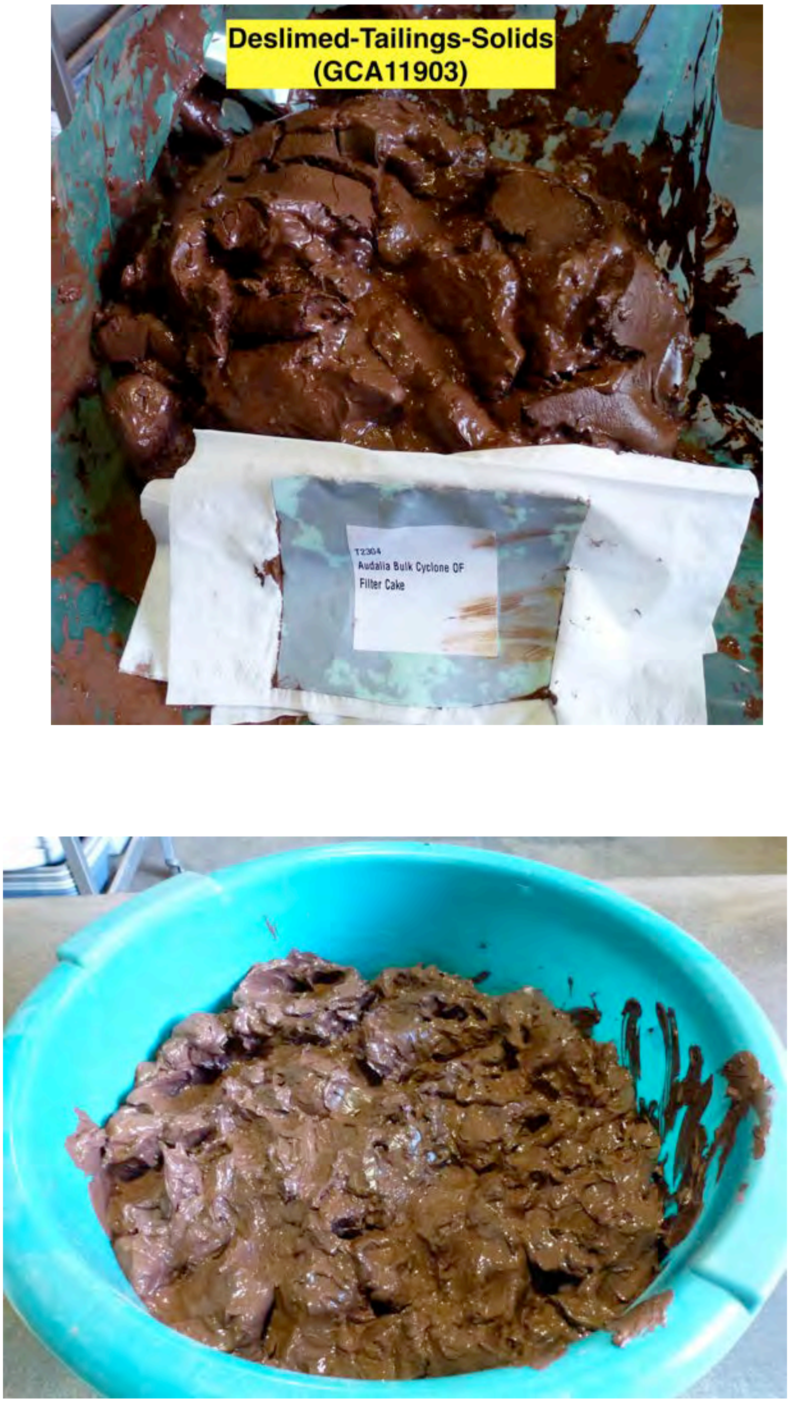

PLATE 3: Supplied 'wet' filter-cake of **Deslimed-Tailings-Solids** initially separated from plastic-bag (top photograph), and after homogenising via hand-mixing in a plastic bowl (bottom photograph).

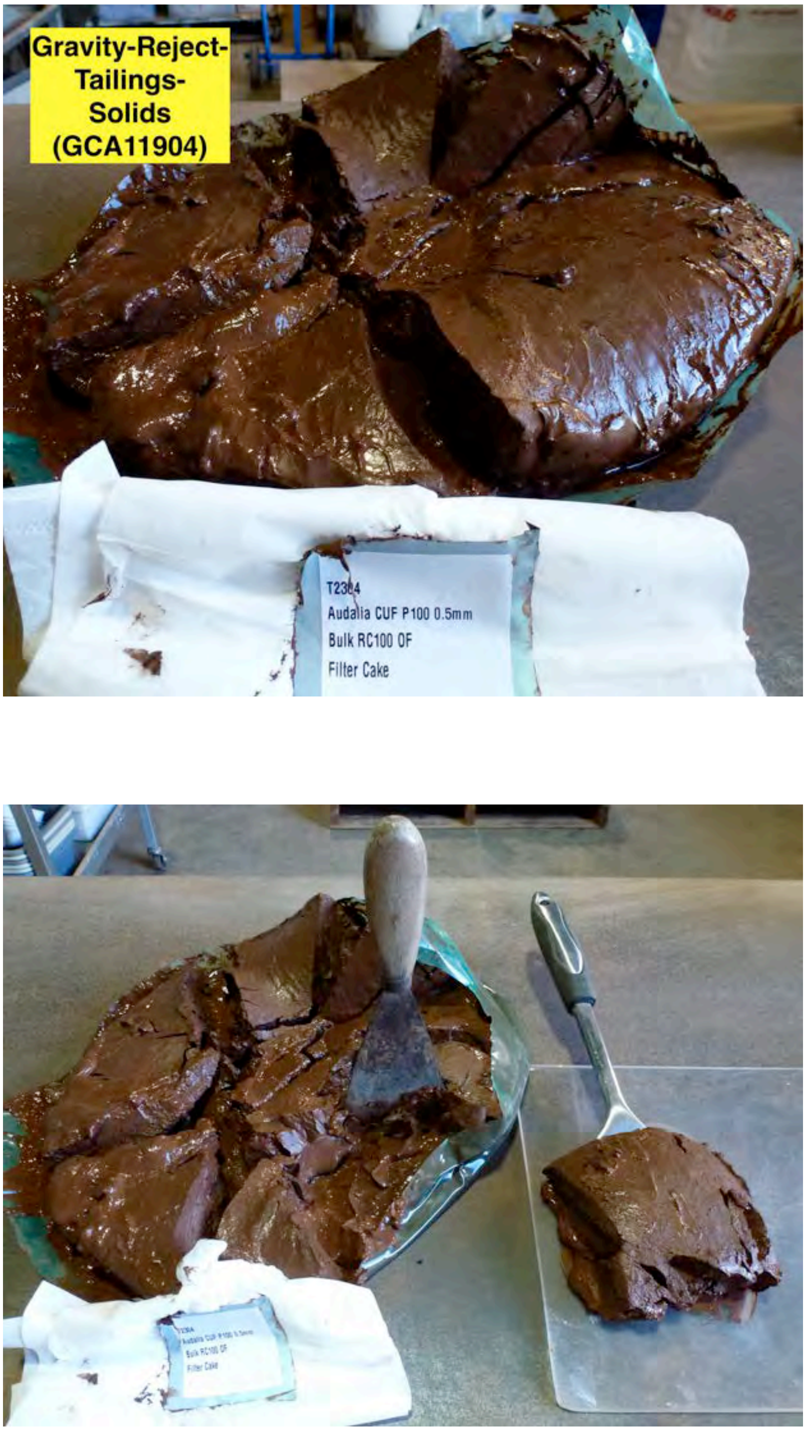

PLATE 4: Supplied 'wet' filter-cake of **Gravity-Reject-Tailings-Solids** initially separated from plastic-bag (top photograph), and demonstration of the 'stiffness' of this tailings stream 'ex-filter-press' (bottom photograph).

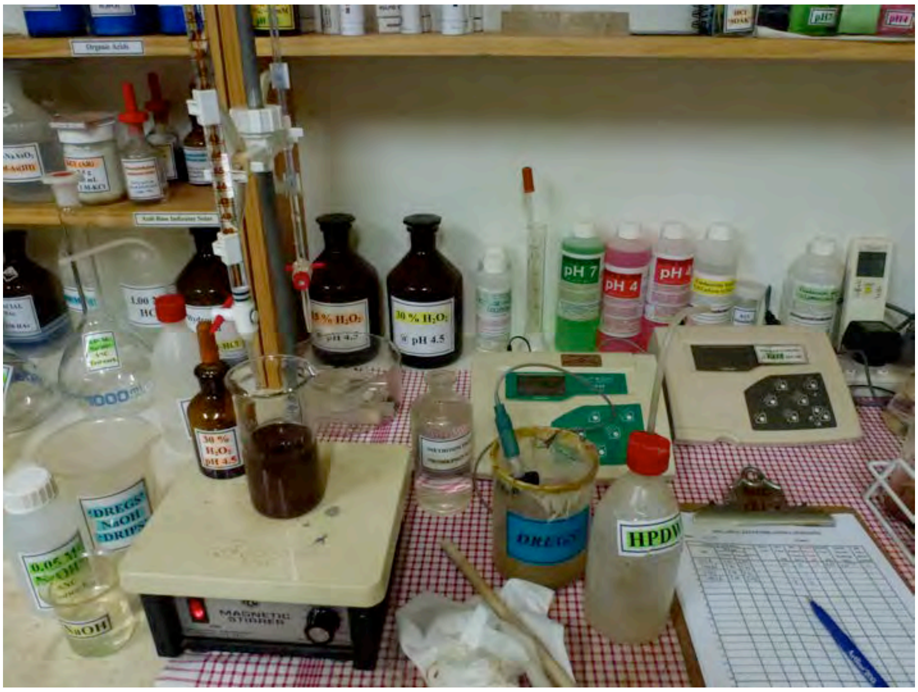

PLATE 5: Acid-Neutralisation-Capacity (ANC) testing using -2mm (dry-sieved) fraction of the dried, crushed tailings-solids.

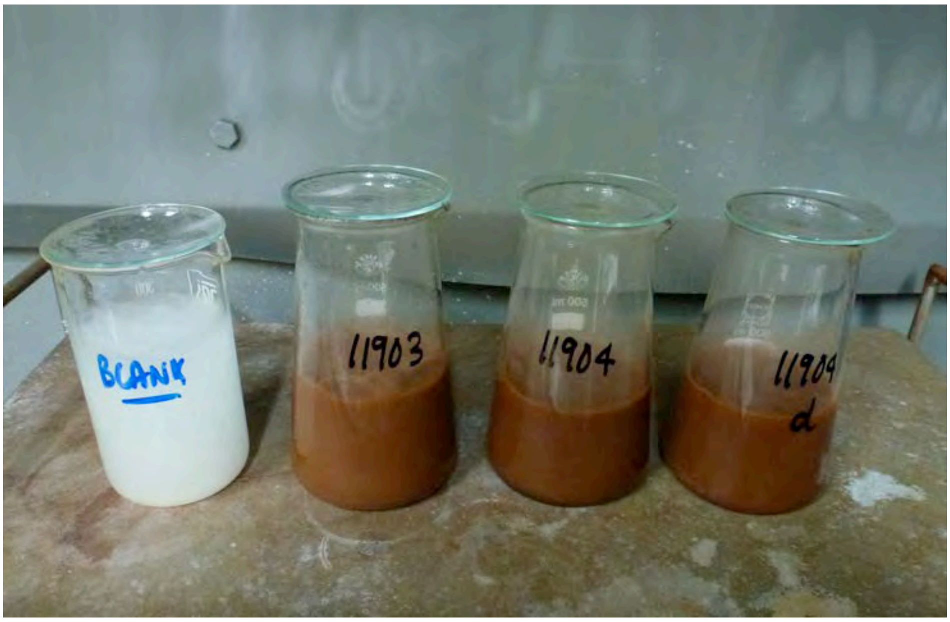

PLATE 6: Net-Acid-Generation (NAG) testing on pulps (-75 µm) using 15 % H_2O_2 (@ pH 4.5). First boiling step shown following ageing overnight.

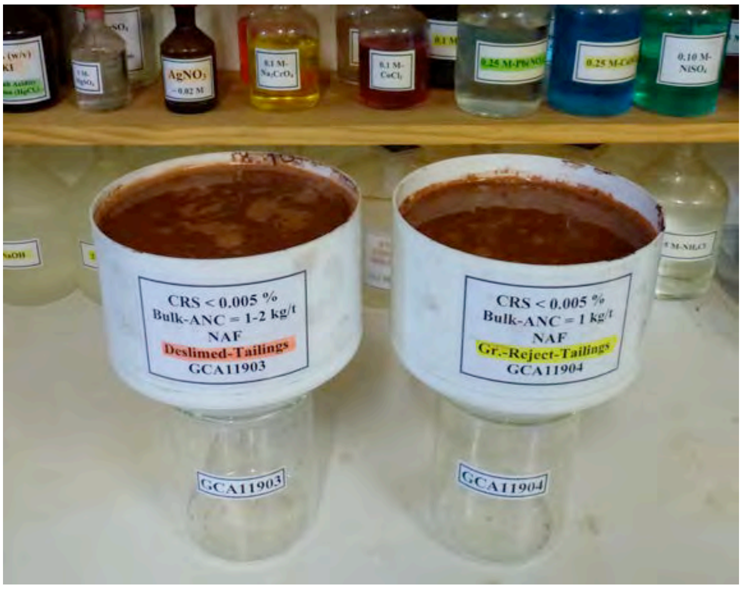

PLATE 7: Initial flushing (= "Cycle-0") of humidity-cells containing dry tailings-solids passed through 4.75 mm stainless-steel sieve prior to packing cells (columns) with 1.00 kg dry-solids of tailings. High-purity-deionised-water (HPDW) used for flushing.

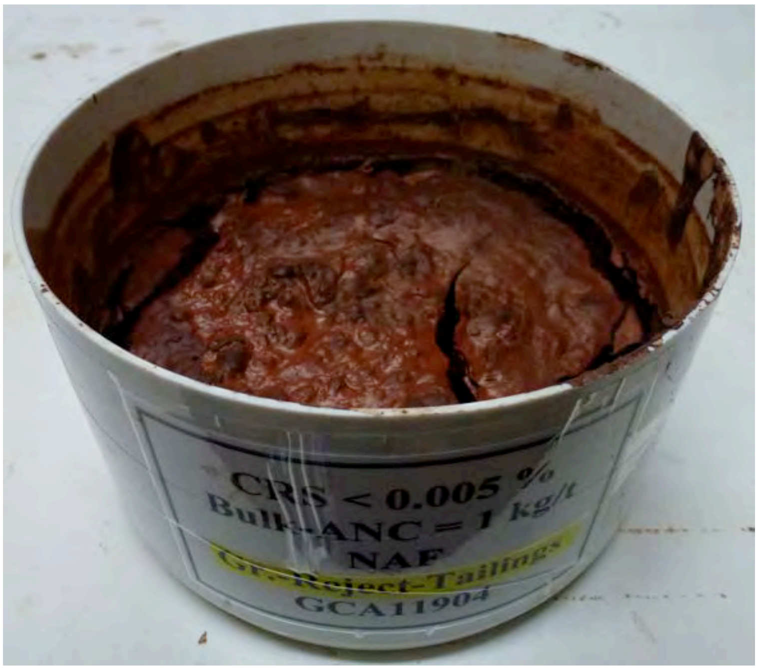

PLATE 8: Desiccation/shrinkage-crack formation during dewatering of Gravity-Reject-Tailings at 30 oC in incubator.

ATTACHMENT I

DETAILS OF METALLURGICAL TESTWORK SAMPLES TO GENERATE THE TAILINGS-SLURRY SAMPLES TESTED IN CURRENT STUDY

audalia
resources limited

Audalia Resources Limited
ABN 49 146 035 690
Level 1, Office F
1139 Hay Street, West Perth
Western Australia 6005
p: +61 8 9321 0715
f: +61 8 9321 0721

Memo

To: Graeme Campbell Associate

From: Geoffrey Han

cc: Karen Logan, Brent Butler, Swan Ong, Phil Scott, Gavin Edwards

Date: 15 January 2019

Re: Preparation of tailings sample for material characterisation

Background

Audalia Resources Ltd (Audalia) is developing the Medcalf Project located in the Bremer Range, Lake Johnston region of Western Australia (WA) approximately 470km east south-east of Perth. Audalia is also progressing the environmental approval application with EPA. As required by the Environmental Scoping Document (ESD), a tailings characterisation study should be undertaken to determine if tailings seepage has the potentials to contaminate the terrestrial environment.

Graeme Campbell Associate has been engaged by Audalia to carry out the material characterisation test work for both tailings and waste rock. This memo outlines the process route of the project and the preparation of tailings samples for the material characterisation test work.

Processing Route

The run of mine (ROM) ore will be processed onsite at a beneficiation plant, which upgrade the ROM ore to a primary concentrate. The beneficiation process consists of a comminution circuit and gravity separation circuit. The comminution circuit includes a three-stage crushing plant, with slimes removal from crushed products via hydrocyclones. Oversize is prepared for the gravity circuit by closed circuit ball milling. The gravity beneficiation circuit includes two stages of Reflux Classifier. The gravity concentrate is dewatered by thickening and filtration, with the filter cake as the final product for export. The only chemical reagent required for the beneficiation process is the non-toxic flocculent used in the thickening process.

There are two types of tailings generated from the beneficiation plant, namely the deslime-fines generated from the comminution circuit by hydrocyclones, and the gravity-reject generated from the gravity circuit by Reflux Classifier. The deslime-fines and gravity-reject are thickened, pumped through pipelines, and disposed in the tailings storage facility (TSF).

Tailings Sample Preparation

Nagrom laboratory in Perth was commissioned by Audalia to prepare the tailings sample for material characterisation test work. The ore sample used in the sample preparation is the composite sample of diamond drill cores collected from a drilling program in 2015 from the proposed mine pits. Core samples were inspected by Audalia first to identify the mineralisation for sample preparation. Perth tap water was used by Nagrom in the sample preparation program.

The drill cores were first crushed to P_{100} 3.35mm by roller crusher. The crushed ore was passed through hydrocyclones at 0.038mm cut-point to remove the fines. The hydrocyclones overflow is the deslime-fines. The hydrocyclones overflow was filter pressed to separate the solid and liquid. The solid and liquid samples were marked “T2304 Audalia Bulk Cyclone OF” as sample ID.

The hydrocyclones underflow was stage ground to P_{100} 0.5mm. The ground hydrocyclones underflow was processed by Reflux Classifier (RC100) to produce primary concentrate and tailings. The RC100 overflow is the gravity-reject tailings. The RC100 overflow was filter pressed to separate the solid and liquid. The solid and liquid samples were marked “T2304 Audalia CUF P_{100} 0.5mm Bulk RC100 OF” as sample ID.

Both solid and liquid samples of deslime-fines and gravity-reject tailings were couriered to Graeme Campbell Associate from Nagrom laboratory.

ATTACHMENT II

LABORATORY REPORTS

TOWNEND
mineralogy laboratory

Graeme Campbell and Assoc, 28-3- 2019

PO Box 247

Bridgetown

WA, 6255

Our reference 24370

Mineralogy (XRD/SEM/PLM) of two rock powders.

R Townend

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RESULTS.

	GCA11903	**GCA11904**
Quartz	Accessory	Accessory
Kaolin	Major	Major
Halloysite 10 ang.		Minor
Hematite	Major	Major
Goethite	Minor	Minor
Ilmenite	Trace	Accessory
Anatase	Accessory	Accessory
Rutile	Accessory	Accessory

Halloysite identification based on XRD, with absence of mica.

In both samples the ? hematite consistently contained about 1% V_2O_5 and some Ti (SEM).

MINERALS
TEST REPORT

CLIENT

GRAEME CAMPBELL
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE	:	143.0/1900523
NO. SAMPLES	:	2
NO. ELEMENTS	:	7
CLIENT ORDER NO.	:	GCA1901/2 (Job 1 of 1)
SAMPLE SUBMISSION NO.	:	
PROJECT	:	MEDCALF
SAMPLE TYPE	:	Various
DATE RECEIVED	:	14/01/2019
DATE REPORTED	:	25/01/2019
DATE PRINTED	:	25/01/2019

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

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:Medcalf
The samples as listed were received as follows:
GCA11903. Approx. 2 kg of dry tailings-solids as hard-clumps
GCA11904. Approx. 3 kg of dry tailings-solids as hard-clumps
Both samples were crushed to nominal -2mm.
~ 300g of the crushed-tailings were pulped to nominal -75µm in zirconia-bowl

The results have been determined according to Genalysis methods codes
Digestions : MPL_W005 (SE1/), MPL_W052 (SG) and MPL_W008 (HG1/)

Analytical Finishes: 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 ~1700°C and the CO_2 and SO_2 measured by infrared detectors
Genalysis method code 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 code MPL_W046

The results included the assay of blanks and international reference standard:
OREAS 45h GTS-2a
Genalysis in house standards:
TOC-1a, Quartz ,Se 0.1ppm and Se 1.0 ppm

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

Intertek Genalysis signatory

Ann Patricia EVERS

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 fo return or collection is received.

LEGEND

X = Less than Detection Limit
SNR = Sample Not Received
* = Result Checked
DTF = Result still to come
IS = Insufficient Sample for Analysis

NA = Not Analysed
UA = Unable to Assay
> = Value beyond Limit of Method
+ = Extra Sample Received Not Listed

ELEMENTS	C	C-Acinsol	C-CO3	Hg	S	SG	Se
UNITS	%	%	%	ppm	%	NONE	ppm
DETECTION LIMIT	0.01	0.01	0.01	0.01	0.01	0.01	0.01
DIGEST		C71/		HG1/		SGP/	SE1/
ANALYTICAL FINISH	/CSA	CSA	/CALC	CV	/CSA	PYC	MS
SAMPLE NUMBERS							
0001 GCA11903	0.19	0.10	0.09	0.03	0.07	3.33	0.19
0002 GCA11904	0.17	0.12	0.05	0.02	0.04	3.90	0.20
CHECKS							
0001 GCA11903	0.18	0.10	0.08	0.05	0.06	3.49	0.24
STANDARDS							
0001 OREAS 45h	0.52				0.04		
0002 TOC-1a		1.26					
0003 Se 0.1ppm							0.10
0004 GTS-2a				0.28			
0005 Quartz						2.70	
BLANKS							
0001 Control Blank	X	X		X	X		X

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** Induction Furnace Analysed by Infrared Spectrometry	**MPL_W043, CSA : MPL_W043**
C71/CSA	Intertek Genalysis Perth **3244 3237** Digestion by hot acid(s) and Induction Furnace Analysed by Infrared Spectrometry	
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.	
SGP/PYC	Intertek Genalysis Perth **3244 3237** Analysed by Instrumental Technique using a gas displacement Pycnometer.	

ANALYTICAL REPORT

Accreditation No. 2562

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. 1901/2**	SGS Reference	**PE131991 R0**
Order Number	**GCA Job No. 1901/2**	Date Received	18 Jan 2019
Samples	2	Date Reported	06 Feb 2019

COMMENTS

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

Metals subcontracted to SGS Perth Minerals, 28 Reid Rd Perth Airport WA, NATA Accreditation Number 1936, WM190639
Report appended

Total Fluoride in Soil: Recovery failed acceptance criteria due to the presence of significant concentration of analyte (i.e. the concentration of analyte exceeds the spike level).

SIGNATORIES

Michael McKay
Inorganics and ARD Supervisor

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name: PE131991.001 Pulp GCA11903	PE131991.002 Pulp GCA11904

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 5/2/2019

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

Total Fluoride in Soil Method: AN142 Tested: 23/1/2019

Total Fluoride	mg/kg	50	80	60

Sample Subcontracted Method: Tested: 4/2/2019

SGS Minerals*	No unit	-	Report appended	Report appended

QC SUMMARY

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)	LB155692	%	0.005	<0.005	0 - 8%	85 - 88%
Chromium Reducible Sulphur (Scr)	LB155692	moles H+/T	5	<5		
Chromium Reducible Sulphur (Scr)	LB155692	kg H2SO4/T	0.25	<0.25		

Total Fluoride in Soil   Method: ME-(AU)-[ENV]AN142

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Total Fluoride	LB155311	mg/kg	50	<50	0%	104%	39%

METHOD	METHODOLOGY SUMMARY
AN142	Fluoride can be measured in soil as water extractable or 'total' by Ion Selective electrode. In this method the solid sample is weighed and then fused with sodium hydroxide at 600°C. The sample is carefully neutralise with hydrochloric acid and the solution of the melt is cooled and made up to volume. The final solution is then compared to synthetic Digestion Matrix standards with analysis by ISE electrode for a total fluoride result after being calculated back to original mass.
AN217	Dried pulped sample is mixed with acid and chromium metal in a rapid distillation unit to produce hydrogen sulfide (H_2S) which is collected and titrated with iodine ($I_2(aq)$) 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 calcuated 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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ACID-NEUTRALISATION-CAPACITY (ANC) TESTWORK: BASED ON AMIRA (2002) WITH VARIATIONS TO CONSTRAIN DISSOLUTION OF NON-CARBONATE-MINERALS UNRELATED TO CIRCUM-NEUTRAL BUFFERING SAVE FOR VANISHINGLY-SMALL RATES OF PYRITE OXIDATION

SAMPLE		**HCl**		**milli moles H+ Added**	**Digest-Slurry-Final-pH**	**NaOH**		**milli moles OH- Added**	**pH after H2O2 Added**	**BULK-ANC (kg H2SO4/ tonne)**
ID	**WT (g)**	**Conc. (M)**	**Pipette Volume (mL)**			**Conc. (M)**	**Titre Volume (mL)**			
GCA11904	6.99	0.10	10	1.00	1.5	0.05	17.15	0.858	> 4.0	**1**
GCA11904 d	7.00	0.10	10	1.00	1.6	0.05	16.50	0.825	> 4.0	**1**
GCA11903	5.01	0.10	10	1.00	1.6	0.05	17.15	0.858	> 4.0	**1**
GCA11903 d	5.02	0.10	10	1.00	1.6	0.05	16.50	0.825	> 4.0	**2**
ANC Std	5.01	0.10	25	2.50	2.2	0.05	7.60	0.380	> 4.0	21
ANC Std d	5.00	0.10	25	2.50	2.2	0.05	7.65	0.383	> 4.0	21
0.1 M-HCl	-	0.10	10	1.00		0.05	20.20	1.01		101.0%
0.1 M-HCl (d)	-	0.10	10	1.00		0.05	20.10	1.01		100.5%

Notes:

1. Testing performed using -2 mm (dry-sieved) fraction of dried (80 oC) tailings-solids.
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-slurries are boiled for *ca.* 1 min to expel any dissolved CO2(aq) which is important for the attainment of a stable pH7 end-point in the subsequent back-titration with NaOH solution.
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.
11. Following completion of H2O2 addition, titration with NaOH continues to a **pH7** 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. autotititration) option applies in ASTM E1915-13, and AS-4969.12-09].
12. ANC Standard is pulped mixture of quartz and AR CaCO3 (CO3-C = 0.27 %; ANC = 22 kg H2SO4/tonne).

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

Dr GD Campbell
17th February 2019

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 H_2SO_4/tonne)		
				NAG-pH	NAG-EC (µS/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
GCA11903	3.00	slight reaction overnight	5.8	5.8	76	-	0.50	<0.5	<0.5	<0.5
GCA11904	3.03	slight reaction overnight	5.6	5.4	81	-	0.20	<0.5	<0.5	<0.5
GCA11904 d	3.03	slight reaction overnight	5.2	5.1	69	-	0.30	<0.5	1.0	<0.5
Blank	-	no apparent reaction overnight	4.3	5.9	52	-	0.30			

Notes: If needed, the pH of the **15 % (v/v) A.R. H_2O_2** 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-$CuSO_4$** is added, and the 2nd-boiling step carried out for *ca.* 1 hr. The added Cu(II) catalyses the decomposition of any residual, unreacted H_2O_2 (AS 4969.12-2009).

(After the 1st-boiling step, and prior to addition of $CuSO_4$, the Blank had a pH value of 7.1).

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.

All testing performed on **pulps** (nominal -75 µm).

Dr GD Campbell **1st February 2019**

Ros Ma

SGS Environmental Services

28 Reid Road
Perth Airport
WA 6105
Australia

Lab Ref	WM190639
Client Ref	**PE131991**
Project	*
Cost Code	NA
Status	Final
Received	23/01/19
Reported	04/02/19
Samples	2
First Sample	PE131991.001 GCA11903
Last Sample	PE131991.002 GCA11904
Pages	8

Notes

Michael King
Laboratory Manager

ANALYTICAL REPORT

Scheme	ICP40Q	ICP40Q	ICP40Q	ICP40Q	ICP40Q	ICP40Q
Units	PPM	PPM	PPM	PPM	PPM	PPM
Detection Limit	100	50	10	5	100	100
Upper Limit	400000	400000	20000	10000	1000000	200000
	Al	Ca	Cr	Cu	Fe	K
PE131991.001 GCA11903	11.5%	250	390	920	24.1%	630
PE131991.002 GCA11904	6.71%	185	405	867	36.0%	260

- not analysed | -- element not determined | I.S. insufficient sample
L.N.R. listed not received | D.I.P destroyed in process

Lab Ref WM190639
Client Ref **PE131991**
Project *
Reported 04/02/19
Status Final
Page Page 3 of 8

ANALYTICAL REPORT

Scheme **Units** **Detection Limit** **Upper Limit**	ICP40Q PPM 20 1000000 Mg	ICP40Q PPM 5 10000 Mn	ICP40Q PPM 50 200000 Na	ICP40Q PPM 5 10000 Ni	ICP40Q PPM 20 100000 P	ICP40Q PPM 20 50000 S
PE131991.001 GCA11903	2260	976	855	453	65	595
PE131991.002 GCA11904	2180	1470	350	437	65	385

- not analysed | -- element not determined | I.S. insufficient sample
L.N.R. listed not received | D.I.P destroyed in process

Lab Ref	WM190639
Client Ref	**PE131991**
Project	*
Reported	04/02/19
Status	Final
Page	Page 4 of 8

ANALYTICAL REPORT

Scheme **Units** **Detection Limit** **Upper Limit**	ICP40Q PPM 10 20000 Ti	ICP40Q PPM 1 10000 V	ICP40Q PPM 5 10000 Zn	IMS40Q PPM 0.05 100 Ag	IMS40Q PPM 1 1000 As	IMS40Q PPM 2 2000 Ba
PE131991.001 GCA11903	>2.00%	2170	142	1.17	2	17
PE131991.002 GCA11904	>2.00%	2910	204	0.73	2	16

- not analysed | -- element not determined | I.S. insufficient sample
L.N.R. listed not received | D.I.P destroyed in process

Results are not intended for commercial settlement purposes.

Lab Ref WM190639
Client Ref **PE131991**
Project *
Reported 04/02/19
Status Final
Page Page 5 of 8

ANALYTICAL REPORT

Scheme	IMS40Q	IMS40Q	IMS40Q	IMS40Q	IMS40Q	IMS40Q
Units	PPM	PPM	PPM	PPM	PPM	PPM
Detection Limit	0.1	0.1	0.1	0.1	1	0.1
Upper Limit	1000	1000	2000	1000	2000	1000
	Bi	Cd	Co	Mo	Pb	Sb
PE131991.001 GCA11903	1.3	<0.1	127	4.3	7	0.1
PE131991.002 GCA11904	1.9	0.1	148	5.3	8	0.2

- not analysed | -- element not determined | I.S. insufficient sample
L.N.R. listed not received | D.I.P destroyed in process

Lab Ref	WM190639
Client Ref	**PE131991**
Project	*
Reported	04/02/19
Status	Final
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ANALYTICAL REPORT

Scheme **Units** **Detection Limit** **Upper Limit**	IMS40Q PPM 2 1000 Se	IMS40Q PPM 0.3 1000 Sn	IMS40Q PPM 0.1 1000 Sr	IMS40Q PPM 0.05 1000 Th	IMS40Q PPM 0.1 1000 Tl	IMS40Q PPM 0.05 1000 U
PE131991.001 GCA11903	<2	2.8	5.4	1.92	0.2	0.58
PE131991.002 GCA11904	2	3.7	4.0	1.90	0.1	0.61

- not analysed | -- element not determined | I.S. insufficient sample
L.N.R. listed not received | D.I.P destroyed in process

Lab Ref	WM190639
Client Ref	**PE131991**
Project	*
Reported	04/02/19
Status	Final
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ANALYTICAL REPORT

Scheme	ICP90Q	ICP90Q	IMS12S	ICP43B	XRF78S
Units	PPM	%	PPM	PPM	%
Detection Limit	20	0.2	0.1	50	0.01
Upper Limit	100000	50	1000	50000	100
	B	Si	Hg	Ti	Ti
PE131991.001 GCA11903	35	14.0	<0.1	2.83%	2.64
PE131991.002 GCA11904	<20	7.3	<0.1	>5.00%	5.39

- not analysed | -- element not determined | I.S. insufficient sample
L.N.R. listed not received | D.I.P destroyed in process

DESCRIPTION

DIG12S : Aqua Regia Digest, 0.4g-20ml, 90C
DIG40Q : Four Acid Digest, 0.2g-20ml
DIG43B : Four Acid Digest, 0.25g-500ml, Ore Grade
DIG90Q : Sodium Peroxide Fusion, 0.25g-100ml
ENV01 : Environmental Levy
ICP40Q : ICPAES after DIG40Q
ICP43B : ICPAES after DIG43B
ICP90Q : ICPAES after DIG90Q
IMS12S : ICPMS after DIG12S
IMS40Q : ICPMS after DIG40Q
SRT01 : Sorting of samples prior to preparation
XRF78S : XRF, Fusion, Whole Rock

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
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Project	**GCA Job No. 1901/2 Medcalf Tailings-Wate**	SGS Reference	**PE131923 R1**
Order Number	**GCA Job No. 1901/2**	Date Received	15 Jan 2019
Samples	2	Date Reported	25 Feb 2019

COMMENTS

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

Metals: Dissolved S: Spike recovery failed acceptance criteria due to the presence of significant concentration of analyte (i.e. the concentration of analyte exceeds the spike level).
This report cancels and supersedes the report No.PE131923 R0 dated 22/1/2019 issued by SGS Environment, Health and Safety due to the addition of Titanium result.

SIGNATORIES

Hue Thanh Ly
Metals Team Leader

LouiseHope

Louise Hope
Laboratory Technician

Mary Ann Ola-A
Inorganics Team Leader

Michael McKay
Inorganics and ARD Supervisor

Ohmar David
Metals Chemist

		Sample Number	PE131923.001	PE131923.002
		Sample Matrix	Water	Water
		Sample Name	GCA11903	GCA11904
Parameter	Units	LOR		
pH in water Method: AN101 Tested: 18/1/2019				
pH**	pH Units	-	7.5	7.1
Conductivity and TDS by Calculation - Water Method: AN106 Tested: 18/1/2019				
Conductivity @ 25 C	µS/cm	2	1000	710
Total Dissolved Solids (TDS) in water Method: AN113 Tested: 18/1/2019				
Total Dissolved Solids Dried at 175-185°C	mg/L	10	600	410
Alkalinity Method: AN135 Tested: 18/1/2019				
Total Alkalinity as CaCO3	mg/L	5	31	21
Carbonate Alkalinity as CO3	mg/L	1	<1	<1
Bicarbonate Alkalinity as HCO3	mg/L	5	38	25
Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 22/1/2019				
Fluoride by ISE	mg/L	0.1	0.4	0.3
Chloride by Discrete Analyser in Water Method: AN274 Tested: 22/1/2019				
Chloride, Cl	mg/L	1	230	160
Sulfate in water Method: AN275 Tested: 22/1/2019				
Sulfate, SO4	mg/L	1	89	57
Nitrate Nitrogen and Nitrite Nitrogen (NOx) by FIA Method: AN258 Tested: 21/1/2019				
Nitrate Nitrogen, NO_3 as N	mg/L	0.05	5.1	5.7
Ammonia Nitrogen by FIA Method: AN261 Tested: 21/1/2019				
Ammonia Nitrogen, NH_3 as N	mg/L	0.05	0.15	<0.05
Cations in Water (Dissolved) by ICPOES Method: AN320 Tested: 21/1/2019				
Calcium, Ca	µg/L	10	15000	10000
Magnesium, Mg	µg/L	10	10000	15000
Potassium, K	µg/L	50	6800	5200
Sodium, Na	µg/L	50	180000	110000

		Sample Number	PE131923.001	PE131923.002
		Sample Matrix	Water	Water
		Sample Name	GCA11903	GCA11904
Parameter	Units	LOR		

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 22/1/2019

Phosphorus, P	µg/L	50	<50	51
Silicon, Si	µg/L	20	13000	10000
Sulfur, S	µg/L	100	39000	23000

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 21/1/2019

Aluminium, Al	µg/L	5	27	26
Antimony, Sb	µg/L	1	<1	<1
Arsenic, As	µg/L	1	5	2
Barium, Ba	µg/L	0.2	27	25
Bismuth, Bi	µg/L	1	<1	<1
Boron, B	µg/L	5	350	300
Cadmium, Cd	µg/L	0.1	0.9	0.3
Chromium, Cr	µg/L	1	<1	<1
Cobalt, Co	µg/L	1	<1	1
Copper, Cu	µg/L	1	4	5
Iron, Fe	µg/L	5	<5	<5
Lead, Pb	µg/L	1	<1	<1
Manganese, Mn	µg/L	1	35	420
Molybdenum, Mo	µg/L	0.5	0.5	0.6
Nickel, Ni	µg/L	1	23	7
Selenium, Se	µg/L	1	1	2
Silver, Ag	µg/L	1	<1	<1
Strontium, Sr	µg/L	1	74	69
Thallium, Tl	µg/L	1	<1	<1
Thorium, Th	µg/L	1	<1	<1
Tin, Sn	µg/L	1	<1	<1
Titanium, Ti	µg/L	1	<1	<1
Uranium, U	µg/L	1	<1	<1
Vanadium, V	µg/L	1	78	1
Zinc, Zn	µg/L	5	33	50

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 21/1/2019

Mercury	µg/L	0.05	<0.05	<0.05

QC SUMMARY

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.

Alkalinity Method: ME-(AU)-[ENV]AN135

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Alkalinity as CaCO3	LB155207	mg/L	5	<5	0%	98%
Carbonate Alkalinity as CO3	LB155207	mg/L	1	<1		
Bicarbonate Alkalinity as HCO3	LB155207	mg/L	5	<5		

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	LB155189	mg/L	0.05	<0.05	0 - 3%	104 - 107%

Cations in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Calcium, Ca	LB155190	µg/L	10	<10	5%	NA
Magnesium, Mg	LB155190	µg/L	10	<10	0%	NA
Potassium, K	LB155190	µg/L	50	<50	0%	NA
Sodium, Na	LB155190	µg/L	50	<50	0%	NA

Chloride by Discrete Analyser in Water Method: ME-(AU)-[ENV]AN274

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Chloride, Cl	LB155239	mg/L	1	<1	0%	103 - 104%	102 - 104%

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB155208	µS/cm	2	<2	0%	98%

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.

Fluoride by Ion Selective Electrode in Water   Method: ME-(AU)-[ENV]AN141

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Fluoride by ISE	LB155223	mg/L	0.1	<0.1	0%	100%	106%

Mercury (dissolved) in Water   Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Mercury	LB155196	µg/L	0.05	<0.05	0 - 195%	85 - 108%	86 - 107%

Metals in Water (Dissolved) by ICPOES   Method: ME-(AU)-[ENV]AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Phosphorus, P	LB155192	µg/L	50	<50	5%	98%	
Silicon, Si	LB155192	µg/L	20	<20	2%	108%	
Sulfur, S	LB155192	µg/L	100	<100	2%	109%	-165%

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

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Nitrate Nitrogen, NO_3 as N	LB155189	mg/L	0.05	<0.05	0 - 3%	NA

pH in water   Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH**	LB155208	pH Units	-	6.0	1%	100%

Sulfate in water   Method: ME-(AU)-[ENV]AN275

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Sulfate, SO4	LB155239	mg/L	1	<1	0 - 4%	102 - 103%	99 - 101%

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.

Total Dissolved Solids (TDS) in water **Method: ME-(AU)-[ENV]AN113**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery	MSD %RPD
Total Dissolved Solids Dried at 175-185°C	LB155136	mg/L	10	<10	0 - 4%	93%	107%	0%

Trace Metals (Dissolved) in Water by ICPMS **Method: ME-(AU)-[ENV]AN318**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Aluminium, Al	LB155164	µg/L	5	<5	6%	99%	
Antimony, Sb	LB155164	µg/L	1	<1	0%	88%	
Arsenic, As	LB155164	µg/L	1	<1	8%	94%	101%
Barium, Ba	LB155164	µg/L	0.2	<0.2	0%	89%	
Bismuth, Bi	LB155164	µg/L	1	<1	0%	87%	
Boron, B	LB155164	µg/L	5	<5	4%	107%	
Cadmium, Cd	LB155164	µg/L	0.1	<0.1	1%	94%	
Chromium, Cr	LB155164	µg/L	1	<1	0%	93%	
Cobalt, Co	LB155164	µg/L	1	<1	0%	91%	93%
Copper, Cu	LB155164	µg/L	1	<1	1%	98%	103%
Iron, Fe	LB155164	µg/L	5	<5	0%	90%	110%
Lead, Pb	LB155164	µg/L	1	<1	0%	91%	
Manganese, Mn	LB155164	µg/L	1	<1	1%	89%	85%
Molybdenum, Mo	LB155164	µg/L	0.5	<0.5	0%	89%	
Nickel, Ni	LB155164	µg/L	1	<1	1%	93%	97%
Selenium, Se	LB155164	µg/L	1	<1	2%	99%	
Silver, Ag	LB155164	µg/L	1	<1	0%	80%	
Strontium, Sr	LB155164	µg/L	1	<1	0%	95%	
Thallium, Tl	LB155164	µg/L	1	<1	0%	89%	
Thorium, Th	LB155164	µg/L	1	<1	0%	88%	83%
Tin, Sn	LB155164	µg/L	1	<1	0%	88%	
Uranium, U	LB155164	µg/L	1	<1	0%	93%	97%
Vanadium, V	LB155164	µg/L	1	<1	3%	90%	
Zinc, Zn	LB155164	µg/L	5	<5	3%	94%	

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.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN113	Total Dissolved Solids: A well-mixed filtered sample of known volume is evaporated to dryness at 180°C and the residue weighed. Approximate methods for correlating chemical analysis with dissolved solids are available. Reference APHA 2540 C.
AN113	The Total Dissolved Solids residue may also be ignited at 550 C and volatile TDS (Organic TDS) and non-volatile TDS (Inorganic) can be determined.
AN135	Alkalinity (and forms of) by Titration: The sample is titrated with standard acid to pH 8.3 (P titre) and pH 4.5 (T titre) and permanent and/or total alkalinity calculated. The results are expressed as equivalents of calcium carbonate or recalculated as bicarbonate, carbonate and hydroxide. Reference APHA 2320. Internal Reference AN135
AN141	Determination of Fluoride by ISE: A fluoride ion selective electrode and reference electrode combination, in the presence of a pH/complexation buffer, is used to determine the fluoride concentration. The electrode millivolt response is measured logarithmically against fluoride concentration. Reference APHA F- C.
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.
AN274	Chloride by Aquakem DA: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference APHA 4500Cl-
AN275	sulfate by Aquakem DA: sulfate is precipitated in an acidic medium with barium chloride. The resulting turbidity is measured photometrically at 405nm and compared with standard calibration solutions to determine the sulfate concentration in the sample. Reference APHA 4500-SO42-. Internal reference AN275.
AN311(Perth)/AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN318	Determination of elements at trace level in waters by ICP-MS technique, in accordance with USEPA 6020A.

METHOD SUMMARY

METHOD	METHODOLOGY SUMMARY
AN320	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components .
AN320	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B.
AN320 LL	Cations Low LOR by ICP-OES: Method is as per routine ICP OES method reporting a variation to the method being lower limit of reporting (LOR) for selected cations as validated by the site. Referenced to APHA 3120B.
Calculation	Free and Total Carbon Dioxide may be calculated using alkalinity forms only when the samples TDS is <500mg/L. If TDS is >500mg/L free or total carbon dioxide cannot be reported. APHA4500CO2 D.

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

Unless it is reported that sampling has been perfomed by SGS, the samples have been 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 calcuated 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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ANALYTICAL REPORT

Accreditation No. 2562

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Project	**GCA Job No.1901/2**
Order Number	**GCA Job No.1901/2**
Samples	4

LABORATORY DETAILS

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SGS Reference	**PE132551 R1**
Date Received	13 Feb 2019
Date Reported	25 Feb 2019

COMMENTS

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

Metals: #4: B, Cu & Zn: Positive results reported. Confirmed by re-analysis
Metals: Over range on ICPMS Method AN318 was taken from ICPOES Method AN320.

This report cancels and supersedes the report No.PE132551 R0 dated 21/2/2019 issued by SGS Environment, Health and Safety due to the addition of Titanium result.

SIGNATORIES

Hue Thanh Ly
Metals Team Leader

Louise Hope

Louise Hope
Laboratory Technician

Mary Ann Ola-A
Inorganics Team Leader

Ohmar David
Metals Chemist

		Sample Number	PE132551.001	PE132551.002
		Sample Matrix	Water	Water
		Sample Name	GCA11903 pH5	GCA11904 pH5
Parameter	Units	LOR		

pH in water Method: AN101 Tested: 14/2/2019

pH**	pH Units	0.1	5.1	5.2

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 14/2/2019

Conductivity @ 25 C	µS/cm	2	610	600

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 19/2/2019

Fluoride by ISE	mg/L	0.1	<0.1	<0.1

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 15/2/2019

Phosphorus, P	µg/L	50	<50	<50
Silicon, Si	µg/L	20	12000	8700
Sulfur, S	µg/L	100	1300	590

Cations in Water (Dissolved) by ICPOES Method: AN320 Tested: 15/2/2019

Calcium, Ca	µg/L	10	2200	3300
Magnesium, Mg	µg/L	10	8100	6900
Potassium, K	µg/L	50	4400	2800
Sodium, Na	µg/L	50	150000	140000

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 15/2/2019

Aluminium, Al	µg/L	5	19	12
Antimony, Sb	µg/L	1	<1	<1
Arsenic, As	µg/L	1	<1	1
Barium, Ba	µg/L	0.2	24	55
Bismuth, Bi	µg/L	1	<1	<1
Boron, B	µg/L	5	220	160
Cadmium, Cd	µg/L	0.1	<0.1	<0.1
Chromium, Cr	µg/L	1	<1	<1
Cobalt, Co	µg/L	1	16	29
Copper, Cu	µg/L	1	17	33
Iron, Fe	µg/L	5	7	<5
Lead, Pb	µg/L	1	<1	<1
Manganese, Mn	µg/L	1	200	720
Molybdenum, Mo	µg/L	0.5	<0.5	<0.5
Nickel, Ni	µg/L	1	16	34
Selenium, Se	µg/L	1	<1	<1
Silver, Ag	µg/L	1	<1	<1
Strontium, Sr	µg/L	1	23	30
Thallium, Tl	µg/L	1	<1	<1

Parameter	Units	LOR	Sample Number PE132551.001 Sample Matrix Water Sample Name GCA11903 pH5	PE132551.002 Water GCA11904 pH5

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 15/2/2019 (continued)

Parameter	Units	LOR	PE132551.001	PE132551.002
Thorium, Th	µg/L	1	<1	<1
Tin, Sn	µg/L	1	<1	<1
Titanium, Ti	µg/L	1	<1	<1
Uranium, U	µg/L	1	<1	<1
Vanadium, V	µg/L	1	<1	<1
Zinc, Zn	µg/L	5	26	73

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 18/2/2019

Parameter	Units	LOR	PE132551.001	PE132551.002
Mercury	µg/L	0.05	<0.05	<0.05

		Sample Number	PE132551.003	PE132551.004
		Sample Matrix	Water	Water
		Sample Name	pH5-FEED	pH5-BLANK
Parameter	Units	LOR		

pH in water Method: AN101 Tested: 15/2/2019

pH**	pH Units	0.1	-	-

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 15/2/2019

Conductivity @ 25 C	µS/cm	2	-	-

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 15/2/2019

Fluoride by ISE	mg/L	0.1	-	-

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 15/2/2019

Phosphorus, P	µg/L	50	<50	<50
Silicon, Si	µg/L	20	27	21
Sulfur, S	µg/L	100	<100	<100

Cations in Water (Dissolved) by ICPOES Method: AN320 Tested: 15/2/2019

Calcium, Ca	µg/L	10	22	26
Magnesium, Mg	µg/L	10	<10	<10
Potassium, K	µg/L	50	<50	<50
Sodium, Na	µg/L	50	140000	150000

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 15/2/2019

Aluminium, Al	µg/L	5	5	<5
Antimony, Sb	µg/L	1	<1	<1
Arsenic, As	µg/L	1	<1	<1
Barium, Ba	µg/L	0.2	0.4	0.5
Bismuth, Bi	µg/L	1	<1	<1
Boron, B	µg/L	5	89	88
Cadmium, Cd	µg/L	0.1	<0.1	<0.1
Chromium, Cr	µg/L	1	<1	<1
Cobalt, Co	µg/L	1	<1	<1
Copper, Cu	µg/L	1	<1	2
Iron, Fe	µg/L	5	<5	<5
Lead, Pb	µg/L	1	<1	<1
Manganese, Mn	µg/L	1	<1	<1
Molybdenum, Mo	µg/L	0.5	<0.5	<0.5
Nickel, Ni	µg/L	1	<1	<1
Selenium, Se	µg/L	1	<1	<1
Silver, Ag	µg/L	1	<1	<1
Strontium, Sr	µg/L	1	<1	<1
Thallium, Tl	µg/L	1	<1	<1

		Sample Number Sample Matrix Sample Name	PE132551.003 Water pH5-FEED	PE132551.004 Water pH5-BLANK
Parameter	Units	LOR		

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 15/2/2019 (continued)

Thorium, Th	µg/L	1	<1	<1
Tin, Sn	µg/L	1	<1	<1
Titanium, Ti	µg/L	1	<1	<1
Uranium, U	µg/L	1	<1	<1
Vanadium, V	µg/L	1	<1	<1
Zinc, Zn	µg/L	5	9	9

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 18/2/2019

Mercury	µg/L	0.05	<0.05	<0.05

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.

Cations in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD
Calcium, Ca	LB156109	µg/L	10	<10	7%
Magnesium, Mg	LB156109	µg/L	10	<10	0%
Potassium, K	LB156109	µg/L	50	<50	0%
Sodium, Na	LB156109	µg/L	50	<50	0%

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB156131	µS/cm	2	<2		99%
	LB156205	µS/cm	2	<2	0%	102%

Fluoride by Ion Selective Electrode in Water Method: ME-(AU)-[ENV]AN141

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Fluoride by ISE	LB156239	mg/L	0.1	<0.1	0 - 5%	103%	98 - 100%

Mercury (dissolved) in Water Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Mercury	LB156184	µg/L	0.05	<0.05	0 - 181%	107 - 112%	87 - 96%

Metals in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN320

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Phosphorus, P	LB156106	µg/L	50	<0	0%	109%
	LB156108	µg/L	50	<50		106%
Silicon, Si	LB156106	µg/L	20	<0	0%	107%
	LB156108	µg/L	20	<20		104%
Sulfur, S	LB156106	µg/L	100	<0	0%	105%
	LB156108	µg/L	100	<100		102%

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.

pH in water **Method: ME-(AU)-[ENV]AN101**

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
pH**	LB156131	pH Units	0.1	5.7	100%
	LB156205	pH Units	0.1	5.5	100%

Trace Metals (Dissolved) in Water by ICPMS **Method: ME-(AU)-[ENV]AN318**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Aluminium, Al	LB156096	µg/L	5	<5	4%	106%	118%
Antimony, Sb	LB156096	µg/L	1	<1	0%	96%	
Arsenic, As	LB156096	µg/L	1	<1	0%	112%	
Barium, Ba	LB156096	µg/L	0.2	<0.2	0%	106%	
Bismuth, Bi	LB156096	µg/L	1	<1	0%	97%	
Boron, B	LB156096	µg/L	5	<5	0%	100%	
Cadmium, Cd	LB156096	µg/L	0.1	<0.1	0%	107%	
Chromium, Cr	LB156096	µg/L	1	<1	0%	102%	
Cobalt, Co	LB156096	µg/L	1	<1	0%	104%	
Copper, Cu	LB156096	µg/L	1	<1	0%	103%	
Iron, Fe	LB156096	µg/L	5	<5	0%	98%	91%
Lead, Pb	LB156096	µg/L	1	<1	0%	108%	
Manganese, Mn	LB156096	µg/L	1	<1	0%	102%	103%
Molybdenum, Mo	LB156096	µg/L	0.5	<0.5	0%	103%	
Nickel, Ni	LB156096	µg/L	1	<1	0%	104%	
Selenium, Se	LB156096	µg/L	1	<1	0%	98%	
Silver, Ag	LB156096	µg/L	1	<1	0%	98%	
Strontium, Sr	LB156096	µg/L	1	<1	0%	101%	
Thallium, Tl	LB156096	µg/L	1	<1	0%	96%	
Thorium, Th	LB156096	µg/L	1	<1	0%	92%	
Tin, Sn	LB156096	µg/L	1	<1	0%	94%	
Uranium, U	LB156096	µg/L	1	<1	0%	96%	
Vanadium, V	LB156096	µg/L	1	<1	0%	103%	
Zinc, Zn	LB156096	µg/L	5	<5	26%	111%	

METHOD	METHODOLOGY SUMMARY
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN141	Determination of Fluoride by ISE: A fluoride ion selective electrode and reference electrode combination, in the presence of a pH/complexation buffer, is used to determine the fluoride concentration. The electrode millivolt response is measured logarithmically against fluoride concentration. Reference APHA F- C.
AN311(Perth)/AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN318	Determination of elements at trace level in waters by ICP-MS technique, in accordance with USEPA 6020A.
AN320	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components .
AN320	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B.
AN320 LL	Cations Low LOR by ICP-OES: Method is as per routine ICP OES method reporting a variation to the method being lower limit of reporting (LOR) for selected cations as validated by the site. Referenced to APHA 3120B.

FOOTNOTES

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

Unless it is reported that sampling has been perfomed by SGS, the samples have been 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 calcuated 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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ANALYTICAL REPORT

Accreditation No. 2562

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Project	**GCA Job No. 1901/3**
Order Number	**GCA Job No. 1901/3**
Samples	6

LABORATORY DETAILS

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SGS Reference	**PE141538 R0**
Date Received	21 Feb 2020
Date Reported	03 Mar 2020

COMMENTS

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

Metals: Dissolved S & Si : Spike recovery failed due to matrix interference.
Alkalinity in Water: Sample #3 insufficient sample volume for analysis.
Dissolved Mercury in Water: Sample #3 insufficient sample volume for analysis.

SIGNATORIES

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Metals Team Leader

LouiseHope

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Laboratory Technician

Mary Ann OLA-A
Inorganics Team Leader

Ohmar DAVID
Metals Chemist

		Sample Number Sample Matrix Sample Name	PE141538.001 Water GCA11903-HC-0	PE141538.002 Water GCA11903-HC-1
Parameter	Units	LOR		

pH in water Method: AN101 Tested: 21/2/2020

pH**	pH Units	0.1	7.9	7.2

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 21/2/2020

Conductivity @ 25 C	µS/cm	2	1900	300

Alkalinity Method: AN135 Tested: 21/2/2020

Bicarbonate Alkalinity as HCO3	mg/L	1	59	37

Chloride by Discrete Analyser in Water Method: AN274 Tested: 24/2/2020

Chloride, Cl	mg/L	1	370	44

Sulfate in water Method: AN275 Tested: 24/2/2020

Sulfate, SO4	mg/L	1	200	46

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 27/2/2020

Fluoride by ISE	mg/L	0.1	0.4	0.7

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/2/2020

Phosphorus, P	µg/L	50	<50	<50
Silicon, Si	µg/L	20	15000	15000
Sulfur, S	µg/L	100	82000	16000

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 24/2/2020

Calcium, Ca	µg/L	10	13000	640
Magnesium, Mg	µg/L	10	30000	1500
Potassium, K	µg/L	50	10000	3100
Sodium, Na	µg/L	50	280000	48000

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/2/2020

Aluminium, Al	µg/L	5	10	86
Antimony, Sb	µg/L	1	<1	<1
Arsenic, As	µg/L	1	5	28
Barium, Ba	µg/L	0.2	20	2.0
Bismuth, Bi	µg/L	1	<1	<1
Boron, B	µg/L	5	580	500
Cadmium, Cd	µg/L	0.1	<0.1	<0.1
Chromium, Cr	µg/L	1	<1	<1

Parameter	Units	LOR	Sample Number PE141538.001 Sample Matrix Water Sample Name GCA11903-HC-0	PE141538.002 Water GCA11903-HC-1

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/2/2020 (continued)

Parameter	Units	LOR	PE141538.001	PE141538.002
Cobalt, Co	µg/L	1	<1	1
Copper, Cu	µg/L	1	10	20
Iron, Fe	µg/L	5	<5	33
Lead, Pb	µg/L	1	<1	<1
Manganese, Mn	µg/L	1	25	14
Molybdenum, Mo	µg/L	0.5	1.9	2.0
Nickel, Ni	µg/L	1	6	5
Selenium, Se	µg/L	1	2	<1
Silver, Ag	µg/L	1	<1	<1
Strontium, Sr	µg/L	1	86	4
Thallium, Tl	µg/L	1	<1	<1
Thorium, Th	µg/L	1	<1	<1
Tin, Sn	µg/L	1	<1	<1
Titanium, Ti	µg/L	1	<1	<1
Uranium, U	µg/L	1	<1	<1
Vanadium, V	µg/L	1	4	11
Zinc, Zn	µg/L	5	<5	<5

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 26/2/2020

Parameter	Units	LOR	PE141538.001	PE141538.002
Mercury	µg/L	0.05	<0.05	<0.05

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 25/2/2020

Parameter	Units	LOR	PE141538.001	PE141538.002
Hexavalent Chromium, Cr6+	mg/L	0.001	<0.001	<0.001

		Sample Number	PE141538.003	PE141538.004
		Sample Matrix	Water	Water
		Sample Name	GCA11903-HC-2	GCA11904-HC-0
Parameter	Units	LOR		

pH in water Method: AN101 Tested: 24/2/2020

pH**	pH Units	0.1	7.3	7.7

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 24/2/2020

Conductivity @ 25 C	µS/cm	2	340	840

Alkalinity Method: AN135 Tested: 26/2/2020

Bicarbonate Alkalinity as HCO3	mg/L	1	IS	33

Chloride by Discrete Analyser in Water Method: AN274 Tested: 24/2/2020

Chloride, Cl	mg/L	1	40	170

Sulfate in water Method: AN275 Tested: 24/2/2020

Sulfate, SO4	mg/L	1	61	70

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 27/2/2020

Fluoride by ISE	mg/L	0.1	0.6	0.2

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/2/2020

Phosphorus, P	µg/L	50	<50	<50
Silicon, Si	µg/L	20	13000	7100
Sulfur, S	µg/L	100	22000	26000

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 24/2/2020

Calcium, Ca	µg/L	10	840	5400
Magnesium, Mg	µg/L	10	2000	13000
Potassium, K	µg/L	50	3200	5200
Sodium, Na	µg/L	50	54000	120000

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/2/2020

Aluminium, Al	µg/L	5	110	12
Antimony, Sb	µg/L	1	2	<1
Arsenic, As	µg/L	1	96	4
Barium, Ba	µg/L	0.2	2.1	31
Bismuth, Bi	µg/L	1	<1	<1
Boron, B	µg/L	5	450	270
Cadmium, Cd	µg/L	0.1	<0.1	<0.1
Chromium, Cr	µg/L	1	<1	1

		Sample Number Sample Matrix Sample Name	PE141538.003 Water GCA11903-HC-2	PE141538.004 Water GCA11904-HC-0
Parameter	Units	LOR		

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/2/2020 (continued)

Cobalt, Co	µg/L	1	4	1
Copper, Cu	µg/L	1	3	19
Iron, Fe	µg/L	5	76	<5
Lead, Pb	µg/L	1	<1	<1
Manganese, Mn	µg/L	1	20	190
Molybdenum, Mo	µg/L	0.5	1.9	<0.5
Nickel, Ni	µg/L	1	17	6
Selenium, Se	µg/L	1	<1	3
Silver, Ag	µg/L	1	<1	<1
Strontium, Sr	µg/L	1	6	47
Thallium, Tl	µg/L	1	<1	<1
Thorium, Th	µg/L	1	<1	<1
Tin, Sn	µg/L	1	<1	<1
Titanium, Ti	µg/L	1	2	<1
Uranium, U	µg/L	1	<1	<1
Vanadium, V	µg/L	1	10	1
Zinc, Zn	µg/L	5	5	10

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 26/2/2020

Mercury	µg/L	0.05	IS	<0.05

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 25/2/2020

Hexavalent Chromium, Cr6+	mg/L	0.001	<0.001	0.004

		Sample Number	PE141538.005	PE141538.006
		Sample Matrix	Water	Water
		Sample Name	GCA11904-HC-1	GCA11904-HC-2
Parameter	Units	LOR		

pH in water Method: AN101 Tested: 21/2/2020

pH**	pH Units	0.1	7.2	7.3

Conductivity and TDS by Calculation - Water Method: AN106 Tested: 21/2/2020

Conductivity @ 25 C	µS/cm	2	370	230

Alkalinity Method: AN135 Tested: 21/2/2020

Bicarbonate Alkalinity as HCO3	mg/L	1	9	13

Chloride by Discrete Analyser in Water Method: AN274 Tested: 24/2/2020

Chloride, Cl	mg/L	1	53	23

Sulfate in water Method: AN275 Tested: 24/2/2020

Sulfate, SO4	mg/L	1	62	48

Fluoride by Ion Selective Electrode in Water Method: AN141 Tested: 27/2/2020

Fluoride by ISE	mg/L	0.1	0.3	0.4

Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 25/2/2020

Phosphorus, P	µg/L	50	<50	<50
Silicon, Si	µg/L	20	11000	10000
Sulfur, S	µg/L	100	23000	17000

Cations in Water (Dissolved) by ICPOES Method: AN020/AN320 Tested: 24/2/2020

Calcium, Ca	µg/L	10	2000	1400
Magnesium, Mg	µg/L	10	4800	3100
Potassium, K	µg/L	50	2900	2300
Sodium, Na	µg/L	50	55000	35000

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/2/2020

Aluminium, Al	µg/L	5	8	6
Antimony, Sb	µg/L	1	<1	<1
Arsenic, As	µg/L	1	6	11
Barium, Ba	µg/L	0.2	7.6	4.6
Bismuth, Bi	µg/L	1	<1	<1
Boron, B	µg/L	5	380	350
Cadmium, Cd	µg/L	0.1	<0.1	<0.1
Chromium, Cr	µg/L	1	<1	<1

Parameter	Units	LOR	Sample Number PE141538.005 Sample Matrix Water Sample Name GCA11904-HC-1	PE141538.006 Water GCA11904-HC-2

Trace Metals (Dissolved) in Water by ICPMS Method: AN318 Tested: 25/2/2020 (continued)

Parameter	Units	LOR	PE141538.005	PE141538.006
Cobalt, Co	µg/L	1	1	1
Copper, Cu	µg/L	1	2	2
Iron, Fe	µg/L	5	<5	5
Lead, Pb	µg/L	1	<1	<1
Manganese, Mn	µg/L	1	130	77
Molybdenum, Mo	µg/L	0.5	0.8	1.1
Nickel, Ni	µg/L	1	3	5
Selenium, Se	µg/L	1	3	2
Silver, Ag	µg/L	1	<1	<1
Strontium, Sr	µg/L	1	16	10
Thallium, Tl	µg/L	1	<1	<1
Thorium, Th	µg/L	1	<1	<1
Tin, Sn	µg/L	1	<1	<1
Titanium, Ti	µg/L	1	<1	<1
Uranium, U	µg/L	1	<1	<1
Vanadium, V	µg/L	1	2	3
Zinc, Zn	µg/L	5	<5	6

Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 26/2/2020

Parameter	Units	LOR	PE141538.005	PE141538.006
Mercury	µg/L	0.05	<0.05	<0.05

Hexavalent Chromium in water by Discrete Analyser Method: AN283 Tested: 25/2/2020

Parameter	Units	LOR	PE141538.005	PE141538.006
Hexavalent Chromium, Cr6+	mg/L	0.001	<0.001	<0.001

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.

Alkalinity Method: ME-(AU)-[ENV]AN135

Parameter	QC Reference	Units	LOR	MB
Bicarbonate Alkalinity as HCO3	LB169387	mg/L	1	<1
	LB169406	mg/L	1	2

Cations in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN020/AN320

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery	MS %Recovery
Calcium, Ca	LB169246	µg/L	10	<10	NA	NA
Magnesium, Mg	LB169246	µg/L	10	<10	NA	NA
Potassium, K	LB169246	µg/L	50	<50	NA	NA
Sodium, Na	LB169246	µg/L	50	<50	NA	NA

Chloride by Discrete Analyser in Water Method: ME-(AU)-[ENV]AN274

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Chloride, Cl	LB169301	mg/L	1	<1	0%	105%	100 - 104%

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB169383	µS/cm	2	<2	0%	98%
	LB169405	µS/cm	2	<2	0%	97%

Fluoride by Ion Selective Electrode in Water Method: ME-(AU)-[ENV]AN141

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Fluoride by ISE	LB169426	mg/L	0.1	<0.1	0 - 8%	100%	80 - 90%

Hexavalent Chromium in water by Discrete Analyser Method: ME-(AU)-[ENV]AN283

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Hexavalent Chromium, Cr6+	LB169324	mg/L	0.001	<0.001	0 - 6%	NA	NA

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.

Mercury (dissolved) in Water Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Mercury	LB169364	µg/L	0.05	<0.00	0%	111 - 113%	112 - 116%

Metals in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN320

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery	MS %Recovery
Phosphorus, P	LB169304	µg/L	50	<50	103%	110%
Silicon, Si	LB169304	µg/L	20	<20	109%	-33%
Sulfur, S	LB169304	µg/L	100	<100	105%	-857%

pH in water Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH**	LB169383	pH Units	0.1	5.7	0%	101%
	LB169405	pH Units	0.1	5.7	0%	100%

Sulfate in water Method: ME-(AU)-[ENV]AN275

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Sulfate, SO4	LB169301	mg/L	1	<1	0 - 2%	101 - 109%	92 - 95%

Trace Metals (Dissolved) in Water by ICPMS Method: ME-(AU)-[ENV]AN318

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Aluminium, Al	LB169306	µg/L	5	<5		111%	
Antimony, Sb	LB169306	µg/L	1	<1		110%	
Arsenic, As	LB169306	µg/L	1	<1	0 - 4%	108%	113%
Barium, Ba	LB169306	µg/L	0.2	<0.2		109%	
Bismuth, Bi	LB169306	µg/L	1	<1		114%	
Boron, B	LB169306	µg/L	5	<5		113%	
Cadmium, Cd	LB169306	µg/L	0.1	<0.1	0%	106%	107%
Chromium, Cr	LB169306	µg/L	1	<1	6 - 18%	103%	105%
Cobalt, Co	LB169306	µg/L	1	<1	2%	104%	
Copper, Cu	LB169306	µg/L	1	<1	1 - 47%	113%	87%
Iron, Fe	LB169306	µg/L	5	<5	3%	117%	
Lead, Pb	LB169306	µg/L	1	<1	0 - 5%	118%	110%
Manganese, Mn	LB169306	µg/L	1	<1		107%	
Molybdenum, Mo	LB169306	µg/L	0.5	<0.5		110%	
Nickel, Ni	LB169306	µg/L	1	<1	11 - 16%	109%	107%
Selenium, Se	LB169306	µg/L	1	<1	1%	102%	
Silver, Ag	LB169306	µg/L	1	<1		113%	
Strontium, Sr	LB169306	µg/L	1	<1		110%	
Thallium, Tl	LB169306	µg/L	1	<1		115%	
Thorium, Th	LB169306	µg/L	1	<1		98%	
Tin, Sn	LB169306	µg/L	1	<1		103%	
Titanium, Ti	LB169306	µg/L	1	<1		80%	
Uranium, U	LB169306	µg/L	1	<1		111%	
Vanadium, V	LB169306	µg/L	1	<1		100%	
Zinc, Zn	LB169306	µg/L	5	<5	0%	117%	122%

METHOD	METHODOLOGY SUMMARY
AN020/AN320 LL	Dissolved Cations Low LOR by ICP-OES: Method is as per routine ICP OES method reporting a variation to the method being lower limit of reporting (LOR) for selected cations as validated by the site. Referenced to APHA 3120B.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN135	Alkalinity (and forms of) by Titration: The sample is titrated with standard acid to pH 8.3 (P titre) and pH 4.5 (T titre) and permanent and/or total alkalinity calculated. The results are expressed as equivalents of calcium carbonate or recalculated as bicarbonate, carbonate and hydroxide. Reference APHA 2320. Internal Reference AN135
AN141	Determination of Fluoride by ISE: A fluoride ion selective electrode and reference electrode combination, in the presence of a pH/complexation buffer, is used to determine the fluoride concentration. The electrode millivolt response is measured logarithmically against fluoride concentration. Reference APHA F- C.
AN274	Chloride by Discrete Analyse: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference APHA 4500Cl-
AN275	sulfate by Discrete Analyse: sulfate is precipitated in an acidic medium with barium chloride. The resulting turbidity is measured photometrically at 405nm and compared with standard calibration solutions to determine the sulfate concentration in the sample. Reference APHA 4500-SO42-. Internal reference AN275.
AN283	Hexavalent Chromium via Discrete Analyser: Soluble hexavalent chromium forms a red/violet colour with diphenylcarbazide in acidic solution. This procedure is very sensitive and nearly specific for Cr6+. If total chromium is also measured the trivalent form of chromium Cr3+ can be calculated from the difference (Total Cr - Cr6+). Reference APHA3500CrB.
AN311(Perth)/AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN318	Determination of elements at trace level in waters by ICP-MS technique,, referenced to USEPA 6020B and USEPA 200.8 (5.4).
AN320	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components .
AN320	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B.

METHOD	METHODOLOGY SUMMARY
Calculation	Free and Total Carbon Dioxide may be calculated using alkalinity forms only when the samples TDS is <500mg/L. If TDS is >500mg/L free or total carbon dioxide cannot be reported. APHA4500CO2 D.

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
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
		NVL	Not Validated

Unless it is reported that sampling has been performed by SGS, the samples have been 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 calcuated 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 and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au/en-gb/environment-health-and-safety.

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