

Hydrogeological investigation

Arrowsmith Hydrogen Project

CW1183400



Prepared for
Infinite Blue energy

3 September 2021

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1 Introduction

1.1 Background

Infinite Blue Energy (“IBE”) is developing a hydrogen-production project in the Arrowsmith area (Site) with associated wind turbines and solar panels. IBE is evaluating the feasibility of using site groundwater for the project. Two wells are located at the Site. IBE retained Cardno to undertake an evaluation of aquifer yield from these Site wells.

The Site is located approximately 320 km north of Perth. As shown on Figure 1-1, the Site is bounded to the east by the Brand highway and to the west by Indian Ocean Road. The shoreline is located approximately 1 km to the west of the western boundary.

1.2 Objectives

The objective of this study was to establish the construction details of each of the two Site wells and undertake pump testing to evaluate the likely yield from each Site well, and determine aquifer characteristics.

1.3 Scope

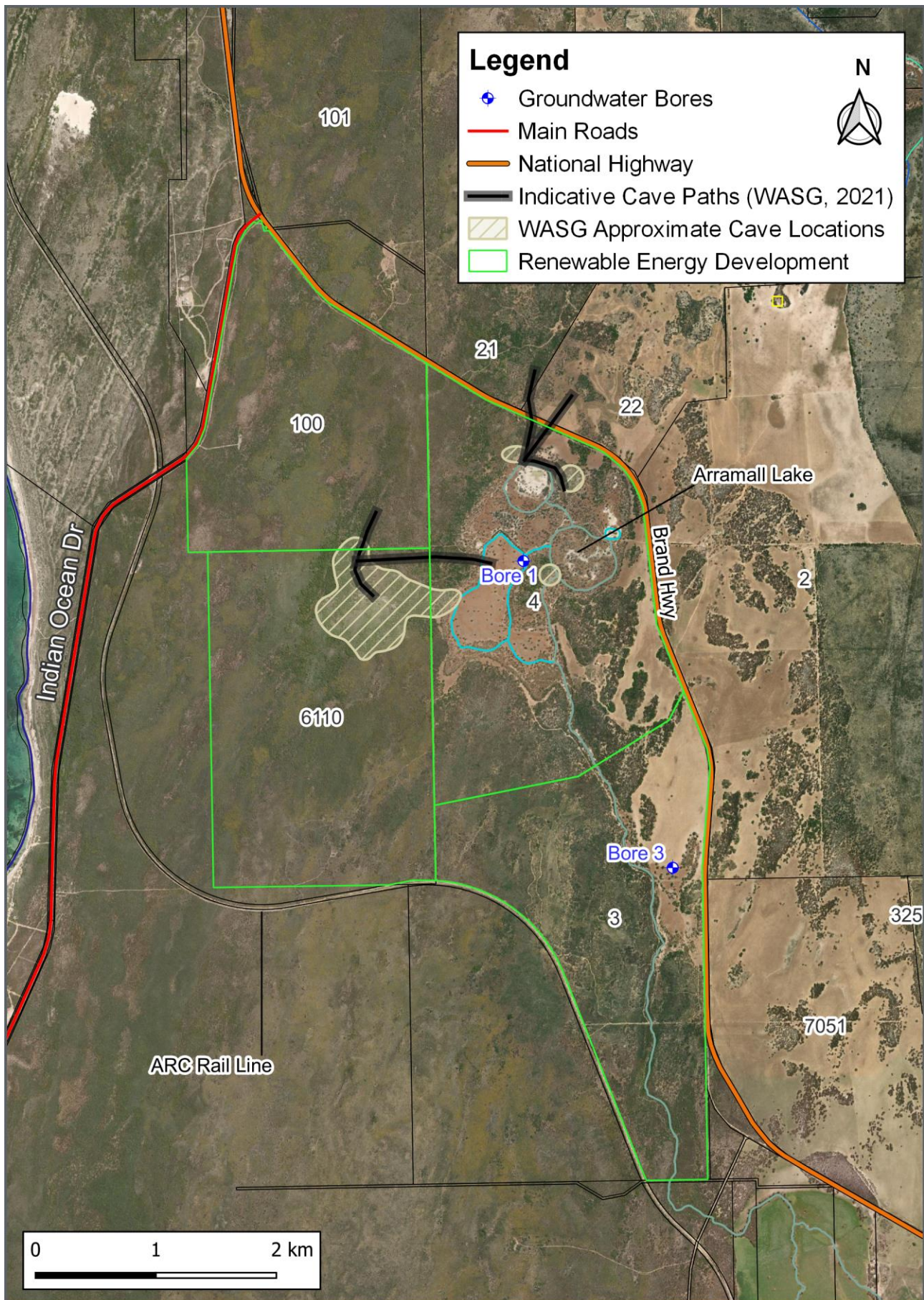
Cardno undertook a desktop investigation to fulfil the project objectives. The scope of this investigation also includes:

1. Installation of pump equipment at bore 1 and bore 3 to complete Step (four steps 1, 2, 3 and 4 L/s) and Constant Rate tests (~4 L/s for 4 hours), and remove.
2. Comparison of data collected as part of the Assessment works against current regulatory assessment criteria appropriate for the current site and beneficial uses. The collection of the additional data will assist in refining the Conceptual Site Model (CSM) for the site.
3. Prepare a succinct Technical Memorandum (this report) presenting the findings of the Assessment, including:
 - a. Field and recorded observations from the downhole camera inspection and test pump data.
 - b. Laboratory Results (groundwater).
 - c. Assessment of test pump data to derive aquifer properties for the site.

1.4 Scope Amendments

Amendments were made to item 1 of the above scope due to observed conditions prior and during the pump. These amendments include testing of Bore 3 in place of Bore 2 and increasing the number of steps for the step rate test from three steps to four steps. The pump rate was increased from approximately 2 L/s to 4 L/s with the duration of pumping decreased from 8 hours to 4 hours.

Figure 1-1 Location plan



2 Previous Investigation

AQ2 was engaged by the IBE to undertake a *Desktop Water Supply and Groundwater-dependent Ecosystem (GDE) Assessment*. Findings of the investigation regarding the site-specific geology and hydrogeology of the site are summarised below:

Site Specific Geology

- > Caves are present in the surficial geological units at the site, with two major caves identified near the lakes, the Arramall Cave and River Cave.
- > Majority of the surface geology across the site comprises the Tamala Limestone unit, which is described as lithified dunes of a calcarenite and sand deposit.
- > The eastern portion of site comprises low lying swamp/lacustrine and aeolian deposits forming Lake Arramall and associated drainage.
- > Formation of extensive karstic features from dissolution of carbonate in the Tamala Limestone include vertical solution channels, pipes as well as cavities developed from calcified root structures.

Hydrogeology

- > AQ2 details the site being underlain by two major regional aquifer systems which are segregated into two levels. The aquifer levels (from top to bottom) and the associated geological units and groundwater salinity of each aquifer are summarised below:
 - **Tamala Limestone - Superficial (unconfined)** – Superficial Formations (Tamala Limestone) from the surface to depth ranging between 10 – 30 mAHD. Hydraulic Conductivity 50 – 1000 m/day (median 300 m/day). The groundwater depth ranges between approximately 5.0 and 10.0 mBGL across the site.
 - **Yarragadee (semi-confined to confined)** – Underlies the Superficial Formation at depth of approximately -20mAHD. Yarragadee sandstone comprises 80% of sand containing medium to very coarse-grained quartz sand with fine-grained intervals. Hydraulic Conductivity 5 – 15 m/day (median 10 m/day).
- > Existing groundwater bores were sampled and tested indicating groundwater to be brackish with salinity ranging between 3,400 uS/cm (500 m south of the lake) and 1,800 uS/cm (3 km south of the lake).
- > Further assessment was conducted on both aquifers with aquifer drawdown analysis detailed in Section 4 (AQ2, 2021). In summary, an abstraction of 500 kL/d from the Superficial Aquifer (Tamala Limestone) and the Yarragadee Aquifer may potentially produce a drawdown of 0.2 m or less and 1-2 m respectively within the project site. The effect of drawdown may be partly mitigated by placement of abstraction bores at significant distance from identified groundwater dependent vegetation.
- > The salinity of natural inflow to the lake, and the variation of lake salinity with seasons is unknown. As such, AQ2 suggested an analysis of salt balance in the lake system will require an understanding of the lake quality during wet and dry periods.
- > The preliminary assessment indicates groundwater level change at the GDE will be small (<0.05m), with the existing vegetation surveys showing a high degradation of vegetation across the site.

3 Field and Recorded Observations

3.1 Downhole Camera

A downhole camera was used to observe the conditions of both Bore 1 and Bore 3. Construction details for each bore are presented in Table 3-1 below. Slot width is approximately 0.5 mm with a slot spacing of approximately 10 mm. The screen condition of both bores is displayed in Figure 3-1 and Figure 3-2. The screens are in good condition with no evidence of clogging or scaling. The open area of the well screens is low (less than approximately 10%) due to the spacing and width of the slots. This low open area may limit the maximum extraction rate (rather than being limited by yield from the aquifer).

Table 3-1 Total depths and screen intervals as observed via downhole camera

Bore ID	Bore Depth (m)	Observed Water Level (mbTOC)	Top of Screen (mbTOC)	Bottom of Screen (mbTOC)	Bore Screen Interval (m)
Bore 1	25.97	13.61	16.9	25.9	9
Bore 3	23.52	13.65	11.5	23.5	12

Figure 3-1 Side view of Bore 1 screen

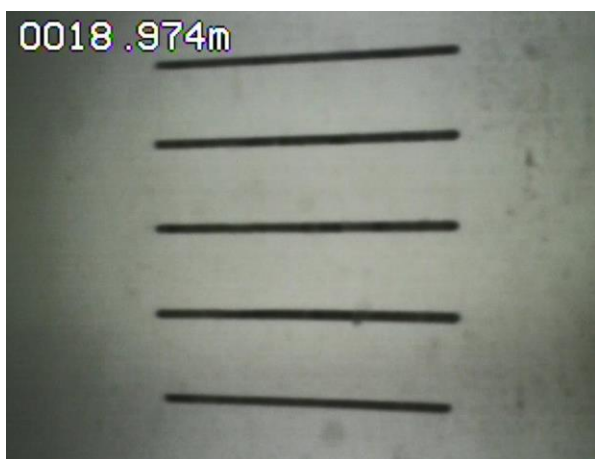
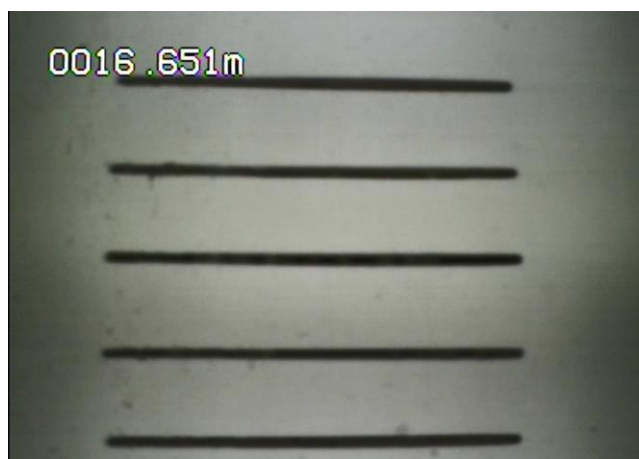


Figure 3-2 Side view of Bore 3 screen



3.2 Pump Test

One step-drawdown test and one constant-rate test was conducted per bore; Bore 1 on 28 July 2021 and Bore 3 on 26 July 2021. Each step rate test involved four, thirty-minute-long intervals of pumping at each rate (approximately 1 L/s, 2 L/s, 3 L/s, and 4 L/s). The constant-rate pump test consisted of 4 hours of pumping at a constant rate of approximately 3.5 L/s for Bore 1 and 4 L/s for Bore 3. The recorded bore data at the time of the pump test is displayed in Table 3-2 below.

Table 3-2 Bore data recorded prior to pump test by contractor

Bore ID	Bore Depth (m)	Water Level (mbTOC)	Top of Screen (mbTOC)	Bottom of Screen (mbTOC)	Bore Screen Interval (m)
Bore 1	26.39	13.94	17.35	26.39	9.04
Bore 3	23.90	14.15	11.54	23.51	11.97

Interpretation of the step-drawdown tests for each bore suggested well efficiency for each bore was less than 10%. Hence, the majority of the drawdown measured in each well during each pumping test reflected non-linear well loss rather than linear losses due to the formation. This is supported by the rapid recovery once pumping ceased, which also suggests low well efficiency in each of the pumped bores.

Interpretations of the constant-rate pump test for each bore was undertaken using a Theis model for unconfined conditions. Displacement versus time plots for each pump test are presented in Appendix C. Interpretation was based on either a 30-m-thick or 50-m-thick aquifer.

Table 3-3 Summary of Constant-Rate Pump Test Interpretations

Tested Bore	Adopted Aquifer Thickness (m)	Interpreted Transmissivity (m ² /day)	Interpreted Hydraulic Conductivity (m/day)
B1	30	1,075	36
B1	50	1,557	31
B3	30	891	30
B3	50	1,411	28

Further information regarding the pump tests can be found in Appendix A.

4 Results and Discussion

4.1 Downhole Camera

Inspections of the downhole-camera video surveys on Bore 1 and Bore 3 indicate that machine-slotted PVC casing with glued joints was used to construct each well. The screens in each well are in good condition with no evidence of clogging or scaling. The open area of the well screens is low (less than approximately 10%) due to the spacing and width of the slots. This low open area may limit the well efficiency and maximum extraction rate (rather than being limited by yield from the aquifer).

4.2 Groundwater Laboratory Results

Groundwater laboratory results were compared against the ANZG Freshwater 95% (FW95), ANZG Freshwater 99% (FW99), and the Department of Health's Non-potable Use guidelines (NPUG) (DoH, 2014) to determine the general water quality and its existing beneficial use.

- > Inorganics exceedances were reported for Sodium, Chloride, and TDS above the NPUG criteria at both Bore 1 and 3.
- > Metals exceedances were reported for Copper and Zinc above the ANZG FW95 criteria at both Bore 1 and 3.
- > All other analytes reported concentrations below the limit of reporting (LOR) value or otherwise detectable concentrations were below the ANZG and DoH guidelines.
- > The toxicant DVGs from the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018) for fresh water for slightly moderately disturbed ecosystems (95% and 99% level of protection) has been adopted.

A summary of the results that exceeded the adopted investigation criteria is provided in Table 4-1. See Appendix B for a summary of laboratory results, and Appendix D for the full laboratory results.

Table 4-1 Groundwater exceedances

Analyte	DoH guideline Value (mg/L)	ANZG FW95 (mg/L)	ANZG FW99 (mg/L)	Bore 1 Result (mg/L)	Bore 3 Result (mg/L)
Sodium (filtered)	180	-	-	348	210
Chloride	250	-	-	750	387
Total Dissolved Solids	600	-	-	1,760	953
Copper	-	0.0014	0.001	0.0058	0.008
Zinc	-	0.008	0.0024	0.057	0.042

4.3 Pump Test

Interpretation of the constant-rate pump tests for Bore 1 and Bore 3 indicated transmissivities ranging between approximately 890 m²/day and 1,400 m²/day. Based on aquifer thickness of 30 m and 50 m, the corresponding values of hydraulic conductivities ranged between approximately 28 m/day and 36 m/day.

Based on the short-term constant-rate pumping test it is anticipated that Bore 1 could be pumped at approximately 3.5 L/sec and Bore 3 at 4 L/sec. With this pumping rate approximately 300,000 L/day and 345,000 L/day could be extracted from Bore 1 and Bore 3 respectively for a total yield of 645,000 L/day.

5 Recommendations

Based on interpretation of the step-drawdown test for Bore 1 and Bore 3, Cardno recommends new bores be drilled and screened with wire-wrap screens to increase the open area of the screened interval, which would improve well efficiency. Once installed, these new wells should be pump-tested using Bore 1 and Bore 3 as observation wells to evaluate well efficiency, specific capacity, and aquifer properties (transmissivity, hydraulic conductivity, and storage coefficient).

6 References

AQ2 Pty Ltd (2021) Arrowsmith Hydrogen Project – Desktop Water Supply/Disposal and GDE Assessment, prepared for Infinite Blue Energy. AQ2 report number 383c-005a

APPENDIX

A

TEST PUMP FIELD NOTES

TEST PUMPING BORE - STEP TESTS

Location:	Arrowsmith Hydrogen (Dongara) - Bore #1		
Date:	28/07/2021	Work Docket No:	84495
Operator:	Bruce Porges & Jason Williams		
SWL (m)	13.94	Total Depth (m)	26.39
Packer (m)	N/A	I.D. (mm)	129

	Step 1	Step 2	Step 3	Step 4	Recovery
Flow rate	1 L/s	2 L/s	3 L/s	4.2 L/s	0 L/s
Time (minutes)	Water Level (m)	Water Level (m)	Water Level (m)	Water Level (m)	Water Level (m)
1	14.88	15.70	16.51	17.51	14.45
2	14.87	15.78	16.47	17.54	14.31
3	14.86	15.80	16.54	17.57	14.24
4	14.86	15.78	16.55	17.59	14.19
5	14.86	15.75	16.56	17.60	14.16
6	14.87	15.75	16.56	17.59	14.13
7	14.88	15.75	16.56	17.59	14.12
8	14.87	15.75	16.56	17.58	14.10
9	14.88	15.75	16.57	17.58	14.09
10	14.88	15.76	16.57	17.58	14.08
11	14.88	15.76	16.58	17.58	Logger still Running
12	14.88	15.76	16.58	17.59	
13	14.88	15.76	16.58	17.60	
14	14.88	15.76	16.58	17.61	
15	14.87	15.76	16.58	17.61	
20	14.89	15.77	16.58	17.63	
25	14.90	15.77	16.59	17.64	
30	14.89	15.77	16.60	17.64	

Comments: 125mm PN9 PVC casing slotted from 17.35m to 26.39m. Possibly 3m sand below that in base of hole. End of dip tube 23.27m during test. Reference point 1m above ground level

TEST PUMPING BORE - Constant Rate Test

Location:	Arrowsmith Hydrogen - Bore #1							Meter at start: 4586.79kL
Operators:	Bruce Porges & Jason Williams			Date:	29/07/2021	Work Docket No:	84495	Meter at finish: 4702.76kL
SWL:	13.97	Total Depth (m)	26.39	Packer (m)	Slotted	I.D. (mm)	129	Average flow rate: 14.50kL/hr = 4.03L/s

Actual Time (minutes)	Elapsed Time (minutes)	Flow rate (L/s)	Water Level (mbtoc)	Actual Time (minutes)	Elapsed Time (minutes)	Flow rate (L/s)	Water Level (mbtoc)	Comments
7.52am	1		17.00		270		17.50	
	2	4	17.15	12.52	300	4.0	17.51	
	3		17.20		330		17.51	
	4	3.9 adjust	17.19	1.52	360	4.0	17.51	
	5	4	17.30		390		17.50	
	6		17.36	2.52	420	4.0	17.51	
	7		17.37		450		17.51	
	8	4	17.38	3.52	480	* 4.0	17.52	** Sand Test = Approx 1 level teaspoon full of varying size of yellow sand, fine to medium size
	9		17.38			RECOVERY		
	10		17.39		1	0.0	14.32	
	15	4	17.43		2	Shut Valve→	14.39	
	20		17.45		3		14.36	
	25	4	17.45		4		14.29	
	30		17.45		5	0.0	14.25	
	35		17.45		6		14.22	
	40		17.45		7		14.20	
	45	4	17.46		8	0.0	14.19	
	50		17.45		9		14.18	
8.52	60	4	17.45		10	0.0	14.17	
	70		17.45					
	80		17.45			Logger still running		
	90	4	17.45					
	100		17.45					
9.52	120		17.45					
	140	4	17.46					
	160		17.47					
10.52	180		17.49					
	210		17.49					
11.52	240		17.49					

** 5 minute sand test

* Take water samples

TEST PUMPING BORE - STEP TESTS

Location:	Arrowsmith Hydrogen (Dongara) - Bore #3		
Date:	26/07/2021	Work Docket No:	84495
Operator:	Bruce Porges & Jason Williams		
SWL (m)	14.15	Total Depth (m)	23.9
Packer (m)	Slotted PVC	I.D. (mm)	129

	Step 1	Step 2	Step 3	Step 4	Recovery
Flow rate	1 L/s	2 L/s	3 L/s	4.2 L/s	0 L/s
Time (minutes)	Water Level (m)	Water Level (m)	Water Level (m)	Water Level (m)	Water Level (m)
1	15.05	16.60	18.17	19.94	
2	15.16	16.51 *	18.20 *	21.18	
3	15.22	16.52 *	18.29	20.26	SEE
4	15.23	16.72	18.33	20.29	LOGGER
5	15.23	16.73	18.34	20.30	
6	15.23	16.73	18.33	20.32	
7	15.24	16.73	18.33	20.33	
8	15.25	16.73	18.33	20.34	
9	15.25	16.73	18.32	20.34	
10	15.25	16.73	18.33	20.35	
11	15.26	16.73	18.33	20.34	
12	15.26	16.73	18.33	20.35	
13	15.26	16.73	18.32		
14	15.26	16.73	18.32		
15	15.26	16.76 *	18.32		
20	15.26 +	16.74 +	18.32		
25	15.26	16.75	18.32		
30	15.26	16.75	18.32		

125mm PN9 PVC casing slotted from 11.54m to 23.51m. Open hole from 23.51m to 23.90m. End of dip tube 21.3m during test. Reference point 0.6m above ground level

Comments:

+ = Sand test at 1L/s nil sand detected

+ = Sand test at 2L/s minimal fine sand approx 1 teaspoon/2 mins

* Denotes adjustment of flow rate.

TEST PUMPING BORE - Constant Rate Test

Location:	Arrowsmith Hydrogen - Bore #3							Meter at start: 4467.39kL
Operators:	Bruce Porges & Jason Williams			Date:	27/07/2021	Work Docket No:	84495	Meter at finish: 4567.86kL
SWL:	14.08	Total Depth (m)	23.9	Packer (m)	Slotted	I.D. (mm)	128	Average flow rate: 12.56kL/hr = 3.49L/s

8.02am start Meter Start 4467.39m³ Meter finish 4567.86m³

Actual Time (minutes)	Elapsed Time (minutes)	Flow rate (L/s)	Water Level (mbtoc)	Actual Time (minutes)	Elapsed Time (minutes)	Flow rate (L/s)	Water Level (m) (mbtoc)	Comments
8.03am	1	3.5	18.42		270	3.5	19.34	
	2		18.72	1.03pm	300		19.34	
	3	3.5	18.91		330	3.5	19.34	
	4		19.00	2.03	360		19.35	
	5		19.03		390	3.5	19.35	
	6		19.05	3.03	420		19.37	
	7	3.5	19.08		450	3.5	19.37	
	8		19.10	4.03	480		19.37	** Sand Test minimal fine yellow sand, approx half teaspoon
	9		19.11			RECOVERY		
	10		19.13		1	0.0	14.48	
	15		19.18		2		14.38	
	20		19.22		3		14.34	
	25	3.5	19.23		4		14.32	
	30		19.22		5		14.28	
	35		19.23		16		14.21	
	40		19.23		18		14.19	
	45		19.23			Logger still running		
	50	3.5	19.24					
9.03	60	3.5	19.24					
	70		19.24					
	80		19.25					
	90	3.5	19.26					
	100		19.24					
10.03	120		19.26					
	140	3.5	19.26					
	160	3.46 *	19.26					
11.03	180	3.5	19.29					
	210	3.46 *	19.31					
12.03pm	240	3.5	19.32					

* adjust flow

** 5 minute sand test

* Take 2 x air free water samples

APPENDIX

B

GROUNDWATER LABORATORY RESULTS SUMMARY

		Alkalinity by PC Titrator	Free and Total CO2	Resistivity	Specific Gravity	Un-ionised Hydrogen Sulfide	Biological		Inorganics																	Lead	Metals									
	Sulfate as SO4 - Turbidimetric (Filtered)	Carbonate Alkalinity as CaCO3	Total Carbon Dioxide as CO2	Resistivity at 25°C	Specific Gravity	Unionized Hydrogen Sulfide	Plate Count (36°C)	PLATE COUNT 22C	Alkalinity (Bicarbonate as CaCO3)	Free Carbon Dioxide as CO2	Alkalinity (Hydroxide) as CaCO3	Alkalinity (total) as CaCO3	Anions Total	Cations Total	Chloride	Electrical conductivity *(lab)	Ionic Balance	Nitrate (as NO3-)	pH (Lab)	Phosphate	Salinity	Sodium (Filtered)	TDS	TSS	Lead	Barium	Calcium (Filtered)	Copper	Iron	Magnesium (Filtered)	Nickel	Potassium (Filtered)	Strontium	Zinc		
LOR	1	1	1	1	0.01	0.01	1	1	1	1	1000	1	0.01	0.01	1	1	0.01	0.01	0.01	100	0.01	1	10	5	0.0001	0.0005	1	0.0005	0.002	1	0.0005	1	0.001	0.001		
DoH 2014 - Non-Potable Use															250				6.5-8.5			180	600		0.1	20		20	0.3		0.2			3		
ANZG (2018) Freshwater 95% toxicant DGVs																									0.0034			0.0014			0.011			0.008		
ANZG (2018) Freshwater 99% toxicant DGVs																									0.001			0.001			0.008			0.0024		

Field_ID Sampled_Date-Time Lab_Report_Number

Bore 1	29/07/2021	EP2108715	71	<1	248	344	1	<0.01	20	15	269	11	<1000	269	28	25.5	750	2910	4.66	2.61	7.69	<100	1.7	348	1760	<5	0.0004	0.0516	153	0.0058	0.015	29	0.0008	14	0.515	0.057
Bore 3	27/07/2021	EP2108715	51	<1	239	592	1	<0.01	24	21	263	8	<1000	263	17.2	14.8	387	1690	7.5	23.6	7.83	<100	0.96	210	953	<5	0.0004	0.0575	76	0.008	0.007	20	0.0007	10	0.786	0.042

Statistical Summary

Number of Results	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Number of Detects	2	0	2	2	2	0	2	2	2	2	0	2	2	2	2	2	2	2	2	0	2	2	2	0	2	2	2	2	2	2	2	2	2	2
Minimum Concentration	51	<1	239	344	1	<0.01	20	15	263	8	<1000	263	17.2	14.8	387	1690	4.66	2.61	7.69	<100	0.96	210	953	<5	0.0004	0.0516	76	0.0058	0.007	20	0.0007	10	0.515	0.042
Minimum Detect	51	ND	239	344	1	ND	20	15	263	8	ND	263	17.2	14.8	387	1690	4.66	2.61	7.69	ND	0.96	210	953	ND	0.0004	0.0516	76	0.0058	0.007	20	0.0007	10	0.515	0.042
Maximum Concentration	71	<1	248	592	1	<0.01	24	21	269	11	<1000	269	28	25.5	750	2910	7.5	23.6	7.83	<100	1.7	348	1760	<5	0.0004	0.0575	153	0.008	0.015	29	0.0008	14	0.786	0.057
Maximum Detect	71	ND	248	592	1	ND	24	21	269	11	ND	269	28	25.5	750	2910	7.5	23.6	7.83	ND	1.7	348	1760	ND	0.0004	0.0575	153	0.008	0.015	29	0.0008	14	0.786	0.057
Average Concentration																																		
Median Concentration	61	0.5	243.5	468	1	0.005	22	18	266	9.5	500	266	22.6	20.15	568.5	2300	6.08	13.105	7.76	50	1.33	279	1356.5	2.5	0.0004	0.05455	114.5	0.0069	0.011	24.5	0.00075	12	0.6505	0.0495
Standard Deviation																																		
Number of Guideline Exceedances	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
Number of Guideline Exceedances(Detects Only)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2

APPENDIX

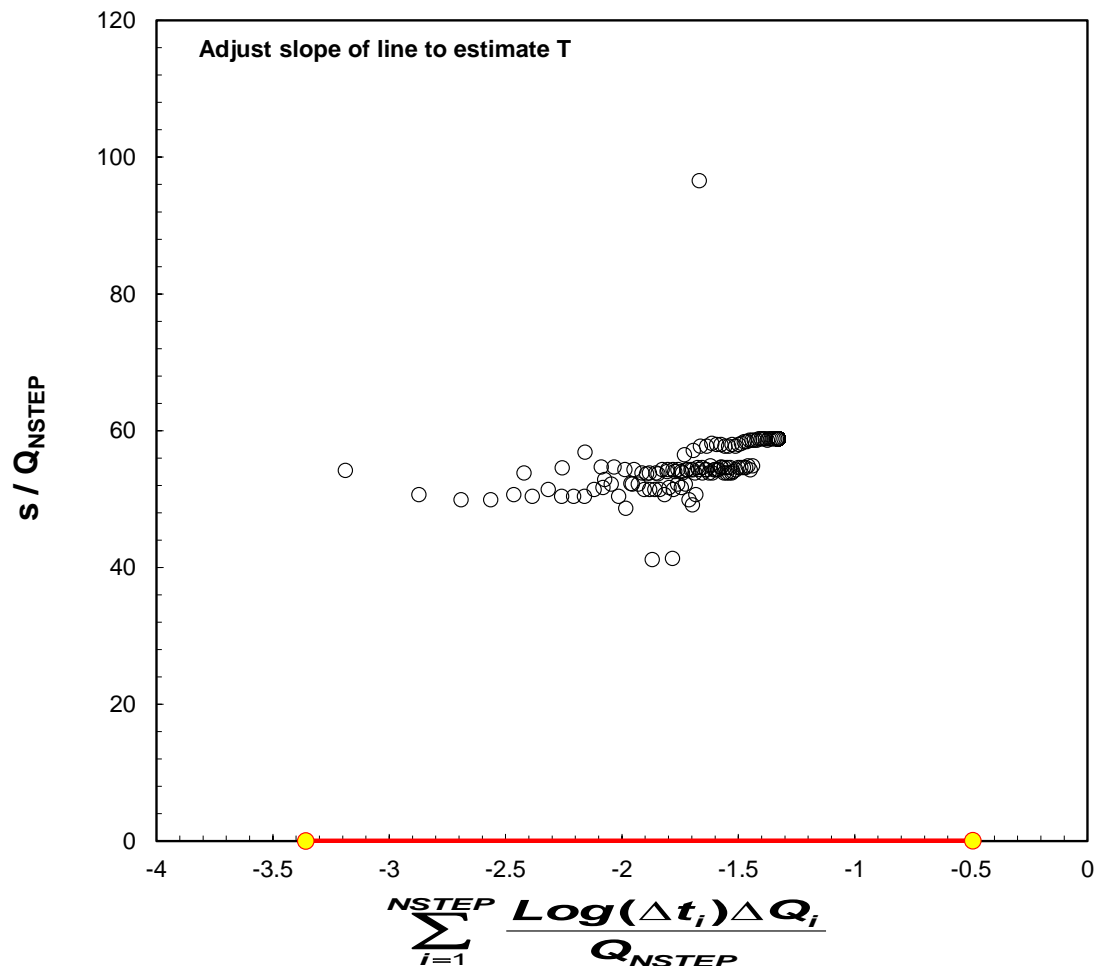
C

PUMP TEST ANALYSIS

WELL ID: Dongara

INPUT		Local ID: Bore 1	
Construction:		Date: 28/07/2021	
Casing dia. (d _c)	0.1 Meter	Time: 11:17	
Annulus dia. (d _w)	26 Meter		
Screen Length (L)	3 Meter		
Depths to:		COMPUTED	
water level (DTW)	13.94 Meter	Aquifer thickness = 40 Meter	
Top of Aquifer	13.94 Meter	0.001 is greater than extreme maximum of 0.00007 for Fine Sand	
Base of Aquifer	50 Meter		
Annular Fill:		<div><div>K = Error Meter/Second</div><div>T = Error Meter²/Second</div><div>S = Error d'less</div><div>K_{annular} = Error Meter/Second</div><div>Skin = Error d'less</div></div>	
across screen -- Gravel			
above screen -- Cement			
Aquifer Material -- Fine Sand			
ASSUMED S = 0.0004 d'less			

K= 0.001 is greater than likely maximum of 0.00007 for Fine Sand



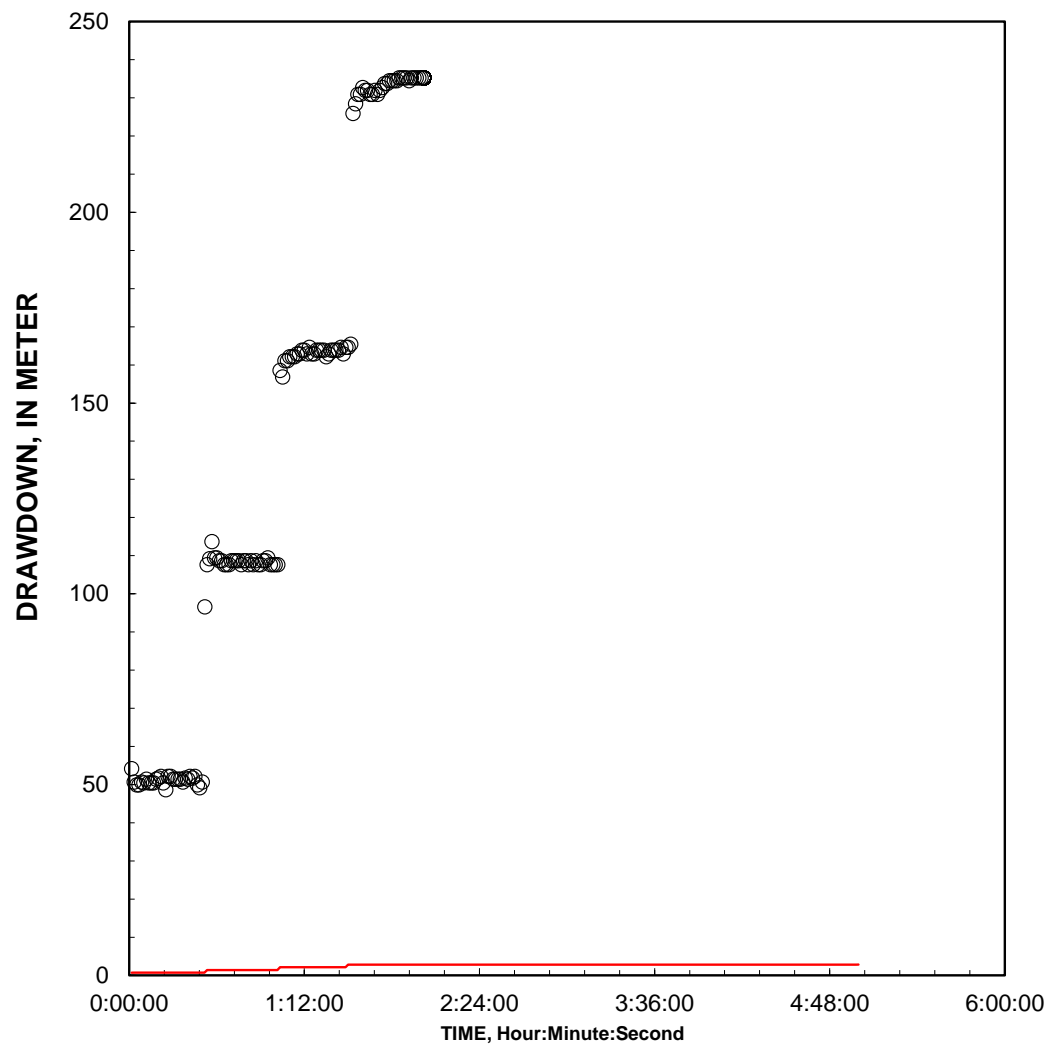
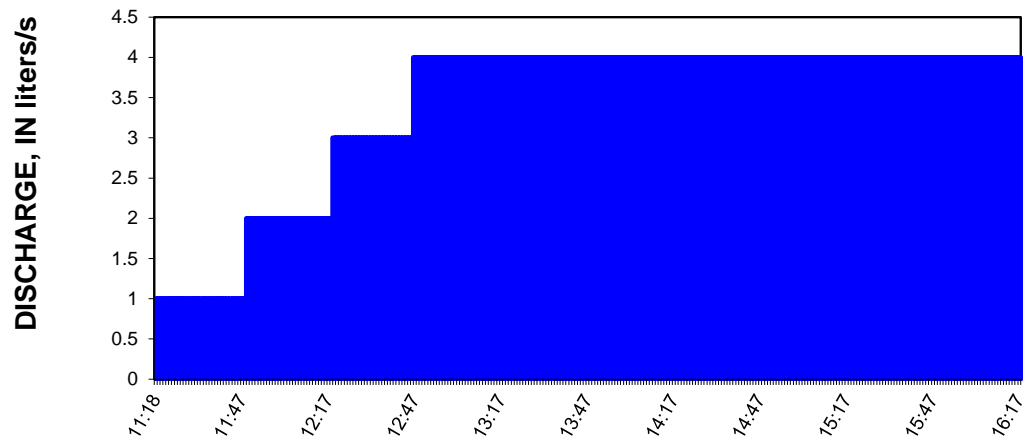
REMARKS:

Step-drawdown analysis of single-well aquifer test

Test from South Vekol Valley, AZ WSP 2453

KANNULAR is estimated by fitting simulated drawdowns to measured drawdowns in a secondary plot. A reasonable storage value must be assigned by the user because storage and KANNULAR cannot be estimated independently. The estimate of T is not affected by changes in estimates of storage and KANNULAR.

WELL ID: Dongara

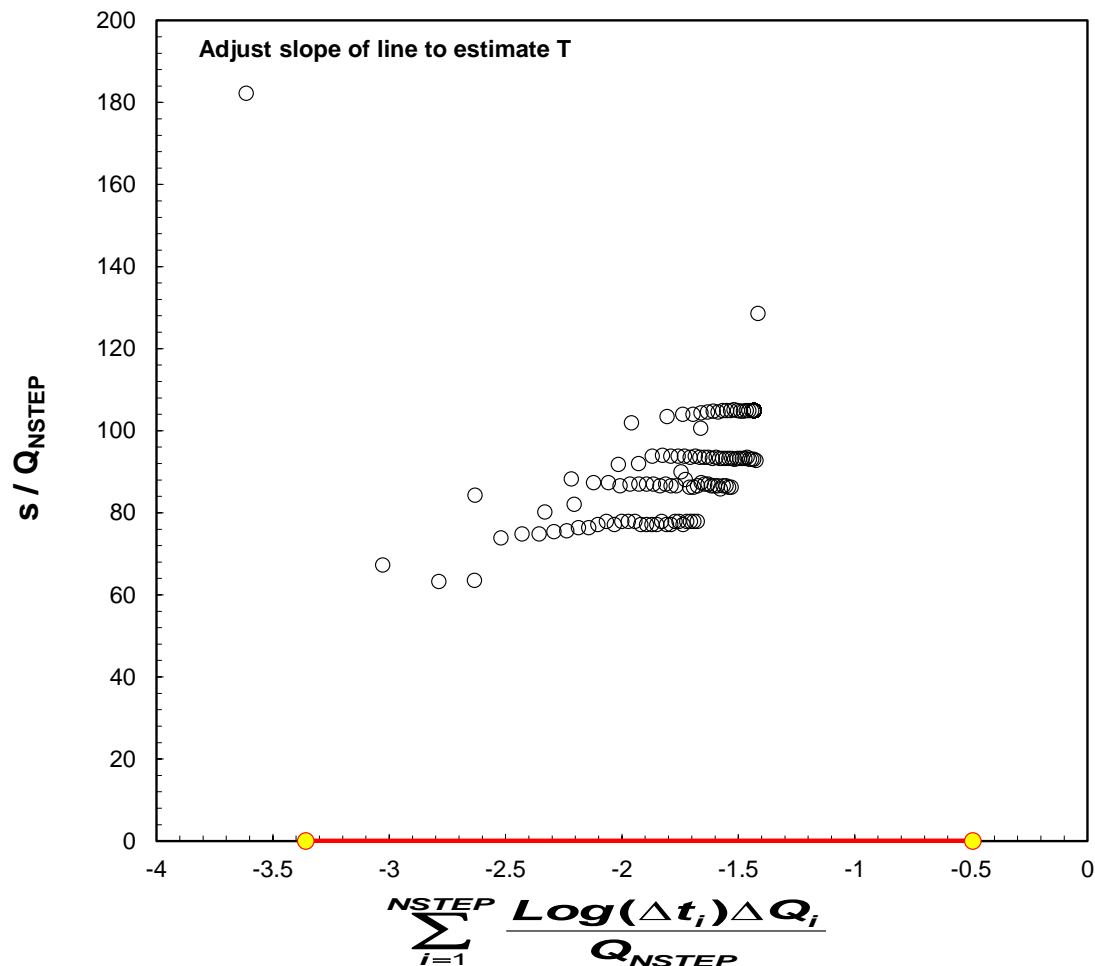


Reduced Data					
Entry	Time, Hr:Min:Sec	Water Level Meter	Entry	Time, Hr:Min:Sec	Water Level Meter
1	11:17:56	1955.17	51	12:07:56	1800.73
2	11:18:56	1878.13	52	12:08:56	1802.16
3	11:19:56	1883.14	53	12:09:56	1800.73
4	11:20:56	1884.22	54	12:10:56	1802.16
5	11:21:56	1884.22	55	12:11:56	1802.16
6	11:22:56	1883.14	56	12:12:56	1800.73
7	11:23:56	1883.50	57	12:13:56	1800.73
8	11:24:56	1882.07	58	12:14:56	1799.65
9	11:25:56	1883.50	59	12:15:56	1802.16
10	11:26:56	1883.50	60	12:16:56	1802.16
11	11:27:56	1883.50	61	12:17:56	1802.16
12	11:28:56	1882.07	62	12:18:56	1802.16
13	11:29:56	1881.71	63	12:19:56	1729.78
14	11:30:56	1880.99	64	12:20:56	1732.28
15	11:31:56	1883.50	65	12:21:56	1726.19
16	11:32:56	1886.01	66	12:22:56	1726.19
17	11:33:56	1880.99	67	12:23:56	1724.76
18	11:34:56	1880.99	68	12:24:56	1724.76
19	11:35:56	1882.07	69	12:25:56	1724.76
20	11:36:56	1882.07	70	12:26:56	1723.68
21	11:37:56	1882.07	71	12:27:56	1723.68
22	11:38:56	1882.07	72	12:28:56	1722.25
23	11:39:56	1883.14	73	12:29:56	1722.25
24	11:40:56	1881.71	74	12:30:56	1723.68
25	11:41:56	1882.07	75	12:31:56	1721.18
26	11:42:56	1880.99	76	12:32:56	1723.68
27	11:43:56	1881.71	77	12:33:56	1723.68
28	11:44:56	1880.99	78	12:34:56	1722.25
29	11:45:56	1884.22	79	12:35:56	1722.25
30	11:46:56	1885.29	80	12:36:56	1722.25
31	11:47:56	1883.14	81	12:37:56	1722.25
32	11:48:56	1817.93	82	12:38:56	1724.76
33	11:49:56	1802.16	83	12:39:56	1723.68
34	11:50:56	1800.01	84	12:40:56	1722.25
35	11:51:56	1793.56	85	12:41:56	1722.25
36	11:52:56	1799.65	86	12:42:56	1722.25
37	11:53:56	1799.65	87	12:43:56	1722.25
38	11:54:56	1800.73	88	12:44:56	1721.18
39	11:55:56	1800.73	89	12:45:56	1723.68
40	11:56:56	1802.16	90	12:46:56	1721.18
41	11:57:56	1802.16	91	12:47:56	1721.18
42	11:58:56	1802.16	92	12:48:56	1720.10
43	11:59:56	1800.73	93	12:49:56	1634.10
44	12:00:56	1800.73	94	12:50:56	1630.52
45	12:01:56	1800.73	95	12:51:56	1626.93
46	12:02:56	1800.73	96	12:52:56	1626.93
47	12:03:56	1802.16	97	12:53:56	1624.43
48	12:04:56	1800.73	98	12:54:56	1625.50
49	12:05:56	1800.73	99	12:55:56	1625.50
50	12:06:56	1802.16	100	12:56:56	1626.93

WELL ID: Dongara

INPUT		Local ID: Bore 3	
Construction:		Date: 26/07/2021	
Casing dia. (d _c)	0.1 Meter	Time: 15:04	
Annulus dia. (d _w)	26 Meter		
Screen Length (L)	3 Meter		
Depths to:		COMPUTED	
water level (DTW)	14.15 Meter	Aquifer thickness = 40 Meter	
Top of Aquifer	14.15 Meter	0.001 is greater than extreme maximum of 0.00007 for Fine Sa	
Base of Aquifer	23.9 Meter		
Annular Fill:		<div><div>K = Error Meter/Second</div><div>T = Error Meter²/Second</div><div>S = Error d'less</div><div>K_{annular} = Error Meter/Second</div><div>Skin = Error d'less</div></div>	
across screen -- Gravel			
above screen -- Cement			
Aquifer Material -- Fine Sand			
ASSUMED S = 0.0004 d'less			

K= 0.001 is greater than likely maximum of 0.00007 for Fine Sand



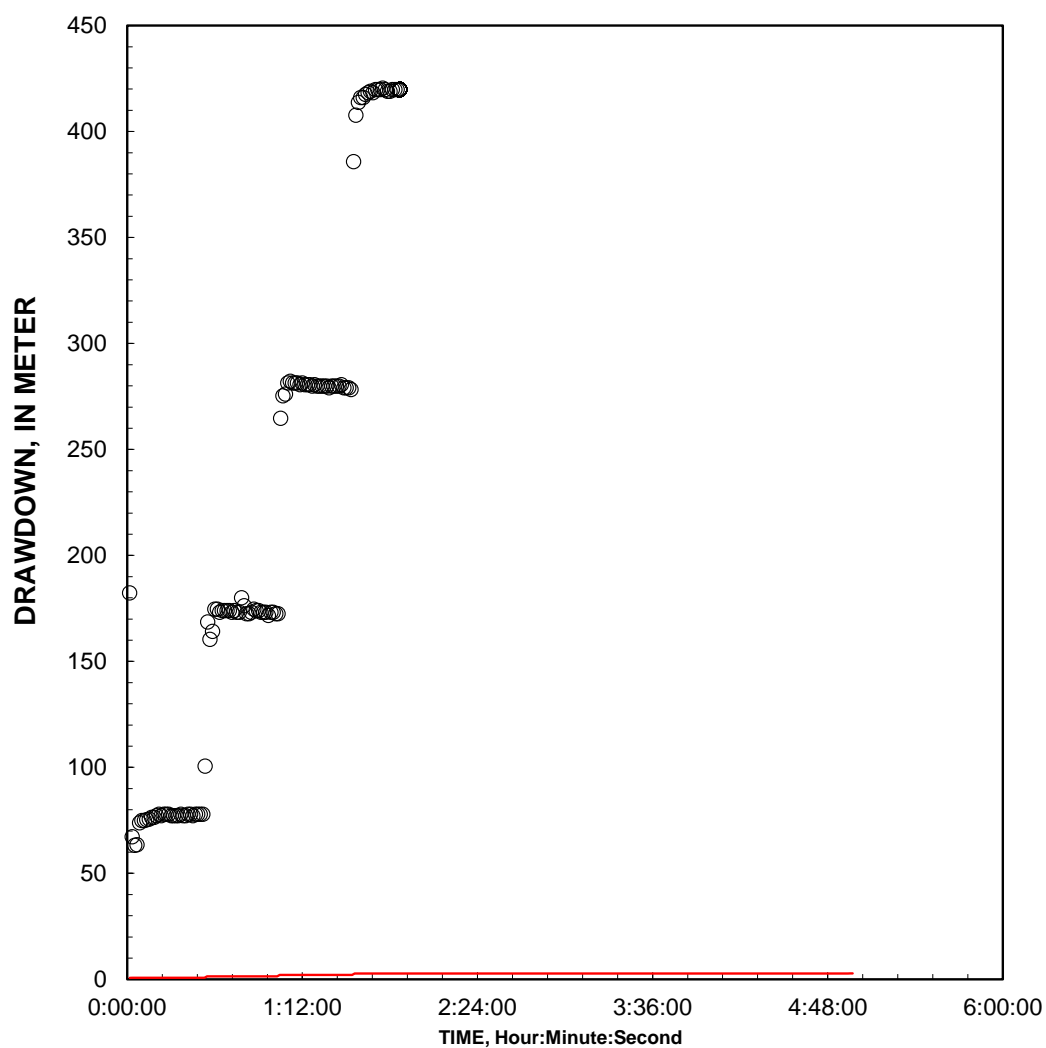
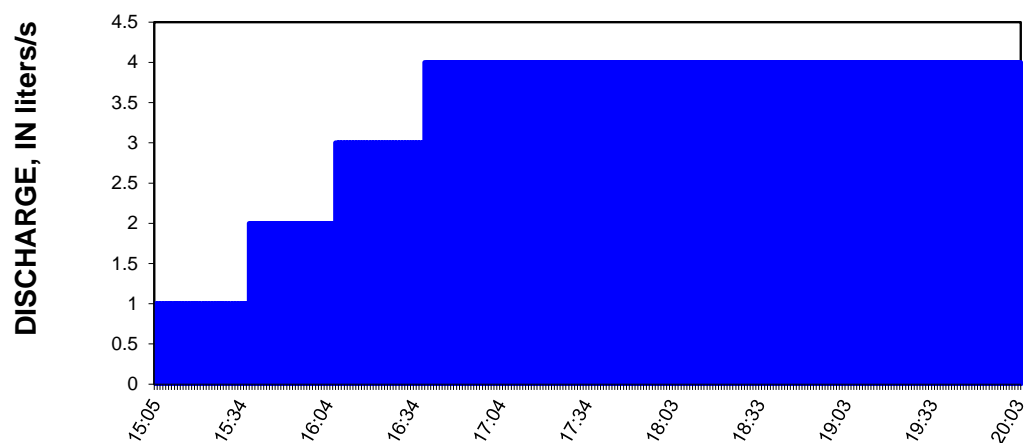
REMARKS:

Step-drawdown analysis of single-well aquifer test

Test from South Vekol Valley, AZ WSP 2453

KANNULAR is estimated by fitting simulated drawdowns to measured drawdowns in a secondary plot. A reasonable storage value must be assigned by the user because storage and KANNULAR cannot be estimated independently. The estimate of T is not affected by changes in estimates of storage and KANNULAR.

WELL ID: Dongara



Reduced Data					
Entry	Time, Hr:Min:Sec	Water Level Meter	Entry	Time, Hr:Min:Sec	Water Level Meter
1	15:04:21	1774.21	51	15:54:21	1529.11
2	15:05:21	1515.13	52	15:55:21	1528.03
3	15:06:21	1678.53	53	15:56:21	1525.88
4	15:07:21	1684.27	54	15:57:21	1526.96
5	15:08:21	1683.91	55	15:58:21	1526.96
6	15:09:21	1669.22	56	15:59:21	1528.03
7	15:10:21	1667.78	57	16:00:21	1528.03
8	15:11:21	1667.78	58	16:01:21	1528.03
9	15:12:21	1667.07	59	16:02:21	1530.18
10	15:13:21	1666.71	60	16:03:21	1528.03
11	15:14:21	1665.63	61	16:04:21	1528.03
12	15:15:21	1665.63	62	16:05:21	1529.11
13	15:16:21	1664.56	63	16:06:21	1529.11
14	15:17:21	1663.48	64	16:07:21	1397.96
15	15:18:21	1664.56	65	16:08:21	1382.91
16	15:19:21	1663.48	66	16:09:21	1381.83
17	15:20:21	1663.48	67	16:10:21	1374.31
18	15:21:21	1663.48	68	16:11:21	1373.23
19	15:22:21	1664.56	69	16:12:21	1374.31
20	15:23:21	1664.56	70	16:13:21	1374.31
21	15:24:21	1664.56	71	16:14:21	1374.31
22	15:25:21	1664.56	72	16:15:21	1375.38
23	15:26:21	1663.48	73	16:16:21	1374.31
24	15:27:21	1664.56	74	16:17:21	1375.38
25	15:28:21	1664.56	75	16:18:21	1375.38
26	15:29:21	1663.48	76	16:19:21	1375.38
27	15:30:21	1663.48	77	16:20:21	1376.46
28	15:31:21	1664.56	78	16:21:21	1375.38
29	15:32:21	1663.48	79	16:22:21	1376.46
30	15:33:21	1663.48	80	16:23:21	1376.46
31	15:34:21	1663.48	81	16:24:21	1376.46
32	15:35:21	1663.48	82	16:25:21	1376.46
33	15:36:21	1631.23	83	16:26:21	1376.46
34	15:37:21	1534.48	84	16:27:21	1377.53
35	15:38:21	1546.31	85	16:28:21	1376.46
36	15:39:21	1540.93	86	16:29:21	1376.46
37	15:40:21	1525.88	87	16:30:21	1376.46
38	15:41:21	1525.88	88	16:31:21	1376.46
39	15:42:21	1528.03	89	16:32:21	1375.38
40	15:43:21	1526.96	90	16:33:21	1377.53
41	15:44:21	1526.96	91	16:34:21	1377.53
42	15:45:21	1526.96	92	16:35:21	1377.53
43	15:46:21	1526.96	93	16:36:21	1378.61
44	15:47:21	1528.03	94	16:37:21	1225.96
45	15:48:21	1526.96	95	16:38:21	1194.78
46	15:49:21	1528.03	96	16:39:21	1186.18
47	15:50:21	1528.03	97	16:40:21	1182.96
48	15:51:21	1518.36	98	16:41:21	1182.96
49	15:52:21	1523.73	99	16:42:21	1180.81
50	15:53:21	1529.11	100	16:43:21	1179.73

APPENDIX

D

LABORATORY RESULTS

CERTIFICATE OF ANALYSIS

Work Order : **EP2108715**
Client : **CARDNO (WA) PTY LTD**
Contact : **RICCARDO DIVITA**
Address : **11 HARVEST TERRACE PO BOX 155**
WEST PERTH WA, AUSTRALIA 6006
Telephone : **+61 08 9273 3888**
Project : **CW1183400 IBE Arrowsmith**
Order number : **----**
C-O-C number : **----**
Sampler : **Western Irrigation**
Site : **----**
Quote number : **EP/693/21_V2**
No. of samples received : **2**
No. of samples analysed : **2**

Page : 1 of 4
Laboratory : Environmental Division Perth
Contact : Nick Courts
Address : 26 Rigali Way Wangara WA Australia 6065
Telephone : +61-8-9406 1301
Date Samples Received : 02-Aug-2021 12:40
Date Analysis Commenced : 02-Aug-2021
Issue Date : 09-Aug-2021 17:19



Accreditation No. 825
 Accredited for compliance with
 ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Efua Wilson	Metals Chemist	Perth Inorganics, Wangara, WA
Vinitha Kesavan	Analyst	Perth Microbiology, Wangara, WA



General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- UHS conducted by ALS Sydney, NATA accreditation no. 825, site no 10911.
- CFU = colony forming unit
- Microbiological Comment: HPC results are reported an approximate (~) when the count of colonies on the plate is outside the range of 10 - 300cfu, in accordance with ALS work instruction QWI-MIC/MW002.
- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- MW002 is ALS's internal code and is equivalent to AS4276.3.1.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	Bore 1	Bore 3	----	----	----
Sampling date / time					29-Jul-2021 00:00	27-Jul-2021 00:00	----	----	----
Compound	CAS Number	LOR	Unit		EP2108715-001	EP2108715-002	-----	-----	-----
				Result	Result		----	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		7.69	7.83	----	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		2910	1690	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	10	mg/L		1760	953	----	----	----
EA020EC: Salinity									
Salinity	----	0.01	g/kg		1.70	0.96	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		<5	<5	----	----	----
EA050: Specific Gravity									
ø Specific Gravity	----	0.01	-		1.00	1.00	----	----	----
EA080: Resistivity									
Resistivity at 25°C	----	1	ohm cm		344	592	----	----	----
EA165: CO2 - Free and Total									
Free Carbon Dioxide as CO2	85540-96-1	1	mg/L		11	8	----	----	----
Total Carbon Dioxide as CO2	85540-96-1	1	mg/L		248	239	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		269	263	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		269	263	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		71	51	----	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		750	387	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		153	76	----	----	----
Magnesium	7439-95-4	1	mg/L		29	20	----	----	----
Sodium	7440-23-5	1	mg/L		348	210	----	----	----
Potassium	7440-09-7	1	mg/L		14	10	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS									
Barium	7440-39-3	0.5	µg/L		51.6	57.5	----	----	----
Copper	7440-50-8	0.5	µg/L		5.8	8.0	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	Bore 1	Bore 3	----	----	----
Sampling date / time					29-Jul-2021 00:00	27-Jul-2021 00:00	----	----	----
Compound	CAS Number	LOR	Unit		EP2108715-001	EP2108715-002	-----	-----	-----
					Result	Result	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS - Continued									
Iron	7439-89-6	2	µg/L		15	7	----	----	----
Lead	7439-92-1	0.1	µg/L		0.4	0.4	----	----	----
Nickel	7440-02-0	0.5	µg/L		0.8	0.7	----	----	----
Strontium	7440-24-6	1	µg/L		515	786	----	----	----
Zinc	7440-66-6	1	µg/L		57	42	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as NO3	14797-55-8	0.01	mg/L		2.61	23.6	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphate	----	0.10	mg/L		<0.10	<0.10	----	----	----
EK084A: Un-ionised Hydrogen Sulfide - Low level									
Unionized Hydrogen Sulfide	----	0.010	mg/L		<0.010	<0.010	----	----	----
EN055: Ionic Balance									
∅ Total Anions	----	0.01	meq/L		28.0	17.2	----	----	----
∅ Total Cations	----	0.01	meq/L		25.5	14.8	----	----	----
∅ Ionic Balance	----	0.01	%		4.66	7.50	----	----	----
MW002: Heterotrophic Plate Count									
Heterotrophic Plate Count (22°C)	----	1	CFU/mL		15	21	----	----	----
Heterotrophic Plate Count (36°C)	----	1	CFU/mL		20	24	----	----	----

Inter-Laboratory Testing

Analysis conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911 (Chemistry) 14913 (Biology).

(WATER) EK084A: Un-ionised Hydrogen Sulfide - Low level

QUALITY CONTROL REPORT

Work Order	: EP2108715	Page	: 1 of 5
Client	: CARDNO (WA) PTY LTD	Laboratory	: Environmental Division Perth
Contact	: RICCARDO DIVITA	Contact	: Nick Courts
Address	: 11 HARVEST TERRACE PO BOX 155 WEST PERTH WA, AUSTRALIA 6006	Address	: 26 Rigali Way Wangara WA Australia 6065
Telephone	: +61 08 9273 3888	Telephone	: +61-8-9406 1301
Project	: CW1183400 IBE Arrowsmith	Date Samples Received	: 02-Aug-2021
Order number	: ----	Date Analysis Commenced	: 02-Aug-2021
C-O-C number	: ----	Issue Date	: 09-Aug-2021
Sampler	: Western Irrigation		
Site	: ----		
Quote number	: EP/693/21_V2		
No. of samples received	: 2		
No. of samples analysed	: 2		



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Efua Wilson	Metals Chemist	Perth Inorganics, Wangara, WA
Vinitha Kesavan	Analyst	Perth Microbiology, Wangara, WA



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The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

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Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
 CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
 LOR = Limit of reporting
 RPD = Relative Percentage Difference
 # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EA005P: pH by PC Titrator (QC Lot: 3825523)									
EP2108713-029	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	6.91	6.91	0.0	0% - 20%
EP2108736-003	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	7.99	7.99	0.0	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 3825521)									
EP2108713-020	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	63900	63700	0.3	0% - 20%
EP2108713-029	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	156000	155000	0.8	0% - 20%
EA015: Total Dissolved Solids dried at 180 ± 5 °C (QC Lot: 3824800)									
EP2108604-003	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	12400	12000	2.9	0% - 20%
EP2108713-008	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	84900	87000	2.5	0% - 20%
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 3824801)									
EP2108715-001	Bore 1	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.0	No Limit
EA050: Specific Gravity (QC Lot: 3835468)									
EP2108715-001	Bore 1	EA050: Specific Gravity	----	0.01	-	1.00	1.00	0.0	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 3825522)									
EP2108713-020	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	0.0	No Limit
EP2108713-029	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	65	74	12.5	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	65	74	12.5	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 3824362)									
EP2108689-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	66	66	1.6	0% - 20%
EP2108715-002	Bore 3	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	51	52	0.0	0% - 20%

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 Work Order : EP2108715
 Client : CARDNO (WA) PTY LTD
 Project : CW1183400 IBE Arrowsmith



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
ED045G: Chloride by Discrete Analyser (QC Lot: 3824361)									
EP2108689-002	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	176	175	0.7	0% - 20%
EP2108715-002	Bore 3	ED045G: Chloride	16887-00-6	1	mg/L	387	390	0.8	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 3825261)									
EP2108701-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	23	22	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	4	4	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	61	62	2.6	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	20	20	0.0	0% - 20%
EP2108726-005	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	43	42	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	39	38	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	128	126	1.5	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	22	22	0.0	0% - 20%
EG094T: Total metals in Fresh water by ORC-ICPMS (QC Lot: 3825462)									
EP2108643-001	Anonymous	EG094B-T: Iron	7439-89-6	2	µg/L	0.108 mg/L	108	0.0	0% - 20%
EP2108667-002	Anonymous	EG094B-T: Iron	7439-89-6	2	µg/L	619	634	2.5	0% - 20%
EG094T: Total metals in Fresh water by ORC-ICPMS (QC Lot: 3825463)									
EP2108643-001	Anonymous	EG094A-T: Lead	7439-92-1	0.1	µg/L	<0.0001 mg/L	<0.1	0.0	No Limit
		EG094A-T: Barium	7440-39-3	0.5	µg/L	185	184	0.4	0% - 20%
		EG094A-T: Copper	7440-50-8	0.5	µg/L	<0.0005 mg/L	<0.5	0.0	No Limit
		EG094A-T: Nickel	7440-02-0	0.5	µg/L	<0.0005 mg/L	<0.5	0.0	No Limit
		EG094A-T: Strontium	7440-24-6	1	µg/L	419	417	0.4	0% - 20%
		EG094A-T: Zinc	7440-66-6	1	µg/L	<0.001 mg/L	<1	0.0	No Limit
EP2108667-002	Anonymous	EG094A-T: Lead	7439-92-1	0.1	µg/L	<0.1	<0.1	0.0	No Limit
		EG094A-T: Barium	7440-39-3	0.5	µg/L	6.3	6.3	0.0	0% - 50%
		EG094A-T: Copper	7440-50-8	0.5	µg/L	2.4	2.3	0.0	No Limit
		EG094A-T: Nickel	7440-02-0	0.5	µg/L	1.4	1.4	0.0	No Limit
		EG094A-T: Strontium	7440-24-6	1	µg/L	206	209	1.4	0% - 20%
		EG094A-T: Zinc	7440-66-6	1	µg/L	7	7	0.0	No Limit
EK084A: Un-ionised Hydrogen Sulfide - Low level (QC Lot: 3830723)									
EP2108715-001	Bore 1	EK084A: Unionized Hydrogen Sulfide	----	0.005	mg/L	<0.010	<0.010	0.0	No Limit



Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Acceptable Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EA005P: pH by PC Titrator (QCLot: 3825523)								
EA005-P: pH Value	----	----	pH Unit	----	4 pH Unit	101	98.5	102
				----	7 pH Unit	100	98.5	102
EA010P: Conductivity by PC Titrator (QCLot: 3825521)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	24800 µS/cm	99.2	92.1	105
EA015: Total Dissolved Solids dried at 180 ± 5 °C (QCLot: 3824800)								
EA015H: Total Dissolved Solids @180°C	----	10	mg/L	<10	246 mg/L	97.6	88.1	114
				<10	1000 mg/L	101	88.1	114
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 3824801)								
EA025H: Suspended Solids (SS)	----	5	mg/L	<5	95 mg/L	97.4	89.1	120
				<5	1000 mg/L	102	89.1	120
ED037P: Alkalinity by PC Titrator (QCLot: 3825522)								
ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-00 1	1	mg/L	<1	----	----	----	----
ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	----	----	----	----
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	20 mg/L	106	81.2	126
				<1	200 mg/L	98.4	90.0	110
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 3824362)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	102	87.7	113
				<1	500 mg/L	101	87.7	113
ED045G: Chloride by Discrete Analyser (QCLot: 3824361)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	94.9	87.9	114
				<1	1000 mg/L	95.0	87.9	114
ED093F: Dissolved Major Cations (QCLot: 3825261)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	96.8	85.9	113
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	97.4	88.0	110
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	105	87.3	118
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	92.5	89.7	108
EG094T: Total metals in Fresh water by ORC-ICPMS (QCLot: 3825462)								
EG094B-T: Iron	7439-89-6	2	µg/L	<2	50 µg/L	89.2	80.3	114
EG094T: Total metals in Fresh water by ORC-ICPMS (QCLot: 3825463)								
EG094A-T: Barium	7440-39-3	0.5	µg/L	<0.5	10 µg/L	105	89.0	114
EG094A-T: Copper	7440-50-8	0.5	µg/L	<0.5	10 µg/L	102	80.6	128



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit			Result	LCS	Low
EG094T: Total metals in Fresh water by ORC-ICPMS (QCLot: 3825463) - continued								
EG094A-T: Lead	7439-92-1	0.1	µg/L	<0.1	10 µg/L	96.6	81.6	113
EG094A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	10 µg/L	103	86.1	122
EG094A-T: Strontium	7440-24-6	1	µg/L	<1	10 µg/L	108	88.8	126
EG094A-T: Zinc	7440-66-6	1	µg/L	<1	10 µg/L	100	86.5	121
EK084A: Un-ionised Hydrogen Sulfide - Low level (QCLot: 3830723)								
EK084A: Unionized Hydrogen Sulfide	----	0.005	mg/L	<0.005	0.05 mg/L	100	71.0	127

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike Concentration	SpikeRecovery(%) MS	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number			Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 3824362)							
EP2108689-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	100 mg/L	104	70.0	130
ED045G: Chloride by Discrete Analyser (QCLot: 3824361)							
EP2108689-001	Anonymous	ED045G: Chloride	16887-00-6	1000 mg/L	102	70.0	130
EG094T: Total metals in Fresh water by ORC-ICPMS (QCLot: 3825463)							
EP2108664-001	Anonymous	EG094A-T: Barium	7440-39-3	50 µg/L	109	70.0	130
		EG094A-T: Copper	7440-50-8	50 µg/L	101	70.0	130
		EG094A-T: Lead	7439-92-1	50 µg/L	94.0	70.0	130
		EG094A-T: Nickel	7440-02-0	50 µg/L	102	70.0	130
		EG094A-T: Zinc	7440-66-6	50 µg/L	103	70.0	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EP2108715	Page	: 1 of 8
Client	: CARDNO (WA) PTY LTD	Laboratory	: Environmental Division Perth
Contact	: RICCARDO DIVITA	Telephone	: +61-8-9406 1301
Project	: CW1183400 IBE Arrowsmith	Date Samples Received	: 02-Aug-2021
Site	: ----	Issue Date	: 09-Aug-2021
Sampler	: Western Irrigation	No. of samples received	: 2
Order number	: ----	No. of samples analysed	: 2

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- **NO** Matrix Spike outliers occur.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA005P: pH by PC Titrator						
Clear Plastic Bottle - Natural Bore 3	----	----	----	03-Aug-2021	27-Jul-2021	7
Clear Plastic Bottle - Natural Bore 1	----	----	----	03-Aug-2021	29-Jul-2021	5
EA050: Specific Gravity						
Clear Plastic Bottle - Natural Bore 3	----	----	----	09-Aug-2021	03-Aug-2021	6
Clear Plastic Bottle - Natural Bore 1	----	----	----	09-Aug-2021	05-Aug-2021	4
MW002: Heterotrophic Plate Count						
Sterile Plastic Bottle - Sodium Thiosulfate Bore 3	----	----	----	02-Aug-2021	28-Jul-2021	5
Sterile Plastic Bottle - Sodium Thiosulfate Bore 1	----	----	----	02-Aug-2021	30-Jul-2021	3

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
Un-ionised Hydrogen Sulfide-Low level	0	2	0.00	10.00	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)					
Un-ionised Hydrogen Sulfide-Low level	0	2	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)					
Un-ionised Hydrogen Sulfide-Low level	0	2	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
Container / Client Sample ID(s)							



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural (EA005-P) Bore 3	27-Jul-2021	----	----	----	03-Aug-2021	27-Jul-2021	✘
Clear Plastic Bottle - Natural (EA005-P) Bore 1	29-Jul-2021	----	----	----	03-Aug-2021	29-Jul-2021	✘
EA010P: Conductivity by PC Titrator							
Clear Plastic Bottle - Natural (EA010-P) Bore 3	27-Jul-2021	----	----	----	03-Aug-2021	24-Aug-2021	✔
Clear Plastic Bottle - Natural (EA010-P) Bore 1	29-Jul-2021	----	----	----	03-Aug-2021	26-Aug-2021	✔
EA015: Total Dissolved Solids dried at 180 ± 5 °C							
Clear Plastic Bottle - Natural (EA015H) Bore 3	27-Jul-2021	----	----	----	03-Aug-2021	03-Aug-2021	✔
Clear Plastic Bottle - Natural (EA015H) Bore 1	29-Jul-2021	----	----	----	03-Aug-2021	05-Aug-2021	✔
EA025: Total Suspended Solids dried at 104 ± 2°C							
Clear Plastic Bottle - Natural (EA025H) Bore 3	27-Jul-2021	----	----	----	03-Aug-2021	03-Aug-2021	✔
Clear Plastic Bottle - Natural (EA025H) Bore 1	29-Jul-2021	----	----	----	03-Aug-2021	05-Aug-2021	✔
EA050: Specific Gravity							
Clear Plastic Bottle - Natural (EA050) Bore 3	27-Jul-2021	----	----	----	09-Aug-2021	03-Aug-2021	✘
Clear Plastic Bottle - Natural (EA050) Bore 1	29-Jul-2021	----	----	----	09-Aug-2021	05-Aug-2021	✘
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural (ED037-P) Bore 3	27-Jul-2021	----	----	----	03-Aug-2021	10-Aug-2021	✔
Clear Plastic Bottle - Natural (ED037-P) Bore 1	29-Jul-2021	----	----	----	03-Aug-2021	12-Aug-2021	✔
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G) Bore 3	27-Jul-2021	----	----	----	02-Aug-2021	24-Aug-2021	✔
Clear Plastic Bottle - Natural (ED041G) Bore 1	29-Jul-2021	----	----	----	02-Aug-2021	26-Aug-2021	✔
ED045G: Chloride by Discrete Analyser							
Clear Plastic Bottle - Natural (ED045G) Bore 3	27-Jul-2021	----	----	----	02-Aug-2021	24-Aug-2021	✔
Clear Plastic Bottle - Natural (ED045G) Bore 1	29-Jul-2021	----	----	----	02-Aug-2021	26-Aug-2021	✔



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural (ED093F) Bore 3	27-Jul-2021	----	----	----	03-Aug-2021	03-Aug-2021	✓
Clear Plastic Bottle - Natural (ED093F) Bore 1	29-Jul-2021	----	----	----	03-Aug-2021	05-Aug-2021	✓
EG094T: Total metals in Fresh water by ORC-ICPMS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG094B-T) Bore 3	27-Jul-2021	03-Aug-2021	23-Jan-2022	✓	03-Aug-2021	23-Jan-2022	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG094B-T) Bore 1	29-Jul-2021	03-Aug-2021	25-Jan-2022	✓	03-Aug-2021	25-Jan-2022	✓
EK067G: Total Phosphorus as P by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK067G) Bore 3	27-Jul-2021	06-Aug-2021	24-Aug-2021	✓	06-Aug-2021	24-Aug-2021	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) Bore 1	29-Jul-2021	06-Aug-2021	26-Aug-2021	✓	06-Aug-2021	26-Aug-2021	✓
MW002: Heterotrophic Plate Count							
Sterile Plastic Bottle - Sodium Thiosulfate (MW002) Bore 3	27-Jul-2021	----	----	----	02-Aug-2021	28-Jul-2021	✗
Sterile Plastic Bottle - Sodium Thiosulfate (MW002) Bore 1	29-Jul-2021	----	----	----	02-Aug-2021	30-Jul-2021	✗

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Evaluation: ✖ = Quality Control frequency not within specification : ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)		Evaluation	Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected		
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Specific Gravity	EA050	1	2	50.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	1	2	50.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	2	19	10.53	10.53	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	2	3	66.67	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite B by ORC-ICPMS	EG094B-T	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Un-ionised Hydrogen Sulfide-Low level	EK084A	0	2	0.00	10.00	✗	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	2	2	100.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	2	19	10.53	10.53	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite B by ORC-ICPMS	EG094B-T	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Un-ionised Hydrogen Sulfide-Low level	EK084A	0	2	0.00	5.00	✗	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Alkalinity by PC Titrator	ED037-P	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	1	2	50.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	1	19	5.26	5.26	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite B by ORC-ICPMS	EG094B-T	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Un-ionised Hydrogen Sulfide-Low level	EK084A	0	2	0.00	5.00	✗	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							

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 Work Order : EP2108715
 Client : CARDNO (WA) PTY LTD
 Project : CW1183400 IBE Arrowsmith



Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Matrix Spikes (MS) - Continued							
Chloride by Discrete Analyser	ED045G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	1	3	33.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH by PC Titrator	EA005-P	WATER	In house: Referenced to APHA 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM Schedule B(3)
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM Schedule B(3)
Total Dissolved Solids (High Level)	EA015H	WATER	In house: Referenced to APHA 2540C. A gravimetric procedure that determines the amount of 'filterable' residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM Schedule B(3)
Salinity	EA020-EC-P	WATER	In house: Referenced to APHA 2520B. Calculation from Electrical conductivity. This method is compliant with NEPM Schedule B(3)
Suspended Solids (High Level)	EA025H	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of 'non-filterable' residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C. This method is compliant with NEPM Schedule B(3)
Specific Gravity	* EA050	WATER	In house: Referenced to ASTM D 1429-86. Density / Specific gravity by Hydrometer
Resistivity	EA080	WATER	In house: Calculation from Electrical conductance
Free and Total CO2	EA165-P	WATER	In house: Referenced to APHA 4500-CO2 D. This method is compliant with NEPM Schedule B(3)
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) on a settled supernatant aliquot of the sample using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G. The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride. In the presence of ferric ions the liberated thiocyanate forms highly-coloured ferric thiocyanate which is measured at 480 nm APHA seal method 2 017-1-L
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM Schedule B(3)
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM Schedule B(3).



Analytical Methods	Method	Matrix	Method Descriptions
Total Metals in Fresh Water -Suite B by ORC-ICPMS	EG094B-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM Schedule B(3).
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO3- F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM Schedule B(3)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	In house: Referenced to APHA 4500-P H, Jirka et al, Zhang et al. This procedure involves sulphuric acid digestion of a sample aliquot to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using discrete analyser. This method is compliant with NEPM Schedule B(3)
Un-ionised Hydrogen Sulfide-Low level	EK084A	WATER	In house: Referenced to APHA 4500-S2- H. Sulfide in the sample is reported as the ionised / unionised fractions by the use of a nomograph and the initial pH. This method is compliant with NEPM Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	* EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM Schedule B(3)
Heterotrophic (Total) Plate Count @ 22C and 36C	MW002	WATER	AS4276.3.1
Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM Schedule B(3)
Digestion for Total Recoverable Metals - ORC	* EN25-ORC	WATER	In house: Referenced to USEPA SW846-3005. This is an Ultrapure Nitric acid digestion procedure used to prepare surface and ground water samples for analysis by ORC- ICPMS. This method is compliant with NEPM Schedule B(3)

