Memo

File No:	47 03 25
Date:	25 June 2008
To:	File
From:	John Hadfield
Subject:	**Hahei Sentinel Well Completion**

1 Introduction

A pair of monitoring wells was constructed at the Hahei coastline to investigate the potential saltwater interface and provide long-term sentinel monitoring of any potential saltwater ingress. Investigation was prompted by the potential for saltwater intrusion as a result of pumping from a number of community and domestic water supply wells in the area. Seasonal decline in groundwater levels below mean sea level is evident. Applications for consent renewal to take groundwater by the Hahei Holiday Resort and the Hahei Water Supply Association are on hold while an investigation into safe aquifer yield is undertaken.

2 Background and hydrogeologic setting

The coastal community of Hahei is approximately 10 km east of Whitianga. Hahei Holiday Resort is located on flat land in the middle of Hahei adjacent to the sea (Figure 1).

Plate 1 Aerial oblique view of Hahei landforms from the south with location of the proposed monitoring well indicated approximately by the arrow.

The geology of the Hahei area is dominated by three rhyolite domes (Figure 2). Remnants of the Moturoa Dome include Motueka and Poikeke Islands. Rhyolite flows of the Wigmore Dome extend from Mahuranga Island to Hotwater Beach. Immediately to the west, Hahei Dome is the youngest of the three (Moore, P.R. 1983). These Ruahine rhyolites (~8 Ma) are part of the Mindon Rhyolite subgroup. They comprise glassy intrusives, domes and flows of porphyritic, crystal rich lava (mhh and mhw in Figure 2).

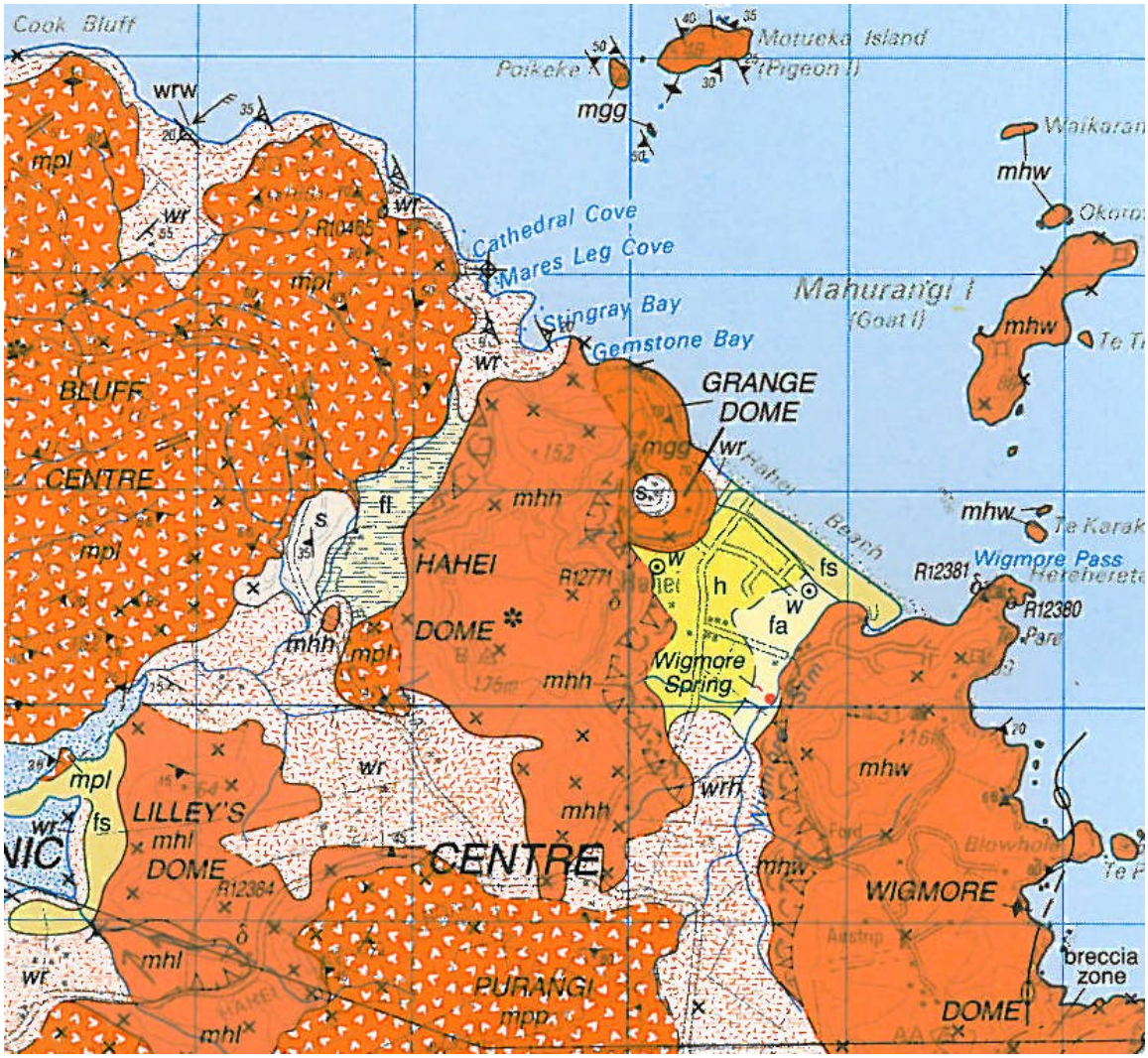

Figure 2 Geology of the Hahei area (Skinner, 1995)

Hotwater Beach Ignimbrite (wrh in Figure 2) also of late Miocene is inferred to underlie much of Hahei between the rhyolite domes (Skinner, 1995). It is a member of the Wharepapa Ignimbrite sub-group comprising non to partly welded, dense, glass shard rich ash flow tuff containing pumice fragments. These are overlain by surficial sediments comprising predominantly silt and dune sand forming the coastal flat upon which the Hahei Holiday Resort is located. Hahei Beach was established at about the current sea level some 6,500 years ago (Homer and Moore, 1992).

Well 60.190 at the Hahei Holiday Resort, logged by DSIR, was drilled to a depth of nearly 50 m. It's log shows a sequence of clays, carbonaceous mudstone, pyritised silica and boulder layers overlying fresh, pink, biotite, rhyolite at a depth of 30 m. Some 10 to 20 m of

Quaternary carbonaceous silts and peats indicate former swampy conditions in the vicinity. The most recently drilled water supply well at Hahei Holiday Resort (well 72.2315) was drilled to a depth of 85 m. The driller's log shows predominantly silts to 38 m underlain by rhyolitic formation. Some peaty sediments were reported at a depth of 15 m to 18 m.

Local groundwater abstraction is predominantly to supply four community water supplies. These are typically from wells 50 m to 100 m deep and mostly centred around the Pa Rd area. Water supply for the community is derived predominantly from a fractured, rhyolite aquifer. The movement of groundwater through the aquifer is fracture dominated. The main, fractured rhyolite aquifer was previously flow tested by the author using a water supply well (60-20) on Pa Rd in 1991 (Hadfield and Robertson, 1991). This work showed the aquifer to be confined and hydraulically limited with a low mean transmissivity of about 13 $m^2 d^{-1}$. Static water levels in the central Hahei area are very shallow and have historically been free flowing artesian.

Seasonal pressure on this aquifer is increasing. Although the current cumulative consented take is no more than 640 $m^3 d^{-1}$, substantial seasonal drawdown below sea level is induced. Safe yield to avoid saltwater intrusion is currently unknown and the focus of investigation.

There is potential for saltwater intrusion into the aquifer from lateral migration of a saltwater interface from the ocean. Saltwater upconing is also a possibility although is considered less likely. This is where saltwater moves upward into a freshwater zone in response to pumping (Reilly and Goodman, 1987).

Figures 3 and 4, show seasonal groundwater level decline in the fractured rhyolite aquifer. Automated monitoring in well 72.2315 shows decline to more than six metres below mean sea level at the resort. Figure 4, shows in plan view that there is drawdown in excess of 10 m below mean sea-level (msl) in February 2006 and that decline below msl extends to the coast.

Groundwater from the TCDC water supply at Pa Rd, Hahei, has been analysed for age dating using tritium, CFC and SF_6 by Geological and Nuclear Sciences (2005). Results indicate this water is old with a mean residence time of over a hundred years.

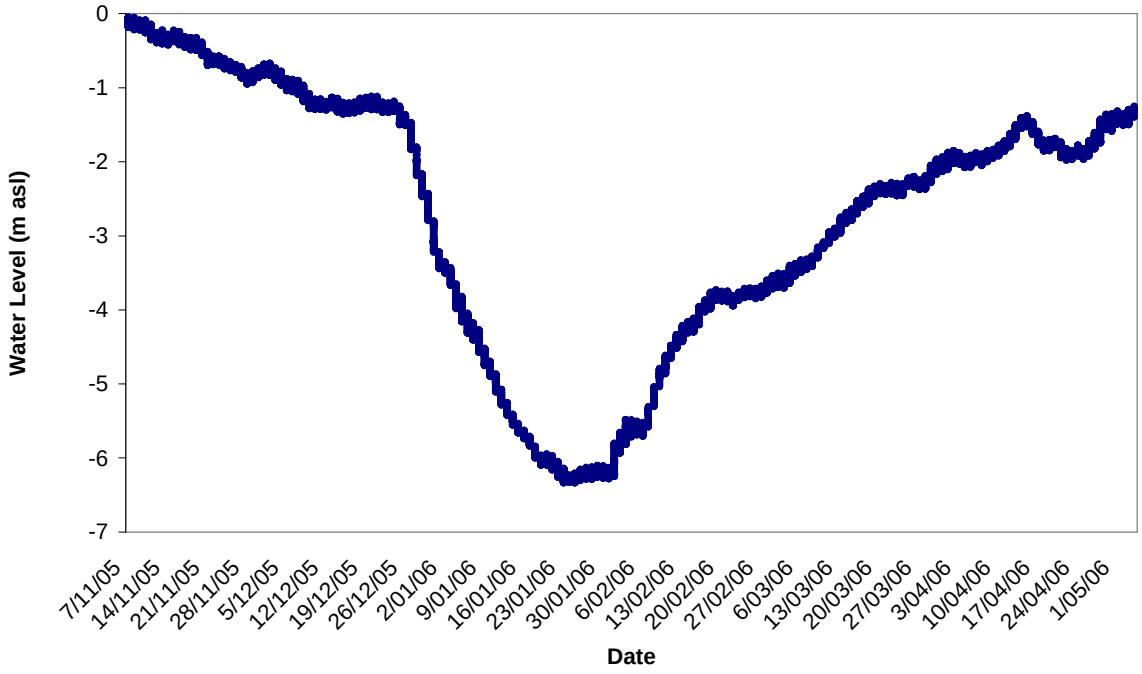

Figure 3 Seasonal groundwater level trend in well 72.2315

Figure 4 Piezometric surface February 1, 2006.

Figure 5 **New sentinel well location map** (T10:61007-80596 marked by arrow)

3 Well construction

Drilling and well construction was undertaken by Boart Longyear (NZ) Ltd using a Mayhew 500 drill-rig. Drilling activities commenced on the 16th of June 2008 using mud flush rotary and a drag bit. A log of the sentinel well is attached in Figure 6 and shows that very little dune sand was encountered. Only a single length of 150 mm diameter temporary casing was required given sands extended only to a depth of 2.6m.

Underlying the sands is a sequence of occasionally peaty, silts and clay silts extending to 34.7 m. Rhyolite gravels and boulders were encountered at this point with firm rhyolite from about 38 m. The 150 mm diameter drag bit was used to the 100 mm casing point at 45.08 m. Subsequent air drilling with a roller cone was steady to a total depth of 104.2 m. This was through consistent very firm to hard, fresh, pinkish grey, fractured rhyolite.

There was a steady increase in water yield estimated to be over 300 m^3 d^{-1} by the end of drilling. The conductivity and temperature of the air lifted groundwater was monitored throughout the drilling. Conductivity and temperature increased gradually from about 220 *u*S cm^{-1} and 19 ^oC at a depth of about 55 m to about 360 *u*S cm^{-1} and 20.7 ^oC at total depth. Although this is an approximate indication of groundwater quality, given the influence of the air compressor, it was however sufficient to be confident that no saltwater interface had been intercepted during drilling. Given the well had been drilled slightly deeper than any of the community water supply wells without any indication of an impending saltwater interface, it was decided not to drill further than 104 m.

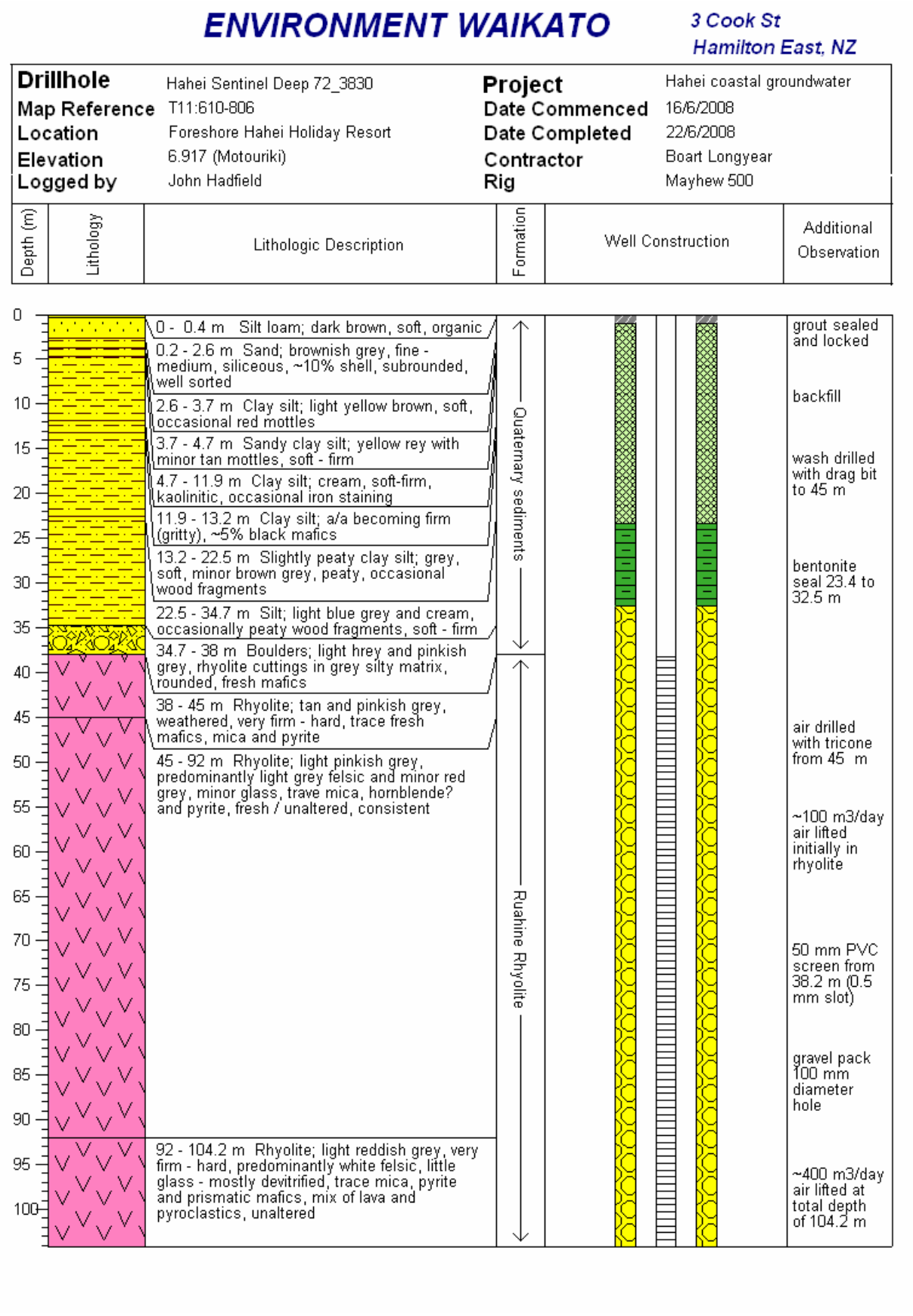

Figure 6 Sentinel monitoring well log

Well construction involved the completion of a ‘deep’ piezometer (72_3830) and an adjacent ‘shallow’ piezometer (72_3831). The ‘deep’ piezometer standpipe is 50 mm diameter PVC, screened from 38.2 m to 104.2 m. A gravel pack extends to 32.5 m below ground, above which there is a bentonite seal to 23.4 m. The drill-hole was then backfilled and sealed with a concrete pad at the surface and lockable toby cover.

Figure 7 Well logging

The adjacent ‘shallow’ piezometer was drilled to a depth of 10.6 m and screened across the water table to a depth of 4.6 m. This piezometer was gravel packed and sealed in a similar fashion. Screen slot size for both piezometers is 0.5 mm with the shallow piezometer screen also having filter sock protection given the silty saturated formation.

Static water level in the deep and shallow piezometers were measured at 6.57 m and 5.73 m respectively on June 26th 2008. The relative levels of the reference point protector rims were measured at 6.917 m and 6.912 m respectively against the Motouriki datum. Water levels indicate there was a shallow recharge gradient at the time of measurement. GPS locations of the deep and shallow piezometers are 2761008 6480598 and 2761007 6480596 respectively.

4 Proposed sentinel well monitoring

It is proposed to monitor water level and water quality at the new sentinel monitoring wells. A transducer will be used to monitor both water level and conductivity in the deeper well and another to monitor level in the shallow well. Water chemistry samples will also be taken from both at regular intervals (at least annually). Initial water quality analysis from sampling of the piezometers on June 26, 2008 is appended. This shows the water to be of high quality, with low salinity and low heavy metals concentrations. The ratios of chloride, iodide, bromide and fluoride do not suggest any seawater influence. Water quality in the shallow piezometer may still be slightly influenced by the drilling process.

Profiles of conductivity will also be measured in the deep well on a regular basis (probably annually). This is to look for any change which may indicate the ingress of a saltwater wedge. The current absence of seawater in the well and isolation provided by a large thickness of fine grained formation overlying the aquifer is reassuring. However, slow changes can still occur and a sustainable yield from this resource is yet to be confirmed.

Appendix 1 Bore reports

Bore Report

Construction Details

Bore Id: 72_3830
Name: Bores (Waikato Region) @ Environment Waikato (Deep)
Hahei Motor Camp
Driller: Boart Longyear Drillwell
Date Completed: 21/06/2008
Map Reference: T11:610-805 **Accuracy:** +/- .01 m
Observed WQ: Good **Geothermal:** N
Casing: PVC **Screen:** PVC
Bore Depth: 104.2 m **Bore Diameter:** 100 mm
Casing Depth: 38.2 m **Casing Diameter:** 50 mm
Screen Interval: 38.2 to 104.2 m **Slot Size:** 0.5 mm
Purpose:
Comments: This is a sentinel monitoring well constructed by EW on DOC land immediately on the beach side of the Hahei Holiday Resort. It will provide warning of any potential saltwater intrusion threat to the Hahei water supplies through conductivity and water level monitoring.
Well surveyed in off bench mark CES334 in sand dunes above toilet block at the camp.Environment waikato survey book HS15 page 20.

Stratigraphic Log

Depth (m)	Primary Lithology	Secondary Lithology	Description
0 - 0.4	Silt	Clay	
0.4 - 2.6	Sands		
2.6 - 3.7	Silt	Clay	
3.7 - 4.7	Silt	Clay	
4.7 - 11.9	Silt	Clay	
11.9 - 13.2	Silt	Clay	
13.2 - 22.5	Silt	Clay	
22.5 - 34.7	Silt		Air drilled from 45 m
34.7 - 38	Gravels		Water inflow initially in rhyolite ~ 100 m3/day
38 - 45	Rhyolite		
45 - 92	Rhyolite		Increasing inflow to ~400 m3/day by TD
92 - 104.2	Rhyolite		

Bore Report

Construction Details

Bore Id: 72_3831
Name: Bores (Waikato Region) @ Environment Waikato (shallow)
Hahei Motor Camp
Driller: Boart Longyear Drillwell
Date Completed: 21/06/2008
Map Reference: T11:610-805 **Accuracy:** +/- .01 m
Observed WQ: Unknown **Geothermal:** N
Casing: PVC **Screen:** PVC
Bore Depth: 10.6 m **Bore Diameter:** 100 mm
Casing Depth: 4.6 m **Casing Diameter:** 50 mm
Screen Interval: 4.6 to 10.6 m **Slot Size:** 0.5 mm
Purpose:
Comments: Shallow monitoring piezometer adjacent to deeper 72_3820. Filter sock used as screened into silt

Sample Results 72_3830

Sample	Date	Parameter	Result	Detection Limit
95634	26/06/2008 11:30:00 a.m.	Alkalinity Total Potentiometric autotitration to pH 4.5. APHA 2320B.	46 g/m3-CaCO3	1
95634	26/06/2008 11:30:00 a.m.	Ammoniacal Nitrogen Filtered Sample. Colorimetry, Phenolhypochlorite Discrete Analyser. APHA Method 4500-NH3 F (modified from manual analysis) (NH4-N = NH4-N + NH3-N).	<.01 g/m3-N	0.01
95634	26/06/2008 11:30:00 a.m.	Antimony Total Recoverable ICP-MS after HNO3 digestion	<.00021 g/m3	0.00005
95634	26/06/2008 11:30:00 a.m.	Arsenic Total Recoverable ICP-MS after HNO3 digestion. APHA 3125 B.	.0076 g/m3	0.0002
95634	26/06/2008 11:30:00 a.m.	Boron Total Recoverable ICP- MS after HNO3 digestion. APHA 3125B.	.027 g/m3	0.005
95634	26/06/2008 11:30:00 a.m.	Bromide Dissolved Ion chromatography. APHA 4110B	.19 g/m3	0.05
95634	26/06/2008 11:30:00 a.m.	Calcium Total ICP-MS after HNO3 digestion	11 g/m3	0.02
95634	26/06/2008 11:30:00 a.m.	Chloride Dissolved Filtered sample, Ion chromotography. APHA 4110B.	59 g/m3	0.5
95634	26/06/2008 11:30:00 a.m.	Conductivity - Field Meter Field meter at 25 deg.C	30.6 mS/m @25"C	0.1
95634	26/06/2008 11:30:00 a.m.	Conductivity - Lab Meter Measured in lab by meter @ 25"C. APHA Method 2510B	31 mS/m @25"C	0.1
95634	26/06/2008 11:30:00 a.m.	Copper Total Recoverable ICP-MS after HNO3 digestion. APHA 3125B.	.0017 g/m3	0.0002
95634	26/06/2008 11:30:00 a.m.	Depth to groundwater manual reading Depth to groundwater, manual reading	6.57 m	
95634	26/06/2008 11:30:00 a.m.	Fluoride Specific ion electrode.APHA 4500-FC.	.078 g/m3	0.05
95634	26/06/2008 11:30:00 a.m.	Free Carbon Dioxide Free Carbon Dioxide Calculation from alkalinity & pH (APHA 4500 CO2D)	19 g/m3-CO2	1
95634	26/06/2008 11:30:00 a.m.	Hardness Total Calculation from Ca and Mg. APHA 2340B.	43 g/m3-CaCO3	1
95634	26/06/2008 11:30:00 a.m.	Iodide Total Sample digestion with aqueous TMAH at 90 degrees. ICP-MS determination. APHA 3125 B	.0067 g/m3	0.0004
95634	26/06/2008 11:30:00 a.m.	Iron Total Recoverable ICP-MS after HNO3 digestion. APHA 3125B.	1.8 g/m3	0.005
95634	26/06/2008 11:30:00 a.m.	Magnesium Total ICP-MS after HNO3 digestion	3.7 g/m3	0.02
95634	26/06/2008 11:30:00 a.m.	Manganese Total Recoverable ICP-MS after HNO3 digestion. APHA 3125B.	.067 g/m3	0.0002
95634	26/06/2008 11:30:00 a.m.	Nitrate Nitrogen - Ion Chromat Ion chromatography. APHA 4110B	<.05 g/m3-N	0.02
95634	26/06/2008 11:30:00 a.m.	Potassium Total ICP-MS after HNO3 digestion. APHA 3215 B.	9.1 g/m3	0.05
95634	26/06/2008 11:30:00 a.m.	Sodium Total ICP-MS after HNO3 digestion	40 g/m3	0.5
95634	26/06/2008 11:30:00 a.m.	Sulphate Turbidimetric. APHA 4500-SO4 E (modified).	8 g/m3	0.5
95634	26/06/2008 11:30:00 a.m.	Total Dissolved Solids (Approx) Calculated from Electrical Conductivity	210 g/m3	2
95634	26/06/2008 11:30:00 a.m.	Water Temp - meter Meter.Field measurement.	19.6 DegC	0
95634	26/06/2008 11:30:00 a.m.	Zinc Total Recoverable ICP-MS after HNO3 digestion. APHA 3125B.	.0086 g/m3	0.0005
95634	26/06/2008 11:30:00 a.m.	pH - Lab Meter Measured in lab by meter. APHA Method 4500-H+ B.	6.7 pH	1

Sample Results 72_3831

Sample	Date	Parameter	Result	Detection Limit
95635	26/06/2008 11:20:00 a.m.	Alkalinity Total Potentiometric autotitration to pH 4.5. APHA 2320B.	260 g/m3-CaCO3	1
95635	26/06/2008 11:20:00 a.m.	Ammoniacal Nitrogen Filtered Sample. Colorimetry, Phenolhypochlorite Discrete Analyser. APHA Method 4500-NH3 F (modified from manual analysis) (NH4-N = NH4-N + NH3-N).	<.01 g/m3-N	0.01
95635	26/06/2008 11:20:00 a.m.	Antimony Total Recoverable ICP-MS after HNO3 digestion	<.00021 g/m3	0.00005
95635	26/06/2008 11:20:00 a.m.	Arsenic Total Recoverable ICP-MS after HNO3 digestion. APHA 3125 B.	<.0011 g/m3	0.0002
95635	26/06/2008 11:20:00 a.m.	Boron Total Recoverable ICP- MS after HNO3 digestion. APHA 3125B.	.02 g/m3	0.005
95635	26/06/2008 11:20:00 a.m.	Bromide Dissolved Ion chromatography. APHA 4110B	.29 g/m3	0.05
95635	26/06/2008 11:20:00 a.m.	Calcium Total ICP-MS after HNO3 digestion	90 g/m3	0.02
95635	26/06/2008 11:20:00 a.m.	Chloride Dissolved Filtered sample, Ion chromotography. APHA 4110B.	57 g/m3	0.5
95635	26/06/2008 11:20:00 a.m.	Conductivity - Field Meter Field meter at 25 deg.C	61.7 mS/m @25"C	0.1
95635	26/06/2008 11:20:00 a.m.	Conductivity - Lab Meter Measured in lab by meter @ 25"C. APHA Method 2510B	69 mS/m @25"C	0.1
95635	26/06/2008 11:20:00 a.m.	Copper Total Recoverable ICP-MS after HNO3 digestion. APHA 3125B.	.00071 g/m3	0.0002
95635	26/06/2008 11:20:00 a.m.	Depth to groundwater manual reading Depth to groundwater, manual reading	5.73 m	
95635	26/06/2008 11:20:00 a.m.	Fluoride Specific ion electrode.APHA 4500-FC.	.089 g/m3	0.05
95635	26/06/2008 11:20:00 a.m.	Free Carbon Dioxide Free Carbon Dioxide Calculation from alkalinity & pH (APHA 4500 CO2D)	36 g/m3-CO2	1
95635	26/06/2008 11:20:00 a.m.	Hardness Total Calculation from Ca and Mg. APHA 2340B.	290 g/m3-CaCO3	1
95635	26/06/2008 11:20:00 a.m.	Iodide Total Sample digestion with aqueous TMAH at 90 degrees. ICP-MS determination. APHA 3125 B	.041 g/m3	0.0004
95635	26/06/2008 11:20:00 a.m.	Iron Total Recoverable ICP-MS after HNO3 digestion. APHA 3125B.	<.021 g/m3	0.005
95635	26/06/2008 11:20:00 a.m.	Magnesium Total ICP-MS after HNO3 digestion	15 g/m3	0.02
95635	26/06/2008 11:20:00 a.m.	Manganese Total Recoverable ICP-MS after HNO3 digestion. APHA 3125B.	.0038 g/m3	0.0002
95635	26/06/2008 11:20:00 a.m.	Nitrate Nitrogen - Ion Chromat Ion chromatography. APHA 4110B	2.1 g/m3-N	0.02
95635	26/06/2008 11:20:00 a.m.	Potassium Total ICP-MS after HNO3 digestion. APHA 3215 B.	3 g/m3	0.05
95635	26/06/2008 11:20:00 a.m.	Sodium Total ICP-MS after HNO3 digestion	33 g/m3	0.5
95635	26/06/2008 11:20:00 a.m.	Sulphate Turbidimetric. APHA 4500-SO4 E (modified).	18 g/m3	0.5
95635	26/06/2008 11:20:00 a.m.	Total Dissolved Solids (Approx) Calculated from Electrical Conductivity	460 g/m3	2
95635	26/06/2008 11:20:00 a.m.	Water Temp - meter Meter.Field measurement.	17.7 DegC	0
95635	26/06/2008 11:20:00 a.m.	Zinc Total Recoverable ICP-MS after HNO3 digestion. APHA 3125B.	.0018 g/m3	0.0005
95635	26/06/2008 11:20:00 a.m.	pH - Lab Meter Measured in lab by meter. APHA Method 4500-H+ B.	7.2 pH	1