TECHNICAL NOTE 2012/02

Department for Environment, Water and Natural Resources

SOUTH EAST TOWN WATER SUPPLY – KINGSTON TWS 14 – KINGSTON SOUTH EAST, SOUTH AUSTRALIA

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December 2012

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INTRODUCTION

In early 2011 the Department for Water (DFW)), now the Department for Environment, Water and Natural Resources (DEWNR), was contracted by the South Australian Water Corporation (SA Water) to drill and construct two production wells for the township of Kingston South East (SE) in the South East region of South Australia, a region also known as the Limestone Coast. This report discusses the drilling and construction of production well Kingston TWS 14 which was drilled as a replacement for the existing production well Kingston TWS 9, and was required as casing integrity checks indicated corrosion of the steel casing which was considered a risk to the long-term viability of the well.

Kangarilla Drilling Pty Ltd was contracted to drill and construct the new well. Drilling commenced on 18 October 2011 and was completed three days later.

DFW Groundwater Technical Services conducted pumping tests from 1–3 December 2011.

KINGSTON SE TOWN WATER SUPPLY

The township of Kingston SE is located on the coast, about 150 km north west of the regional centre of Mount Gambier and is currently reliant on groundwater from the Mepunga Formation confined aquifer to supply a population of about 2200 people (2011 census). Prior to commencement of this project four production wells were in use: TWS 8, TWS 9, TWS 12 and TWS 13.

The groundwater salinity in the vicinity of Kingston TWS 9 in the Mepunga Formation is approximately 800 mg/L.

The pumping rate from Kingston TWS 9 was approximately 8 L/s.

Details of the Kingston SE production wells (historic and current) are given in Table 1. The location of the pre-existing wells is given in Fig. 1.

Well name	Unit number	Drill date	Depth (m)	Obs date	DTW (m)	Obs date	TDS (mg/L)	Obs date	Yield (L/s)
Kingston TWS 1	6824 - 464	1956	69.9	1956	Flow	1976	700	1956	7.5
Kingston TWS 2	6824 - 472	1959	69.8	1959	Flow	1987	1235	1990	4
Kingston TWS 3	6824 - 473	1959	69.2	1959	Flowi	1959	1200	1959	1
Kingston TWS 4	6824 - 438	1960	62.1	1960	Flow	1986	950	1973	2.5
Kingston TWS 5	6824 - 474	1968	77.1	1968	Flow	1968	1385	1968	4
Kingston TWS 6	6824 - 439	1969	65	1969	Flow	1986	950	1969	17.4
Kingston TWS 7	6824 - 462	1973	70	1973	Flow	1976	2840	1973	1.3
Kingston TWS 8	6824 - 470	1973	64.6	1973	Flow	1976	960	1973	17.4
Kingston TWS 9	6824 - 69	1973	65.1	1973	Flow	1976	755	1973	15.6
Kingston TWS 10	6824 - 222	1975	97	1976	Flow	1978	735	1976	5
Kingston TWS 11	6824 - 844	1977	65.2	1977	Flow	1977	790	1977	9
Kingston TWS 12	6824 - 1602	1991	73.9	1991	Flow	1991	799	1991	14
Kingston TWS 13	6824 - 1876	1999	62.5	1999	Flow	2011	980	1999	12
Kingston TWS 14	6824 - 2301	2011	67	2011	Flow	2011	800	2011	12

 Table 1.
 Kingston SE production well details (Mepunga Formation)



Figure 1. Location of Kingston SE production wells

WELL DESIGN AND CONSTRUCTION

Kangarilla Drilling Pty Ltd was engaged by DFW to drill and construct the production well. The drilling rig employed for the drilling operations was an Ingersoll Rand TH60. This rig is capable of rotary air and rotary mud drilling methods.

The site of Kingston TWS 14 (Fig. 2) was chosen by SA Water taking in account the following factor(s):

• Targeting the confined Mepunga Formation aquifer system away from stressed areas of the aquifer and where lower salinity groundwater could be intercepted.

Kingston TWS 14 was drilled as a production well under permit number 197233 (well unit number 6824-2301) and was completed on 21 October 2011.

The final design of Kingston TWS 14 was based on information gathered during drilling. Strata samples were initially collected every two metres which increased to every one metre through the aquifer zone. The well construction diagram (Fig. 3) shows the lithology encountered during drilling.

The well was drilled and constructed according to the following steps:

- The pilot drillhole was mud drilled to a depth of 79 m using a 203 mm (8 inch) bit
- The top 18 m of the pilot drillhole was reamed using a 406 mm (16 inch) bit
- Steel surface control casing 355 mm (14 inch) ID was run into the drillhole to a depth of 18 m
- The pilot drillhole was reamed to 59 m using a 343 mm (13.5 inch) reamer
- A Class 12 PVC 253 mm (10 inch) ID casing string was run into the drillhole to a depth of 59 m
- The casing was pressure cemented to surface through the drill string
- Once the grout was set, the pilot drillhole was re-opened to 67 m using a 254 mm (10 inch) bit
- A stainless steel (304 grade) telescopic wire-wound screen 220 mm (8.7 inch) ID, 1 mm aperture, was set over the interval 59–65 m
- The screen was run with a Figure-K Packer and using a J-latch
- A riser pipe of 200 mm (8.7 inch) ID stainless steel (304 grade) zero-wound screen was set over the interval 57–59 m
- A sump of 220 mm (8.7 inch) ID stainless steel (304 grade) zero-wound screen was set over the interval 65–67 m
- The well was completed with a flange plate and a gate valve
- Development of the well was undertaken by airlifting from a depth of 57 m (2 m above the top of the screen) until the groundwater produced was clear and free of suspended solids. Airlifting was controlled and full development was achieved after approximately 120 min. The well was airlifted to a maximum yield of 15 L/s.

Sterilisation of the well was achieved by adding chlorine to the drilling fluid and maintaining this throughout the drilling process.

A small artesian head approximately 4 m above ground surface and a yield of 8 L/s were recorded at the conclusion of drilling.

Groundwater salinity was 780 mg/L (1410 uScm) based on the result of laboratory water chemisty analysis.

The Drillers Well Construction Report (Schedule 8) is given in Appendix A and a water well log (including lithological / stratigraphic description) is given in Appendix B.



Figure 2. Location of Kingston TWS 14



Figure 3. Well construction diagram and lithological sequence Kingston TWS 14

STRATIGRAPHY

The stratigraphy in the vicinity of Kingston SE town water supply has not been well understood to date.

The location of Kingston SE marks the approximate boundary of the Gambier and the Murray Basins. The stratigraphy in this area has been subject to major uplift, and associated erosion and shearing resulted in a very thin Tertiary sediment sequence.

As a result the Dilwyn Formation is absent below the Mepunga Formation in the vicinity of the current production wells. At the base of the Tertiary sequence the Pember Mudstone occurs as a pale grey, non-calcareous clay.

PUMPING TESTS

CONDUCT OF TEST

The pumping tests conducted on Kingston TWS 14 consisted of a step drawdown test and a constant rate discharge test and recovery test over the period 1–4 December 2011. Test details are given in Table 2 and the results are given in Appendix C.

DFW Groundwater Technical Services conducted the testing. Further development of the well was initially carried out during which pumping rates and groundwater levels were monitored. From this preliminary data, rates were selected for the step drawdown test.

Groundwater samples were analysed at the Australian Water Quality Centre (AWQC) (Appendix D).

Test type	Test date	Step	Duration (min)	Pumping Rate (L/s)
Step drawdown	1 December 2011	1	100	9
		2	100	12
		3	100	15
Constant rate discharge	2–3 December 2011	1	1440	12
Recovery	3–4 December 2011	-	1380	0

Table 2. Pumping test details Kingston TWS 14

STEP DRAWDOWN TEST

Analysis of the step drawdown results (Fig. 4) leads to the following well equation:

$s(t) = 25.43 Q + 2.31 Q^2 + 6.41 \log (t) Q$

Equation (1)

The well equation can be used as a predictive tool. Table 3 gives predicted drawdown after 1 000 000 minutes (approximately 2 years) of continuous pumping at a range of pumping rates assuming available drawdown is the casing length, 59 m.

Table 3. Predicted drawdown Kingston TWS 14

Pumping rate (L/s)	Theoretical Available DD (m)	Duration (min)	Predicted DD (m)
5	59	1 000 000	19.4
10	59	1 000 000	39.2
15	59	1 000 000	59.4
20	59	1 000 000	80.0



Figure 4. Step drawdown test analysis of drawdown using Hazel method Kingston TWS 14

CONSTANT RATE DISCHARGE TEST

Production Well

Drawdown (residual drawdown) were recorded during the constant rate discharge test and recovery (Fig. 5).



Figure 5. Linear-linear plot of drawdown Kingston TWS 14 constant rate discharge test

Drawdown versus time and residual drawdown versus t/t_1 (where t is the time since pumping began and t_1 is the time since pumping stopped) are given in Fig. 6.



Figure 6. Log-linear plot of drawdown / residual drawdown Kingston TWS 14 constant rate discharge test

The following general comments can be made:

• The well equation slightly over-predicts the observed drawdown at the test rate of 12 L/s, predicting a value of 34.1 m after 1440 minutes compared to the actual value of 32.6 m.

Observation Well

The data from the observation well Kingston TWS 9 at a radial distance of 21 m from the production well were analysed using the Hantush method (Fig.7). The following general comments can be made:

- A drawdown of 13.7 m developed during the test
- The Mepunga Formation exhibited a drawdown signature at the observation well consistent with a leaky confined aquifer
- The hydraulic parameters of Mepunga Formation and overlying aquitard are given Table 5.

Table 5. Analysis results observation well Kingston TWS 9

Observation Well	Radial distance to production well (m)	Transmissivity (m²/day)	Storage coefficient	Hydraulic resistance (day)	Method
Kingston TWS 9	21	44	8.5 x 10-5	20139	Hantush



Figure 7. Hantush analysis of drawdown observation well Kingston TWS 9

GROUNDWATER SALINITY

Groundwater salinity (Fig. 9) was continuously recorded in the field during the constant rate discharge test. Groundwater salinity decreased slightly by approximately 40 mg/L during the test, perhaps due to lateral flow of less saline groundwater from the east, ending at around 790 mg/L. Groundwater salinity was 780 mg/L (1410 uScm) based on the result of laboratory water chemisty analysis.



Figure 8. Groundwater salinity Kingston TWS 14 constant rate discharge test

RECOMMENDATIONS

It is recommended that Kingston TWS 14 be pumped operationally and monitored for a full 12 months to confirm the long-term hydraulic behaviour of the well. The recommended pumping rate and pump depth are given in Table 6.

The current program of work included the design, implementation and testing of the production well. The report includes a brief analysis and interpretation of the constant rate discharge test. This analysis and interpretation can be futher explored in a future program of work dealing with regional aquifer and aquitard assessment.

	Parameter Description	Kingston TWS 14
Well Design	Target aquifer	Mepunga Formation
	Assumed depth to water (m)	-4 ¹ (artesian)
	Casing inner diameter (mm)	253
	Casing length (m)	59
	Available drawdown (m)	59 ²
SA Water Specification	Required pumping rate (L/s)	18
	Required pumping duration	Assume 24 h ³
DFW Recommendation	Pumping rate (L/s)	18
	Pumping duration	24 h (1440 min)
	Predicted drawdown (m)	52.0
	Pump intake depth (m)	54 ⁴
	Resultant available drawdown safety factor (m)	6.00 ⁵

Table 6.	Well completion details a	and numping test	t summary Kingston	TWS 14
Table 0.	wen completion details a	and pumping tes	t summary kingston	1442 14

Note:

¹ Measurement taken at start of constant rate discharge test and rounded to a whole number

² Assume available drawdown from surface to casing point, ignore artesian head as a safety factor

³ Parameter arbitrary as not set by SA Water

⁴ Pump intake depth based on 3 metre pump column lengths

⁵ Increased available drawdown due to artesian conditions, i.e. safety factor (2 m) + artesian head (4 m) = 6 m

APPENDIXES

A. WELL CONSTRUCTION REPORT

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B. WATER WELL LOG

Project:	South East TWS – Kingston S	E	
Permit Number:	197233	Backfilled (Y/N):	Ν
Date Completed:	21/10/2011	Final Depth (m):	67
Unit No:	6824-2301	Drill Method:	Rotary Mud
Drillhole Name:	Kingston TWS 14	Drilling Company:	Kangarilla Drilling Pty Ltd
Logged By:	J Lawson	Driller:	J Mason supervised
			by M Fosdike

Coordinates

Easting:	401769	Ground Elevation (mAHD):	2.25 DEM
Northing:	5920448	Reference Elevation (mAHD):	TBD
Zone:	54	Reference Point Type:	тос
Datum:	GDA94		

General Comments:

n/a

Lithological Description

Depth	(m)	Major	Lithology	Formation
From	То	Lithological Unit(s)		
0	2		Pale grey to slight orange strongly cemented sandstone composed of sand and well rounded fossil fragments.	
2	6	SANDSTONE	Pale grey to slight orange coarse-grained. High percentage of well preserved bi valve and gastropod shells.	FORMATION
6	8		Transition zone. Elements of limestone and sandstone.	
8	10	LIMESTONE	White unconsolidated fine-grained. Occasional well preserved bryozoal, mostly indistinguishable.	
10	12		Soft, slightly marly. Strongly bryozoal.	
12	16	MARL	White, soft, well bounded. Minor limestone component.	
16	20		Grey well bounded marl. Minor fossil component.	CAMPIED
20	22	LIMESTONE	Soft, weakly bound. Glauconitic staining well preserved bryozoa. Fine to medium grained. Some partially silicified fragments.	LIMESTONE (Greenways Member)
22	26	MARL	Mottled white and grey marl. Soft, pliable. 5 – 10% fossil content.	Member)
26	30	FLINT	Varies from flint and partially silicified flint to weakly cemented grey limestone.	
30	36	MARL	Grey soft marl. 25 – 35% Flint – black angular fragments.	
36	38		Grey well bounded marl. Minor flint.	

Depth	(m)	Major	Lithology	Formation
From	То	Lithological		
38	42	Unit(s)	Pale grey, well bounded marl. Occasional angular flint fragments.	
42	46		Slightly darker colouration, indicating the first glauconitic stained fragments. Weakly bounded marl, with higher % of bryozoa and other fossils.	
46	48		Generally off white marl well bounded. Up to 20% limestone fossil fragments. Strong presence of glauconitic stained fragments giving an overall green tinge.	
48	50		Similar to above but with a stronger influence of glauconitic staining. Occasional strongly cemented fine grained limestone fragments.	
50	54	MARL	Classic Narrawaturk Marl. Calcareous marl with very strong green staining via two mechanisms. Glauconitic staining of fossil fragments, but also the appearance of the classic dark green (almost black) very rounded grains. Not dissimilar to the limonitic grains of the Mepunga Formation.	NARRAWATURK MARL
54	55		With a pale green tinge. Carbonate material with abundant rounded green grains from glauconitic staining.	
55	56		Brown soft pliable clay.	
56	58	CLAY	Dark brown clay. Glauconitic grains present but likely up-hole contamination. Fine quartz, some mica.	
58	59		10 - 20% coarse sand present.	
59	60	SANDY CLAY	Very coarse sand to 1cm. Weaker clay breaks down in water quite easily. Sand is sub rounded.	
60	61		Extremely coarse sand. 87% of the sample is greater than 2.4mm.	MEPUNGA FORMATION
61	62		Extremely coarse sand. 90% of the sample is greater than 2.4mm.	
62	63	SAND	Extremely coarse sand. 92% of the sample is greater than 2.4mm.	
63	64		Extremely coarse sand. 93% of the sample is greater than 2.4mm.	
64	66		Extremely coarse sand. 87% of the sample is greater than 2.4mm.	
66	70	CLAY	Pale grey grading towards off white. Soft pliable. Some quartz grains but probable up-hole contamination. Clay when broken down is composed of fine silt and quartz.	PEMBER
70	75		Pale grey but with also a smaller component of dark grey clay. END OF LOG	MUDSTONE

Water Cut Information

Dept	:h (m)	Depth	Supply				Water An	alysis
From	То	to Water (m)	Yield (L/s)	Test Length (min)	Method	Sample No.	Salinity	Salinity Unit (mg/L or EC)
55	66	-4	12	1440	Pump	N/A	N/A	N/A

Casing and Production Zone Information

Case or	Dept	h (m)	Inner	Material	Aperture		Cementir	ng
Production Zone	From	То	Diam (mm)		(mm)	Y/N	From (m)	To (m)
Surface control casing	0	18	355	Schedule 20 steel	-	Y	0	18
Well Casing	0	59	253	Class 12 PVC	-	Y	0	59
Production zone	59	65	220	304 Stainless wire-wound screen	1			
Sump	65	67	220	Zero aperture stainless steel				

C. PUMPING TEST DATA

C.1 STEP DRAWDOWN TEST

KINGSTON TWS 14

Start date	Start time	Step	Duration (min)	Q (L/s)	Well Name	Well Type	r (m)	Aquifer	Ref Elev. (mAHD)
					Kingston			Mepunga	Not
1/12/2011	09:00	1	100	9	TWS 14	Production	0	Formation	surveyed
"	10:40	2	100	12	u	"	"	"	"
"	12:20	3	100	15	"	"	"	"	"

KINGSTON TWS 14 MANUAL DATA

Step No.	Q (L/s)	Time (min)	DTW (m)	DD (m)
1	9	0	-4.18	0.00
1	9	1	10.08	14.26
1	9	2	11.06	15.24
1	9	3	11.70	15.88
1	9	4	12.14	16.32
1	9	5	12.65	16.83
1	9	6	12.87	17.05
1	9	7	13.10	17.28
1	9	8	13.32	17.50
1	9	9	13.52	17.70
1	9	10	13.73	17.91
1	9	12	14.00	18.18
1	9	14	14.17	18.35
1	9	16	14.39	18.57
1	9	18	14.54	18.72
1	9	20	14.68	18.86
1	9	22	14.87	19.05
1	9	24	15.00	19.18
1	9	26	15.10	19.28
1	9	28	15.21	19.39
1	9	30	15.34	19.52
1	9	35	15.55	19.73
1	9	40	15.78	19.96
1	9	45	15.94	20.12
1	9	50	16.08	20.26
1	9	55	16.25	20.43
1	9	60	16.34	20.52
1	9	70	16.60	20.78
1	9	80	16.74	20.92
1	9	90	16.90	21.08
1	9	100	17.06	21.24

Step No.	Q (L/s)	Time (min)	DTW (m)	DD (m)
2	12	101	20.58	24.76
2	12	102	21.80	25.98
2	12	103	22.34	26.52
2	12	104	22.67	26.85
2	12	105	22.87	27.05
2	12	106	23.06	27.24
2	12	107	23.20	27.38
2	12	108	23.28	27.46
2	12	109	23.33	27.51
2	12	110	23.38	27.56
2	12	112	23.48	27.66
2	12	114	23.68	27.86
2	12	116	23.76	27.94
2	12	118	23.82	28.00
2	12	120	23.90	28.08
2	12	122	23.95	28.13
2	12	124	24.01	28.19
2	12	126	24.12	28.30
2	12	128	24.21	28.39
2	12	130	24.27	28.45
2	12	135	24.36	28.54
2	12	140	24.48	28.66
2	12	145	24.58	28.76
2	12	150	24.69	28.87
2	12	155	24.80	28.98
2	12	160	24.94	29.12
2	12	170	25.08	29.26
2	12	180	25.20	29.38
2	12	190	25.34	29.52
2	12	200	25.46	29.64
3	15	201	29.16	33.34
3	15	202	30.44	34.62
3	15	203	30.90	35.08
3	15	204	31.22	35.40
3	15	205	31.47	35.65
3	15	206	31.64	35.82
3	15	207	31.78	35.96
3	15	208	31.94	36.12
3	15	209	32.05	36.23
3	15	210	32.13	36.31
3	15	212	32.25	36.43
3	15	214	32.37	36.55

Step No.	Q (L/s)	Time (min)	DTW (m)	DD (m)
3	15	216	32.50	36.68
3	15	218	32.61	36.79
3	15	220	32.66	36.84
3	15	222	32.72	36.9
3	15	224	32.76	36.94
3	15	226	32.81	36.99
3	15	228	32.86	37.04
3	15	230	32.90	37.08
3	15	235	32.99	37.17
3	15	240	33.12	37.30
3	15	245	33.24	37.42
3	15	250	33.31	37.49
3	15	255	33.36	37.54
3	15	260	33.41	37.59
3	15	270	33.66	37.84
3	15	280	33.76	37.94
3	15	290	33.91	38.09
3	15	300	34.02	38.20

C.2 CONSTANT RATE DISCHARGE TEST

Start date	Start time	Step	Duration (min)	Q (L/s)	Well Name	Well Type	r (m)	Aquifer	Ref Elev. (mAHD)
			Pumping 1440		Kingston			Mepunga	Not
2/12/2011	09:30	1	Recovery 1380	12	TWS 14	Production	0	Formation	surveyed
					Kingston			Mepunga	Not
					TWS 9	Observation	21	Formation	surveyed

KINGSTON TWS 14

KINGSTON TWS 14 MANUAL DATA

Q (L/s)	Time (min)	DTW (m)	DD (m)
12	0	-3.88	0.00
12	1	-	-
12	2	15.26	19.14
12	3	16.38	20.26
12	4	17.45	21.33
12	5	18.13	22.01
12	6	18.65	22.53
12	7	19.10	22.98
12	8	19.46	23.34
12	9	19.72	23.60
12	10	19.94	23.82
12	12	20.33	24.21
12	14	20.69	24.57
12	16	20.98	24.86
12	18	21.23	25.11
12	20	21.48	25.36
12	22	21.68	25.56
12	24	21.85	25.73
12	26	21.99	25.87
12	28	22.15	26.03
12	30	22.25	26.13
12	35	22.60	26.48
12	40	22.80	26.68
12	45	23.10	26.98
12	50	24.22	28.10
12	55	23.51	27.39
12	60	23.66	27.54
12	70	23.88	27.76
12	80	24.16	28.04
12	90	24.49	28.37
12	100	24.66	28.54
12	120	24.94	28.82
12	140	25.23	29.11

Q (L/s)	Time (min)	DTW (m)	DD (m)
12	160	25.50	29.38
12	180	25.78	29.66
12	200	25.87	29.75
12	250	26.28	30.16
12	315	26.61	30.49
12	350	26.70	30.58
12	400	26.98	30.86
12	450	27.14	31.02
12	500	27.28	31.16
12	550	27.44	31.32
12	600	27.55	31.43
12	650	27.68	31.56
12	700	27.76	31.64
12	750	27.88	31.76
12	800	27.94	31.82
12	850	28.06	31.94
12	900	28.16	32.04
12	950	28.24	32.12
12	1000	28.28	32.16
12	1050	28.38	32.26
12	1100	28.43	32.31
12	1150	28.49	32.37
12	1200	28.51	32.39
12	1250	28.56	32.44
0	1300	28.60	32.48
0	1350	28.65	32.53
0	1400	28.70	32.58
0	1440	28.69	32.57
0	1441	17.08	20.96
0	1442	12.45	16.33
0	1443	9.66	13.54
0	1444	8.03	11.91
0	1445	6.98	10.86
0	1446	6.31	10.19
0	1447	5.79	9.67
0	1448	5.40	9.28
0	1449	5.04	8.92
0	1450	4.76	8.64
U	1452	4.33	8.21
U	1454	3.96	7.84
U	1456	3.66	7.54
U	1458	3.40	1.28

Q (L/s)	Time (min)	DTW (m)	DD (m)
0	1460	3.19	7.07
0	1462	2.97	6.85
0	1464	2.80	6.68
0	1466	2.62	6.50
0	1468	2.49	6.37
0	1470	2.35	6.23
0	1475	2.05	5.93
0	1480	1.78	5.66
0	1485	1.55	5.43
0	1490	1.35	5.23
0	1495	1.12	5.00
0	1500	1.01	4.89
0	1510	0.72	4.60
0	1520	0.49	4.37
0	1530	0.21	4.09
0	1540	0.09	3.97
0	1560	-0.20	3.68
0	1580	-0.41	3.47
0	1600	-0.71	3.17
0	1620	-0.92	2.96
0	1640	-1.02	2.86
0	1690	-1.33	2.55
0	1740	-1.53	2.35
0	1790	-1.84	2.04
0	1840	-1.94	1.94
0	1890	-2.14	1.74
0	2010	-2.45	1.43
0	2160	-2.65	1.23
0	2790	-3.26	0.62

KINGSTON TWS 9 MANUAL DATA

Q (L/s)	Time (min)	DTW (m)	DD (m)
	0	-4.49	0.00
	1	-2.86	1.63
	2	-2.04	2.45
	3	-1.53	2.96
	4	-1.22	3.27
	5	-0.92	3.57
	6	-0.61	3.88
	7	-0.41	4.08
	8	-0.10	4.39

Q (L/s)	Time (min)	DTW (m)	DD (m)
	9	-	-
	10	-	-
	12	1.31	5.80
	14	1.54	6.03
	16	1.78	6.27
	18	2.01	6.50
	20	2.20	6.69
	22	2.38	6.87
	24	2.55	7.04
	26	2.79	7.28
	28	2.84	7.33
	30	2.97	7.46
	35	3.28	7.77
	40	3.58	8.07
	45	3.81	8.30
	50	4.00	8.49
	55	4.17	8.66
	60	4.33	8.82
	70	4.55	9.04
	80	4.78	9.27
	90	5.00	9.49
	100	5.27	9.76
	120	5.56	10.05
	140	5.78	10.27
	160	5.99	10.48
	180	6.19	10.68
	200	6.41	10.90
	250	6.79	11.28
	315	7.13	11.62
	350	7.31	11.80
	400	7.50	11.99
	450	7.67	12.16
	500	7.75	12.24
	550	7.97	12.46
	600	8.09	12.58
	650	8.21	12.70
	700	8.30	12.79
	750	8.41	12.90
	800	8.50	12.99
	850	8.59	13.08
	900	8.67	13.16
	950	8.75	13.24

Q (L/s)	Time (min)	DTW (m)	DD (m)
	1000	8.81	13.30
	1050	8.88	13.37
	1100	8.94	13.43
	1150	8.99	13.48
	1200	9.04	13.53
	1250	9.08	13.57
	1300	9.12	13.61
	1350	9.17	13.66
	1400	9.21	13.70
	1440	9.23	13.72
	1441	8.12	12.61
	1442	7.18	11.67
	1443	6.31	10.80
	1444	5.60	10.09
	1445	5.02	9.51
	1446	4.64	9.13
	1447	4.29	8.78
	1448	4.00	8.49
	1449	3.74	8.23
	1450	3.52	8.01
	1452	3.06	7.55
	1454	2.76	7.25
	1456	2.48	6.97
	1458	2.24	6.73
	1460	2.04	6.53
	1462	1.86	6.35
	1464	1.69	6.18
	1466	1.53	6.02
	1468	1.39	5.88
	1470	1.27	5.76
	1475	1.07	5.56
	1480	0.82	5.31
	1485	0.61	5.10
	1490	0.41	4.90
	1495	0.24	4.73
	1500	0.10	4.59
	1510	-	-
	1520	-0.20	4.29
	1530	-0.41	4.08
	1540	-0.51	3.98
	1560	-0.82	3.67
	1580	-1.02	3.47

Q (L/s)	Time (min)	DTW (m)	DD (m)
	1600	-1.22	3.27
	1620	-1.43	3.06
	1640	-1.53	2.96
	1690	-1.94	2.55
	1740	-2.24	2.25
	1790	-2.35	2.14
	1840	-2.55	1.94
	1890	-2.75	1.74
	2010	-2.96	1.53
	2160	-3.16	1.33
	2820	-3.88	0.61

D. WATER CHEMISTRY

PO Box 1751 Adelaide SA 5001 250 Victoria Square Adelaide SA 5000 Tel: 1300 653 366 Fax: 1300 883 171 Internet: www.awqc.com.au Email: awqc@sawater.com.au



SAW Infrastructure ATTN: James Simmons SA Water House Adelaide SA 5000 AUSTRALIA

09/01/2012

Dear James

Please find attached the Final Analytical Report for

Customer Service Request:	105296-2011-CSR-19
Account:	105296
Project:	AWQC-53013 SAW Infrastructure - Kingston Bore Commissioning 11/12

This report has also been sent to: Maree Shephard

Please note AWQC Sample Receipt hours are Monday to Friday 8.30am - 4.30pm.

Yours sincerely,

Rill

Pat Poldervaart Account Manager Pat.Poldervaart@sawater.com.au +61 8 7424 2095



ABN 69336525019

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Page 1 of 10

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AWQC-53013

SAW Infrastructure

105296-2011-CSR-19

Internet: www.awqc.com.au Email: awqc@sawater.com.au



FINAL REPORT: 95961

Report Information

Project Name Customer CSR_ID

Analytical Results

Customer Sample Description Sampling Point Sampled Date Sample Received Date Sample ID Status **Collection Type**

Kingston TWS 14 70004-SAW General Request South East 1/12/2011 2:00:00PM 2/12/2011 8:41:00AM *2011-004-8120 Endorsed Endorsed Customer Collected

Inorganic Chemistry - Metals	LOR	Result
Aluminium - Acid Soluble TIC-003 W09	-023	
Aluminium - Acid Soluble	0.001	0.001 mg/L
Aluminium - Soluble TIC-003 W09-023		
Aluminium - Soluble	0.001	<0.001 mg/L
Aluminium - Total TIC-003 W09-023		
Aluminium - Total	0.001	0.006 mg/L
Antimony - Soluble TIC-003 W09-023		
Antimony - Soluble	0.0005	<0.0005 mg/L
Antimony - Total TIC-003 W09-023		
Antimony - Total	0.0005	<0.0005 mg/L
Arsenic - Soluble TIC-003 W09-023		
Arsenic - Soluble	0.0003	0.0004 mg/L
Arsenic - Total TIC-003 W09-023		
Arsenic - Total	0.0003	0.0005 mg/L
Barium - Soluble TIC-003 W09-023		
Barium - Soluble	0.0005	0.0962 mg/L
Barium - Total TIC-003 W09-023		
Barium - Total	0.0005	0.1497 mg/L
Beryllium - Soluble TIC-003 W09-023		
Beryllium - Soluble	0.0003	<0.0003 mg/L
Beryllium - Total TIC-003 W09-023		
Beryllium - Total	0.0003	<0.0003 mg/L
Boron - Soluble TIC-003 W09-023		
Boron - Soluble	0.020	0.308 mg/L
Cadmium - Soluble TIC-003 W09-023		
Cadmium - Soluble	0.0001	<0.0001 mg/L
Cadmium - Total TIC-003 W09-023		
Cadmium - Total	0.0001	<0.0001 mg/L
Calcium TIC-003 W09-023		
Calcium	0.04	54.4 mg/L
Chromium - Soluble TIC-003 W09-023		
Corporate Accreditation No.1115 Chemical and Biological Testing This document is issued in accordance with NATA's accreditation requirements.		Notes 1. The last figure of the result value is a significant figure. 2. Samples are analysed as received. 3. # determination of the component is not covered by NATA Accreditation.

determination of the component is not covered by NATA Accreditation.
 A: indicates result is out of specification according to the reference Guideline. Refer to Report footer.
 indicates incident have been recorded against the sample. Refer to Report footer.
 Inclates the results have changed since the last issued report.
 The Limit of Reporting (LOR) is the lowest concentration of analyte which is reported at the AWQC and is based on the LOQ rounded up to a more readily used value. The Limit of Quantitation (LOQ) is the lowest concentration of analyte for which quantitative results may be obtained within a specified degree of conflictnece.

ABN 69336525019

WORLD RECOGNISED

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FINAL REPORT: 95961

Analytical Results			
Customer Sample Description Sampling Point Sampled Date Sample Received Date Sample ID Status Collection Type	Kingston TW 70004-SAW 1/12/2011 2/12/2011 *2011-004-8 Endorsed Customer Co	Kingston TWS 14 70004-SAW General Request South East 1/12/2011 2:00:00PM 2/12/2011 8:41:00AM *2011-004-8120 Endorsed Customer Collected	
Chromium - Soluble TIC-003 W09	9-023		
Chromium - Soluble	0.0001	<0.0001 ma/L	
Chromium - Total TIC-003 W09-0	23		
Chromium - Total	0 0001	<0.0001 ma/L	
Copper - Soluble TIC-003 W09-02	23		
Copper - Soluble	0.0001	0.0007 mg/L	
Copper - Total TIC-003 W09-023			
Copper - Total	0.0001	0.0015 mg/L	
Iron - Soluble TIC-003 W09-023		,	
Iron - Soluble	0.0005	0.0010 mg/L	
Iron - Total TIC-003 W09-023			
Iron - Total	0.0005	0.5903 mg/L	
Langelier Index W09-023		-	
Langelier Index		-0.1	
Lead - Soluble TIC-003 W09-023			
Lead - Soluble	0.0001	<0.0001 mg/L	
Lead - Total TIC-003 W09-023			
Lead - Total	0.0001	<0.0001 mg/L	
Magnesium TIC-003 W09-023			
Magnesium	0.04	16.7 mg/L	
Manganese - Soluble TIC-003 W0	9-023		
Manganese - Soluble	0.0001	0.0162 mg/L	
Manganese - Total TIC-003 W09-	023		
Manganese - Total	0.0001	0.0170 mg/L	
Mercury - Soluble TIC-003 W09-0	23		
Mercury - Soluble	0.00003	0.00003 mg/L	
Mercury - Total TIC-003 W09-023			
Mercury - Total	0.00003	<0.00003 mg/L	
Molybdenum - Soluble TIC-003 V	V09-023		
Molybdenum - Soluble	0.0001	0.0002 mg/L	
Molybdenum - Total TIC-003 W09	9-023		
Molybdenum - Total	0.0001	0.0002 mg/L	
Nickel - Soluble TIC-003 W09-023	3		
Nickel - Soluble	0.0001	0.0001 mg/L	
Nickel - Total TIC-003 W09-023			
Nickel - Total	0.0001	0.0001 mg/L	
Potassium TIC-003 W09-023			
Potassium	0.040	15.3 mg/L	
WORLD RECOGNISED ACCREDITATION	ia g dance ements.	 The last figure of the result value is a significant figure. Samples are analysed as received. # determination of the component is not covered by NATA Accreditation. * indicates result is out of specification according to the reference Guideline. Refer to Report footer. * indicates incident have been recorded against the sample. Refer to Report footer. * indicates incident have been recorded against the sample. Refer to Report footer. * Indicates incident have been recorded against the sample. Refer to Report footer. * Indicates incident have been recorded against the sample. Refer to Report footer. * Indicates the results have changed since the last issued report. The Limit of Reporting (LOR) is the lowest concentration of analyte which is reported at the AWQC and is based on the LOQ rounded up to a more readily used 	
		value. The Limit of Quantitation (LOQ) is the lowest concentration of analyte for which quantitative results may be obtained within a specified degree of confidence. Page 3 of 10	
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FINAL REPORT: 95961

Analytical Results			
Customer Sample Description Sampling Point Sampled Date Sample Received Date Sample ID Status Collection Type	Kingston TWS 14 70004-SAW General Request South East 1/12/2011 2:00:00PM 2/12/2011 8:41:00AM *2011-004-8120 Endorsed Customer Collected		
Selenium - Soluble TIC-003 W09-023			
Selenium - Soluble	0.0001	<0.0001_mg/l	
Selenium - Total TIC-003 W09-023	0.0001		
Selenium - Total	0.0001	<0.0001 mg/l	
Silica - Total TIC-004 W09-023	0.0001	-0.0001 mg/L	
Silica - Total	2.0	12.6 mg/l	
Silver - Soluble TIC-003 W09-023	2.0		
Silver - Soluble	0.00003	<0.00003 mg/L	
Silver - Total TIC-003 W09-023			
Silver - Total	0.00003	<0.00003 ma/L	
Sodium TIC-003 W09-023			
Sodium	0.04	202 mg/L	
Strontium - Total TIC-003 W09-023		ů –	
Strontium - Total	0.0001	0.4770 mg/L	
Sulphur TIC-004 W09-023		-	
Sulphate	1.5	30.6 mg/L	
Tin - Soluble TIC-003 W09-023			
Tin - Soluble	0.0005	<0.0005 mg/L	
Tin - Total TIC-003 W09-023			
Tin - Total	0.0005	<0.0005 mg/L	
Total Hardness as CaCO3 W09-023			
Total Hardness as CaCO3	2.0	205 mg/L	
Uranium - Soluble TIC-003 W09-023			
Uranium - Soluble	0.0001	0.0001 mg/L	
Uranium - Total TIC-003 W09-023			
Uranium - Total	0.0001	<0.0001 mg/L	
Zinc - soluble TIC-003 W09-023			
Zinc - Soluble	0.0003	0.0101 mg/L	
Zinc - Total TIC-003 W09-023			
Zinc - Total	0.0003	0.0110 mg/L	
		– <i>u</i>	
Inorganic Chemistry - Nutrients	LOR	Result	
Ammonia as N T0100-01 W09-023			
Ammonia as N	0.005	0.344 mg/L	
Bromide T0114-01 W09-023			
Bromide	0.025	0.49 mg/L	
Chloride T0104-02 W09-023			
Corporate Accreditation No.1115 Chemical and Biological Testing This document is issued in accordance with NATA's accreditation requirements.		Notes 1. The last figure of the result value is a significant figure. 2. Samples are analysed as received. 3. # determination of the component is not covered by NATA Accreditation. 4. ^ indicates result is out of specification according to the reference Guideline. Refer to Report footer. 5. * indicates incident have been recorded against the sample. Refer to Report footer. 6. & Indicates the results have changed since the last issued report. 7. The Limit of Reporting (LOR) is the lowest concentration of analyte which is reported at the AWQC and is based on the LOQ rounded up to a more readily used value. The Limit of Quantitation (LOQ) is the lowest concentration of analyte for which quantitative results may be obtained within a specified degree of confidence. Pane 4 of 10	

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FINAL REPORT: 95961

Analytical Results				
Customer Sample Description Sampling Point Sampled Date Sample Received Date Sample ID Status Collection Type	Kingston TWS 14 70004-SAW General Request South East 1/12/2011 2:00:00PM 2/12/2011 8:41:00AM *2011-004-8120 Endorsed Customer Collected			
Chloride T0104-02 W09-023				
Chloride	4.0	277 mg/L		
Fluoride W09-023		Celefol - 494 - 20020		
Fluoride	0.10	0.31 mg/L		
lodide T0117-01 W09-023				
lodide	0.01	0.01 mg/L		
Nitrate + Nitrite as N T0161-01 W09-023				
Nitrate + Nitrite as N	0.003	<0.003 mg/L		
Nitrate + Nitrite as NO3 T0161-01 W09-023				
Nitrate + Nitrite as NO3	0.02	<0.02 mg/L		
Organic Chemistry	LOR	Result		
Acidic Herbicides T0803-03 W09-023				
# 2 4 5-T	0.05	<0.05 µg/L		
# 2 4-D	0.05	<0.05 µg/L		
# Chlorsulfuron	0.05	<0.05 µg/L		
# Clopyralid	0.5	<0.5 µg/L		
# Dicamba	0.2	<0.2 µg/L		
# MCPA	0.05	<0.05 µg/L		
# Metsulfuron Methyl	0.05	<0.05 µg/L		
# Picloram	0.2	<0.2 µg/L		
# Silvex	0.05	<0.05 µg/L		
# Sulfometuron	0.05	<0.05 µg/L		
# Triclopyr	0.1	<0.1 µg/L		
Dissolved Organic Carbon W09-023				
Dissolved Organic Carbon	0.3	1.3 mg/L		
GCMS Scan - Dichloromethane T1072-0	1 W09-023			



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70			
Analytical I	Results		
Customer Sam Sampling Poin Sampled Date Sample Receiv Sample ID Status Collection Type	ple Description t ed Date e	Kingston TWS 14 70004-SAW General Request South East 1/12/2011 2:00:00PM 2/12/2011 8:41:00AM *2011-004-8120 Endorsed Customer Collected	
GCMS Scan -	Dichloromethane T1072-0	1 W09-023	
# GCMS Scan	Diemoromethane 11072-0	1 1105-025	The GC scan showed the sample contained a
			number of semi-volatile organic compounds. Some compounds may not have even been extracted using dichloromethane and/or detected by GC/MS. The following compounds reported are based on the best percentage match using NIST Mass Spectral Search Program 2002:
			2,3-dihydro-1,1,3-trimethyl-3-phenyl-1H-indene
			butvlated hydroxytoluene
			phthalate
			Other peaks were unable to be identified as NIST Mass Spectral Search Program showed very poor matches.
OrganoChlori	ine Pesticides T0700-01 W	09-023	natorioo.
Aldrin		0.01	<0.01 µg/L
Chlordane-a		0.01	<0.01 µg/L
Chlordane-g		0.01	<0.01 µg/L
Chlorothalonil		0.05	<0.05 µg/L
Chlorpyrifos		0.05	<0.05 µg/L
Chlorthal-Dimet	hyl	0.05	<0.05 µg/L
DDD		0.05	<0.05 µg/L
DDE		0.05	<0.05 µg/L
DDT		0.05	<0.05 μg/L
Dieldrin		0.01	<0.01 µg/L
Endosulfan 1		0.05	<0.05 μg/L
Endosulfan 2		0.05	<0.05 µg/L
Endosulfan Sulp	ohate	0.05	<0.05 µg/L
Endrin		0.05	<0.05 µg/L
Heptachlor		0.05	<0.05 µg/L
Heptachlor Epo	kide	0.05	<0.05 µg/L
Hexachlorobenz	ene	0.05	<0.05 µg/L
Lindane		0.05	<0.05 µg/L
Methoxychlor	D: 11:	0.05	<0.05 µg/L
Total Aldrin and	Dieldrin	0.02	<0.02 µg/L
		0.05	<0.05 µg/L
Organophoer	horous and Triazine Poeti	nides TASAA-	<0.03 μg/L .01 W09_023
Organophosp	biolous and mazine restr		01 009-023
WORLD RECOGNISED ACCREDITATION	Corporate Accreditation No.1115 Chemical and Biological Testing This document is issued in accordance with NATA's accreditation requirements.		Notes 1. The last figure of the result value is a significant figure. 2. Samples are analysed as received. 3. # determination of the component is not covered by NATA Accreditation. 4. ^ Indicates result is out of specification according to the reference Guideline. Refer to Report footer. 5. * indicates incident have been recorded against the sample. Refer to Report footer. 6. & Indicates the results have changed since the last issued report. 7. The Limit of Reporting (LOR) is the lowest concentration of analyte which is reported at the AWQC and is based on the LOQ rounded up to a more readily used value. The Limit of Quantitation (LOQ) is the lowest concentration of analyte for which quantitative results may be obtained within a specified degree of confidence.

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Analytical Results		
Customer Sample Description Sampling Point Sampled Date Sample Received Date Sample ID Status Collection Type	Kingston TW 70004-SAW 1/12/2011 2/12/2011 *2011-004-8 Endorsed Customer Co	/S 14 General Request South East 2:00:00PM 3:41:00AM 120 pollected
Organophosphorous and Triazine Pest	icides T0800	-01 W09-023
Atrazine	0.5	<0.5 µa/L
Azinphos-methyl	0.5	<0.5 µg/L
Diazinon	0.5	<0.5 µg/L
Fenitrothion	0.5	<0.5 µg/L
Hexazinone	0.5	<0.5 µg/L
Malathion	0.5	<0.5 µg/L
Parathion	0.5	<0.5 µg/L
Parathion methyl	0.3	<0.3 µg/L
Prometryne	0.5	<0.5 µg/L
Simazine	0.5	<0.5 µg/L
Inorganic Chemistry - Physical	LOR	Result
Alkalinity Carbonate Bicarbonate and	Hydroxide T0)101-01 W09-023
Alkalinity as Calcium Carbonate		304 mg/L
Bicarbonate		371 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Colour - Apparent (456nm) Unfiltered T	0029-01 W09	-023
Colour - Apparent (456nm)	1	82 HU
Conductivity & Total Dissolved Solids	T0016-01 W0	9-023
Conductivity	1	1410 µScm
Total Dissolved Solids (by EC)	1.0	780 mg/L
pH T0010-01 W09-023		
pH		7.3 pH units
Turbidity T0018-01 W09-023		
Turbidity	0.1	7.1 NTU
·		
Inorganic Chemistry - Waste Water	LOR	Result
Chlorine Demand - 24 hrs T0136-03 W0	9-023	
Chlorine Demand 24hrs		3.65 mg/L
Chlorine Demand - 30 mins T0136-03 W	/09-023	
Chlorine Demand 30 mins		3.88 ma/L
Chlorine Demand - 8 hrs T0136-03 W09	-023	
Chlorine Demand 8 hrs		3.29 mg/l
Cvanide - Total T0167-03 W09-023		0.20 mg/2
Cyanide as CN - Total	0.05	<0.05 mg/l
Sulphide - Soluble T0168-01 W09-023	0.00	-0.00 Hig/L
Comercia Accorditation No.444E		Nata
Corporate Accreditation No.1115 Chemical and Biological Testing This document is issued in accordance with NATA's accreditation requirements.		 1. The last figure of the result value is a significant figure. 2. Samples are analysed as received. 3. # determination of the component is not covered by NATA Accreditation. 4. ^ indicates result is out of specification according to the reference Guideline. Refer to Report footer. 5. * indicates incident have been recorded against the sample. Refer to Report footer. 6. * indicates incident have been recorded against the sample. Refer to Report footer. 7. The Limit of Reporting (LOR) is the lowest concentration of analyte which is reported at the AWQC and is based on the LOQ rounded up to a more readily used value. The Limit of Quantitation (LOQ) is the lowest concentration of analyte for which quantitative results may be obtained within a specified degree of confidence.

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Analytical Results Customer Sample Description Sampling Point Sample Date Sample Received Date Sample ID Status Collection Type	Kingston 70004-S/ 1/12/201 2/12/201 *2011-00 Endorsec Custome	Kingston TWS 14 70004-SAW General Request South East 1/12/2011 2:00:00PM 2/12/2011 8:41:00AM *2011-004-8120 Endorsed Customer Collected		
Sulphide - Soluble T0168-01 W09-023				
Sulphide as S - Soluble	0.1	<0.1 mg/L		
Sulphide - Total T0168-01 W09-023				
Sulphide as S - Total	0.1	<0.1 mg/L		
Western Radiation Services	LOR	Result		
Gross Alpha Activity W09-023				
!External Lab Report No.		WRS-J6675		
Gross Alpha Activity	0.005	0.078 Bq/L		
Gross Beta Activity (K-40 corrected)	W09-023			
External Lab Report No.		WRS-J6675		
Gross Beta Activity (K-40 corrected)	0.010	0.049 Bq/L		

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NATA Signatories



Sgor BHOND

Roger Kennedy - Inorganic Chemistry Process Coordinator

John Martini - Organic Chemistry Scientific Officer

Stephanie Semczuk - Inorganic Chemistry Team Leader

Kamilla Springer - Organic Chemistry Technical Officer

Boutsaba Vorakoumane - Organic Chemistry Scientific Officer



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Incidents

Sample ID	S.Point	Description	Sampled Date	Analysis (where Applicable)	Incident Description
2011-004-8120	70004	Kingston TWS 14	1/12/2011	Mercury - Total	Dependent results are within acceptable analytical uncertainty

Analytical Method

Analytical Method Code	Description
TIC-003	Elemental Analysis - ICP Mass Spectrometry
TIC-004	Determination of Metals - ICP Spectrometry by ICP2
W-052	Preparation of Samples for Metal Analysis
T0803-03	Acidic Herbicides by LCMS
T1072-01	Fullscan by GCMS
T0010-01	Determination of pH
T0016-01	Determination of Conductivity
T0018-01	Turbidity - Nephelometric Measurement
T0029-01	Colour, True - Spectrophotometric Measurement
T0100-01	Ammonia/Ammonium - Automated Flow Colorimetry
T0101-01	Alkalinity - Automated Acidimetric Titration
T0104-02	Chloride - Automated Flow Colorimetry
T0114-01	Bromide
T0117-01	lodide
T0136-03	Chlorine Demand
T0161-01	Nitrate + Nitrate (NOx) - Automated Flow Colorimetry
T0167-03	Cyanide - Total
T0168-01	Sulfide as S
T0700-01	Chlorinated Pesticides
T0800-01	Nitrogen and Phosphorous Containing Pesticides

Sampling Method

Sampling Method Code	Description		
W09-023	Sampling Method for Chemical Analyses		
Laboratory Information			
Laboratory	NATA accreditation ID		
Inorganic Chemistry - Metals	1115		
Inorganic Chemistry - Nutrients	1115		
Organic Chemistry	1115		
Inorganic Chemistry - Physical	1115		
Inorganic Chemistry - Waste Water	1115		
Western Radiation Services	14174		



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