Investigative Drilling, Aquifer and Groundwater Salinity Testing - Naracoorte Water Supply, Bool Lagoon Investigation

DEWNR Technical note 2015/03

Government of South Australia
Department of Environment, Water and Natural Resources

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Summary

The Naracoorte town water supply is currently sourced from the confined Dilwyn Formation aquifer, which has a groundwater salinity between 1,200 and 1,300 mg/L. The Australian Drinking Water Guidelines 6 (2011) recommend that municipal supplies should aim for a salinity of less than 1,000 mg/L. The salinity in the unconfined Gambier Limestone aquifer in the Naracoorte area also exhibits salinities in the range of 1,200 to 1,500 mg/L, suggesting a downward connectivity between the aquifers, probably occurring via the Kanawinka Fault, a major stratigraphic feature located at the western edge of the Naracoorte Range.

A South Australian Water Corporation (SA Water) investigation (Somaratne and Lawson, 2010) defined an area 20 to 25 kilometres south-west of Naracoorte near Bool Lagoon to be a potential source of low salinity groundwater in the Dilwyn Formation. Privately-drilled confined-aquifer production wells indicated groundwater salinities between 660 and 700 mg/L.

In early 2013 the Department of Environment, Water and Natural Resources (DEWNR) was contracted by SA Water to supervise the drilling and construction of several investigation wells primarily targeting the Dilwyn Formation. Aquifer tests were conducted and groundwater quality sampling was undertaken.

The unconfined Gambier Limestone and confined Dilwyn Formation in the investigation area show a groundwater head difference of 12 m, indicating natural inter-aquifer leakage has a potential to occur from the unconfined to the confined aquifer. However, the markedly different groundwater salinities between aquifers indicate limited exchange is occurring. The main aquifer test provided information through interpreted transmissivity values, groundwater salinity data and groundwater head comparisons on the degree of confinement between the Dilwyn Formation and the overlying Gambier Limestone. Both the groundwater level and groundwater salinity results indicate the aquifer is has a high level of confinement.

At all investigation well sites, the confined aquifer is continuous with coarse, highly-transmissive sands capable of producing large volumes of groundwater. Aquifer tests produced low salinity groundwater from the confined Dilwyn Formation with the development of very little drawdown. The results allow SA Water to pick the best location for a well field to provide for the long term municipal water supply for Naracoorte if that becomes part of future planning.

The Bool Lagoon investigation area can produce low salinity groundwater from the confined Dilwyn Formation which can be developed as a town water supply wellfield to provide the long-term solution for a Naracoorte town water supply. Salinity varies between 580 mg/L (Dilwyn Formation observation well 2) and 720 mg/L (Dilwyn Formation production well), which is below the ADWG recommendation that municipal supplies should have salinity less than 1000 mg/L.

The Bool Lagoon investigation area can provide a secure water supply from the confined aquifer contained within the Dilwyn Formation. The production and observation wells demonstrate the following features that indicate a secure supply into the future including:

- Thickness of the aquifer (> than 60 m)
- Very high transmissivity rates (>3,500 m^2/day)
- Small drawdown (<4 m from an pumping rate of 50 L/sec).

1 Introduction

The Naracoorte water supply is provided from the confined Dilwyn Formation aquifer, which has a groundwater salinity between 1,200 and 1,300 mg/L. The Australian Drinking Water Guidelines 6 (2011) recommend that municipal supplies should aim for a salinity less than 1,000 mg/L.

The salinity in the unconfined Gambier Limestone aquifer in the Naracoorte area also exhibits salinities between 1,200 to 1,500 mg/L suggesting a downward connectivity between the aquifers may be occurring via the Kanawinka Fault, a major structural stratigraphic feature located at the western edge of the Naracoorte Range.

A South Australian Water Corporation (SA Water) investigation (Somaratne and Lawson, 2010) defined an area 20 to 25 kilometres south-west of Naracoorte near Bool Lagoon as a potential source of low salinity groundwater in the Dilwyn Formation. Privately-drilled confined-aquifer production wells indicated groundwater salinities between 660 and 700 mg/L.

In early 2013 the Department of Environment, Water and Natural Resources (DEWNR) was contracted by SA Water to supervise the drilling and construction of several wells. SA Water engaged two drilling contractors Water Dynamics and Thompson Drilling.

The project involved the drilling and construction of one production well 7023-7371 (ROB037) completed in the Dilwyn Formation, three observation wells completed in the Dilwyn Formation [7023-7369 (KLN017), 7023-7368 (KLN018), 7023-7370 (ROB036)] and one observation well completed in the Gambier Limestone [7023-7367 (ROB038)]. The sites were selected by SA Water to target the first sand unit of the Dilwyn Formation which was expected to contain the lowest salinity groundwater. The southern well (7023–7369 KLN017) was located in the confined aquifer groundwater flow path leading from the confined aquifer recharge zone in the Nangwarry area. The eastern well (7023–7368 KLN018) allowed determination of the Dilwyn Formation to the east of the groundwater flow path. An additional well at this site was completed in the shallow sandstone aquifer adjacent to the confined well, to supply water for drilling and also allowed the head difference between the aquifers to be determined. The well details are given in Table 1 and the locations shown in Figure 1 and 2.

DEWNR Groundwater Technical Services conducted aquifer testing on all four wells completed in the Dilwyn Formation. A 72 hour (3 day) duration aquifer test was conducted on the production well, followed by 24 hour (1 day) of recovery monitoring. The objective of this test was to determine the hydraulic connection between the target formation, the Dilwyn Formation, and the overlying Gambier Limestone and any changes in groundwater salinity. The Gambier Limestone observation well was completed at the base of limestone to determine if leakage could be induced downwards when the confined aquifer was pumped. This was required to address any concerns from local residents that development of a town water supply well field in the Dilwyn Formation may affect the Gambier Limestone and in-turn the hydrology of Bool Lagoon.

This report discusses the drilling and construction of the wells and the results of the aquifer tests which formed the preliminary phase of an investigation into a new water supply for Naracoorte. This report format is in the form and level of detail agreed between SA Water and DEWNR.

Table 1 Production and observation well details

Unit No.	Obs. No.	Permit No.	Purpose	Target Aquifer
7023-7371	ROB037	231396	Production well	Dilwyn Formation
7023-7369	KLN017	229330	Observation well-1	Dilwyn Formation
7023-7368	KLN018	229306	Observation well-2	Dilwyn Formation
7023-7370	ROB036	229331	Observation well-3	Dilwyn Formation
7023-7367	ROB038	229304	Observation well	Gambier Limestone
7023-7379	KLN016	--	Observation well	Shallow Sandstone

Figure 1 Location of investigation area

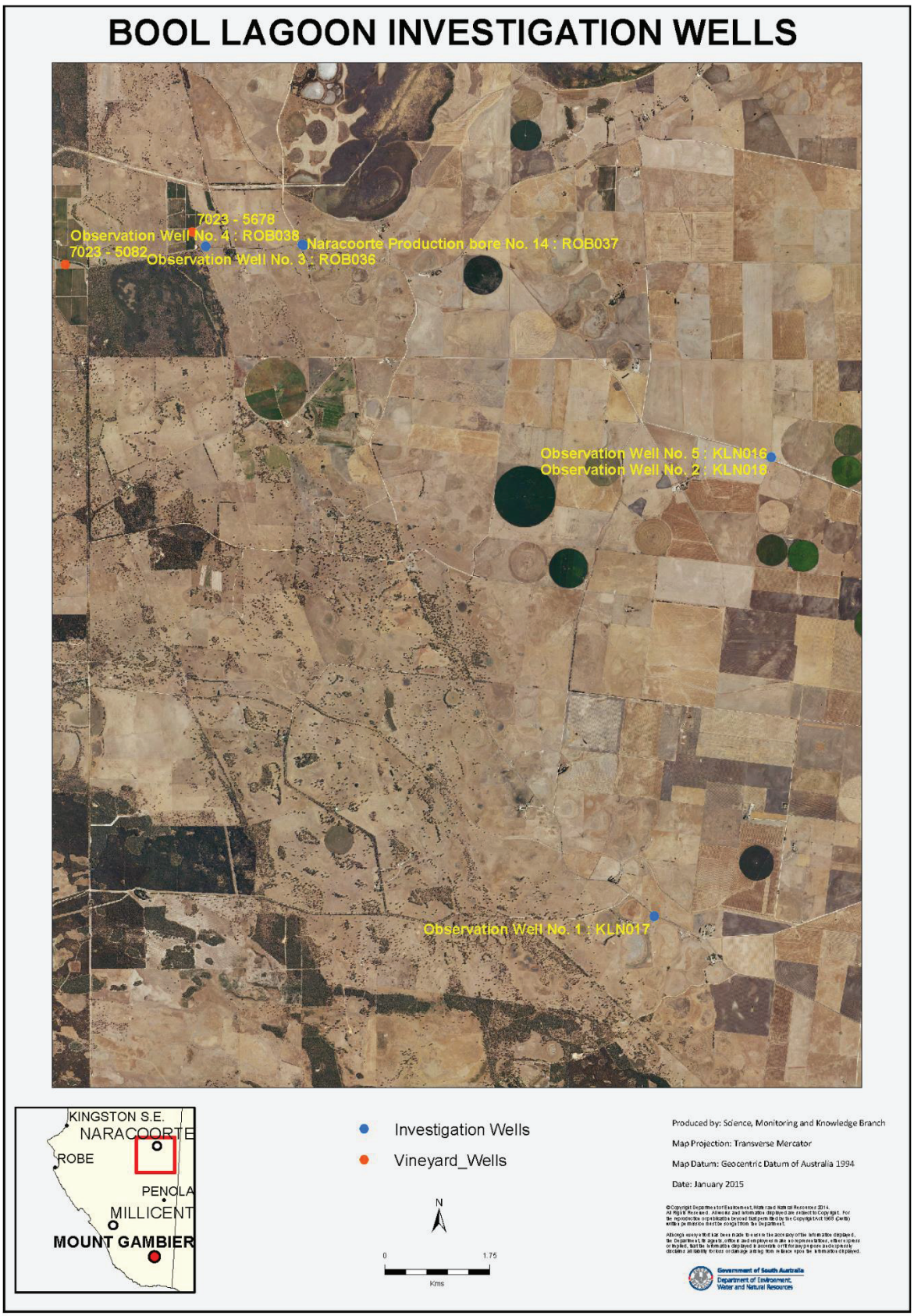


Figure 2 Location of production and observation wells

2 Well Design and Construction

Three confined aquifer wells 7023-5082, 7023-5678, 7023-1850 (KLN010) had been previously drilled in the investigation area but had not been lithologically logged. Strata samples from these wells were logged to obtain a better understanding of the stratigraphy prior to commencing the new drilling program.

Investigation holes were drilled at the site of the Dilwyn Formation production well 7023-7371 (ROB037) and Dilwyn Formation observation well-2 7023-7368 (KLN018) to inform well design. The information allowed the final design of the wells to be determined and allowed exact lengths of casing and screens to be pre ordered prior to drilling and construction.

The Drilling Contractor Well Construction Reports are given in Appendix 9.1. The water well log (including lithological / stratigraphic description) for the previously drilled wells and the new wells is given in Appendix 9.2. Sieve analysis curves for the Dilwyn Formation production well 7023-7371 (ROB037) are given in Appendix 9.3. The details of the drilling and construction of the production well are given in Table 2. Well construction diagrams are given in Figures 3 to Figure 7.

- The sandstone observation well 7023-7379 (KLN016) was completed on 3/2/2014.
- The Gambier Limestone observation well 7023-7367 (ROB038) was completed on 9/4/2014 using permit number 229304. The casing was tremie line cemented in place.
- Dilwyn Formation observation well-2 7023-7368 (KLN018) was completed on 12/4/2014 using permit number 229306. The casing was pressure cemented using drill pipe.
- Dilwyn Formation observation well-1 7023-7369 (KLN017) was drilled completed on 4/5/2014 using permit number 229330. The casing was pressure cemented using drill pipe.
- Dilwyn Formation observation well-3 7023-7370 (ROB036) was completed on 7/5/2014 using permit number 229331. The casing was pressure cemented using drill pipe.
- The Dilwyn Formation production well 7023-7371 (ROB037) was completed on 14/5/2014 using permit number 231396. The casing was pressure cemented using drill pipe.

Table 2 Production and observation well details

Well Number	Drilling depths and diameters (m)	Casing and Production Zone Details (m)
Dilwyn Fm.prod. Well 7023-7371 (ROB037)	0 – 7 and 560 mm 7 – 145 and 380 mm 145 – 157.5 and 250 mm	0 – 7 and 395 mm Steel 0 – 144 and 254 mm FRP 141 – 144.5 and 203 mm Stainless Steel 144.5 – 149.7 and 200 mm Stainless Steel Screen – 0.6 mm aperture 149.7 – 154.5 and 200 mm Stainless Steel screen – 1 mm aperture 154.5 – 156.7 203 mm Stainless steel sump and end cap
Gambier Limestone obs. well 7023-7367 (ROB038)	0 – 6 and 310 mm 6 – 62 and 230 mm 62 – 80 and 160 mm	0 – 6 and 250 mm Steel 0 – 60 and 160 mm PVC Open hole 60 to 80 .
Dilwyn Fm. obs. well-1 7023-7369 (KLN017)	0 – 6 and 350 mm 6 – 220 and 230 mm 220 – 234 and 160 mm	0 – 6 and 250 mm Steel 0 – 216 and 161 mm PVC 203 – 225 and 100 mm PVC 225 – 231 and 96 mm ID Stainless Steel with 0.5 mm aperture. 231 – 233 and 96 mm PVC sump and end cap
Dilwyn Fm. obs. well-2 7023-7368 (KLN018)	0 – 6 and 310 mm 6 – 172 and 230 mm 172 – 186 and 160 mm	0 – 6 and 250 mm Steel 0 – 165 and 161 mm PVC 153 – 177.7 and 100 mm PVC 177.5 – 183.5 and 96 mm ID Stainless Steel with 0.5 mm aperture 183.5 – 185.5 and 100 mm PVC sump and end cap
Dilwyn Fm. obs. well-3 7023-7370 (ROB036)	0 – 6 and 350 mm 6 – 154 and 230 mm 154 – 162 and 160 mm	0 – 6 and 250 mm Steel 0 – 150 and 161 mm PVC 131.8 – 153.8 and 100 mm PVC 153.8 – 159.8 and 96 mm ID Stainless Steel with 0.5 mm aperture 159.8 – 161.8 and 100 mm PVC sump and end cap
Sandstone obs. well 7023-7379 (KLN016)	0 – 8.6 and 205 mm	0 – 8.6 and 159 mm PVC Slotted from 2.3 to 8.6

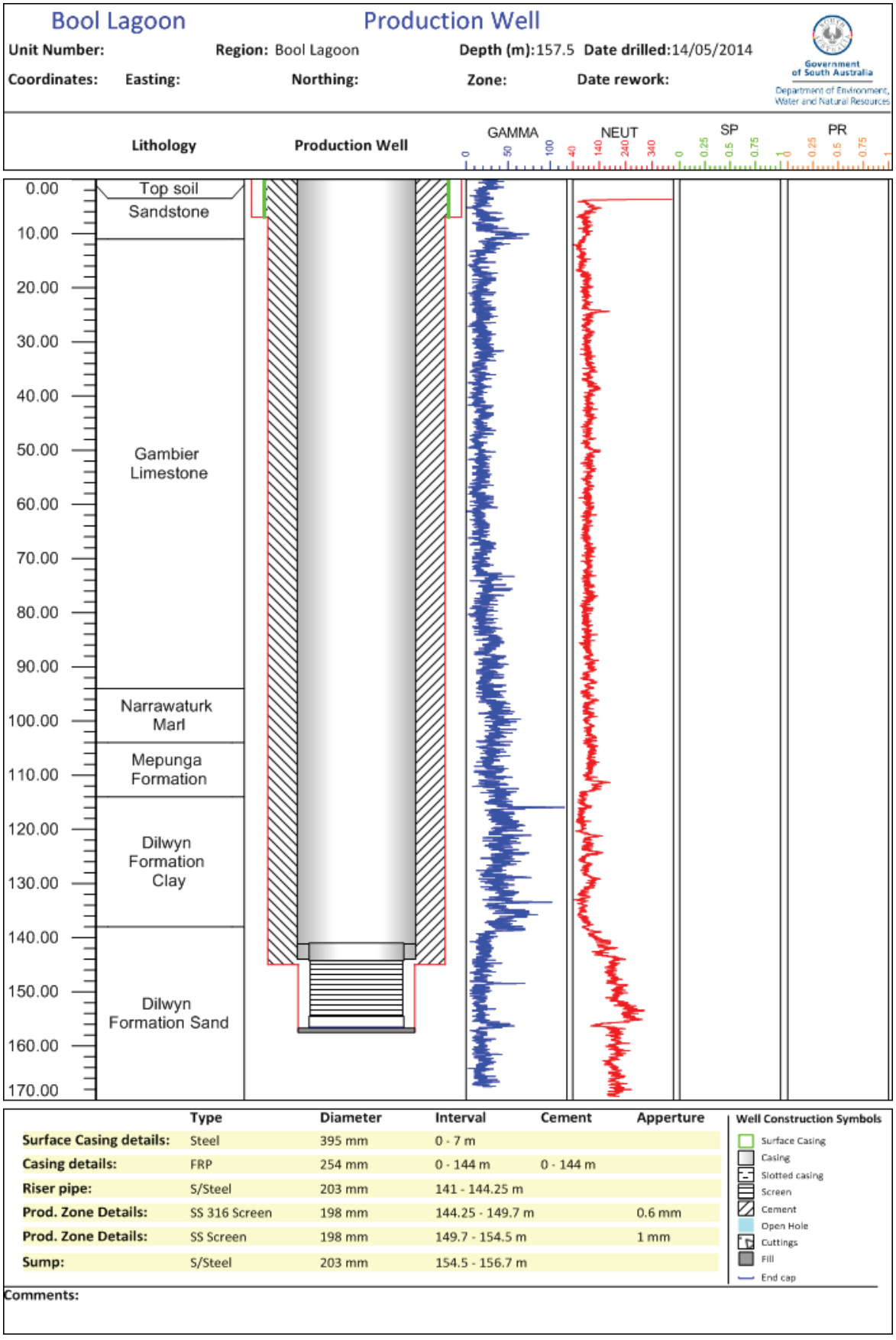


Figure 3 Dilwyn Formation production well 7023-7371 (ROB037) well construction diagram

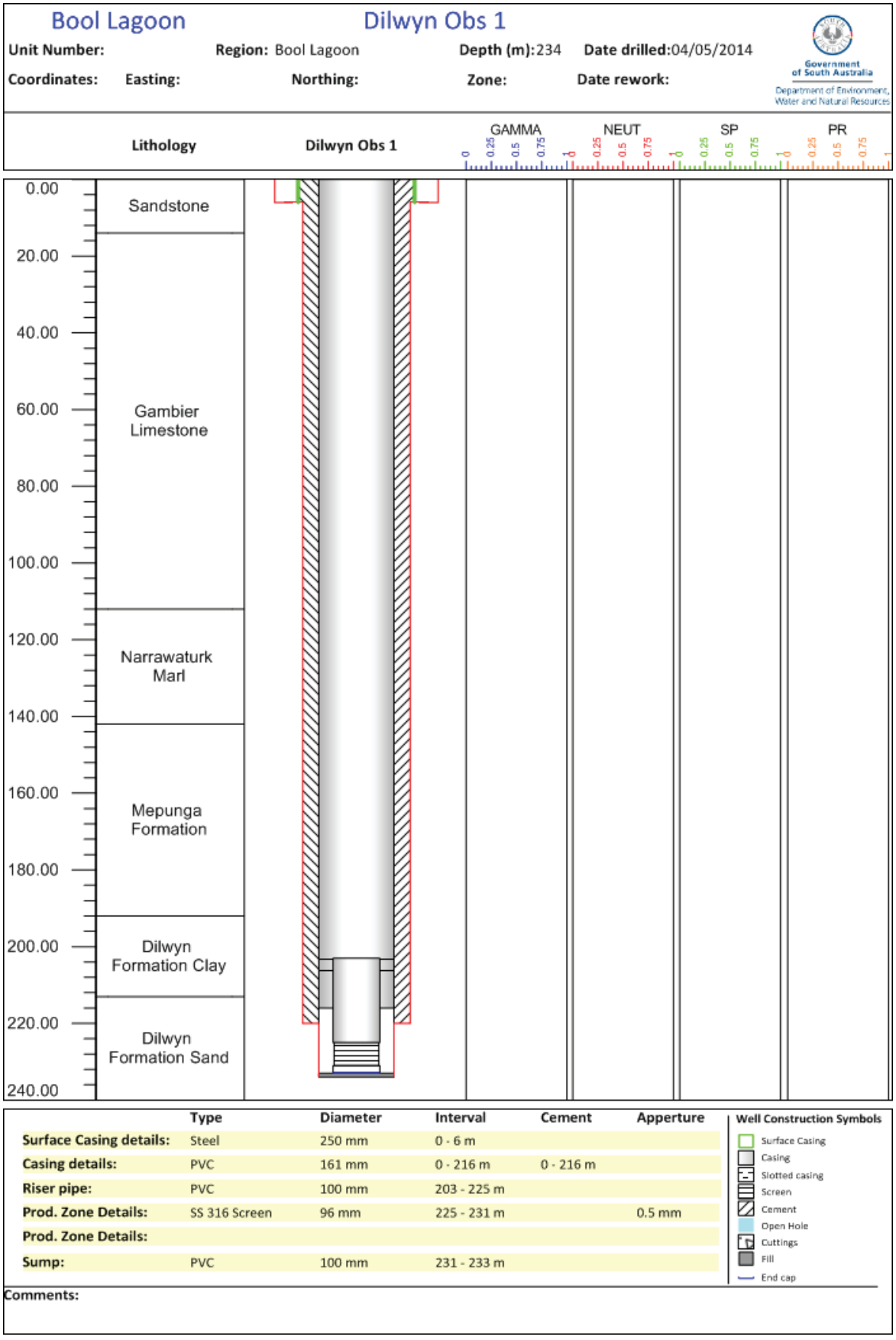


Figure 4 Dilwyn Formation observation well-1 7023-7369 (KLN017) well construction diagram

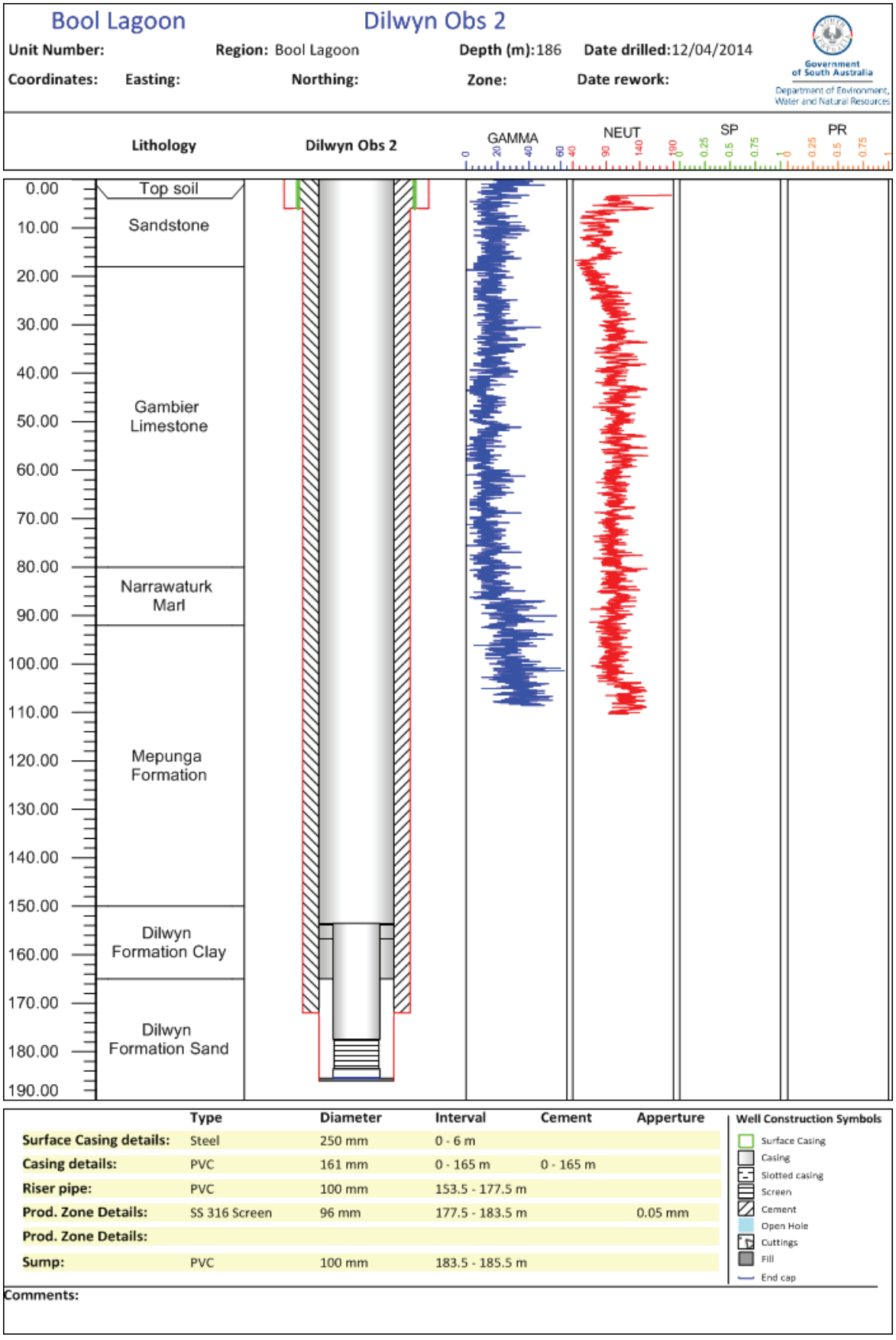


Figure 5 Dilwyn Formation observation well-2 7023-7368 (KLN018) well construction diagram

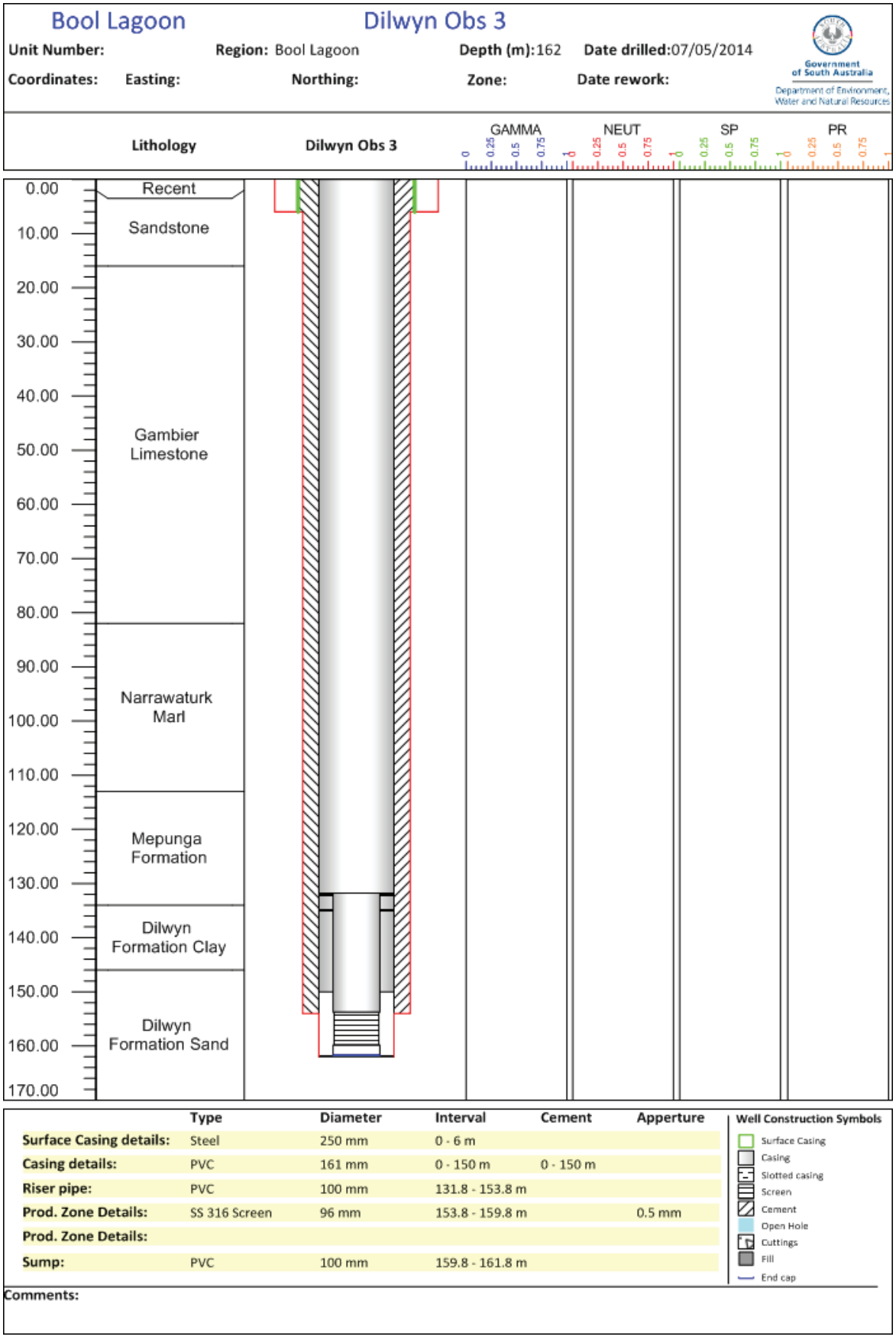


Figure 6 Dilwyn Formation observation well-3 7023-7370 (ROB036) well construction diagram

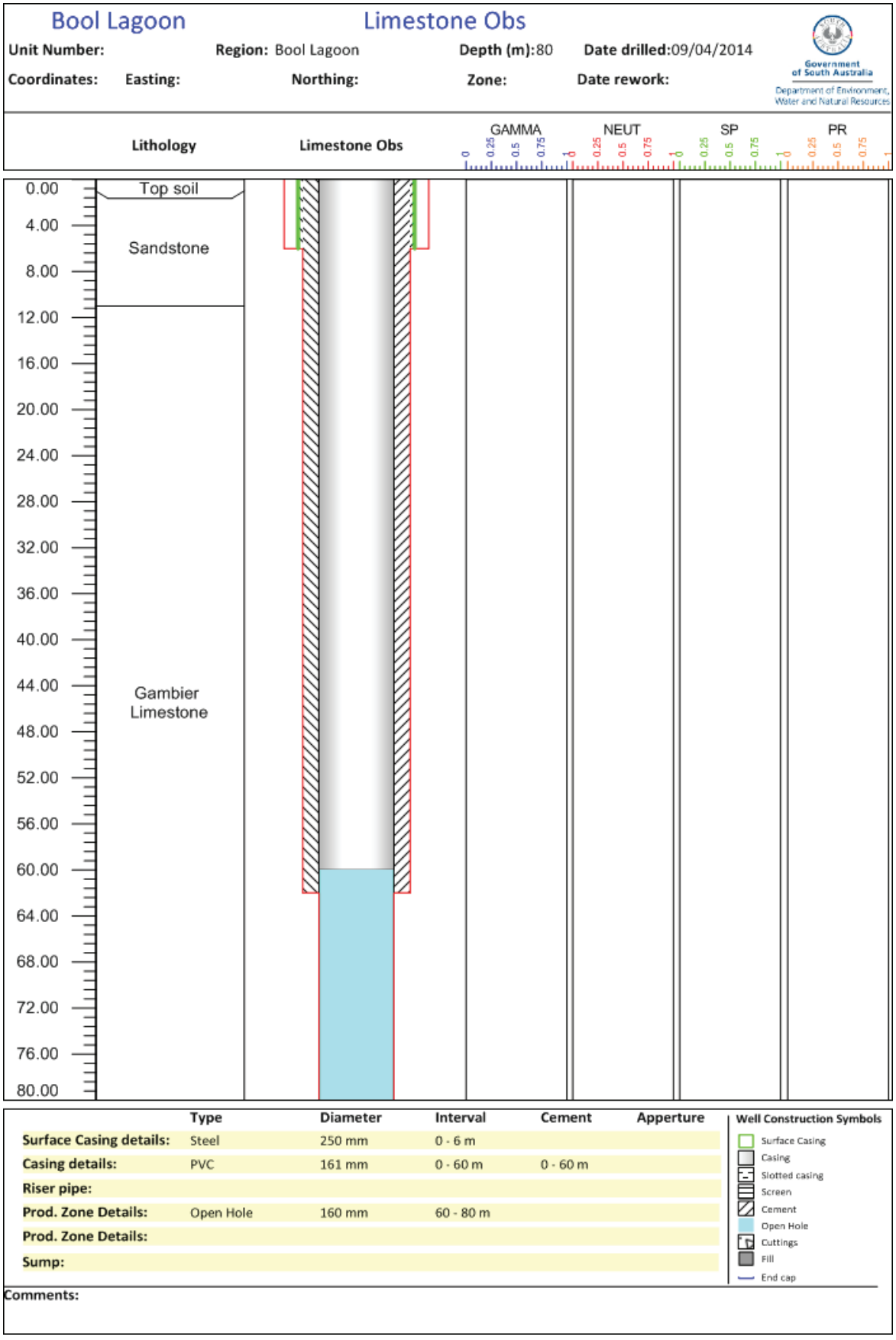


Figure 7 Gambier Limestone observation well 7023-7367 (ROB038) well construction diagram

3 Geology and Hydrogeology

3.1 STRATIGRAPHY

The investigation area is located to the west of the uplifted and Kanawinka Fault controlled Naracoorte Range, resulting in deeper intersection depths for the Dilwyn Formation. The stratigraphy in the investigation area is further complicated by fault activity. At the Penola town water supply well #7 the top of the Dilwyn Formation clay is intersected 107 m below ground surface. At Dilwyn Formation observation well-1 7023-7369 (KLN017) the same surface is intersected at 192 m below ground surface.

Three additional wells as part of the program were drilled further north across typically flat country with the aquitard surface intersected at the following depths:

- 114 m in Dilwyn Formation production well 7023-7371 (ROB037)
- 150 m in Dilwyn Formation observation well-2 7023-7368 (KLN018)
- 134 m in Dilwyn Formation observation well-3 7023-7370 (ROB036).

The fault controlled surfaces will be explored further in a more detailed investigation report in preparation by Lawson.

3.2 AQUITARD ASSESSMENT

Within the Tertiary section of the Gambier Basin, there are two aquifers generally containing low salinity groundwater:

- The unconfined Gambier Limestone often referred to as the Tertiary Limestone Aquifer (TLA). Over most of the region this is overlain by a saturated sandstone section but both units are hydraulically inter-connected.
- A deeper confined aquifer located within the Dilwyn Formation and referred to as the Tertiary Confined Sand Aquifer (TCSA)

These aquifers are isolated from each other by a clay aquitard which is the unit located at the top of the Dilwyn Formation. In most areas there is a stratigraphic transition unit located above the clay unit known as the Mepunga Formation. This can be observed as a light brown clay, but can also occur only as a sand aquifer and in many cases is very thin. The Dilwyn Formation clay aquitard can vary from 2 to 10 m in thickness and can occur either as a dense clay or a sandy clay.

The vertical hydraulic gradient and hydraulic conductivity of the aquitard control the extent of leakage occurring between the two aquifers.

In the investigation area a major consideration was whether leakage could occur between the unconfined and confined aquifers resulting in possible inducement of higher salinity groundwater downwards. From the drilling program an observed head difference of about 12 m occurs, meaning the confined aquifer water level is lower than the unconfined water level, creating a potential pressure differential to allow groundwater to leak downwards. Inter aquifer leakage through the region occurs naturally via the aquitard, however if the clay is thick and dense this may take a long time to occur.

In the study area three stratigraphic units form the aquitard:

- Narrawaturk Marl – a basal limestone marl with strong glauconitic staining. The top of the unit can be difficult to determine as many parts of the limestone can be glauconitically stained.
- Mepunga Formation – occurs both as a marl/clay and also as a sand unit. It can both be an aquitard but also have a transmissive section.
- Dilwyn Formation C1 Aquitard – the thick dark clays at the top of the formation. The sand content embedded in the clay can vary but it is commonly observed as a strongly bound clay.

Table 3 shows that the total aquitard is thickest at around 100 m at the southern end of the investigation area. The densest section at the C1 aquitard is 21 m thick. At Dilwyn Formation observation well-3 7023-7370 (ROB036), 1.5 km west, the C1 aquitard is 12 m thick.

To put these numbers in context, in the Nangwarry forest area where the most recharge is understood to occur to the confined aquifer, the aquitard is often 5 m or less in thickness (Holmes and Colville 1970, Love 1991, Brown, 2000).

Table 3 Interpreted aquitard thickness at the four locations of drilling

Well Identification	Formation	Depth from and to	Thickness
Dilwyn Formation observation well-1 7023-7369 (KLN017)	Narrawaturk Marl	112 – 142	30
	Mepunga Formation	142 – 192	50
	Dilwyn Formation C1	192 – 213	21
		TOTAL	**101**
Dilwyn Formation observation well-2 7023-7368 (KLN018)	Narrawaturk Marl	80 – 92	12
	Mepunga Formation	92 – 150	58
	Dilwyn Formation C1	150 – 165	15
		TOTAL	**85**
Dilwyn Formation observation well-3 7023-7370 (ROB036)	Narrawaturk Marl	82 – 113	31
	Mepunga Formation	113 – 134	21
	Dilwyn Formation C1	134 – 146	12
		TOTAL	**64**
Dilwyn Formation production well 7023-7371 (ROB037)	Narrawaturk Marl	94 – 104	10
	Mepunga Formation	104 – 114	10
	Dilwyn Formation C1	114 - 138	24
		TOTAL	**44**

3.3 HYDROGEOLOGY

The difference in the hydraulic head between a confined and unconfined aquifer can be an initial indication of potential hydraulic connectivity. If the water levels were similar hydraulic inter-connectivity would be expected be high. At Mount Gambier a 16 m head difference exists between the two aquifers, although across some faults this has been observed to be less indicating some degree of connectivity.

In the investigation area there were two sites where a head difference could be measured:

1. The confined Dilwyn Formation observation well-2 7023-7368 (KLN018) had a reduced groundwater level of 36.88 m (December 2014) and the unconfined sandstone observation well 7023-7379 (KLN016) had a reduced groundwater level of 49.52 m (December 2014), indicating a head difference of 12.64 m and the potential for downward leakage.
2. The confined Dilwyn Formation production well 7023-7371 (ROB037) had a reduced groundwater level of 47.04 m (December 2014) and the unconfined Gambier Limestone observation well 7023-7367 (ROB038) had a reduced groundwater level of 35.72 m (December 2014), indicating a head difference of 11.32 m and the potential for downward leakage.

These are considered to be significant inter-aquifer head differences indicating that in all probability little leakage is occurring. This is further supported by the local groundwater data showing the Dilwyn Formation confined aquifer having groundwater salinities ranging from 600 to 700 mg/L, while the Gambier Limestone unconfined aquifer has groundwater salinities in the 2,000 mg/L range.

3.4 AQUIFER ASSESSMENT

The Dilwyn Formation sand aquifer is indicated in all wells as an extensive course grained sequence as indicated by the sand sieve analysis (Appendix 9.3). None of the wells drilled in the current program penetrated the base of the formation into the next aquitard. The occurrence of coarse sand would normally indicate a potential high production and small drawdown aquifer and this was confirmed by the aquifer tests.

Dilwyn Formation production well 7023-7371 (ROB037)

Other than a thin clay band between 155 and 157 m (observed on downhole geophysics) the sand sequence is continuous from 138 m to 168 m (30 m). The 50% retained average sand size was a coarse 0.8 mm. At a depth of 168 m the sand was still present, however drilling ceased due to sufficient aquifer being available to obtain the required 50 litre per second pumping rate.

This aquifer sequence could meet the long term supply for Naracoorte, especially as SA Water have indicated it intends to pump at a rate between 25 to 30 L/s, approximately half the rate the aquifer test on the production well was conducted at.

Dilwyn Formation observation well-1 7023-7369 (KLN017)

This site is similar to the production well site. The sand sequence was intersected between 213 and 232 m (19 m). The 50% retained average sand size was 0.77 mm.

The well it replaced, 7023-1850 (KLN010), was logged prior to the commencement of the drilling program and indicated the sand sequence occurring from 213 to 297 m (84 m) with sections being described as gravel. The aquifer production capability at this site is very high.

Dilwyn Formation observation well-2 7023-7368 (KLN018)

At this site the sand sequence was intersected between 135 and 186 m (21 m). The 50% retained average sand size was 0.69 mm which is still a coarse grained aquifer. This site has good production capability.

Dilwyn Formation observation well-3 7023-7370 (ROB036)

At this site the sand sequence was intersected between 146 and 162 m (16 m). The 50% retained average sand size was 1.58 mm sufficient to supply large volumes of groundwater efficiently.

4 Aquifer Test Theory

4.1 Aquifer Test Objectives

An aquifer test is conducted by pumping a well and observing the aquifer response or drawdown in the well and / or neighbouring observation wells. Aquifer tests are carried out on wells to determine one or more of the following:

1. The aquifer and aquitard hydraulic parameters used to determine the ability of the aquifer to store and transmit water and which can be used in analytical and numerical groundwater modelling
2. The existence and potentially location of sub-surface hydraulic boundaries which may affect (beneficially or adversely) the long-term hydraulic behaviour and pumping performance of the well
3. The long-term pumping rate of the well
4. The design efficiency of the well
5. The performance of the groundwater basin.

In this study aquifer tests were required to determine:

1. The maximum sustainable pumping rate for a range of pumping times
2. Hydraulic connection between the target formation, the Dilwyn Formation, and the overlying Gambier Limestone
3. Changes in groundwater salinity during pumping from the Dilwyn Formation.

The aquifer tests that were conducted consisted of a step drawdown test and a constant rate discharge test.

4.2 Step Drawdown Test

The step drawdown test allows determination of the hydraulic behaviour of the well under pumping stress and also evaluate well loss**.** The test usually consists of three or more steps at increasing pumping rates which remain constant throughout each step.

The objective of step drawdown testing is to determine the well equation (below) which reflects the efficiency of the well design and relates the three parameters drawdown, pumping rate and time. This equation (ideally) allows prediction of the hydraulic performance of production wells for a design pumping rate and generation of yield drawdown curves for any given time.

The well equation allows determination of the maximum sustainable pumping rate of the well and consequently the selection of a suitable pumping rate for the constant rate discharge test and long term operational pumping.

$s(t) = (a\,Q + c\,Q^2) + b \log(t)\,Q$

Where:

s(t)	=	drawdown (m)
Q	=	pumping rate (m^3/min)
t	=	time (min)
a	=	constant related to well loss for laminar flow
c	=	constant related to well loss for turbulent flow
b	=	constant related to aquifer loss for laminar flow

and,

Well loss (m) = $a Q + c Q^2$

Aquifer loss (m) = $b \log(t) Q$

Well efficiency = aquifer loss as a percentage of S(t)

The specific capacity is defined as:

SC = Q/S = (L/s)/m of drawdown

4.3 Constant Rate Discharge Test

The constant rate discharge test allows determination of the hydraulic behaviour of the aquifer system under longer term pumping stress. This test is conducted at a constant pumping rate for a duration commensurate with the intended use of the well, however this is often compromised by the cost of running long-term tests.

The drawdown (water level) data collected from the constant rate discharge test allows determination of:

- Aquifer and aquitard hydraulic parameters
- Presence of hydraulic boundaries, which may affect pumping sustainability under long-term operational pumping
- Dewatering of the aquifer system, which may affect pumping sustainability under long-term operational pumping
- Interference with neighbouring production wells.

The constant rate discharge test should ideally be followed by a period of groundwater-level monitoring during the recovery of the well, although this is frequently not undertaken to reduce cost. Recovery is ideally monitored until 95% of the drawdown has been recovered.

The residual drawdown (water level) data collected from the recovery monitoring can be used to determine whether interference effects are present from either recharge boundaries, or conversely from impermeable boundaries or dewatering of the aquifer:

- If no interference is present, the extrapolated residual drawdown should intersect the zero residual drawdown line at $t/t1 = 1$
- If a recharge boundary has been encountered, the line will intersect the zero residual drawdown line at a value of $t/t1 > 1$
- If dewatering has occurred or an impermeable boundary has been encountered, the line will intersect the zero residual drawdown line at a value of $t/t1 < 1$.

Water level measurements made at observation wells during aquifer tests provide important data for gaining a better understanding of the broader aquifer system. Data are more reliable than those measured in the production well where turbulence may exist due to the pump. The data indicate the extent of the hydraulic influence of the production well and allow more accurate determination of aquifer and aquitard hydraulic parameters.

4.4 Groundwater Quality Test

Preliminary groundwater sampling for a town water supply production well with domestic application should be tested for the following suite of chemical parameters (G Dworak and J West (SA Water) 2011 pers. comm. 5 May):

- Basic chemistry: TDS, Na, Ca, Mg, K, CO_3, HCO_3, Cl, F, SO_4, hardness and alkalinity
- pH, colour and turbidity
- nutrients: NH_3, NO_3, NO_2, soluble P and DOC
- metals (total and soluble): Al, Cd, Sb, Ni, Cu, Zn, Pb, Cr, Mn, Fe, As, Ba, Mo, Se, Hg, B, Ag, Be, I, CN, Sn, Zn, Br and U
- radioactivity.

5 Target Well Aquifer Test Results

5.1 Aquifer Test Procedure

The aquifer tests conducted on the Bool Lagoon Dilwyn Formation investigation / production well 7023-7371 (ROB037) consisted of a step drawdown test, a constant rate discharge test followed by recovery monitoring all in July 2014. Test details are given in Table 4 and the results are given in Appendix 9.4 and 9.5.

The former Department for Water 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). Water chemistry results are given in Appendix 9.9.

Table 4 Aquifer test schedule

Test Type	Test Commence Date	Step / Stage	Duration (minutes)	Pumping rate (L/s)
Step drawdown	18/07/2014	1	60	30
		2	60	40
		3	60	50
Constant rate discharge	19/07/2014	1	4,320	50
Recovery	22/07/2014	-	1,440	-

5.2 Step Drawdown Test

Analysis of the step drawdown test results for the Bool Lagoon investigation / production well 7023-7371 (ROB037) (Figure 8) using the Hazel method applicable in sedimentary aquifer results in the following well equation:

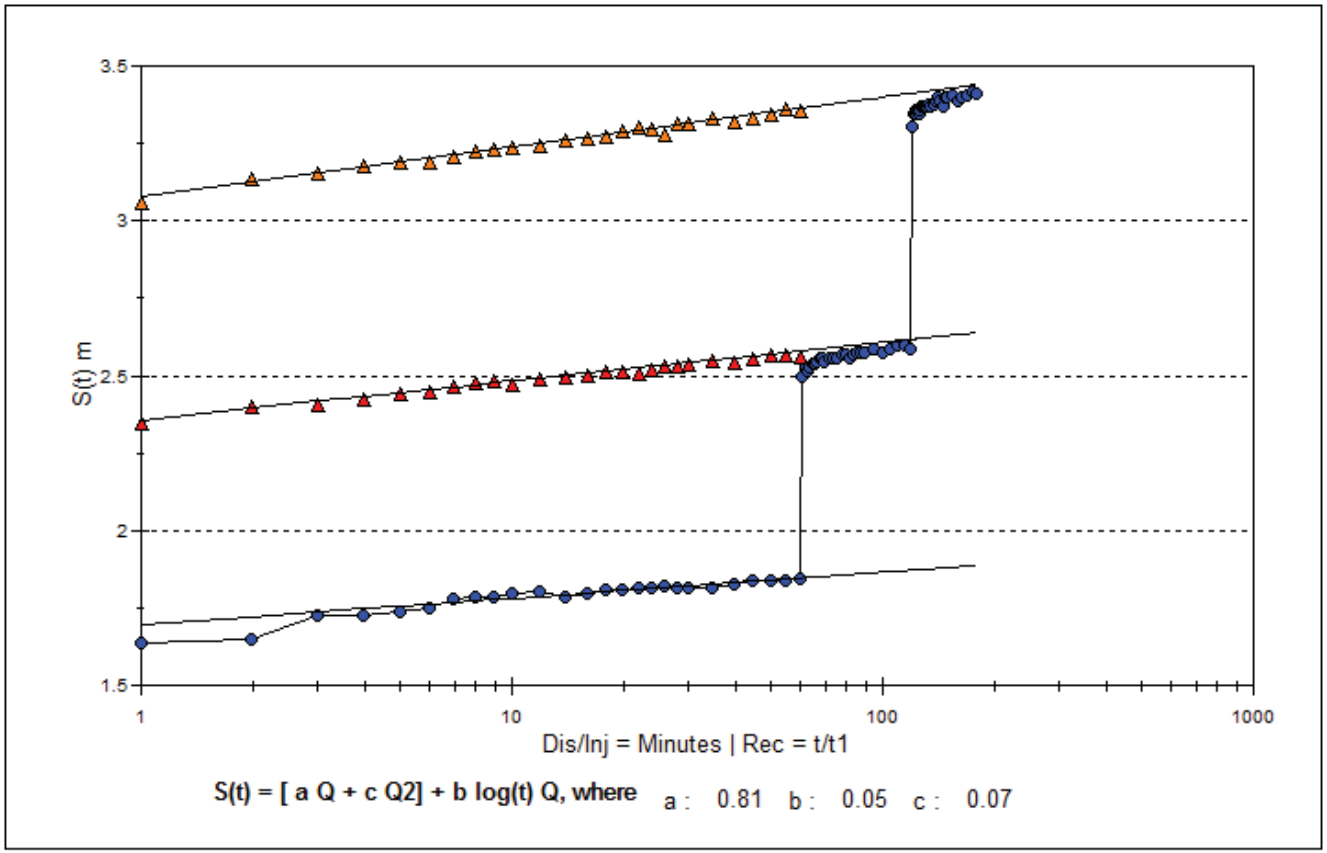
$s(t) = 0.81\ Q + 0.07\ Q^2 + 0.05 \log (t)\ Q$

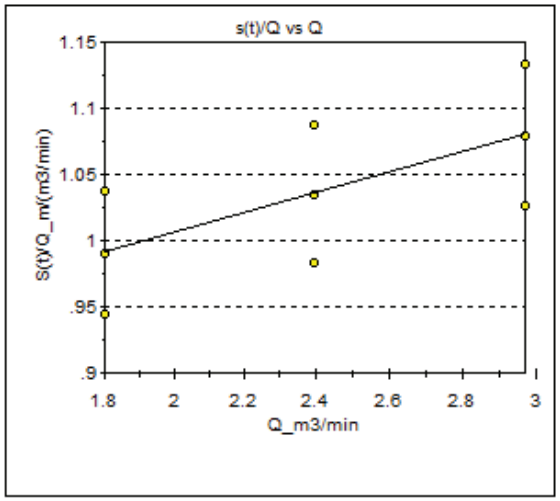
The well equation can be used as a predictive tool for the range of pumping rates used in the step drawdown test and can probably be extended to higher pumping rates. Table 5 gives the predicted drawdown for 1,000,000 minutes (approximately 2 years) of continuous pumping at a range of pumping rates. While the theoretical available drawdown is 107 m, drawdowns are extremely small and this would obviously never be utilised.

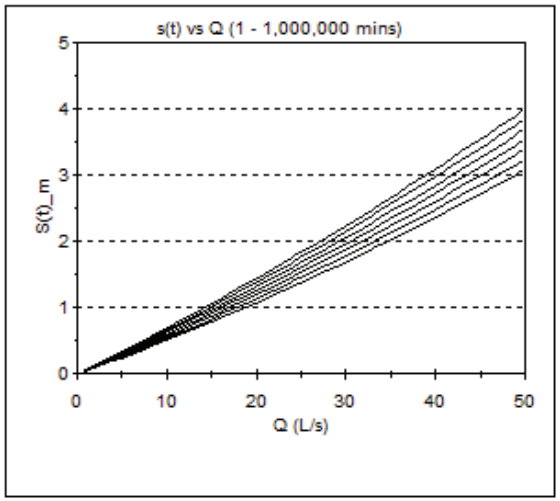
Table 5 Predicted drawdown Dilwyn Formation production well 7023-7371 (ROB037)

Pumping rate (L/s)	*DTW (m)	Casing length (m)	Theoretical available drawdown (m)	Duration (mins)	Predicted drawdown (m)
30	15.3	144	128	1,000,000	2.43
40	15.3	144	128	1,000,000	3.34
50	15.3	144	128	1,000,000	4.31

*Measurement taken at start of step drawdown test and rounded to a whole number







TheStep	Q_L/s	Q_m3/min	Duration_min	St1	St1/Q	St10	St10/Q	St100	St100/Q	dS	dS/Q	T_m2/day
1	30.00	1.80	60	1.70	0.94	1.78	0.99	1.87	1.04	0.08	0.05	5647
2	40.00	2.40	60	2.36	0.98	2.49	1.04	2.61	1.09	0.13	0.05	5060
3	50.00	3.00	60	3.08	1.03	3.24	1.08	3.40	1.13	0.16	0.05	4910
maintest	50.00	3.00	4320									

Figure 8 Dilwyn Formation Production well 7023-7371 (ROB037) step drawdown test analysis Hazel method

5.3 Constant Rate Discharge Test

5.3.1 Design

The wells used in the constant rate discharge test are given in Table 6. The drawdown from the production and observation wells is given in Figure 9. The data from the observation well has been analysed to determine aquifer and aquitard hydraulic parameters. The locations of the observation wells was selected by SA Water and resulted in the principal observation well completed in the target aquifer, the Dilwyn Formation, being sited at a radial distance of 1,627 m from the Dilwyn Formation production well 7023-7371 (ROB037). At this distance the drawdown in minimal and may be influenced by other factors. This means that the results of the analysis, particularly in terms of the hydraulic resistance which is required to understand the hydraulic connection between the target Dilwyn Formation and the overlying Gambier Limestone, are less definitive than may have been the case if a closer observation well was available for use in the test.

Table 6 Constant rate discharge test details

Well	Radial distance to production well (m)	Target Aquifer
Production well 7023-7371 (ROB037)	0	Dilwyn Formation
Observation well-3 7023-7370 (ROB036)	1,627	Dilwyn Formation
Observation well 7023-7367 (ROB038)	23	Gambier Limestone

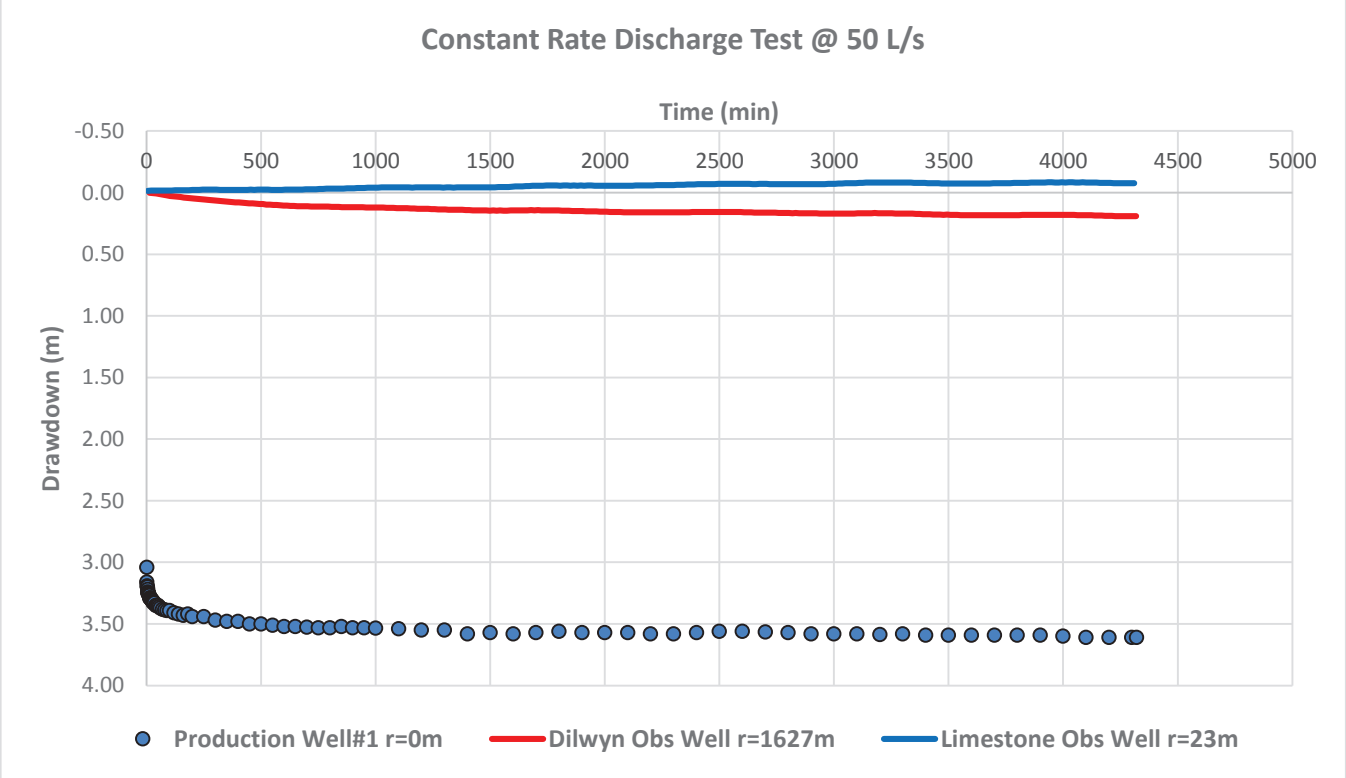


Figure 9 Constant rate discharge test drawdown all wells

5.3.2 Dilwyn Formation production Well 7023-7371 (ROB037), r = 0 m

Drawdown and residual drawdown recorded during the constant rate discharge test and recovery are given in Figure 10.

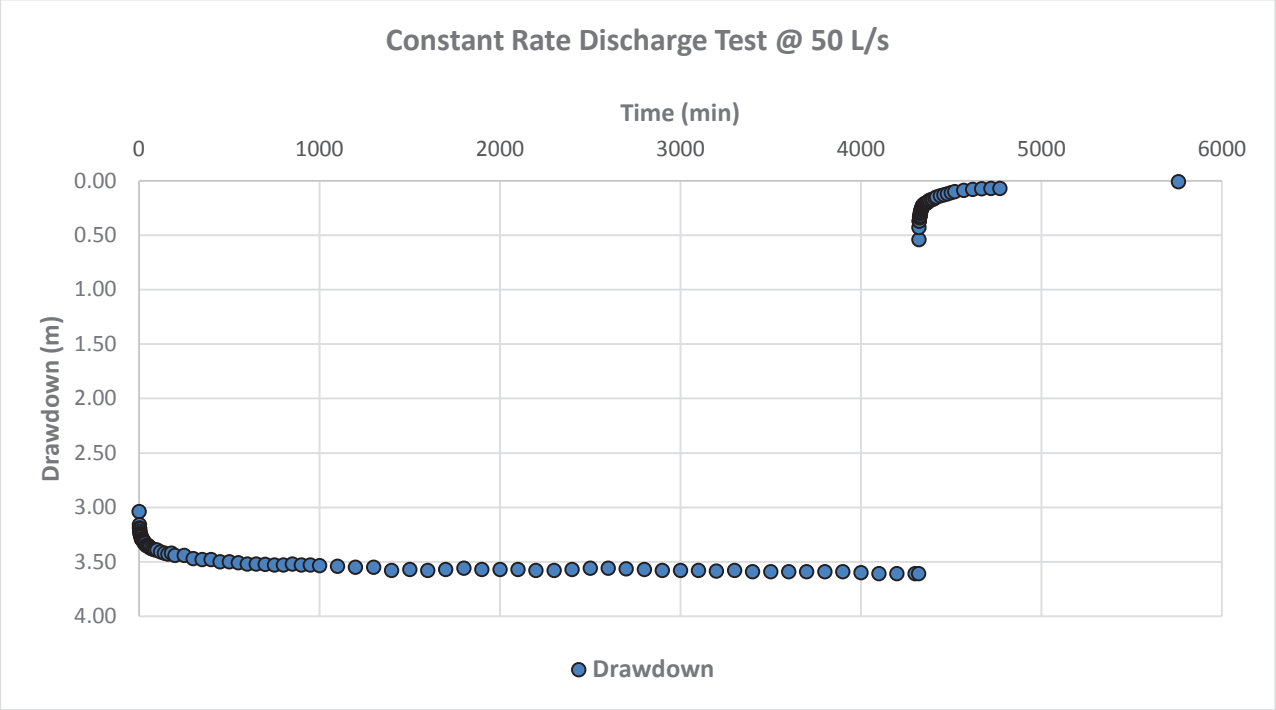


Figure 10 Dilwyn Formation production well 7023-7371 (ROB037) drawdown

Drawdown versus time and residual drawdown versus t/t1 (where t is the time since pumping began and t1 is the time since pumping stopped) are given in Figure 11. The following general comments can be made:

- A drawdown of 3.61 m developed during the test
- The well equation determined from the step drawdown test accurately predicts the drawdown to within 1% of that observed at the end of the constant rate discharge test (Figure 12).
- The specific capacity at the end of the test was 13.8 L/s per metre of drawdown
- Well loss was 85% of drawdown at the end of the test
- Recovery was monitored until the residual drawdown was within 1% of the total drawdown developed. Monitoring was terminated at 1,440 minutes. There is no evidence of dewatering as would be expected in the Dilwyn Formation which is an extensive regional confined aquifer.

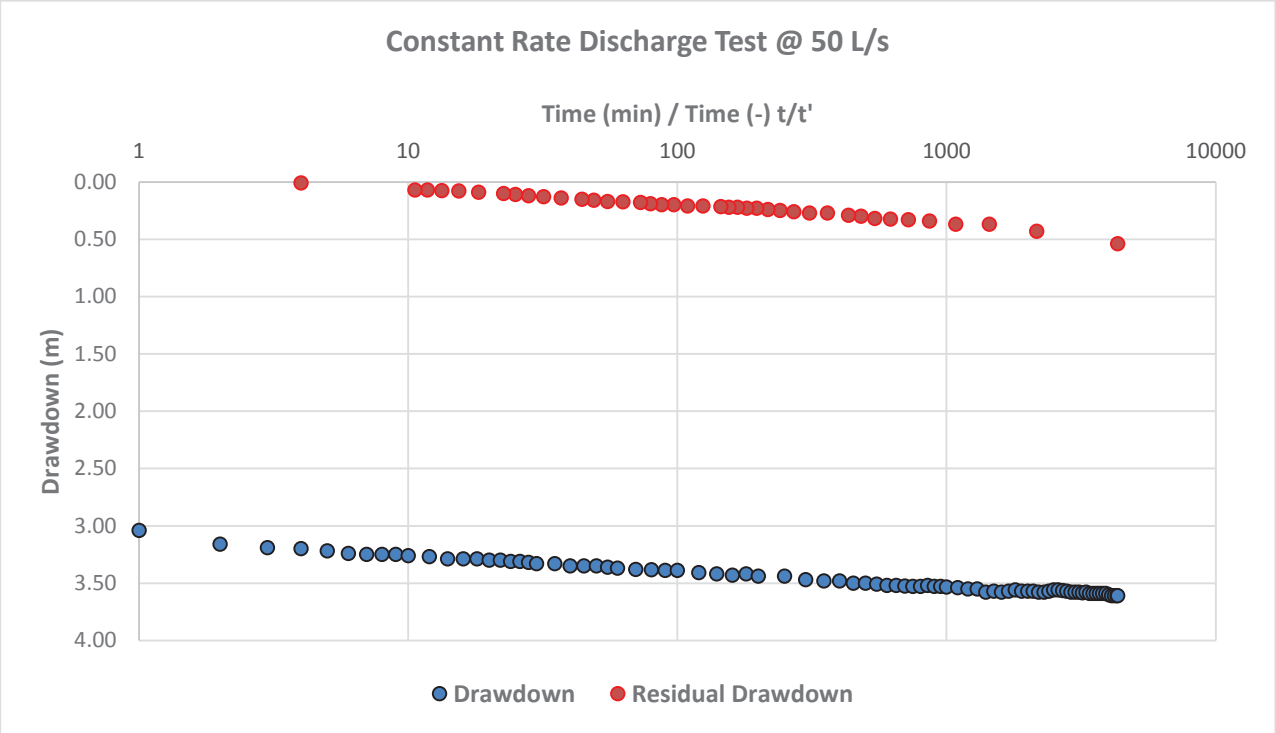


Figure 11 Dilwyn Formation production well 7023-7371 (ROB037) drawdown/residual drawdown

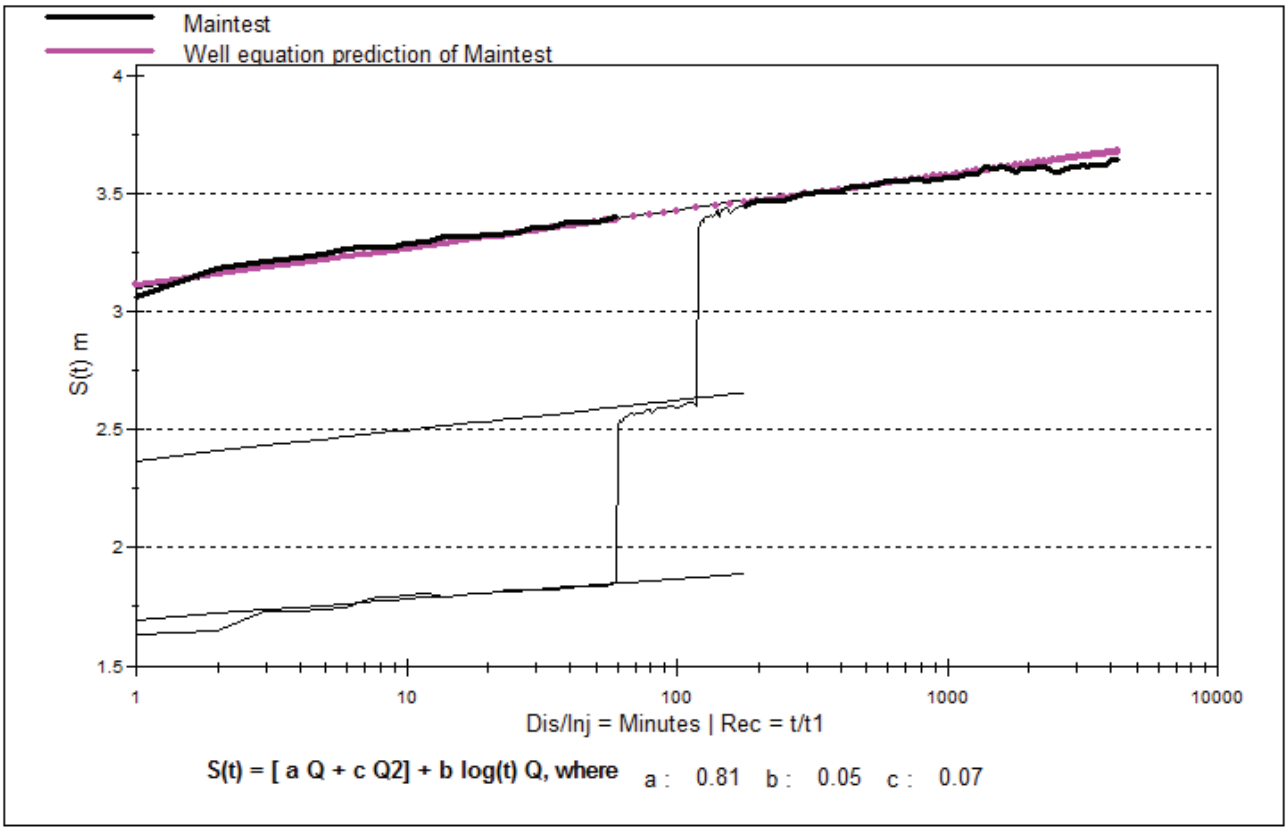


Figure 12 Well equation prediction of Dilwyn Formation production well 7023-7371 (ROB037) drawdown

5.3.3 Dilwyn observation well-3 7023-7370 (ROB036), r = 1,627 m

Drawdown versus time and residual drawdown versus t/t1 are given in Figure 13. The following general comments can be made:

- A drawdown of only 0.192 m developed during the test. This is consistent with the magnitude of drawdown calculated using the Theis equation and which would be expected to develop during the test conducted on a well completed in a confined aquifer.
- The Dilwyn Formation exhibited a drawdown signature at the observation well consistent with a well confined aquifer
- During the period of the test no hydraulic boundaries were evident

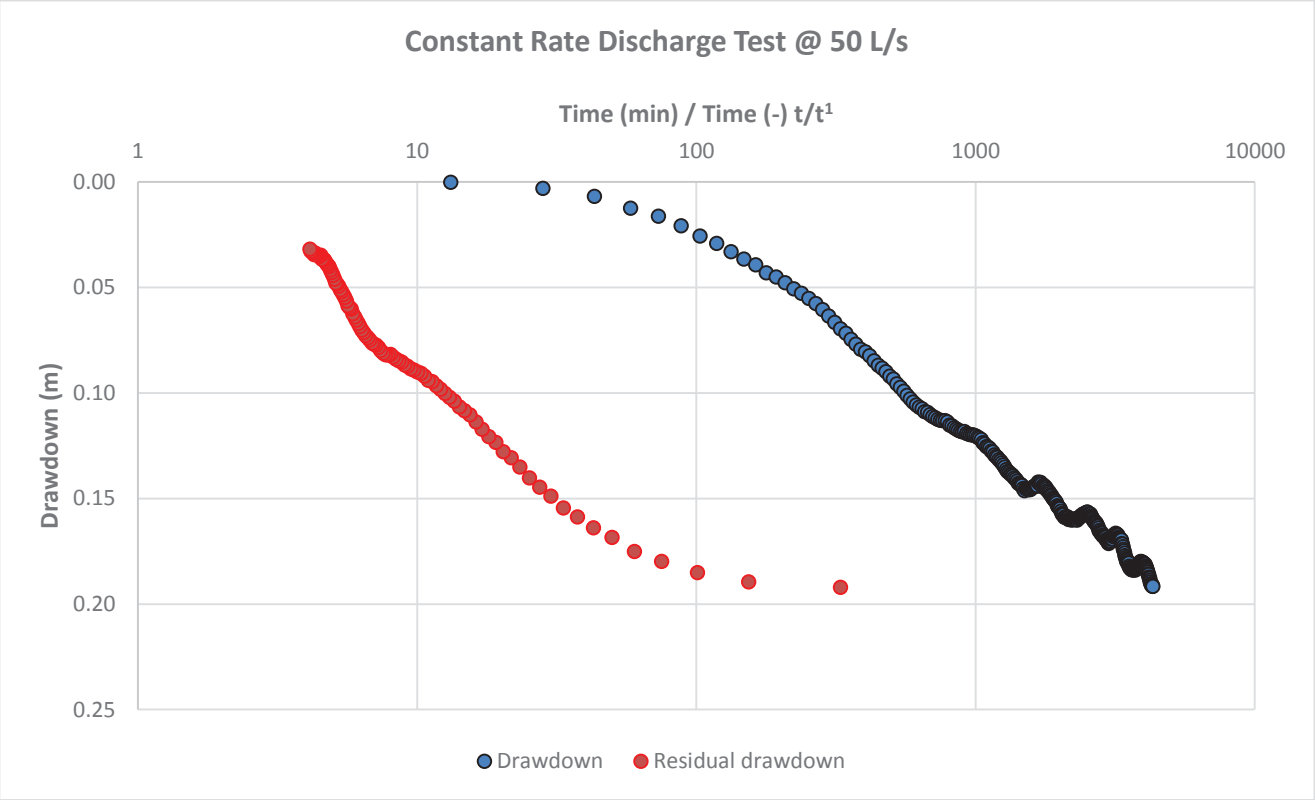


Figure 13 Dilwyn Formation observation well-3 7023-7370 (ROB036) drawdown / residual drawdown

5.3.4 Gambier Limestone observation well 7023-7367 (ROB038), r = 23 m

Drawdown versus time is given in Figure 14. The following general comments can be made:

- A drawdown of -0.078 m developed during the aquifer test, with -0.1 m developing by the end of the recovery
    - This rise in groundwater levels is consistent with the Dilwyn Formation having a high level of well confinement
    - Groundwater level rose through the entire test indicating that pumping in the Dilwyn Formation was not affecting groundwater levels in the Gambier Limestone
    - The rising trend in the groundwater levels is consistent with a response to the falling barometric pressure during the test which indicates that the Gambier Limestone is not fully unconfined at this location
    - There no apparent response to pumping from the Dilwyn Formation

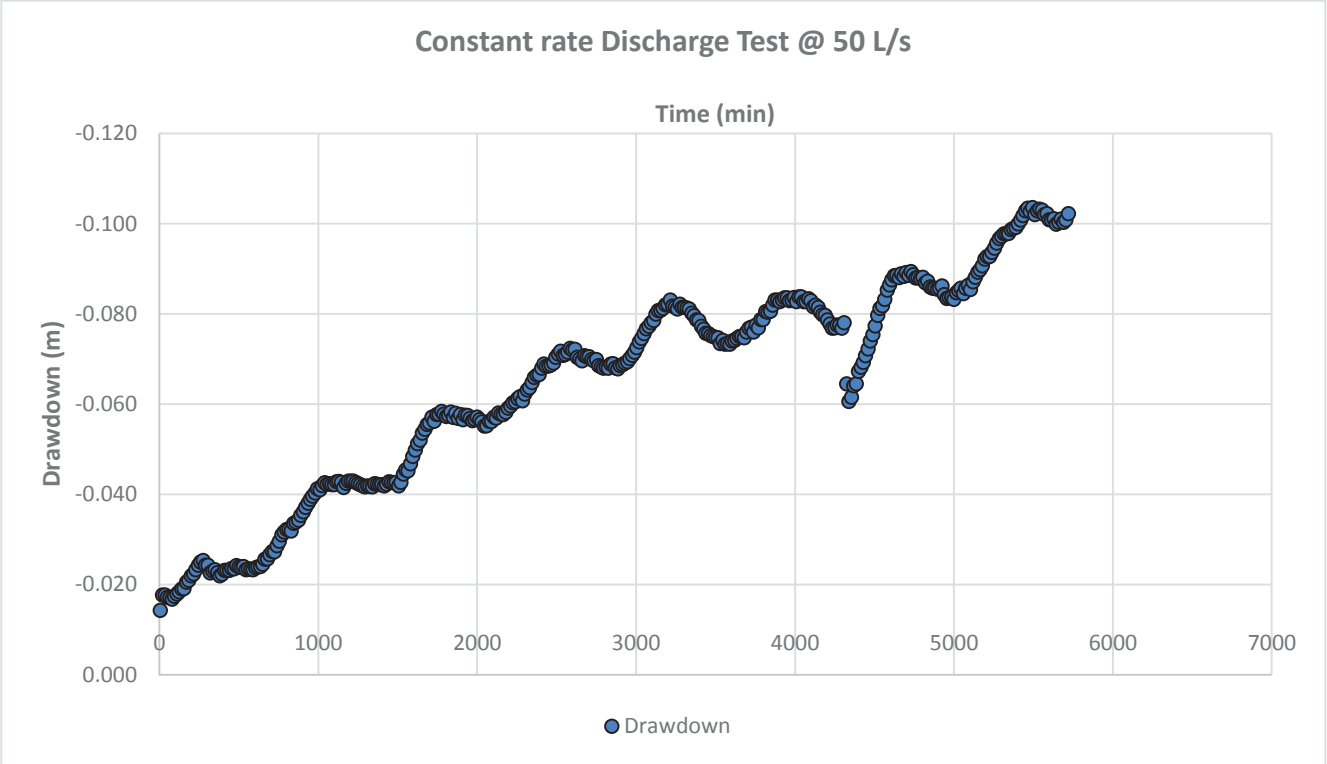


Figure 14 Gambier limestone observation well 7023-7367 (ROB038) drawdown

5.3.5 Aquifer and aquitard hydraulic parameters

Schlumberger Water Services AquiferTest Pro (Version: 2013.1) was used for analysis of the constant rate discharge test data. Hydraulic properties for the Dilwyn Formation aquifer and overlying aquitard determined from the analysis of the constant rate discharge test are given in Table 7. Drawdown data was corrected for barometric changes. The following general comments can be made:

- The very high value of transmissivity averaging 6,120 m^2/day is determined from the observation well. The value of 3910 m^2/day determined from the Dilwyn Formation production well 7023-7371 (ROB037) should be used in calculations as the observation well is at such a great distance other influences on groundwater levels cannot be ruled out.
- The storage coefficient between 2.8E-4 and 3.71E-4 can be considered acceptable
- The drawdown data can be analysed with the Theis analysis method (Figure 15) for confined aquifers. The Theis analysis and the Hantush analysis indicate very similar results.
- If the Hantush-Jacob analysis method for leaky confined aquifers is applied a value for the hydraulic resistance of 9.51E7 minutes (66,041 days) is obtained (Figure 16) which is extremely large and confirms the Dilwyn Formation has a high level of confinement in this area with minimal leakage expected to be occurring from the Gambier Limestone unconfined aquifer. Some caution needs to be applied when using the hydraulic resistance in calculations as the observation well is at such a great distance other influences on groundwater levels cannot be ruled out.

Table 7 Aquifer and aquitard hydraulic parameters table format

Well	Radial distance to production well (m)	T (m^2/day)	S (-)	c (min)	Analysis method
Dilwyn Fm. obs. well-3 7023-7370 (ROB036)	1,627	6,700	2.80E-4	-	Cooper-Jacob
		5,970	3.58E-4	-	Theis
		5,690	3.71E-4	9.51E7	Hantush
Dilwyn Fm. prod. well 7023-7371 (ROB037)	0	3910	1E-7		Cooper Jacob

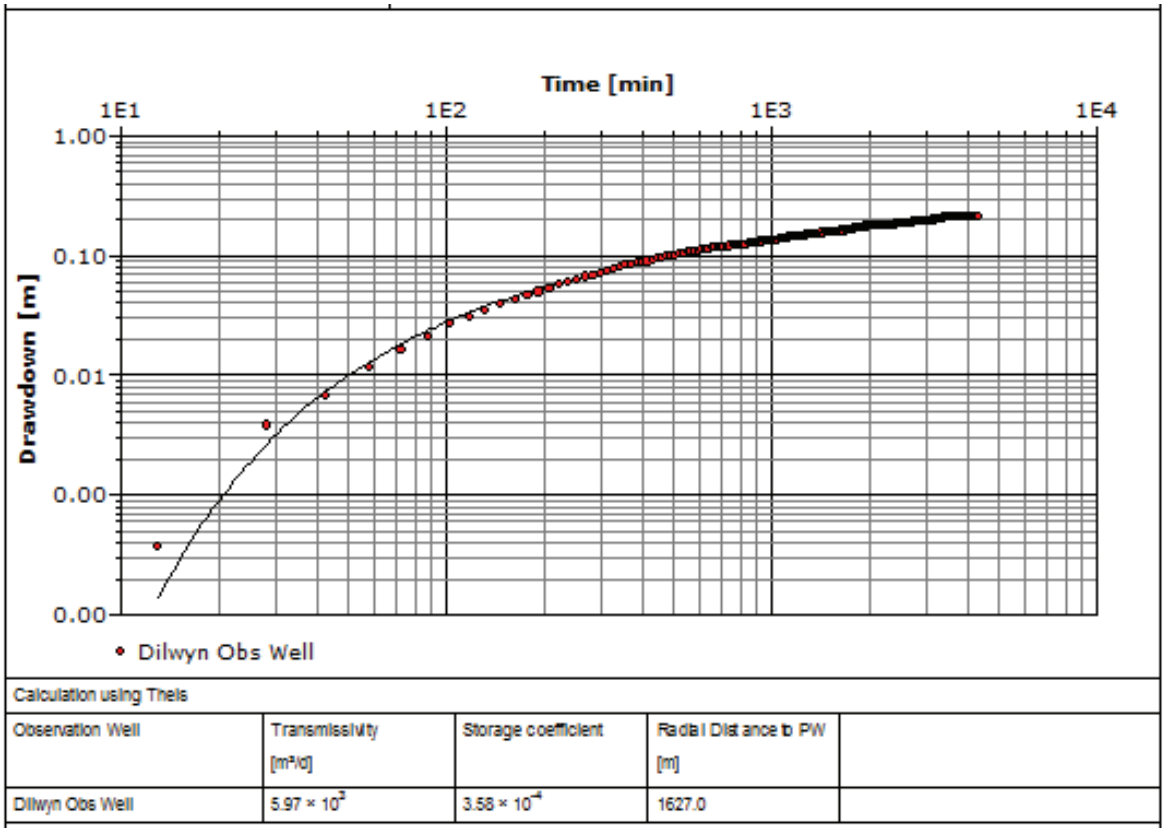
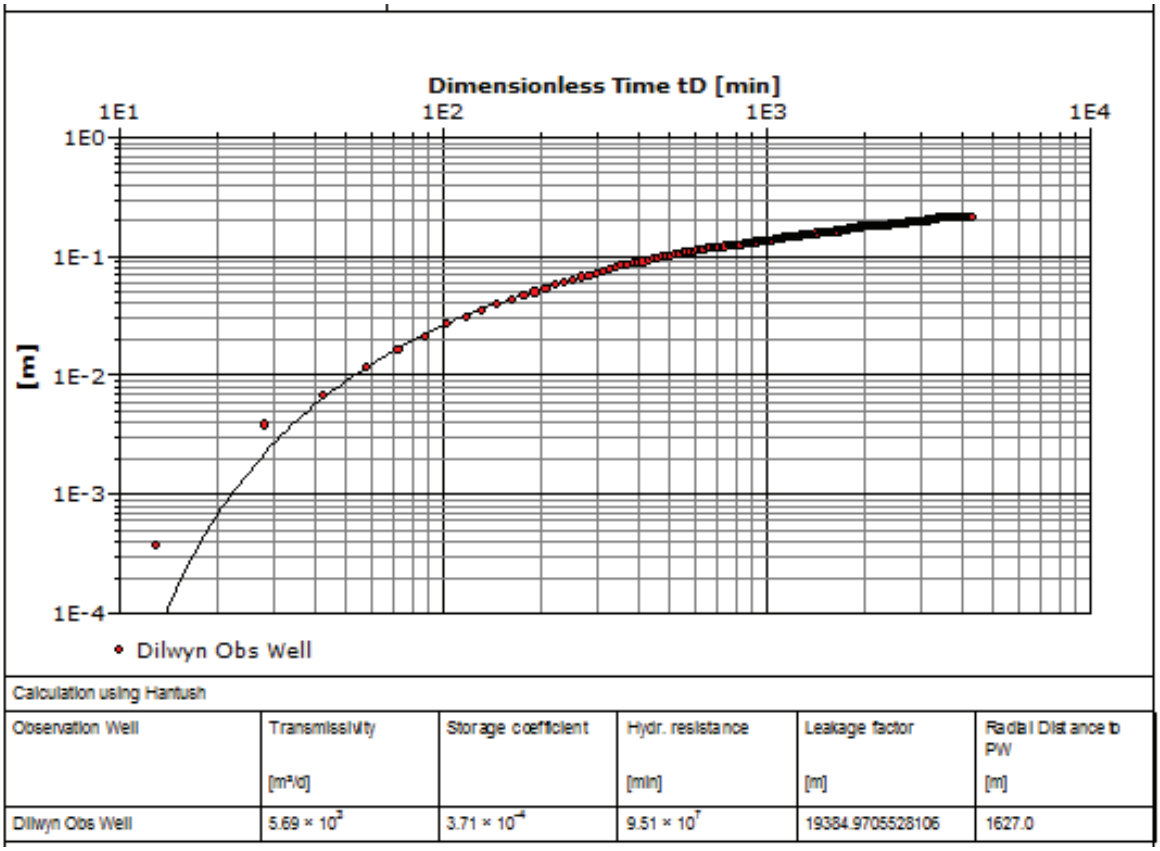


Figure 15 Dilwyn Formation observation well-3 7023-7370 (ROB036) Theis analysis



Calculation using Hantush

Observation Well	Transmissivity [m²/d]	Storage coefficient	Hydr. resistance [min]	Leakage factor [m]	Radial Distance to PW [m]
Dilwyn Obs Well	5.69×10^{3}	3.71×10^{-4}	9.51×10^{7}	19384.9705528106	1627.0

Figure 16 Dilwyn Observation well-3 7023-7370 (ROB036) Hantush analysis

5.4 Groundwater Salinity

Groundwater salinity results are given in Figure 17 which indicates the salinity remained constant between 712 and 720 mg/L across 72 hours of pumping. The Gambier Limestone has a groundwater salinity of approximately 2,000 mg/L and the results indicate that no leakage is occurring from the unconfined aquifer to the Dilwyn Formation confined aquifer during the period of the aquifer test.

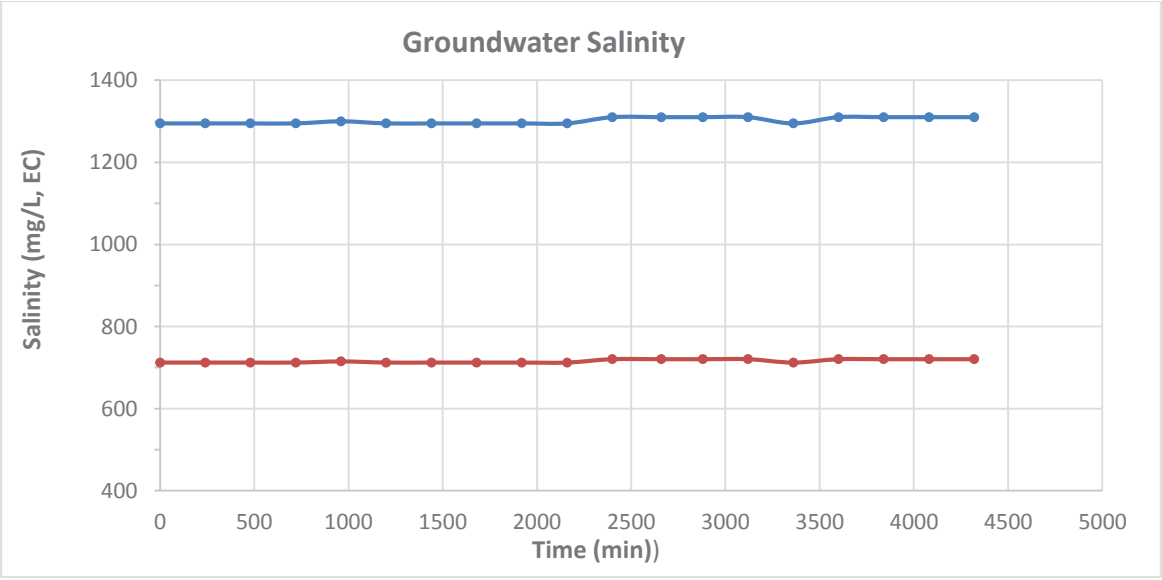


Figure 17 Dilwyn Formation production well 7023-7371 (ROB037) groundwater salinity

6 Observation Well Aquifer Test Results

6.1 Aquifer test Procedure

A constant rate discharge test followed by a brief period of recovery monitoring was conducted on each of the three Bool Lagoon investigation/observation wells completed in the Dilwyn Formation (Table 8). This work was undertaken in addition to the original program of work in order to determine changes in groundwater salinity during pumping. Test details are given in Table 8 and the results are given in Appendix 9.6, 9.7 and 9.8. Groundwater samples were analysed at the AWQC (Appendix 9.9).

Table 8 Aquifer test details observation wells

Well	Test Type	Test Date	Duration (min)	Pumping rate (L/s)
Dilwyn Fm. obs. well-1 7023-7369 (KLN017)	Constant Rate discharge	06/08/2014	1,440	20
Dilwyn Fm. obs. well-2 7023-7368 (KLN018)	Constant Rate Discharge	09/08/2014	1,440	20
Dilwyn Fm. obs. well-3 7023-7070 (ROB036)	Constant Rate Discharge	12/08/2014	480	20

6.2 Constant Rate Discharge Tests

6.2.1 Dilwyn Formation observation well-1 7023-7369 (KLN017)

Drawdown versus time and residual drawdown versus t/t1 for the observation well is given in Figure 18. The drawdown data steady state immediately and cannot be used for determining aquifer hydraulic parameters. Groundwater salinity results are given in Figure 19 which indicates the salinity remained constant between 602 and 608 mg/L.

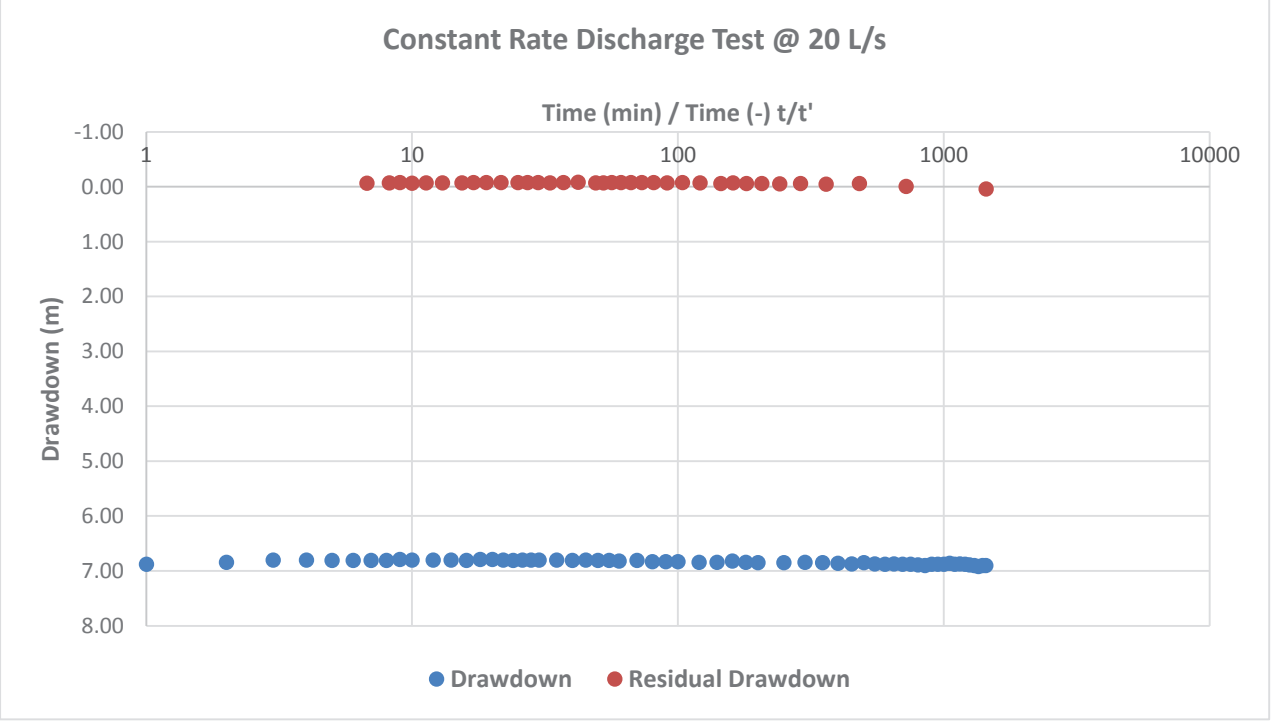


Figure 18 Dilwyn Formation observation well-1 7023-7369 (KLN017) drawdown / residual drawdown

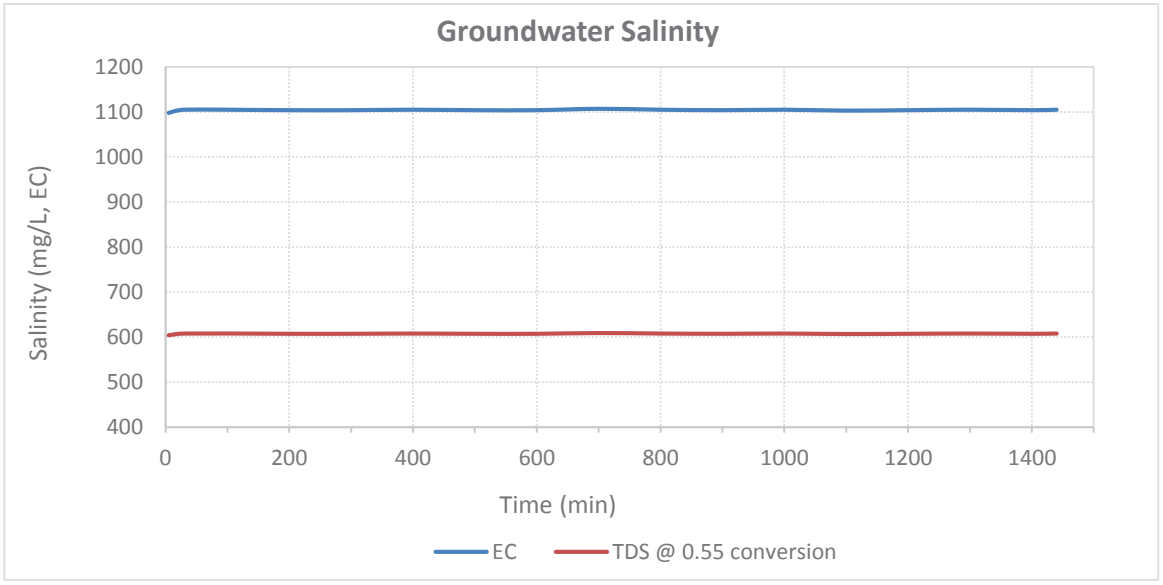


Figure 19 Dilwyn Formation observation well-1 7023-7369 (KLN017) groundwater salinity

6.2.2 Dilwyn Formation observation well-2 7023-7368 (KLN018)

Drawdown versus time and residual drawdown versus t/t1 for the observation well is given in Figure 20. The drawdown data steady state immediately and cannot be used for determining aquifer hydraulic parameters. Groundwater salinity results are given in Figure 21 which indicates the salinity remained constant between 578 and 581 mg/L.

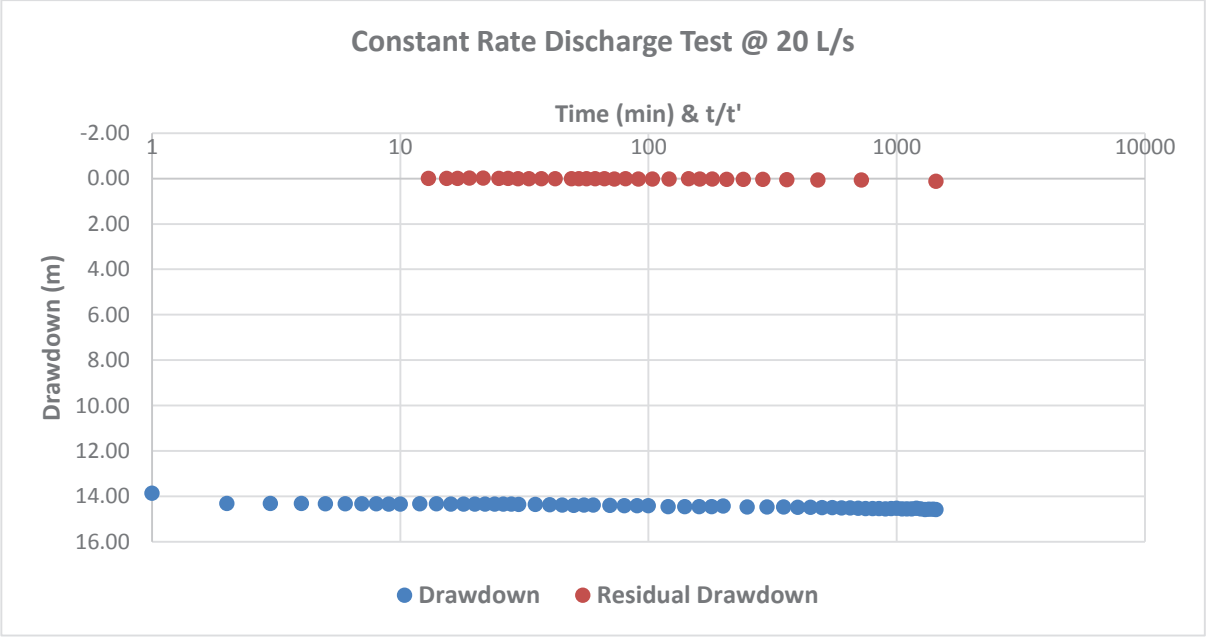


Figure 20 Dilwyn Formation observation well-2 7023-7368 (KLN018) drawdown / residual drawdown

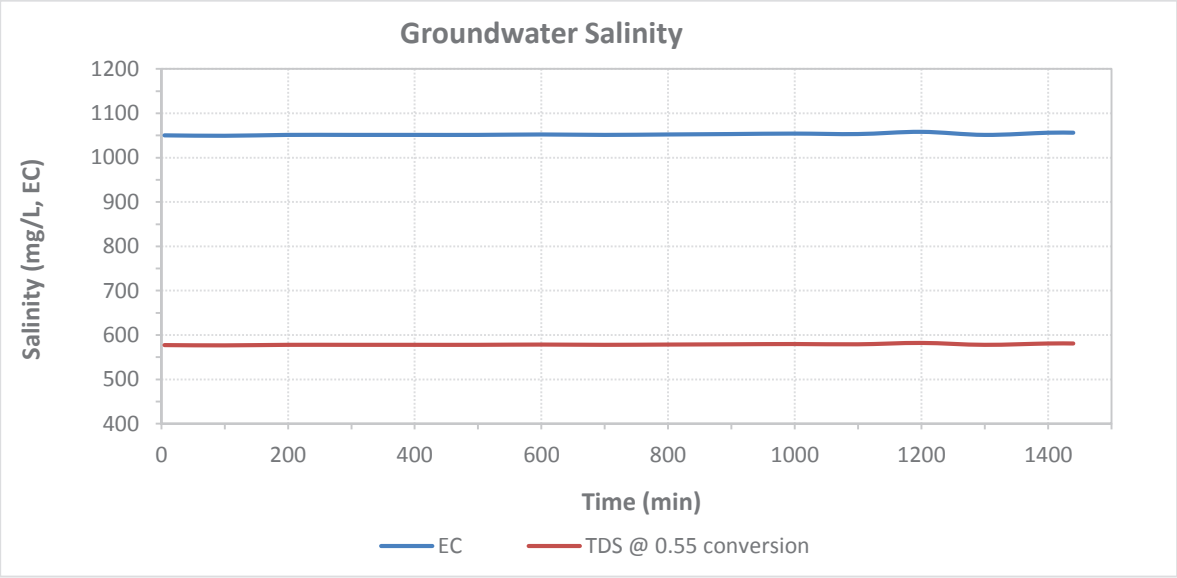


Figure 21 Dilwyn Formation observation well-2 7023-7368 (KLN018) groundwater salinity

6.2.3 Dilwyn Formation observation well-3 7023-7370 (ROB036)

Drawdown versus time and residual drawdown versus t/t1 for the observation well is given in Figure 22. The drawdown data steady state immediately and cannot be used for determining aquifer hydraulic parameters. Groundwater salinity results are given in Figure 23 which indicates the salinity remained constant between 700 and 695 mg/L.

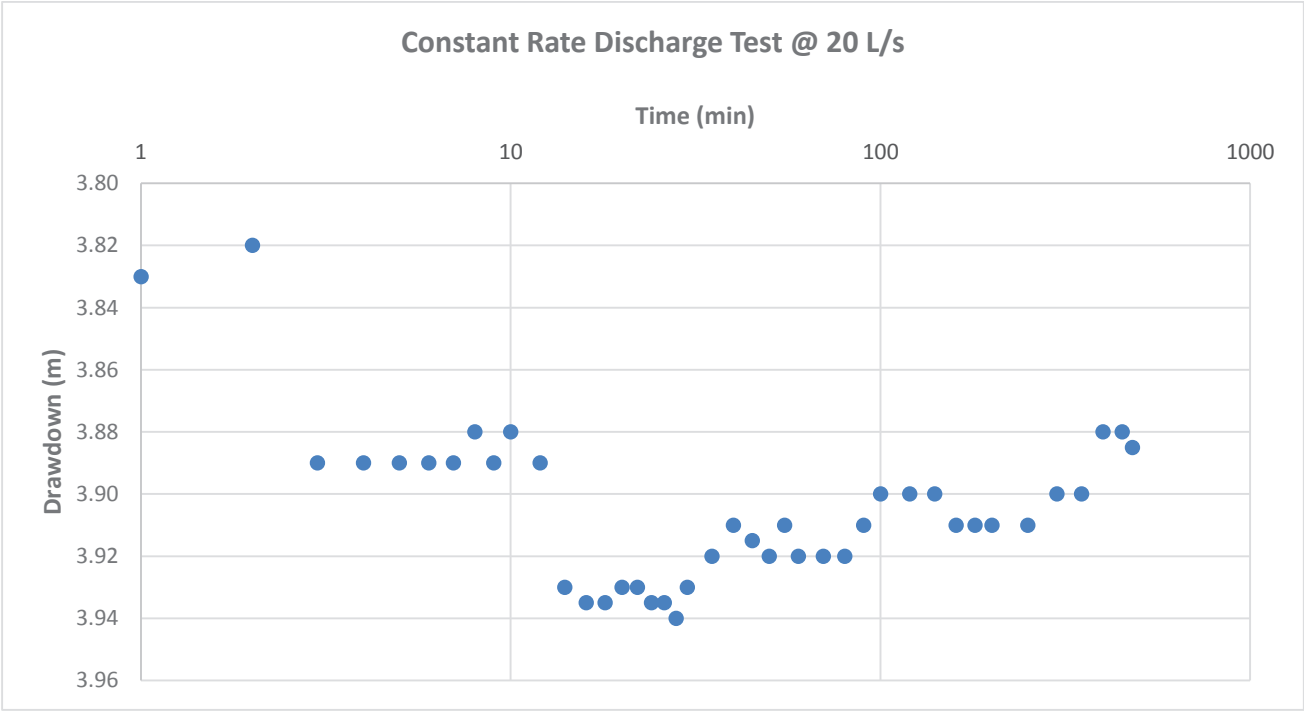


Figure 22 Dilwyn Formation observation well-3 7023-7370 (ROB036) drawdown / residual drawdown

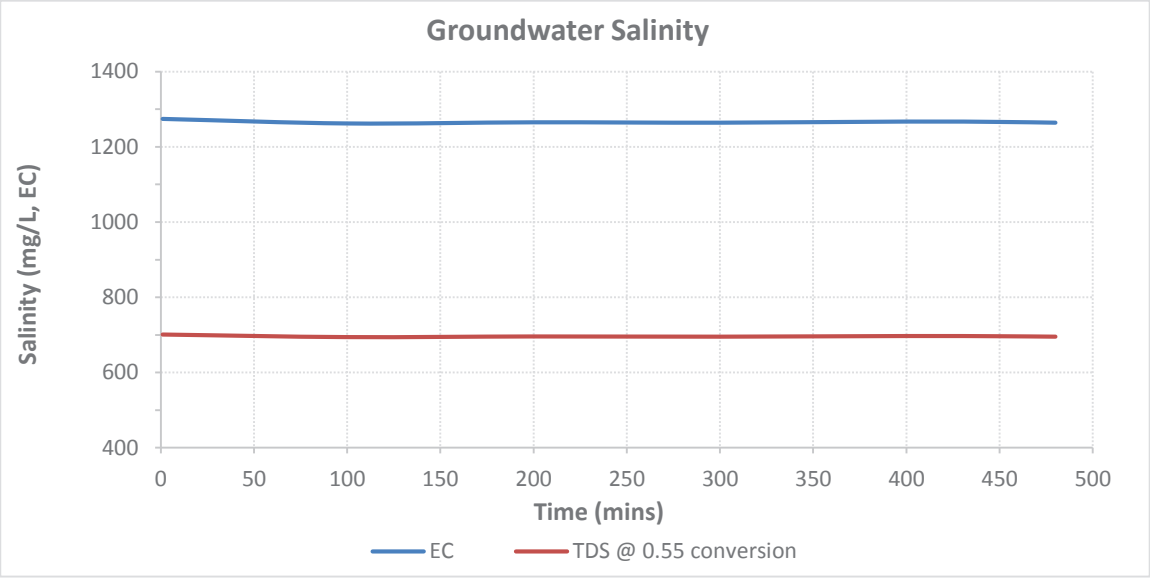


Figure 23 Dilwyn Formation observation well-3 7023-7370 (ROB036) groundwater salinity

The results from the testing of the confined aquifer observation wells gives good agreement with the results calculated earlier for the production well and observation well. Each of the observation wells were equipped with a 6 m screen with a 0.5 mm aperture. Because the wells were very efficient, the production area or thickness of the aquifer for the purposes of calculating the Hydraulic conductivity has been assessed as 20 m. Table 9 shows that the transmissivities and hydraulic conductivities are high meaning that the confined aquifer in this area can produce strong water supplies at high efficiency.

Table 9 Aquifer parameters for the three confined aquifer observation wells

Well	Aquifer Stage	T (m^2/d)	K (m/d)
Dilwyn Fm. obs. well-1 7023-7369 (KLN017)	Aquifer pumping	5540	277
	Aquifer recovery	5424	271
Dilwyn Fm. obs. well-2 7023-7368 (KLN018)	Aquifer pumping	2573	129
	Aquifer recovery	6087	304
Dilwyn Fm. obs. well-3 7023-7370 (ROB036)	Aquifer pumping	3678	184
	Averages	**4660**	**233**

7 Conclusions

In summary the following conclusions are drawn from the investigations conducted at the Bool Lagoon observation wells:

1. The five main wells in the drilling program were successfully completed, aquifer tests conducted and analysed, and samples collected for groundwater chemistry.
2. The complex groundwater chemistry will be explained in a separate report by Innovative Groundwater Solutions 2015.
3. The stratigraphy in the investigation area is fault controlled with the deeper confined sediments of the Dilwyn Formation occuring to the west of the uplifted Kanawinka Fault.
4. The confined Dilwyn Formation in the area is generally composed of a coarse sand and aquifer tests resulted in small drawdowns indicating high aquifer transmissivity.
5. Strata samples collected during drilling of all wells indicated an uninterupted and thick Dilwyn Formation sand sequence. In the previously drilled production well 7023-1850 (KLN010) this extended from 213 to 297 m (84 m).
6. The unconfined Gambier Limestone and confined Dilwyn Formation in the investigation area show an observed groundwater head difference of 12 m indicating inter-aquifer leakage has a potential to occur from the unconfined to the confined aquifer. However, the markedly different groundwater salinities between aquifers indicate limited exchange is occurring.
7. The aquifer test conducted on the Dilwyn Formation production well 7023-7371 (ROB037) provided information through interpreted transmissivity values, groundwater salinity data and groundwater head comparisons on the degree of confinement between the Dilwyn Formation and the overlying Gambier Limestone.
8. The drawdown observed in the principal Dilwyn Formation observation well-3 7023-7370 (ROB036) indicated that the aquifer has a high level of confinment. This is supported by the drawdown results from the Gambier Limestone observation well 7023-7367 (ROB038) located 23 m from the production well which indicated a response to barometric changes rather than pumping.
9. No groundwater salinity changes were evident during the aquifer tests conducted on the Dilwyn Formation production well 7023-7371 (ROB037) well or the observation wells, indicating that no leakage or mixing with other sources of groundwater occurred during the tesing period, supporting the assertion that the Dilwyn Formation has a high level of confinement.
10. Dilwyn Formation observation well-2 7023-7368 (KLN018) had the lowest groundwater salinity (581 mg/L) of the investigation wells.
11. The Dilwyn Formation production well 7023-7371 (ROB037) has a slightly higher salinity (720 mg/L) than the private irrigation wells located a little to the east with indicated salinities of about 650 mg/L.
12. The investigation area has very high confined aquifer transissivity values, greater than most other areas in the region.
13. The investigation area is a source of low salinity confined aquifer groundwater that could potentially supply the township of Naracoorte.

8 Recommendations

The following recommendations are made:

1. In order to confirm the understanding of the hydraulic connection between the target the Dilwyn Formation and the overlying Gambier Limestone, an additional observation well could be drilled at close proximity to the Dilwyn Formation production well 7023-7371 (ROB037) and the constant rate discharge test repeated. It is however noted that the results obtained from the Gambier Limestone observation well 7023-7367 (ROB038) indicate that there is no hydraulic connection between the two aquifers which confirms the hydraulic resistance indicated from the Dilwyn Formation observaton well-3 7023-7370 (ROB036).
2. Further desktop studies could be undertaken in relation to the stratigraphy and hydrostratigraphy in the investigation area to better understand the fault conditions and aquifer variations that exist across the area. Data collected and displayed in this report is probably enough to make good future planning decisions.
3. The Bool Lagoon investigation area can produce low salinity groundwater from the confined Dilwyn Formation, which could be developed as a town water supply wellfield to provide water for Naracoorte. The salinity varies between 580 mg/L (observation well 2) and 720 mg/L (Dilwyn Formation production well), which is below the ADWG recommendation that municipal supplies should have salinity less than 1000 mg/L.
4. The Bool Lagoon investigation area can provide a secure water supply from the confined aquifer contained within the Dilwyn Formation. The production and observation wells demonstrate the following features that indicate a secure supply into the future including:
    a. Thickness of the aquifer (> than 60 m)
    b. Very high transmissivity rates (>3,500 m^2/day), and
    c. Small drawdown (<4 m for an pumping rate of 50 L/sec).

9 Appendices

9.1 DRILLING CONTRACTOR WELL CONSTRUCTION REPORTS

Dilwyn Formation production well 7023-7371 (ROB037)

GOVERNMENT OF SOUTH AUSTRALIA
DRILLERS WELL CONSTRUCTION REPORT
Natural Resource Management Act 2004

1. PERMIT NO: 231396 Site

NAME OF DRILLER Josh Pech Licence No: 131725
Contact Phone/Mobile No.: 0468 942 313
Name of plant operator if under supervision

PERMIT HOLDER or land occupier S.A Water Corporation
Postal Address PO Box 603
Mount Gambier S.A. Post Code 5290

2. LOCATION OF WELL
Date of Survey 11.05.2014 Surveyed by L.Moore Method G.P.S
GPS COORDINATES AND DATUM USED
☐ GDA 94 (WGS84)
☐ AGD 66/84
S 37° 09. 584
E 140 39. 138
☐ ZONE 52 ☐ ZONE 53 ☐ ZONE 54

3. WELL NAME
4. LAND IDENTIFICATION
Hundred or Pastoral Lease: B. Robertson
Parcel ID or CT number 5934/706
Name of Property Section 52

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*
Date work Commenced 8.5.2014 Date work Completed 14.05.2014
Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☐
Is this a Replacement well? YES/NO if yes please quote replaced well number
Is this an Existing well? YES/NO **If yes please quote well number or GPS coordinates**
Was well Abandoned? YES/NO if so please state reason and method of backfill
Maximum Depth Drilled 157.5 (m) Final Depth 156.7 (m) Final Standing Water Level (m) Final Yield 45 (L/sec)

6. DRILLING DETAILS If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	7	560	Rotary	PAC
7	145	380	Rotary	PAC
145	157.5	230	Rotary	PAC

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste

7. CASING LEFT IN WELL

7.1 Dimensions / 7.2 Type / 7.3 Casing Cemented

From (m)	To (m)	Internal Diam. (mm)	Swell Joint, Welded Collar, Steel, FRP, PVC, etc.	Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
0	7	395	Steel	☐	☑							
0	144	254	FRP	☑	☐	0	144	300	7350	300kg Bent	Drill pipe	5% Bent.
141	144.75	203	S/Steel	☐	☑							
154.5	156.7	203	S/Steel	☐	☑							

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 Method
☐ Open Hole
☐ Slotted Casing
☑ Screen(s)
☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base
S/Steel	144.5	149.7	0.6	198	210	S/Steel	Johnson	2.2m Sump
S/Steel	149.7	154.5	1.0	198	210	S/Steel	Johnson	End cap.

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)
Rubber	141	203

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Jet	7	
Airlift	7	

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES
The provision of the Natural Resource Management Act 2004 and Regulations require that strata and water samples must be obtained. If any samples have not been obtained state reasons:
As per Jaquson Mt. Gambier
As the person responsible I advise that the work has been completed as described above.

Signature of Licensed Driller [signature] Date 15/05/2014

Driller to deliver this copy together with water samples collected and well location map within 14 days of completion to any of the below locations:
Department of Water Land and Biodiversity Conservation
Water Laboratory and Geophysical Services, 23 Conyngham Street GLENSIDE SA 5065 or
Mount Gambier Regional Office, 11 Helen Street MOUNT GAMBIER SA 5290 or
Naracoorte Regional Office, 101 Cedar Avenue, NARACOORTE SA 5271

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	1	Top Soil
1	95	Lime Stone
95	110	Marls
110	130	Brown Clay & Sands
130	138	Black clays
138	157.5	Sands.

UNIT NUMBER

Dilwyn Formation observation well-1 7023-7369 (KLN017)

GOVERNMENT OF SOUTH AUSTRALIA
DRILLERS WELL CONSTRUCTION REPORT
Natural Resource Management Act 2004

1. PERMIT NO: 229330 Site:

NAME OF DRILLER: Josh Pech Licence No: 131725
Contact Phone/Mobile No.: 0468 942 313
Name of plant operator if under supervision:

PERMIT HOLDER or land occupier: S.A. Water Corporation
Postal Address: po Box 603
Mount gambier S.A. Post Code: 5290

2. LOCATION OF WELL
Date of Survey: 12.05.2014 Surveyed by: Lloyd Method: GPS
GPS COORDINATES AND DATUM USED: S 37° 15 . 643 / E 140° 43 . 069
☐ GDA 94 (WGS84) ☐ AGD 66/84 ☐ ZONE 52 ☐ ZONE 53 ☐ ZONE 54

3. WELL NAME:
4. LAND IDENTIFICATION
(Hundred) or Pastoral Lease: Killanoola
Parcel ID or (CT) number: 1135/34
Name of Property: Section 422

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*
Date work Commenced: 14.4.2014 Date work Completed: 4.5.2014
Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☐
Is this a Replacement well? YES/NO if yes please quote replaced well number:
Is this an Existing well? YES/NO If yes please quote well number or GPS coordinates:
Was well Abandoned? YES/NO if so please state reason and method of backfill:
Maximum Depth Drilled: 234 (m) Final Depth: 233 (m) Final Standing Water Level: 15.42 (m) Final Yield: 20 (L/sec)

6. DRILLING DETAILS If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	6	350	Rotary	PAC
6	220	230	Rotary	PAC
220	234	161	Rotary	PAC

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste

7. CASING LEFT IN WELL

7.1 From (m)	7.1 To (m)	7.1 Internal Diam. (mm)	7.2 Type Swell Joint, Welded Collar, Steel, FRP, PVC, etc.	7.3 Casing Cemented Yes	7.3 Casing Cemented No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
0	6	250	Steel	☐	☑							
0	216	161	P.V.C	☑	☐	0	216	150	3675	150kg Bent	Drillpipe	5% Bent
203	225	100	P.V.C	☐	☑							
231	233	100	P.V.C	☐	☑							

8. CONSTRUCTION AT PRODUCTION LEVEL
8.1 Method: ☐ Open Hole ☐ Slotted Casing ☑ Screen(s) ☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Bore
S/Steel	225	231	0.5mm	96	110	S/Steel	Johnson	2m Sump With end cap.

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)
Rubber	203	100
Rubber	206	100

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Jet	1hr	30
Air lift	1	30

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES
The provision of the Natural Resource Management Act 2004 and Regulations require that strata and water samples must be obtained. If any samples have not been obtained state reasons:
As per J.Lawson Mt. Gambier
As the person responsible I advise that the work has been completed as described above.

Signature of Licensed Driller: JPech Date: 15/5/2014

Driller to deliver this copy together with water samples collected and well location map within 14 days of completion to any of the below locations:
Department of Water Land and Biodiversity Conservation
Water Laboratory and Geophysical Services, 23 Conyngham Street GLENSIDE SA 5065 or
Mount Gambier Regional Office, 11 Helen Street MOUNT GAMBIER SA 5290 or

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	1	Top Soil
1	150	Lime Stone
		18m to 20m Hard band's &
		lost Circulation.
150	168	Green to grey Marl
168	194	Bands of brown Clay & Sands.
194	212	Black & Clay
212	234	Sand.

Dilwyn Formation observation well-2 7023-7368 (KLN018)

GOVERNMENT OF SOUTH AUSTRALIA

DRILLERS WELL CONSTRUCTION REPORT

Natural Resource Management Act 2004

1. PERMIT NO: 229306 Site

NAME OF DRILLER Josh Pech Licence No: 131725

Contact Phone/Mobile No.: 0468

Name of plant operator if under supervision

PERMIT HOLDER or land occupier S.A. Water Corporation

Postal Address P.O. Box 603

Mount Gambier S.A. Post Code 5290

2. LOCATION OF WELL

Date of Survey 12.5.2014 Surveyed by L.Moore Method G.P.S.

GPS COORDINATES AND DATUM USED

☐ GDA 94 (WGS84) S 37° 11.505

☐ AGD 66/84 E 140° 44.405

☐ ZONE 52 ☐ ZONE 53 ☐ ZONE 54

3. WELL NAME

4. LAND IDENTIFICATION

(Hundred) or Pastoral Lease: Robertson

Parcel ID or (CT) number 5951/59

Name of Property Section 50

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*

Date work Commenced 09.04.2014 Date work Completed 12.04.2014

Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☐

Is this a Replacement well? YES/NO if yes please quote replaced well number

Is this an Existing well? YES/NO **if yes please quote well number or GPS coordinates**

Was well Abandoned? YES/NO if so please state reason and method of backfill

Maximum Depth Drilled 186 (m) Final Depth 185.5 (m) Final Standing Water Level 15.25 (m) Final Yield 20 (L/sec)

6. DRILLING DETAILS If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	6	310mm	Rotary	Mud
6	172	230mm	Rotary	Mud
172	186	160mm	Rotary	Mud

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste

7. CASING LEFT IN WELL

7.1 From (m)	7.1 To (m)	7.1 Internal Diam (mm)	7.2 Type Swell Joint, Welded Collar, Steel, FRP, PVC, etc.	7.3 Casing Cemented Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
0	6	250mm	Steel	☐	☑							
0	165	161mm	P.V.C	☑	☐	0	165	120x20kg	2440L	120kg Ben	Drill pipe	5% Ben
153.5	177.5	100mm	P.V.C	☐	☑							
				☐	☐							

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 Method

☐ Open Hole

☐ Slotted Casing

☑ Screen(s)

☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base
S/S Screen	177.5	183.5	0.05mm	96mm	110mm	S/Steel	Johnson	2m Sump With end Cap

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)
Ks-packer	153.5	100mm
Ks-Packer	156.5	100mm

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Jet & Air Lift	6	

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES

The provision of the Natural Resource Management Act 2004 and Regulations require that strata and water samples must be obtained. If any samples have not been obtained state reasons:

As Supplied to Geoff Iwson Mt Gambier office

As the person responsible I advise that the work has been completed as described above.

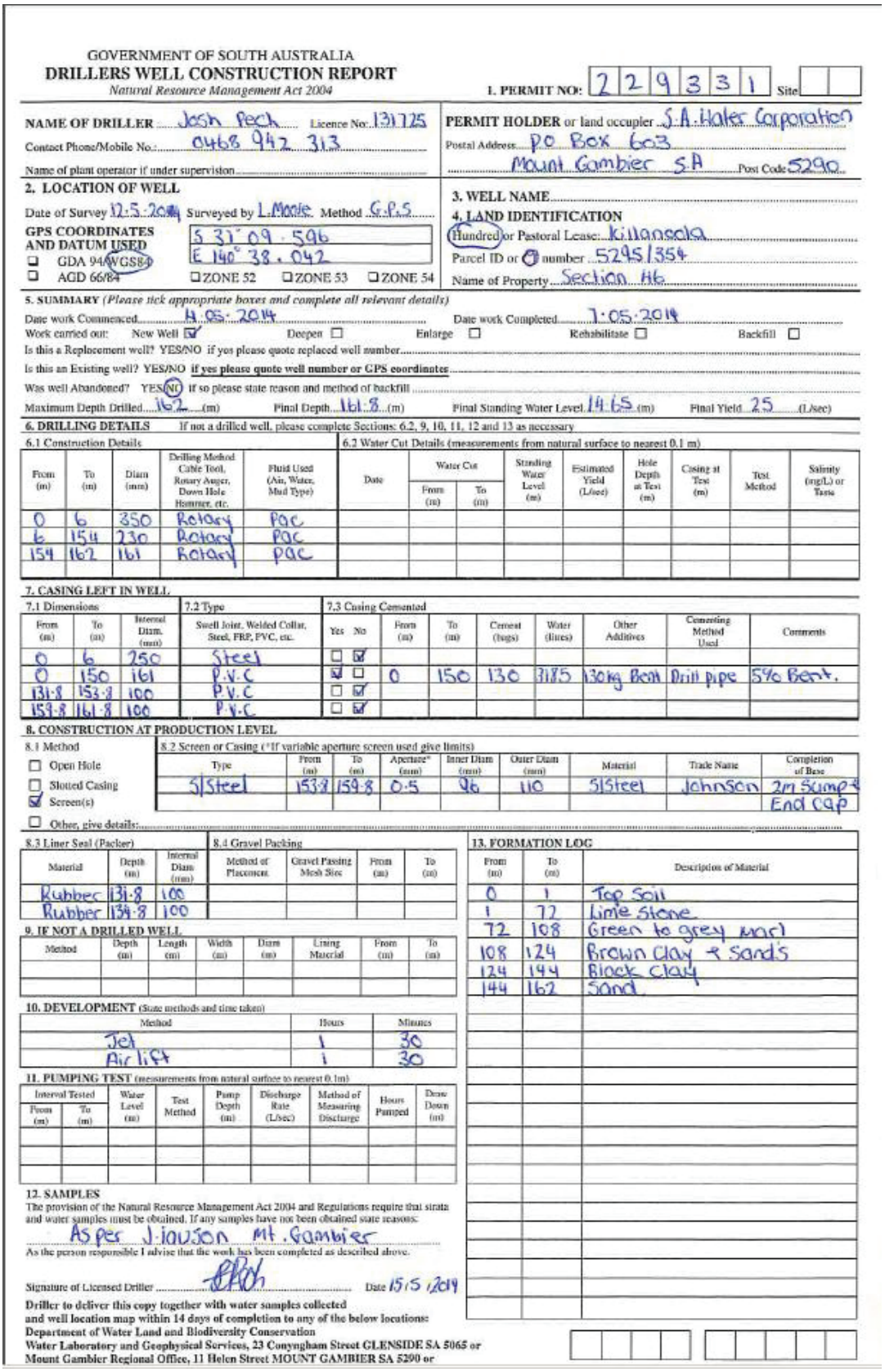
Signature of Licensed Driller JPech Date 17 / 4 / 2014

Driller to deliver this copy together with water samples collected and well location map within 14 days of completion to any of the below locations:
Department of Water Land and Biodiversity Conservation
Water Laboratory and Geophysical Services, 23 Conyngham Street GLENSIDE SA 5065 or
Mount Gambier Regional Office, 11 Helen Street MOUNT GAMBIER SA 5290 or

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	2	Top Soil
2	98	Hard Lime stone
98	110	Limestone
110	120	Brown clay
120	140	Brown Sand
140	150	Clay
150	164	Brown clay
164	172	Sand.
172	186	Sand.

Dilwyn Formation observation well-3 7023-7370 (ROB036)



GOVERNMENT OF SOUTH AUSTRALIA
DRILLERS WELL CONSTRUCTION REPORT
Natural Resource Management Act 2004

1. PERMIT NO: 229331 Site

NAME OF DRILLER Josh Pech Licence No: 131725
Contact Phone/Mobile No: 0468 942 313
Name of plant operator if under supervision

PERMIT HOLDER or land occupier S.A. Water Corporation
Postal Address PO Box 603
Mount Gambier SA Post Code 5290

2. LOCATION OF WELL
Date of Survey 12.5.2014 Surveyed by L.Maple Method G.P.S.
GPS COORDINATES AND DATUM USED
S 37° 09 . 596
E 140° 38 . 042
☐ GDA 94/WGS84
☐ AGD 66/84 ☐ ZONE 52 ☐ ZONE 53 ☐ ZONE 54

3. WELL NAME
4. LAND IDENTIFICATION
(Hundred) or Pastoral Lease: Killanoola
Parcel ID or (Plan) number 5295/354
Name of Property Section 116

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*
Date work Commenced 11.05.2014 Date work Completed 7.05.2014
Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☐
Is this a Replacement well? YES/NO if yes please quote replaced well number
Is this an Existing well? YES/NO **if yes please quote well number or GPS coordinates**
Was well Abandoned? YES/(NO) if so please state reason and method of backfill
Maximum Depth Drilled 162 (m) Final Depth 161.8 (m) Final Standing Water Level 14.65 (m) Final Yield 25 (L/sec)

6. DRILLING DETAILS If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	6	350	Rotary	Poc
6	154	230	Rotary	Poc
154	162	161	Rotary	poc

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste

7. CASING LEFT IN WELL

7.1 Dimensions / 7.2 Type / 7.3 Casing Cemented

From (m)	To (m)	Internal Diam. (mm)	Swell Joint, Welded Collar, Steel, FRP, PVC, etc.	Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
0	6	250	Steel	☐	☑							
0	150	161	P.V.C	☑	☐	0	150	130	3185	130kg Bent	Drill pipe	5% Bent.
131.8	153.8	100	P.V.C	☐	☑							
159.8	161.8	100	P.V.C	☐	☑							

8. CONSTRUCTION AT PRODUCTION LEVEL
8.1 Method
☐ Open Hole
☐ Slotted Casing
☑ Screen(s)
☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base
S/Steel	153.8	159.8	0.5	96	110	S/Steel	Johnson	2m Sump + End cap

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)
Rubber	131.8	100
Rubber	159.8	100

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Jet	1	30
Air lift	1	30

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

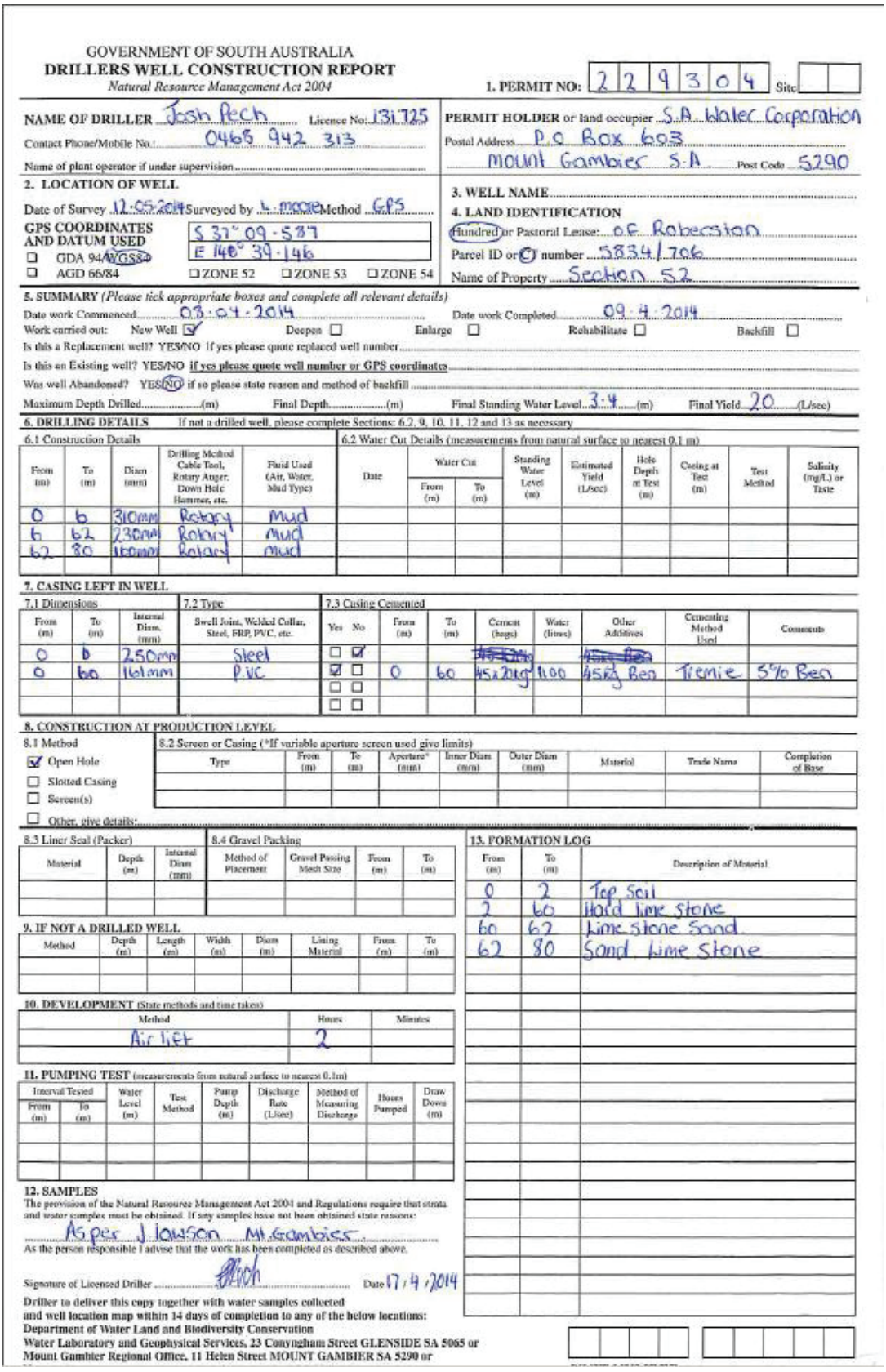
12. SAMPLES
The provision of the Natural Resource Management Act 2004 and Regulations require that strata and water samples must be obtained. If any samples have not been obtained state reasons:
As per Johnson Mt. Gambier
As the person responsible I advise that the work has been completed as described above.
Signature of Licensed Driller Date 15/5/2014

Driller to deliver this copy together with water samples collected and well location map within 14 days of completion to any of the below locations:
Department of Water Land and Biodiversity Conservation
Water Laboratory and Geophysical Services, 23 Conyngham Street GLENSIDE SA 5065 or
Mount Gambier Regional Office, 11 Helen Street MOUNT GAMBIER SA 5290 or

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	1	Top Soil
1	72	Lime Stone
72	108	Green to grey marl
108	124	Brown Clay + Sands
124	144	Black Clay
144	162	Sand

Gambier Limestone observation well 7023-7367 (ROB038)



GOVERNMENT OF SOUTH AUSTRALIA
DRILLERS WELL CONSTRUCTION REPORT
Natural Resource Management Act 2004

1. PERMIT NO: 229304 Site:

NAME OF DRILLER: Josh Pech Licence No: 131725
Contact Phone/Mobile No: 0468 942 313
Name of plant operator if under supervision:

PERMIT HOLDER or land occupier: S.A. Water Corporation
Postal Address: P.O Box 603
Mount Gambier S.A Post Code: 5290

2. LOCATION OF WELL
Date of Survey: 12.05.2014 Surveyed by: L. moore Method: GPS
GPS COORDINATES AND DATUM USED: S 37° 09 · 587 / E 140° 39 · 146
☐ GDA 94 (WGS84) ☐ AGD 66/84 ☐ ZONE 52 ☐ ZONE 53 ☐ ZONE 54

3. WELL NAME:
4. LAND IDENTIFICATION
(Hundred) or Pastoral Lease: OF Robertson
Parcel ID or (C) number: 5834/706
Name of Property: Section 52

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*
Date work Commenced: 03.04.2014 Date work Completed: 09.4.2014
Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☐
Is this a Replacement well? YES/NO If yes please quote replaced well number:
Is this an Existing well? YES/NO if yes please quote well number or GPS coordinates:
Was well Abandoned? YES/(NO) if so please state reason and method of backfill:
Maximum Depth Drilled: (m) Final Depth: (m) Final Standing Water Level: 3.4 (m) Final Yield: 20 (L/sec)

6. DRILLING DETAILS If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	6	310mm	Rotary	Mud
6	62	230mm	Rotary	Mud
62	80	160mm	Rotary	mud

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste

7. CASING LEFT IN WELL

7.1 Dimensions / 7.2 Type / 7.3 Casing Cemented

From (m)	To (m)	Internal Diam. (mm)	Swell Joint, Welded Collar, Steel, FRP, PVC, etc.	Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
0	6	250mm	Steel	☐	☑			~~45x20kg~~		~~45kg Ben~~		
0	60	161mm	PVC	☑	☐	0	60	45x20kg	1100	45kg Ben	Tremie	5% Ben
				☐	☐							
				☐	☐							

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 Method
☑ Open Hole
☐ Slotted Casing
☐ Screen(s)
☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Air lift	2	

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES
The provision of the Natural Resource Management Act 2004 and Regulations require that strata and water samples must be obtained. If any samples have not been obtained state reasons:
As per J. Lawson Mt Gambier
As the person responsible I advise that the work has been completed as described above.
Signature of Licensed Driller: Date 17/4/2014

Driller to deliver this copy together with water samples collected and well location map within 14 days of completion to any of the below locations:
Department of Water Land and Biodiversity Conservation
Water Laboratory and Geophysical Services, 23 Conyngham Street GLENSIDE SA 5065 or
Mount Gambier Regional Office, 11 Helen Street MOUNT GAMBIER SA 5290 or

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	2	Top Soil
2	60	Hard Lime Stone
60	62	Lime Stone Sand
62	80	Sand, Lime Stone

9.2 WATER WELL LOGS

Dilwyn Formation production well 7023-7371 (ROB037)

Project: BOOL LAGOON DRILLING INVESTIGATION

Permit Number: **229649/ 231396**
Backfilled (Y/N): **Y**
Date Completed: **14/05/2014**
Total Depth (m): **170 and 157.5**
Unit No: **7023-7371**
Drill Method: **Rotary mud**
Observation Number: **ROB037**
Drilling Company: **Water Dynamics/ Thompson Drill**
Logged By: **Jeff Lawson**
Driller: **Greg Cram/ Josh Pech**

Coordinates
Easting: **469126**
Ground Elevation (mAHD): **49.86**
Northing: **5887349**
Reference Elevation (mAHD): **49.9**
Zone: **54**
Reference Point Type: **TOC**
Datum: **GDA94**

General Comments: There were 2 wells drilled at this site. A test well to enable the well design to occur (then backfilled) and the production well construction. The test well went a little deeper to investigate the aquifer and to make sure enough water could be obtained to potentially stress the unconfined aquifer.

Lithological Description

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
0	1	**TOPSOIL**	Fine sand and organic material.	**RECENT**
1	2	**MARLY SANDSTONE**	Light brown with occasional darker brown inclusions. Moderate to well bound marl. Sand and fine calcareous material embedded in the marl.	
2	4		Off white, moderate to well bound marl. Sand and fine calcareous material.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
4	6		Increasing percentage of fine grained, iron stained, strongly cemented fragments	**BRIDGEWATER FORMATION**
6	11	**MARL**	White well bound marl. Fossil quality improving but sand still present.	
11	12	**LIMESTONE**	Pale brown unconsolidated fine fossil content.	**GAMBIER LIMESTONE Green Point Member Unit 3**
12	14	**MARL**	Mottled off white to dark brown marl, strongly bounded. 10 to 20% embedded fossil content.	
14	16		Weakly to moderately bound marl in response to increasing fossil content. Shell fragments to 5mm.	
16	18	**LIMESTONE**	Pale brown, unconsolidated fine to medium grained well preserved fossils. 10 to 15% flint.	
18	24		Off white, medium to coarse grained.	
24	26		Off white minor flint.	**GAMBIER LIMESTONE Green Point Member Unit 4**
26	30		Essentially coarse grained. Minor flint.	
30	32		No flint. Limestone corals to 4mm.	
32	36		5 – 10% flint – some partially silicified.	
36	38		Becoming slightly marly.	
38	40		Fine grained limestone with 10% marl.	
40	42		Off white, medium grained fossil content.	
42	48		Coarse fossil content. Minor flint.	**GAMBIER LIMESTONE**
48	50		Slightly finer. Medium to coarse grained.	
50	52		Coarse grained limestone. 35 to 45% flint – brown, dark grey to light grey, partially silicified fragments.	
52	54		20% flint	
54	56		10% flint	
56	58		Overall medium grained limestone although a coarser component is present.	
58	60		Off white. Fine grained limestone with a minor marl component.	
60	62	**LIMESTONE**	Fine, medium to coarse grained fossils. Overall medium to coarse grained. High percentage of glauconitic staining.	
62	64		Fine to medium grained.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
64	68		Off white, unconsolidated, overall fine grained with some medium sized fossils. Minor marl content. Glauconitic stained fossils.	**Camelback Member**
68	70		Much stronger glauconitic staining.	
70	72		Less glauconitic staining.	
72	74		Off white, unconsolidated coarse grained limestone. Minor grey marl.	
74	78	**MARL**	Grey moderately bound. 5 to 10% flint. Coarse limestone present but probable up hole sample.	**GAMBIER LIMESTONE Greenways Member**
78	82	**LIMESTONE**	Off white unconsolidated, medium grained fossil content. Some glauconitic staining. Minor flint.	
82	84		Medium to coarse grained unconsolidated limestone. Up to 30% partially silicified grey flint.	
84	88		Strong glauconitic staining and less flint.	
88	90	**FLINT**	Grey to pale grey partially silicified. 30% coarse limestone fossil and glauconitic staining. Minor marl.	
90	92	**MARLY LIMESTONE**	Grey marl and uncemented fine to medium grained fossils. Minor flint.	
92	94	**MARL**	Strongly bound marl. 5 to 10% fine limestone.	
94	96	**MARL**	Well bounded grey and green marl. Strong overall glauconitic staining with glauconitic grains also embedded in the marl. 5 to 15% limestone.	**NARRAWATURK MARL**
98	100		Strongly bound marl with extremely minor fossil content.	
100	102		Darker grey, soft medium bound. No strong glauconitic staining but abundant glauconitic inclusions in the marl.	
102	104	**SAND**	Fine sand either iron stained or limonitic grained. High percentage of fossil material and glauconitic grains.	
104	108		Less up hole contamination.	**MEPUNGA FORMATION**
108	112		Strong iron staining and limonitic grains. Grain size overall coarser. Some up hole in the sample.	
112	114	**SAND/ CLAY**	Brown higher percentage of unconsolidated sand with approximately 30% clay. Transitioning to the Dilwyn Formation.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
114	118	CLAY	Brown strongly bound. Fine sand content.	DILWYN FORMATION Clay Unit 1 (C1)
118	124		Mottled light and dark brown clay. Strongly bound but gritty with a fine sand content.	
124	128		Brown, soft, pliable, well bounded. Minor fine sand.	
128	130		Slight increase in sand content.	
130	138		Minor sand	
138	139	SAND	Coarse grains, generally frosted. Est ave >1mm	DILWYN FORMATION Sand Unit 1 (S1)
139	140		50% sand average – 0.43mm	
140	141		50% sand average – 1.2mm	
141	142		50% sand average – 0.92mm	
142	143		50% sand average – 0.9mm	
143	144		50% sand average – 0.79mm	
144	145		50% sand average – 0.68mm	
145	146		50% sand average – 0.59mm	
146	147		50% sand average – 0.52mm	
147	148		50% sand average – 0.58mm	
148	149		50% sand average – 0.9mm	
149	150		50% sand average – 0.63mm	
150	151		50% sand average – 1mm	
151	152		50% sand average – 1.1mm	
152	153		50% sand average – 1.3mm	
153	154		50% sand average – 1.1mm	
154	155		50% sand average – 1.1mm	
155	157		Thin clay band	
156	157		50% sand average – 0.88mm	
157	158		50% sand average – 0.69mm	
158	159		50% sand average – 0.75mm	
159	160		50% sand average – 0.49mm	
160	161		50% sand average – 0.95mm	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
161	162		50% sand average – 0.68mm	
162	163		50% sand average – 0.55mm	
163	164		50% sand average – 0.7mm	
164	165		50% sand average – 0.65mm	
165	166		50% sand average – 0.6mm	
166	167		50% sand average – 0.62mm	
167	168		50% sand average – 0.55mm	

Dilwyn Formation observation well-1 7023-7369 (KLN017)

Project: BOOL LAGOON DRILLING INVESTIGATION

Permit Number: **229330**
Backfilled (Y/N): **N**
Date Completed: **4/5/2014**
Total Depth (m): **234**
Unit No: **7023 - 7369**
Drill Method: **Rotary Mud**
Observation Number: **KLN017**
Drilling Company: **Thompson Drilling**
Logged By: **Jeff Lawson**
Driller: **Josh Pech**

Coordinates

Easting: **476925**
Ground Elevation (mAHD): **52.75**
Northing: **5883820**
Reference Elevation (mAHD): **52.67**
Zone: **54**
Reference Point Type: **TOC**
Datum: **GDA94**

General Comments:

Lithological Description

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
0	8		Grey, soft, plastic. High percentage of embedded calcareous fragments.	
8	10		Weakly bounded. Minor shell and flints.	**BRIDGEWATER FORMATION**
10	12	**MARL**	Off white to pale grey. Well bounded marl with a high percentage of calcareous fragments.	
12	14		Pale grey, grey, pale brown marl. Well bounded marl with a high percentage of calcareous fragments.	
14	20		Pale brown. Essentially unconsolidated sand with about 30% calcareous remnants.	
20	22		Increasing percentage of shell and fossil material (fragments to 1cm). Mainly unconsolidated sediment but some strongly cemented fragments.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
22	24	**CALCITE**	Overall very pale brown. Individually clear to frosted calcite crystallisation. Essentially unconsolidated but with weakly to strongly cemented fragments.	**GAMBIER LIMESTONE**
34	40		Pale grey, weakly to strongly cemented with minor unconsolidated rhomb's. Essentially rhombic with occasional bryozoa fossils.	
40	44	**LIMESTONE**	Pale grey, weakly cemented. Transitioning from a calcite to a limestone. Still a high % of rhomb's.	
44	46	**MARLY LIMESTONE**	Essentially pale grey, weakly bound marl. Percentage of weakly cemented grey limestone.	
46	50	**MARL**	Grey, weakly bound marl. Minor flint.	
50	54		With 20 – 30%fine unconsolidated limestone	
54	58		Minor flint	
58	60		Very pale grey, moderately cemented marl. 15 – 20% limestone fossil content.	
60	66		Very pale grey, well bounded marl. Minor limestone and flint.	
66	70	**LIMESTONE**	Off white, unconsolidated fossil content. Fine to medium grained with some coarse fossils.	
70	72		Strongly cemented fragments with a percentage of unconsolidated fossils. Fine to medium grained.	
72	74		Minor grey flint.	
74	76	**FLINT**	Black. 30 – 40% limestone – white, unconsolidated. 5 – 10% marl – off white.	
76	80	**LIMESTONE**	White, weakly cemented to uncemented. Some coarse fossilization. Overall medium to coarse grained. 10 – 15% flint.	
80	82		Off white to pale grey. Weakly to strongly cemented to uncemented. Fine to medium grained. 10 – 15% flint – grey to black.	
82	84		Off white. Fine to medium grained. 5 – 10% flint.	
84	90		White, unconsolidated, fine to medium grained limestone. Minor flint.	
90	92		15 – 20% flint.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
92	94		Coarse limestone. 5 – 15% flint.	
92	102	**MARLY LIMESTONE**	Grey marl with fine to medium grained limestone. 5 – 10% flint.	
102	106	**LIMESTONE**	White unconsolidated limestone. Medium to coarse grained limestone. 20 – 30% flint.	
106	108		Minor flint.	
108	112		Fine to medium grained.	
112	114		As above with 15 – 20% marl – pale grey with strong glauconitic staining.	**NARRAWATURK MARL**
114	120	**MARLY LIMESTONE**	Weakly bound marl. 40% unconsolidated limestone, fine grained. 5 – 10% flint. Glauconitic staining.	
120	122	**MARL**	Off white, weak to moderate bound marl. Glauconitic staining. 25 – 35% limestone content.	
122	124	**MARLY LIMESTONE**	50:50 marl to limestone.	
124	130	**MARL**	Grey with strong white mottling, strongly bound. Minor limestone.	
130	134		Pale grey, medium bound clay. Glauconitic staining. 20 – 30% limestone.	
134	140		Glauconitic staining. 5 – 10% limestone.	
140	142		Minor limestone.	
142	148	**MARL**	Pale brown to pale orange, strongly bound. Sand embedded – dominantly iron stained and limonitic grains.	
148	150		Mottled grey and pale orange. Strongly bound marl.	
150	154		Mottled brown, light brown and pale orange. Minor fine sand.	
154	156		Sand content increasing. High limonitic content.	
156	160		Light brown, grey, orange colour. Recrystallised material, glauconitic grains, fine sand and limonitic grains. Some carbonated material (uphole?)	
160	170		Mottled dark and light brown. Strongly bound, Fine sand.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
170	176	**CLAY**	Dark brown with lighter brown patches. Strongly bound clay. Strong limonitic sand content.	**MEPUNGA FORMATION**
176	178		Dark brown. Weakly bound clay. High sand content with clear, iron stained and limonitic grains.	
178	180	**SAND**	Frosted, milky, iron stained coarse sand grains. Sub rounded to well rounded.	
180	182	**SANDY CLAY**	Light brown clay. Fine to coarse sand – 50:50 ratio.	
182	186	**CLAY**	Light brown with mottle light orange. Strongly bound – minor sand.	
186	188	**SANDY CLAY**	Light brown. Clay breaks down in water. Strong medium to coarse sand content.	
188	192	**SAND**	Coarse sand – est ave >1mm. Iron stained, limonitic, frosted grains. Minor clay.	
192	198	**CLAY**	Dark brown, strongly bound clay. Smooth, pliable.	**DILWYN FORMATION Clay Unit 1 (C1)**
198	202		Some fine sand.	
202	213		Dark brown, strongly bound, soft, pliable.	
213	220	**SAND**	50% sand average –0.85 mm	**DILWYN FORMATION Sand Unit 1 (S1)**
220	222		Coarse sand. 50% average – 1 mm	
222	224		50% sand average – 0.66 mm	
224	226		50% sand average –0.8 mm	
226	228		50% sand average – 0.7 mm	
228	230		50% sand average – 0.7 mm	
230	232		50% sand average – 0.65 mm	

Dilwyn Formation observation well-2 7023-7368 (KLN018)

Project: BOOL LAGOON DRILLING INVESTIGATION

Permit Number: **229306**

Backfilled (Y/N): **N**

Date Completed: **12/04/2014**

Total Depth (m): **185.5**

Unit No: **7023 -7368**

Drill Method: **Rotary Mud**

Observation Number: **KLN018**

Drilling Company: **Water Dynamics/Thompson Drill**

Logged By: **Jeff Lawson**

Driller: **Greg Cram/ Josh Pech**

Coordinates

Easting: **476925**

Ground Elevation (mAHD): **52**

Northing: **5883820**

Reference Elevation (mAHD): **51.96**

Zone: **54**

Reference Point Type: **TOC**

Datum: **GDA94**

General Comments: Bool Lagoon Monitoring well 2. This lithological log is based on the test well drilled by Greg Cram. Thompson drilling then constructed the main well and added greater depth as it was realised the well was still in the Mepunga sands.

Lithological Description

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
0	1	**TOPSOIL**	Black peat, organic topsoil.	**RECENT**
1	2	**SANDSTONE**	White strongly cemented fine grained chips.	**BRIDGEWATER FORMATION**
2	6	**MARLY SANDSTONE**	White strongly cemented chips bound in weak white marl.	
6	10		Strongly bound marl. Less of the strongly cemented fragments.	
10	12	**MARL**	Changing colour to mottled light brown/ light orange. Percentage of strongly cemented fine grained fragments increasing.	
12	16		Light brown strongly bounded marl with some sandstone fragments. Minor sand.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
16	18	**SANDSTONE**	Pale yellow and orange weakly cemented pieces. Coarse sand grains to 2mm and shell fragments to 4mm.	
18	20	**LIMESTONE**	Off white to pale grey. Weakly cemented fragments. Excellent quality fossils and minor flint.	
20	24	**FLINT**	Grey plus a high percentage of light grey partially silicified fragments. 20% limestone.	
24	32		Increasing percentage (30 to 40%) of unconsolidated coarse fossils.	
32	34		Dark grey angular fragments. 30 to 40% limestone – grey, generally finer grained although occasional medium sized bryozoa.	
34	36	**LIMESTONE**	Grey, varies from fine grained strongly cemented fragments to generally fine to medium grained unconsolidated fossil content. Shell fragments to 4mm. 15 to 20% Flint.	
36	38	**FLINT**	Dark grey. 20 to 30% limestone – pale grey, unconsolidated, fine grained.	
38	40	**LIMESTONE**	Off white to pale grey. Medium to coarse grained limestone. 10% flint.	**GAMBIER LIMESTONE**
40	42		Fine to medium grained. Glauconitic stained fossil remnants. 5% flint.	
42	44		Pale grey, fine grained limestone. Minor marl percentage.	
44	46		Off white, fine to medium grained unconsolidated fossil content. 15 – 25% brown flint. Minor marl.	
46	50		Minor flint.	
50	52		10 – 15% brown flint, but about another 15 – 20% fine grained, strongly cemented partially silicified fragments.	
52	54		Off white, fine grained unconsolidated fossil content. 5% white marl. Minor flint.	
54	58	**MARLY LIMESTONE**	White to off white. High percentage limestone embedded in the marl.	
58	60	**LIMESTONE**	White to off white. Essentially medium to coarse grained unconsolidated fossil content. Minor marl – probable up hole.	
60	62	**FLINT**	Brown, minor limestone.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
62	64	**LIMESTONE**	White to off white. Medium to coarse grained, unconsolidated fossil content. 30% brown flint.	
64	66		Minor flint.	
66	68	**FLINT**	Brown to grey. High marl content and strong unconsolidated fossil %.	
68	70	**MARLY LIMESTONE**	Pale grey. Strong fossil content embedded in the marl. 10% Flint.	
70	72	**LIMESTONE**	Off white medium grained limestone. Some coarse fossil content.	
72	76		Medium to coarse grained.	
76	80		Overall finer grained with some medium sized fossil content.	
80	82		Glauconitic stained grains.	**NARRAWATURK MARL**
82	86	**GLAUCONITIC MARL**	Green marl highlighted by occasional green grains (sand?) embedded in the marl. Minor limestone content.	
86	88	**MARL**	Grey soft pliable. Some glauconitic staining. Medium to coarse limestone present.	
88	92	**GLAUCONITIC MARL**	Off white to green. Strong glauconitic staining in sections.	
92	102	**SAND**	Fine sand.	**MEPUNGA FORMATION**
106	117		Fine brown sand.	
117	120	**CLAY**	Brown, soft, pliable. Minor fine sand	
120	124		Fine sand content decreasing.	
124	126		Dark brown, strongly bound. Fine and coarse sand embedded in the clay.	
126	130		Soft, pliable, minor fine sand.	
130	140		Brown clay. Fine sand varying from frosted, iron stained to limonitic grains.	
140	141		Brown, weak to moderately bound clay. Strong sand content embedded in the clay.	
141	144		Fine to medium grained sand. Frosted, iron stained, limonitic grains. Sub angular to well rounded.	
144	146		Fine sand.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
146	150		Moderately bound clay. 20 – 30% sand – highly limonitic.	
150	152	CLAY	Dark brown clay, strongly bound, soft, pliable. Embedded with fine sand.	DILWYN FORMATION Clay Unit – (C1)
152	154		Not so strongly bound.	
154	165		Dark brown, strongly bound clay. Minor very fine sand.	
165	166	SAND	Start of S1. Estimated contact point – no geophysics. Medium to coarse grained sand. Clear to frosted grains.	DILWYN FORMATION Sand Unit - (S1)
166	168		Micaceous sand. 50% sand average - 0.61 mm	
168	170		50% sand average - 0.66 mm	
170	172			
172	174		Brown sand. 50% sand average - 1.2 mm	
174	176		Highly Micaceous brown sand. 50% sand average - 0.83 mm	
176	178		Brown sand. 50% sand average - 0.52 mm	
178	180		50% sand average - 0.43 mm	
180	182		Brown sand. 50% sand average - 0.79 mm	
182	184		50% sand average - 0.47 mm	
184	186		50% sand average - 0.66 mm	

Dilwyn Formation observation well-3 7023-7370 (ROB036)

Project: BOOL LAGOON DRILLING INVESTIGATION

Permit Number: **229331**

Date Completed: **7/05/2014**

Unit No: **7023 - 7370**

Observation Number: **ROB036**

Logged By: **Jeff Lawson**

Backfilled (Y/N): **N**

Total Depth (m): **162**

Drill Method: **Rotary Mud**

Drilling Company: **Thompson Drilling**

Driller: **Josh Pech**

Coordinates

Easting: **467510**

Northing: **5887322**

Zone: **54**

Datum: **GDA94**

Ground Elevation (mAHD): **49.85**

Reference Elevation (mAHD): **49.78**

Reference Point Type: **TOC**

General Comments: Monitoring well 3 – Confined aquifer observation well drilled 1.5 kilometres from the production well.

Lithological Description

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
0	2	**SANDY CLAY**	Brown, weakly bound clay. Strong fine sand content with extensive iron stained grains.	**RECENT**
2	4	**SANDSTONE**	White, strongly cemented fine grained fragments. 10 - 15% Marl – white.	**BRIDGEWATER FORMATION**
4	6		White to brown fragments (iron content). Fine grained, strongly cemented.	
6	12		Pale brown. Varies from weakly to strongly cemented fragments to unconsolidated sand.	
12	16		Pale orange. Strong iron content. Occasional fossils present, mostly poor quality. Strong sand content.	
16	18		Off white, unconsolidated fossils, strongly bryozoal. Fine grained. 5 - 10% flint.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
18	20		Fine to medium grained.	
20	22		Pale grey, weakly cemented. Occasional iron stained strongly cemented fine grained fragments. Slightly marly. 5 - 10% Flint.	
22	26		Off white, weakly cemented to uncemented. Medium to coarser grained. 5 – 10% Flint.	**GAMBIER LIMESTONE Camelback Member**
26	28		Coarser limestone.	
28	30	**LIMESTONE**	Off white to pale grey. Strongly cemented to uncemented. Fine grained with minor flint.	
30	32		Off white, unconsolidated, coarse grained limestone. 20 – 30% Flint – grey to black.	
32	36		No flint.	
36	40		Medium to coarse grained.	
40	42	**MARL**	Pale grey, weakly bound marl. High limestone content.	
42	44	**LIMESTONE**	Off white to pale grey. Strongly cemented fine grained fragments.	
44	46	**MARLY LIMESTONE**	Off white. Medium grained in a weakly bound marl.	
46	48	**MARL**	Grey, well bound marl. 20 – 30% limestone content.	
48	52	**FLINT**	Black to grey flint. Minor marl.	
52	56		Off white, unconsolidated medium grained.	
56	58		Off white, essentially unconsolidated, fine to medium grained. Smaller percentage strongly cemented, fine grained fragments. 25 – 35% Flint.	**GAMBIER LIMESTONE Greenways Member**
58	62		Off white, unconsolidated, medium to coarser grained.	
62	68	**LIMESTONE**	Off white, weakly cemented to uncemented. Fine to medium grained. 5 – 10% Flint.	
68	70		Finer grained. Minor marl content.	
70	76		Weakly cemented to uncemented. Fine grained, glauconitic staining.	
76	78	**MARL**	Pale grey, weakly bound marl. Some glauconitic staining. High limestone content.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
78	80	**LIMESTONE**	White, unconsolidated, fine to medium grained. 30% marl. Minor glauconitic staining.	
80	82		White and grey. Bryozoal limestone with grey partially silicified fine grained fragments.	
82	88	**MARL**	Grey weakly bound marl. High percentage of limestone in the sample. Minor flint.	**NARRAWATURK MARL**
88	112		Stronger marl – less limestone. Glauconitic staining and grains.	
112	113		Slight colour change. Becoming pale grey with some brown patches. Still glauconitic grains and no limonitic grains.	
113	120	**MARL**	Pale brown with also orange colouration. Essentially marly (HCl reaction) with some limonitic grains.	**MEPUNGA FORMATION**
120	122		More sand embedded in the clay – dominantly limonitic/ iron stained sand.	
122	128		Brown and light orange mottling.	
128	132		Strong sand content – coarser grains – strongly limonitic.	
132	134	**SAND**	Clear, frosted, milky, iron stained, limonitic grains. Rounded to well rounded	
134	144	**CLAY**	Dark brown, soft, pliable. Minor sand content.	**DILWYN FORMATION Clay Unit 1 (C1)**
144	146		Increasing sand content.	
146	148	**SAND**	50% sand average – 1.65 mm	**DILWYN FORMATION Sand Unit 1 (S1)**
148	150		50% sand average – 1.8 mm	
150	152		50% sand average – 2 mm	
152	154		50% sand average – 2 mm	
154	156		50% sand average – 1.8 mm	
156	158		50% sand average – 1 mm	
158	160		50% sand average – 1 mm	
160	162		50% sand average – 1.4 mm	

Project: South East Confined Observation Well Drilling

Permit Number: **90244**

Date Completed: **4/2/1980**

Unit No: **7023 - 1850**

Observation Number: **KLN010**

Logged By: **Jeff Lawson**

Backfilled (Y/N): **N**

Total Depth (m): **297**

Drill Method: **Cable Tool & Rotary**

Drilling Company: **Mines and Energy**

Driller:

Coordinates

Easting: **474863**

Northing: **5876225**

Zone: **54**

Datum: **GDA94**

Ground Elevation (mAHD): **TBD**

Reference Elevation (mAHD): **TBD**

Reference Point Type: **TOC**

General Comments: This well was logged at the Glenside core library in 2014 which is a long time after completion. Many of the samples were very dry which affected the clays the most and hindered description.

Lithological Description

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
0	0.5	**TOPSOIL**	Fine brown sand and organic material.	**RECENT**
0.1	1	**CLAY**	Brown.	
6	10	**SANDSTONE**	White, strongly cemented fragments.	**BRIDGEWATER FORMATION**
10	14		Overall grey colour. Strongly cemented fragments.	
14	18		Unconsolidated shell material.	
18	28		Pale yellow, unconsolidated sand with occasional poor quality fossil remnants.	
28	30		Off white, strongly cemented fine grained fragments.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
30	44	**LIMESTONE**	Off white, fine grained unconsolidated limestone.	**GAMBIER LIMESTONE**
44	58	**MARL**	Off white.	
58	60	**FLINT**	Grey to black. 30% medium grained limestone.	
60	68	**MARL**	Off white.	
69	70	**MARL/ FLINT**	Well bounded marl and flint.	
70	76	**LIMESTONE**	White unconsolidated. Essentially fine grained.	
76	78	**FLINT**	Black with coarse limestone.	
78	84	**LIMESTONE**	Fine to medium grained.	
84	86	**MARLY LIMESTONE**	White.	
86	90	**LIMESTONE**	White unconsolidated fossils. Essentially fine grained but containing a percentage of medium fossils.	
90	94		White fine grained. Marl component.	
94	100	**MARL**	White.	
100	114	**LIMESTONE**	White unconsolidated fossils. Fine to medium grained. Minor flint.	
114	128	**MARL**	White well bounded.	
128	134	**LIMESTONE**	Off white, very fine grained. Minor marl.	
134	140	**MARL**	Off white, well bounded marl.	
140	143		White marl. Minor fossil content.	
143	146		Pale brown with minor fine fossils.	
146	148	**CLAY/ MARL**	Interface between the Narrawaturk Marl and Mepunga Formation.	**NARRAWATURK MARL**
148	158	**CLAY**	Pale brown – light orange. Fine limonitic grains.	**MEPUNGA FORMATION**
158	159	**SAND**	Overall brown colour, fine grained strong limonitic component.	
159	162	**CLAY**	Deep brown, break down to a silt component of very fine sand.	
162	170		Slightly lighter colour.	
170	190	**CLAY/ SAND**	Probably Mepunga clay but very dry and breaks down to a fine silt sand. Sand is brown, fine grained unconsolidated. Iron staining of grains common. Limonitic grains still present.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
190	193	**CLAY/ SANDY CLAY**	Black clay. Coarse sand grains (up hole?)	**DILWYN FORMATION** **Clay Unit (C1)**
193	204		Black clay, coarse sand grains to 1mm or greater.	
204	213	**CLAY**	Black. Minor fine sand.	
213	216	**SAND**	Overall brown colour. Clear, frosted, milky unconsolidated sand. Estimated ave <0.7mm.	**DILWYN FORMATION** **Sand Unit (S1)**
216	218		Becoming coarser. Average around 1mm or a little greater.	
218	222	**GRAVEL**	Milky, frosted to pale grey. Unconsolidated sand. Very coarse with grains to >1cm – ave 2to 3 mm.	
222	228		Sand a little cleaner. Less huge grains but still extremely coarse with most grains to 1cm. Traces of mica, slight iron staining.	
228	232	**SAND**	Milky, frosted to grey unconsolidated grains. Coarse sand. Trace of mica and marcasite.	
232	234	**GRAVEL**	Overall light brown. Coarse grains to >1cm.	
234	246	**SAND**	Overall light grey. Coarse unconsolidated sand. More even distribution of grain sizes.	
246	248		Coarse sand. Ave approx. 1mm but finer than before.	
248	297		Not as coarse. Estimated ave <1mm	

Project: South East Confined Observation Well Drilling

Permit Number: **31365A**

Date Completed: **9/8/1994**

Unit No: **7023 - 5082**

Drillhole Name:

Logged By: **Jeff Lawson**

Backfilled (Y/N): **N**

Total Depth (m): **246**

Drill Method: **Rotary Mud**

Drilling Company: **Thompson Drilling**

Driller: **Mike Thompson**

Coordinates

Easting: **465172**

Northing: **5887028**

Zone: **54**

Datum: **GDA94**

Ground Elevation (mAHD): **TBD**

Reference Elevation (mAHD): **TBD**

Reference Point Type: **TOC**

General Comments: This well was logged at the Glenside core library. Due to storage time and sample drying some sections were difficult to interpret.

Lithological Description

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
0	2	**SANDSTONE**	Off white to pale orange, fine grained, strongly cemented. High iron staining from the clay content.	**BRIDGEWATER FORMATION**
2	4		Less clay content. Unconsolidated sandstone.	
4	12		Slight pinkish hue. Overall white to off white, strongly cemented fine grained fragments.	
12	16		Off white, weakly cemented to unconsolidated sediments.	
16	18		Strongly cemented, fine grained fragments.	
18	28		Very pale yellow, strongly cemented sandstone. Minor unconsolidated percentage.	
28	32	**LIMESTONE**	Off white, generally unconsolidated good quality fossil remnants. 5 – 10% black flint.	
32	34	**MARL**	White. 5 – 10% flint.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
34	36		Flint content increasing.	
36	40	**FLINT**	Black angular fragments. 40% marl, unconsolidated fossils.	
40	46	**LIMESTONE**	White coarse unconsolidated bryozoa.	**GAMBIER LIMESTONE**
46	54	**FLINT**	Black. Minor marl.	
54	80		Sample quality poor. Looks like a marly limestone with occasional flints and unconsolidated fossils.	
80	82	**MARL**	Strong glauconitic staining in parts.	
82	100	**MARLY LIMESTONE**	Appears as a marly limestone.	
100	136	**MARL**	White, well bounded marl.	
136	140	**MARL**	Light brown. Combination of marl and strongly cemented fine grained limestone. Unconsolidated fossil and glauconitic grains.	**NARRAWATURK MARL**
140	142	**MARL**	Transitioning from Narrawaturk Marl to Mepunga Formation	**MEPUNGA FORMATION**
142	144	**CLAY**	Brown, well bounded clay.	
144	146	**CLAY/ SAND**	Brown clay and fine to coarse sand.	
146	150	**SAND**	Mainly coarse sand, strongly iron stained.	
150	154	**CLAY**	Brown to black. Relatively high percentage of coarse and fine sands (up hole contamination).	**DILWYN FORMATION Clay Unit 1 (C1)**
154	156		Brown strongly bounded clay. Minor fine sand	
156	162	**SANDY CLAY**	Brown. Dominantly fine to coarse sand with about 30 to 40% of clay.	
162	170	**SAND**	Clear, frosted to milky. Unconsolidated sand, rounded to well rounded. Overall coarse sand – estimated ave 0.7mm.	
170	174		Coarser. Grains to 5mm. Estimated ave 1mm.	
174	190		Finer. Estimated ave 0.5 to 0.7mm.	
190	192		Slightly coarser.	
192	194		Individual grains to 5mm. Estimated ave 0.7 to 1mm.	
194	200		Estimated ave – 1mm or greater.	
200	202		A little finer. Estimated ave 0.7mm.	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
202	204		Sand becoming finer - <0.7mm. Also becoming slightly clayey.	**DILWYN FORMATION Sand Unit 1 (S1)**
204	206	**SANDY CLAY**	Clay content about 60%. Sand becoming fine although some coarse grains.	
206	208	**SAND**	Becoming coarser. Estimated ave 0.5 to 0.7mm. Approx. 20% clay content.	
208	210		No clay. Sand as above.	
210	212		Some coarse grains. Ave 0.5 to 0.7mm.	
212	222		Becoming little coarser. Estimated ave 0.6 to 0.7mm.	
222	226		Even grain size. Estimated ave <0.7mm.	
226	228		Coarser – 0.7 to1mm.	
228	230		Estimated ave 0.5 to 0.7mm.	
230	234		Estimated ave 0.7mm.	
234	236		Sand becoming finer with minor clay.	
236	238		Coarser sand but with an increase in clay content.	
238	240	**SANDY CLAY**	Brown clay mixed with very coarse sand. Grains to 1mm.	
240	244	**SAND**	Estimated ave 0.5 to0.7mm.	
244	246		Finer. Estimated ave 0.3 to 0.5mm.	

Project: South East Confined Observation Well Drilling

Permit Number: **45412**

Backfilled (Y/N): **N**

Date Completed: **11/7/1998**

Total Depth (m): **162**

Unit No: **7023 - 5678**

Drill Method: **Rotary**

Drillhole Name:

Drilling Company:

Logged By: **Jeff Lawson**

Driller: **Lloyd Moore**

Coordinates

Easting: **467292**

Ground Elevation (mAHD): **TBD**

Northing: **5887571**

Reference Elevation (mAHD): **TBD**

Zone: **54**

Reference Point Type: **TOC**

Datum: **GDA94**

General Comments:

Lithological Description

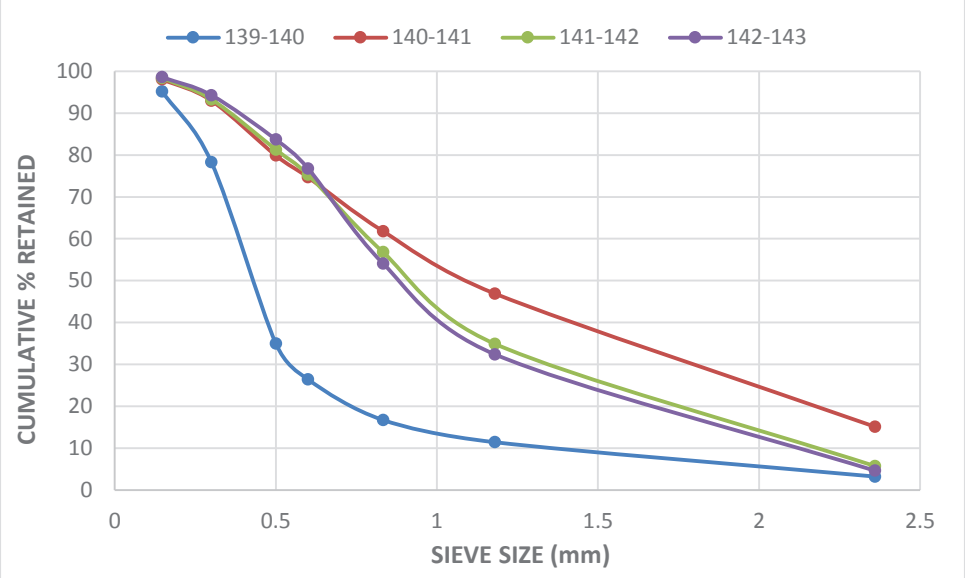
Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
0	3	**CLAY**	Yellow clay with minor sandstone inclusions.	**RECENT/ HOLOCENE**
3	9	**SANDSTONE**	Very pale brown. Fine grained strongly cemented fragments and unconsolidated shell material.	**BRIDGEWATER FORMATION**
9	12		White, strongly cemented fragments. Some poor quality fossilization.	
12	15		Large shell fragments.	
15	21	**LIMESTONE**	White, unconsolidated medium grained fossil content.	**GAMBIER LIMESTONE Green Point Member Unit 4**
21	27		20% flint.	
27	30		Overall brown colour. White coarse unconsolidated fossil content.	
30	36		White unconsolidated fine to medium grained fossils.	

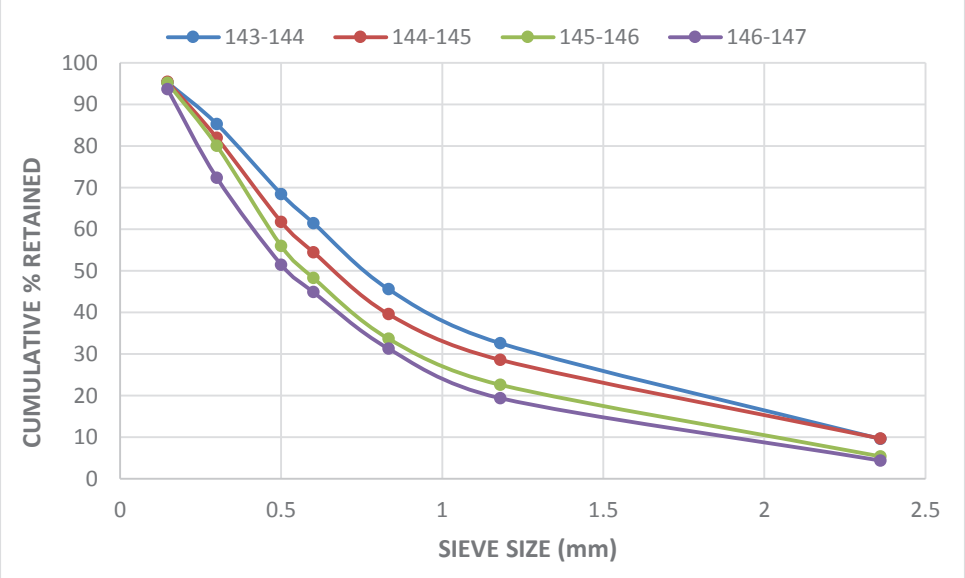
Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
36	42		Becoming finer. Still overall medium grained fossil content. Minor flint.	
42	45		Flint content increasing.	
45	48	**FLINT**	Black to grey fragments. 40% fine grained limestone.	
48	57	**LIMESTONE**	White, unconsolidated, fine to medium grained limestone. 5 to 10% flint.	**GAMBIER LIMESTONE Camelback Member**
57	60		Coarse fossil sticks and shells up to 5mm.	
60	63		Overall fine grained.	
63	75		Fine to medium grained.	
75	105	**MARL**	Grey. Fine minor limestone component.	**GAMBIER LIMESTONE Greenways Member**
105	114	**MARL**	Well bounded marl. Strong glauconitic staining. Minor sand grains	**NARRAWATURK MARL**
114	120	**CLAY**	Light brown clay. Strong limonitic stained fine sand grains	**MEPUNGA FORMATION**
120	126		Mottled light and dark brown clay. Fine sand embedded in the clay. Limonitic grains.	
126	129	**SAND**	Overall brown/ orange colour due to iron staining. Grains also milky and frosted. Some limonitic grains. Estimated sand ave – 0.7 to 1mm.	
129	132	**SANDY CLAY**	Sand dominant with strong iron staining.	
132	135	**CLAY**	Brown, strong and component although clay is dominant.	**DILWYN FORMATION Clay Unit 1 (C1)**
135	138	**SANDY CLAY**	Light to darker brown. Confining clay with a strong sand content – leaky?	
138	144	**SAND**	Estimated average >1mm.	**DILWYN FORMATION Sand Unit 1 (S1)**
144	147		Varies from very coarse to fine. Estimated ave 0.7 to 1mm. Some clay from up hole.	
147	150		Estimated average 1mm.	
150	152		Milky grains. Very coarse, estimated ave >1mm. Grains to 5mm	

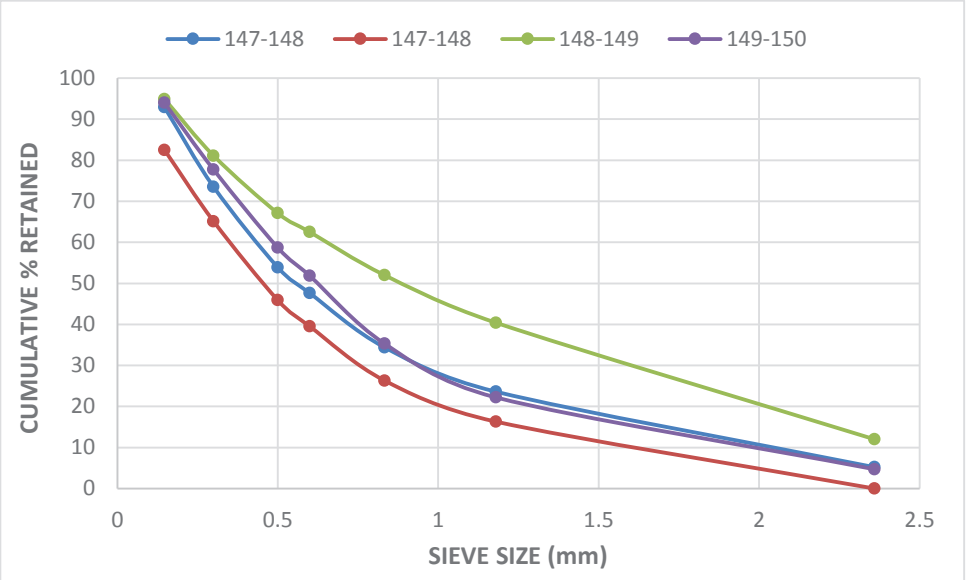
Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
152	159		Clear frosted to milky, unconsolidated sand. Coarse sand estimated ave 0.7 to 1mm. Grains to 5mm.	

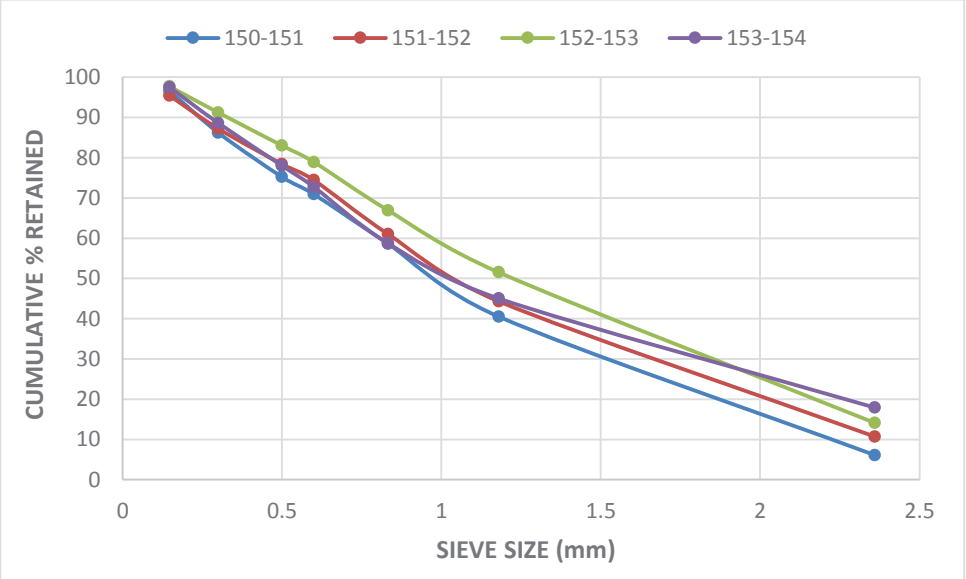
9.3 DILWYN FORMATION SIEVE ANALYSIS

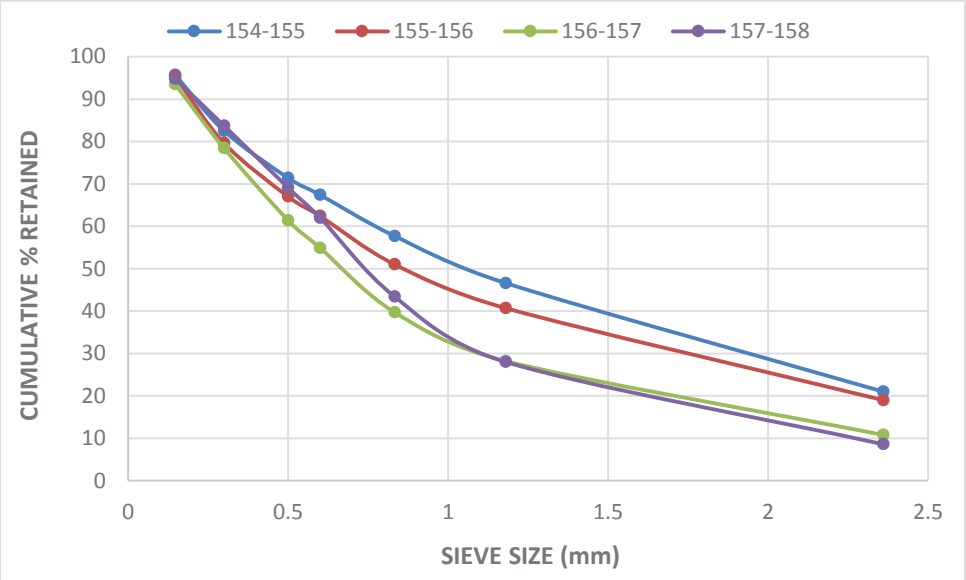
Dilwyn Formation production 7023-7371 (ROB037)

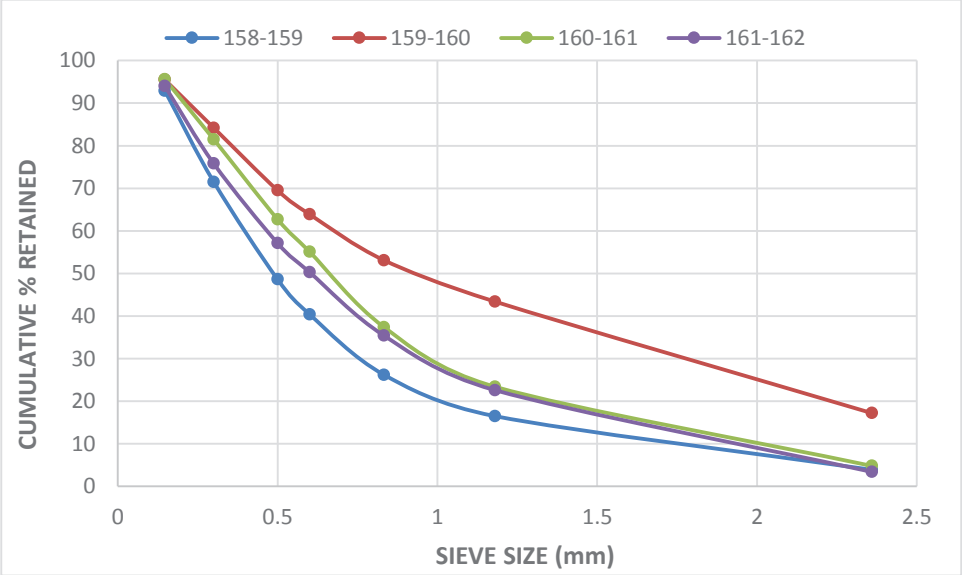


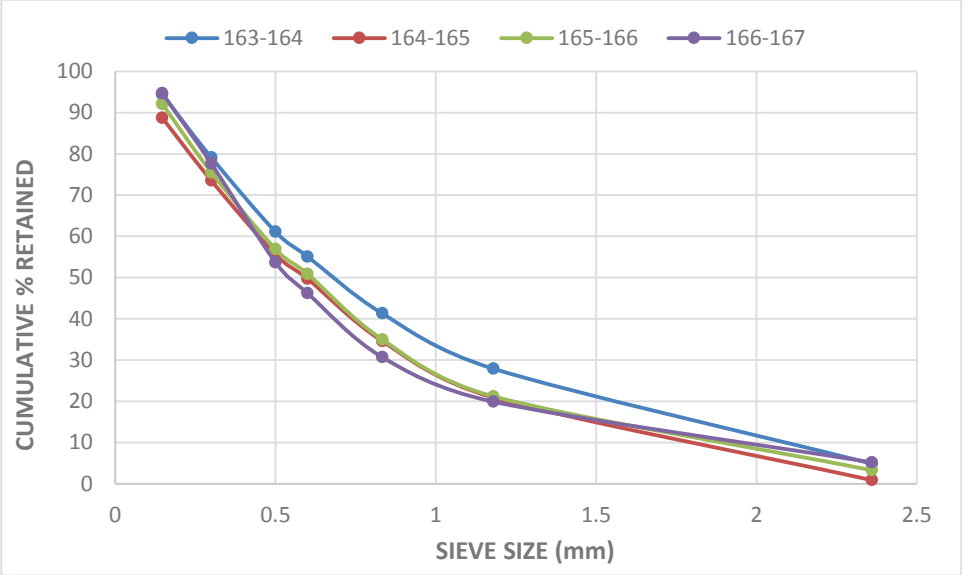



147-148
147-148
148-149
149-150
CUMULATIVE % RETAINED
SIEVE SIZE (mm)

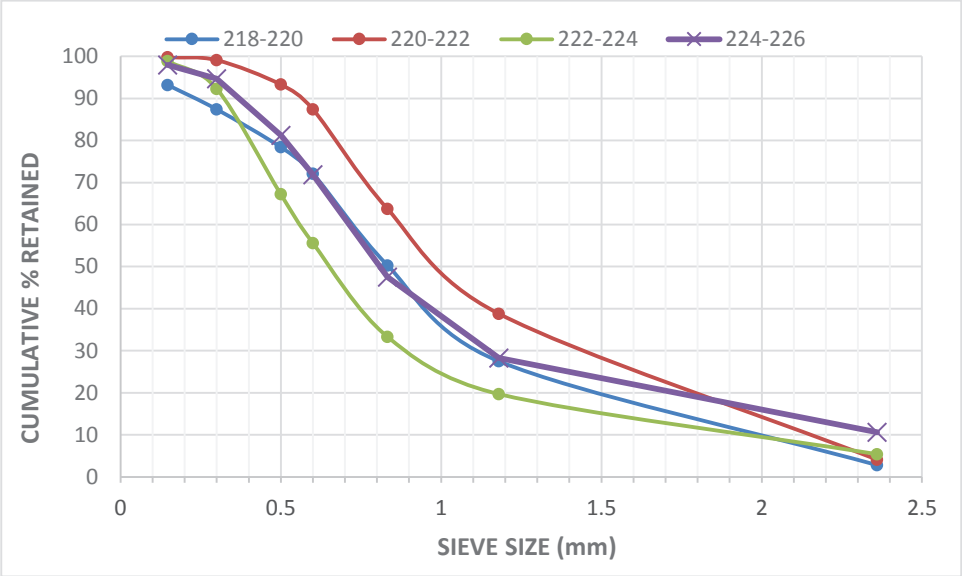

150-151
151-152
152-153
153-154
CUMULATIVE % RETAINED
SIEVE SIZE (mm)

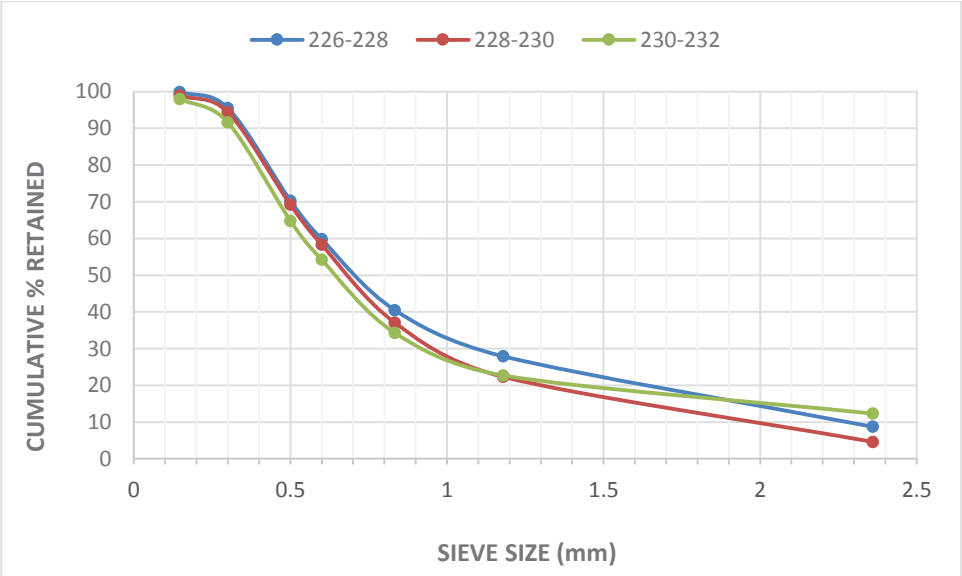

154-155
155-156
156-157
157-158
CUMULATIVE % RETAINED
SIEVE SIZE (mm)


158-159
159-160
160-161
161-162
CUMULATIVE % RETAINED
SIEVE SIZE (mm)

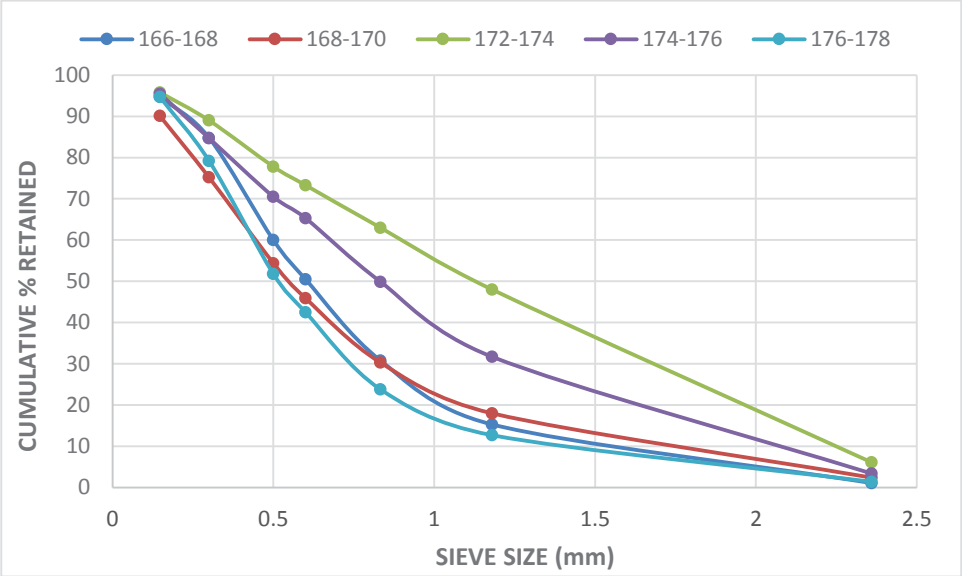

163-164
164-165
165-166
166-167
CUMULATIVE % RETAINED
100
90
80
70
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
SIEVE SIZE (mm)

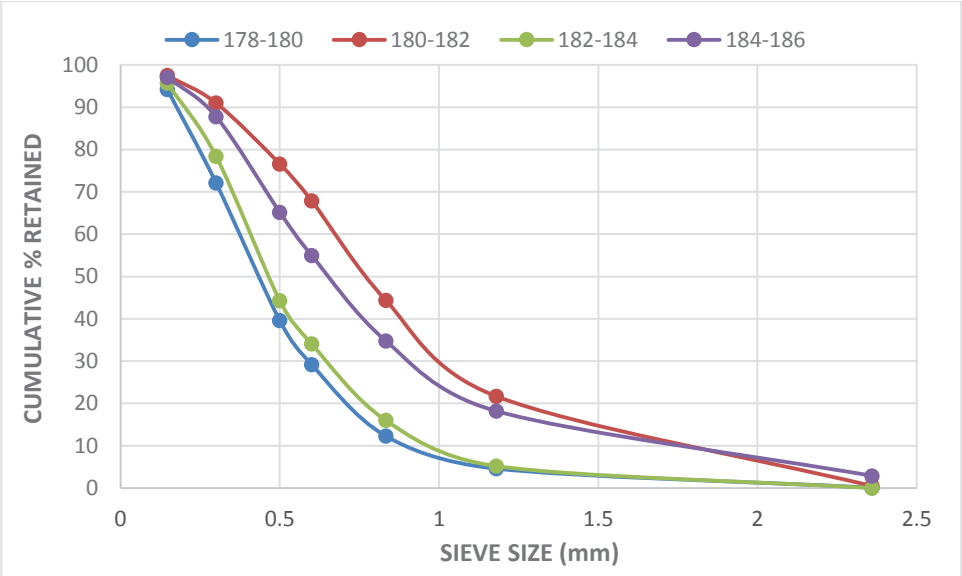
Dilwyn Formation observation well-1 7023-7369 (KLN017)



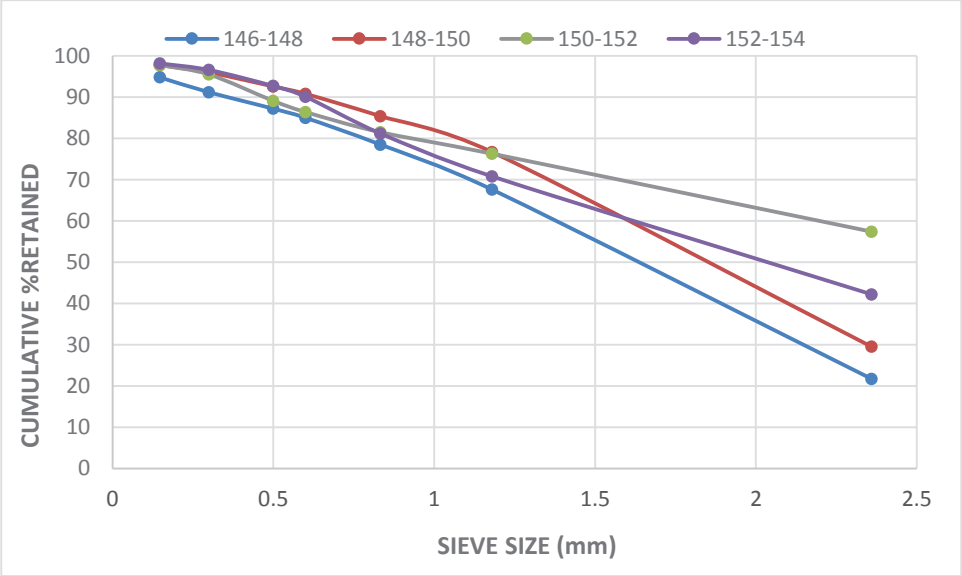


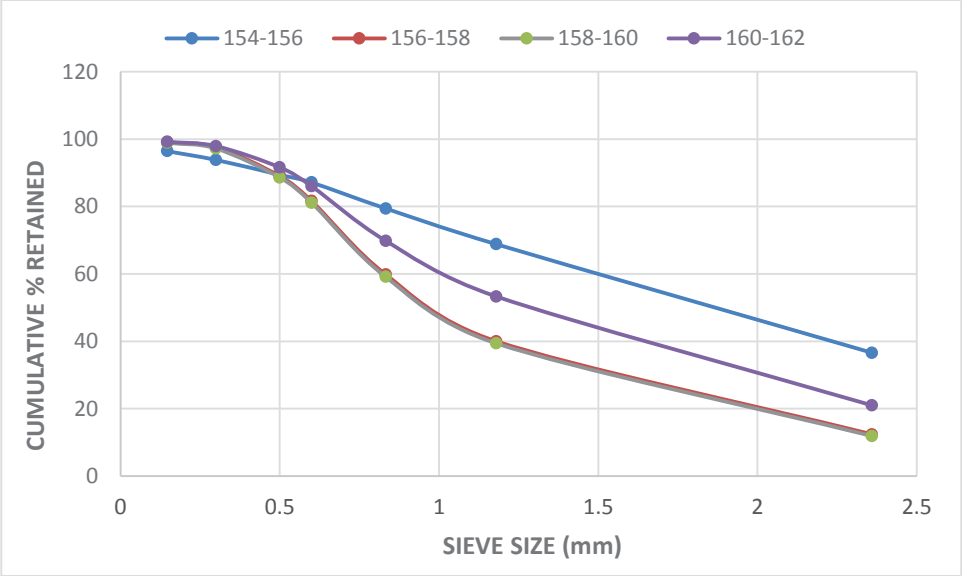
Dilwyn Formation observation well-2 7023-7368 (KLN018)





Dilwyn Formation observation well-3 7023-7370 (ROB036)





9.4 DILWYN FM. PROD. WELL 7023-7371 (ROB037) STEP DRAWDOWN TEST

Start Date	Start time	Step	Duration (mins)	Q (L/s)	Well Name	Well Type	r (m)	Target aquifer	Ref. Elev. (mAHD)
18/07/2014	1000	1	60	30	7023-7371 (ROB037)	Prod.	0	Dilwyn	
		2	60	40	"	"	"	"	"
		3	60	50	"	"	'	'	"

Dilwn production well 7023-7371 (ROB037)

Step No.	Pumping Rate (L/s)	Time (mins)	Water level (m)	Drawdown (m)
		0	15.30	0.00
1	30	1	16.94	1.64
1	30	2	16.95	1.65
1	30	3	17.03	1.73
1	30	4	17.03	1.73
1	30	5	17.04	1.74
1	30	6	17.05	1.75
1	30	7	17.08	1.78
1	30	8	17.09	1.79
1	30	9	17.09	1.79
1	30	10	17.10	1.80
1	30	12	17.11	1.81
1	30	14	17.09	1.79
1	30	16	17.10	1.80
1	30	18	17.11	1.81
1	30	20	17.11	1.81
1	30	22	17.12	1.82
1	30	24	17.12	1.82
1	30	26	17.13	1.83
1	30	28	17.12	1.82
1	30	30	17.12	1.82
1	30	35	17.12	1.82
1	30	40	17.13	1.83
1	30	45	17.14	1.84
1	30	50	17.14	1.84
1	30	55	17.14	1.84
1	30	60	17.15	1.85
2	40	61	17.80	2.50
2	40	62	17.83	2.53
2	40	63	17.82	2.52
2	40	64	17.83	2.53
2	40	65	17.84	2.54
2	40	66	17.84	2.54
2	40	67	17.85	2.55
2	40	68	17.86	2.56
2	40	69	17.86	2.56
2	40	70	17.85	2.55
2	40	72	17.86	2.56
2	40	74	17.86	2.56
2	40	76	17.86	2.56
2	40	78	17.87	2.57
2	40	80	17.87	2.57
2	40	82	17.86	2.56

2	40	84	17.87	2.57
2	40	86	17.88	2.58
2	40	88	17.88	2.58
2	40	90	17.88	2.58
2	40	95	17.89	2.59
2	40	100	17.88	2.58
2	40	105	17.89	2.59
2	40	110	17.90	2.60
2	40	115	17.90	2.60
2	40	120	17.89	2.59
3	50	121	18.61	3.31
3	50	122	18.65	3.35
3	50	123	18.65	3.35
3	50	124	18.66	3.36
3	50	125	18.66	3.36
3	50	126	18.65	3.35
3	50	127	18.66	3.36
3	50	128	18.67	3.37
3	50	129	18.67	3.37
3	50	130	18.67	3.37
3	50	132	18.67	3.37
3	50	134	18.68	3.38
3	50	136	18.68	3.38
3	50	138	18.68	3.38
3	50	140	18.69	3.39
3	50	142	18.70	3.40
3	50	144	18.69	3.39
3	50	146	18.67	3.37
3	50	148	18.70	3.40
3	50	150	18.70	3.40
3	50	155	18.71	3.41
3	50	160	18.69	3.39
3	50	165	18.70	3.40
3	50	170	18.71	3.41
3	50	175	18.72	3.42
3	50	180	18.72	3.42

9.5 DILWYN FM. PROD. WELL 7023-7371 (ROB037) CONST. RATE DISCHARGE TEST

Start Date	Start time	Step	Duration (mins)	Q (L/s)	Well Name	Well Type	r (m)	Target aquifer	Ref. Elev. (mAHD)
19/07/2014	0900	1	Pumping 4,320 Recovery 1,440	50	7023-7371 (ROB037)	Prod.	0	Dilwyn	
					7023-7370 (ROB036)	Obs.	1,627	Dilywn	
					7023-7367 (ROB038)	Obs.	23	Gambier L/S	

Dilwyn Formation production well 7023-7371 (ROB037)

Step	Pumping Rate (L/s)	Time (mins)	Water level (m)	Drawdown (m)
1		0	15.31	0.00
1	50	1	18.35	3.04
1	50	2	18.47	3.16
1	50	3	18.50	3.19
1	50	4	18.51	3.20
1	50	5	18.53	3.22
1	50	6	18.55	3.24
1	50	7	18.56	3.25
1	50	8	18.56	3.25
1	50	9	18.56	3.25
1	50	10	18.57	3.26
1	50	12	18.58	3.27
1	50	14	18.60	3.29
1	50	16	18.60	3.29
1	50	18	18.60	3.29
1	50	20	18.61	3.30
1	50	22	18.61	3.30
1	50	24	18.62	3.31
1	50	26	18.62	3.31
1	50	28	18.63	3.32
1	50	30	18.64	3.33
1	50	35	18.64	3.33
1	50	40	18.66	3.35
1	50	45	18.66	3.35
1	50	50	18.66	3.35
1	50	55	18.67	3.36
1	50	60	18.68	3.37
1	50	70	18.69	3.38
1	50	80	18.70	3.39
1	50	90	18.70	3.39
1	50	100	18.70	3.39
1	50	120	18.72	3.41
1	50	140	18.73	3.42
1	50	160	18.74	3.43
1	50	180	18.73	3.42
1	50	200	18.75	3.44
1	50	250	18.75	3.44
1	50	300	18.78	3.47
1	50	350	18.79	3.48
1	50	400	18.79	3.48
1	50	450	18.81	3.50

1	50	500	18.81	3.50
1	50	550	18.82	3.51
1	50	600	18.83	3.52
1	50	650	18.83	3.52
1	50	700	18.84	3.53
1	50	750	18.84	3.53
1	50	800	18.84	3.53
1	50	850	18.83	3.52
1	50	900	18.84	3.53
1	50	950	18.84	3.53
1	50	1000	18.85	3.54
1	50	1100	18.85	3.54
1	50	1200	18.86	3.55
1	50	1300	18.86	3.55
1	50	1400	18.89	3.58
1	50	1500	18.88	3.57
1	50	1600	18.89	3.58
1	50	1700	18.88	3.57
1	50	1800	18.87	3.56
1	50	1900	18.88	3.57
1	50	2000	18.88	3.57
1	50	2100	18.88	3.57
1	50	2200	18.89	3.58
1	50	2300	18.89	3.58
1	50	2400	18.88	3.57
1	50	2500	18.87	3.56
1	50	2600	18.87	3.56
1	50	2700	18.88	3.57
1	50	2800	18.88	3.57
1	50	2900	18.89	3.58
1	50	3000	18.89	3.58
1	50	3100	18.89	3.58
1	50	3200	18.90	3.59
1	50	3300	18.89	3.58
1	50	3400	18.90	3.59
1	50	3500	18.90	3.59
1	50	3600	18.90	3.59
1	50	3700	18.90	3.59
1	50	3800	18.90	3.59
1	50	3900	18.90	3.59
1	50	4000	18.91	3.60
1	50	4100	18.92	3.61
1	50	4200	18.92	3.61
1	50	4300	18.92	3.61
1	50	4320	18.92	3.61
1	0	4321	15.85	0.54
1	0	4322	15.74	0.43
1	0	4323	15.68	0.37
1	0	4324	15.68	0.37
1	0	4325	15.65	0.34
1	0	4326	15.64	0.33
1	0	4327	15.64	0.32
1	0	4328	15.63	0.32
1	0	4329	15.61	0.30
1	0	4330	15.60	0.29

1	0	4332	15.58	0.27
1	0	4334	15.58	0.27
1	0	4336	15.57	0.26
1	0	4338	15.56	0.25
1	0	4340	15.55	0.24
1	0	4342	15.54	0.23
1	0	4344	15.54	0.23
1	0	4346	15.53	0.22
1	0	4348	15.53	0.22
1	0	4350	15.53	0.22
1	0	4355	15.52	0.21
1	0	4360	15.52	0.21
1	0	4365	15.51	0.20
1	0	4370	15.51	0.20
1	0	4375	15.50	0.19
1	0	4380	15.49	0.18
1	0	4390	15.49	0.17
1	0	4400	15.48	0.17
1	0	4410	15.47	0.16
1	0	4420	15.46	0.15
1	0	4440	15.45	0.14
1	0	4460	15.44	0.13
1	0	4480	15.43	0.12
1	0	4500	15.42	0.11
1	0	4520	15.41	0.10
1	0	4570	15.40	0.09
1	0	4620	15.39	0.08
1	0	4670	15.39	0.07
1	0	4720	15.38	0.07
1	0	4770	15.38	0.07
1	0	5760	15.32	0.01

Dilwyn Formation observation well-3 7023-7370 (ROB036)

Step	Pumping Rate (L/s)	Time (mins)	Water Level (m)	Drawdown (m)
1		0	15.380	0.000
1		13	15.380	0.000
1		28	15.383	0.003
1		43	15.387	0.007
1		58	15.392	0.012
1		73	15.396	0.016
1		88	15.401	0.021
1		103	15.406	0.026
1		118	15.409	0.029
1		133	15.413	0.033
1		148	15.416	0.036
1		163	15.419	0.039
1		178	15.423	0.043
1		193	15.425	0.045
1		208	15.428	0.048
1		223	15.431	0.051
1		238	15.433	0.053
1		253	15.435	0.055
1		268	15.438	0.058
1		283	15.440	0.060
1		298	15.443	0.063
1		313	15.447	0.067
1		328	15.449	0.069
1		343	15.452	0.072
1		358	15.455	0.075
1		373	15.457	0.077
1		388	15.459	0.079
1		403	15.460	0.080
1		418	15.462	0.082
1		433	15.465	0.085
1		448	15.467	0.087
1		463	15.468	0.088
1		478	15.470	0.090
1		493	15.472	0.092
1		508	15.473	0.093
1		523	15.476	0.096
1		538	15.477	0.097
1		553	15.479	0.099
1		568	15.481	0.101
1		583	15.483	0.103
1		598	15.484	0.104
1		613	15.486	0.106
1		628	15.487	0.107
1		643	15.488	0.108
1		658	15.489	0.109
1		673	15.489	0.109
1		688	15.490	0.110
1		703	15.491	0.111
1		718	15.492	0.112
1		733	15.492	0.112
1		748	15.493	0.113
1		763	15.493	0.113

1	778	15.493	0.113
1	793	15.494	0.114
1	808	15.495	0.115
1	823	15.495	0.115
1	838	15.496	0.116
1	853	15.497	0.117
1	868	15.498	0.118
1	883	15.498	0.118
1	898	15.498	0.118
1	913	15.498	0.118
1	928	15.499	0.119
1	943	15.499	0.119
1	958	15.500	0.120
1	973	15.500	0.120
1	988	15.500	0.120
1	1003	15.500	0.120
1	1018	15.501	0.121
1	1033	15.501	0.121
1	1048	15.502	0.122
1	1063	15.504	0.124
1	1078	15.504	0.124
1	1093	15.505	0.125
1	1108	15.506	0.126
1	1123	15.506	0.126
1	1138	15.507	0.127
1	1153	15.508	0.128
1	1168	15.509	0.129
1	1183	15.510	0.130
1	1198	15.510	0.130
1	1213	15.511	0.131
1	1228	15.512	0.132
1	1243	15.513	0.133
1	1258	15.514	0.134
1	1273	15.515	0.135
1	1288	15.516	0.136
1	1303	15.517	0.137
1	1318	15.518	0.138
1	1333	15.518	0.138
1	1348	15.519	0.139
1	1363	15.519	0.139
1	1378	15.520	0.140
1	1393	15.521	0.141
1	1408	15.522	0.142
1	1423	15.523	0.143
1	1438	15.523	0.143
1	1453	15.523	0.143
1	1468	15.524	0.144
1	1483	15.525	0.145
1	1498	15.526	0.146
1	1513	15.525	0.145
1	1528	15.526	0.146
1	1543	15.525	0.145
1	1558	15.526	0.146
1	1573	15.526	0.146
1	1588	15.525	0.145

1	1603	15.525	0.145
1	1618	15.524	0.144
1	1633	15.524	0.144
1	1648	15.524	0.144
1	1663	15.524	0.144
1	1678	15.522	0.142
1	1693	15.523	0.143
1	1708	15.522	0.142
1	1723	15.523	0.143
1	1738	15.524	0.144
1	1753	15.524	0.144
1	1768	15.524	0.144
1	1783	15.525	0.145
1	1798	15.525	0.145
1	1813	15.526	0.146
1	1828	15.527	0.147
1	1843	15.527	0.147
1	1858	15.528	0.148
1	1873	15.529	0.149
1	1888	15.530	0.150
1	1903	15.530	0.150
1	1918	15.531	0.151
1	1933	15.531	0.151
1	1948	15.532	0.152
1	1963	15.533	0.153
1	1978	15.534	0.154
1	1993	15.534	0.154
1	2008	15.535	0.155
1	2023	15.536	0.156
1	2038	15.537	0.157
1	2053	15.538	0.158
1	2068	15.538	0.158
1	2083	15.539	0.159
1	2098	15.539	0.159
1	2113	15.539	0.159
1	2128	15.539	0.159
1	2143	15.539	0.159
1	2158	15.540	0.160
1	2173	15.540	0.160
1	2188	15.540	0.160
1	2203	15.540	0.160
1	2218	15.540	0.160
1	2233	15.540	0.160
1	2248	15.540	0.160
1	2263	15.540	0.160
1	2278	15.540	0.160
1	2293	15.540	0.160
1	2308	15.540	0.160
1	2323	15.539	0.159
1	2338	15.539	0.159
1	2353	15.539	0.159
1	2368	15.539	0.159
1	2383	15.538	0.158
1	2398	15.538	0.158
1	2413	15.538	0.158

1	2428	15.537	0.157
1	2443	15.537	0.157
1	2458	15.537	0.157
1	2473	15.537	0.157
1	2488	15.537	0.157
1	2503	15.536	0.156
1	2518	15.536	0.156
1	2533	15.537	0.157
1	2548	15.538	0.158
1	2563	15.537	0.157
1	2578	15.537	0.157
1	2593	15.538	0.158
1	2608	15.539	0.159
1	2623	15.539	0.159
1	2638	15.540	0.160
1	2653	15.541	0.161
1	2668	15.541	0.161
1	2683	15.541	0.161
1	2698	15.541	0.161
1	2713	15.542	0.162
1	2728	15.543	0.163
1	2743	15.543	0.163
1	2758	15.544	0.164
1	2773	15.545	0.165
1	2788	15.545	0.165
1	2803	15.546	0.166
1	2818	15.547	0.167
1	2833	15.546	0.166
1	2848	15.547	0.167
1	2863	15.548	0.168
1	2878	15.548	0.168
1	2893	15.548	0.168
1	2908	15.548	0.168
1	2923	15.548	0.168
1	2938	15.549	0.169
1	2953	15.550	0.170
1	2968	15.550	0.170
1	2983	15.551	0.171
1	2998	15.551	0.171
1	3013	15.551	0.171
1	3028	15.550	0.170
1	3043	15.550	0.170
1	3058	15.549	0.169
1	3073	15.549	0.169
1	3088	15.549	0.169
1	3103	15.548	0.168
1	3118	15.548	0.168
1	3133	15.547	0.167
1	3148	15.547	0.167
1	3163	15.547	0.167
1	3178	15.546	0.166
1	3193	15.547	0.167
1	3208	15.547	0.167
1	3223	15.547	0.167
1	3238	15.547	0.167

1	3253	15.548	0.168
1	3268	15.549	0.169
1	3283	15.549	0.169
1	3298	15.549	0.169
1	3313	15.549	0.169
1	3328	15.550	0.170
1	3343	15.551	0.171
1	3358	15.552	0.172
1	3373	15.553	0.173
1	3388	15.554	0.174
1	3403	15.555	0.175
1	3418	15.556	0.176
1	3433	15.557	0.177
1	3448	15.558	0.178
1	3463	15.559	0.179
1	3478	15.560	0.180
1	3493	15.559	0.179
1	3508	15.560	0.180
1	3523	15.561	0.181
1	3538	15.561	0.181
1	3553	15.562	0.182
1	3568	15.563	0.183
1	3583	15.563	0.183
1	3598	15.563	0.183
1	3613	15.563	0.183
1	3628	15.564	0.184
1	3643	15.563	0.183
1	3658	15.564	0.184
1	3673	15.563	0.183
1	3688	15.564	0.184
1	3703	15.563	0.183
1	3718	15.563	0.183
1	3733	15.564	0.184
1	3748	15.563	0.183
1	3763	15.563	0.183
1	3778	15.563	0.183
1	3793	15.562	0.182
1	3808	15.562	0.182
1	3823	15.561	0.181
1	3838	15.561	0.181
1	3853	15.561	0.181
1	3868	15.561	0.181
1	3883	15.561	0.181
1	3898	15.560	0.180
1	3913	15.560	0.180
1	3928	15.560	0.180
1	3943	15.560	0.180
1	3958	15.560	0.180
1	3973	15.560	0.180
1	3988	15.560	0.180
1	4003	15.561	0.181
1	4018	15.561	0.181
1	4033	15.561	0.181
1	4048	15.561	0.181
1	4063	15.562	0.182

1	4078	15.562	0.182
1	4093	15.563	0.183
1	4108	15.564	0.184
1	4123	15.564	0.184
1	4138	15.565	0.185
1	4153	15.566	0.186
1	4168	15.566	0.186
1	4183	15.567	0.187
1	4198	15.568	0.188
1	4213	15.568	0.188
1	4228	15.570	0.190
1	4243	15.570	0.190
1	4258	15.571	0.191
1	4273	15.571	0.191
1	4288	15.571	0.191
1	4303	15.572	0.192
1	4318	15.572	0.192
1	4333	15.572	0.192
1	4348	15.570	0.190
1	4363	15.565	0.185
1	4378	15.560	0.180
1	4393	15.555	0.175
1	4408	15.548	0.168
1	4423	15.544	0.164
1	4438	15.539	0.159
1	4453	15.534	0.154
1	4468	15.529	0.149
1	4483	15.525	0.145
1	4498	15.520	0.140
1	4513	15.515	0.135
1	4528	15.511	0.131
1	4543	15.508	0.128
1	4558	15.503	0.123
1	4573	15.501	0.121
1	4588	15.497	0.117
1	4603	15.494	0.114
1	4618	15.490	0.110
1	4633	15.488	0.108
1	4648	15.487	0.107
1	4663	15.484	0.104
1	4678	15.482	0.102
1	4693	15.480	0.100
1	4708	15.478	0.098
1	4723	15.477	0.097
1	4738	15.475	0.095
1	4753	15.474	0.094
1	4768	15.472	0.092
1	4783	15.471	0.091
1	4798	15.470	0.090
1	4813	15.469	0.089
1	4828	15.468	0.088
1	4843	15.467	0.087
1	4858	15.467	0.087
1	4873	15.465	0.085
1	4888	15.465	0.085

1	4903	15.464	0.084
1	4918	15.463	0.083
1	4933	15.462	0.082
1	4948	15.462	0.082
1	4963	15.462	0.082
1	4978	15.461	0.081
1	4993	15.460	0.080
1	5008	15.458	0.078
1	5023	15.457	0.077
1	5038	15.457	0.077
1	5053	15.456	0.076
1	5068	15.455	0.075
1	5083	15.454	0.074
1	5098	15.453	0.073
1	5113	15.451	0.071
1	5128	15.450	0.070
1	5143	15.448	0.068
1	5158	15.447	0.067
1	5173	15.445	0.065
1	5188	15.444	0.064
1	5203	15.442	0.062
1	5218	15.440	0.060
1	5233	15.439	0.059
1	5248	15.439	0.059
1	5263	15.436	0.056
1	5278	15.435	0.055
1	5293	15.433	0.053
1	5308	15.432	0.052
1	5323	15.431	0.051
1	5338	15.429	0.049
1	5353	15.428	0.048
1	5368	15.428	0.048
1	5383	15.426	0.046
1	5398	15.424	0.044
1	5413	15.423	0.043
1	5428	15.422	0.042
1	5443	15.420	0.040
1	5458	15.419	0.039
1	5473	15.419	0.039
1	5488	15.418	0.038
1	5503	15.417	0.037
1	5518	15.417	0.037
1	5533	15.417	0.037
1	5548	15.415	0.035
1	5563	15.415	0.035
1	5578	15.415	0.035
1	5593	15.415	0.035
1	5608	15.414	0.034
1	5623	15.414	0.034
1	5638	15.414	0.034
1	5653	15.413	0.033
1	5668	15.413	0.033
1	5683	15.413	0.033
1	5698	15.412	0.032

Gambier Limestone observation well 7023-7367 (ROB038)

Step	Pumping Rate (L/s)	Time (mins)	Water Level (m)	Drawdown (m)
1		0	2.355	0.000
1		5	2.369	-0.014
1		20	2.373	-0.018
1		35	2.373	-0.018
1		50	2.372	-0.017
1		65	2.372	-0.017
1		80	2.372	-0.017
1		95	2.372	-0.017
1		110	2.373	-0.018
1		125	2.373	-0.018
1		140	2.374	-0.019
1		155	2.374	-0.019
1		170	2.376	-0.021
1		185	2.376	-0.021
1		200	2.377	-0.022
1		215	2.377	-0.022
1		230	2.378	-0.023
1		245	2.379	-0.024
1		260	2.380	-0.025
1		275	2.380	-0.025
1		290	2.379	-0.024
1		305	2.379	-0.024
1		320	2.378	-0.023
1		335	2.378	-0.023
1		350	2.378	-0.023
1		365	2.378	-0.023
1		380	2.377	-0.022
1		395	2.377	-0.022
1		410	2.378	-0.023
1		425	2.378	-0.023
1		440	2.378	-0.023
1		455	2.379	-0.024
1		470	2.378	-0.023
1		485	2.379	-0.024
1		500	2.379	-0.024
1		515	2.379	-0.024
1		530	2.379	-0.024
1		545	2.378	-0.023
1		560	2.378	-0.023
1		575	2.378	-0.023
1		590	2.378	-0.023
1		605	2.379	-0.024
1		620	2.379	-0.024
1		635	2.379	-0.024
1		650	2.379	-0.024
1		665	2.381	-0.026
1		680	2.381	-0.026
1		695	2.382	-0.027
1		710	2.382	-0.027
1		725	2.382	-0.027
1		740	2.384	-0.029
1		755	2.385	-0.030

1	770	2.386	-0.031
1	785	2.387	-0.032
1	800	2.387	-0.032
1	815	2.387	-0.032
1	830	2.387	-0.032
1	845	2.389	-0.034
1	860	2.389	-0.034
1	875	2.389	-0.034
1	890	2.390	-0.035
1	905	2.391	-0.036
1	920	2.392	-0.037
1	935	2.393	-0.038
1	950	2.394	-0.039
1	965	2.395	-0.040
1	980	2.395	-0.040
1	995	2.396	-0.041
1	1010	2.396	-0.041
1	1025	2.397	-0.042
1	1040	2.398	-0.043
1	1055	2.397	-0.042
1	1070	2.397	-0.042
1	1085	2.397	-0.042
1	1100	2.397	-0.042
1	1115	2.398	-0.043
1	1130	2.398	-0.043
1	1145	2.398	-0.043
1	1160	2.397	-0.042
1	1175	2.397	-0.042
1	1190	2.398	-0.043
1	1205	2.398	-0.043
1	1220	2.398	-0.043
1	1235	2.398	-0.043
1	1250	2.397	-0.042
1	1265	2.397	-0.042
1	1280	2.397	-0.042
1	1295	2.397	-0.042
1	1310	2.397	-0.042
1	1325	2.397	-0.042
1	1340	2.397	-0.042
1	1355	2.397	-0.042
1	1370	2.397	-0.042
1	1385	2.397	-0.042
1	1400	2.397	-0.042
1	1415	2.397	-0.042
1	1430	2.397	-0.042
1	1445	2.398	-0.043
1	1460	2.398	-0.043
1	1475	2.398	-0.043
1	1490	2.398	-0.043
1	1505	2.397	-0.042
1	1520	2.398	-0.043
1	1535	2.399	-0.044
1	1550	2.400	-0.045
1	1565	2.400	-0.045
1	1580	2.402	-0.047

1	1595	2.403	-0.048
1	1610	2.405	-0.050
1	1625	2.406	-0.051
1	1640	2.407	-0.052
1	1655	2.409	-0.054
1	1670	2.409	-0.054
1	1685	2.410	-0.055
1	1700	2.411	-0.056
1	1715	2.412	-0.057
1	1730	2.411	-0.056
1	1745	2.413	-0.058
1	1760	2.413	-0.058
1	1775	2.413	-0.058
1	1790	2.413	-0.058
1	1805	2.412	-0.057
1	1820	2.413	-0.058
1	1835	2.413	-0.058
1	1850	2.412	-0.057
1	1865	2.413	-0.058
1	1880	2.412	-0.057
1	1895	2.413	-0.058
1	1910	2.412	-0.057
1	1925	2.413	-0.058
1	1940	2.412	-0.057
1	1955	2.412	-0.057
1	1970	2.411	-0.056
1	1985	2.412	-0.057
1	2000	2.412	-0.057
1	2015	2.412	-0.057
1	2030	2.411	-0.056
1	2045	2.410	-0.055
1	2060	2.410	-0.055
1	2075	2.411	-0.056
1	2090	2.411	-0.056
1	2105	2.412	-0.057
1	2120	2.412	-0.057
1	2135	2.413	-0.058
1	2150	2.413	-0.058
1	2165	2.413	-0.058
1	2180	2.413	-0.058
1	2195	2.414	-0.059
1	2210	2.415	-0.060
1	2225	2.415	-0.060
1	2240	2.415	-0.060
1	2255	2.416	-0.061
1	2270	2.417	-0.062
1	2285	2.416	-0.061
1	2300	2.417	-0.062
1	2315	2.418	-0.063
1	2330	2.419	-0.064
1	2345	2.420	-0.065
1	2360	2.421	-0.066
1	2375	2.421	-0.066
1	2390	2.422	-0.067
1	2405	2.423	-0.068

1	2420	2.424	-0.069
1	2435	2.423	-0.068
1	2450	2.423	-0.068
1	2465	2.424	-0.069
1	2480	2.424	-0.069
1	2495	2.425	-0.070
1	2510	2.426	-0.071
1	2525	2.427	-0.072
1	2540	2.426	-0.071
1	2555	2.426	-0.071
1	2570	2.427	-0.072
1	2585	2.427	-0.072
1	2600	2.427	-0.072
1	2615	2.427	-0.072
1	2630	2.425	-0.070
1	2645	2.425	-0.070
1	2660	2.425	-0.070
1	2675	2.426	-0.071
1	2690	2.425	-0.070
1	2705	2.425	-0.070
1	2720	2.425	-0.070
1	2735	2.425	-0.070
1	2750	2.425	-0.070
1	2765	2.424	-0.069
1	2780	2.423	-0.068
1	2795	2.423	-0.068
1	2810	2.423	-0.068
1	2825	2.423	-0.068
1	2840	2.424	-0.069
1	2855	2.424	-0.069
1	2870	2.423	-0.068
1	2885	2.423	-0.068
1	2900	2.424	-0.069
1	2915	2.424	-0.069
1	2930	2.424	-0.069
1	2945	2.424	-0.069
1	2960	2.425	-0.070
1	2975	2.426	-0.071
1	2990	2.427	-0.072
1	3005	2.428	-0.073
1	3020	2.429	-0.074
1	3035	2.430	-0.075
1	3050	2.431	-0.076
1	3065	2.432	-0.077
1	3080	2.432	-0.077
1	3095	2.433	-0.078
1	3110	2.434	-0.079
1	3125	2.435	-0.080
1	3140	2.436	-0.081
1	3155	2.436	-0.081
1	3170	2.436	-0.081
1	3185	2.437	-0.082
1	3200	2.437	-0.082
1	3215	2.438	-0.083
1	3230	2.437	-0.082

1	3245	2.436	-0.081
1	3260	2.436	-0.081
1	3275	2.437	-0.082
1	3290	2.436	-0.081
1	3305	2.436	-0.081
1	3320	2.436	-0.081
1	3335	2.436	-0.081
1	3350	2.435	-0.080
1	3365	2.435	-0.080
1	3380	2.434	-0.079
1	3395	2.434	-0.079
1	3410	2.432	-0.077
1	3425	2.432	-0.077
1	3440	2.431	-0.076
1	3455	2.431	-0.076
1	3470	2.430	-0.075
1	3485	2.430	-0.075
1	3500	2.430	-0.075
1	3515	2.430	-0.075
1	3530	2.428	-0.073
1	3545	2.429	-0.074
1	3560	2.428	-0.073
1	3575	2.428	-0.073
1	3590	2.428	-0.073
1	3605	2.429	-0.074
1	3620	2.429	-0.074
1	3635	2.430	-0.075
1	3650	2.430	-0.075
1	3665	2.430	-0.075
1	3680	2.430	-0.075
1	3695	2.431	-0.076
1	3710	2.432	-0.077
1	3725	2.432	-0.077
1	3740	2.431	-0.076
1	3755	2.433	-0.078
1	3770	2.432	-0.077
1	3785	2.434	-0.079
1	3800	2.434	-0.079
1	3815	2.435	-0.080
1	3830	2.435	-0.080
1	3845	2.436	-0.081
1	3860	2.437	-0.082
1	3875	2.438	-0.083
1	3890	2.438	-0.083
1	3905	2.438	-0.083
1	3920	2.438	-0.083
1	3935	2.439	-0.084
1	3950	2.439	-0.084
1	3965	2.438	-0.083
1	3980	2.438	-0.083
1	3995	2.439	-0.084
1	4010	2.438	-0.083
1	4025	2.439	-0.084
1	4040	2.439	-0.084
1	4055	2.438	-0.083

1	4070	2.438	-0.083
1	4085	2.438	-0.083
1	4100	2.438	-0.083
1	4115	2.437	-0.082
1	4130	2.437	-0.082
1	4145	2.436	-0.081
1	4160	2.435	-0.080
1	4175	2.435	-0.080
1	4190	2.435	-0.080
1	4205	2.434	-0.079
1	4220	2.433	-0.078
1	4235	2.432	-0.077
1	4250	2.432	-0.077
1	4265	2.433	-0.078
1	4280	2.432	-0.077
1	4295	2.432	-0.077
1	4310	2.433	-0.078
1	4325	2.419	-0.064
1	4340	2.416	-0.061
1	4355	2.417	-0.062
1	4370	2.419	-0.064
1	4385	2.419	-0.064
1	4400	2.422	-0.067
1	4415	2.423	-0.068
1	4430	2.424	-0.069
1	4445	2.426	-0.071
1	4460	2.427	-0.072
1	4475	2.429	-0.074
1	4490	2.430	-0.075
1	4505	2.432	-0.077
1	4520	2.435	-0.080
1	4535	2.436	-0.081
1	4550	2.437	-0.082
1	4565	2.438	-0.083
1	4580	2.440	-0.085
1	4595	2.441	-0.086
1	4610	2.443	-0.088
1	4625	2.443	-0.088
1	4640	2.444	-0.089
1	4655	2.443	-0.088
1	4670	2.444	-0.089
1	4685	2.443	-0.088
1	4700	2.444	-0.089
1	4715	2.444	-0.089
1	4730	2.444	-0.089
1	4745	2.444	-0.089
1	4760	2.443	-0.088
1	4775	2.443	-0.088
1	4790	2.443	-0.088
1	4805	2.443	-0.088
1	4820	2.442	-0.087
1	4835	2.442	-0.087
1	4850	2.441	-0.086
1	4865	2.441	-0.086
1	4880	2.441	-0.086

1	4895	2.440	-0.085
1	4910	2.441	-0.086
1	4925	2.441	-0.086
1	4940	2.439	-0.084
1	4955	2.438	-0.083
1	4970	2.439	-0.084
1	4985	2.439	-0.084
1	5000	2.438	-0.083
1	5015	2.440	-0.085
1	5030	2.440	-0.085
1	5045	2.441	-0.086
1	5060	2.439	-0.084
1	5075	2.441	-0.086
1	5090	2.441	-0.086
1	5105	2.440	-0.085
1	5120	2.442	-0.087
1	5135	2.443	-0.088
1	5150	2.444	-0.089
1	5165	2.445	-0.090
1	5180	2.446	-0.091
1	5195	2.447	-0.092
1	5210	2.448	-0.093
1	5225	2.448	-0.093
1	5240	2.449	-0.094
1	5255	2.450	-0.095
1	5270	2.451	-0.096
1	5285	2.452	-0.097
1	5300	2.452	-0.097
1	5315	2.453	-0.098
1	5330	2.453	-0.098
1	5345	2.453	-0.098
1	5360	2.454	-0.099
1	5375	2.454	-0.099
1	5390	2.454	-0.099
1	5405	2.455	-0.100
1	5420	2.456	-0.101
1	5435	2.457	-0.102
1	5450	2.458	-0.103
1	5465	2.458	-0.103
1	5480	2.458	-0.103
1	5495	2.459	-0.104
1	5510	2.457	-0.102
1	5525	2.458	-0.103
1	5540	2.458	-0.103
1	5555	2.458	-0.103
1	5570	2.457	-0.102
1	5585	2.457	-0.102
1	5600	2.456	-0.101
1	5615	2.456	-0.101
1	5630	2.456	-0.101
1	5645	2.455	-0.100
1	5660	2.455	-0.100
1	5675	2.456	-0.101
1	5690	2.455	-0.100
1	5705	2.456	-0.101

1	5720	2.457	-0.102

9.6 DILWYN FM. OBS. WELL-1 7023-7369 (KLN017) CONST. RATE DISCHARGE TEST

Start Date	Start time	Step	Duration (mins)	Q (L/s)	Well Name	Well Type	r (m)	Target aquifer	Ref. Elev. (mAHD)
06/08/2014	0900	1	Pumping 1,440 Recovery 120	20	7023-7369 (KLN017)	Prod.	0	Dilwyn	

Dilwyn Formation observation well-1 7023-7369 (KLN017)

Step	Pumping rate (L/s)	Time (mins)	Water level (m)	Drawdown (m)
1	20	0	16.35	0.00
1	20	1	23.23	6.88
1	20	2	23.19	6.84
1	20	3	23.15	6.80
1	20	4	23.15	6.80
1	20	5	23.16	6.81
1	20	6	23.16	6.81
1	20	7	23.16	6.81
1	20	8	23.16	6.81
1	20	9	23.14	6.79
1	20	10	23.15	6.80
1	20	12	23.15	6.80
1	20	14	23.15	6.80
1	20	16	23.16	6.81
1	20	18	23.14	6.79
1	20	20	23.14	6.79
1	20	22	23.15	6.80
1	20	24	23.16	6.81
1	20	26	23.15	6.80
1	20	28	23.15	6.80
1	20	30	23.15	6.80
1	20	35	23.15	6.80
1	20	40	23.16	6.81
1	20	45	23.15	6.80
1	20	50	23.16	6.81
1	20	55	23.16	6.81
1	20	60	23.17	6.82
1	20	70	23.16	6.81
1	20	80	23.18	6.83
1	20	90	23.18	6.83
1	20	100	23.18	6.83
1	20	120	23.19	6.84
1	20	140	23.19	6.84
1	20	160	23.17	6.82
1	20	180	23.19	6.84
1	20	200	23.20	6.85
1	20	250	23.20	6.85
1	20	300	23.19	6.84
1	20	350	23.20	6.85
1	20	400	23.21	6.86
1	20	450	23.22	6.87
1	20	500	23.20	6.85
1	20	550	23.22	6.87
1	20	600	23.23	6.88
1	20	650	23.22	6.87

1	20	700	23.23	6.88
1	20	750	23.23	6.88
1	20	800	23.24	6.89
1	20	850	23.25	6.90
1	20	900	23.23	6.88
1	20	950	23.23	6.88
1	20	1000	23.23	6.88
1	20	1050	23.21	6.86
1	20	1100	23.23	6.88
1	20	1150	23.22	6.87
1	20	1200	23.23	6.88
1	20	1250	23.24	6.89
1	20	1300	23.25	6.90
1	20	1350	23.27	6.92
1	20	1400	23.25	6.90
1	20	1440	23.25	6.90
1	20	1460	16.39	0.04
1	20	1460	16.34	-0.01
1	20	1460	16.29	-0.06
1	20	1460	16.30	-0.05
1	20	1460	16.29	-0.06
1	20	1460	16.30	-0.05
1	20	1460	16.29	-0.06
1	20	1460	16.29	-0.06
1	20	1460	16.28	-0.07
1	20	1460	16.29	-0.06
1	20	1460	16.28	-0.07
1	20	1460	16.28	-0.08
1	20	1460	16.28	-0.07
1	20	1460	16.27	-0.08
1	20	1460	16.27	-0.08
1	20	1460	16.27	-0.08
1	20	1460	16.27	-0.08
1	20	1460	16.27	-0.08
1	20	1460	16.28	-0.07
1	20	1460	16.28	-0.07
1	20	1460	16.27	-0.09
1	20	1460	16.27	-0.08
1	20	1460	16.28	-0.07
1	20	1460	16.27	-0.08
1	20	1460	16.27	-0.08
1	20	1460	16.27	-0.08
1	20	1460	16.27	-0.08
1	20	1460	16.27	-0.08
1	20	1460	16.28	-0.08
1	20	1460	16.28	-0.07
1	20	1460	16.28	-0.07
1	20	1460	16.28	-0.07
1	20	1460	16.29	-0.07
1	20	1460	16.27	-0.08
1	20	1460	16.28	-0.07
1	20	1460	16.29	-0.07

9.7 DILWYN FM. OBS. WELL-2 7023-7368 (KLN018) CONST. RATE DISCHARGE TEST

Start Date	Start time	Step	Duration (mins)	Q (L/s)	Well Name	Well Type	r (m)	Target aquifer	Ref. Elev. (mAHD)
09/08/2014	0900	1	Pumping 1,440 Recovery 250	20	7023-7368 (KLN018)	Prod.	0	Dilwyn	

Dilwyn Formation observation well-2 7023-7368 (KLN018)

Step	Pumping Rate (L/s)	Time (mins)	Water level (m)	Drawdown (m)
1	20	0	16.22	0.00
1	20	1	30.08	13.86
1	20	2	30.52	14.30
1	20	3	30.53	14.31
1	20	4	30.53	14.31
1	20	5	30.54	14.32
1	20	6	30.54	14.32
1	20	7	30.54	14.32
1	20	8	30.54	14.32
1	20	9	30.55	14.33
1	20	10	30.55	14.33
1	20	12	30.55	14.33
1	20	14	30.54	14.32
1	20	16	30.55	14.33
1	20	18	30.55	14.33
1	20	20	30.55	14.33
1	20	22	30.55	14.33
1	20	24	30.56	14.34
1	20	26	30.56	14.34
1	20	28	30.56	14.34
1	20	30	30.57	14.35
1	20	35	30.57	14.35
1	20	40	30.58	14.36
1	20	45	30.60	14.38
1	20	50	30.61	14.39
1	20	55	30.60	14.38
1	20	60	30.60	14.38
1	20	70	30.61	14.39
1	20	80	30.62	14.40
1	20	90	30.63	14.41
1	20	100	30.63	14.41
1	20	120	30.66	14.44
1	20	140	30.66	14.44
1	20	160	30.66	14.44
1	20	180	30.66	14.44
1	20	200	30.64	14.42
1	20	250	30.68	14.46
1	20	300	30.68	14.46
1	20	350	30.68	14.46
1	20	400	30.69	14.47
1	20	450	30.70	14.48
1	20	500	30.71	14.49
1	20	550	30.71	14.49
1	20	600	30.73	14.51
1	20	650	30.72	14.50

1	20	700	30.74	14.52
1	20	750	30.75	14.53
1	20	800	30.75	14.53
1	20	850	30.76	14.54
1	20	900	30.76	14.54
1	20	950	30.75	14.53
1	20	1000	30.74	14.52
1	20	1050	30.76	14.54
1	20	1100	30.76	14.54
1	20	1150	30.76	14.54
1	20	1200	30.74	14.52
1	20	1250	30.77	14.55
1	20	1300	30.79	14.57
1	20	1350	30.78	14.56
1	20	1400	30.78	14.56
1	20	1440	30.79	14.57
1	20	1441	16.34	0.12
1	20	1442	16.28	0.06
1	20	1443	16.28	0.06
1	20	1444	16.27	0.05
1	20	1445	16.26	0.04
1	20	1446	16.26	0.04
1	20	1447	16.25	0.03
1	20	1448	16.24	0.02
1	20	1449	16.24	0.02
1	20	1450	16.23	0.01
1	20	1452	16.24	0.02
1	20	1454	16.24	0.02
1	20	1456	16.24	0.02
1	20	1458	16.23	0.01
1	20	1460	16.24	0.02
1	20	1462	16.23	0.01
1	20	1464	16.23	0.01
1	20	1466	16.22	0.00
1	20	1468	16.22	0.00
1	20	1470	16.23	0.01
1	20	1475	16.22	0.00
1	20	1480	16.22	0.00
1	20	1485	16.22	0.00
1	20	1490	16.22	0.00
1	20	1495	16.21	-0.01
1	20	1500	16.21	-0.01
1	20	1510	16.20	-0.02
1	20	1520	16.20	-0.02
1	20	1530	16.21	-0.01
1	20	1540	16.22	0.00
1	20	1560	16.21	-0.01

9.8 DILWYN FM. OBS. WELL-3 7023-7370 (ROB036) CONST. RATE DISCHARGE TEST

Start Date	Start time	Step	Duration (mins)	Q (L/s)	Well Name	Well Type	r (m)	Production Aquifer	Ref. Elev. (mAHD)
12/08/2014	0900	1	Pumping 480	20	7023-7370 (ROB036)	Prod.	0	Dilwyn	

Dilwyn Formation observation well-3 7023-7370 (ROB036)

Step	Pumping rate (L/s)	Time (mins)	Water level (m)	Drawdown (m)
1	20	0	15.38	0.00
1	20	1	19.21	3.83
1	20	2	19.20	3.82
1	20	3	19.27	3.89
1	20	4	19.27	3.89
1	20	5	19.27	3.89
1	20	6	19.27	3.89
1	20	7	19.27	3.89
1	20	8	19.26	3.88
1	20	9	19.27	3.89
1	20	10	19.26	3.88
1	20	12	19.27	3.89
1	20	14	19.31	3.93
1	20	16	19.32	3.94
1	20	18	19.32	3.94
1	20	20	19.31	3.93
1	20	22	19.31	3.93
1	20	24	19.32	3.94
1	20	26	19.32	3.94
1	20	28	19.32	3.94
1	20	30	19.31	3.93
1	20	35	19.30	3.92
1	20	40	19.29	3.91
1	20	45	19.30	3.92
1	20	50	19.30	3.92
1	20	55	19.29	3.91
1	20	60	19.30	3.92
1	20	70	19.30	3.92
1	20	80	19.30	3.92
1	20	90	19.29	3.91
1	20	100	19.28	3.90
1	20	120	19.28	3.90
1	20	140	19.28	3.90
1	20	160	19.29	3.91
1	20	180	19.29	3.91
1	20	200	19.29	3.91
1	20	250	19.29	3.91
1	20	300	19.28	3.90
1	20	350	19.28	3.90
1	20	400	19.26	3.88
1	20	450	19.26	3.88
1	20	480	19.27	3.89

9.9 WATER CHEMISTRY

Dilwyn Formation production 7023-7371 (ROB037)

Date/time				14/05/2014	21/07/14	07/08/14	11/08/14	12/08/14
SP #	**UNITS**	**ADWG LIMITS**		**22522**	**22522**	**22523**	**22524**	**22525**
Bore		**Health**	**Aesthetic**	**PB1**	**PB1**	**MB1**	**MB2**	**MB3**
2 4 5-T	µg/L	100			<0.05			
2 4-D	µg/L	30			<0.05			
Aldrin	µg/L				<0.01			
Alkalinity as Calcium Carbonate	mg/L				336	291	276	311
Aluminium - Acid Soluble	mg/L		0.2	0.002	<0.001	<0.001	<0.001	0.004
Aluminium - Soluble	mg/L			0.003	<0.001	<0.001	<0.001	0.001
Aluminium - Total	mg/L			0.036	<0.001	0.002	0.002	0.004
Ammonia as N	mg/L		0.5			0.214	0.243	0.21
Antimony - Soluble	mg/L				<0.0005	<0.0005	<0.0005	<0.0005
Antimony - Total	mg/L	0.003		<0.0005	0.0006	<0.0005	<0.0005	<0.0005
Arsenic - Soluble	mg/L			<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Arsenic - Total	mg/L	0.01		<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Atrazine	µg/L	20			<0.5			
Azinphos-methyl	µg/L	30			<0.5			
Barium - Soluble	mg/L			0.017	0.0197	0.018	0.015	0.0985
Barium - Total	mg/L	2		0.0178	0.0202	0.0183	0.0141	0.1025
Benzene	µg/L	1			<1			
Beryllium - Soluble	mg/L			<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Beryllium - Total	mg/L	0.06		<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Bicarbonate	mg/L				409	355	337	379
Boron - Soluble	mg/L	4		0.151	0.078	0.074	0.12	0.199
Bromide	mg/L			0.71	0.69	0.57	0.57	0.74

Cadmium - Soluble	mg/L			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cadmium - Total	mg/L	0.002		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Calcium	mg/L			112	105	89	82.1	83.8
Calcium Hardness as CaCO3	mg/L				262	222	205	209
Carbon Dioxide - Free	mg/L				52	28	27	19
Carbonate	mg/L				0	0	0	0
Carbonate hardness as CaCO3	mg/L				336	291	273	301
Chlordane-a	µg/L	2			<0.01			
Chlordane-g	µg/L	2			<0.01			
Chloride	mg/L		250		209	181	182	248
Chlorides - Total as NaCl	mg/L				344	298	300	409
Chlorothalonil	µg/L	50			<0.05			
Chlorpyrifos	µg/L	10			<0.05			
Chlorsulfuron	µg/L	200			<0.05			
Chlorthal-Dimethyl	µg/L				<0.05			
Chromium - Soluble	mg/L			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium - Total	mg/L	0.05		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Clopyralid	µg/L	2000			<0.5			
Coliforms	org/100mL			650	2	0	0	0
Coliforms - Presumptive	org/100mL			650	2	0	0	0
Colour - True (456nm)	HU		15	8	3	<1	3	4
Conductivity	µScm			1370	1290	1120	1060	1280
Copper - Soluble	mg/L			<0.0001	<0.0001	0.0005	0.0002	0.0006
Copper - Total	mg/L	2	1	<0.0001	0.0027	0.0006	0.0011	0.001
Cyanide as CN - Total	mg/L	0.08		<0.05	<0.05	<0.05	<0.05	<0.05
DDD	µg/L				<0.05			
DDE	µg/L				<0.05			
DDT	µg/L	9			<0.05			
Diazinon	µg/L	4			<0.5			
Dicamba	µg/L	100			<0.2			

Dieldrin	µg/L				<0.01			
Dissolved Organic Carbon	mg/L			2.3	2.2	3.3	3	3.2
Dissolved solids by calculation	mg/L				684	582	565	
E.coli	org/100mL	0		1	0	0	0	0
E.coli - Presumptive	org/100mL			1	0	0	0	0
Endosulfan 1	µg/L	20			<0.05			
Endosulfan 2	µg/L	20			<0.05			
Endosulfan Sulphate	µg/L	20			<0.05			
Endrin	µg/L				<0.05			
Ethylbenzene	µg/L	300	3		<1			
Fenitrothion	µg/L	7			<0.5			
Fluoride	mg/L	1.5		0.13	0.13	0.13	0.16	0.19
Heptachlor	µg/L	0.3			<0.05			
Heptachlor Epoxide	µg/L				<0.05			
Hexachlorobenzene	µg/L				<0.05			
Hexazinone	µg/L	400			<0.5			
Hydroxide	mg/L				0	0	0	0
Iodide	mg/L	0.5		0.03	0.02	0.02	0.02	0.02
Ion balance	%				0.09	-2.1		
Iron - Soluble	mg/L			0.3635	0.2509	0.0032	0.0083	0.0076
Iron - Total	mg/L		0.3	0.4798	0.4482	1.096	1.095	0.1839
Langelier Index	-				0.08	0.15	0.1	0.35
Lead - Soluble	mg/L			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Lead - Total	mg/L	0.01		<0.0001	0.001	<0.0001	<0.0001	<0.0001
Lindane	µg/L	10			<0.05			
Magnesium	mg/L			22.8	21.3	16.8	16.5	22.4
Magnesium Hardness as CaCO3	mg/L				88	69	68	92
Malathion	µg/L	70			<0.5			
Manganese - Soluble	mg/L			0.0297	0.0433	0.025	0.0169	0.0244
Manganese - Total	mg/L	0.5	0.1	0.0334	0.0432	0.0252	0.0155	0.0254

MCPA	µg/L	40			<0.05			
Mercury - Soluble	mg/L			<0.00003	<0.00003	<0.00003	<0.00003	<0.00003
Mercury - Total	mg/L	0.001		<0.00003	<0.00003	<0.00003	<0.00003	<0.00003
Methoxychlor	µg/L	300			<0.05			
Metsulfuron Methyl	µg/L	40			<0.05			
Molybdenum - Soluble	mg/L			0.0002	0.0002	<0.0001	<0.0001	0.0004
Molybdenum - Total	mg/L	0.05		0.0002	0.0002	<0.0001	<0.0001	0.0004
m-p-xylene	µg/L				<1			
Nickel - Soluble	mg/L			<0.0001	0.0008	<0.0001	0.0001	<0.0001
Nickel - Total	mg/L	0.02		0.0001	0.001	<0.0001	<0.0001	<0.0001
Nitrate + Nitrite as N	mg/L			<0.003	<0.003	<0.003	<0.003	<0.003
Nitrate + Nitrite as NO3	mg/L				<0.02	<0.02	<0.02	<0.02
Nitrate as Nitrogen	mg/L	11			<0.005	<0.005	<0.005	<0.005
Nitrite as Nitrogen	mg/L	0.9			<0.003	0.005	<0.003	<0.003
Noncarbonate hardness as CaCO3	mg/L				14	<2	<2	<2
o-xylene	µg/L				<1			
Parathion	µg/L	20			<0.5			
Parathion methyl	µg/L	0.7			<0.3			
pH	-	6.5 to 8.5		7.8	7.1	7.3	7.3	7.5
Phosphorus - Filterable Reactive as P	mg/L				0.021	0.01	0.005	0.024
Phosphorus - Total	mg/L				0.026	0.027	0.018	
Picloram	µg/L	300			<0.2			
Potassium	mg/L			4.71	3.86	3.09	3.16	6.09
Prometryne	µg/L				<0.5			
Selenium - Soluble	mg/L			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Selenium - Total	mg/L	0.01		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Silica - Reactive	mg/L		80		11	11	12	12
Silver - Soluble	mg/L			<0.00003	<0.00003	<0.00003	<0.00003	<0.00003
Silver - Total	mg/L	0.1		<0.00003	<0.00003	<0.00003	<0.00003	<0.00003
Silvex	µg/L				<0.05			

Simazine	µg/L	20			<0.5			
Sodium	mg/L		180	145	129	105	102	136
Sodium Adsorption Ratio - Calculation	-				3	2.68	2.69	3.41
Sodium/Total cations ratio	%				44.2	43.6	44.5	48.9
Sulfometuron	µg/L				<0.05			
Sulphate	mg/L	500	250		3.9	<1.5	<1.5	2.7
Temperature	mg/L					25.2	23.3	25.8
Tin - Soluble	mg/L			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Tin - Total	mg/L			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
TKN as Nitrogen	mg/L				0.13	0.24	0.27	0.22
Toluene	µg/L	800	25		<1			
Total Aldrin and Dieldrin	µg/L	0.3			<0.02			
Total Dissolved Solids (by EC)	mg/L		600	750	710	620	580	710
Total Hardness as CaCO3	mg/L		200		350	291	273	301
Triclopyr	µg/L	20			<0.1			
Trifluralin	µg/L	90			<0.05			
Turbidity	NTU		5	1.9	4.4	13	14	0.76
Uranium - Soluble	mg/L			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Uranium - Total	mg/L	0.017		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Vinclozolin	µg/L				<0.05			
Zinc - Soluble	mg/L			<0.0003	0.0213	0.0037	0.0028	0.0034
Zinc - Total	mg/L		3	0.0005	0.0234	0.0061	0.0044	0.0035

10 References

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