Department of Primary Industries
Water

Broken Hill emergency water supply investigation

Renmark Group test production bores

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More information

DPI Water – groundwater management unit

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Acknowledgments

Cover photo - Mark Mitchell

Executive summary

DPI Water commenced investigations to source an emergency drought water supply for Broken Hill in late 2014. The investigation focussed on the geological formation known as the Renmark Group on the northern margin of Lake Menindee.

A preliminary proposal prepared by NSW Public Works (2014) identified that emergency water supply should aim to provide for average summer demand of 25ML/d (approximately 77% of Peak Day Demand (32 ML/d)).

Scope

The construction of six test production bores to assess the potential yield and water quality of the Renmark Group at a depth of between 200 and 250 m, as a source of water to supply Broken Hill following appropriate treatment.

Investigation area

The investigation area is on the northern margin of Lake Menindee and was selected due to:

- The proximity to an electricity sub-station to supply power to the bore field and the reverse osmosis plant, and
- The potential to locate a evaporation basin for the residual water produced from the reverse osmosis treatment of groundwater

Conceptual hydrogeological setting

The investigation area is within a geological feature known as the Menindee Trough. The existing available information indicated that the Calivil Formation which is a shallow aquifer (<80m in depth) in the area was not suitable due the absence of a suitable lithology to achieve the required water supply requirements.

The Remark Group was identified as the target aquifer due to a number of existing bores drilled into the formation to depths in excess of 200 m within the Menindee Trough which identified the presence of a fine to coarse sand. It was assumed based on the available information that this sand layer was extensive throughout the Renmark Group within the Menindee Trough.

Drilling investigation

The drilling investigation resulted in the construction of 5 test production bores. (MEN-1, MEN-2, MEN-6, MEN-9 and MEN-11) and 1 test bore (MEN-17).The test production bores intersected fine to coarse sands at a depth of about 200 m. The maximum depth of these sands was 212 m below ground with the thickness of the sands ranging from 6 to 18 m. The groundwater salinity ranged between 15,500 and 25,800 μS/cm.

To confirm the western margin of the Menindee Trough a test bore was drilled approximately 1500 m west of the interconnecting channel between Copi Hollow and Lake Menindee in the vicinity of the intersection of the Wilcannia and Broken Hill – Menindee Roads. At this site weathered Palaeozoic sediments underlying the Renmark Group were intersected at a depth of 92 m below ground, confirming that it was outside the western margin of the Menindee Trough. At this site 29 m of medium to coarse sand is present from 49 to 78 m below ground in the Calivil Formation. Field measurements of the water salinity identified that it was 25,700 μS/cm. Further investigations are required to assess the suitability of the Calivil Formation aquifer in this area if it is to be considered as part of a long term drought supply for Broken Hill.

Pumping tests

The pumping tests of the 5 test production bores consisted of a step-drawdown test of 3 steps of 2 hours duration, and a 4 day constant rate test at 4 sites and a 48 hour test at 1 site (MEN-11).

The constant rate tests were conducted to assess aquifer parameters and the presence of any barriers that may impact on the long term extraction. In one bore, (MEN-9) a barrier may have been detected. The potential long term impact is uncertain however, the long term pumping rates have considered this influence. If extended pumping caused a further impact on the aquifer parameters it would influence the potential yield from this bore.

Long term pumping rates

The potential long term pump rates for the 5 test production bore sites are based on the results of the assessment of aquifer parameters from the pump tests and assume that they are reflective of the long term behaviour of the aquifer system.

The existing constructed test production bores could potentially supply 132.6 L/s (11 ML/d). This is based on the assumption that the bore pump is installed at a depth of 90m. The ability to achieve this yield is dependent on the ability to source a bore pump that is able to achieve this yield as well as the head losses that occur in the bore and the bore field pipeline.

The maximum potential yield from the test production bore sites could be 243 L/s (21 ML/d), with suitably constructed bores. This would be from 4 of the 5 test production bore sites. The yield from the most western site (MEN-1) in the long term is less than 10 L/s, which is further reduced due to interference from the other production bores.

Groundwater quality

Samples were collected for laboratory analysis by ALS and NSW Health, which are both NATA registered laboratories. The samples analysed by NSW Health were collected daily at each site except MEN1 where a single sample was collected. The samples collected for analysis by ALS were collected at a minimum of 33 hours following the commencement of the constant rate pump test at each test production bore.

The dominate ions are sodium chloride with the lowest total dissolved solids (TDS) being 9,590 mg/L at MEN-1 and highest of 15,400 mg/L at MEN-11.

Future works

The preliminary proposal by NSW Public Works (2014) identified a drought water supply of 25 ML/d was required for Broken Hill. To achieve this supply will require a bore field yield from the Renmark Group of 32 ML/d to account for losses from the reverse osmosis treatment process.

The two identified options for the design of a bore field to supply 32 ML/d from the Renmark Group are:

Option 1 A bore field of 11 production bores, consisting of:

- the 4 existing test production bores at MEN-2, MEN-6, MEN-9 and MEN -11, plus
- 7 new additional bores at new sites (6 to supply the required yield plus 1 additional bore to ensure the security of supply during periods of bore maintenance or any unforeseen breakdowns), or

Option 2 A bore field of 9 production bores, consisting of:

- 2 new larger diameter bores at MEN-2 and MEN-11 sites (as at these sites yield estimates are informed by the predictions from the pumping tests conducted on MEN 2 and Men 11 bores),
- the 2 existing test production bores MEN-6 and MEN-9, plus
- 5 new additional bores at new sites (4 to supply the required yield plus 1 additional bore to ensure the security of supply during periods of bore maintenance or any unforeseen breakdowns).

Option 1 requires construction of 7 new production bores at new sites to add to the existing four most productive test bores already in place to make up the required yield of the field. It assumes that the additional new sites will achieve the required yield.

Option 2 requires the construction of 7 new production bores to add to two existing test production bores already in place to make up the required yield of the field, 5 new bores at new sites and the construction of two larger diameter bores at sites MEN-2 and MEN-11. The benefit of Option 2 is that the yield at MEN-2 and MEN-11 is known based on the predictions from the pumping tests conducted at these sites.

Contents

1.0 Introduction

Broken Hill has a high reliance on the Menindee Lakes System (MLS) for its water supply. On average 8 in every 10 years water is sourced from MLS at Menindee. During periods of drought and low operating levels, salinity and other water quality problems occur which require the raw water to be treated prior to being supplied to Broken Hill.

Modelling by DPI Water in April 2015 showed that with little or no inflows from the Darling River, the MLS supply to Broken Hill would expire during the middle of 2016, Emergency works were completed at Copi Hollow to secure the water quality and supply until December 2015. By November 2015, salinity in Copi Hollow is expected to exceed 1,200 µS/cm and continue to climb. To ensure surface water supplies past the end of 2015 it is proposed to establish treatment processes to ensure the suitability of the supply for Broken Hill (NOW 2015).

Much of the Darling River catchment is in drought and significant rain events are required to allow flows to reach the Menindee Lakes. Minor flows from the Darling River are likely to increase salinity in Lake Wetherell. To improve the availability and water quality from the MLS a significant inflow from the Darling River is required.

Broken Hill's average summer demand is 25 ML/day, with an annual requirement of 5,200 ML to 10,000 residential customers and around 600 non-residential customers. Non-potable water is also supplied to rural users along the Menindee to Broken Hill pipeline for domestic and stock purposes. The largest non-residential customer is the mining company, Perilya Ltd (Perilya), which uses approximately 20% to 25% of the total water supplied. CBH Resources, a second mine, also operates in Broken Hill (NSW Public Works 2014).

A preliminary proposal prepared by NSW Public Works (2014) for the emergency drought water supply investigations outlined the requirements for the establishment of a groundwater supply from the Menindee Lakes region. This proposal also compliments a key objective of the larger Menindee Lakes Water Savings Project which is to safeguard a secure drought water supply to Broken Hill into the future.

The NSW Public Works proposal identified a key component of the Menindee Lakes Water Savings Project as being a drought water supply that provides for an average summer demand of 25ML/d (approximately 77% of Peak Day Demand (31 ML/d)) and it should aim to provide water supply for 12 months in every ten years (NSW Public Works 2014).

DPI Water commenced investigations to source a drought water supply for Broken Hill in late 2014, this focussed on the Renmark Group aquifers on the northern margin of Lake Menindee, due to the close proximity to the existing required infrastructure including the water supply pipeline and power lines for the supply of power.

This report is on the outcomes of the groundwater investigation completed on the Renmark Group aquifer and recommendations for further works.

2.0 Previous studies

The first significant investigation in the area for an alternative water supply scheme was conducted by Country Energy in the mid 2000s. The investigation constructed and pumping tested bores in the Calivil Formation and also drilled a test bore into the Renmark Group near the pump station at Menindee.

The test bore in the Renmark Group located about 25 m of medium to coarse sands in the Renmark Group at a depth of about 205 m. The yield and water quality of these sands is uncertain due to a failure in the bore casing preventing a pumping test from being completed and a water quality sample being collected. However, it was estimated that the groundwater salinity was about 20,000 µS/cm (Jewell 2008). The results of the pumping tests of the Calivil Formation identified that a bore field of 3 bores screened in the Calivil Formation could supply 1.8 ML/d.

In the late 2000s a groundwater investigation was undertaken by Geoscience Australia, with the results presented in five separate reports (Lawrie *et al* 2012a, Lawrie *et al.* 2012b, Lawrie *et al.* 2012c, Lawrie *et al.* 2012d, and Lawrie *et al.* 2012e). The groundwater investigation is known as the Broken Hill Managed Aquifer Recharge (BHMAR) project. The project focussed on the identification of a managed aquifer recharge system that could provide enhanced drought security for periods up to 3 years (~30 GL) (Lawrie *et al,* 2013a)

The BHMAR project investigated the Calivil Formation and the Renmark Group to a depth of about 100m in fourteen separate investigation areas. The investigation areas included the northern margin of Lake Menindee and areas to the north and south of the village of Menindee.

The project identified that the Calivil Formation under the northern area of Lake Menindee and its northern margin as being recharged by lake waters. This water is of a low salinity with the potentially highest yielding part of the aquifer lies largely beneath Lake Menindee. It was identified that the construction of a bore field on the lake bed would be challenging from an infrastructure perspective and that recovery efficiencies would be significantly lower if a MAR option was pursued only around the lake margins (Lawrie *et al*., 2012c)

The BHMAR project investigation focused on the identification of a managed aquifer recharge scheme in the investigation area known as GWR3 or Jimargil. This area was selected as the most suitable area for a managed aquifer recharge scheme due to the thickness of sands in the Calivil Formation, an overlying confining clay layer and suitable water quality characteristics. The site is about 15 kilometres to the south of weir 32 on the eastern side of the Darling River adjacent to Lake Emu.

Another prospective managed aquifer recharge site was in the vicinity of weir 32. It was not considered a suitable managed aquifer recharge site due to the potential for upwelling of saline groundwater from the underlying Renmark Group and the potential to also cause horizontal flow of saline groundwater within the Calivil Formation.

An output from the BHMAR project was an aerial electromagnetic survey. This survey was ground validated through the construction of investigation bores throughout the area. An outcome was an interpreted stratigraphy of about the top 100m. This interpreted stratigraphy identifies the potential location of sands within the predominantly clay profile of the Calivil Formation.

3.0 Scope

The scope of this investigation was to construct six test production bores to assess the potential yield and water quality of the Renmark Group at a depth of between 200 and 250 m, as a source of water for to supply Broken Hill following appropriate treatment.

The investigation drilled test production bores rather than undertaking an investigative drilling program, due to the short predicted timeframe for the requirement for the scheme. The influencing factors were the low storage levels in the Menindee Lakes Scheme (MLS) and lead time required to obtain planning approval and build the supply scheme.

An investigation area on the northern margin of Lake Menindee was selected due to the

- proximity to an electricity substation to supply power to the bore field and the reverse osmosis plant, and
- the potential to locate a evaporation basin for the residual water produced from the reverse osmosis process.

The investigation area is located in the vicinity of the interconnecting channel between Copi Hollow and Lake Menindee. It extends to the south east for approximately 10 kilometres adjacent to the Broken Hill water supply pipeline, see **Figure 1**.

4.0 Menindee Lakes geomorphology

The principal lakes in the Menindee Lakes system are Menindee, Cawndilla and Pamamaroo, with smaller lakes including Tandure, Speculation, Spectale, Bijiji, Balaka, Malta, Eurobili and Emu. Lake Wetherell is a man-made lake constructed as part of the regulation of the MLS in the 1960s.

The majority of these lakes were originally flood out lakes, with overflow to separate lake basins eg. Lake Menindee to Lake Cawndilla and Speculation. The lakes are shallow and flat with fan deltas located at the channel entrance and multiple channels crossing the deltas (Lawrie *et al.* 2012c.). Lawrie et al. (2012b) noted that "the morphology of the lake bottoms is controlled largely by the presence of flat-lying, lacustrine Blanchetown Clay aquitards that underlie the floors of most of the lakes". On the downwind shorelines the lakes are characterised by lunette dines (Bowler 1973 in Lawrie *et al.* 2012c).

As they are flood out lakes, prior to river regulation they filled only during high river flows when flows breach the river bank. Following the lakes filling they would have either drained back into the river or slowly evaporated.

5.0 Geology

Prior to the BHMAR by Geoscience Australia there was only a very broad regional understanding of the Murray Geological Basin and tectonic history of the Menindee area such as by Brown and Stephenson (1991), Brodie (1994), Brodie (1998) and Lewis *et al.* (2008).

The regional geology and stratigraphy is described in detail in Lawrie *et al.* (2012c, 2012d and 2012e). The BHMAR study focused of the shallow confined to semi-confined sediments of the Cenozoic Murray Geological Basin to a depth of about 100m.

5.1 Tectonic framework

The following summary of the tectonic framework is derived from the Broken Hill managed aquifer recharge project (Lawrie *et al.* 20012d).

The investigation area is within the Devonian and Mesozoic Menindee Trough which is one of three troughs in the area, the other two being the Wentworth and Blantyre Troughs. The Menindee Trough is separated from the Wentworth and Blantyre Troughs to the east by the Lake Wintlow High, see **Figure 2**.

These troughs are thought to have formed as a result of transcurrent faulting on the Darling River Lineament (horizontal movement) and north trending sinistral normal faults (horizontal to the left as well as upward movement). The Darling River Lineament is a 1000 km long northeast-southwest trending structure that the Darling River follows from Bourke through to Menindee.

The Menindee Trough occurs within the Menindee Fault System (MFS), which is interpreted as consisting of zones of slip transfer between over-stepping, subparallel strike slip faults. This has created a rhombic shaped pull-apart basin in the unconsolidated Murray Basin sediments.

The principal bounding faults of the MFS are coincident with basement faults that define the depocentre of the Menindee Trough. These faults have been reactivated post-Pleistocene with some active in the Neogene to the present day. Sinistral displacement has occurred along the major strike-slip zones at a regional scale (Lawrie *et al.* 2012d).

The location and orientation of individual extensional faults within the MFS depends on the overall stepping geometry of the strike-slip zone, the inter-relationship between adjacent en-echelon strike slip faults, and relationships to underlying basement heterogeneities.

Figure 1: Location of investigation sites

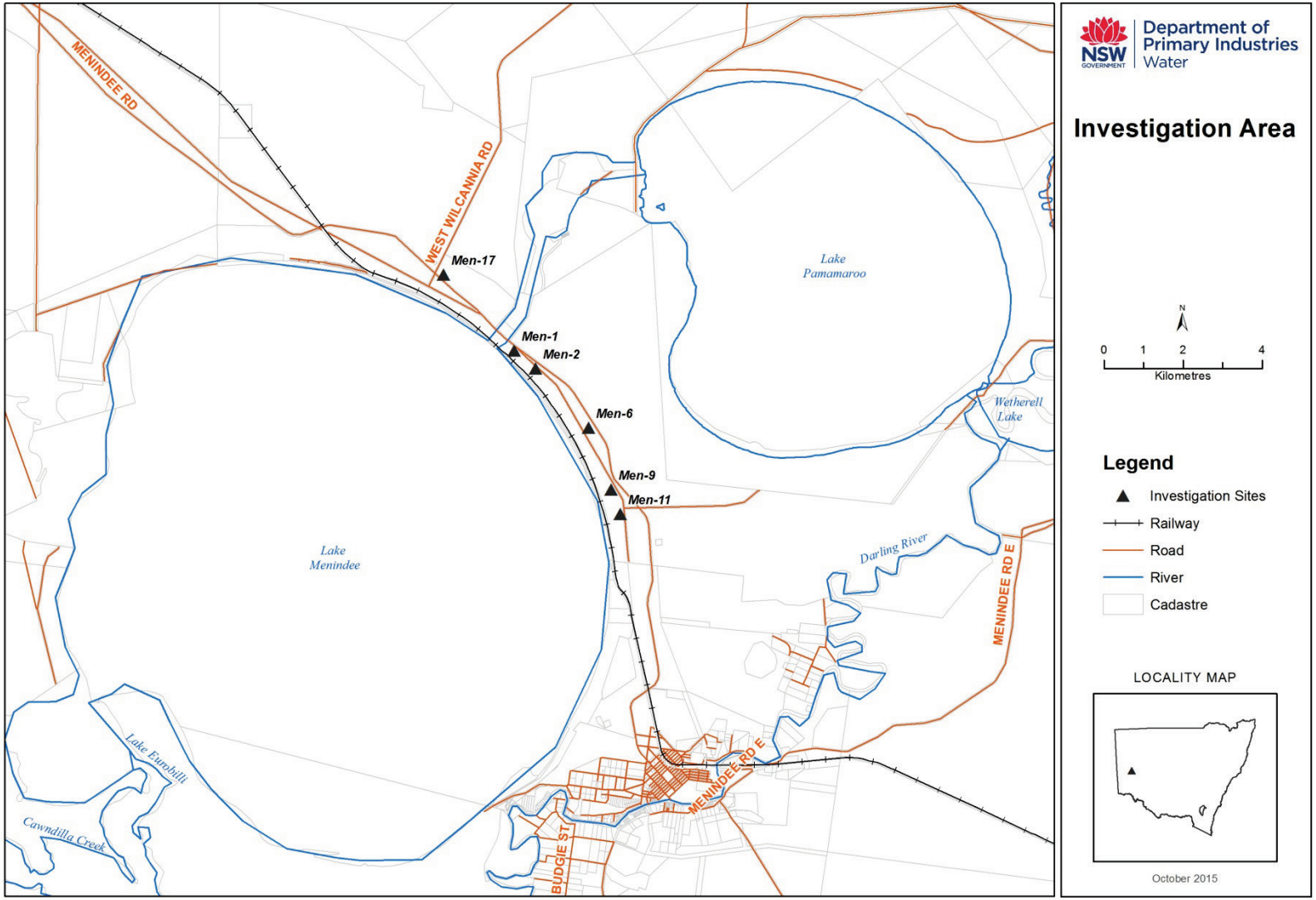
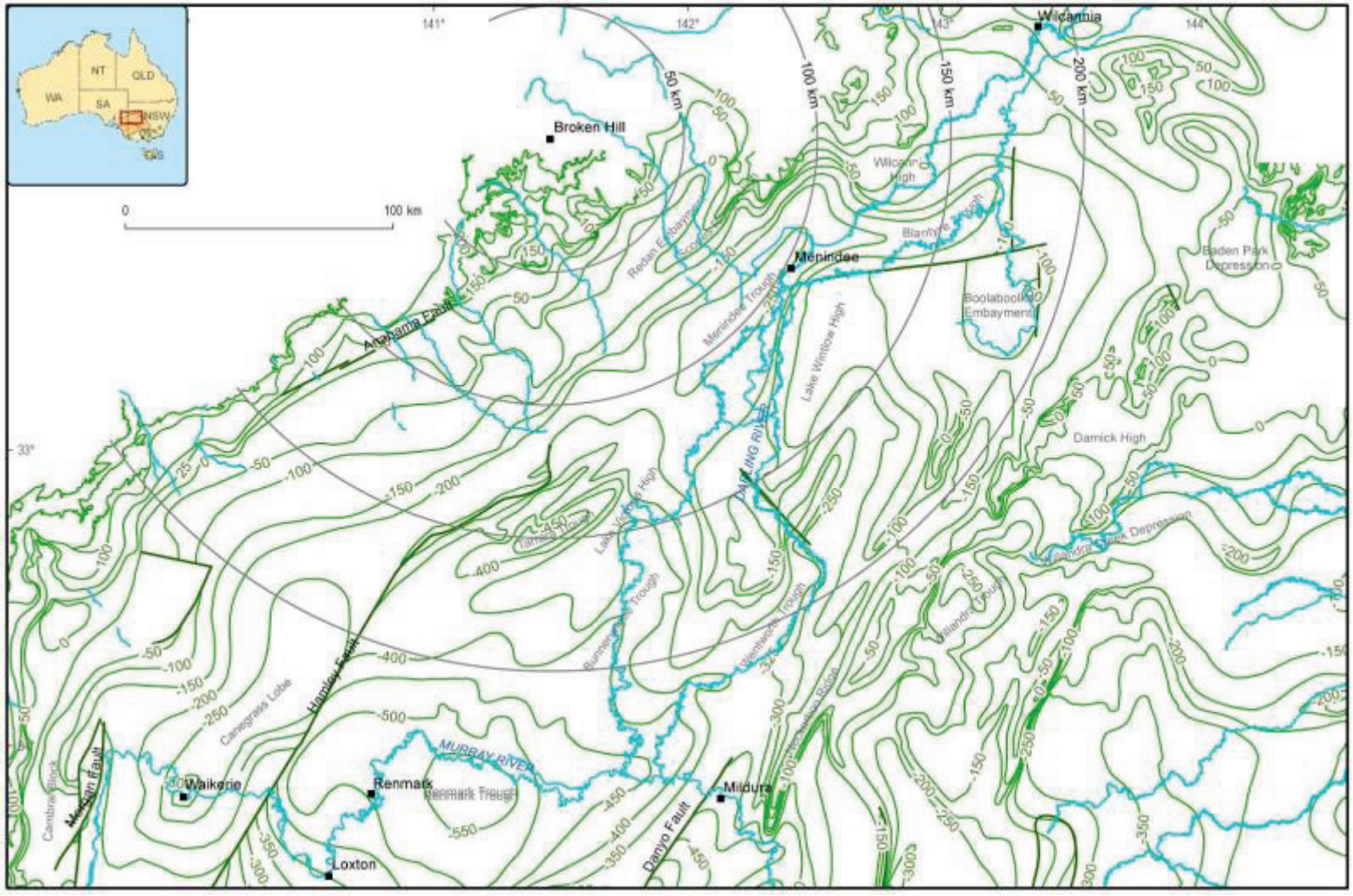


Figure 2: Structural contours – Menindee region



Structural contours for the base of Murray Geological Basin (MGB) sediments, and locations of underlying infrabasins such as the Menindee Trough. These contours show the variable thickness of sediments in the MGB, and that the north-west margin of the basin abuts the Proterozoic Broken Hill Domain (after Brodie, 1994).

5.2 Stratigraphy

The stratigraphy in the Menindee area is of a fluvio-lacustrine origin and is not consistent with elements of the Riverine Plan sequence previously generalised for the whole Murray Basin (Lawrie *et al*. 2012b). The stratigraphy of the study area is summarised in **Figure 3**.

Figure 3: Stratigraphy of the Menindee region (Table 5-1 Lawrie *et al.* 2012e)

Lithostratigraphy	Age	Lithology	Hydrostratigraphy	
Coonambidgal Formation (Qa)	Holocene To younger Pleistocene 0 - ?40 ka	Near-surface mud drape	Aquitard, typically unsaturated to partially saturated	
		Sandy base	Shallow unconfined aquifer near leakage, otherwise unsaturated	
Menindee Formation (Qam)	Younger Pleistocene ?50 ka - >150 ka	Muddy top	Thin aquitard, typically unsaturated	
		Sandy base	Shallow unconfined aquifer near leakage, otherwise unsaturated	
Willotia beds (Qaw)	>150 ka - ?500 ka	Mostly sand	Perched or shallow unconfined aquifer near leakage, otherwise unsaturated	
Woorinen Formation (Qdw)	Middle Pleistocene 0 - ?500 ka	Muddy top	Thin unsaturated aquitard	
		Sandy base	Shallow unsaturated sands	
Blanchetown Clay (Qpc)	Older Pleistocene ?500 ka - 2.5 Ma	Mud	Regional confining aquitard, partially to fully saturated	
Chowilla Formation (Tpcs)	?2.5-?2.6 Ma	Sand	Very localised semi-confined aquifer	
Calivil Formation (Tpc)	Pliocene 2.6 - 5.3 Ma	Local muddy top	Locally confining aquitard, typically saturated	
		Predominantly sandy with local muddy units	Regional aquifer, mostly semi-confined to confined. Unconfined marginal to leakage areas.	
Loxton-Parilla Sands (Tps)	Pliocene 2.6 - 5.3 Ma	Fine to medium sands	Regional semi-confined to confined aquifer. Unconfined marginal to leakage areas. Underlying to laterally equivalent to Calivil Formation, southern part of project area only	
Renmark Group (Ter)	Tertiary (Paleocene to Miocene)	Upper Renmark Group- Muds with sandy channels	Local semi-confined to confined aquifer	Aquitard base to overlying Calivil Formation target aquifer
		Middle Renmark Group - Mud with minor sand	Regional aquitard	
		Lower Renmark Group – Sands, silt and lignite	Confined aquifer in regional troughs	
Paleozoic (Devonian)	Paleozoic >251 Ma	Metasediments	Fractured and weathered rock aquifer	

The main lithostratigraphic units in the Menindee area are:

- Coonambidgal Formation – A Quaternary fluvial deposit that is associated with the modern Darling River. It is about 14m thick and with basal fine to coarse sand that is overlain by overbank muds.
- Menindee Formation – Deposits of the higher older flood plain. It is about 14m in thickness with a basal fine to coarse sand that are overlain by overbank muds. The basal sands form a shallow unconfined aquifer in the river corridor and become progressively unsaturated as the watertable deepens away from the modern drainage.
- Willotia Beds – Fluvial to lacustrine sediments which bound the Darling floodplain. They are interpreted by Lawrie *et al.* (2012b) to be down valley and lateral fluvial and deltaic units feeding into Lake Bungunnia. Following the lowering of Lake Bungannia deposition of fluvial sediments transgressed over and/or were deposited in valleys that incised the Blanchetown Clay.
- Blanchetown Clay – It was deposited in a mega Lake Bungunnia (Stephenson 1986). It comproses of hard brown to light grey massive to fine bedded sandy clay, with local fine calcareous and manganese cement. Lawrie *et al.* (2012d) identified that it is between 5 and 10m thick in the Menindee area.

  The Blanchetown Clay forms a regional aquitard, however 'holes' in the layer permit localised recharge to the underlying Calivil Formation. The absence of the layer is possibly due to non deposition, facies change or faulting and erosion.
- Calivil Formation – It was deposited in deep braided streams across a dissected sedimentary landscape. It varies in thickness from 0 to 70m and at a regional scale sands are gravels are widely distributed with particularly good aquifers developed in palaeochannels and at the confluence of palaeo-river systems. However, at a local scale 10s to 100s metres there is considerable lithological heterogeneity.

  The lower bounding surface of the Formation is marked by a distinct erosional contact with Renmark Group sediments. There is a 10 million year hiatus between deposition of the Renmark Group and the Calivil Formation

  It forms a regionally extensive unconfined to confined aquifer comprising of filled gravels and sands and local fine grained units representing abandoned channels and local floodplain sediments.
- Renmark Group – This is the focus of this investigation and discussed in detail in **5.2.1 Renmark Group**

5.2.1 Renmark Group

In the Menindee region the Renmark Group comprises non-marine Palaeocene to Miocene sediments of the Murray Geological Basin (Brown and Stephenson 1991). It is laterally equivalent to the Oligo-Miocene Murray Group marine deposits.

In the Menindee region the Renmark Group is poorly understood. Lawrie et al. (2012b) have inferred that the upper Renmark Group was deposited on a low relief sedimentary plain dominated by anastomosing fixed channel streams, flowing southwards into a complex low energy coastal plain with numerous lagoons and bays.

Deposition of the Renmark Group in the project area is controlled by the Menindee Trough (Lawrie *et al.* 2012d). The Trough limits the lower Renmark Group and influences the thickness of the middle and upper Renmark Group, which are considered to be Olney Formation.

Evans and Kellett (1989) identify that the lower Renmark Group occurs only in tectonically controlled infrabasin troughs and is absent over upthrown ridges between the troughs. At the base of the lower Renmark Group is the Warina Sand. It is a medium to coarse grained quartz sands and minor interbeds of carbonaceous bearing fine sand, silt and clay. In the Menindee Trough the lower Renmark is estimated to 80 to 120m in thickness (Lewis *et al.* 2008).

Palynological studies place most of the sequence in the Middle Eocene to Early Oligocene (Kellett 1989). Similar to the overlying middle and upper Renmark deposition consists of silt and clay rich deposits occurring in extensive floodplains and lakes, with sands deposited in meandering channels (Lewis *et al.* 2008).

The majority of the middle and upper Renmark Group consists of muds (silt, clay and sandy muds). These are interpreted by Lawrie *et al.* (2012b) as overbank deposits, including floodplains, lakes, swamps, levees, and abandoned channel fills. Within these deposits they identified lignites, palaeosols and insect nests. However, they are mainly floodplain sediments of clay rich muds that are either organic rich or strongly gleyed composition (wetland environment). They are predominantly grey, green and dark brown in colour, in places it is bright yellow indicating localised oxidation.

Lawrie *et al.* (2012b) identified that in the upper to middle Renmark Group where sand beds occur they are generally less than 1m in thickness but occur up to 5 to 6m in thickness and infrequently between 7 and 22m in thickness. The 1 to 3m thick sand beds were interpreted as being levee bank and crevasse splay deposits, 3 to 6m thick as single storey channel deposits and those greater than 7m as multistorey stacked channels.

Kellett (1989) identified that the middle Renmark Group as the finest grained unit of the Renmark Group, that forming a continuous 100m thick blanket on the up basin side of the Geera Clay boundary. It consist of dark grey or blue to black silty medium sand grading upwards into laminated clay and silt which grade upwards into fine sand.

The upper Renmark Group is about 60m thick in the troughs and consists mostly of medium to fine sand with minor silt interbeds in the Riverine Plain. Its colour varies from brownish grey to greenish grey (Kellett 1989).

6.0 Hydrogeological conceptualisation

The investigation area is located between Lake Menindee and Lake Pamamaroo adjacent to the Broken Hill water supply pipeline. It extends for about 10 km east from the intersection of the Wilcannia and Broken Hill- Menindee Roads towards the township of Menindee, see **Figure 1**. The area is perpendicular to the north-east to south-west orientation of the Menindee Trough, see **Figure 2**.

The available information on the tectonic structure and stratigraphy of the Menindee Trough is primarily reliant on the interpretation conducted as part of the Broken Hill management aquifer recharge project (Lawrie *et a.* 2012 a-e), a seismic geophysical survey (Geophysical Associates Pty Ltd 1963) and a limited number of bores within the Menindee Trough that have been drilled to depths greater than 200m.

It is anticipated that the investigation area is towards the western margin of the Menindee Trough, with the eastern margin anticipated to be to the east of the township of Menindee.

From bore records there are 6 sites that have been drilled to depths greater than 160m in the Menindee Trough that intersect sand material to depths up to 300m in the Renmark Group, see **Figure 4**. The four of these sites are located to the south-west of Lake Tandou, which is approximately 55 kilometres to the south-west of the investigation area.

A high proportion of the Calivil Formation, Renmark Group and overlying material at these locations has a high clay content which is consistent with the findings of Lawrie *et al* 2012 a-e. There are various intervals with sand layers ranging in thickness from about 6 m to 10m. The thickest intervals occur at GW006310 (195m to 218m), GW600180 (196m to 226m), GW036838 (236m to 312m), GW054679 (183m to 187m & 192 to 197m), GW007561 (209m to 221m & 230m to 235m) and BHMAR33-1 (190 to 205m). Based on the limited information from these broadly dispersed sites there is potentially the existence of a sand layer at a depth between 190m and 240m.

The likely significant continuous thickness of silty clay and clay material in the Calivil Formation and Renmark Group sands suggest that these sands at a depth of 200 m would be a confined aquifer.

Literature on the Renmark Group including the results of the Broken Hill managed aquifer recharge project (Kellett 1989 and Lawrie *et al.* 2012 a-e) suggests that these are possibly meandering channel deposits that potentially have a general north-south orientation that are laterally disconnected. Their extent and distribution in the Menindee Trough is unknown.

The age of the palynostratigraphic analysis of a sample from a depth of 205m from site BHMAR33-1 conducted as part of the Broken Hill managed aquifer recharge investigation (Lawrie *et al.* 2012 a-e) placed a minimum at of Middle Miocene. This places the Renmark Group at this location as potentially being upper Renmark Group.

7.0 Drilling and bore construction

7.1 Groundwater licence

DPI Water obtained the groundwater works approval 60WA583221 to construct production bores on land owned by the Water Administration Ministerial Corporation (Lot 1 DP 1171514).

The NSW DPI Water also sought an exemption under Clause 36(1)(a) of the Water Management (general) Regulation 2011 for the construction of test production bores on crown land (Lot 1 DP 1115389 and Lot 4521 DP 767598). The licence RI547384 was obtained from Crown Lands for the construction of test production bores on these lots.

This exemption was sought to enable the continuation of drilling operations while an amendment to the work approval 60WA583221 was being assessed to include the crown land lots.

7.2 General

Prior to the commencement of drilling a Review of Environmental Factors (REF) was completed for a number of potential drilling sites. The sites included in the REF are shown in **Figure 1**.

Drilling commenced in mid-November 2014 and was completed by early April 2015. The work was completed by the DPI Water Groundwater Drilling Unit using rigs with rotary top heads and direct rotary mud circulation.

The drilling program was carried out in accordance with the 'Minimum Construction Requirements for Water Bores in Australia Third Edition' (NUDLC, 2012).

A pilot hole was drilled at each site to enable geological logging of the drill cuttings as well as geophysical logs. Collectively this information was used to select the optimum bore screen depths prior to the hole being reamed out to a larger diameter hole for the installation of the bore casing.

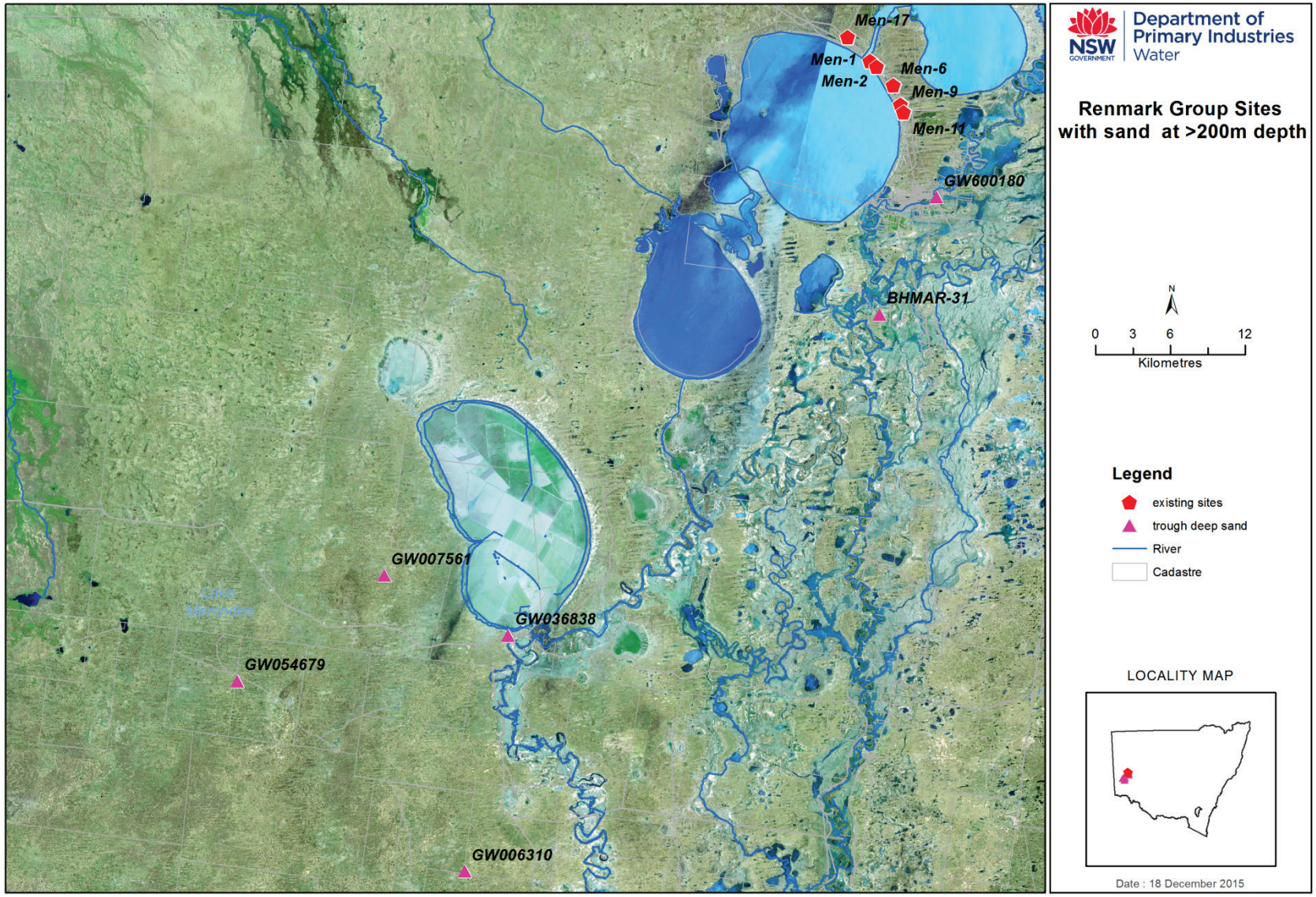
7.3 Bore design

Given the short lead time of the drilling project and inability to stage the drilling program to enable a progressive assessment of the site conditions, there were consequent limitations on the installed bore construction. Prior to the commencement of the drilling program a preliminary bore design based on the available information on the sands in the Renmark Group aquifer was developed. This was the basis on which the casing, screen and gravel pack material were sourced to commence drilling the initial test production bores.

Based on the available information the bore design selected was:

- 200mm ID ABS casing
- 1.5 mm machine slotted screen aperture,
- 1 to 3 mm rounded gravel pack for the screen interval.

Figure 4: Location of existing sites in the Renmark Group intersecting sand at a depth of greater than 200m.



Sufficient casing was ordered for the first three test production bores. However, the ABS casing was not delivered prior to the commencement of drilling of the first site (MEN-2), which was cased with 203mm ID class 18 uPVC.

The bore design was modified following the completion of the first test production bore at MEN-2 and the sieve analysis of the Renmark Group aquifer sands. The results of the sieve analysis are in **Appendix 2**.

A revised design was 250mm ID casing, 2.2 mm screen aperture and 3 to 5 mm gravel pack for the screen interval. Since sufficient casing was ordered initially for three production bores, the initial three sites were cased with 203mm ID ABS. However, the wider 2.2mm screen aperture was used at these sites.

The last two production bores were cased with Class 18 uPVC 250mm ID casing due to ABS casing not being able to be sourced prior to the construction of these bores.

8.0 Drilling results

8.1 Bore construction

A total of seven bores (6 test production and 1 test/monitoring) were constructed during the drilling program. The initial bore at site MEN-2 was abandoned following the casing separating in the hole, leaving 5 test productions bores completed and 1 test/monitoring bore. The location, drilled and completed depths of the bores is summarised in **Table 1** the location of the sites is shown in **Figure 1**. The Form A bore construction details for each bore are at **Appendix 1** – Form A.

Test holes were initially drilled at the test production sites at a diameter of 260 mm, these were reamed out to 370mm for the installation of the bore casing. The completion details of the bores are summarised in

Table 2.

The water bearing zones were gravel packed from below the screen interval to the top of the Renmark Group. A bentonite seal was installed to separate the Renmark Group and Calivil Formation aquifers.

The bore casing extended about 800 mm above surface with a 500 mm temporary steel casing protector installed to prevent vandalism until the final surface infrastructure design is confirmed.

The bores were developed by airlifting and air surging until the discharge was sediment free. Development was carried out for between 8 and 31 hours at each site. The development water was removed from site and disposed at the Menindee landfill facility, for a disposal fee.

Table 1: Bore drilling summary

Site	Work no.	Hole diameter (mm)	Drilled depth (m)	Completed depth (m)	Zone	Easting	Northing	Completion Date
MEN-1	GW273318	356	211	209	54	629537	6426070	06/02/2015
MEN-2	GW273319	360	211	215	54	630083	6425635	21/03/2015
MEN-2	GW273324	356	245	214	54	630078	6425635	14/12/2014
	Bore abandoned due to separation of the casing in the bore							
MEN-6	GW273322	360	210.5	215.5	54	631391	6424131	29/03/2015
MEN-9	GW273321	370	220	220	54	631420	6424414	01/04/2015
MEN-11	GW273320	356	218	221	54	632227	6421939	5/03/2015
MEN-17	GW273323	216	202	202	54	627755	6427995	20/04/2015

Table 2: Bore construction summary

Site ID	Work No.	Casing diameter ID (mm)	Casing Material	Screen interval	Screen aperture (mm)	Gravel Pack diameter (mm)	Development time (hours)	SWL (m btoc)
MEN-1	GW273318	200	ABS	197 - 203	1.5	3 - 5	31	26.96
MEN-2	GW273319	200	ABS/ Class 18 uPVC	193 - 205	2.2	1 – 3	10	28.3
MEN-2	GW273324 Bore abandoned	230	Class 18 uPVC	193-205	2.2	1 - 3	20	28.3
MEN-6	GW273322	226	Class 18 uPVC	192.5 – 204.5	2.2	3 – 5	10	28.0
MEN-9	GW273321	226	Class 18 uPVC	176 - 191	2.2	3 – 5	12	28.11
MEN-11	GW273320	200	ABS	194 - 212	2.2	3 – 5	8	29.72
MEN-17	GW273323	68	Class 18uPVC	70 - 76	2.0	3 – 5	10	19.2

8.2 Geological logs

Samples were collected at 1m intervals at all of the drilled sites. The material was logged by DPI Water hydrogeologists with samples collected in sample bags and chip trays. The pictures of the lithological chip trays are shown in **Appendix 3**.

The geological logs show that the dominant geological units are the Calivil Formation and Renmark Group. Overlying the Calivil Formation is site dependent and consists of the Menindee Formation, Blachetown Clay, Willotia beds, Woorinen Formation and Lunette material.

The Calivil Formation at the test production bore sites is predominantly clay to silty clay. However, at MEN-17 there is approximately 29m of fine to coarse sand between 49 m ad 78 m below ground. This is interpreted to be located outside of the Menindee Trough and Palaeozoic mudstones at a depth of about 92m.

The Renmark Group is the thickness geological unit drilled during the investigation. The initial test production bore was drilled to 245 m (MEN-2). Medium to coarse sands were intersected at 197 m to 209 m, which were underlain by approximately 13m of lignite and then clay and silty clay to the completed depth of 245 m. Based on the results of the hole the following test production bores were drilled to identify the extent of the sand layer at approximately 200 m.

At all of the test production bore sites fine to coarse sands were intersected at this depth. The exception was MEN-9 and MEN-11 where two sand layers were intersected (160m to 180m and 190 m to 212 m). At MEN-9, the shallower sand were screened based on the results of the geophysical log and the lithological samples. The deeper sands contained clay indicating the potential of multiple clay layers within the sand interval, whereas the shallower sands although finer grained did not appear to contain any clay layers.

At MEN-17 the thickness of the Renmark Group is interpreted to be only about 12 m in thickness (80 m to 92 m), being underlain by consolidated Palaeozoic weathered mudstone.

Geological logs and interpreted stratigraphy are in **Appendix 4**.

8.3 Geophysics

Geophysical logs were run at each site to assist in determining aquifer horizons. The geophysical logs are then matched with geological log of the drill cuttings. Collectively this information is used to select the optimum bore screen depths.

The following wire line logs (or a combination there of) were performed on each hole.

Caliper logs record borehole diameter. Changes in borehole diameter are related to well construction, such as casing or drilling-bit size, and to fracturing or caving along the borehole wall. Because borehole diameter commonly affects log response, the caliper log is useful in the analysis of other geophysical logs.

Gamma logs record the amount of natural gamma radiation emitted by the rocks surrounding the borehole. Clay and fine grained sedimentary rocks commonly emit relatively high gamma radiation because they include weathering products of potassium feldspar and mica and tend to concentrate uranium and thorium by ion absorption and exchange.

Spontaneous-potential (SP) logs record potentials or voltages developed between the borehole fluid and the surrounding rock and fluids. Spontaneous-potential logs can be used in the determination of lithology and water quality.

Resistivity (induction conductivity) logs record the electrical resistivity of the borehole environment and surrounding rocks and water as measured by variably spaced potential electrodes on the logging probe.

The wire line geophysical logging performed on the holes was carried out by Groundsearch Australia. **Table 3** summarises the geophysics performed on each hole. A copy of the geophysical logs for each hole is attached in **Appendix 5 – Geophysical logs**.

Table 3: Geophysical logs

Site	Work no.	Performed by	Geophysics
MEN-1	GW273318	Groundsearch Australia	Gamma,Restivity, Spontaneous potential, Lateral resistivity, Resistivity SG, Resistivity DG
MEN-2	GW273319	Groundsearch Australia	Gamma,Restivity, Spontaneous potential, Lateral resistivity, Resistivity 16N, Resistivity 64N
MEN-6	GW273322	Groundsearch Australia	Gamma,Restivity, Lateral resistivity, Resistivity 16N, Resistivity 64N
MEN-9	GW273321	Groundsearch Australia	Gamma,Restivity, Spontaneous potential, Lateral resistivity, Resistivity 16N, Resistivity 64N
MEN-11	GW273320	Groundsearch Australia	Gamma,Restivity, Spontaneous potential, Lateral resistivity, Resistivity 16N, Resistivity 64N
MEN-17*	GW273323	Groundsearch Australia	Gamma,Restivity, Spontaneous potential, Lateral resistivity, Resistivity 16N, Resistivity 64N

* MEN-17 geophysics was conducted once the hole was cased due to logistical constraints at the time of bore construction.

8.4 Palynological analysis

Underlying the sand layer screened in all of the test production bores (MEN-1, MEN-2, MEN-6, MEN-9 & MEN-11) at about 200 m is about 10m of lignite. Palynological samples were collected and analysed to provide additional information on the depositional environment and potentially the age of the material by Macphail (2015).

The analysis of the samples has enabled the dating of the lignite as late Middle to Late Eocene (Middle Nothofagidites asperus Zone Equivalent). This places the lignite in the Olney Formation of the Renmark Group.

The samples from the lignite represent freshwater peat swamp facies deposited on a floodplain of the palaeo Darling River drainage system during periods when the water table level was close to ground level (Macphail 2015).

The palynofloras represent warm temperate rainforest dominated by species of conifers (Podocarpaceae) and southern beech (Nothofagus). The nearest living relatives are now confined to other landmasses, including southern South America, Papua New Guinea, New Zealand and Tasmania.

Sediments of Eocene age are uncommon in the northern margin of the Murray Geological Basin. The presence of the late Middle-Late Eocene lignite facies reflects the greater accommodation space available within the Menindee Trough and conditions conducive to the accumulation of organic rich sediments

The analysis identified weak circumstantial evidence of locally brackish water conditions. Salt sources could be halite units underlying basement rocks or extension of a saltwater wedge upstream into the Menindee Trough during a marine transgression responsible for the deposition of the Buccleugh Bed Equivalents in the south west of the Murray Geological Basin (Macphail 2015). The presence of marine transgression in the Menindee trough is likely to have occurred via the Tarraara and Renmark Troughs.

9.0 Pump tests

9.1 General

A pumping test program was undertaken by the NSW DPI Water drilling unit on the five test production bores between 20 February and 28 April 2015 using a submersible pump set at 117m depth. Discharge rates were measured using a digital flow meter and water levels were measured in the production bores, and adjacent test production bores were used as observation bores, see **Table 4**.

The program comprised of a step-drawdown test of 3 steps of 2 hours duration and a four day constant-rate pumping test and a recovery test at each bore.

Prior to the commencement of the step-drawdown test a trial pumping rate was conducted for between four and six hours. This was conducted to assess the likely drawdown and pumping rates to be used in the subsequent step-drawdown test.

Two 30,000L relocatable storage tanks were used to initially hold water produced during pump testing. The water was then pumped via a 150mm diameter poly pipe across the adjacent lunette and discharged on the foreshore of Lake Menindee.

Table 4: Production bores pump tested and monitoring sites

Site ID	Work No.	Test Date	Monitoring bores
MEN-1	GW273318	23/02/2015	N/A
MEN-2	GW273319	25/03/2015	GW273318
MEN-6	GW273322	23/04/2015	GW273321 GW273319
MEN-9	GW273321	16/04/2015	GW273322 GW273320
MEN-11	GW273320	19/03/2015	N/A

9.2 Step-drawdown tests

The step-drawdown tests were performed to assess bore performance and to determine an appropriate rate for the constant-rate test and the relative proportions of laminar and turbulent flow occurring at any pump rate. The analysis was conducted using the Hantush-Bierschenk method.

Plots of drawdown versus time for the tests are presented for MEN-1 through MEN-11 in **Appendix 6**, the analyses of the tests are summarised in **Table 5**.

Table 5: Summary step–rate test

Site ID	Works No.	Step rates (L/S)	Analysis Results		Laminar Flow % at Constant Rate test rate
			B	C	
MEN-1	GW273318	3.79, 6.99, 10.54	0.034	0.000032	54.11
MEN-2	GW273319	10.34, 15.62, 20.80	0.009	0.00000155	76.37
MEN-6	GW273322	12.32, 16.41, 20.94	0.0058	0.00000244	56.71
MEN-9	GW273321	12.55, 16.74, 21.30	0.0055	0.00000153	66.13
MEN-11	GW273320	6.14, 11.55, 21.71	0.0036	0.000000667	74.24

9.3 Constant rate tests

Constant rate pump tests were conducted on the five test production bores. The duration of the tests was for 4 days except for MEN11 which was conducted for 48 hours. A 48 hour test was conducted at MEN11, due to the minimal drawdown associated with the high hydraulic conductivity of the aquifer at this location and to ensure the timely completion of the investigation.

Water levels during the constant rate tests were monitored at the test production bore and where available adjacent test production bores. The pump tests were conducted in parallel to the construction of the test production bores. The availability of observation monitoring sites was subject to the proximity of adjacent test production bores and the progress of drilling.

The analysis of the constant rate test was conducted using the Cooper-Jacob and Theis methods. A summary of the constant rate tests parameters and outcomes are shown in **Table 6**. Plots and analyses of the constant-rate data are presented in **Appendix 6**.

All of the pump tests showed a continual drawdown with time; the exception is MEN-9 which after about 13 hours of pumping showed an increased decline in groundwater levels, see **Appendix 6**. This infers that the ability for the bore to draw water from the aquifer was reduced at this time. MEN-9 is screened in sands at a depth of 176 to 191 m which is above those of the other test production bores that are screen at a depth of approximately 200 m.

Observations of the groundwater levels were made at MEN-6 and MEN-11 during the MEN-9 pump test. Groundwater levels at these sites responded to pumping, demonstrating that the shallower sands screened at MEN-9 are hydraulically connected to the deeper sands. However, there is likely a barrier influencing the hydraulic connectivity between these two sand layers

To calculate the efficiency of a bore the difference between the theoretical calculated drawdown just outside the borehole and that inside the well is compared (Driscoll 1986). A good bore efficiency is greater than 80%. A low bore efficiency causes additional head losses which may influence the potential pumping costs. The factors that influence bore efficiency can be either design or construction factors.

The design factors that may influence the bore efficiency include:

- The screen aperture size is insufficient and makes the entrance velocity too high.
- Poor distribution of screen openings causing excessive convergence of flow near the individual openings.
- Insufficient screen length causing partial penetration of the aquifer, distorting the flow pattern around the well.
- Inappropriate gravel pack material or inappropriate gravel pack size.

The construction factors that may influence bore efficiency include:

- Inadequate development of the bore leaving too much drilling fluid and small particles in the formation around the screen, and
- Improper placement of the well screen may put it at a depth that does not correspond to the best water bearing material (Driscoll 1986).

The bore efficiency and the laminar flow for the test production bores are shown in **Table 6**. These results show that the majority of the head loss is associated with laminar flow.

The low bore efficiency of the test production bores is unlikely to be due to the gravel pack or the screen aperture as a sieve analysis of the productive sands and gravels in the Renmark Group aquifer was conducted. This analysis identified that the gravel pack should consist of gravel with a diameter between 3mm and 6mm and a screen aperture of 2.5mm. The actual gravel pack diameter was 2 to 5 mm due to availability of material while the screen aperture used was

2.2mm. This is a small variation that would not cause a measurable influence on the bore efficiency.

A potential contributing factor to the bore efficiency is the use of machine slotted casing rather than wire wound screen. A wire wound screen has more open area, which would allow more water to enter the screen internal and potentially reduce the amount of head loss within the bore.

Wire wound screens were not used due to the potential corrosive impacts of the salinity of the Renmark Group aquifer. The future use of wire wound screens would require analysis of the water quality to determine if there is a suitable corrosive resistant metal alloy that could be used to construct the screens.

9.4 Estimated long-term pumping rate

The Renmark Group aquifer in the investigation area is a confined aquifer. Knowledge of the thickness, extent and characteristics of the aquifer are unknown, therefore the long term supply of water requires further investigation.

The findings from the step-drawdown and constant rate rest provide an indication of the potential long term pumping rates from the test production bores. These have been assessed based on the assumption that the results from the four day constant rate pump tests reflect the long term behaviour of the aquifer system and that the aquifer system is regionally extensive.

The combined potential yield of the 5 test production bores is 138.6L/s (12ML/d), subject to the scheme design and bore pump capacities. The pumping rates and pump setting have been based on a precautionary principal of the bores operating continuously for 10 years and accounts for the pumping interference between the test production bores, sees **Table 7**.

The anticipated maximum potential long term yield from the 5 test production bore locations is 243L/s (21 ML/d), see **Table 7**. This predicted pumping rate could be achieved if a larger casing diameter was installed at sites MEN-2 and MEN-11. At MEN-6 there is minimal difference between the potential maximum yield and the theoretical maximum yield from the existing test production bore. Increasing the casing diameter at this site would potentially be of minimal benefit.

The extraction of the maximum potential long term yield also excludes the test production bore at MEN-1 due to its low potential pumping rate which would be further reduced due to interference from pumping of the other sites.

The reliability of this source as a long term emergency drought water supply is dependent on the frequency, duration and required supply from the scheme and the regional extent of this aquifer system.

The physical characteristics of the lithology within the investigation area suggest that there would be limited recharge to the aquifer. However, connectivity to recharge sources may exist within the area.

Table 6: Summary constant rate tests

Site ID	Pump Rate (L/s)	Duration (hours)	Initial standing water level (m)	Drawdown (m)	Solution method	Pump Test T (m^2/d)	Solution methods	Recovery T (m^2/d)	B (m)	k (m/d)	Obs bore	Solution method	S	Bore efficiency (%)	Laminar flow (%)
MEN-1	10.43	96	27.75	61.97	Papadopulos	76	Theis (Aqtesolv)	20.3	5	4.6	N/A		N/A	95	54
					Cooper-Jacob	23.5	Cooper-Jacob	22		4.7					
MEN-2	20.79	96	28.77	22.37	Papadopulos	331	Theis (Aqtesolv)	373	12	30.2	MEN-1	Cooper-Jacob	9×10^{-5}	42	76
					Cooper-Jacob	328	Cooper-Jacob	365		27.3					
MEN-6	20.96	96	30.15	19.82	Papadopulos	450	Theis (Aqtesolv)	846	12	38.7	MEN-2	Cooper-Jacob	1×10^{-4}	60	57
					Cooper-Jacob	473	Cooper-Jacob	828		39.4	MEN-9	No result*			
MEN-9	21.26	102	29.11	21.17	Theis/Hantush	310	Theis (Aqtesolv)	810	16	18.5	MEN-6	Cooper-Jacob	4×10^{-4}	59	66
					Cooper-Jacob	258	Cooper-Jacob	747		16	MEN-11	Cooper-Jacob	6×10^{-3}		
MEN-11	21.69	48	30.72	9.78	Theis/Hantush	881	Theis (Aqtesolv)	1606	18	80.3	N/A		N/A	21	74
					Cooper-Jacob	1380	Cooper-Jacob	1491		76.7					

T = transmissivity, b aquifer thickness, k = hydraulic conductivity, S = storativity

* The MEN-6 pump test was completed directly following the test of MEN-9. The groundwater level in MEN-9 continued to recover during the MEN-6 pump test

Table 7: Long term pump rate analysis

Site ID	Works No.	Casing diameter (ID)	Pump setting metres below ground	laminar flow (%)	Maximum yield existing bore[1] (L/s)	Predicted potential long term yield[2]	
						Laminar flow (%)	Potential maximum pumping rate (L/s)
MEN-1	GW273318	200	90	67	6.0	N/A	N/A
MEN-2	GW273319	200	90	75	22.1	61	43
MEN-6	GW273322	226	90	38	44.2	37	47
MEN-9	GW273321	226	90	49	44.2	45	51
MEN-11	GW273320	200	90	74	22.1	38	102

[1] The potential yield based on either aquifer parameters or bore casing diameter. The maximum discharge rates for bore casing diameter from Table 13.2 in Driscoll (1986).
[2] The potential maximum pumping rate is based on a minimum 10 years of continuous pumping. Altering the period sightly causes minimal change due to the analysis being based on a logarithmic scale.

10.0 Water quality

Water quality samples were collected for the purpose of enabling the assessment of the treatment required of the water for it to meet the Australian Drinking Water Guidelines (NHMRC, NRMMC 2011).

At the test production bores the field parameters of pH, electrical conductivity, redox potential and percentage dissolved oxygen were analysed throughout the period of the pumping test to monitor potential changes in water quality. This analysis identified that the field parameters remained stable throughout the period of the pumping tests, see **Appendix 7 – Field water quality**.

Water quality samples were taken for detailed laboratory analyses for the assessment of the treatment required to meet the Australian Drinking Water Guidelines (NHMRC, NRMMC 2011). The laboratory analysis was completed by NSW Health. An additional sample was taken at each site for analysis by Australian Laboratory Services (ALS) of a suite of parameters defined by Water NSW. The samples were taken on behalf of Water NSW as the project managers for the Broken Hill emergency water supply project. The NSW Health and ALS laboratories are NATA registered laboratories for the analysis undertaken.

At MEN-17, which was completed as a monitoring bore, water quality samples were taken for analysis by NSW Health and ALS following pumping of the bore for a sufficient period to enable the field parameters to stabilise. The laboratory analysis results from NSW Health and ALS for the test production bores and MEN-17 are reported in full in **Appendix 8 – Laboratory water quality**.

The laboratory analyses show that the concentrations of the various parameters in the samples from the Renmark Group aquifer are similar. However, the sample from Men-17 which was completed in the overlying Calivil Formation shows variation in some parameters when compared to those collected from the test production bores. These differences may be due to the sample being sourced from a separate aquifer; however the presence of suspended sediments in the water sample may also be impacting on the results. The presence of the suspended sediments is possibly due to the presence of sediment in the bore sump that had not been fully removed during development of the bore.

The field measurements show that the water is saline, with a natural pH and a negative redox potential, indicating a reducing environment. An analysis of the major ions from the ALS laboratory results identifies that the dominant ions are sodium and chloride, see **Figure 5**.

Figure 5: Pipe plot major ions – ALS laboratory results

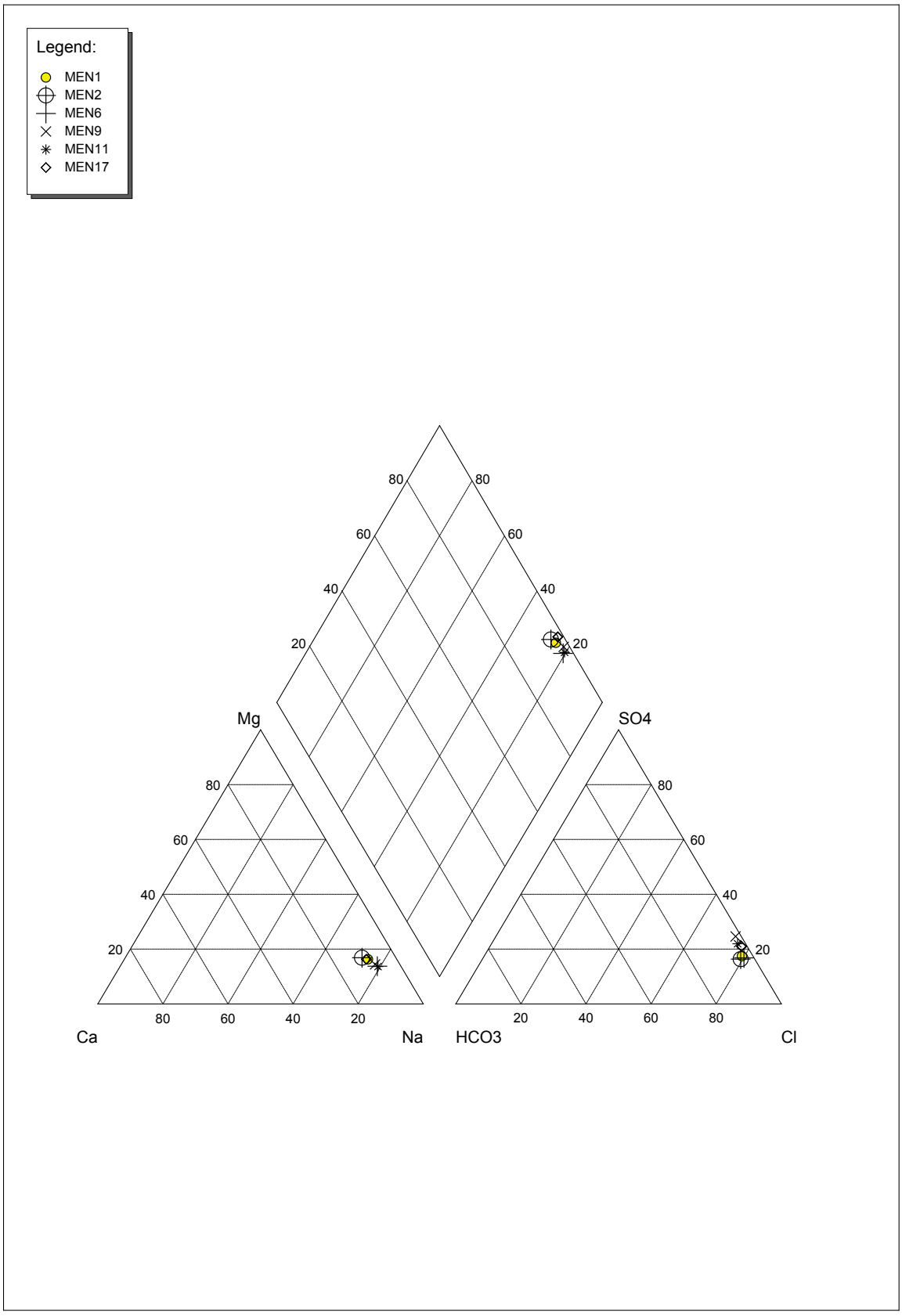


Table 8: Laboratory samples sampling time

Site ID	Works No.	Laboratory	Sample date	Sample time
MEN-1	GW273318	NSW Health	25/02/2015	14:30
		ALS	24/02/2015	08:00
MEN-2	GW273319	NSW Health	27/03/2015	16:45
		NSW Health	28/03/2015	16:30
		NSW Health	29/03/2015	15:30
		NSW Health	30/03/2015	07:00
		ALS	29/03/2015	11:45
MEN-6	GW273322	NSW Health	25/04/2015	09:00
		NSW Health	26/04/2015	09:00
		NSW Health	27/04/2015	07:00
		NSW Health	28/04/2015	07:00
		ALS	28/04/2015	07:00
MEN-9	GW273321	NSW Health	18/04/2015	15:20
		NSW Health	19/04/2015	11:30
		NSW Health	20/04/2015	7:00
		NSW Health	21/04/2015	7:00
		ALS	19/04/2015	11:30
MEN-11	GW273320	NSW Health	21/03/2015	8:10
		NSW Health	22/03/2015	7:00
		ALS	21/03/2015	8:00
MEN-17	GW273323	NSW Health	28/04/2015	12:15
		ALS	28/04/2015	11:30

11.0 Revised hydrogeological conceptualisation

The original hydrogeological conceptualisation was that the investigation area extended from the western margin of the Menindee Trough and that there was an extensive sand layer at a depth of approximately 200 m.

The margin of the Menindee Trough occurs between sites MEN-17 and MEN-1 as indicated by the thin layer of the Renmark Group being present at site MEN-17 and the increasing thickness of the sand layer from 5 m at MEN-1 to about 19 m at MEN-11 at a depth of approximately 200 m.

At sites MEN-9 and MEN-11 there are two distinct sand layers; the shallower occurs at depths of about 160 to 180m and have thicknesses of 18 m and 7m respectively in the two bores. This shallower layer is not likely to be as extensive and is hydraulically connected to the underlying sands at a depth of about 200 m.

The drilling conducted as part of this investigation and at site GW600180 infers that there is potentially a continuous sand layer at a depth of approximately 200 m in this region of the Menindee Trough. This is also supported by the response observed in the adjacent test production bores during the pumping tests, see the observed storativity values in **Table 6**.

The palynological analysis of the lignite underlying the sands screened in the test production bores indicates that the material was representative of late Middle to Late Eocene freshwater peat swamp facies on the palaeo Darling River drainage system. It is possible due to the presence of halophytes that they were also deposited during a marine transgression in the Murray Geological Basin.

The presence of the lignite at the test production bore sites infers a uniform depositional environment in the investigation area. The sands within the investigation area may be more extensive than the lignite due to the presence of 30 m of sands from 196 m to 226 m at GW600180 at Menindee as well as 15 m from 190 m to 205 m at BHMAR 33-1.

A potential conceptualisation is that due to the potential greater thickness of sands along the eastern margin of the Menindee Trough that the main drainage line occurred in this area. To the west within the investigation area of this project there was the freshwater peat swamp environment. However, the peat swamps may have extended across the Menindee Trough in the vicinity of the investigation area and been later eroded with the deposition of the sands identified at GW600180 and BHMAR 33-1.

It is likely following the deposition the lignite material there was an extensive lateral sequences of multiple stacked channels of meandering channel deposits of the Renmark Group across the investigation area of the Menindee Trough. The deposition of these meandering channel deposits would be consistent with the depositional environment proposed by Lawrie *et al.* (2012b).

Evidence from the palynological analysis of a potential marine transgression could support the conceptualisation of an increased thickness of the sand sequence at a depth of 200 m in the Menindee Trough to the south. This is inferred by the bores in the Renmark Group located to the south of Lake Tadou having sands present at a depth of about 200 m with a minimum thickness of about 12 m.

This conceptualisation infers that the sands screened in the investigation could be extensive and possibly increase in thickness towards the south. However, there is insufficient information to confirm this conceptualisation.

12.0 Recommendations for future work

12.1 Broken Hill water supply bore field options

The preliminary proposal (NSW Public Works 2014) for the current drought emergency supply and the Menindee Lakes Water Savings Project identified that an emergency water supply should aim to provide for an average summer demand of 25ML/d (approximately 77% of Peak Day Demand (31 ML/d)) and should aim to provide water supply for 12 months in every ten years.

The groundwater supply will require reverse osmosis treatment due to the groundwater salinity. The initial indication is that to supply 25 ML/d will require a groundwater supply of about 32 ML/d to accommodate for losses from the reverse osmosis treatment process.

The preliminary proposal identified that a reverse osmosis plant would potentially be located on the northern side of the Broken Hill – Menindee Road adjacent to the northern side of the interconnecting channel between Copi Hollow and Lake Menindee.

12.1.1 Supplied from the Renmark Group

This investigation has identified that the Renmark Group aquifer has the potential to supply a drought water supply for Broken Hill. To achieve this supply from the Renmark Group aquifers in the investigation area will require the drilling of additional production bores. In conjunction with the use of the test production bores drilled as part of this investigation, options include the construction of larger diameter bores at MEN-2 and MEN-11 where the potential yield of the site exceeds the current capacity of the bores as well as additional sites. The yield of the existing test production bores is 11 ML/d (excluding MEN-1 due to its low yield and further reduced yield caused by interference from the other bores). Assuming that each additional bore would yield 40 L/s, which is equivalent to the potential yield of MEN-2, MEN-6 and MEN-9.

The two identified options for the design of a bore field to supply 32 ML/d from the Renmark Group are:

Option 1 A bore field of 11 production bores, consisting of:

- the 4 existing test production bores at MEN-2, MEN-6, MEN-9 and MEN -11, plus
- 7 new additional bores at new sites (6 to supply the required yield plus 1 additional bore to ensure the security of supply during periods of bore maintenance or any unforeseen breakdowns), or

Option 2 A bore field of 9 production bores, consisting of:

- the 2 existing test production bores MEN-6 and MEN-9,
- 2 new larger diameter bores at MEN-2 and MEN-11 sites (as at these sites yield estimates are informed by the predictions from the pumping tests conducted on MEN 2 and Men 11 bores), plus
- 5 new additional bores at new sites (4 to supply the required yield plus 1 additional bore to ensure the security of supply during periods of bore maintenance or any unforeseen breakdowns).

Option 1 requires construction of 7 new production bores at new sites to add to the existing four most productive test bores already in place to make up the required yield of the field. It assumes that the additional new sites will achieve the required yield.

Option 2 requires the construction of 7 new production bores to add to two existing test production bores already in place to make up the required yield of the field, 5 new bores at new sites and the construction of two larger diameter bores at sites MEN-2 and MEN-11. The benefit of Option 2 is that the yield at MEN-2 and MEN-11 is known based on the predictions from the pumping tests conducted at these sites.

The selection of the potential production bores will need to consider the suitability of the site for drilling, the availability of power and minimisation of interference between bore sites. Potential production bore sites are shown in **Figure 6**.

In the circumstance that 7 production bores are required, the potential sites to minimise the length of a bore field pipeline would be MEN-4, MEN-5, MEN-7, MEN-8, MEN-10, MEN-12, and MEN-19 through MEN-25 as shown on **Figure 6**. The REF completed as part of this investigation identified that there was a higher risk of disturbing cultural heritage at sites MEN-3 and MEN-13.

The revised hydrogeological conceptualisation from this study infers that the sands at about 200 m depth in the Renmark Group potentially increase in thickness towards the eastern margin of the Menindee Trough.

An increased thickness in the sands may infer a higher hydraulic conductivity and yield. Any future investigation should target sites to the east of MEN-11 as a priority to assess the validity of the conceptual model and the potential to minimise the number of production bores required.

The selection of production bores will be influenced by site factors and characteristics as well as infrastructure considerations.

12.1.2 Supplied from the Calivil Formation

The Calivil Formation on the northern side of the interconnecting channel between Copi Hollow and Lake Menindee was out of scope for this investigation. The findings from site MEN-17 indicate its potential for inclusion in any future bore field.

The potential of the Calivil Formation is inferred from:

- The hydrogeological modelling of the Calivil Formation conducted as part of the BHMAR project,
- The presence of approximately 30 m of medium to coarse sands at MEN-17, and
- The preliminary investigation results of the Calivil Formation being undertaken by Water NSW on the Lake Menindee bed. The lithology of the sands at the lake bed sites and MEN-17 are similar in composition. The Initial results from pumping tests of the lake bed sites infer the potential to achieve the assumed yields as the Renmark Group.

A total of four potential sites targeting the Calivil Formation have been identified on the northern side of the interconnecting channel, further investigation of the area would be required to confirm the extent and the long term viability of the Calivil Formation as a supply source.

12.1.3 Assumptions and risks

The identification of the potential production bore sites are based on the following assumptions:

- Uniformity in the depth and thickness of the sands found in the Calivil Formation and Renmark Group during this investigation.
- These aquifers can sustain pumping to achieve the desired long term drought supply for Broken Hill.
- The target aquifer in the Calivil Formation is the fine to coarse sands at a depth of between about 50 and 80 m below ground on the northern side of the interconnecting channel between Copi Hollow and Lake Menindee.

The key risks for abstraction from the bore field are considered to be:

- The extent of the Renmark Group aquifer identified in this investigation is unknown.
- Potential long term viability of the Renmark Group resource is unknown due to the length of the investigation pumping tests.
- The ability to source the additional required supply.

- The water quality at potential new sites being significantly different to what was identified in this investigation.
- The long term stability of the water quality and the potential impact on a reverse osmosis plant from any change.

12.2 Other considerations

In conducting future works the following sections outline the activities that should be considered in the development of the bore sites. This excludes any activities beyond the construction of the water supply bores such as the borefield pipeline and infrastructure associated with the treatment of the water to ensure that it meets the Australian Drinking Water Guidelines. In developing the water supply borefield additional investigation works should be undertake to assess the long term viability of the resource and the influence of extraction.

12.2.1 Licensing and approvals

Any new bores constructed to establish a water supply bore field may be able to be added to the existing works approval through an amendment to include the new locations, NSW DPI Water licencing group can assist with this process. Environmental approvals will be needed for any new bores and would need to address cultural heritage impacts and the disposal of the water extracted from the bores during pump testing.

12.2.2 Bore field design and monitoring

At each production bore site a pilot hole should be constructed to confirm the presence of the sands identified during this investigation. This hole should be completed as a long term monitoring bore to be used to monitoring groundwater levels during pump testing and for long term monitoring.

The observation bores should be drilled at each of the proposed production bore sites prior to the construction of the production bores. This will to enable the appropriate bore casing diameter, screen aperture and gravel pack to be selected and sourced.

The production bores should fully screen the productive aquifer and constructed a minimum of 10 m from the pilot hole site, if to be used as a monitoring site during pump testing.

Additional observation bores should be constructed in the vicinity of the bore field to further improve the knowledge of the aquifer system, to be used as monitoring bores during pump testing of the production bores and to provide long term monitoring of the impact of the bore field. These bores should be constructed to the equivalent standard as the pilot bores.

12.2.3 Pilot bore design

The pilot bores should be a small diameter (200 to 250mm) mud rotary pilot hole, drilled to the base of the Renmark Group sands targeted during this investigation. This will identify the thickness of the sand and gravel aquifer at the location. Samples of the aquifer material should be collected for sieve analysis to determine the appropriate screen aperture and casing diameter of the production bore.

All pilot bores should have continuous lithological logging of the drill cuttings carried out by a hydrogeologist, with samples collected and bagged on a 1m interval basis. Downhole geophysical surveying should be undertaken, including; Gamma, Resistivity (long and short normal, lateral, point and mud, or alternatives proposed by the geophysical contractor) and Calliper logs.

In consultation with the geophysical contractor this logging may be conducted in the completed observation bore to ensure the efficient use of resources.

The pilot hole should be completed with 100mm Class 18 uPVC casing, with the full length of the Renmark Group sands is to be screened. Based on the results of this investigation the holes should be completed with a 2 mm machine slotted screen aperture. A 2 to 5mm diameter gravel pack placed from the base of the hole to 2m below the boundary between the Calivil Formation and Renmark Group. A bentonite seal of 4m should be installed across the Calivil Formation and

Renmark Group boundary. The remaining annulus should be filled with a 5% bentonite cement grout back to surface, or an equivalent approved method.

The bore should be developed for a sufficient period to remove drilling muds and fines from the bore to the standard outline in then Minimum Construction Requirements for Water Bores in Australia Third Edition' (NUDLC, 2012). A lockable steel monument at least 1m above ground surface should be installed in a concrete plinth at the surface to protect the casing.

Field measureable parameters of electrical conductivity (EC), pH, total dissolved solids (TDS), redox potential, dissolved oxygen and temperature should be measured following sufficient pumping of the bore to obtain a representative result of the aquifer water quality.

12.2.4 Production bore design

The detailed design of production bores at each site is subject to the findings from the pilot bores. However, based on the findings of the initial groundwater investigation it is anticipated that the following may reflect the potential design of the bores:

- A 400 to 425mm diameter mud rotary bore to the target depth using polymer muds.
- Install 300mm ID ABS screw casing with centralisers spaced every 6m along the casing.
- 316 stainless steel wedge wire wound well screen for the length of the Renmark Group aquifer, with a default 2.5 mm screen aperture. This is subject to an assessment of their resistance to corrosion from the quality of the water in the Renmark Group aquifer. Alternatively machine slotted screens could be used.
- Gravel pack with a 2 to 5mm diameter is to be placed from the base of the hole to 2m below the boundary between the Calivil Formation and Renmark Group.
- The selection of the actual gravel pack and screen aperture will be dependent on the outcomes of the sieve analysis of the Renmark Group.
- Include a 6m sump at the base of the screen interval.
- A bentonite seal of 4m should be installed across the Calivil Formation and Renmark Group boundary. The remaining annulus should be filled with a 5% bentonite cement grout back to surface, or an equivalent approved method.
- Surface completion is to be determined once the final site design is completed. As a temporary measure a steel casing protector should be installed to cover the surface expression of the casing. The casing protector should consist of steel pipe with a steel plate welded to seal one end of the pipe.

12.2.5 Pumping tests

All completed production bores should be pumping tested in accordance with Australian Standard AS 2368-1900.

The pumping tests should consist of the following:

- A trail test to check all equipment and to obtain information to inform the rates for the following step-drawdown and constant rate tests.
- A step-drawdown test to evaluate the drawdown response, evaluate the bore characteristics and the selection of a pumping rate for the constant rate test. The test should consist of at least 3 steps of 2 hours duration.
- A constant rate test for a period of a minimum of seven days. This will enable an understanding of the aquifer system in the vicinity of the bore. A seven day test is recommended to evaluate the long term yield of the bore and identify if potential barriers exist that may influence the long term yield.

  In addition to monitoring the water level in the test production bore, time series pressure transducer loggers should be installed in all adjacent observation bores. The measurement

of the groundwater levels in these bores provides additional information on the aquifer storativity as well as the influence of pumping the test production bore on the aquifer. This information greatly assists in establishing long term pumping rates and evaluating potential interference effects between the production bores.

- Groundwater levels should be monitoring following the completion of the pump test to monitoring the residual recovery and potentially identify the extent to which the aquifer storage has been depleted by the test.
- Water quality samples should be collected every 24 hours during the constant rate test and sent for analysis to a NATA registered laboratory for a comprehensive suite of analytes.

  Multiple field measurements of water quality parameters should be monitored throughout the duration of the tests. These parameters should include electrical conductivity (EC), temperature, pH, Redox potential and dissolved oxygen.

12.2.6 Numerical modelling

The development of a numerical model for the area of the existing test production bores and future proposed bores would assist to evaluate the maximum potential yields and pumping interference from the existing test production bores and the proposed additional production bores.

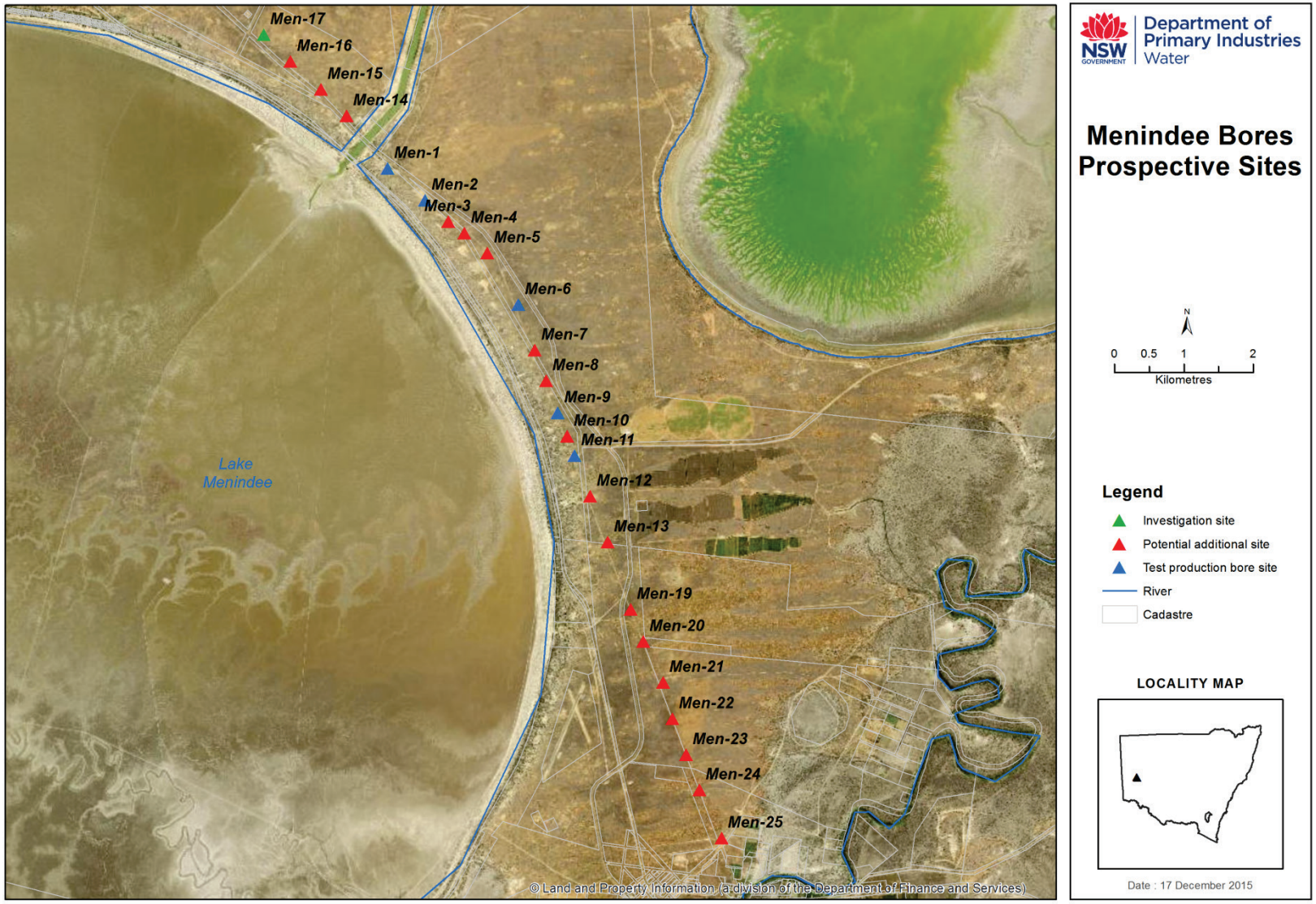
The model should be designed to enable it to be easily updated once new production bores have been completed to evaluate the potential long term production bore pumping rates and the long term influence of the extraction.

The model may provide a tool to communicate the potential area of influence of the scheme and allow estimation of the time required for water levels to potentially recover post pumping.

12.2.7 Reporting

The outcomes of any further investigation / construction of a water supply bore field should be analysed and documented to identify the potential long term yield from the bore field, assumptions, risks to the long term operation of the scheme and to contribute to the increased knowledge and understanding of the groundwater characteristics and geology in this area.

Figure 6: Potential production bore sites



13.0 References

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Appendix 1 – Form A

MEN-1

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 1

Driller's Licence No:	2055	1
Class of Licence:	6	
Driller's Name:	Alan Southwell	
Assistant Driller:	Daniel Quintal	
Contractor:		
New bore	X	Replacement bore
Deepened		Enlarged
Reconditioned		Other (specify)
Final Depth	209 m	

Work Licence No:	60WA583221	2
Name of Licensee:	NSW Office of Water	
Intended Use:	Town Water	
Completion Date:	6th February 2015	

DRILLING DETAILS 3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method See Code 3
0	2	400	7
2	211	356	7

WATER BEARING ZONES 4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method See Code 4		D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
197	202	5	26.96									

CASING / LINER DETAILS 5

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
1	234	17	-1	197	5
1	234	17	203	209	5

Casing support method (See Code 5): 3

Type of casing bottom (See Code 5): 2

Centralisers installed (Yes/No): Yes (indicate on sketch)

Sump installed (Yes/No): Yes From 203 m To 209 m

Pressure cemented (Yes/No): No From m To m

Casing Protector cemented in place: YES

WATER ENTRY DESIGN 6

General Material Code 5	General OD (mm)	General Wall Thickness (mm)	General From (m)	General To (m)	General Opening type See Code 6	General Fixing See Code 5	Screen Aperture (mm)	Slot Details Length (mm)	Slot Details Width (mm)	Slot Details Alignment See Code 6
1	232	16	197	203	5	5		100	1.5	H

GRAVEL PACK 7

Type		Grade		Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded	X	Graded	X	3	5	0	211		30
Crushed		Ungraded							

Bentonite/Grout seal (Yes/No): Yes

Method of placement of Gravel Pack (See Code 7): 1

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Scientific and Technical Operating Procedures

Form: A Issue: 3 Date issued: 28Aug2009

Page 1 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 2

Work Licence No: 60WA583221

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No) Yes Name:

Method	Bailing/Surging	Jetting	Airlifting	Backwashing	Pumping	Other:
	[ ]	[ ]	[X]	[X]	[ ]	
Duration	hrs	hrs	31 hrs	1 hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery		
								Water level (m)	Time taken (hrs)	(mins)
Multi stage (stepped drawdown)	Stage 1	22/02/2015	117	26.75	3.8	42.2	2			
	Stage 2	22/02/2015	117	57.6	7	60.7	2			
	Stage 3	22/02/2015	117	71.3	10.5	85.64	2			
	Stage 4									
Single stage (constant rate)		23/02/2015	117	26.75	10.4	89.72	96	29.01	6	

Height of measuring point above ground level m Test Method See Code 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: m Is work partly backfilled: (Yes/No)

Is work abandoned: (Yes/No) Method of abandonment: Backfilled [ ] Plugged [ ] Capped [ ]

Has any casing been left in the work (Yes/No) From m To m

Sealing / fill type See Code 11	From depth (m)	To depth (m)	Sealing / fill type See Code 11	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist [ ] Geologist [ ] Driller [ ] Diviner [ ] Client [ ] Other [ ] 12

13

Lot No DP No

Work Location Co ordinates Easting 630078 Northing 6425635 Zone 54

GPS: (Yes/No) Yes >> AMG/AGD [X] or MGA/GDA [ ] (See explanation)

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: Alan Southwell **Licensee:**

Date: 6th February 2015 **Date:**

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 2 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 3

Work Licence No:

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY) — 15

Depth From (m)	Depth To (m)	Description (See Code 15)	WORK CONSTRUCTION SKETCH
0	6	Brown Silt	
6	11	Red Clay	
11	12	Brown Sandy Clay	
12	4	Brown Clay	
24	25	Brown Sandy Clay	
25	41	Red Clay	
41	42	Hard	
42	49	Yellow Sandstone	
49	64	Yellow / Brown Sandy Clay	
64	69	Grey Clay	
69	75	Grey Sandy Clay	
75	99	Grey / Brown Clayey Sand	
99	111	Grey Csandy Clay	
111	197	Grey Clay	
19	202	Sand	
202	217	Dsark Brown / Black Lignite	

WORK NOT CONSTRUCTED BY DRILLING RIG — 16

Method of excavation: Hand dug [ ] Back hoe [X] Dragline [ ] Dozer [ ] Other [ ]

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available — 17

Geologist log (Yes/No)	Yes	Laboratory analysis of water Sample (Yes/No)	Yes	Pumping test(s) (Yes/No)	No
Geophysical log (Yes/No)	Yes	Sieve analysis of aquifer material (Yes/No)	No	Installed Pump details (Yes/No)	No

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 3 of 4

MEN-2

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 1

Driller's Licence No:	2040	1
Class of Licence:	6	
Driller's Name:	Mathew Lazarou	
Assistant Driller:	Daniel Quintal	
Contractor:		
New bore	X	Replacement bore
Deepened		Enlarged
Reconditioned		Other (specify)
Final Depth	211 m	

Work Licence No:	60WA583221	2
Name of Licensee:	NSW Office of Water	
Intended Use:	Town Water	
Completion Date:	21st March 2015	

DRILLING DETAILS 3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method See Code 3
0	215	360	7

WATER BEARING ZONES 4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method See Code 4	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
195	209	14	28.3								

CASING / LINER DETAILS 5

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
6	250	12	0.5	24	1
1	234	17	24	193	5
1	234	17	205	211	5

Casing support method See Code 5: 3

Type of casing bottom See Code 5: 2

Centralisers installed (Yes/No)	Yes	(indicate on sketch)						
Sump installed (Yes/No)	Yes	From	205	m	To	211	m	
Pressure cemented (Yes/No)	No	From		m	To		m	
Casing Protector cemented in place	YES							

WATER ENTRY DESIGN 6

General Material Code 5	General OD (mm)	General Wall Thickness (mm)	General From (m)	General To (m)	General Opening type See Code 6	General Fixing See Code 5	Screen Aperture (mm)	Slot Details Length (mm)	Slot Details Width (mm)	Slot Details Alignment See Code 6
1	234	17	193	205	5	5		100	2.2	H

GRAVEL PACK 7

Type		Grade		Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded	X	Graded	X	1	3	160	215		8
Crushed		Ungraded	X	4	6	0	160		20
Bentonite/Grout seal (Yes/No)	Yes					121	125		
Method of placement of Gravel Pack				See Code 7	1				

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~~Scientific and Technical Operating Procedures~~

Form: A Issue: 3 Date issued: 28Aug2009

Page 1 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 2

Work Licence No: 60WA583221

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No) | Name:

Method	Bailing/Surging	Jetting	Airlifting	Backwashing	Pumping	Other:
			X			
Duration	hrs	hrs	10 hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1	25/03/2015	117	27.63	10.3	36.87	2			
	Stage 2	25/03/2015	117	36.87	15.6	42.73	2			
	Stage 3	25/03/2015	117	42.73	20.8	48.98	2	28.94	5	30
	Stage 4									
Single stage (constant rate)		26/03/2015	117	27.77	20.8	50.14	96	29.91	7	0

Height of measuring point above ground level: 1 m | Test Method: 5 | See Code 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: m | Is work partly backfilled: (Yes/No)

Is work abandoned: (Yes/No) | Method of abandonment: Backfilled | Plugged | Capped

Has any casing been left in the work (Yes/No) | From m To m

Sealing / fill type (See Code 11)	From depth (m)	To depth (m)	Sealing / fill type (See Code 11)	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist | Geologist | Driller | Diviner | Client | Other 12

13

Lot No | DP No

Work Location Co ordinates Easting 630083 Northing 6425635 Zone 54

GPS: (Yes/No) Yes >> AMG/AGD X or MGA/GDA (See explanation)

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: Mathew Lazarou **Licensee:** .....

Date: 21st March 2015 **Date:** .....

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 2 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 3

Work Licence No:

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY) — 15

Depth From (m)	Depth To (m)	Description (See Code 15)
0	3	Red Fine Sand
3	17	Fine Sand
17	19	White Silt and Sand Some Clay
19	21	Silt
21	26	Clay
26	34	Red / Brown Sand
34	38	Red / Brown Sandy Clay
38	53	Red / Brown Clay
53	55	Red / Brown Sandy Clay
55	83	Light Brown Clay
83	197	Grey Clay
197	210	Grey Coarse Sand
210	223	Black Lignite

WORK CONSTRUCTION SKETCH

WORK NOT CONSTRUCTED BY DRILLING RIG — 16

Method of excavation: Hand dug [ ] Back hoe [X] Dragline [ ] Dozer [ ] Other [ ]

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available — 17

Geologist log (Yes/No)	Yes	Laboratory analysis of water Sample (Yes/No)	Yes	Pumping test(s) (Yes/No)	No
Geophysical log (Yes/No)	Yes	Sieve analysis of aquifer material (Yes/No)	No	Installed Pump details (Yes/No)	No

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 3 of 4

MEN-2 Abandoned

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 1

Driller's Licence No:	2055	1
Class of Licence:	6	
Driller's Name:	Alan Southwell	
Assistant Driller:	Daniel Quintal	
Contractor:		
New bore		Replacement bore
Deepened		Enlarged
Reconditioned		Other (specify) X
Final Depth	214 m	Abandoned

Work Licence No:	60WA583221	2
Name of Licensee:	NSW Office of Water	
Intended Use:	Town Water	
Completion Date:	14th December 2014	

DRILLING DETAILS 3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method See Code 3
0	245	216	7
0	214	356	7

WATER BEARING ZONES 4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method See Code 4		D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
195	209	14	28.3									

CASING / LINER DETAILS 5

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
6	250	10	0	196	1
6	250	10	208	214	1

Casing support method See Code 5: 3

Type of casing bottom See Code 5: 2

Centralisers installed (Yes/No): No (indicate on sketch)

Sump installed (Yes/No): No From 208 m To 214 m

Pressure cemented (Yes/No): No From m To m

Casing Protector cemented in place: YES

WATER ENTRY DESIGN 6

General Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Opening type See Code 6	Fixing See Code 5	Screen Aperture (mm)	Slot Details Length (mm)	Width (mm)	Alignment See Code 6
6	250	10	196	208	5	1	1	80	1	H

GRAVEL PACK 7

Type		Grade		Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded	X	Graded	X	1	3	125	245		20
Crushed		Ungraded				40	121		
Bentonite/Grout seal (Yes/No)						121	125		
Method of placement of Gravel Pack		See Code 7							

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Scientific and Technical Operating Procedures

Form: A Issue: 3 Date issued: 28Aug2009

Page 1 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 2

Work Licence No: 60WA583221

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No) | Name:

Method	Bailing/Surging	Jetting	Airlifting	Backwashing	Pumping	Other:
			X			
Duration	hrs	hrs	10 hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1	25/03/2015	117	27.63	10.3	36.87	2			
	Stage 2	25/03/2015	117	36.87	15.6	42.73	2			
	Stage 3	25/03/2015	117	42.73	20.8	48.98	2	28.94	5	30
	Stage 4									
Single stage (constant rate)		26/03/2015	117	27.77	20.8	50.14	96	29.91	7	0

Height of measuring point above ground level: 1 m | Test Method: 5 | See Code 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: m | Is work partly backfilled: (Yes/No)

Is work abandoned: (Yes/No) | Method of abandonment: Backfilled | Plugged | Capped

Has any casing been left in the work (Yes/No) | From m To m

Sealing / fill type See Code 11	From depth (m)	To depth (m)	Sealing / fill type See Code 11	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist | Geologist | Driller | Diviner | Client | Other 12

13

Lot No | DP No

Work Location Co ordinates Easting 630083 Northing 6425635 Zone 54

GPS: (Yes/No) Yes >> AMG/AGD X or MGA/GDA (See explanation)

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: Mathew Lazarou **Licensee:** .....

Date: 21st March 2015 **Date:** .....

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 2 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 3

Work Licence No:

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY) — 15

Depth From (m)	Depth To (m)	Description (See Code 15)	WORK CONSTRUCTION SKETCH
0	3	Red Fine Sand	
3	17	Fine Sand	
17	19	White Silt and Sand Some Clay	
19	21	Silt	
21	26	Clay	
26	34	Red / Brown Sand	
34	38	Red / Brown Sandy Clay	
38	53	Red / Brown Clay	
53	55	Red / Brown Sandy Clay	
55	83	Light Brown Clay	
83	197	Grey Clay	
197	210	Grey Coarse Clay	
210	223	Black Lignite	
223	245	Grey Clay	

WORK NOT CONSTRUCTED BY DRILLING RIG — 16

Method of excavation: Hand dug [ ] Back hoe [X] Dragline [ ] Dozer [ ] Other [ ]

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available — 17

Geologist log (Yes/No)	Yes	Laboratory analysis of water Sample (Yes/No)	Yes	Pumping test(s) (Yes/No)	No
Geophysical log (Yes/No)	Yes	Sieve analysis of aquifer material (Yes/No)	No	Installed Pump details (Yes/No)	No

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 3 of 4

MEN-6

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 1

Driller's Licence No:	2040	1	
Class of Licence:	6		
Driller's Name:	Mathew Lazarou		
Assistant Driller:	Daniel Quintal		
Contractor:			
New bore	X	Replacement bore	
Deepened		Enlarged	
Reconditioned		Other (specify)	
Final Depth	210.5 m		

Work Licence No:	60WA583221	2	
Name of Licensee:	NSW Office of Water		
Intended Use:	Town Water		
Completion Date:	29th March 2015		

DRILLING DETAILS 3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method (See Code 3)
0	215.5	360	7

WATER BEARING ZONES 4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method (See Code 4)		D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
192.5	204.5	12	28	20								

CASING / LINER DETAILS 5

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
6	250	12	-0.5	192.5	1
6	250	12	204.5	210.5	1

Casing support method (See Code 5): 3

Type of casing bottom (See Code 5): 2

Centralisers installed (Yes/No): Yes (indicate on sketch)

Sump installed (Yes/No): Yes From 204.5 m To 211 m

Pressure cemented (Yes/No): Yes From 0 m To m

Casing Protector cemented in place: YES

WATER ENTRY DESIGN 6

General Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Opening type (See Code 6)	Fixing (See Code 5)	Screen Aperture (mm)	Slot Details Length (mm)	Width (mm)	Alignment (See Code 6)
6	250	12	192.5	204.5	5	1		100	2.5	H

GRAVEL PACK 7

Type		Grade		Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded	X	Graded	X	3	5	160	215		8
Crushed		Ungraded	X	7	10	0	160		15
Bentonite/Grout seal (Yes/No)	Yes					120	124	80	
Method of placement of Gravel Pack (See Code 7)	1								

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Scientific and Technical Operating Procedures

Form: A Issue: 3 Date issued: 28Aug2009

Page 1 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 2

Work Licence No: 60WA583221

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No) No Name:

Method	Bailing/Surging	Jetting	Airlifting	Backwashing	Pumping	Other:
			X			
Duration	hrs	hrs	10 hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1	23/04/2015	117	29.24	12.3	38.15	2			
	Stage 2	23/04/2015	117	38.15	16.4	42.41	2			
	Stage 3	23/04/2015	117	42.41	20.9	48.03	2	29.68		15
	Stage 4									
Single stage (constant rate)		24/04/2015	117	48.97	20.9	48.97	96	30.85	9	

Height of measuring point above ground level 1 m Test Method 5 See Code 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: m Is work partly backfilled: (Yes/No)

Is work abandoned: (Yes/No) Method of abandonment: Backfilled Plugged Capped

Has any casing been left in the work (Yes/No) From m To m

Sealing / fill type See Code 11	From depth (m)	To depth (m)	Sealing / fill type See Code 11	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist Geologist Driller Diviner Client Other 12

13

Lot No DP No

Work Location Co ordinates Easting 631391 Northing 6242131 Zone 54

GPS: (Yes/No) Yes >> AMG/AGD X or MGA/GDA (See explanation)

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: Mathew Lazarou **Licensee:** .....

Date: 29th March 2015 **Date:** .....

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 2 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 3

Work Licence No:

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY) — 15

Depth From (m)	Depth To (m)	Description (See Code 15)	WORK CONSTRUCTION SKETCH
0	4	Top Soil Red Clayey Sand	
4	9	White / Brown Sandy Clay	
9	35	Orange / White Clay	
35	47	Red / Brown Clay	
47	72	Red / Grey Clay	
72	82	Grey Clay Sandy / Silty	
82	192	White / Grey Clay Sandy	
192	204	Medium / Course Sand 60% Quartz	
204	214	Grey Clay Puggy	
214	215.5	Lignite	

WORK NOT CONSTRUCTED BY DRILLING RIG — 16

Method of excavation: Hand dug [ ] Back hoe [X] Dragline [ ] Dozer [ ] Other [ ]

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available — 17

Geologist log (Yes/No)	Yes	Laboratory analysis of water Sample (Yes/No)	Yes	Pumping test(s) (Yes/No)	No
Geophysical log (Yes/No)	Yes	Sieve analysis of aquifer material (Yes/No)	No	Installed Pump details (Yes/No)	No

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 3 of 4

MEN-9

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 1

Driller's Licence No:	2075	1
Class of Licence:	2	
Driller's Name:	John Brien	
Assistant Driller:	Harrison Mcmahon	
Contractor:		
New bore	X	Replacement bore
Deepened		Enlarged
Reconditioned		Other (specify)
Final Depth	220 m	

Work Licence No:	60WA583221	2
Name of Licensee:	NSW Office of Water	
Intended Use:	Town Water	
Completion Date:	1st April 2015	

DRILLING DETAILS 3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method See Code 3
0	2	400	5
2	220	370	7

WATER BEARING ZONES 4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method See Code 4		D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
176	191	15	28.11									

CASING / LINER DETAILS 5

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
6	250	12	-1	176	1
6	250	12	191	209	1

Casing support method — See Code 5

Type of casing bottom — See Code 5

Centralisers installed (Yes/No) Yes (indicate on sketch)

Sump installed (Yes/No) Yes From 191 m To 209 m

Pressure cemented (Yes/No) Yes From 0 m To m

Casing Protector cemented in place YES

WATER ENTRY DESIGN 6

General Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Opening type See Code 6	Fixing See Code 5	Screen Aperture (mm)	Slot Details Length (mm)	Width (mm)	Alignment See Code 6
6	250	12	176	179	5	1		100	2.2	H
6	250	12	179	191	5	1		100	2.5	H

GRAVEL PACK 7

Type		Grade		Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded	X	Graded	X	3	6	0	98		25
Crushed		Ungraded	X			100	220		8
Bentonite/Grout seal (Yes/No)		Yes				98	100		
Method of placement of Gravel Pack		See Code 7		1					

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Scientific and Technical Operating Procedures

Form: A Issue: 3 Date issued: 28Aug2009

Page 1 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 2

Work Licence No: 60WA583221

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No) No Name:

Method	Bailing/Surging	Jetting	Airlifting	Backwashing	Pumping	Other:
			X			
Duration	hrs	hrs	12 hrs	hrs	hrs	hrs

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1	16/04/2015	117	28.1	12.5	35.79	2			
	Stage 2	16/04/2015	117	35.79	16.8	39.3	2			
	Stage 3	16/04/2015	117	39.3	21.4	43.69	2	28.39	1	30
	Stage 4									
Single stage (constant rate)		17/04/2015	117	28.11	21.2	45.28	96	30.64	5	

Height of measuring point above ground level 1 m Test Method 5 See Code 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: m Is work partly backfilled: (Yes/No)

Is work abandoned: (Yes/No) Method of abandonment: Backfilled Plugged Capped

Has any casing been left in the work (Yes/No) From m To m

Sealing / fill type (See Code 11)	From depth (m)	To depth (m)	Sealing / fill type (See Code 11)	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist Geologist Driller Diviner Client Other 12

13

Lot No DP No

Work Location Co ordinates Easting 631420 Northing 6424114 Zone 54

GPS: (Yes/No) Yes >> AMG/AGD X or MGA/GDA (See explanation)

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: John Brien **Licensee:**

Date: 1st April 2015 **Date:**

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 2 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 3

Work Licence No:

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY)			15
Depth		Description	WORK CONSTRUCTION SKETCH
From (m)	To (m)	See Code 15	
0	2	Red Sand	
2	13	Orange Sandy Clay	
13	43	Grey / Brown Sandy Clay	
43	75	Orange Sandy Clay	
75	86	Grey / Brown Sandy Clay	
86	91	Brown Sand	
91	112	Brown Sandy Clay	
112	164	Orange Clayey Sand	
164	182	Grey Sand	
182	193	Grey Clay	
193	212	Grey Sand	
212	220	Black Lignite	

WORK NOT CONSTRUCTED BY DRILLING RIG — 16

Method of excavation: Hand dug [ ] Back hoe [X] Dragline [ ] Dozer [ ] Other [ ]

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available — 17

Geologist log	(Yes/No) Yes	Laboratory analysis of water Sample	(Yes/No) Yes	Pumping test(s)	(Yes/No) No
Geophysical log	(Yes/No) Yes	Sieve analysis of aquifer material	(Yes/No) No	Installed Pump details	(Yes/No) No

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 3 of 4

MEN-11

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 1

Driller's Licence No:	1679	1
Class of Licence:	6	
Driller's Name:	Michael Wilson	
Assistant Driller:	Daniel Quintal	
Contractor:		
New bore	X	
Deepened		
Reconditioned		
Replacement bore		
Enlarged		
Other (specify)		
Final Depth	221 m	

Work Licence No:	60WA583221	2
Name of Licensee:	NSW Office of Water	
Intended Use:	Town Water	
Completion Date:	5th March 2015	

DRILLING DETAILS 3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method See Code 3
0	2	400	7
2	221	356	7

WATER BEARING ZONES 4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method See Code 4		D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
194	203	9	29.72			9	B					
204	212	8										

CASING / LINER DETAILS 5

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
1	234	17	0	194	5
1	234	17	212	218	5

Casing support method See Code 5: 3

Type of casing bottom See Code 5: 2

Centralisers installed (Yes/No): Yes (indicate on sketch)

Sump installed (Yes/No): Yes From 212 m To 218 m

Pressure cemented (Yes/No): Yes From m To m

Casing Protector cemented in place: YES

WATER ENTRY DESIGN 6

General Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Opening type See Code 6	Fixing See Code 5	Screen Aperture (mm)	Slot Details Length (mm)	Width (mm)	Alignment See Code 6
1	234	17	194	212	5	5		100	2.2	H

GRAVEL PACK 7

Type	Grade	Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded	Graded	5	7	0	100		15
Crushed	Ungraded	3	5	102	221		15
				100	102		

Bentonite/Grout seal (Yes/No): Yes

Method of placement of Gravel Pack: See Code 7: 1

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Scientific and Technical Operating Procedures

Form: A Issue: 3 Date issued: 28Aug2009

Page 1 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 2

Work Licence No: 60WA583221

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No)		Name:											
Method	Bailing/Surging		Jetting		Airlifting	X	Backwashing	X	Pumping		Other:		
Duration		hrs		hrs	8	hrs	2	hrs		hrs		hrs	

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery		
								Water level (m)	Time taken (hrs)	(mins)
Multi stage (stepped drawdown)	Stage 1	19/03/2015	117	29.67	6.1	31.71	2			
	Stage 2	19/03/2015	117	31.71	11.6	34.19	2			
	Stage 3	19/03/2015	117	34.19	21.6	39.01	2	30.79	1	
	Stage 4									
Single stage (constant rate)		20/03/2015	117	29.72	21.7	40.5	96	30.04	6	

Height of measuring point above ground level: 1 m — Test Method: 5 — See Code 4

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: m — Is work partly backfilled: (Yes/No)

Is work abandoned: (Yes/No) — Method of abandonment: Backfilled Plugged Capped

Has any casing been left in the work (Yes/No) — From m To m

Sealing / fill type See Code 11	From depth (m)	To depth (m)	Sealing / fill type See Code 11	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist Geologist Driller Diviner Client Other 12

13

Lot No DP No

Work Location Co ordinates Easting 627755 Northing 6427995 Zone 54

GPS: (Yes/No) Yes >> AMG/AGD X or MGA/GDA (See explanation)

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: Michael Wilson ..... **Licensee:** .....

Date: ..... **Date:** .....

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 2 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 3

Work Licence No:

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY) — 15

Depth From (m)	Depth To (m)	Description (See Code 15)	WORK CONSTRUCTION SKETCH
0	11	Brown Top Soil	
11	32	Light Grey Clay	
32	40	Red Clay	
40	55	Yellow / Brown Sandy Clay	
55	170	Red Clay	
170	173	Grey Sand	
173	194	Light Blue / Grey Sandy Clay	
194	213	Grey Sand	
213	221	Grey Lignite	

WORK NOT CONSTRUCTED BY DRILLING RIG — 16

Method of excavation: Hand dug [ ] Back hoe [X] Dragline [ ] Dozer [ ] Other [ ]

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

Please attach copies of the following if available — 17

Geologist log	(Yes/No) Yes	Laboratory analysis of water Sample	(Yes/No) Yes	Pumping test(s)	(Yes/No) No
Geophysical log	(Yes/No) Yes	Sieve analysis of aquifer material	(Yes/No) No	Installed Pump details	(Yes/No) No

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 3 of 4

MEN-17

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 1

Driller's Licence No:	1679	1
Class of Licence:	6	
Driller's Name:	Michael Wilson	
Assistant Driller:	Daniel Quintal	
Contractor:		
New bore	X	Replacement bore
Deepened		Enlarged
Reconditioned		Other (specify)
Final Depth	202 m	

Work Licence No:	60WA583221	2
Name of Licensee:	NSW Office of Water	
Intended Use:	Town Water	
Completion Date:	20th April 2015	

DRILLING DETAILS 3

From (m)	To (m)	Hole Diameter (mm)	Drilling Method See Code 3
0	2	311	7
2	202	216	7

WATER BEARING ZONES 4

From (m)	To (m)	Thickness (m)	S W L (m)	Estimated Yield (L/s) Individual Aquifer	Estimated Yield (L/s) Cumulative	Test method See Code 4	D D L at end of test (m)	Duration Hrs	Duration min	Salinity (Conductivity or TDS) Cond (µS/cm)	Salinity (Conductivity or TDS) TDS (mg/L)
50	81	31				1					

CASING / LINER DETAILS 5

Material Code 5	OD (mm)	Wall Thickness (mm)	From (m)	To (m)	Method Fixing Code 5
1	80	6	0	70	5
1	80	6	76	202	5

Casing support method — See Code 5: 3

Type of casing bottom — See Code 5: 2

Centralisers installed (Yes/No): Yes (indicate on sketch)

Sump installed (Yes/No): Yes — From 76 m To 202 m

Pressure cemented (Yes/No): Yes — From m To m

Casing Protector cemented in place: YES

WATER ENTRY DESIGN 6

General Material Code 5	General OD (mm)	General Wall Thickness (mm)	General From (m)	General To (m)	General Opening type See Code 6	General Fixing See Code 5	Screen Aperture (mm)	Slot Details Length (mm)	Slot Details Width (mm)	Slot Details Alignment See Code 6
1	80	6	70	76	5	5		100	2	H

GRAVEL PACK 7

Type		Grade		Grain size (mm) From	Grain size (mm) To	Depth (m) From	Depth (m) To	Quantity Litres	Quantity m^3
Rounded		Graded		3	5				9
Crushed		Ungraded							

Bentonite/Grout seal (Yes/No):

Method of placement of Gravel Pack — See Code 7:

For Departmental use only: GW 27332 3

Scientific and Technical Operating Procedures

Form: A Issue: 3 Date issued: 28Aug2009

Page 1 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 2

Work Licence No: 60WA583221

BORE DEVELOPMENT 8

Chemical used for breaking down drilling mud (Yes/No) [ ] Name: [ ]

Method	Bailing/Surging	Jetting	Airlifting	Backwashing	Pumping	Other:
	[ ]	[ ]	[X]	[X]	[ ]	[ ]
Duration	[ ] hrs	[ ] hrs	10 hrs	2 hrs	[ ] hrs	[ ] hrs

DISINFECTION ON COMPLETION 9

Chemical(s) used	Quantity applied (Litres)	Method of application

PUMPING TESTS ON COMPLETION 10

Test type		Date	Pump intake depth (m)	Initial Water Level (SWL) (m)	Pumping rate (L/s)	Water Level at end of pumping (DDL) (m)	Duration of Test (hrs)	Recovery: Water level (m)	Recovery: Time taken (hrs)	Recovery: Time taken (mins)
Multi stage (stepped drawdown)	Stage 1									
	Stage 2									
	Stage 3									
	Stage 4									
Single stage (constant rate)										

Height of measuring point above ground level [ ] m Test Method [ ] See Code 4 [ ]

WORK PARTLY BACKFILLED OR ABANDONED 11

Original depth of work: [ ] m Is work partly backfilled: (Yes/No) [ ]

Is work abandoned: (Yes/No) [ ] Method of abandonment: Backfilled [ ] Plugged [ ] Capped [ ]

Has any casing been left in the work (Yes/No) [ ] From [ ] m To [ ] m

Sealing / fill type (See Code 11)	From depth (m)	To depth (m)	Sealing / fill type (See Code 11)	From depth (m)	To depth (m)

Site chosen by: Hydrogeologist [ ] Geologist [ ] Driller [ ] Diviner [ ] Client [ ] Other [ ] 12

13

Lot No [ ] DP No [ ]

Work Location Co ordinates Easting 627755 Northing 6427995 Zone 54

GPS: (Yes/No) Yes >> AMG/AGD [X] or MGA/GDA [ ] (See explanation)

Please mark the work site with "X" on the CLID provided map.

Indicate also the distances in metres from two (2) adjacent boundaries, and attach the map to this Form A package.

Signatures:

Driller: Michael Wilson ..... **Licensee:** .....

Date: 21st May 2015 ..... **Date:** .....

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 2 of 4

NSW GOVERNMENT Office of Water

Form A Particulars of completed work

Page 3

Work Licence No:

DRILLER'S ROCK/STRATA DESCRIPTION (LITHOLOGY) — 15

Depth From (m)	Depth To (m)	Description (See Code 15)	WORK CONSTRUCTION SKETCH
0	7	Brown Top Soil	
7	12	Orange Sandy Clay	
12	32	White Clay	
32	49	Red Sandy Clay	
52	81	Grey / Brown Sand	
81	90	Grey / Blue Clay	
90	202	Light Blue Clay	

WORK NOT CONSTRUCTED BY DRILLING RIG — 16

Method of excavation: Hand dug [ ] Back hoe [X] Dragline [ ] Dozer [ ] Other [ ]

Depth (m)	Length (m)	Width (m)	Diameter (m)	Lining material	Dimentions of liner (m)	From Depth (m)	To Depth (m)

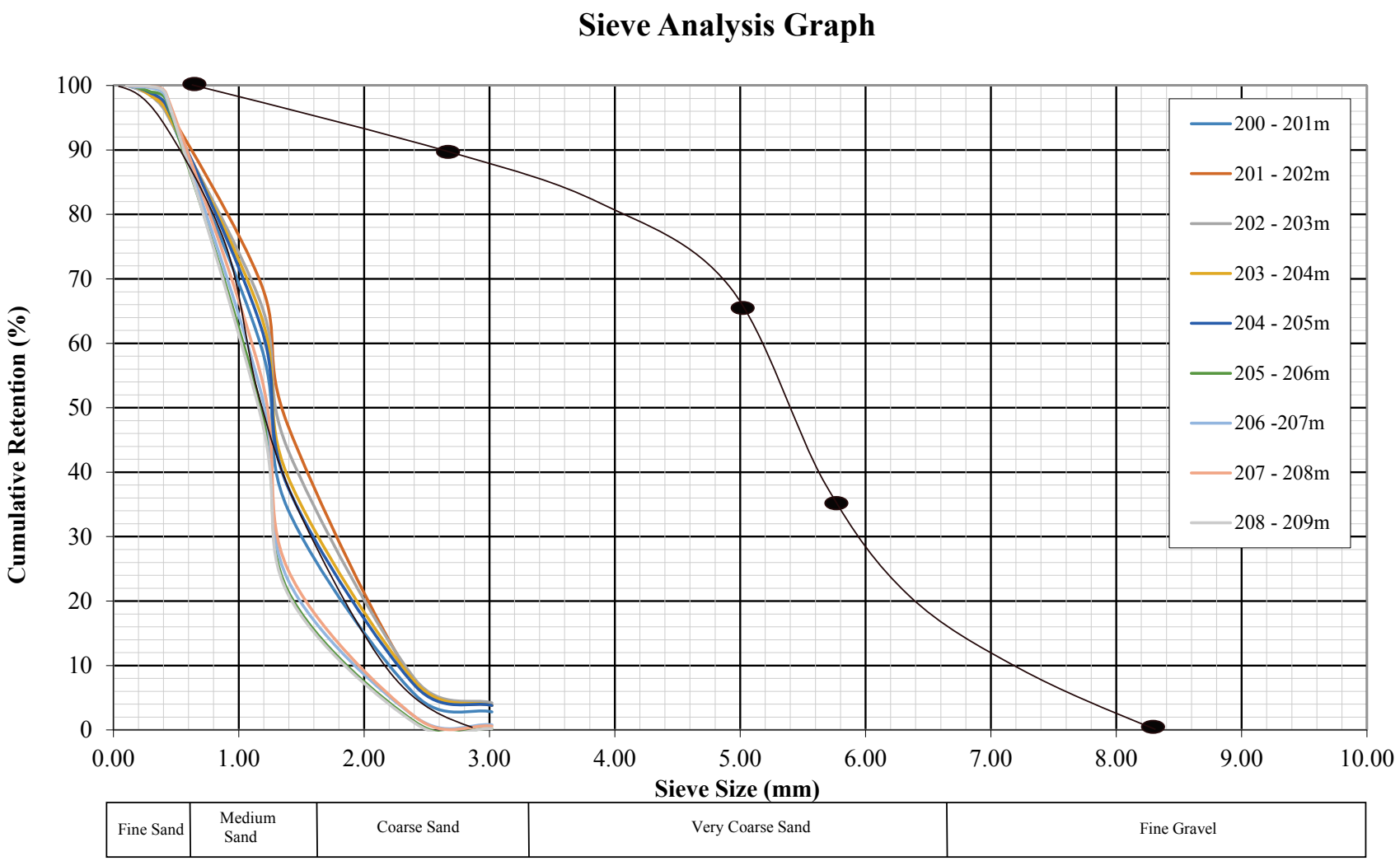
Please attach copies of the following if available — 17

Geologist log (Yes/No)	Yes	Laboratory analysis of water Sample (Yes/No)	Yes	Pumping test(s) (Yes/No)	No
Geophysical log (Yes/No)	Yes	Sieve analysis of aquifer material (Yes/No)	No	Installed Pump details (Yes/No)	No

Scientific and Technical Operating Procedures
Form: A Issue: 3 Date issued: 28Aug2009

Page 3 of 4

Appendix 2 – Sieve analysis



Appendix 3 – Chip tray photographs

Chip photography

MEN-1

0 – 20m

20 – 40m

40 – 60m

60 – 80m

80 – 100m

100 – 120m

120 – 140m

140 – 160m

160 – 180m

180 – 200m

200 – 217m End of Hole

MEN-2

0 – 20m

20 – 40m

40 – 60m

60 – 80m

80 – 100m

100 – 120m

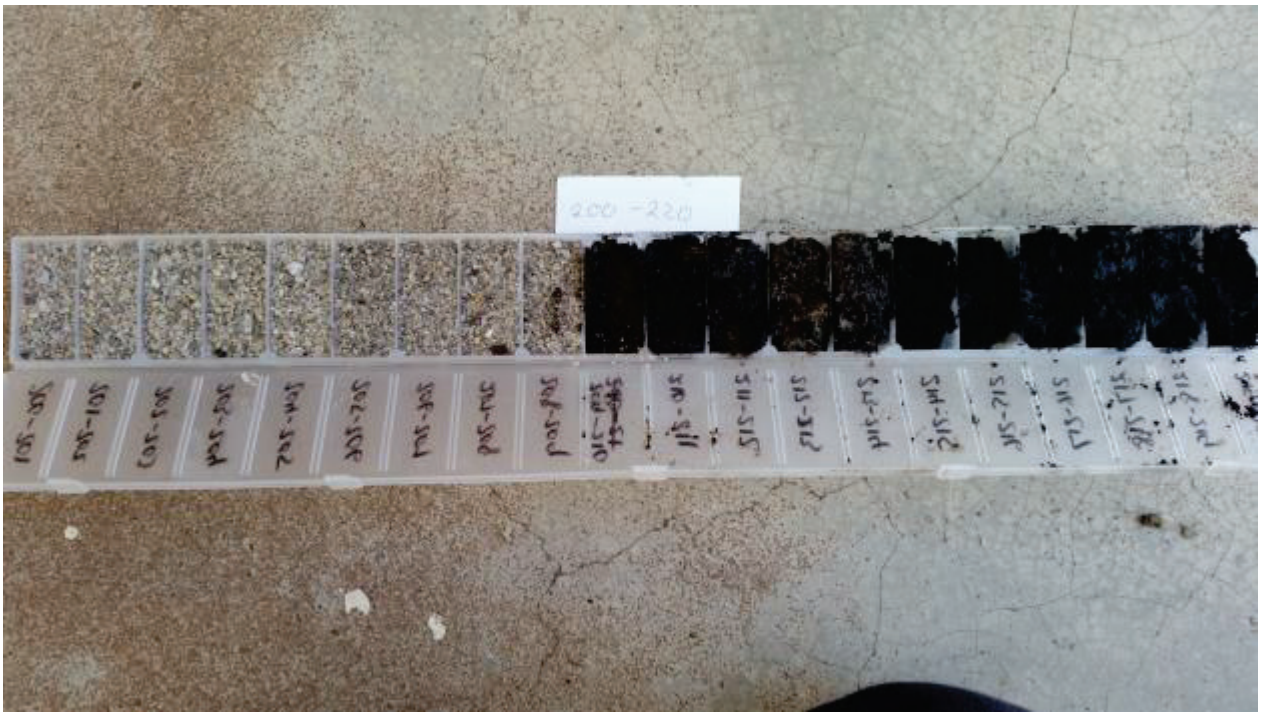
120 – 140m

140 – 160m

160 – 180m

180 – 200m

200 – 220m



220 – 240m

240 – 245m End of Hole

MEN-6

0 – 20m

20 – 40m

40 – 60m

60 – 80m

80 – 100m

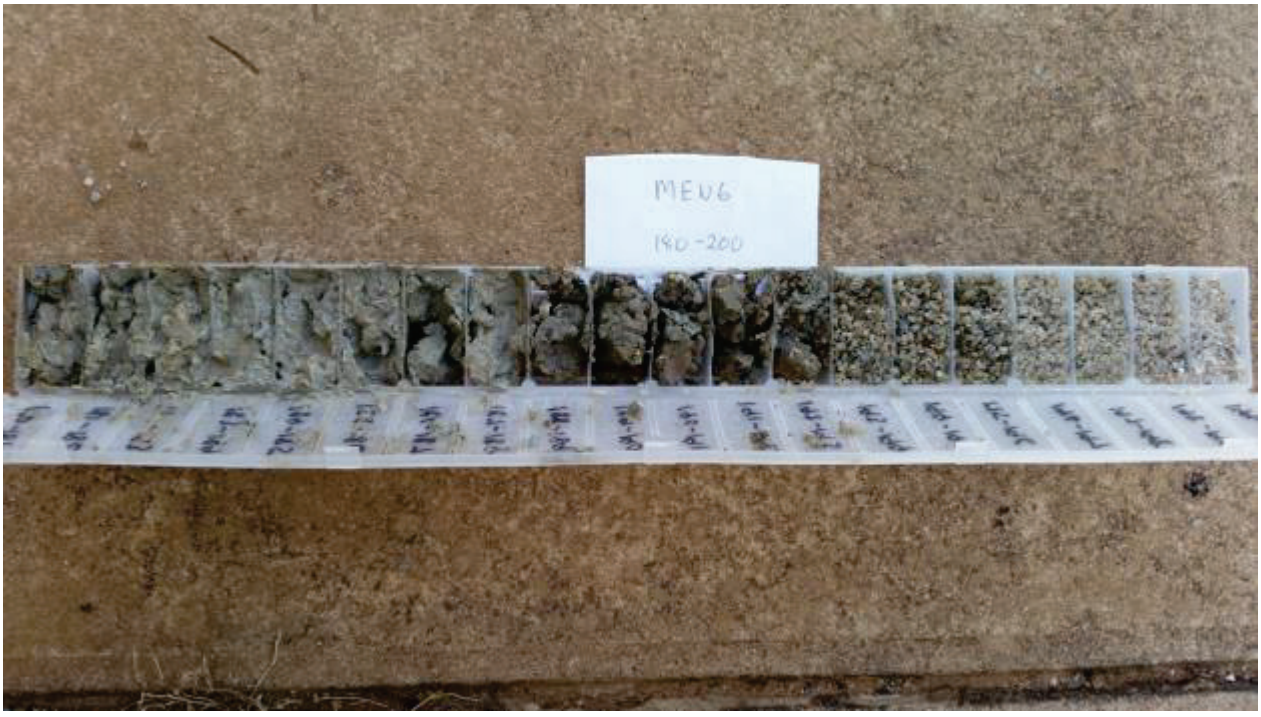
100 – 120m

120 – 140m

140 – 160m

160 – 180m

180 – 200m



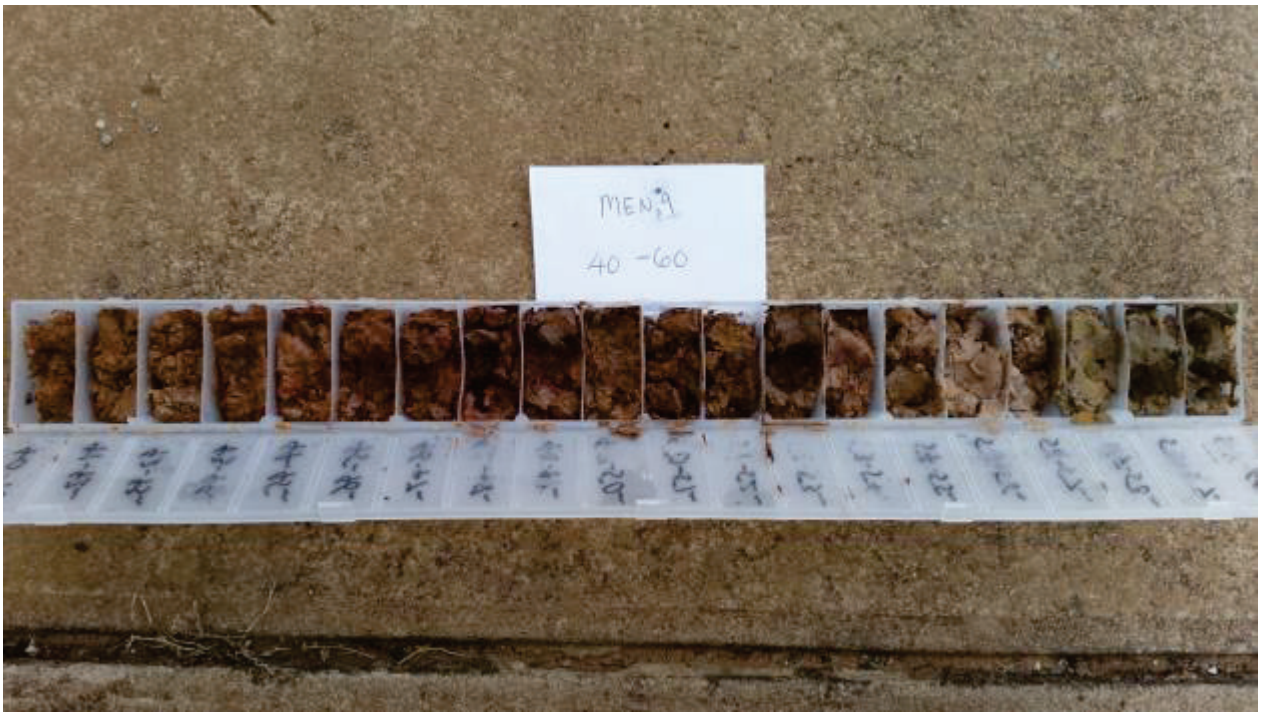
200 – 215m End of Hole

MEN-9

0 – 20m

20 – 40m

40 – 60m



60 – 80m

80 – 100m

100 – 120m

120 – 140m

140 – 160m

160 – 180m

180 – 200m

200 – 220m End of Hole

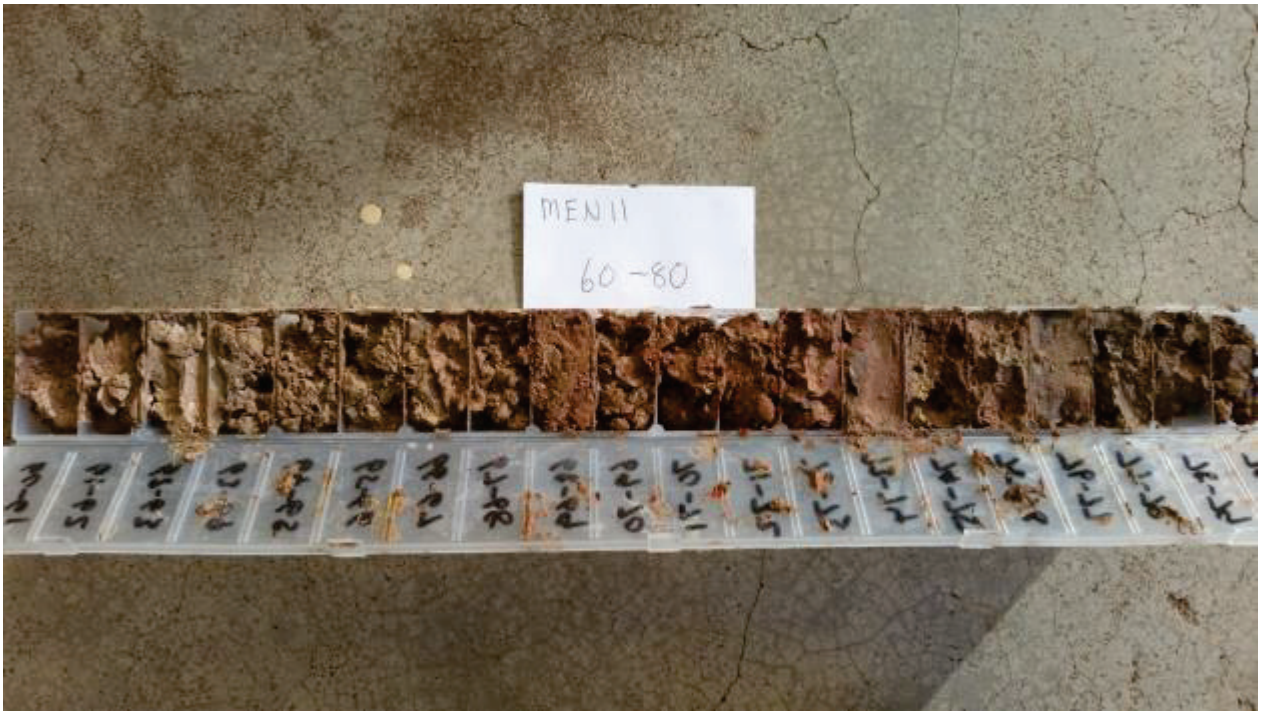
MEN-11

0 – 20m

20 – 40m

40 – 60m

60 – 80m



80 – 100m

100 – 120m

120 -140m

140 -160m

160 – 180m

180 – 200m

200 -220m

MEN-17

0 – 20m

20 – 40m

40 – 60m

60 – 80m

80 – 100m

100 – 120m

120 – 140m

140 – 160m

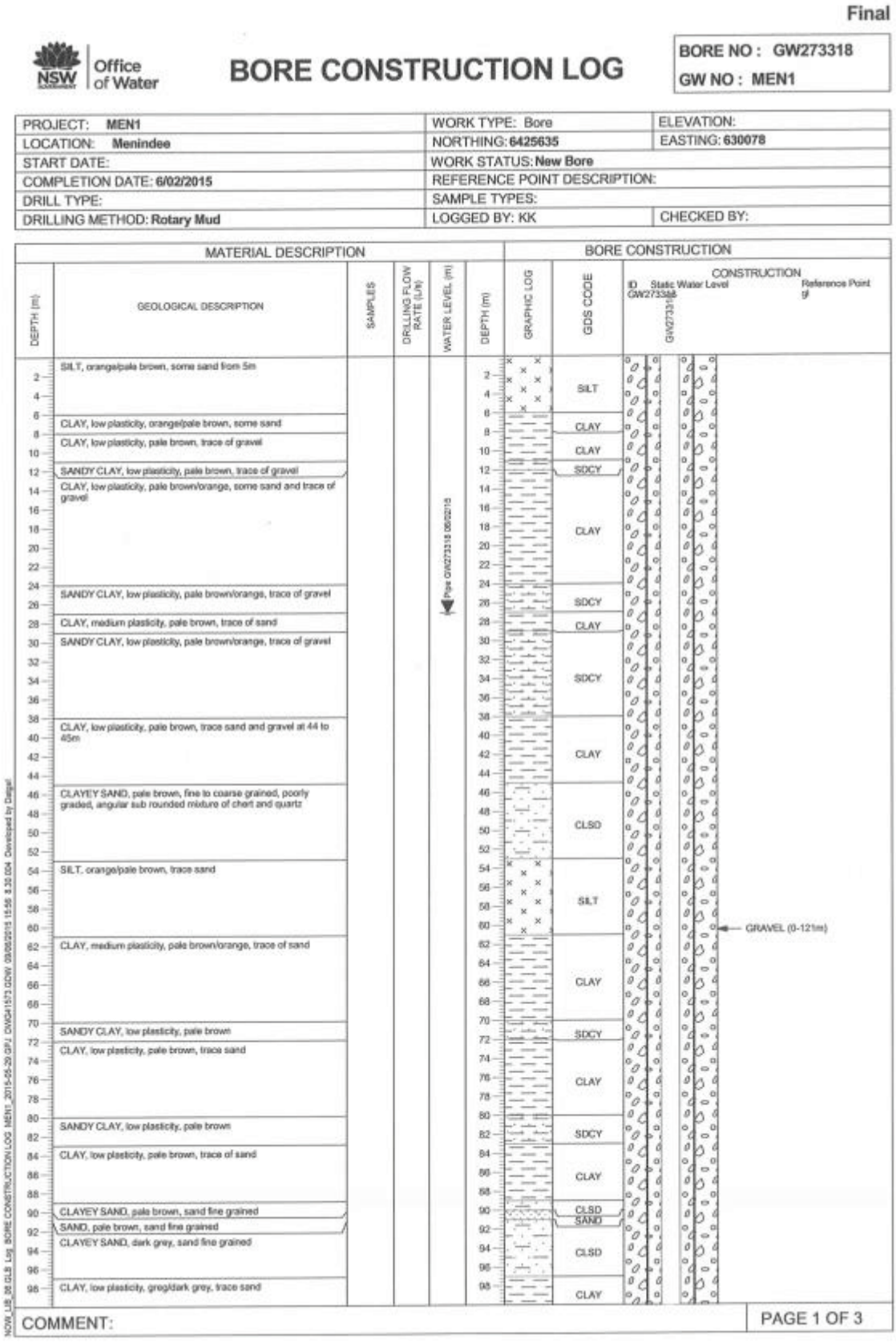
160 – 180m

160 – 180m

180 – 200m End of Hole

Appendix 4 – Lithological logs

MEN-1



Final

NSW Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273318
GW NO : MEN1

PROJECT: MEN1	WORK TYPE: Bore	ELEVATION:
LOCATION: Menindee	NORTHING: 6425635	EASTING: 630078
START DATE:	WORK STATUS: New Bore	
COMPLETION DATE: 6/02/2015	REFERENCE POINT DESCRIPTION:	
DRILL TYPE:	SAMPLE TYPES:	
DRILLING METHOD: Rotary Mud	LOGGED BY: KK	CHECKED BY:

MATERIAL DESCRIPTION

DEPTH (m)	GEOLOGICAL DESCRIPTION	SAMPLES	DRILLING FLOW RATE (L/s)	WATER LEVEL (m)
0–2	SILT, orange/pale brown, some sand from 5m			
2–8	CLAY, low plasticity, orange/pale brown, some sand			
8–10	CLAY, low plasticity, pale brown, trace of gravel			
10–12	SANDY CLAY, low plasticity, pale brown, trace of gravel			
12–24	CLAY, low plasticity, pale brown/orange, some sand and trace of gravel			
24–28	SANDY CLAY, low plasticity, pale brown/orange, trace of gravel			
28–30	CLAY, medium plasticity, pale brown, trace of sand			
30–38	SANDY CLAY, low plasticity, pale brown/orange, trace of gravel			
38–46	CLAY, low plasticity, pale brown, trace sand and gravel at 44 to 45m			
46–54	CLAYEY SAND, pale brown, fine to coarse grained, poorly graded, angular sub rounded mixture of chert and quartz			
54–62	SILT, orange/pale brown, trace sand			
62–70	CLAY, medium plasticity, pale brown/orange, trace of sand			
70–72	SANDY CLAY, low plasticity, pale brown			
72–82	CLAY, low plasticity, pale brown, trace sand			
82–90	SANDY CLAY, low plasticity, pale brown			
90–92	CLAY, low plasticity, pale brown, trace of sand			
92–94	CLAYEY SAND, pale brown, sand fine grained			
94–96	SAND, pale brown, sand fine grained			
96–98	CLAYEY SAND, dark grey, sand fine grained			
98–100	CLAY, low plasticity, grey/dark grey, trace sand			

BORE CONSTRUCTION

DEPTH (m)	GRAPHIC LOG	GDS CODE
0–2		SILT
2–8		CLAY
8–10		CLAY
10–12		SDCY
12–24		CLAY
24–28		SDCY
28–30		CLAY
30–38		SDCY
38–46		CLAY
46–54		CLSD
54–62		SILT
62–70		CLAY
70–72		SDCY
72–82		CLAY
82–90		SDCY
90–92		CLAY
92–94		CLSD
94–96		SAND
96–98		CLSD
98–100		CLAY

CONSTRUCTION

ID GW273318 — Static Water Level — Reference Point gl

GRAVEL (0-121m)

Pipe GW273318 06/02/15

COMMENT:

PAGE 1 OF 3

Final

NSW Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273318
GW NO : MEN1

PROJECT: **MEN1**	WORK TYPE: Bore	ELEVATION:
LOCATION: **Menindee**	NORTHING: **6425635**	EASTING: **630078**
START DATE:	WORK STATUS: **New Bore**	
COMPLETION DATE: **6/02/2015**	REFERENCE POINT DESCRIPTION:	
DRILL TYPE:	SAMPLE TYPES:	
DRILLING METHOD: **Rotary Mud**	LOGGED BY: KK	CHECKED BY:

MATERIAL DESCRIPTION

DEPTH (m)	GEOLOGICAL DESCRIPTION
102	CLAY, low plasticity, grey/dark grey, trace sand
104	CLAYEY SAND, grey to dark grey, sand fine grained
108	
108	SANDY CLAY, low plasticity, grey
110	
112	CLAY, low plasticity, grey, trace sand, grey/black organics 178-180 and 190-197
198	SAND, grey, medium to coarse grained (10% ,1mm,80% 1-2mm, 30%>2mm)

SAMPLES | DRILLING FLOW RATE (L/s) | WATER LEVEL (m)

BORE CONSTRUCTION

DEPTH (m) | GRAPHIC LOG | GDS CODE

CLAY
CLSD
SDCY
CLAY
SAND

CONSTRUCTION
ID GW273318 | Static Water Level | Reference Point gl

BENTONITE (121-125m)
GRAVEL (125-217m)

COMMENT:

PAGE 2 OF 3

Final

NSW Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273318
GW NO : MEN1

PROJECT: **MEN1**	WORK TYPE: Bore	ELEVATION:
LOCATION: **Menindee**	NORTHING: **6425635**	EASTING: **630078**
START DATE:	WORK STATUS: **New Bore**	
COMPLETION DATE: **6/02/2015**	REFERENCE POINT DESCRIPTION:	
DRILL TYPE:	SAMPLE TYPES:	
DRILLING METHOD: **Rotary Mud**	LOGGED BY: KK	CHECKED BY:

MATERIAL DESCRIPTION					BORE CONSTRUCTION		
DEPTH (m)	GEOLOGICAL DESCRIPTION	SAMPLES	DRILLING FLOW RATE (L/s)	WATER LEVEL (m)	GRAPHIC LOG	GDS CODE	CONSTRUCTION ID GW273318 Static Water Level Reference Point gl
202						SAND	
204	SANDY CLAY, low plasticity, dark grey					SDCY	
206							
208	CLAY, black, 40% lignite					CLAY	
210							
212							
214							
216							
218	Bottom of hole at 217.00m						
220							
222							
224							
226							
228							
230							
232							
234							
236							
238							
240							
242							
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256							
258							
260							
262							
264							
266							
268							
270							
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284							
286							
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290							
292							
294							
296							
298							

COMMENT:

PAGE 3 OF 3

WON_LIB_06.GLB Log: BORE CONSTRUCTION LOG MEN1 2015-09-29.GPJ DWG#1573.DGN 09/06/2015 15:59 8.30.004 Developed by Datgel

MEN-2

Final

NSW Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273319
GW NO : MEN2

PROJECT: MEN2	WORK TYPE: Bore	ELEVATION:
LOCATION: Menindee	NORTHING: 6300078	EASTING: 6425635
START DATE:	WORK STATUS: New Bore	
COMPLETION DATE: 21/03/2015	REFERENCE POINT DESCRIPTION:	
DRILL TYPE: Rotary Mud	SAMPLE TYPES:	
DRILLING METHOD: Rotary Mud	LOGGED BY: DT, KK, mm	CHECKED BY:

MATERIAL DESCRIPTION

DEPTH (m)	GEOLOGICAL DESCRIPTION
2	SILTY SAND, fine, to 0.5 mm, uniform, angular, Red
4	SILTY SAND, fine, to 0.5 mm, uniform, angular, Brown
18	SAND, fine to coarse grained, to 1 mm, poorly graded, angular, Brown, Mainly silty fine sand minor clay
20	SILTY SAND, fine to medium, to 0.5 mm, poorly graded, angular, Brown
22	CLAY, low plasticity, Grey
28	CLAY, fine, to 0.5 mm, angular, Brown/grey, trace fine sand
34	SANDY CLAY, fine to coarse, to 1 mm, poorly graded, angular, Red/brown, mostly coarse quartz sand
38	CLAY, Red/brown, trace of sand
54	SANDY CLAY, Red/brown, Sand mostly angular sedimentary fragments
56	CLAY, Light brown
84	CLAY, Grey

SAMPLES | DRILLING FLOW RATE (L/s) | WATER LEVEL (m) | DEPTH (m)

Pipe MEN2 21/03/15

BORE CONSTRUCTION

GRAPHIC LOG | GDS CODE

GDS CODE
Silty Sand
Silty Sand
SAND
Silty Sand
CLAY
CLAY
SDCY
CLAY
SDCY
CLAY
CLAY

CONSTRUCTION
ID MEN2 | Static Water Level | Reference Point gl

MEN2

GRAVEL (0-121m) (4 - 6MM)

COMMENT:

PAGE 1 OF 3

Final

NSW Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273319
GW NO : MEN2

PROJECT: **MEN2**	WORK TYPE: Bore	ELEVATION:
LOCATION: **Menindee**	NORTHING: **6430078**	EASTING: **6425635**
START DATE:	WORK STATUS: **New Bore**	
COMPLETION DATE: **21/03/2015**	REFERENCE POINT DESCRIPTION:	
DRILL TYPE: **Rotary Mud**	SAMPLE TYPES:	
DRILLING METHOD: **Rotary Mud**	LOGGED BY: DT, KK, mm	CHECKED BY:

MATERIAL DESCRIPTION					BORE CONSTRUCTION		
DEPTH (m)	GEOLOGICAL DESCRIPTION	SAMPLES	DRILLING FLOW RATE (L/s)	WATER LEVEL (m)	DEPTH (m)	GRAPHIC LOG	GDS CODE	CONSTRUCTION ID MEN2 Static Water Level Reference Point gl
102–198	CLAY, Grey						CLAY	
110–114	CLAYEY SAND, Dark grey with red sand						CLSD	
116–130	CLAY, medium plasticity, Dark grey						CLAY	BENTONITE (121-125m)
130–132							CLAY	
134–146	SILTY CLAY, medium plasticity, Dark grey						SLCY	GRAVEL (125-160m) (4 - 6MM)
146–154	CLAY, medium plasticity, Dark grey to red						CLAY	
154–156	SILTY CLAY, Dark grey, Streaks of red clay and trace of silt and fine sand						SLCY	
158	SILTY CLAY, medium plasticity, Black and grey						SLCY	
160	CLAY, medium plasticity, Grey, Black streaks and trace of silt						CLAY	
162–198	CLAY, medium plasticity, Grey, Streaks of red and black clay, trace of silt						CLAY	GRAVEL (160-215m) (1 - 3MM)
198	SAND, fine to coarse grained, to 3 mm, poorly graded, angular, Grey, Some gravel, sand (80% medium, 10% coarse, 10% fine						SAND	

COMMENT:

PAGE 2 OF 3

NOW_LIB_00 GLB Log BORE CONSTRUCTION LOG MENG.GPJ CWGB0211 GDW 04/06/2015 16:03 8.30.004 Developed by Datgel

Final

Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273319
GW NO : MEN2

PROJECT: MEN2	WORK TYPE: Bore	ELEVATION:
LOCATION: Menindee	NORTHING: 630078	EASTING: 6425635
START DATE:	WORK STATUS: New Bore	
COMPLETION DATE: 21/03/2015	REFERENCE POINT DESCRIPTION:	
DRILL TYPE: Rotary Mud	SAMPLE TYPES:	
DRILLING METHOD: Rotary Mud	LOGGED BY: DT, KK, mm	CHECKED BY:

MATERIAL DESCRIPTION

DEPTH (m)	GEOLOGICAL DESCRIPTION
202	sands) Consists of mica and sulphides
204	SANDY CLAY, low plasticity, Grey
206	SAND, fine to coarse grained, to 3 mm, poorly graded, sub-angular to angular, Grey, Some gravel, sand (80% medium, 10% coarse, 10% fine)
208	SAND, fine to coarse grained, to 3 mm, poorly graded, sub-angular to angular, Grey, Some gravel, sand (80% medium, 10% coarse, 10% fine). Consists of mica, quartz and sulphides
210	SAND, fine to coarse grained, to 3 mm, poorly graded, sub-angular to angular, Black, Organic material in sand (mix of lignite and sand) sand (80% medium, 5-10% fine), 10 to 20% lignite
212	CLAY, Black, Friable black flakes of lignite and clay
214	CLAYEY SAND, fine to coarse, to 2 mm, poorly graded, sub-angular to angular, Black
216	CLAYEY, Black, Clayey lignite, friable black flakes or lignite and clay
218	CLAY, medium plasticity, Grey, Contains white clay
220	
222	
224	
226	
228	
230	
232	
234	
236	
238	
240	
242	
244	
246	Bottom of hole at 245.00m
248	
250	
252	
254	
256	
258	
260	
262	
264	
266	
268	
270	
272	
274	
276	
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286	
288	
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292	
294	
296	
298	

SAMPLES | DRILLING FLOW RATE (L/s) | WATER LEVEL (m)

BORE CONSTRUCTION

DEPTH (m)	GRAPHIC LOG	GDS CODE
202		SDCY
204		SAND
206		SAND
208		SAND
210		CLAY
212		CLSD
214		Clayey
216		
218		
220		
222		
224		CLAY
226		
228		
230		
232		
234		
236		
238		
240		
242		
244		
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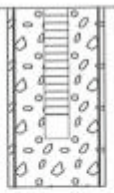
298		

CONSTRUCTION
ID MEN2 Static Water Level Reference Point gl



COMMENT:

PAGE 3 OF 3

NOW_LIB_06.GLB Log: BORE CONSTRUCTION LOG MEN2.GPJ DWG#93211.GDW 09/09/2015 16:53 # 30.004 Developed by Datgel

MEN-6

Final

Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273322
GW NO : MEN6

PROJECT: **MEN6**	WORK TYPE: Bore	ELEVATION:
LOCATION: **Menindee**	NORTHING: **6242131**	EASTING: **631394**
START DATE:	WORK STATUS: **New Bore**	
COMPLETION DATE: **29/03/2015**	REFERENCE POINT DESCRIPTION:	
DRILL TYPE: **Rotary Mud**	SAMPLE TYPES:	
DRILLING METHOD: **Rotary Mud**	LOGGED BY: MM	CHECKED BY:

MATERIAL DESCRIPTION | BORE CONSTRUCTION

DEPTH (m)	GEOLOGICAL DESCRIPTION	SAMPLES	DRILLING FLOW RATE (L/s)	WATER LEVEL (m)	DEPTH (m)	GRAPHIC LOG	GDS CODE	CONSTRUCTION ID GW273322 Static Water Level Reference Point
0–2	TOPSOIL, light brown, fine to medium silt						TPSL	
2–12	SILTY CLAY, brown, carbonate nodules and red-oranghe oxidation						SLCY	
12–20	CLAY, brown, carbonate, grey clay and minor orange oxidation						CLAY	
20–36	SILTY CLAY, grey, minor orange oxidation			Pure GW273322 29/03/15			SLCY	
36–46	SILTY CLAY, red, red oxidation and some grey clay						SLCY	
46–58	SILTY CLAY, light grey, carbonaceous, minor red-orange oxidation						SLCY	
58–60	SILTY CLAY, grey, tan, pink and orange oxidation						SLCY	
60–70	SILTY CLAY, light grey, carbonaceous and minor black organics and trace orange oxidation						SLCY	
70–86	SILTY CLAY, grey, gypsum crystals, minor yellow orange oxidation						SLCY	
86–96	SILTY CLAY, dark grey, minor orange oxidation and black organics						SLCY	GRAVEL (0-120m) (7 TO 10MM)

COMMENT:

PAGE 1 OF 3

Final

Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273322
GW NO : MEN6

PROJECT: MEN6	WORK TYPE: Bore	ELEVATION:
LOCATION: Menindee	NORTHING: 6242131	EASTING: 631394
START DATE:	WORK STATUS: New Bore	
COMPLETION DATE: 29/03/2015	REFERENCE POINT DESCRIPTION:	
DRILL TYPE: Rotary Mud	SAMPLE TYPES:	
DRILLING METHOD: Rotary Mud	LOGGED BY: MM	CHECKED BY:

MATERIAL DESCRIPTION					BORE CONSTRUCTION		
DEPTH (m)	GEOLOGICAL DESCRIPTION	SAMPLES	DRILLING FLOW RATE (L/s)	WATER LEVEL (m)	GRAPHIC LOG	GDS CODE	CONSTRUCTION ID Static Water Level GW273322 Reference Point
102–198	SILTY CLAY, grey to dark grey, trace black organics					SLCY	
102–198	SILTY CLAY, light grey, medium plasticity					SLCY	
102–198	CLAY, light grey, low plasticity, minor fine silt					CLAY	BENTONITE (120-124m)
102–198	CLAY, light grey, low plasticity, minor fine silt minor black organics					CLAY	GRAVEL (124-160m) (7 TO 10MM)
102–198	CLAY, light grey, medium plasticity, stiff clay, minor black organics and red-orange oxidation					CLAY	
102–198	CLAY, grey, minor fine silt, minor black organics and red-orange oxidation					CLAY	
102–198	CLAY, dark grey, minor silt, trace oxidation, low plasticity					CLAY	
102–198	CLAY, light grey to grey, carbonaceous, black organics and trace oxidations					CLAY	
102–198	CLAY, dark grey, carbonaceous, black organics and trace oxidation					CLAY	GRAVEL (160-215m) (3 TO 5MM)
102–198	SAND, grey, medium to coarse, sub angular quartz, 60% coarse, 40% medium and minor clay					SAND	
102–198	SAND, grey, fine to medium sub angular quartz sand 50% fine and 50% medium clean sand					SAND	

COMMENT:

PAGE 2 OF 3

NOW_LIB_05.GLB Log: BORE CONSTRUCTION LOG MEN6.GPJ DW0280373.GDW 09/06/2015 15:54 8.30.004 Developed by Datgel

Final

NSW Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273322
GW NO : MEN6

PROJECT: **MEN6**	WORK TYPE: Bore	ELEVATION:
LOCATION: **Menindee**	NORTHING: **6242131**	EASTING: **631394**
START DATE:	WORK STATUS: **New Bore**	
COMPLETION DATE: **29/03/2015**	REFERENCE POINT DESCRIPTION:	
DRILL TYPE: **Rotary Mud**	SAMPLE TYPES:	
DRILLING METHOD: **Rotary Mud**	LOGGED BY: MM	CHECKED BY:

MATERIAL DESCRIPTION

DEPTH (m)	GEOLOGICAL DESCRIPTION
202–214	SAND, grey, fine 10%, medium 60%, coarse 20%, gravel 10%, sub angular, gravel 4 to 5mm
204–214	SAND, grey, coarse sand to gravel subangular, 10% clay
206–214	CLAY, dark grey/black, minor black streaks
214	PEAT, black, with wood and vegetation material
215	Bottom of hole at 215.00m

SAMPLES | DRILLING FLOW RATE (L/s) | WATER LEVEL (m)

BORE CONSTRUCTION

DEPTH (m) | GRAPHIC LOG | GDS CODE | CONSTRUCTION

GDS CODE: SAND, CLAY, PEAT

CONSTRUCTION: ID GW273322 — Static Water Level — Reference Point

COMMENT:

MEN-9

Final

NSW Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273321
GW NO : MEN9

PROJECT: MEN9	WORK TYPE: Bore	ELEVATION:
LOCATION: Menindee	NORTHING: 6424114	EASTING: 631420
START DATE:	WORK STATUS: New Bore	
COMPLETION DATE: 1/04/2015	REFERENCE POINT DESCRIPTION:	
DRILL TYPE: Rotary Mud	SAMPLE TYPES:	
DRILLING METHOD: Rotary Mud	LOGGED BY: MM	CHECKED BY:

MATERIAL DESCRIPTION

DEPTH (m)	GEOLOGICAL DESCRIPTION
2	SILTY SAND, red
4	SILTY CLAY, white
6	SILT, low liquid limit, pale brown-orange, minor sand and clay from 7 to 13m
14	SILTY CLAY, light grey, pale brown oxidation, fine sand and silt
38	SANDY CLAY, low plasticity, mottled grey and orange
44	CLAY, low plasticity, pale brown-orange (mottled in parts), some silt and sand
64	SANDY CLAY, low plasticity, mottled pale brown-orange
66	CLAY, medium plasticity, dark grey-orange, possible some organics
76	CLAY, low plasticity, dark grey to black, some organics in round nodules up to 5mm
86	SANDY CLAY, low plasticity, dark grey - black, some organics
88	SAND, medium to coarse grained sub angular to angula (80% grains 1 to 2mm) some clay
90	SANDY CLAY, low plasticity, grey
92	SAND, pale brown, medium to coarse grained sub angular to angular
96	SAND, pale brown, fine to medium grained sub angular to angular
98	CLAYEY SAND, brown, medium to coarse, some organics at

BORE CONSTRUCTION

DEPTH (m)	GRAPHIC LOG	GDS CODE
2		Silty Sand
4		SLCY
10		SILT
18		SLCY
30		SLCY
40		SDCY
54		CLAY
66		SDCY
70		CLAY
78		CLAY
86		SDCY
88		SAND
90		SDCY
94		SAND
96		SAND
98		CLSD

CONSTRUCTION
ID GW273321 | Static Water Level | Reference Point gl
GW273321

GRAVEL (0-98m) (3 TO 6MM)

COMMENT:

PAGE 1 OF 3

NOW_LB_26.GLB Log BORE CONSTRUCTION LOG MEN9.GPJ GW061197.GDW 08/06/2015 15:58 8.30.934 Developed by Datgel

Final

Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273321
GW NO : MEN9

PROJECT: **MEN9**	WORK TYPE: Bore	ELEVATION:
LOCATION: **Menindee**	NORTHING: **6424114**	EASTING: **631420**
START DATE:	WORK STATUS: **New Bore**	
COMPLETION DATE: **1/04/2015**	REFERENCE POINT DESCRIPTION:	
DRILL TYPE: **Rotary Mud**	SAMPLE TYPES:	
DRILLING METHOD: **Rotary Mud**	LOGGED BY: MM	CHECKED BY:

MATERIAL DESCRIPTION					BORE CONSTRUCTION		
DEPTH (m)	GEOLOGICAL DESCRIPTION	SAMPLES	DRILLING FLOW RATE (L/s)	WATER LEVEL (m)	GRAPHIC LOG	GDS CODE	CONSTRUCTION ID GW273321 Static Water Level Reference Point gl
102	106m CLAYEY SAND, brown, medium to coarse, some organics at 106m					CLSD	BENTONITE (98-100m)
108	SANDY CLAY, low plasticity, pale brown and dark grey, some gravel and organics					SDCY	
112	CLAY, medium plasticity, pale brown to orange, some black organic nodules					CLAY	
162	SANDY CLAY, low plasticity, pale brown orange, medium to coarse sand					SDCY	GRAVEL (100-220m) (3 TO 5MM)
164	SAND, brown, fine to coarse grained (40% <1mm, 50% 1-2mm and 10% >2mm) trace of gravel.					SAND	
182	CLAY, medium plasticity, pale brown, trace of black streaks					CLAY	
194	SAND, pale brown, coarse grained, sub-rounded to round (1mm to 2mm 10%, 2 to 4mm 70%,>4mm 20%), quartz dominated					SAND	

COMMENT:

PAGE 2 OF 3

NSW_LIB_06.GLB Log BORE CONSTRUCTION LOG MEN9.GPJ DWG21327.GDW 06/06/2015 15:58 8.33.004 Developed by Datgel

Final

Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273321
GW NO : MEN9

PROJECT: **MEN9**	WORK TYPE: Bore	ELEVATION:
LOCATION: **Menindee**	NORTHING: **6424114**	EASTING: **631420**
START DATE:	WORK STATUS: **New Bore**	
COMPLETION DATE: **1/04/2015**	REFERENCE POINT DESCRIPTION:	
DRILL TYPE: **Rotary Mud**	SAMPLE TYPES:	
DRILLING METHOD: **Rotary Mud**	LOGGED BY: MM	CHECKED BY:

MATERIAL DESCRIPTION					BORE CONSTRUCTION		
DEPTH (m)	GEOLOGICAL DESCRIPTION	SAMPLES	DRILLING FLOW RATE (L/s)	WATER LEVEL (m)	DEPTH (m)	GRAPHIC LOG	GDS CODE	CONSTRUCTION ID GW273321 Static Water Level Reference Point gl
202	SAND, pale brown, coarse grained, sub rounded to round (1mm to 2mm 10%, 2 to 4mm 70%,>4mm 20%), quartz dominated				202		SAND	
212	PEAT, grey-black, gravelly sand				212		PEAT	
214	PEAT, black				214		PEAT	
218	PEAT, black, trace of gravel				218		PEAT	
220	Bottom of hole at 220.00m				220			

COMMENT:

PAGE 3 OF 3

MEN-11

Final

Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273320
GW NO : MEN11

PROJECT: MEN11	WORK TYPE: Bore	ELEVATION:
LOCATION: Menindee	NORTHING: 6427995	EASTING: 627755
START DATE:	WORK STATUS: New Bore	
COMPLETION DATE: 5/03/2015	REFERENCE POINT DESCRIPTION:	
DRILL TYPE: Rotary Mud	SAMPLE TYPES:	
DRILLING METHOD: Open Hole - Mud	LOGGED BY: mm	CHECKED BY:

MATERIAL DESCRIPTION | BORE CONSTRUCTION

DEPTH (m)	GEOLOGICAL DESCRIPTION	SAMPLES	DRILLING FLOW RATE (L/s)	WATER LEVEL (m)	DEPTH (m)	GRAPHIC LOG	GDS CODE	CONSTRUCTION ID GW273320	Static Water Level	Reference Point gl
2	SILTY CLAY, Brown				2		SLCY			
12	CLAY, Light grey				12		CLAY			
14	SANDY CLAY, sub-rounded to sub-angular, Light grey				14		SDCY			
16	CLAY, medium plasticity, Grey				16		CLAY			
22	CLAY, medium plasticity, Red				22		CLAY			
24	SANDY CLAY, medium plasticity, Red				24		SDCY			
28	CLAY, medium plasticity, Grey				26		CLAY			
30				Pipe GW273320 05/03/15	30		CLAY			
32					32		CLAY			
40	CLAY, medium plasticity, Red/Grey				40		CLAY			
56	CLAY, medium plasticity, Grey				56		CLAY			
74	CLAY, medium plasticity, Grey/red				74		CLAY			
78	CLAY, Grey/red				78		CLAY			
86	CLAY, Dark grey				86		CLAY			
88					88		CLAY			
90					90		CLAY			
98					98		CLAY			

GRAVEL (0-100m) (5 TO 7MM)

COMMENT:

PAGE 1 OF 3

NOW_LIB_06.GLB Log BORE CONSTRUCTION LOG MEN11.GPJ DWG0244.GDW 08/06/2015 19:07 8.30.664 Developed by Datgel

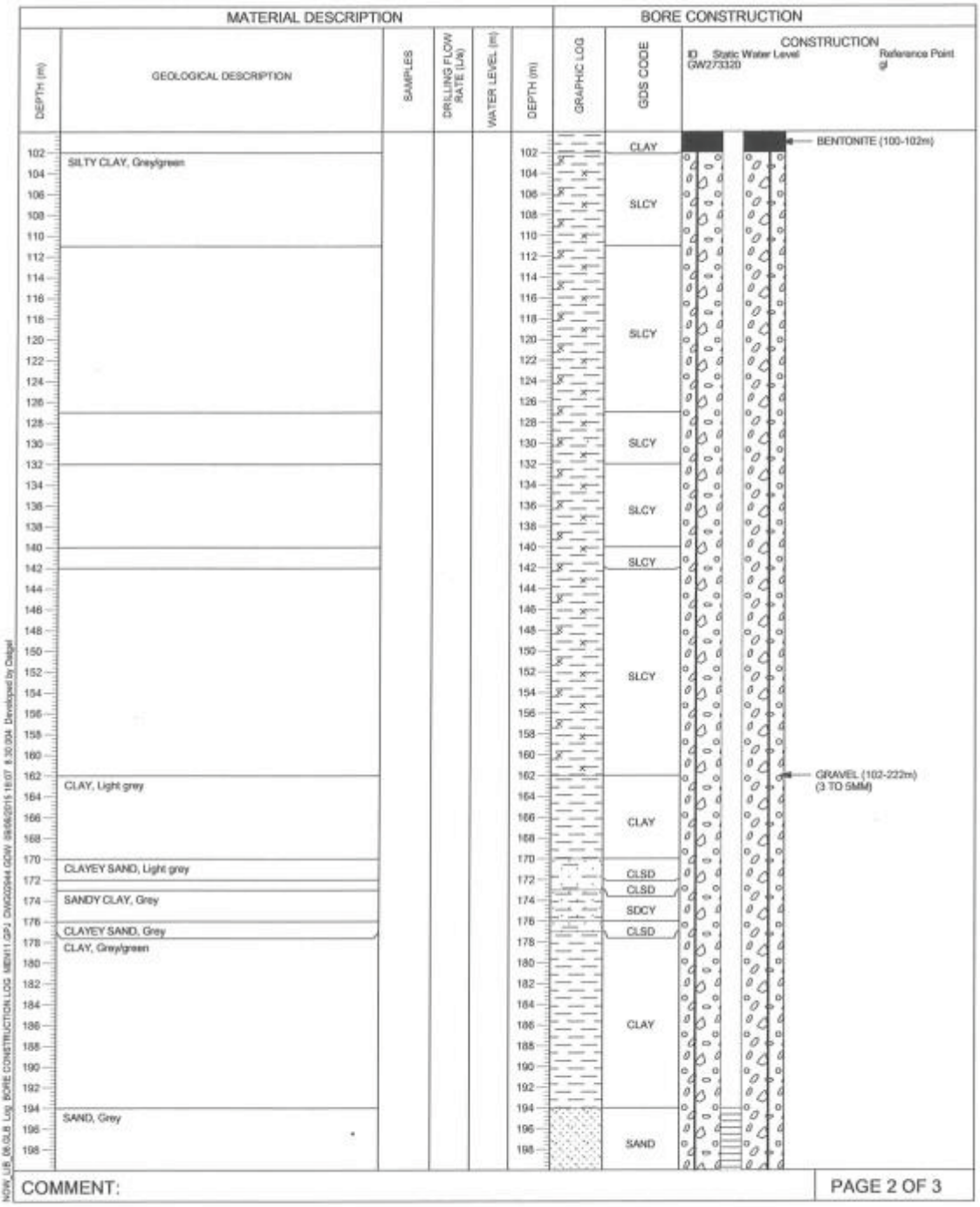
Final

Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273320
GW NO : MEN11

PROJECT: MEN11	WORK TYPE: Bore	ELEVATION:
LOCATION: Menindee	NORTHING: 6427995	EASTING: 627755
START DATE:	WORK STATUS: New Bore	
COMPLETION DATE: 5/03/2015	REFERENCE POINT DESCRIPTION:	
DRILL TYPE: Rotary Mud	SAMPLE TYPES:	
DRILLING METHOD: Open Hole - Mud	LOGGED BY: mm	CHECKED BY:



COMMENT:

PAGE 2 OF 3

Final

NSW Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273320
GW NO : MEN11

PROJECT: MEN11	WORK TYPE: Bore	ELEVATION:
LOCATION: Menindee	NORTHING: 6427995	EASTING: 627755
START DATE:	WORK STATUS: New Bore	
COMPLETION DATE: 5/03/2015	REFERENCE POINT DESCRIPTION:	
DRILL TYPE: Rotary Mud	SAMPLE TYPES:	
DRILLING METHOD: Open Hole - Mud	LOGGED BY: mm	CHECKED BY:

MATERIAL DESCRIPTION | BORE CONSTRUCTION

DEPTH (m)	GEOLOGICAL DESCRIPTION	SAMPLES	DRILLING FLOW RATE (L/s)	WATER LEVEL (m)	DEPTH (m)	GRAPHIC LOG	GDS CODE	CONSTRUCTION
202–298	GRAVEL, Grey						SAND, SAND, GRVL, GRVL, GRVL, GRVL	ID Static Water Level GW273320; Reference Point gl
214–222	CLAY, Black						CLAY	
222	Bottom of hole at 222.00m							

COMMENT:

PAGE 3 OF 3

NOW_LIB_06.GLB Log BORE CONSTRUCTION LOG MEN11.GPJ DWG23044.SDN 09/06/2015 16:07 8.33.024 Developed by Datgel

MEN-17

Final

Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273323
GW NO : MEN17

PROJECT: MEN17	WORK TYPE: Bore	ELEVATION:
LOCATION: Menindee	NORTHING: 6427995	EASTING: 627755
START DATE:	WORK STATUS: New Bore	
COMPLETION DATE:	REFERENCE POINT DESCRIPTION:	
DRILL TYPE:	SAMPLE TYPES:	
DRILLING METHOD: Rotary Mud	LOGGED BY: MM	CHECKED BY:

MATERIAL DESCRIPTION					BORE CONSTRUCTION		
DEPTH (m)	GEOLOGICAL DESCRIPTION	SAMPLES	DRILLING FLOW RATE (L/s)	WATER LEVEL (m)	GRAPHIC LOG	GDS CODE	CONSTRUCTION ID GW273323 Static Water Level / Reference Point pc-toc
2	SILTY SAND, orange-red, silt and fine sand			Piez GW273323 20/04/15		Silty Sand	
4	SILTY CLAY, low plasticity, orange					SLCY	
8	CLAY, orange/brown					CLAY	
12	CLAY, medium plasticity, mottled grey/orange					CLAY	
28	SILTY CLAY, low plasticity, orange, oxidised					SLCY	
36	SILTY CLAY, low plasticity, yellow/grey, mottled oxidised					SLCY	
42	CLAY, low plasticity, grey, yellow oxidised					CLAY	
46	SILTY CLAY, grey, orange mottle					SLCY	
50	CLAYEY SAND, grey/orange, grey medium quartz sand 2 to 3mm					CLSD	
52	SAND, orange, fine sand					SAND	
58	SAND, Orange, medium to coarse quartz angular to sub angular sand 2 to 3mm					SAND	
72	SAND, burgandy, quartz medium to coarse sand 1 to 3mm					SAND	
78	CLAYEY SAND, grey, Quartz medium to coarse sub angular sand					CLSD	
80	SANDY CLAY, grey, Oxidised tellow and orange sub angular sand medium to coarse grained approximetly 30%					SDCY	
88	CLAY, low plasticity, dark grey, oxidised organge and black clay					CLAY	
92	CLAY, low plasticity, dark grey, large clay chips					CLAY	
98							

COMMENT:

PAGE 1 OF 3

Final

NSW Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273323
GW NO : MEN17

PROJECT: **MEN17**	WORK TYPE: Bore	ELEVATION:
LOCATION: **Menindee**	NORTHING: **6427995**	EASTING: **627755**
START DATE:	WORK STATUS: **New Bore**	
COMPLETION DATE:	REFERENCE POINT DESCRIPTION:	
DRILL TYPE:	SAMPLE TYPES:	
DRILLING METHOD: **Rotary Mud**	LOGGED BY: MM	CHECKED BY:

MATERIAL DESCRIPTION						BORE CONSTRUCTION		
DEPTH (m)	GEOLOGICAL DESCRIPTION	SAMPLES	DRILLING FLOW RATE (L/s)	WATER LEVEL (m)	DEPTH (m)	GRAPHIC LOG	GDS CODE	CONSTRUCTION ID Static Water Level Reference Point GW273323 pc-toc
102	CLAY, low plasticity, dark grey, large clay chips				102		CLAY	GRAVEL (0-202m) (3 TO 5MM)
104	mudstone, light to dark grey, oxidised faces				104			
106	mudstone, light to dark grey, oxidised faces, large flakes of gypsum 1 to 2mm thick and up to 50mm in diameter				106			
108					108			
110					110			
112					112			
114					114			
116					116			
118	mudstone, dark grey to black, some unconsolidated clay				118			
120					120			
122					122			
124					124			
126					126			
128					128			
130					130			
132	mudstone, light grey, oxidised faces on clay chips				132			
134					134			
136					136			
138	mudstone, light grey, oxidised faces , 10% black chips of mudstone				138			
140					140			
142					142			
144					144			
146					146			
148	mudstone, light grey, clay 150 to 156m				148			
150					150			
152					152			
154					154			
156					156			
158					158			
160					160			
162	mudstone, grey/green with oxidised faces				162			
164					164			
166					166			
168					168			
170					170			
172	mudstone, dark grey and black				172			
174					174			
176					176			
178	mudstone, green/grey				178			
180					180			
182	mudstone, green/grey, minor black mudstone chips with oxidised orange faces				182			
184					184			
186					186			
188					188			
190					190			
192					192			
194	mudstone, grey/green				194			
196					196			
198					198			

NOW_LIB_05.GLB Log: BORE CONSTRUCTION LOG MEN17.GPJ DWG2ST03.GDW 09/06/2015 15:59 6.30.034 Developed by Datgel

COMMENT:

PAGE 2 OF 3

Final

NSW Office of Water

BORE CONSTRUCTION LOG

BORE NO : GW273323
GW NO : MEN17

PROJECT: MEN17	WORK TYPE: Bore	ELEVATION:
LOCATION: Menindee	NORTHING: 6427995	EASTING: 627755
START DATE:	WORK STATUS: New Bore	
COMPLETION DATE:	REFERENCE POINT DESCRIPTION:	
DRILL TYPE:	SAMPLE TYPES:	
DRILLING METHOD: Rotary Mud	LOGGED BY: MM	CHECKED BY:

MATERIAL DESCRIPTION					BORE CONSTRUCTION		
DEPTH (m)	GEOLOGICAL DESCRIPTION	SAMPLES	DRILLING FLOW RATE (L/s)	WATER LEVEL (m)	DEPTH (m)	GRAPHIC LOG	GDS CODE	CONSTRUCTION ID GW273323 Static Water Level Reference Point pc-toc
202	mudstone, grey/green				202			
	Bottom of hole at 202.00m							

COMMENT:

PAGE 3 OF 3

Geological units

MEN-1

From	To	Geological Unit
0	6	Woorinen Formation
6	12	Willotia Beds
12	24	Blanchetown Clay
24	91	Calivil Formation
91	217	Renmark Group

MEN-2

From	To	Geological unit
1	3	Woorinen Formation
3	17	Willotia Beds
17	34	Blanchetown Clay
34	83	Calivil Formation
83	245	Renmark Group

MEN-6

From	To	Geological unit
0	12	Lunette
12	20	Willotia Beds
20	26	Blanchetown Clay
26	86	Calivil Formation
86	215	Renmark Group

MEN-9

From	To	Geological unit
0	2	Woorinen Formation
2	22	Willotia Beds
22	37	Blachetown Clay
37	64	Calivil Formation
64	220	Renmark group

MEN-11

From	To	Geological unit
0	11	Woorinen Formation
11	15	Willotia Beds
15	24	Blanchetown Clay
24	55	Calivil Formation
55	222	Renmark Group

MEN-17

From	To	Geological unit
0	2	Woorinen Formation
2	11	Willotia Beds
11	27	Blanchetown Clay
27	80	Calivil Formation
80	92	Renmark Group
92	202	Palaeozoic

Appendix 5 – Geophysical logs

Geophysical logs

Appendix-5_MEN-1_geophysics

Appendix-5_MEN-2_geophysics

Appendix-5_MEN-6_geophysics

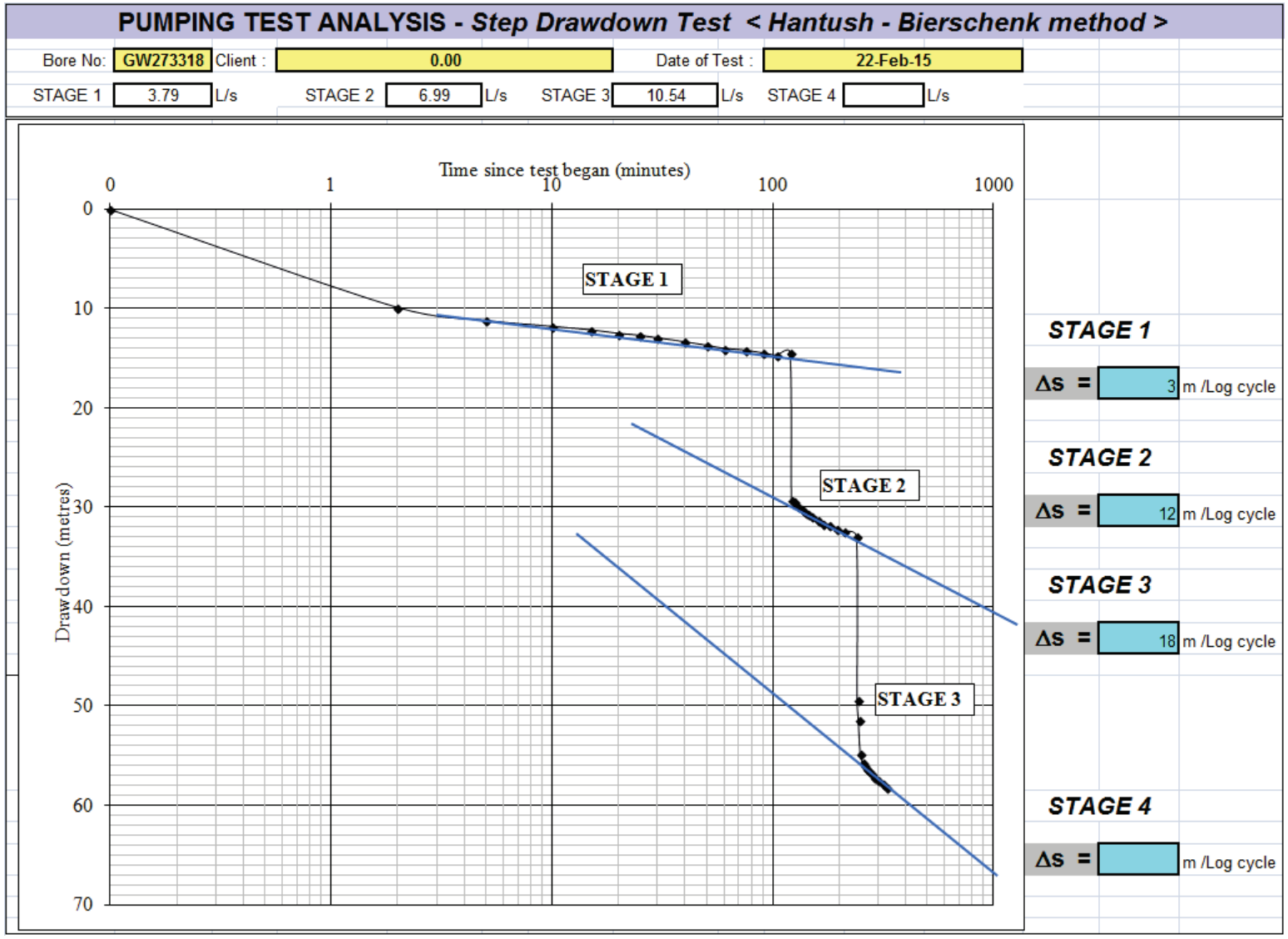
Appendix-5_MEN-9_geophysics

Appendix-5_MEN-11_geophysics

Appendix-5_MEN-17_geophysics

Appendix 6 – Pump test results

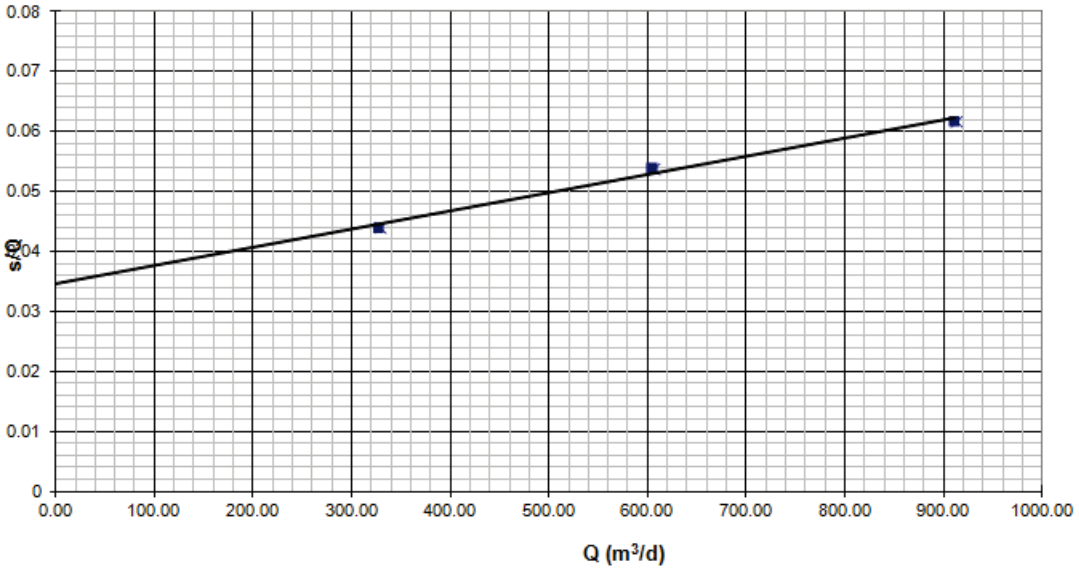
MEN-1: Step drawdown test



PUMPING TEST ANALYSIS - *Step Drawdown Test < Hantush - Bierschenk method >*

STAGE	$\Delta s_{w(n)}$ PROJECTED m	$s_{w(n)}$ CUMULATIVE m	Q_n YIELD m^3/d	$s_{w(n)}/Q_n$ d/m^2
1	14.45	14.45	327.47	0.04412613
2	18.11	32.56	603.91	0.05391493
3	23.74	56.30	910.76	0.06181672
4				

Bore No: GW273318 Client : 0.00 Date of Test : 22-Feb-15



Intercept **B** = 0.034

Slope Calculation

X Axis value = 500

Y Axis value = 0.05

Slope **C** = 0.000032

Proposed pumping rate Q = *10.43* L/s

Laminar flow percentage

$$L_p = \frac{BQ}{BQ + CQ^2} \times 100$$

54.11 % Laminar Flow

DRAWDOWN EQUATION [After 120 minutes]

$s_w = BQ + CQ^2$ = **56.63 metres**

BORE EFFICIENCY ANALYSIS From Constant Rate Pumping Test < Cooper & Jacob Equation >

From Constant Rate Pumping Test

Discharge Rate "Q"		10.43	L/s	Theoretical Specific Capacity =	**14.913**	$m^3/D/m$
Drawdown "s"after	4 Day/s	63.37	m			See page 1021
Transmissivity "T"		22.79	m^2/D	Actual Specific Capacity [Q/s]	**14.227**	$m^3/D/m$
Storativity "S"		0.00009				

BORE EFFICIENCY = 95.4 %

"t" for Theoretical Specific Capacity= 1 to 4 days

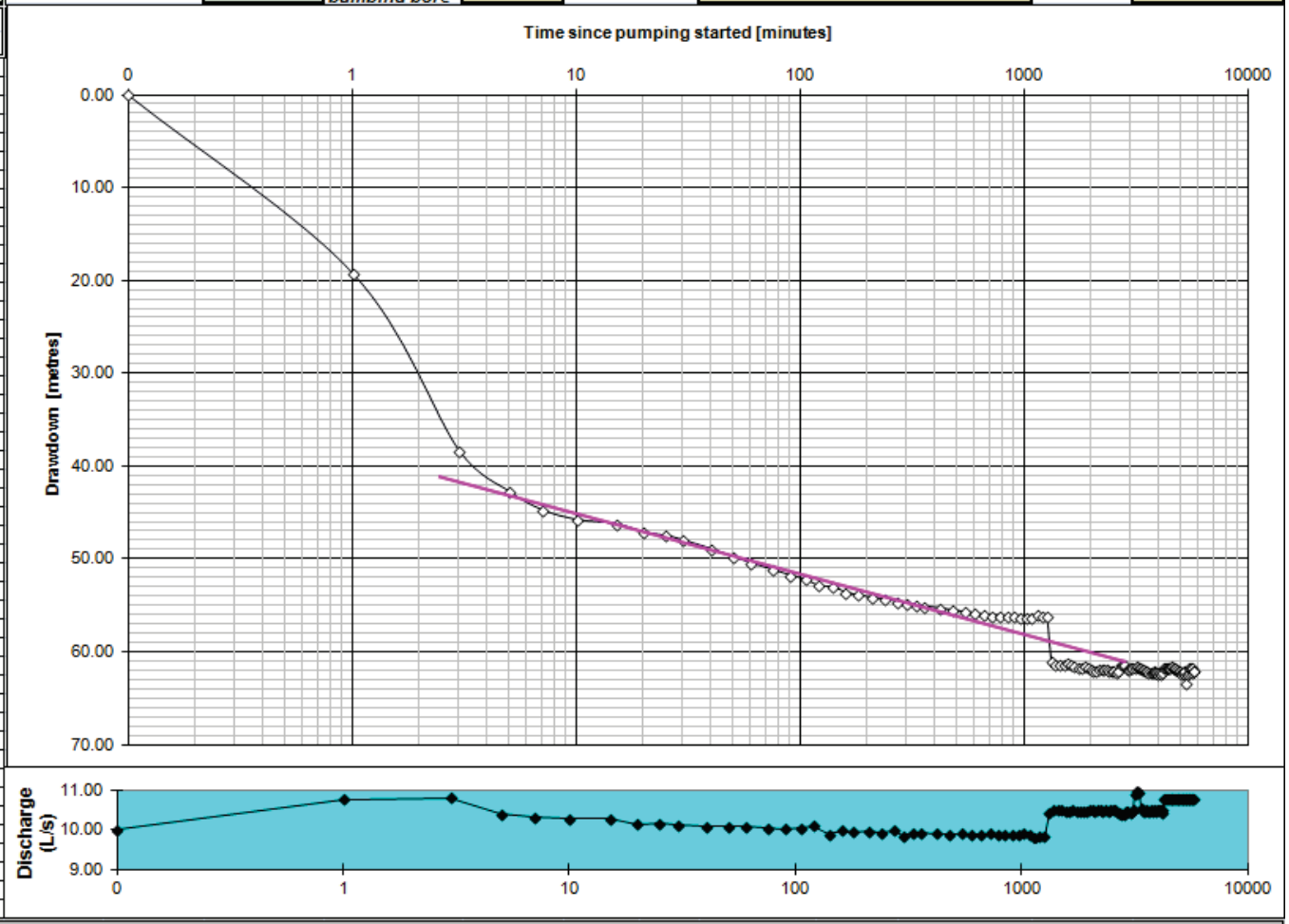
MEN-1: Constant rate (Jacob straight line)

SWL =	27.75	m	
Q =	10.43	L/s	
Any Observation Bore? Yes / No	no		

PUMPING TEST ANALYSIS - *Time Drawdown Data [pumping bore]*

Pumping Bore No.:	GW273318	Owner :	NSW Office of Water			Date of Test :	23-Feb-15
Observation Bore No.:		Distance from pumping bore		Analysed by:	Mark Mitchell	Date :	4-Mar-15

Time (min)	DDL (m)	Drawdown (m)
0.1	27.75	0.00
1	46.92	19.17
3	66.11	38.36
5	70.46	42.71
7	72.43	44.68
10	73.51	45.76
15	73.94	46.19
20	74.86	47.11
25	75.2	47.45
30	75.72	47.97
40	76.65	48.90
50	77.48	49.73
60	78.18	50.43
75	78.87	51.12
90	79.5	51.75
105	79.95	52.20
120	80.6	52.85
140	80.79	53.04
160	81.35	53.60
180	81.6	53.85
210	81.91	54.16
240	82.1	54.35
270	82.35	54.60
300	82.6	54.85
330	82.68	54.93
360	82.86	55.11
420	83.03	55.28
480	83.27	55.52
540	83.42	55.67
600	83.6	55.85
660	83.74	55.99
720	83.82	56.07
780	83.82	56.07
840	83.94	56.19
900	83.98	56.23
1560	89	61.25
2160	89.65	61.90
2220	89.56	61.81
2280	89.64	61.89
5340	90.05	62.30
5400	89.94	62.19
5460	89.39	61.64
5520	89.47	61.72
5580	89.42	61.67
5640	89.97	62.22
5760	89.72	61.97



Δs =	7	m	Q =	10.43	L/s	901.56	m^3 / d	T = [0.183Q / Δs] =	23.573	m^2 / d

MEN-1 : Recovery

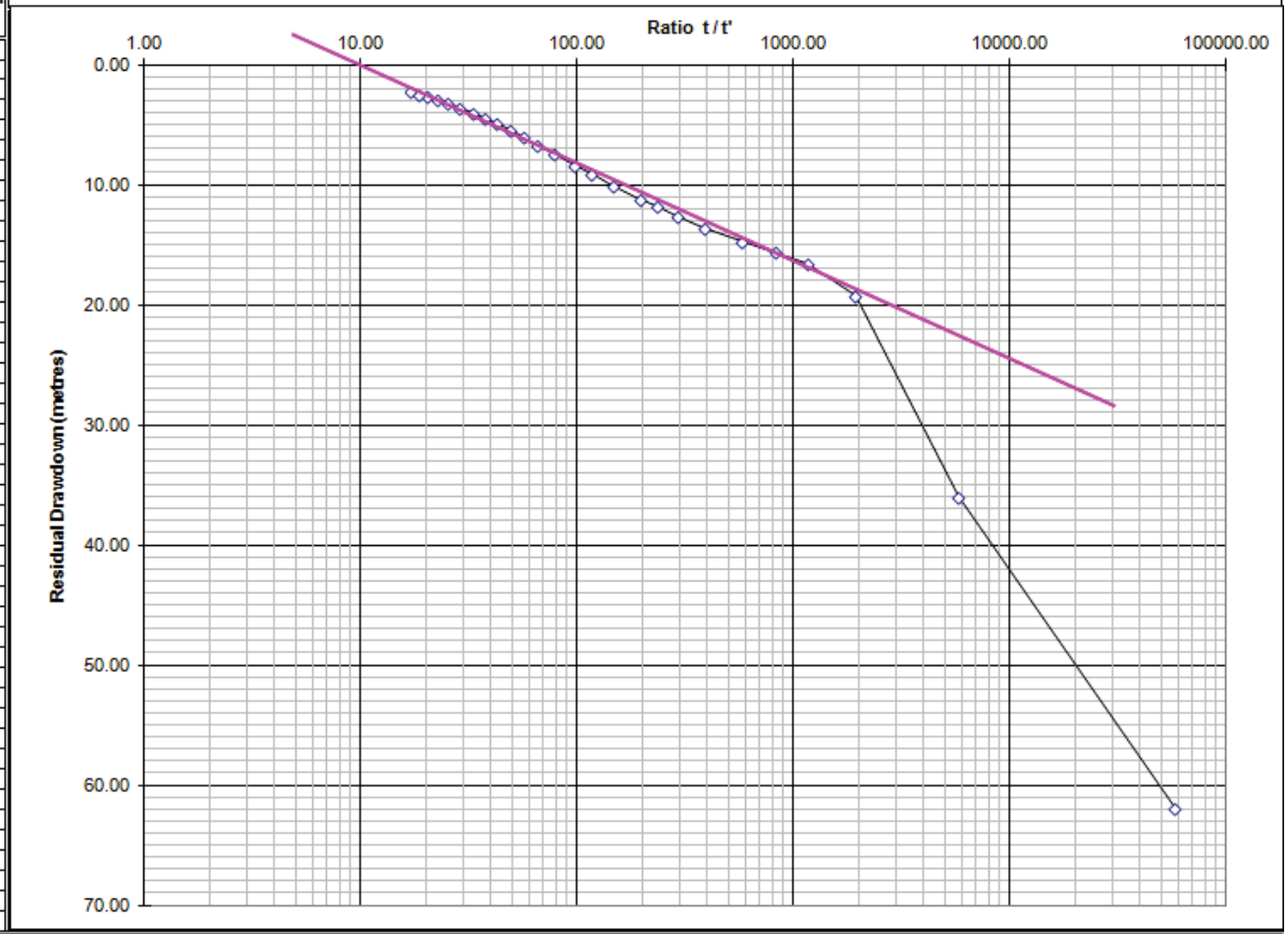
SWL =	27.75	m
DDL =	89.72	m
Q =	10.43	L/s
Duration :	5760	minutes

PUMPING TEST ANALYSIS - *Recovery Data [pumping bore]*

Pumping Bore No. : *GW273318* Owner : *NSW Office of Water* Date of test *23-Feb-15*

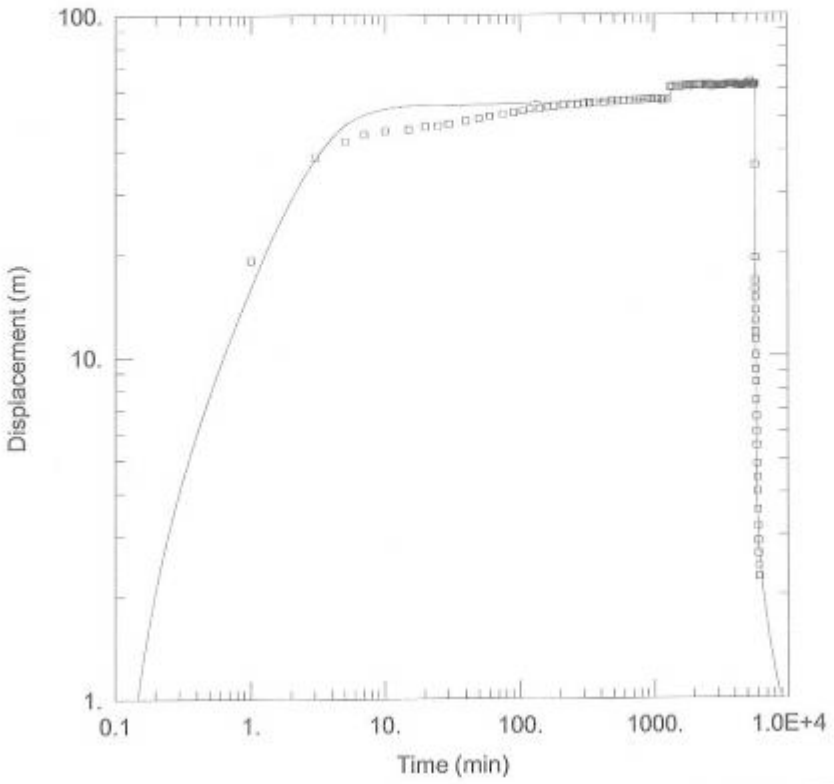
Analysis carried out by : *Mark Mitchell* Date : *4-Mar-15*

Time (t') (min)	Depth to Water (m)	Ratio t/t'	Residual Drawdown (m)
0	89.72	57601.00	61.97
1	63.75	5761.00	36.00
3	47.02	1921.00	19.27
5	44.31	1153.00	16.56
7	43.39	823.86	15.64
10	42.47	577.00	14.72
15	41.31	385.00	13.56
20	40.40	289.00	12.65
25	39.50	231.40	11.75
30	38.89	193.00	11.14
40	37.80	145.00	10.05
50	36.87	116.20	9.12
60	36.12	97.00	8.37
75	35.16	77.80	7.41
90	34.40	65.00	6.65
105	33.75	55.86	6.00
120	33.22	49.00	5.47
140	32.58	42.14	4.83
160	32.15	37.00	4.40
180	31.77	33.00	4.02
210	31.30	28.43	3.55
240	30.93	25.00	3.18
270	30.63	22.33	2.88
300	30.39	20.20	2.64
330	30.19	18.45	2.44
360	30.01	17.00	2.26



Δs =	7.50	m	Q =	10.4	L/s	901.56	m3 / d	T = [0.183Q / Δs] = 21.998 m2 / d

MEN-1: Constant rate (Aqtesolv analysis)



WELL TEST ANALYSIS

Data Set: F:\...\constant_rate_test_2015-05-16.aqt
Date: 05/18/15 Time: 09:55:01

PROJECT INFORMATION

Company: NSW Office of Water
Client: Essential energy
Location: Lake Menindee
Test Well: MEN1
Test Date: 23/2/2015

AQUIFER DATA

Saturated Thickness: 5. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
MEN1	629537	6426070

Observation Wells

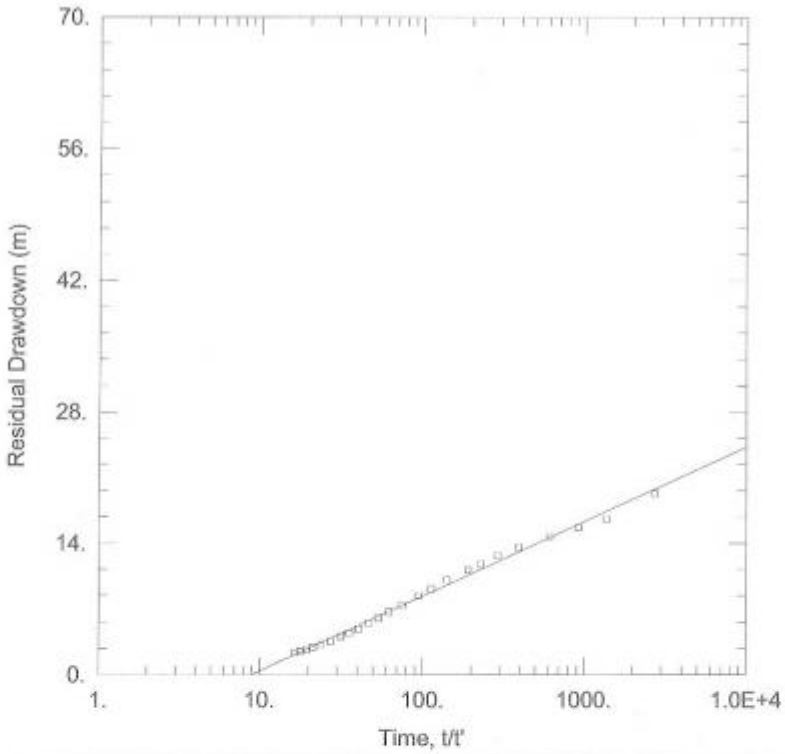
Well Name	X (m)	Y (m)
MEN1	629537	6426070

SOLUTION

Aquifer Model: Confined Solution Method: Papadopulos-Cooper

T = 76.42 m^2/day S = 3.074E-6
r(w) = 1.135E-10 m r(c) = 0.1072 m

MEN-1: Recovery (Aqtesolv analysis)



WELL TEST ANALYSIS

Data Set: U:\...\constant_rate_test_2015-03-03.aqt
Date: 05/04/15 Time: 14:38:28

PROJECT INFORMATION

Company: NSW Office of Water
Client: Essential energy
Location: Lake Menindee
Test Well: MEN1
Test Date: 23/2/2015

AQUIFER DATA

Saturated Thickness: 5. m Anisotropy Ratio (Kz/Kr): 1.

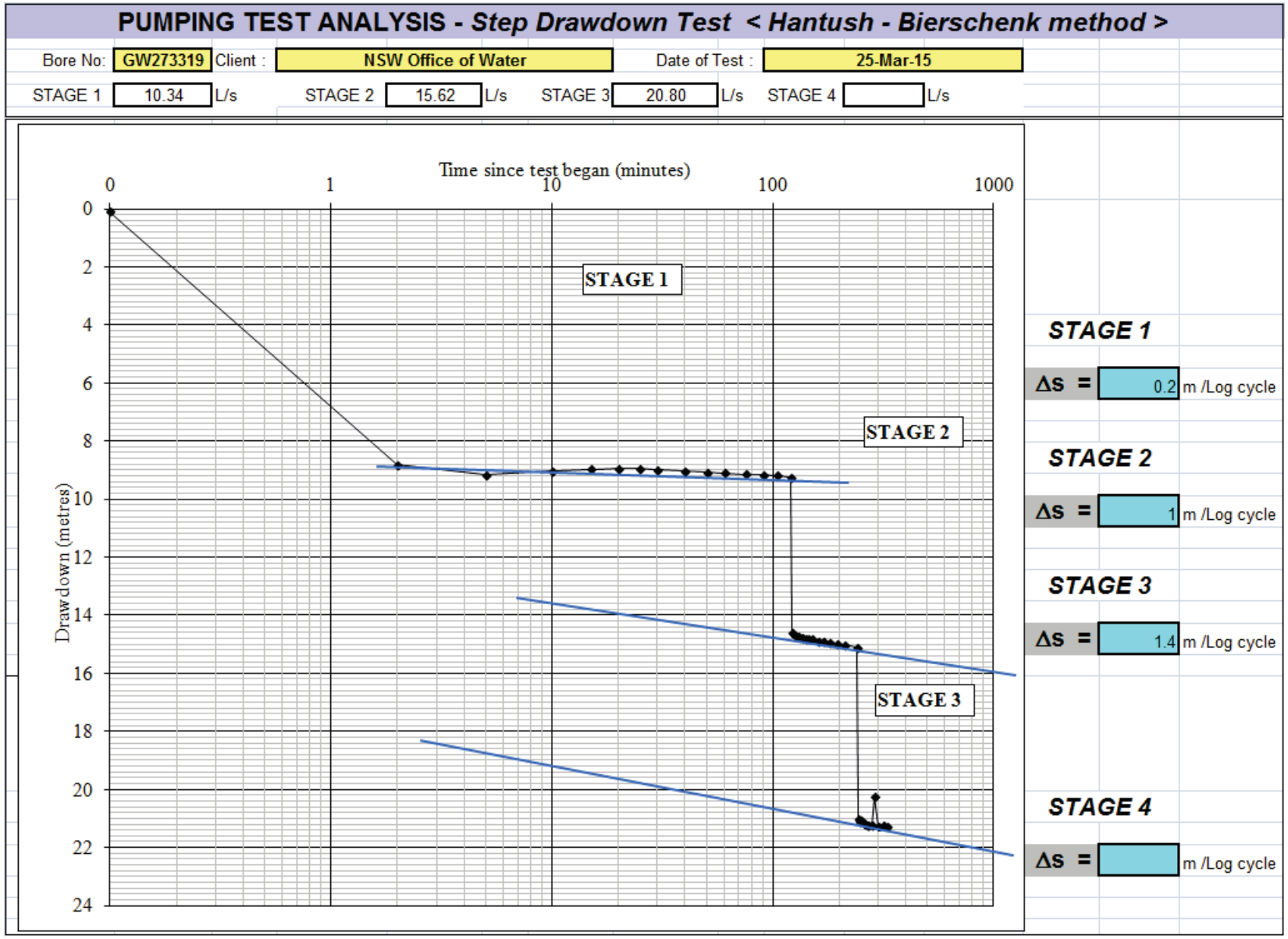
WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
MEN1	629537	6426070	MEN1	629537	6426070

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)
T = 21.44 m^2/day S/S' = 8.973

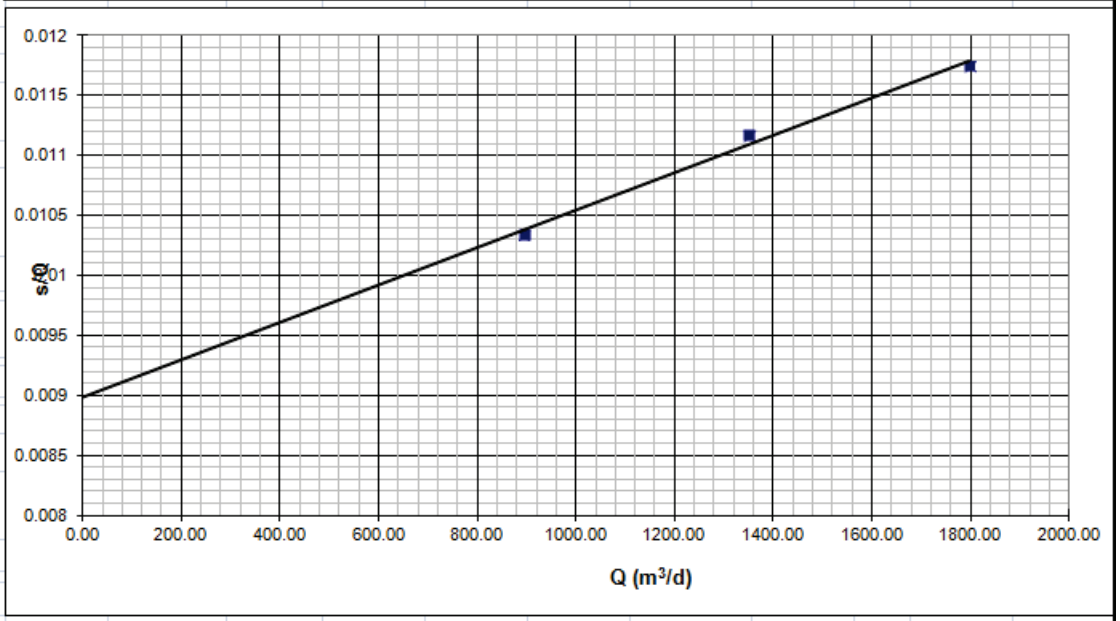
MEN-2: Step drawdown test



PUMPING TEST ANALYSIS - *Step Drawdown Test < Hantush - Bierschenk method >*

STAGE	$\Delta s_{w(n)}$ PROJECTED m	$s_{w(n)}$ CUMULATIVE m	Q_n YIELD m^3/d	$s_{w(n)}/Q_n$ d/m^2
1	9.24	9.24	893.59	0.01034029
2	5.83	15.07	1349.30	0.01117171
3	6.04	21.11	1797.12	0.0117488
4				

Bore No: GW273319 Client : NSW Office of Water Date of Test : 25-Mar-15



Intercept **B** = 0.009

Slope Calculation

X Axis value = 1600

Y Axis value = 0.01148

Slope **C** = 1.55E-06

Proposed pumping rate Q = *20.79* L/s

Laminar flow percentage

$$L_p = \frac{BQ}{BQ + CQ^2} \times 100$$

76.37 % Laminar Flow

DRAWDOWN EQUATION [After 120 minutes]

$s_w = BQ + CQ^2$ = **21.17 metres**

BORE EFFICIENCY ANALYSIS From Constant Rate Pumping Test < Cooper & Jacob Equation >

From Constant Rate Pumping Test

Discharge Rate "Q"		20.79	L/s	Theoretical Specific Capacity =	198.899	$m^3/D/m$
Drawdown "s"after	4 Day/s	22.44	m			See page 1021
Transmissivity "T"		346.94	m^2/D	Actual Specific Capacity [Q/s]	80.031	$m^3/D/m$
Storativity "S"		0.00009				

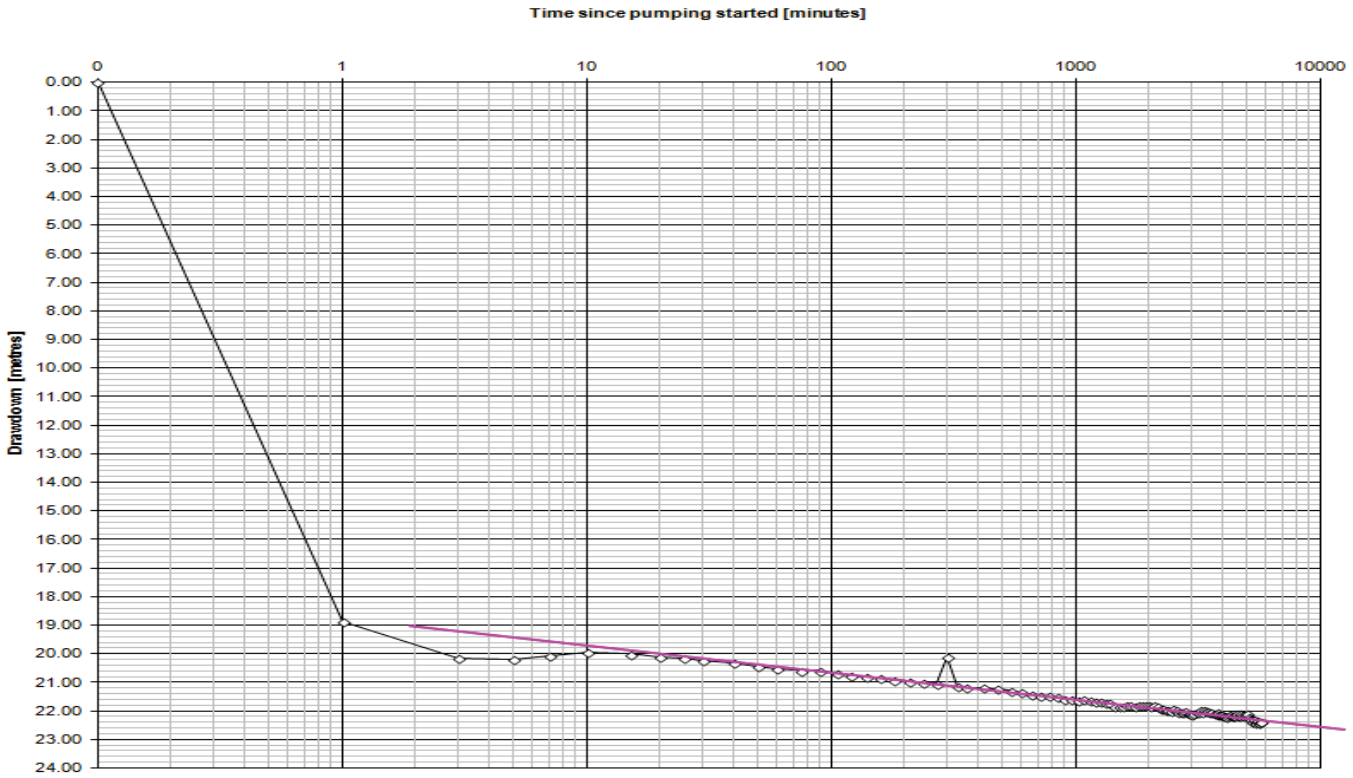
BORE EFFICIENCY = 40.24 %

"t" for Theoretical Specific Capacity= 1 to 4 days

MEN-2: Constant rate test (Jacob straight line)

SWL =	28.77	m	PUMPING TEST ANALYSIS - *Time Drawdown Data [pumping bore]*						
Q =	20.79	L/s	Pumping Bore No.:	GW273319	Owner :	NSW Office of Water		Date of Test :	26-Mar-15
Any Observation Bore? Yes / No	yes		Observation Bore No.:	GW273318	Distance from pumping bore	705	Analysed by:	Mark Mitchell	Date : 26-Mar-15

Time (min)	DDL (m)	Drawdown (m)
0.1	28.77	0.00
1	47.65	18.88
2940	50.85	22.08
3000	50.89	22.12
3060	50.87	22.10
3120	50.82	22.05
3180	50.81	22.04
3240	50.72	21.95
3300	50.8	22.03
3360	50.74	21.97
3420	50.78	22.01
3480	50.79	22.02
3540	50.82	22.05
3600	50.81	22.04
3660	50.86	22.09
3720	50.86	22.09
3780	50.83	22.06
3840	50.91	22.14
3900	50.91	22.14
3960	50.9	22.13
4020	50.94	22.17
4080	50.94	22.17
4140	50.97	22.20
4200	50.96	22.19
4260	50.9	22.13
4320	50.93	22.16
4380	50.95	22.18
4440	50.96	22.19
4500	50.95	22.18
4560	50.88	22.11
4620	50.94	22.17
4680	50.95	22.18
4740	50.88	22.11
4800	50.89	22.12
4860	50.93	22.16
4920	50.89	22.12
4980	50.94	22.17
5040	50.88	22.11
5100	50.97	22.20
5160	51.03	22.26
5220	51.08	22.31
5280	51.14	22.37
5340	51.08	22.31
5400	51.13	22.36
5460	51.18	22.41
5520	51.09	22.32
5580	51.21	22.44
5640	51.18	22.41
5700	51.14	22.37
5760	51.14	0.60



Δs =	1	m	Q =	21.69	L/s	1795.90	m^3 / d	T = [0.183Q / Δs] =	328.704	m^2 / d

MEN-2: Recovery

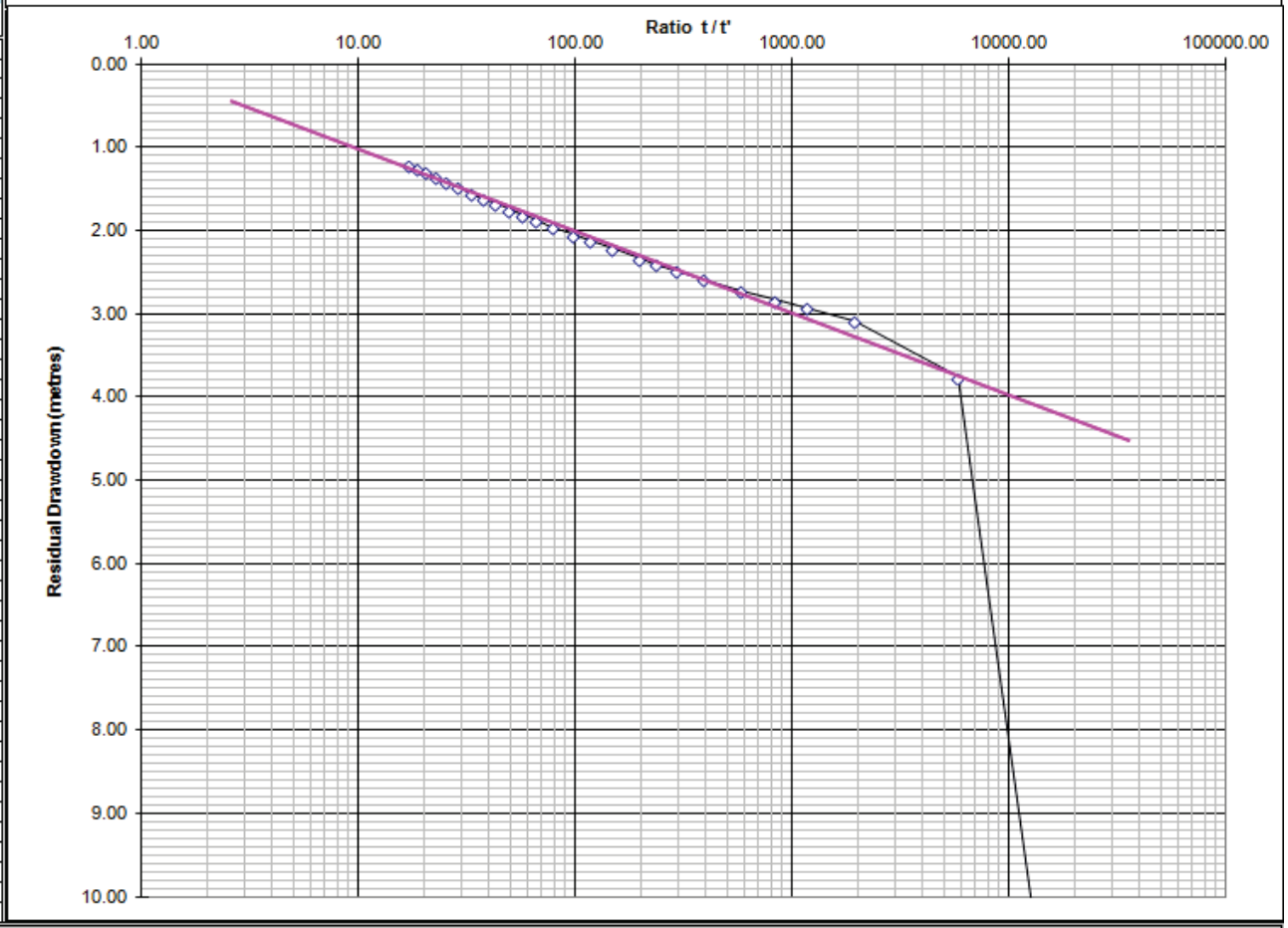
SWL =	28.77	m
DDL =	51.14	m
Q =	20.79	L/s
Duration :	5760	minutes

PUMPING TEST ANALYSIS - *Recovery Data [pumping bore]*

Pumping Bore No. : *GW273319* Owner : *NSW Office of Water* Date of test *26-Mar-15*

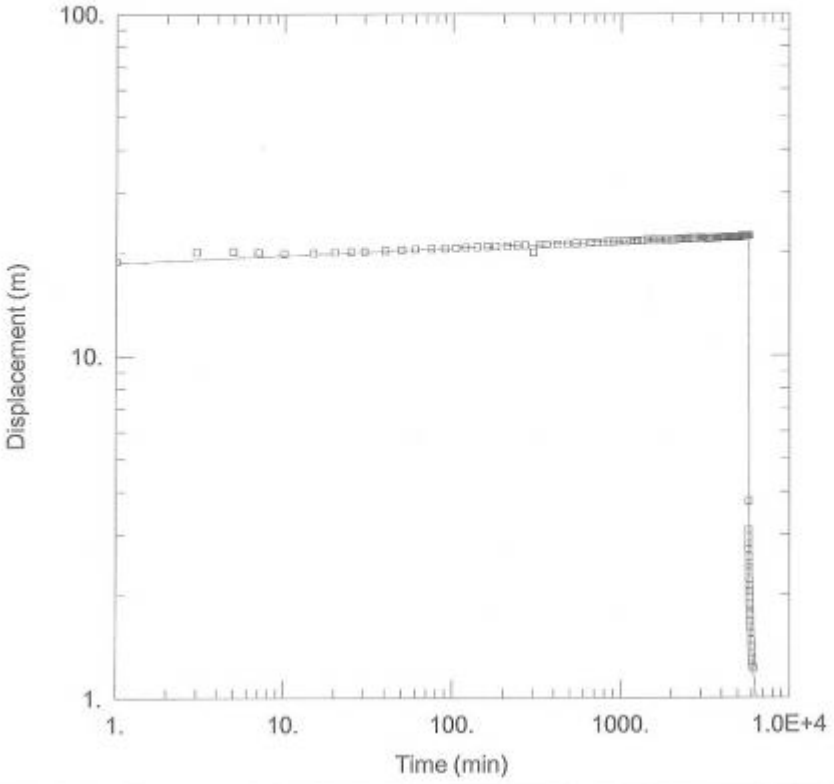
Analysis carried out by : *Mark Mitchell* Date : *26-Mar-15*

Time (t') (min)	Depth to Water (m)	Ratio t/t'	Residual Drawdown (m)
0	51.14	57601.00	22.37
1	32.53	5761.00	3.76
3	31.86	1921.00	3.09
5	31.70	1153.00	2.93
7	31.60	823.86	2.83
10	31.49	577.00	2.72
15	31.35	385.00	2.58
20	31.25	289.00	2.48
25	31.17	231.40	2.40
30	31.10	193.00	2.33
40	30.98	145.00	2.21
50	30.89	116.20	2.12
60	30.82	97.00	2.05
75	30.73	77.80	1.96
90	30.64	65.00	1.87
105	30.58	55.86	1.81
120	30.52	49.00	1.75
140	30.44	42.14	1.67
160	30.38	37.00	1.61
180	30.32	33.00	1.55
210	30.24	28.43	1.47
240	30.18	25.00	1.41
270	30.12	22.33	1.35
300	30.07	20.20	1.30
330	30.02	18.45	1.25
360	29.99	17.00	1.22
			0.00
			0.00



Δs = 0.90 m Q = 20.8 L/s 1795.9 m3 / d **T =** [0.183Q / Δs] = 365.167 m2 / d

MEN-2: Constant rate (Aqtesolv analysis)



WELL TEST ANALYSIS

Data Set: F:\...\aqtesolv_men2_constant_rate_trial-2015-05-16.aqt
Date: 05/18/15 Time: 09:13:43

PROJECT INFORMATION

Company: NSW Office of Water
Client: Essential energy
Location: Lake Menindee
Test Well: MEN2
Test Date: 26/3/2015

AQUIFER DATA

Saturated Thickness: 12. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
MEN2	630083	6425635

Observation Wells

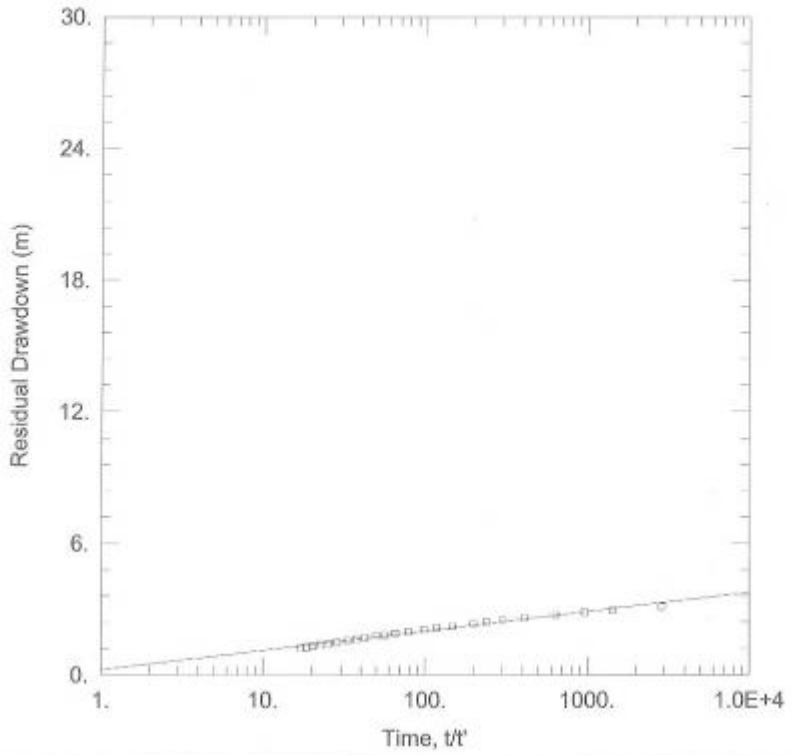
Well Name	X (m)	Y (m)
MEN2	630083	6425635

SOLUTION

Aquifer Model: Confined Solution Method: Papadopulos-Cooper

T = 331. m^2/day S = 3.624E-5
r(w) = 4.898E-8 m r(c) = 0.04677 m

MEN-2: Recovery



WELL TEST ANALYSIS

Data Set: U:\...\aqtesolv_men2_constant_rate_2015-03-31.aqt
Date: 05/04/15 Time: 14:29:14

PROJECT INFORMATION

Company: NSW Office of Water
Client: Essential energy
Location: Lake Menindee
Test Well: MEN2
Test Date: 26/3/2015

AQUIFER DATA

Saturated Thickness: 12. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
MEN2	630083	6425635

Observation Wells

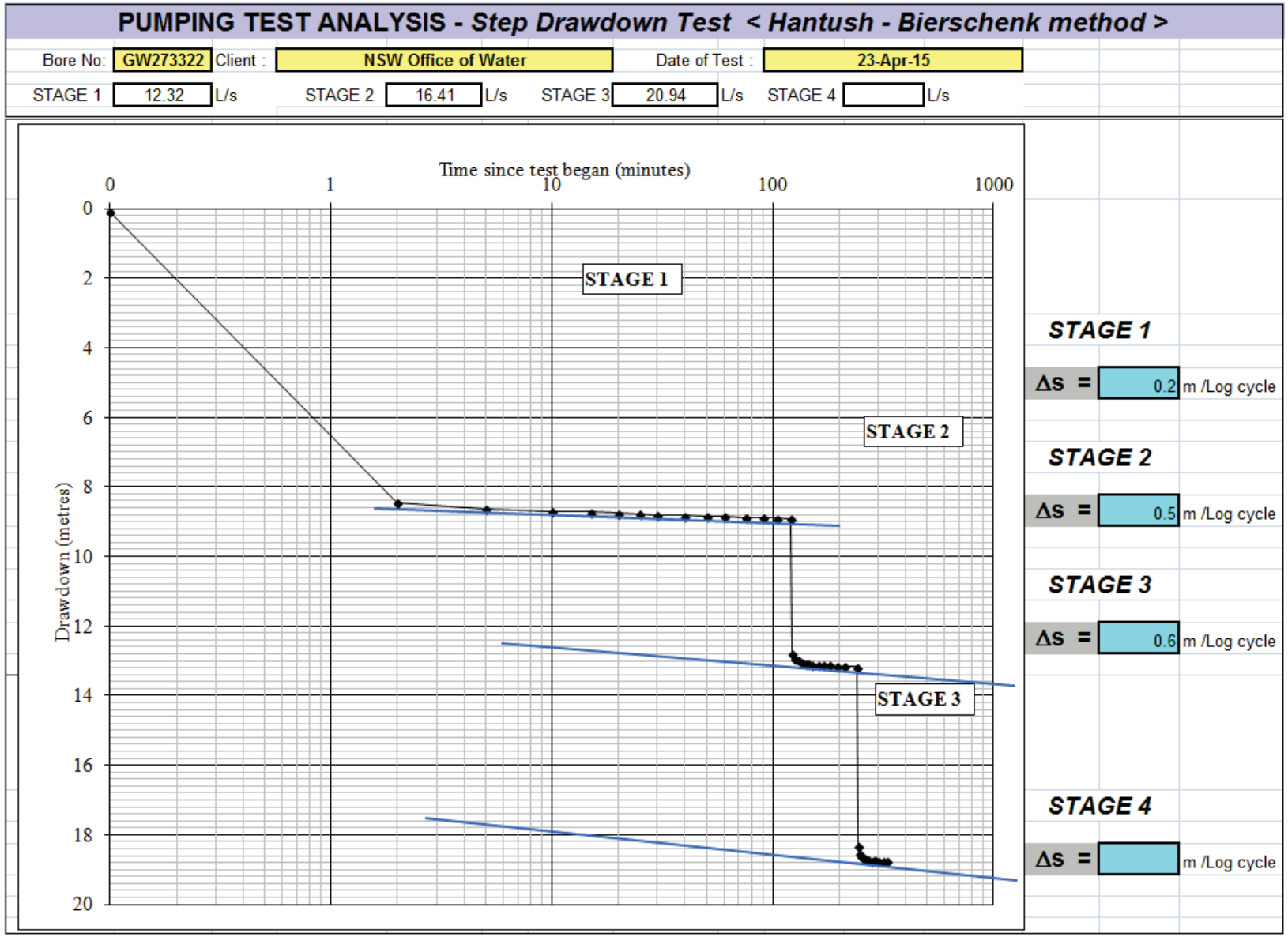
Well Name	X (m)	Y (m)
MEN2	630083	6425635

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 372.7 m^2/day S/S' = 0.5631

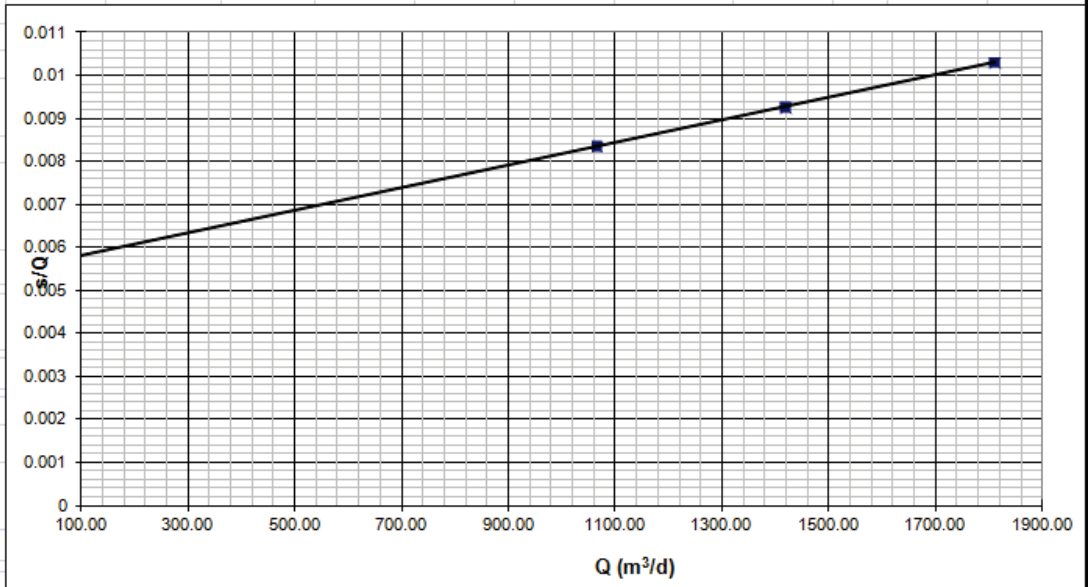
MEN-6: Step drawdown test



PUMPING TEST ANALYSIS - *Step Drawdown Test < Hantush - Bierschenk method >*

STAGE	$\Delta s_{w(n)}$ PROJECTED m	$s_{w(n)}$ CUMULATIVE m	Q_n YIELD m^3/d	$s_{w(n)}/Q_n$ d/m^2
1	8.91	8.91	1064.44	0.00837059
2	4.23	13.14	1417.57	0.00927219
3	5.53	18.67	1809.07	0.01031966
4				

Bore No: GW273322 Client : NSW Office of Water Date of Test : 23-Apr-15



Intercept **B** = 0.0058

Slope Calculation

X Axis value = 900

Y Axis value = 0.008

Slope **C** = 2.44E-06

Proposed pumping rate **Q** = 47 L/s

Laminar flow percentage

$$L_p = \frac{BQ}{BQ + CQ^2} \times 100$$

36.88 % Laminar Flow

DRAWDOWN EQUATION [After 120 minutes]

$s_w = BQ + CQ^2$ = **63.86 metres**

BORE EFFICIENCY ANALYSIS From Constant Rate Pumping Test < Cooper & Jacob Equation >

From Constant Rate Pumping Test

Discharge Rate "**Q**"		20.96	L/s
Drawdown "**s**"after	4 Day/s	19.83	m
Transmissivity "**T**"		258.00	m^2/D
Storativity "**S**"		0.00012	

Theoretical Specific Capacity = **151.954** $m^3/D/m$ See page 1021

Actual Specific Capacity [**Q/s**] **91.304** $m^3/D/m$

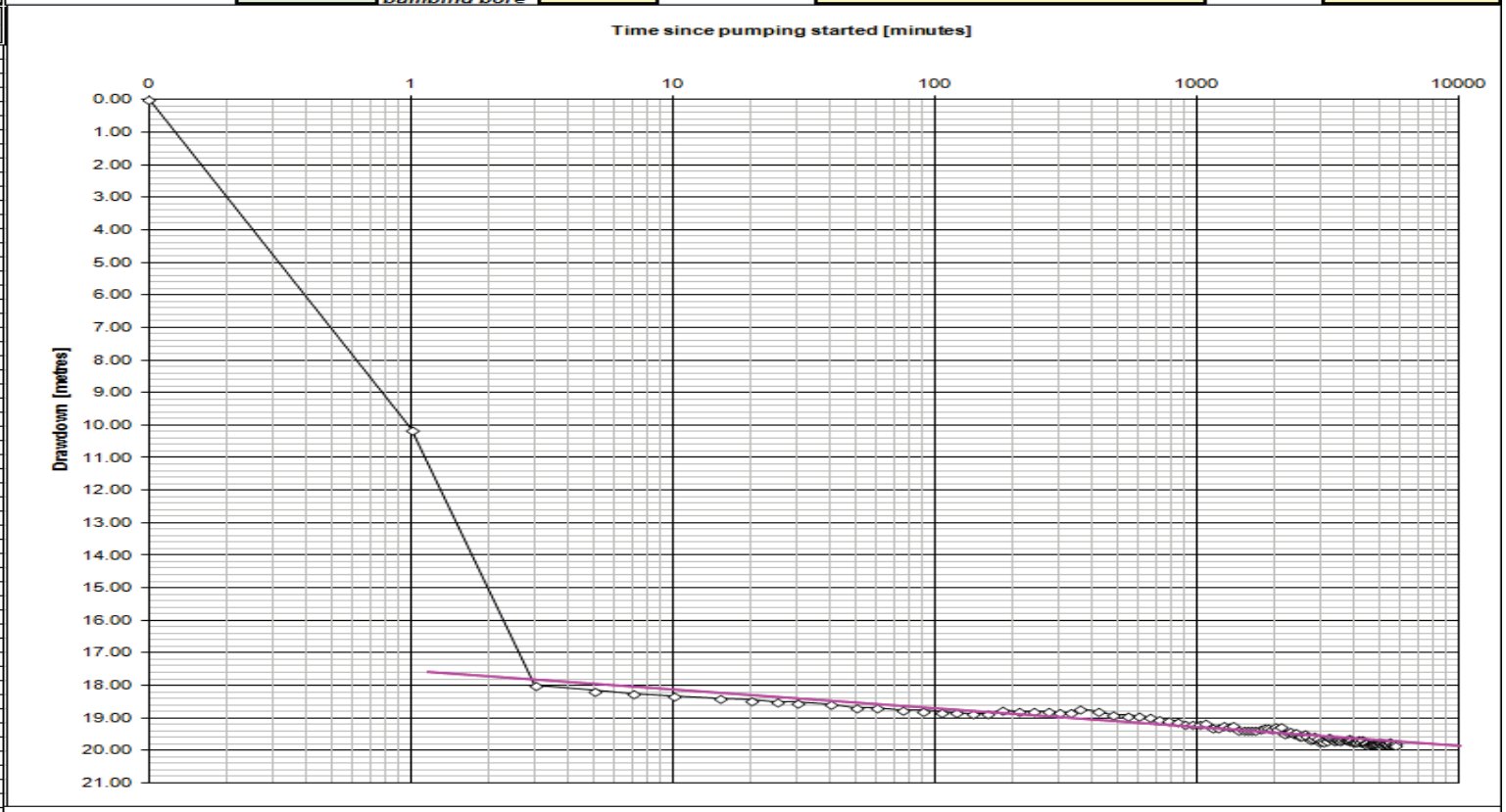
BORE EFFICIENCY = 60.09 %

"t" for Theoretical Specific Capacity= 1 to 4 days

MEN-6: Constant rate (Jacob straight line)

SWL =	30.15	m	PUMPING TEST ANALYSIS - *Time Drawdown Data [pumping bore]*					
Q =	20.96	L/s	Pumping Bore No.:	GW273322	Owner :	NSW Office of Water	Date of Test :	24-Apr-15
Any Observation Bore? Yes / No	yes		Observation Bore No.:	GW273319	Distance from pumping bore	660	Analysed by:	Mark Mitchell	Date :	1-May-15

Time (min)	DDL (m)	Drawdown (m)
0.1	30.15	0.00
1	40.28	10.13
2940	49.87	19.72
3000	49.85	19.70
3060	49.88	19.73
3120	49.85	19.70
3180	49.74	19.59
3240	49.75	19.60
3300	49.79	19.64
3360	49.83	19.68
3420	49.82	19.67
3480	49.82	19.67
3540	49.85	19.70
3600	49.79	19.64
3660	49.79	19.64
3720	49.82	19.67
3780	49.77	19.62
3840	49.85	19.70
3900	49.8	19.65
3960	49.87	19.72
4020	49.88	19.73
4080	49.88	19.73
4140	49.82	19.67
4200	49.86	19.71
4260	49.82	19.67
4320	49.92	19.77
4380	49.92	19.77
4440	49.92	19.77
4500	49.98	19.83
4560	49.95	19.80
4620	49.96	19.81
4680	49.94	19.79
4740	49.9	19.75
4800	49.93	19.78
4860	49.93	19.78
4920	49.87	19.72
4980	49.89	19.74
5040	49.91	19.76
5100	49.94	19.79
5160	49.92	19.77
5220	49.92	19.77
5280	49.9	19.75
5340	49.94	19.79
5400	49.88	19.73
5460	49.87	19.72
5520	49.94	19.79
5580	49.98	19.83
5640	49.97	19.82
5700	49.91	19.76
5760	49.97	19.82



Δs =	0.7	m	Q =	20.96	L/s	1810.56	m^3 / d	T = [0.183Q / Δs] =	473.409	m^2 / d

MEN-6: Recovery

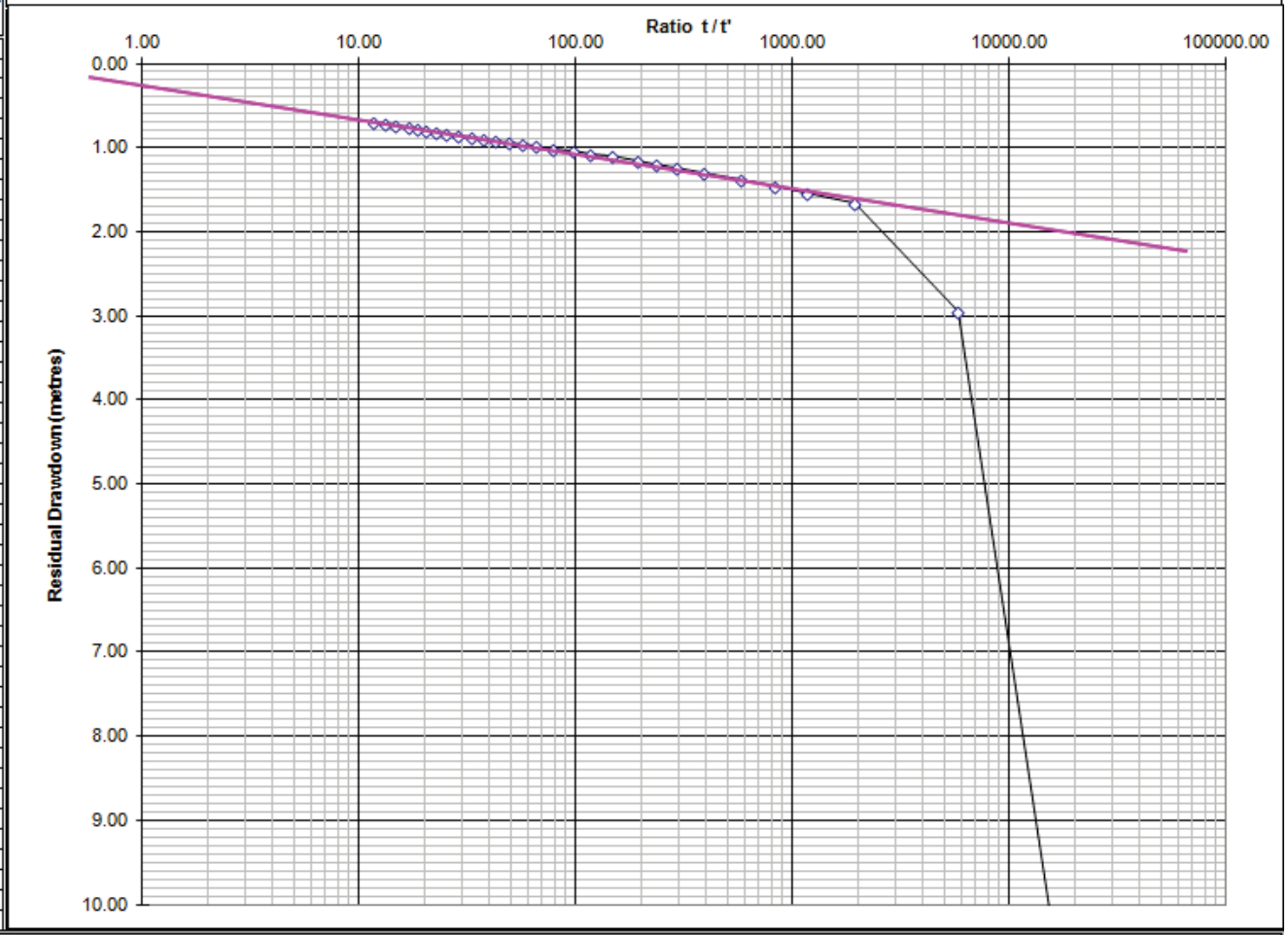
SWL =	30.15	m
DDL =	49.97	m
Q =	20.96	L/s
Duration :	5760	minutes

PUMPING TEST ANALYSIS - *Recovery Data [pumping bore]*

Pumping Bore No. : *GW273322* Owner : *NSW Office of Water* Date of test *24-Apr-15*

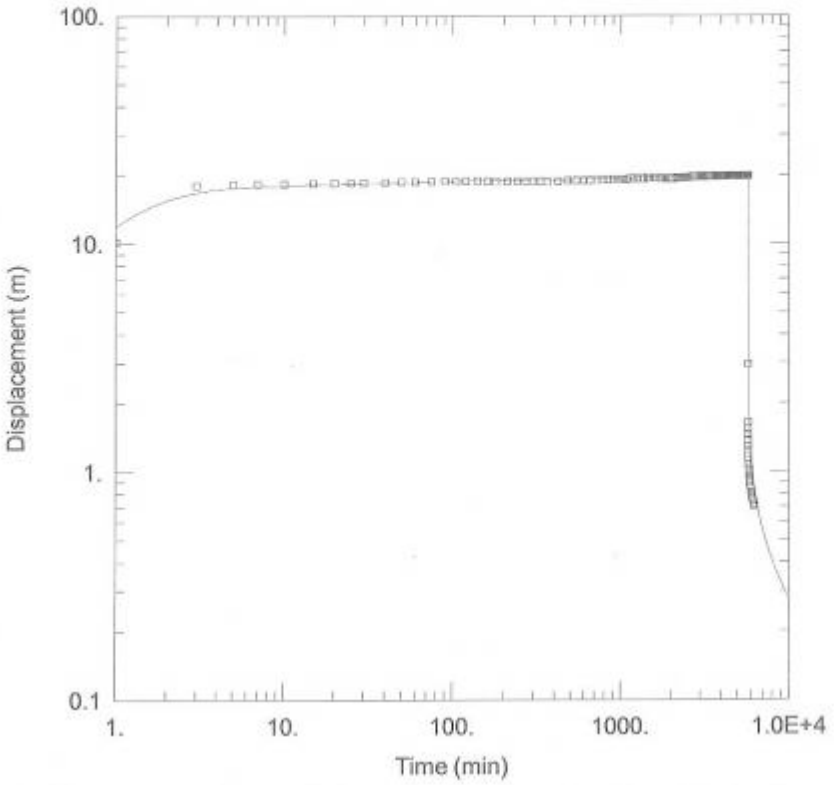
Analysis carried out by : *Mark Mitchell* Date : *1-May-15*

Time (t') (min)	Depth to Water (m)	Ratio t/t'	Residual Drawdown (m)
0	49.97	57601.00	19.82
1	33.10	5761.00	2.95
3	31.80	1921.00	1.65
5	31.68	1153.00	1.53
7	31.60	823.86	1.45
10	31.52	577.00	1.37
15	31.44	385.00	1.29
20	31.38	289.00	1.23
25	31.34	231.40	1.19
30	31.30	193.00	1.15
40	31.25	145.00	1.10
50	31.22	116.20	1.07
60	31.19	97.00	1.04
75	31.16	77.80	1.01
90	31.13	65.00	0.98
105	31.10	55.86	0.95
120	31.08	49.00	0.93
140	31.06	42.14	0.91
160	31.04	37.00	0.89
180	31.02	33.00	0.87
210	31.00	28.43	0.85
240	30.98	25.00	0.83
270	30.96	22.33	0.81
300	30.94	20.20	0.79
330	30.92	18.45	0.77
360	30.91	17.00	0.76
420	30.89	14.71	0.74
480	30.87	13.00	0.72
540	30.85	11.67	0.70



Δs = 0.40 m Q = 21 L/s 1810.6 m3 / d T = [0.183Q / Δs] = 828.330 m2 / d

MEN-6: Constant rate (Aqtesolv analysis)



WELL TEST ANALYSIS

Data Set: F:\...\men6_constant_rate_pap_2015-05-16.aqt
Date: 05/18/15 Time: 09:14:01

PROJECT INFORMATION

Company: NSW Office of Water
Client: Essential energy
Location: Lake Menindee
Test Well: MEN6
Test Date: 24/4/2015

AQUIFER DATA

Saturated Thickness: 12. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
MEN6	631391	6424131

Observation Wells

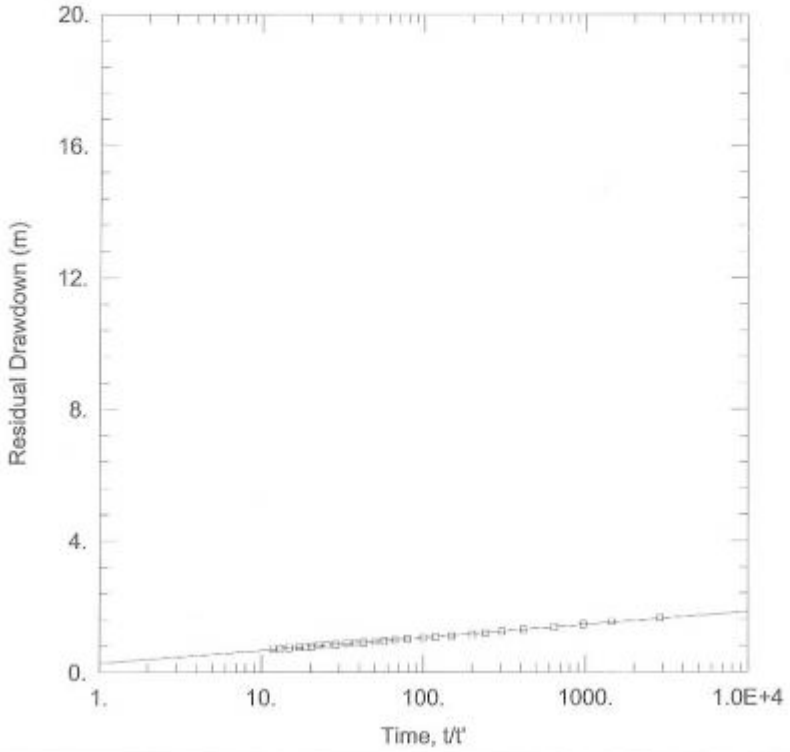
Well Name	X (m)	Y (m)
MEN6	631391	6424131

SOLUTION

Aquifer Model: Confined Solution Method: Papadopulos-Cooper

T = 450. m^2/day S = 0.0003776
r(w) = 1.0E-10 m r(c) = 0.1476 m

MEN-6: Recovery (Aqtesolv)



WELL TEST ANALYSIS

Data Set: U:\...\men6_constant_rate.aqt
Date: 05/04/15 Time: 14:11:42

PROJECT INFORMATION

Company: NSW Office of Water
Client: Essential energy
Location: Lake Menindee
Test Well: MEN6
Test Date: 24/4/2015

AQUIFER DATA

Saturated Thickness: 12. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
MEN6	631391	6424131

Observation Wells

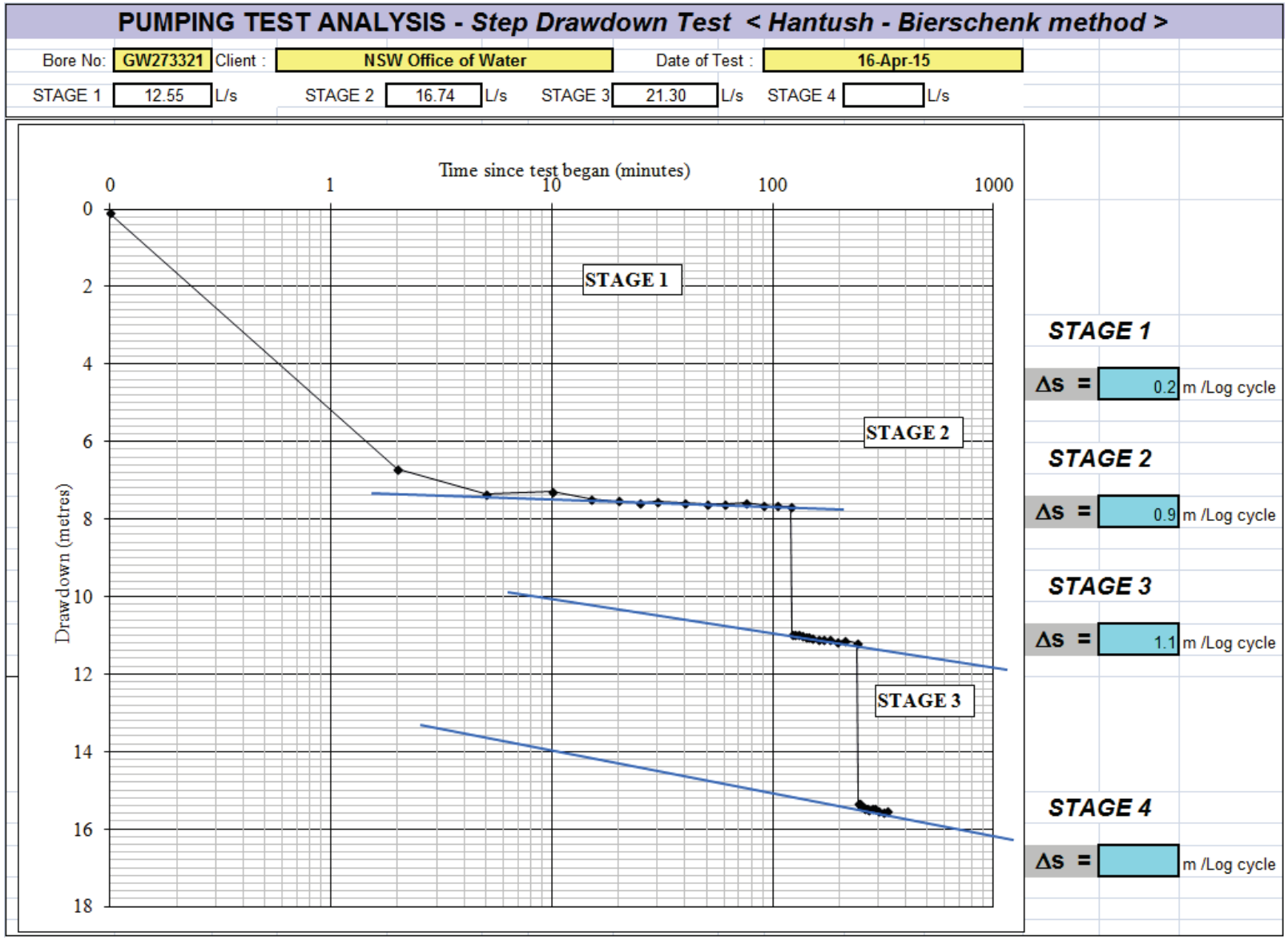
Well Name	X (m)	Y (m)
MEN6	631391	6424131

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 846.1 m^2/day S/S' = 0.1999

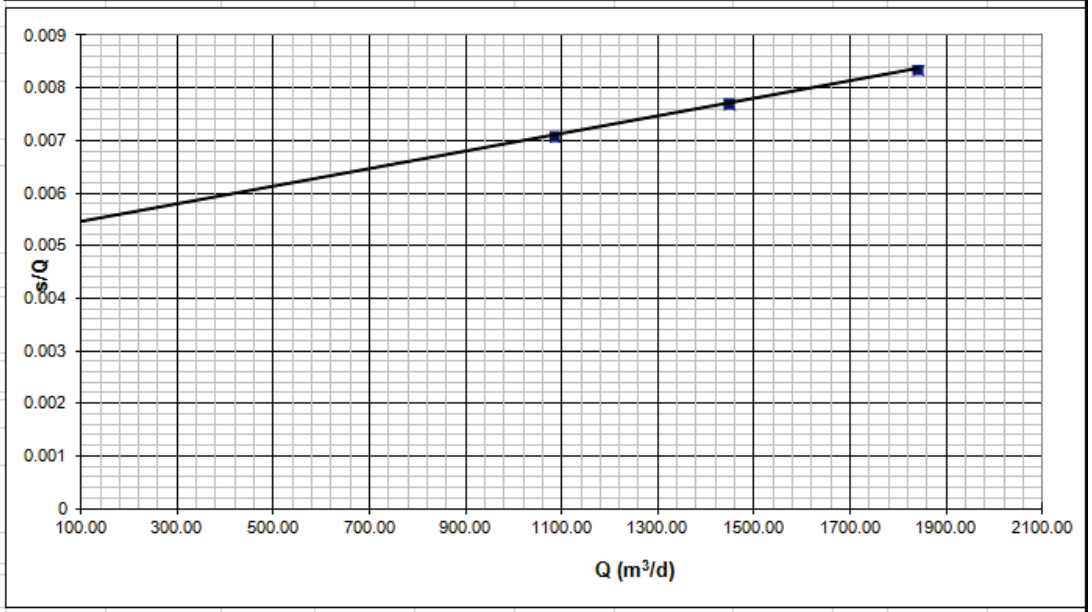
MEN-9: Step drawdown test



PUMPING TEST ANALYSIS - *Step Drawdown Test < Hantush - Bierschenk method >*

STAGE	$\Delta s_{w(n)}$ PROJECTED m	$s_{w(n)}$ CUMULATIVE m	Q_n YIELD m^3/d	$s_{w(n)}/Q_n$ d/m^2
1	7.69	7.69	1084.29	0.00709219
2	3.48	11.17	1446.41	0.00772534
3	4.21	15.39	1840.72	0.00835925
4				

Bore No: GW273321 Client : NSW Office of Water Date of Test : 16-Apr-15



Intercept **B** = 0.0055

Slope Calculation

X Axis value = 1500

Y Axis value = 0.0078

Slope **C** = 1.53E-06

Proposed pumping rate **Q** = *51* L/s

Laminar flow percentage

$$L_p = \frac{BQ}{BQ + CQ^2} \times 100$$

44.87 % Laminar Flow

DRAWDOWN EQUATION [After 120 minutes]

$s_w = BQ + CQ^2$ = **54.01 metres**

BORE EFFICIENCY ANALYSIS From Constant Rate Pumping Test < Cooper & Jacob Equation >

From Constant Rate Pumping Test

Discharge Rate "**Q**"		21.26	L/s
Drawdown "**s**"after	4 Day/s	17.21	m
Transmissivity "**T**"		258.00	m^2/D
Storativity "**S**"		0.0032	

Theoretical Specific Capacity = **179.550** $m^3/D/m$ See page 1021

Actual Specific Capacity [**Q/s**] **106.755** $m^3/D/m$

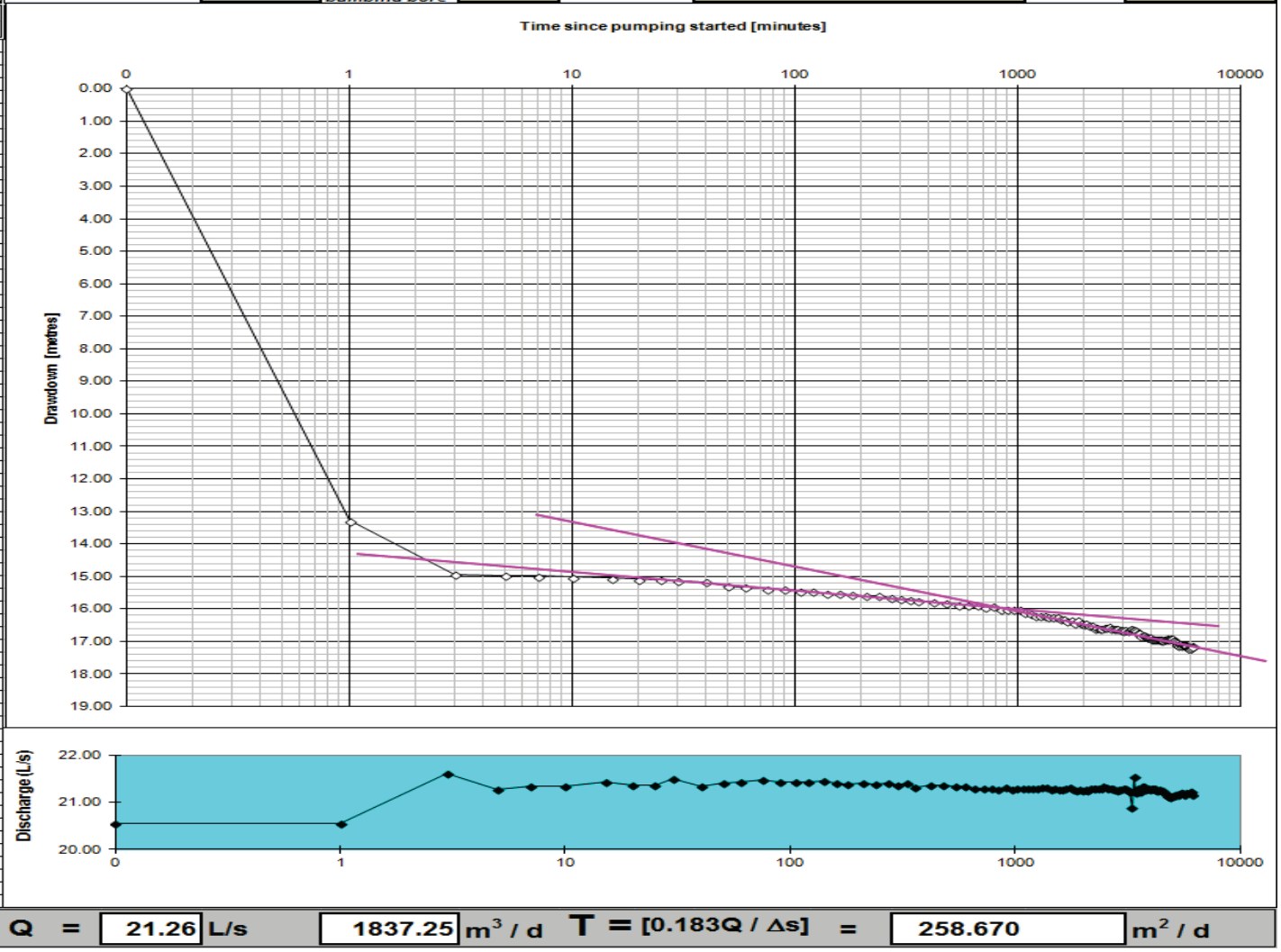
BORE EFFICIENCY = 59.46 %

"t" for Theoretical Specific Capacity= 1 to 4 days

MEN-9: Constant rate (Jacob straight line)

SWL =	29.11	m	PUMPING TEST ANALYSIS - *Time Drawdown Data [pumping bore]*						
Q =	21.26	L/s	Pumping Bore No.:	GW273319	Owner :	NSW Office of Water		Date of Test :	17-Apr-15
Any Observation Bore? Yes / No	yes		Observation Bore No.:	GW273322	Distance from pumping bore	660	Analysed by:	Mark Mitchell	Date : 24-Apr-15

Time (min)	DDL (m)	Drawdown (m)
0.1	29.11	0.00
1	42.4	13.29
2940	45.74	16.63
3000	45.77	16.66
3060	45.75	16.64
3120	45.78	16.67
3180	45.74	16.63
3240	45.73	16.62
3300	45.76	16.65
3360	45.75	16.64
3420	45.79	16.68
3480	45.84	16.73
3540	45.86	16.75
3600	45.94	16.83
3660	45.91	16.80
3720	45.94	16.83
3780	45.96	16.85
3840	45.99	16.88
3900	45.98	16.87
3960	45.96	16.85
4020	46.04	16.93
4080	46.03	16.92
4140	46.03	16.92
4200	46.03	16.92
4260	46.04	16.93
4320	46.05	16.94
4380	46.06	16.95
4440	46.05	16.94
4500	46.06	16.95
4560	46.05	16.94
4620	46.04	16.93
4680	46.01	16.90
4740	46.04	16.93
4800	46.04	16.93
4860	46.01	16.90
4920	46.02	16.91
4980	46.06	16.95
5040	46.09	16.98
5100	46.11	17.00
5160	46.13	17.02
5220	46.2	17.09
5280	46.23	17.12
5340	46.18	17.07
5400	46.2	17.09
5460	46.23	17.12
5520	46.22	17.11
5580	46.23	17.12
5640	46.22	17.11
6000	46.29	17.18
6120	46.28	0.60



Δs =	1.3	m	Q =	21.26	L/s	1837.25	m^3 / d	T = [0.183Q / Δs] = 258.670 m^2 / d

MEN-9: Recovery

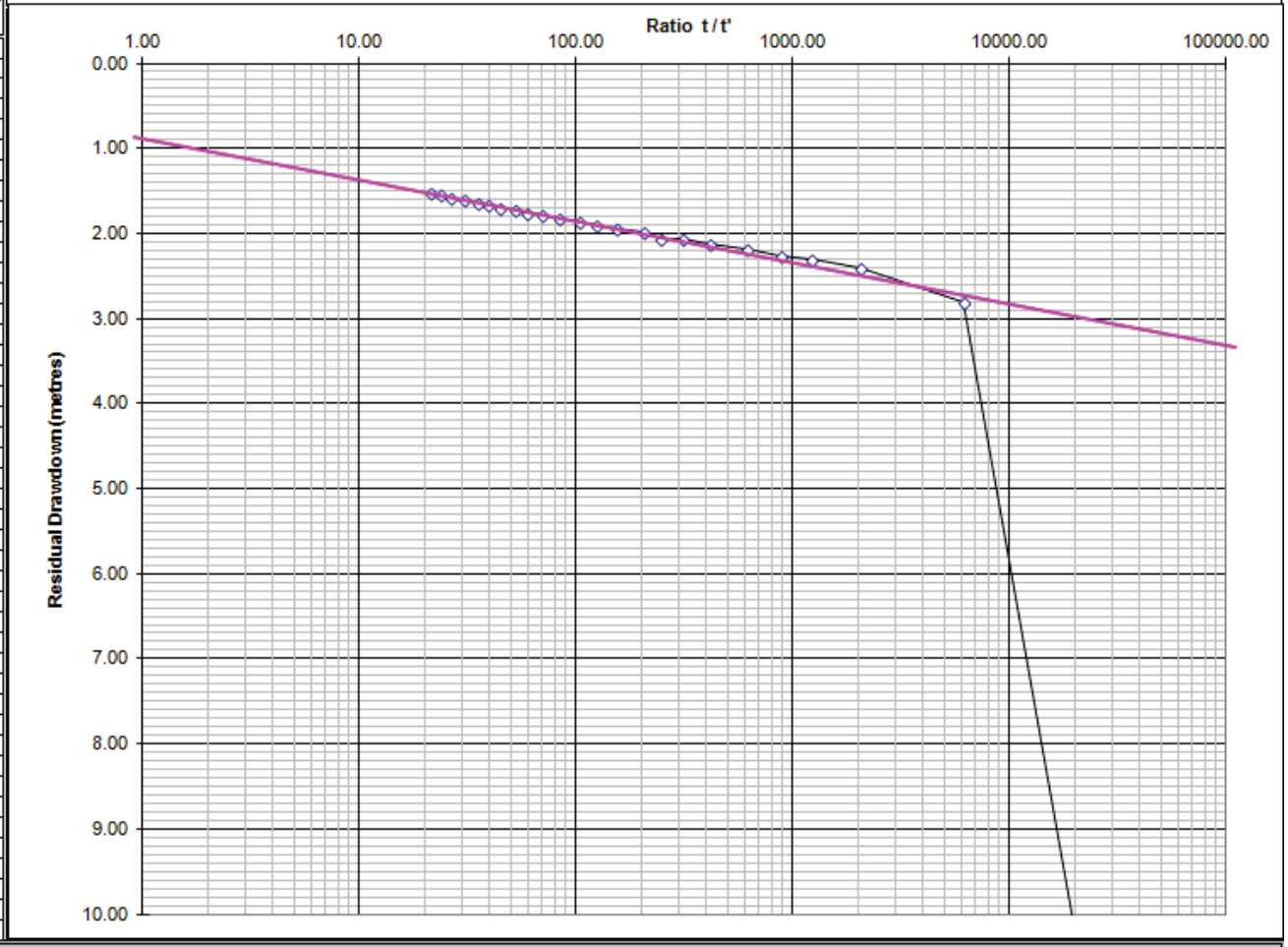
SWL =	29.11	m
DDL =	46.28	m
Q =	21.26	L/s
Duration :	6120	minutes

PUMPING TEST ANALYSIS - *Recovery Data [pumping bore]*

Pumping Bore No. : *GW273321* Owner : *NSW Office of Water* Date of test *17-Apr-15*

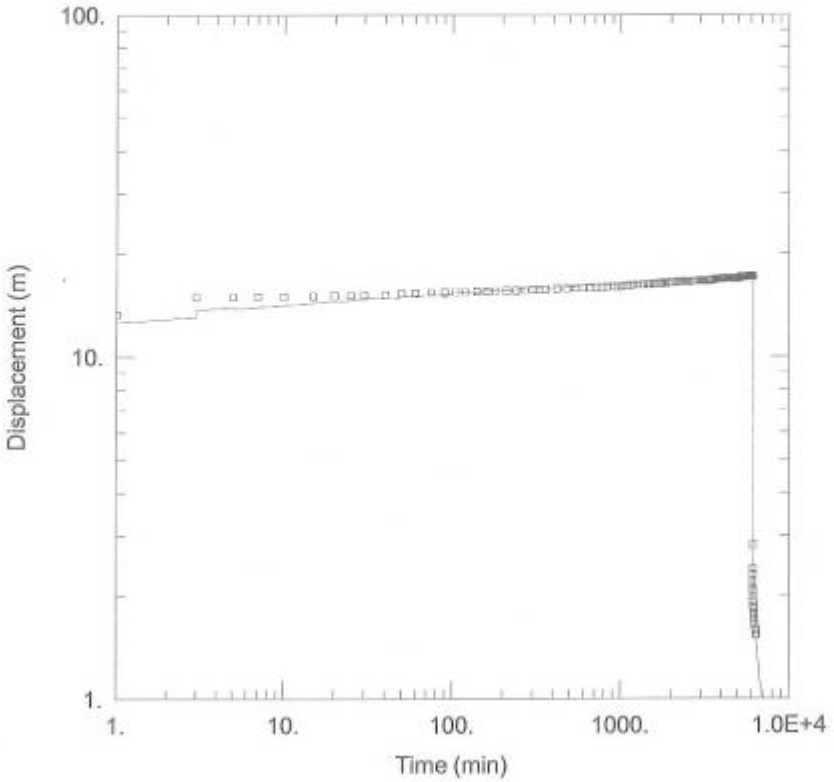
Analysis carried out by : *Mark Mitchell* Date : *24-Apr-15*

Time (t') (min)	Depth to Water (m)	Ratio t/t'	Residual Drawdown (m)
0	46.28	61201.00	17.17
1	31.92	6121.00	2.81
3	31.51	2041.00	2.40
5	31.42	1225.00	2.31
7	31.37	875.29	2.26
10	31.30	613.00	2.19
15	31.23	409.00	2.12
20	31.17	307.00	2.06
25	31.17	245.80	2.06
30	31.10	205.00	1.99
40	31.05	154.00	1.94
50	31.01	123.40	1.90
60	30.97	103.00	1.86
75	30.94	82.60	1.83
90	30.90	69.00	1.79
105	30.87	59.29	1.76
120	30.84	52.00	1.73
140	30.82	44.71	1.71
160	30.78	39.25	1.67
180	30.75	35.00	1.64
210	30.72	30.14	1.61
240	30.69	26.50	1.58
270	30.65	23.67	1.54
300	30.64	21.40	1.53
			0.00
			0.00
			0.00
			0.00



Δs = 0.45 m Q = 21.3 L/s 1837.2 m3 / d T = [0.183Q / Δs] = 747.146 m2 / d

MEN-9: Constant rate (aqutesolv)



WELL TEST ANALYSIS

Data Set: F:\...\men9_constant_rate_2015-05-16.aqt
Date: 05/18/15 Time: 09:19:34

PROJECT INFORMATION

Company: NSW Office of Water
Client: Essential energy
Location: Lake Menindee
Test Well: MEN9
Test Date: 17/4/2015

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
MEN9	631420	6424414

Observation Wells

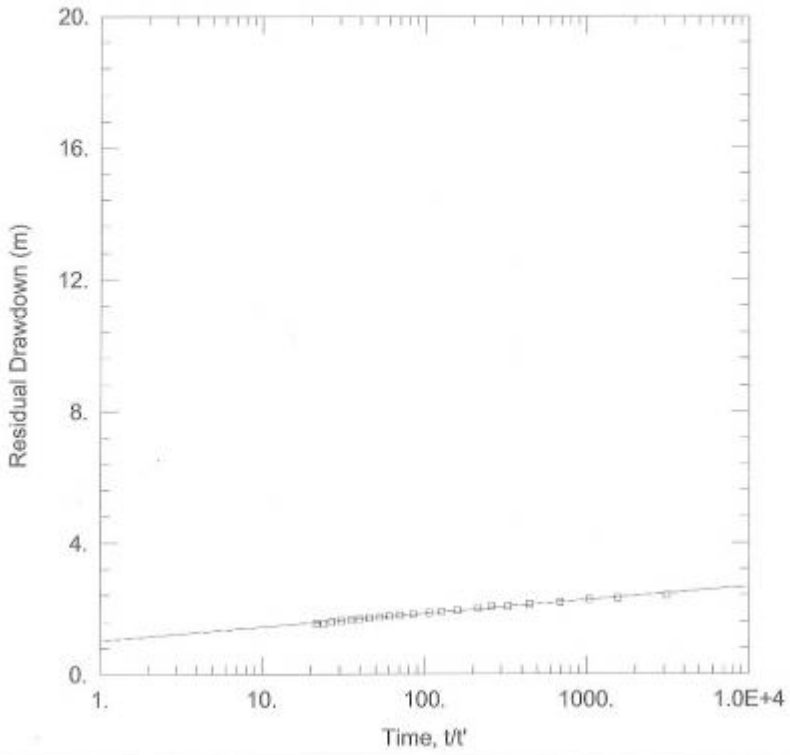
Well Name	X (m)	Y (m)
MEN9	631420	6424414

SOLUTION

Aquifer Model: Confined
Solution Method: Theis

T = 310.4 m^2/day
Kz/Kr = 1.
S = 0.0006024
b = 16. m

MEN-9: Recovery



WELL TEST ANALYSIS

Data Set: U:\...\men9_constant_rate.aqt
Date: 05/04/15 Time: 14:13:59

PROJECT INFORMATION

Company: NSW Office of Water
Client: Essential energy
Location: Lake Menindee
Test Well: MEN9
Test Date: 17/4/2015

AQUIFER DATA

Saturated Thickness: 16. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
MEN9	631420	6424414

Observation Wells

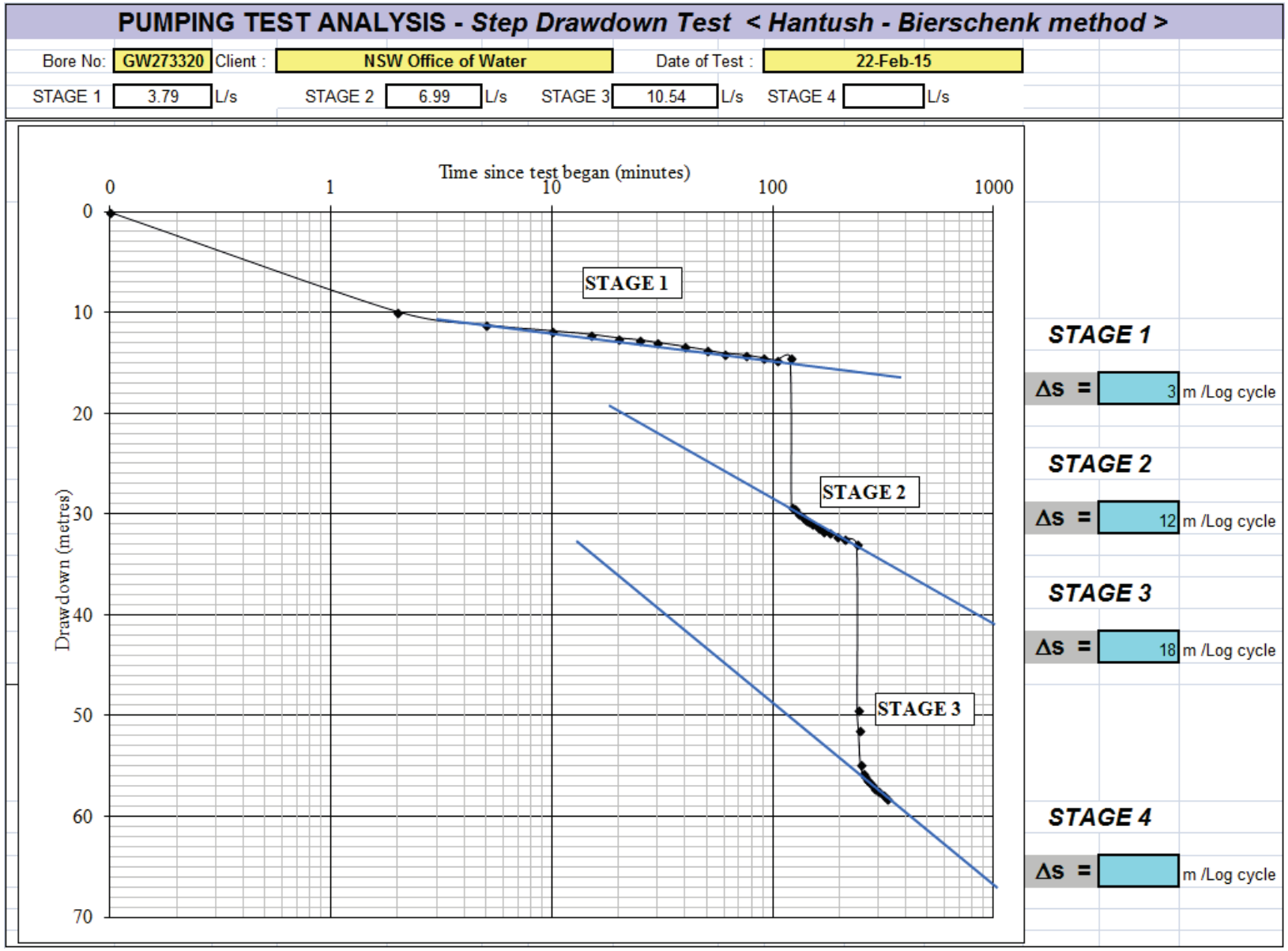
Well Name	X (m)	Y (m)
▫ MEN9	631420	6424414

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 809.7 m^2/day S/S' = 0.003622

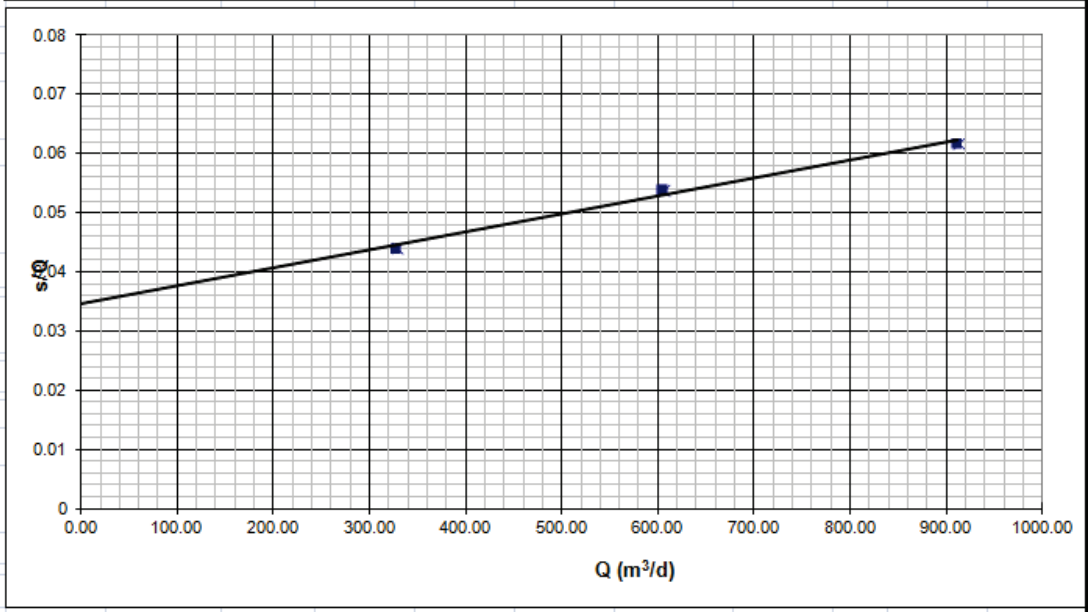
MEN-11: Step drawdown



PUMPING TEST ANALYSIS - *Step Drawdown Test < Hantush - Bierschenk method >*

STAGE	$\Delta s_{w(n)}$ PROJECTED m	$s_{w(n)}$ CUMULATIVE m	Q_n YIELD m^3/d	$s_{w(n)}/Q_n$ d/m^2
1	14.45	14.45	327.47	0.04412613
2	18.11	32.56	603.91	0.05391493
3	23.74	56.30	910.76	0.06181672
4				

Bore No: GW273320 Client : NSW Office of Water Date of Test : 22-Feb-15



Intercept **B** = 0.034

Slope Calculation

X Axis value = 500

Y Axis value = 0.05

Slope **C** = 0.000032

Proposed pumping rate Q = 6 L/s

Laminar flow percentage

$$L_p = \frac{BQ}{BQ + CQ^2} \times 100$$

67.21 % Laminar Flow

DRAWDOWN EQUATION [After 120 minutes]

$s_w = BQ + CQ^2$ = **26.23 metres**

BORE EFFICIENCY ANALYSIS From Constant Rate Pumping Test < Cooper & Jacob Equation >

From Constant Rate Pumping Test

Discharge Rate "Q"		10.84	L/s	Theoretical Specific Capacity =	15.542	$m^3/D/m$
Drawdown "s"after	4 Day/s	9.78	m			
Transmissivity "T"		23.66	m^2/D	Actual Specific Capacity [Q/s]	95.734	$m^3/D/m$
Storativity "S"		0.0001				

See page 1021

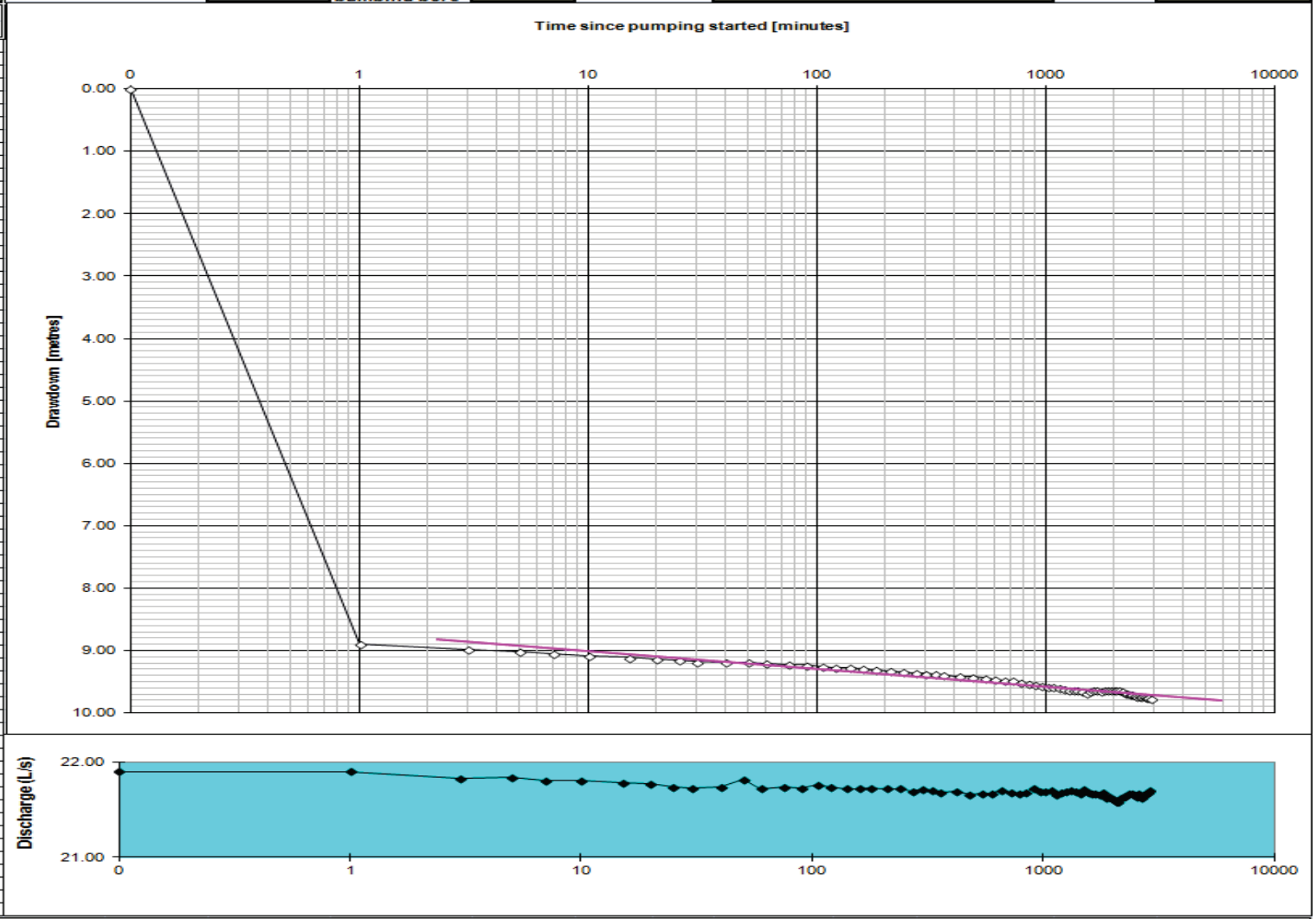
BORE EFFICIENCY = 616 %

"t" for Theoretical Specific Capacity= 1 to 4 days

MEN-11: Constant rate (Jacob straight line)

SWL =	30.72	m	PUMPING TEST ANALYSIS - *Time Drawdown Data [pumping bore]*				
Q =	21.69	L/s	Pumping Bore No.:	GW273220	Owner :	NSW Office of Water	Date of Test : 20-Mar-15
Any Observation Bore? Yes / No	no		Observation Bore No.:		Distance from pumping bore		Analysed by: Mark Mitchell Date : 26-Mar-15

Time (min)	DDL (m)	Drawdown (m)
0.1	30.72	0.00
1	39.62	8.90
3	39.7	8.98
5	39.74	9.02
7	39.77	9.05
10	39.8	9.08
15	39.83	9.11
20	39.86	9.14
25	39.88	9.16
30	39.9	9.18
40	39.91	9.19
50	39.91	9.19
60	39.92	9.20
75	39.94	9.22
90	39.95	9.23
105	39.98	9.26
120	39.99	9.27
140	40	9.28
160	40.01	9.29
180	40.03	9.31
210	40.05	9.33
240	40.07	9.35
270	40.08	9.36
300	40.09	9.37
330	40.1	9.38
360	40.12	9.40
420	40.13	9.41
480	40.14	9.42
540	40.16	9.44
600	40.18	9.46
660	40.2	9.48
720	40.2	9.48
780	40.23	9.51
840	40.25	9.53
900	40.26	9.54
960	40.29	9.57
1020	40.31	9.59
1080	40.3	9.58
1140	40.32	9.60
1200	40.34	9.62
1260	40.35	9.63
1320	40.35	9.63
1380	40.36	9.64
1440	40.38	9.66
1500	40.4	9.68
1560	40.38	9.66
1620	40.36	9.64
1680	40.35	9.63
1740	40.38	9.66
1800	40.35	9.63
1860	40.35	9.63
1920	40.35	9.63
1980	40.35	9.63
2040	40.35	9.63
2100	40.36	9.64
2160	40.38	9.66
2220	40.41	9.69
2280	40.41	9.69
2340	40.43	9.71
2400	40.43	9.71
2460	40.44	9.72
2520	40.46	9.74
2580	40.46	9.74
2640	40.46	9.74
2700	40.46	9.74
2760	40.48	9.76
2820	40.47	9.75
2880	40.5	9.78



Δs =	0.25	m	Q =	21.69	L/s	1874.43	m^3 / d	T = [0.183Q / Δs] =	1372.307	m^2 / d

MEN-11: Recovery

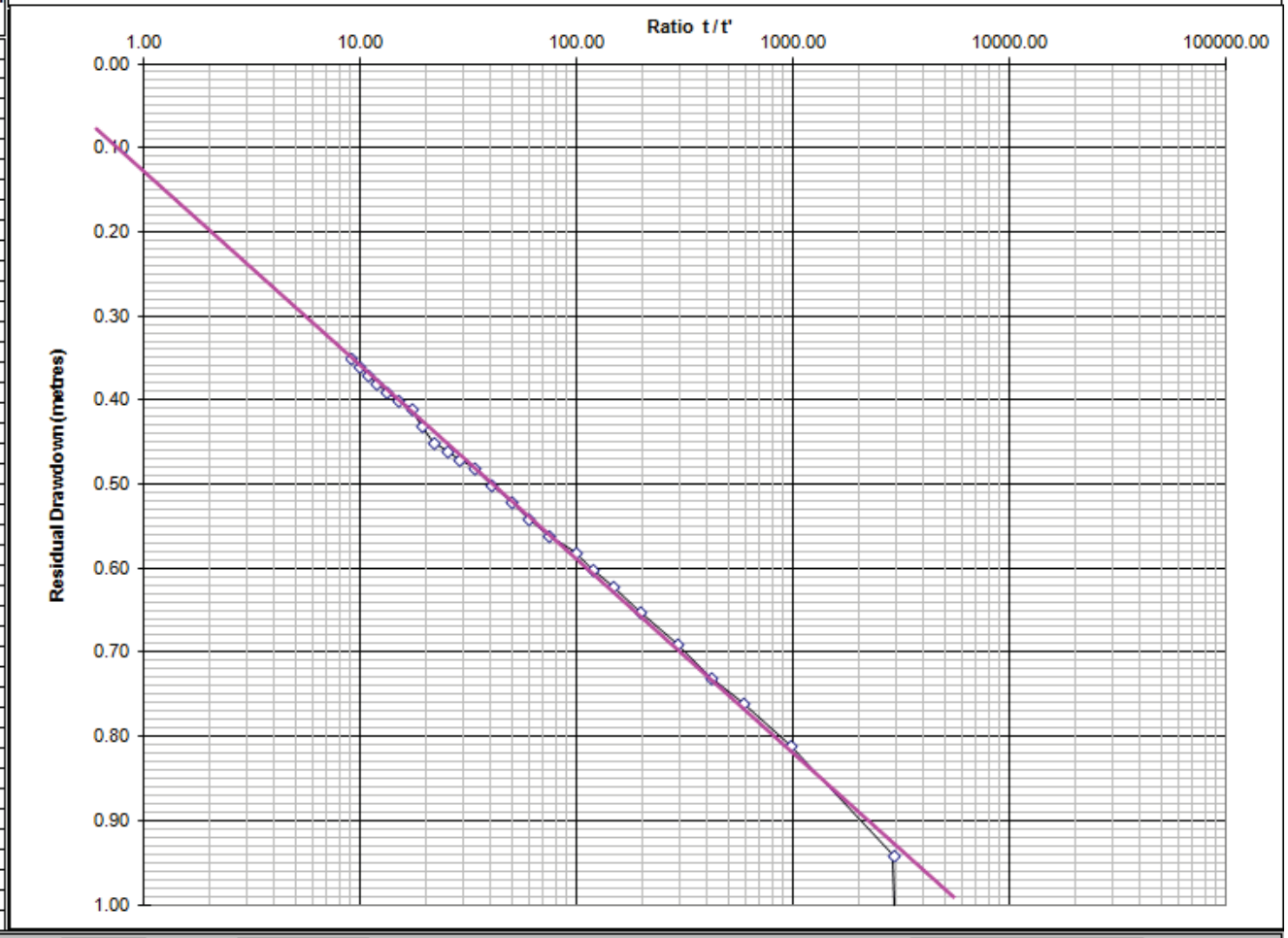
SWL =	30.72	m
DDL =	40.50	m
Q =	21.69	L/s
Duration :	2880	minutes

PUMPING TEST ANALYSIS - *Recovery Data [pumping bore]*

Pumping Bore No. : *GW273220* Owner : *NSW Office of Water* Date of test *20-Mar-15*

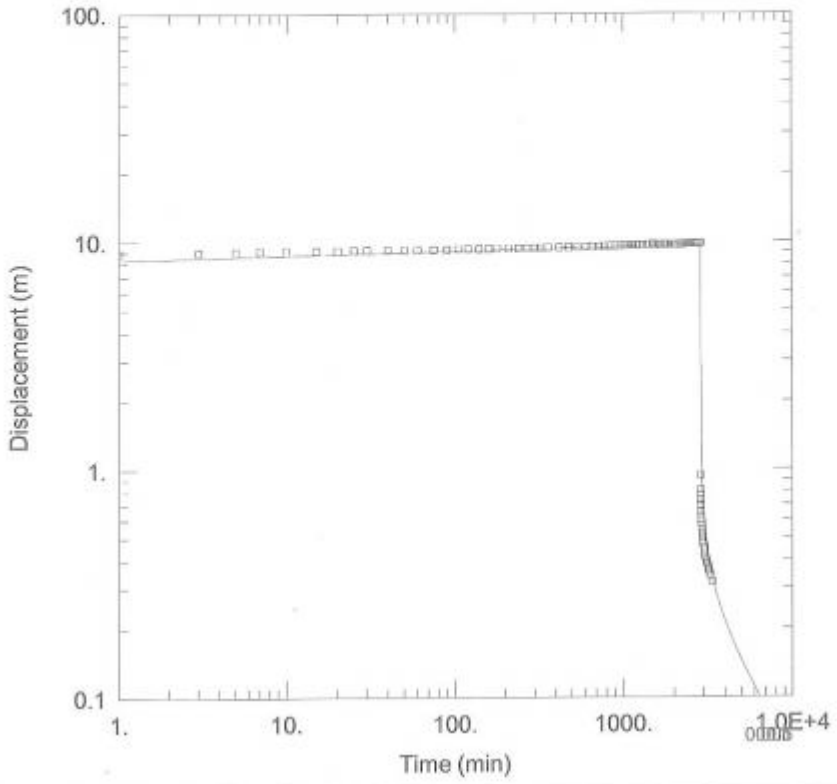
Analysis carried out by : *Mark Mitchell* Date : *26-Mar-15*

Time (t') (min)	Depth to Water (m)	Ratio t/t'	Residual Drawdown (m)
0	40.50	######	9.78
1	31.66	2881.00	0.94
3	31.53	961.00	0.81
5	31.48	577.00	0.76
7	31.45	412.43	0.73
10	31.41	289.00	0.69
15	31.37	193.00	0.65
20	31.34	145.00	0.62
25	31.32	116.20	0.60
30	31.30	97.00	0.58
40	31.28	73.00	0.56
50	31.26	58.60	0.54
60	31.24	49.00	0.52
75	31.22	39.40	0.50
90	31.20	33.00	0.48
105	31.19	28.43	0.47
120	31.18	25.00	0.46
140	31.17	21.57	0.45
160	31.15	19.00	0.43
180	31.13	17.00	0.41
210	31.12	14.71	0.40
240	31.11	13.00	0.39
270	31.10	11.67	0.38
300	31.09	10.60	0.37
330	31.08	9.73	0.36
360	31.07	9.00	0.35
420	31.06	7.86	0.34
480	31.04	7.00	0.32



Δs =	0.23	m	Q =	21.7	L/s	1874.4	m3 / d	T = [0.183Q / Δs] = 1491.393 m2 / d

MEN-11: Constant rate (Aquesolv)



WELL TEST ANALYSIS

Data Set: F:\...\men11_constant_rate.aqt
Date: 05/18/15 Time: 10:13:06

PROJECT INFORMATION

Company: NSW Office of Water
Client: Essential energy
Location: Lake Menindee
Test Well: MEN11
Test Date: 19/3/2015

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
MEN11	632227	6421939

Observation Wells

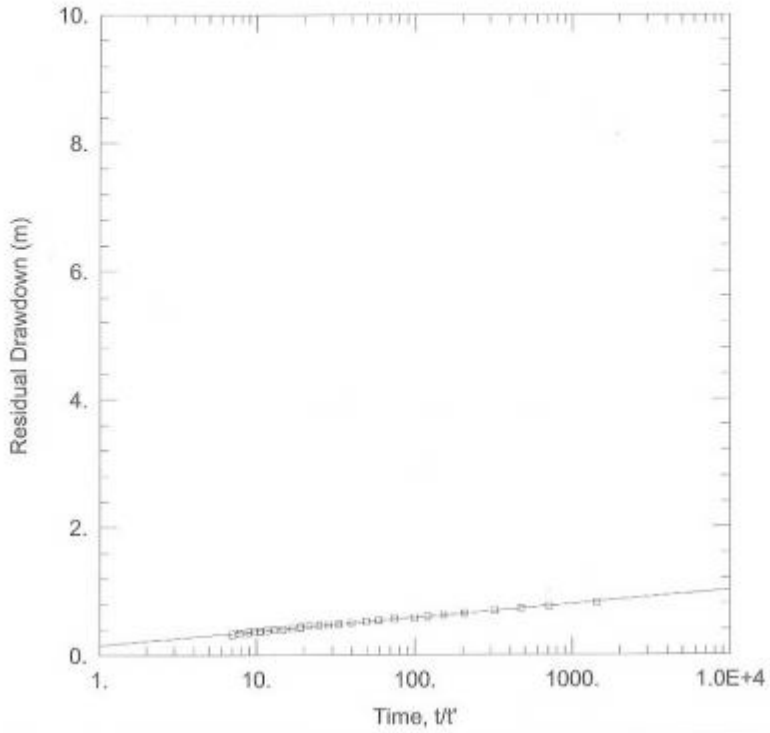
Well Name	X (m)	Y (m)
MEN11	632227	6421939

SOLUTION

Aquifer Model: Confined
Solution Method: Theis

T = 880.8 m^2/day
S = 1.714E-20
Kz/Kr = 1.
b = 18. m

MEN-11: Recovery (Aqutesolv)



WELL TEST ANALYSIS

Data Set: U:\...\men11_constant_rate.aqt
Date: 05/04/15 Time: 14:17:30

PROJECT INFORMATION

Company: NSW Office of Water
Client: Essential energy
Location: Lake Menindee
Test Well: MEN11
Test Date: 19/3/2015

AQUIFER DATA

Saturated Thickness: 18. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
MEN11	632227	6421939	MEN11	632227	6421939

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)
T = 1605.6 m^2/day S/S' = 0.1929

Appendix 7 – Field water quality

Site ID	Work No.	Date	Time	Electrical conductivity (µS/m)	pH	Redox potential (mV)	Dissolved oxygen (%)	Temperature (ºC)
MEN-1	GW273318	21/02/2015	13:40	15,450	6.91	-240.5	18.6	29.5
		22/02/2015	8:30	15,270	6.78	-222.3	16.5	28.9
		22/02/2015	10:00	15,400	6.79	-265.8	13.4	28.7
		22/02/2015	12:30	15,500	6.8	-263.6	17.1	28.4
		23/02/2015	17:30	15,420	6.79	-233.6	15.9	28.3
		24/02/2015	8:50	15,450	6.74	-206.9	17.1	27.6
		25/02/2015	9:30	15,450	6.86	-185.0	17.0	27.4
		25/02/2015	14:30	15,420	6.88	-174.3	21.9	28.6
		26/02/2015	7:00	15,460	6.84	-95.0	14.5	29.0
		26/02/2015	15:00	15,560	6.9	-165.0	20.0	29.1
		27/02/2015	9:30	15,500	6.87	-165.9	26.9	28.1
MEN-2	GW273319	25/03/2015	8:15	15,860	7.03	-124.8	32.7	27.7
		25/03/2015	10:45	15,690	6.95	-131.1	31.2	27.8
		25/03/2015	13:15	15,530	6.97	-121.0	41.9	27.8
		26/03/2015	14:00	15,670	7.06	-129.6	36.0	27.6
		26/03/2015	17:00	15,630	6.96	-142.4	39.0	27.8
		27/03/2015	8:30	15,600	7.01	-147.2	38.0	27.3
		27/03/2015	13:45	15,620	7.00	-122.5	38.3	28.0
		27/03/2015	16:45	15,700	6.93	-126.4	35.2	27.9
		28/03/2015	9:00	15,660	6.95	-139.6	34.2	27.5
		28/03/2015	12:50	15,670	6.98	-124.8	43.5	27.9
		28/03/2015	16:30	15,650	6.98	-130.0	35.9	28.1
		29/03/2015	11:00	15,670	7.06	-135.6	40.2	27.6
		29/03/2015	15:30	15,700	7.04	-125.5	41.2	27.8

Site ID	Work No.	Date	Time	Electrical conductivity (µS/m)	pH	Redox potential (mV)	Dissolved oxygen (%)	Temperature (ºC)
MEN-6	GW273322	24/04/2015	12:30	18,380	7.14	-203.8	40.1	27.5
		25/01/2015	9:00	18.440	7.24	-172.9	45.6	25.4
		25/04/2015	11:20	18,410	7.24	-167.6	37.0	26.1
		25/04/2015	14:00	18,300	7.31	-164.3	46.6	25.9
		25/04/2015	16:00	18,420	7.38	-165.9	49.1	25.5
		26/04/2015	9:00	18,270	7.32	-168.0	36.1	26.0
		26/04/2015	13:00	18,280	7.30	-169.6	48.6	26.7
		26/04/2015	15:00	18,380	7.23	-173.0	46.0	26.9
		27/04/2015	9:00	18,300	7.32	-166.8	37.8	25.6
		27/04/2015	12:00	18,250	7.28	-168.3	39.7	27.2
		27/04/2015	16:00	18,280	7.27	-168.2	43.6	26.9
MEN-9	GW273321	16/04/2015	11:30	11,000	7.09	-25.0	44.0	26.6
		17/04/2015	10:15	25,700	7.03	-33.0	42.6	26.2
		17/04/2015	15:40	25,200	6.93	-40.0	44.2	26.6
		18/04/2015	11:00	25,800	6.90	-42.6	44.0	26.7
		18/04/2015	15:20	25,800	6.92	-40.3	42.1	26.7
		18/04/2015	17:30	25,800	6.92	-43.2	39.1	26.6
		19/04/2015	11:30	25,700	6.94	-42.9	42.6	26.5
MEN-11	GW273320	19/03/2015	9:20	21,800	7.17	-47.1	45.7	22.4
		19/03/2015	8:30	21,900	7.18	-44.3	44.4	23.0
		20/03/2015	11:20	20,800	7.15	-116.9	39.0	28.2
		21/03/2015	14:45	21,500	7.04	-81.1	45.1	29.7
MEN-17	GW273323	28/04/2015	12:15	25,700				23.2

Appendix 8 – Laboratory water quality

NSW Health

		MEN1	MEN2	MEN2	MEN2	MEN2	MEN-6	MEN-6	MEN-6	MEN-6
Analyte	**Units**	**24/02/2015 1:15PM**	**27/03/2015 4:45PM**	**28/03/2015 4:30PM**	**29/03/2015 3:30PM**	**30/03/2015 7:00am**	**25/04/2015 09:00am**	**26/04/2015 09:00am**	**27/04/2015 07:00am**	**28/04/2015 07:00am**
Aluminium	mg/L	0.03	0.01	0.01	0.01	0.01	0.02	0.01	<.01	0.01
Antimony	mg/L	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	<.001	0.003	0.003	0.002	0.004	0.009	0.008	0.008	0.009
Barium	mg/L	0.082	0.07	0.072	0.07	0.066	0.057	0.057	0.054	0.049
Boron	mg/L	0.9	1.2	1.2	1.2	1.2	1	0.9	0.9	0.8
Cadmium	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Calcium	mg/L	285.5	275.4	293	281.9	281.8	252.6	258.8	261.7	251.3
Chloride	mg/L	4542	4814	4820	4800	4800	5482	5415	5446	5488
Chromium	mg/L	0.008	<0.005	<0.005	<0.005	<0.005	0.024	0.024	0.023	0.021
Copper	mg/L	0.011	0.017	0.022	0.015	0.013	0.006	0.005	0.007	<0.005
Escherichia coli	CFU/100mL	<1								
Fluoride	mg/L	0.22	<0.1	<0.1	<0.1	0.17	<0.1	<0.1	<0.1	<0.1
Iodine	mg/L	1.37	1.07	1.05	1.06	1.01	2.36	2.3	2.26	2.28
Iron	mg/L	0.08	0.08	0.08	0.08	0.08	0.06	0.04	0.1	0.04
Lead	mg/L	0.005	<0.002	0.003	<0.002	<0.002	<.002	<.002	<.002	<.002
Magnesium	mg/L	346.2	324.7	334	266.8	264.9	310.1	322.1	305.3	294.7
Manganese	mg/L	0.213	0.279	0.282	0.277	0.262	0.33	0.329	0.312	0.279
Mercury	mg/L	<0.0001	0.0002	0.0003	0.0002	0.0002	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nickel	mg/L	0.02	0.01	0.01	0.01	0.01	<0.01	<0.01	0.01	<0.01
Nitrate as N	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrite as N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
pH Value	pH Unit	7.2	7.2	7.2	7.2	7.2	7.3	7.3	7.3	7.3
Selenium	mg/L	0.003	<0.002	<.002	0.008	0.009	0.002	0.013	0.01	0.007
Silver	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Sodium	mg/L	2735	2355	2480	2417	2429	3223	3335	3175	3075
Sulfate as SO4 2-	mg/L	1252	1359	1360	1353	1354	1568	1546	1538	1543
Total Dissolved Solids @180°C	mg/L	9125	7918	7929	9626	9805	11321	11425	11425	11280
Total Hardness as CaCO3	mg/L	2138.5	2024.8	2107	1802.6	1794.5	1907.7	1972.6	1910.7	1841.1
True Colour	Colour Units	10	9	9	9	8	10	10	10	10
Turbidity	NTU	0.1	0.1	0.1	0.3	0.2	0.5	0.3	<0.1	<0.1
Zinc	mg/L	0.05	0.06	0.04	0.03	0.04	0.21	0.03	0.1	0.02

		MEN-9	MEN-9	MEN-9	MEN-9	MEN11	MEN11	MEN-17
Analyte	**Units**	**18/04/2015 09:00am**	**19/04/2015 09:00am**	**20/04/2015 07:00am**	**21/04/2015 07:00am**	**21/03/2015 8:10AM**	**22/03/2015 7:00AM**	**28/04/2014 12:15PM**
								Suspended sediment >1% impacted on results
Aluminium	mg/L	0.02	0.02	0.01	0.01	0.03	0.01	116.7
Antimony	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.003	0.003	0.006	0.008	0.024	0.027	0.0006
Barium	mg/L	0.034	0.033	0.028	0.028	0.037	0.04	0.097
Boron	mg/L	1.3	1.3	1.6	1.6	1	1.2	2.4
Cadmium	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Calcium	mg/L	402.6	406.5	410.9	425.2	307.2	294.3	510.2
Chloride	mg/L	7586	7726	7553	7492	6519	6676	7629
Chromium	mg/L	0.011	0.01	0.025	0.025	0.008	0.007	0.019
Copper	mg/L	0.017	0.007	0.018	0.017	0.022	0.016	0.01
Fluoride	mg/L	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.1
Iodine	mg/L	1.18	1.08	2.1	2.12	1.34	1.13	2.6
Iron	mg/L	4.97	3.91	3.8	4.26	0.29	0.26	170.6
Lead	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.009
Magnesium	mg/L	546	536.6	475.1	511.2	417.4	389	543.7
Manganese	mg/L	0.356	0.35	0.448	0.448	0.284	0.309	0.641
Mercury	mg/L	0.0006	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.018
Nickel	mg/L	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.03
Nitrate as N	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrite as N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
pH Value	pH Unit	7.1	7.1	7	7.1	7.4	7.4	7.2
Selenium	mg/L	0.003	0.007	<0.002	0.005	<.002	0.004	0.014
Silver	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Sodium	mg/L	5041	4928	4432	4979	4007	3668	3916
Sulfate as SO4 2-	mg/L	2432	2495	2288	2294	2139	2139	2701
Total Dissolved Solids @180°C	mg/L	16592	16530	12950	16571	13488	13550	16759
Total Hardness as CaCO3	mg/L	3253.7	3224.7	2982.5	3166.8	2485.9	2336.8	3512.9
True Colour	Colour Units	1	1	1	1	3	<1	2
Turbidity	NTU	54.9	51.9	47.7	54.5	2.1	2.7	440
Zinc	mg/L	0.08	0.08	0.08	0.08	0.07	0.05	1.4

ALS Environmental

	MEN01	MEN02	MEN06	MEN09	MEN11	MEN17
Sample ID	**615001240**	**615001241**	**615001244**	**615001243**	**615001242**	**615001245**
Station Code	**BHMN01P**	**BHMN02P**	**BHMN06P**	**BHMN09P**	**BHMN11P**	**BHMN17P**
Date	**24/02/2015 8:00**	**29/03/2015 11:45**	**27/04/2015 11:30**	**19/04/2015 11:30**	**22/03/2015 8:00**	**28/04/2015 11:30**
Coliforms Total (cfu/100mL)	~<1	~<2	<1	~<2	<1	
E. coli by Membrane	~<1	~<2	<1	~<2	<1	
Gross Alpha	<0.25	0.094±0.031	0.329±0.058	0.164±0.038	0.043±0.023	1.8 ± 0.14
Gross Beta	<0.50	0.129±0.044	0.262±0.047	0.155±0.046	0.104±0.044	0.395 ± 0.069
Antimony -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Antimony Total (mg/L)	<0.001	<0.001	<0.010		<0.001	<0.010
Arsenic Filtered mg/L	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Arsenic Total (mg/L)	<0.001	<0.001	<0.010		<0.001	<0.010
Barium Filtered (mg/L)	0.084	0.076	0.069	0.033	0.036	0.078
Barium Total (mg/L)	0.082	0.075	0.076		0.035	0.322
Beryllium-Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Beryllium-Total (mg/L)	<0.001	<0.001	<0.010		<0.001	<0.010
Bismuth - Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Bismuth Total (mg/L)	<0.001	<0.001	<0.010		<0.001	<0.010
Boron Filtered (mg/L)	1.01	0.98	0.54	0.92	0.78	2.39
Boron Total (mg/L)	0.99	1.02	0.62		0.88	2.94
Cadmium Filtered mg/L	<0.0001	<0.0001	<0.0010	<0.0010	<0.0001	<0.0010
Cadmium Total mg/L	<0.0001	<0.0001	<0.0010		<0.0001	<0.0010
Cerium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Cerium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	0.097
Cesium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Cesium Total (mg/L)	0.006	<0.001	<0.010		<0.001	<0.010
Chromium Filtered mg/L	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Chromium Total mg/L	<0.001	<0.001	<0.010		<0.001	0.086
Cobalt -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	0.018
Cobalt Total (mg/L)	<0.001	<0.001	<0.010		<0.001	0.059
Copper Filtered mg/L	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Copper Total mg/L	0.004	0.007	0.016		0.011	0.054
Dysprosium -Filtered (mgL)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Dysprosium Total (mgL)	<0.001	<0.001	<0.010		<0.001	<0.010
Erbium -Filtered (mgl/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Erbium Total (mgl/L)	<0.001	<0.001	<0.010		<0.001	<0.010
Europium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Europium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	<0.010
Gadolinium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Gadolinium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	0.013
Gallium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Gallium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	0.019
Hafnium -Filtered (mg/L)	<0.01	<0.01	<0.10	<0.10	<0.01	<0.10
Hafnium Total (mg/L)	<0.01	<0.01	<0.10		<0.01	<0.10
Holmium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Holmium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	<0.010
Indium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Indium Total (mg/L)		<0.001	<0.010			<0.010
Lanthanum -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Lanthanum Total (mg/L)	<0.001	<0.001	<0.010		<0.001	0.041

	MEN01	MEN02	MEN06	MEN09	MEN11	MEN17
Sample ID	**615001240**	**615001241**	**615001244**	**615001243**	**615001242**	**615001245**
Station Code	**BHMN01P**	**BHMN02P**	**BHMN06P**	**BHMN09P**	**BHMN11P**	**BHMN17P**
Date	**24/02/2015 8:00**	**29/03/2015 11:45**	**27/04/2015 11:30**	**19/04/2015 11:30**	**22/03/2015 8:00**	**28/04/2015 11:30**
Lead Filtered mg/L	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Lead Total (mg/L)	<0.001	<0.001	<0.010		<0.001	0.029
Lithium -Filtered (mg/L)	0.043	0.043	0.071	0.145	0.093	0.072
Lithium Total (mg/L)	0.041	0.049	0.085		0.106	0.082
Lutetium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Lutetium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	<0.010
Mercury Filtered mg/L		<0.0001				
Mercury Total (mg/L)		<0.0001				
Molybdenum Filtered (mg/L)	0.002	<0.001	<0.010	<0.010	<0.001	0.017
Molybdenum Total (mg/L)	<0.001	<0.001	<0.010		<0.001	0.016
Neodymium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Neodymium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	0.066
Nickel Filtered (mg/L)	0.002	0.001	<0.010	<0.010	<0.001	0.011
Nickel Total (mg/L)	0.003	0.001	<0.010		0.005	0.06
Praseodymium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Praseodymium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	0.015
Rubidium -Filtered (mg/L)	0.055	0.068	0.069	0.063	0.07	0.043
Rubidium Total (mg/L)	0.054	0.058	0.078		0.059	0.115
Samarium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Samarium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	0.014
Selenium Filtered (mg/L)	0.3	<0.01	0.0004	0.14	<0.01	0.0112
Selenium Total (mg/L)	0.3	0.0004	0.0004	0.0005	<0.01	0.011
Silver Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	0.001	<0.010
Silver Total (mg/L)	<0.001	<0.001	<0.010		0.002	<0.010
Strontium -Filtered (mg/L)	5.54	6.9	8.38	9.91	7	8.5
Strontium Total (mg/L)	5.46	5.95	9.16		7.02	13.1
Tellurium -Filtered (mg/L)	<0.005	<0.005	<0.050	<0.050	<0.005	<0.050
Tellurium Total (mg/L)	<0.005	<0.005	<0.050		<0.005	<0.052
Terbium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Terbium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	<0.010
Thallium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Thallium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	<0.010
Thorium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Thorium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	0.016
Thulium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Thulium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	<0.010
Tin -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	0.014
Tin Total (mg/L)	<0.001	<0.001	<0.010		<0.001	<0.010
Titanium -Filtered (mg/L)	<0.01	<0.01	<0.10	<0.10	<0.01	<0.10
Titanium Total (mg/L)	<0.01	<0.01	<0.10		<0.01	0.16
Uranium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	0.024
Uranium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	0.039
Vanadium -Filtered (mg/L)	<0.01	<0.01	<0.10	<0.10	<0.01	<0.10
Vanadium Total (mg/L)	<0.01	<0.01	<0.10		<0.01	0.16
Ytterbium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010

	MEN01	MEN02	MEN06	MEN09	MEN11	MEN17
Sample ID	**615001240**	**615001241**	**615001244**	**615001243**	**615001242**	**615001245**
Station Code	**BHMN01P**	**BHMN02P**	**BHMN06P**	**BHMN09P**	**BHMN11P**	**BHMN17P**
Date	**24/02/2015 8:00**	**29/03/2015 11:45**	**27/04/2015 11:30**	**19/04/2015 11:30**	**22/03/2015 8:00**	**28/04/2015 11:30**
Ytterbium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	<0.010
Yttrium -Filtered (mg/L)	<0.001	<0.001	<0.010	<0.010	<0.001	<0.010
Yttrium Total (mg/L)	<0.001	<0.001	<0.010		<0.001	0.045
Zinc Filtered mg/L	<0.005	0.007	<0.050	<0.050	<0.005	0.425
Zinc Total (mg/L)	0.01	0.008	<0.050		0.037	1.2
Zirconium -Filtered (mg/L)	<0.005	<0.005	<0.050	<0.050	<0.005	<0.050
Zirconium Total (mg/L)	<0.005	<0.005	<0.050		<0.005	<0.052
Aluminium Filtered (mg/L)	<0.01	<0.01	<0.10	<0.10	<0.01	<0.10
Aluminium Total (mg/L)	0.01	<0.01	<0.10		0.05	57.8
Calcium Filtered (mg/L)	293	312	271	404	317	457
Calcium Total (mg/L)		287	255			729
Iron Filtered (mg/L)	<0.01	0.06	<0.10	4.24	0.15	0.14
Iron Total (mg/L)	0.03	0.07	<0.10		0.2	77
Magnesium Filtered	326	306	312	464	369	482
Magnesium Total (mg/L)		323	309			706
Manganese Filtered (mg/L)	0.224	0.244	0.202	0.312	0.262	0.425
Manganese Total (mg/L)	0.225	0.29	0.216		0.268	0.728
Potasium Total (mg/L)		54.2	44.9			262
Potassium Filtered (mg/L)	42	38	35	35	35	33
Sodium Filtered (mg/L)	2840	2500	3390	4750	4060	4170
Sodium Total (mg/L)		2550	3450			3570
Chloride (mg/L)	4660	4410	5640	6870	6660	7860
Cyanide Total (mg/L)	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Fluoride mg/L	0.986	<0.500	0.417	<1.00	1.98	<0.200
Sulphate (mg/L)	1390	1230	1600	3110	2620	2890
Dissolved Organic Carbon (mg/L)	2.7	3	<1	1	4	7
Total Organic Carbon (mg/L)	2.8	3	1	1	4	13
UV Absorbing constituents (organic)		0.125	0.134	0.232		14
Nitrate as N	<0.002	<0.002	0.045	0.012	<0.002	0.003
Nitrite as N	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Nitrogen Ammoniacal (mg/L)	0.62	0.468	0.933	0.726	0.817	<0.005
Nitrogen Total (mg/L)		0.84	1.35	0.95		1.82
Phosphorus Total (mg/L)		0.191	0.24	0.055		3.4
Silicate Reactive (SiO2 mg/L)			12.4			41.5
Alkalinity (mgCaCO3/L)	343	412	375	279	334	301
Bicarbonate alkalinity	343	412	375	279	334	301
Conductivity Field (mS/cm)	15.3		18.1	26	22	24.7
Conductivity uS/cm	15300		18100	26000	22000	24700
Dissolved Oxygen (%Sat)						
Dissolved Oxygen (mg/L)						
Odour Drinking Water	1	<1	<1	<1	1	<1
pH (Field)						
pH (Lab/Field)	7.63	7.42	7.79	7.88	7.68	7.55
Suspended Solids (mg/L)	1	<5	<5	<5	<1	1120
Temperature (Deg C)						
Total Dissolved Solids (mg/L)	10800	9590	9850	17400	15400	16900
Total Hardness (mgCaCO3/L)	2070	2040	1960	2920	2310	3130

	MEN01	MEN02	MEN06	MEN09	MEN11	MEN17
Sample ID	**615001240**	**615001241**	**615001244**	**615001243**	**615001242**	**615001245**
Station Code	**BHMN01P**	**BHMN02P**	**BHMN06P**	**BHMN09P**	**BHMN11P**	**BHMN17P**
Date	**24/02/2015 8:00**	**29/03/2015 11:45**	**27/04/2015 11:30**	**19/04/2015 11:30**	**22/03/2015 8:00**	**28/04/2015 11:30**
True Colour at 400nm	8	9	8	52	11	13
True Colour at 420nm	18	19	18	149	27	36
Turbidity (lab)	0.4	0.4	0.2	80.1	2.7	1850
"Benzo(g,h,i)perylene (ug/L)"		<1.0	<1.0	<1.0		<1.0
"Dibenz(a,h)anthracene (ug/L)"		<1.0	<1.0	<1.0		<1.0
"Indeno(1,2,3,cd)pyrene (ug/L)"		<1.0	<1.0	<1.0		<1.0
Acenaphthene (ug/L)		<1.0	<1.0	<1.0		<1.0
Acenaphthylene (ug/L)		<1.0	<1.0	<1.0		<1.0
Anthracene (ug/L)		<1.0	<1.0	<1.0		<1.0
Benz(a)anthracene (ug/L)		<1.0	<1.0	<1.0		<1.0
Benzene (ug/L)		<0.05	<0.05	<0.05		<0.25
Benzo(a)pyrene (ug/L)		<0.5	<0.5	<0.5		<0.5
Benzo(k)fluoranthene (ug/L)		<1.0	<1.0	<1.0		<1.0
C10 - C14 Fraction (ug/L)	<50	<50	<50	<50	<50	<50
C15 - C28 Fraction (ug/L)	<100	<100	<100	<100	<100	540
C29 - C36 Fraction (ug/L)	<50	<50	<50	<50	<50	240
C6 - C9 Fraction (ug/L)	<20	<20	<20	<20	<20	400
Chrysene (ug/L)		<1.0	<1.0	<1.0		<1.0
Ethylbenzene (ug/L)		<0.05	<0.05	<0.05		<0.25
Fluoranthene (ug/L)		<1.0	<1.0	<1.0		<1.0
Fluorene (ug/L)		<1.0	<1.0	<1.0		<1.0
m & p-Xylene (ug/L)		<0.05	<0.05	<0.05		<0.50
Naphthalene (ug/L)		<0.05	<0.05	<0.05		<0.25
Oil and Grease (mg/L)	<5	<5	<5	<5	6	<5
o-Xylene (ug/L)		<0.05	<0.05	<0.05		<0.25
Phenanthrene (ug/L)		<1.0	<1.0	<1.0		<1.0
Pyrene (ug/L)		<1.0	<1.0	<1.0		<1.0
Toluene (ug/L)		<0.5		<0.5		1.6
Redox Potential		197	7.65	7.79		7.19
Carbonate Alkalinity as CaCO3			<1			<1
Benzo(b+j)fluoranthene		<1.0	<1.0	<1.0		<1.0
C10 - C36 Fraction (sum)	<50	<50	<50	<50	<50	780
C6 - C10 Fraction	<20	<20	<20	<20	<20	410
C6 - C10 Fraction minus BTEX (F1)	<20	<20	<20	<20	<20	410
>C10 - C16 Fraction	<100	<100	<100	<100	<100	<100
>C16 - C34 Fraction	<100	<100	<100	<100	<100	720
>C34 - C40 Fraction	<100	<100	<100	<100	<100	<100
>C10 - C40 Fraction (sum)	<100	<100	<100	<100	<100	720
Sum of polycyclic aromatic hydrocarbons		<0.5	<0.5	<0.5		<0.5
Total Xylene	<1	<1	<1	<1	<1	<1
Benzo(a)pyrene TEQ (zero)		<0.5	<0.5	<0.5		<0.5