Lower Gwydir Groundwater Source

Groundwater Management Area 004

Groundwater Status Report – 2008

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Contents

1 History of groundwater management 8
2 Water sharing plan 8
3 Groundwater access licences 10
4 Groundwater allocations 11
5 Groundwater accounts 12
6 Extraction limits 13
7 Groundwater dealings and assignments 15
8 Groundwater usage 16
9 Rainfall 18
10 Monitoring Bore Drilling Program 19
11 Geology 19
12 Hydrogeology 20
Bore yields 20
Groundwater recharge 20
Groundwater quality 20
Cross sections 21
13 Groundwater levels 22
Introduction 22
Hydrographs 26
Hydrograph summary 31
Contour diagrams 32
Community consultation and management of drawdown impacts 36
14 References 37
Appendix A Dealings assessment criteria 38
Lower Gwydir Groundwater Source dealing assessment criteria 38
Appendix B Geological Cross Sections 41

Figures

Figure 1 Location of the Lower Gwydir Groundwater Source 9
Figure 2 Annual extraction limits for the Lower Gwydir Groundwater Source 14
Figure 3 Lower Gwydir groundwater usage since 1993–94 16
Figure 4 Production bore distribution and average groundwater usage 2002–2007 in the Lower Gwydir 17
Figure 5 Annual Rainfall at Moree and Warialda 30 years 1978–2008 18
Figure 6 Cumulative deviation from mean monthly rainfall, Moree and Gravesend 1890–2008 19
Figure 7 Lower Gwydir basement contour map 23
Figure 8 Location of monitoring bores and key representative sites 24
Figure 9 Location of cross sections 25
Figure 10 Hydrograph for groundwater monitoring site GW030423 26
Figure 11 Hydrograph for groundwater monitoring site GW030390 26
Figure 12 Hydrograph for groundwater monitoring site GW030159 27
Figure 13 Hydrograph for groundwater monitoring site GW036050 27
Figure 14 Hydrograph for groundwater monitoring site GW036018 28
Figure 15 Hydrograph for groundwater monitoring site GW030456 28
Figure 16 Hydrograph for groundwater monitoring site GW030397 29
Figure 17 Hydrograph for groundwater monitoring site GW036146 29
Figure 18 Hydrograph for groundwater monitoring site GW036115 30
Figure 19 Hydrograph for groundwater monitoring site GW036112 30
Figure 20 Hydrograph for groundwater monitoring site GW036160 31
Figure 21 Hydrograph for groundwater monitoring site GW036162 31
Figure 22 Pre development potentiometric surface and groundwater flow direction in deep aquifer 32
Figure 23 2007–08 Recovered potentiometric surface and groundwater flow directions in deep aquifer 33
Figure 24 Potentiometric surface and groundwater flow directions in deep aquifer (2007–08 pumping season) 34
Figure 25 1970s to 2007 Recovery decline 35
Figure 26 Trade restricted areas in the Lower Gwydir Groundwater Source 36

Figure A1 Trading areas of the Lower Gwydir Groundwater Source. 40

Maps

Map B1 Cross Section location map Lower Gwydir 41
Map B2 Pallamallawa geological cross section 42
Map B3 Royden geological cross section 43
Map B4 Moree/Ashley geological cross section..... 44
Map B5 The Raft geological cross section..... 45
Map B6 Gingham geological cross section 46

Tables

Table 1 Number of water access licences and unit shares at start 2008–09 water year 10
Table 2 Available water determinations for supplementary water access licences..... 11
Table 3 Summary of Lower Gwydir Water Sharing Plan account rules..... 12
Table 4 Summary of water held in accounts from 2006–2008 12
Table 5 Annual extraction limits under the Lower Gwydir Water Sharing Plan 13
Table 6 Permanent dealings since commencement of the water sharing plan 15
Table 7 Temporary dealings since commencement of the water sharing plan 15
Table 8 Groundwater usage since commencement of the water sharing plan..... 16

Executive Summary

This report presents the status of the Lower Gwydir Groundwater Source for 2006–2008.
From 1 October 2006 the Lower Gwydir Groundwater Source has been managed under the *Water Management Act 2000* through the Lower Gwydir Groundwater Source Water Sharing Plan (the Plan). The Plan sets the framework for managing groundwater in the Lower Gwydir until 30 June 2017. The Lower Gwydir Groundwater Source refers to groundwater contained within alluvial sediments associated with the Gwydir and Mehi Rivers and their tributaries west of Biniguy. Bores into the underlying Great Artesian Basin are tapping a different water source and are not included in this report. The estimated average annual recharge at commencement of the Plan was 38,000 megalitres (ML) per year with 5,700 ML of this being reserved as an environmental provision.

In addition to basic landholder rights, three categories of groundwater access licence are held in the Lower Gwydir Groundwater Source. These are aquifer access licences, supplementary water access licences and local water utility access licences. At the start of the 2008–09 water year there were 171 Aquifer access licences with a total of 28,858 unit shares, 41 supplementary water access licences with a total of 13,930 unit shares, and two local water utility access licences with a total volume of 3,572 ML. Supplementary water access licence allocations reduce progressively from 2009–10 until 2015, after which there will be no groundwater available under these licences.

Under the Plan, annual extraction limits have been set at the supplementary water access allocations plus 85 per cent of the estimated average annual recharge. As the supplementary water allocations are reduced, the extraction limit also reduces until it reaches 32,300 ML in 2015, Year 10 of the Plan.

Since commencement of the Plan groundwater trading has been active. There have been 19 permanent transfers totalling 2872 ML and 97 temporary transfers totalling 15,037 ML up to December 2008. During the 2006–2007 water year groundwater usage was 47,400 ML and in the 2007–08 year it was 39,500 ML.

There are 65 monitoring bores located through out the Lower Gwydir. A review of data from these bores show the largest drawdown and recovery declines occur along the Royden, Moree/Ashley and Raft Sections north of the Gwydir River where the majority of extraction occurs. The most significant drawdowns occur in the area between Moree and Ashley. With growth in groundwater usage from the deep aquifer since the 1980s, the pressure in this aquifer has fallen due to extraction. This is inducing downwards leakage from the shallow aquifer causing a decline in water levels in the shallow aquifers and reversal in hydraulic gradient in some areas. During the wetter years of 1996–2001 there was a period of reduced extraction and water levels in most parts of the aquifer stabilised or recovered. However, since the onset of the drought in 2001 water levels have continued to decline in these areas. Data from the bores close to the Gwydir and Gingham Rivers show water level peaks after major flood events. The water level responses to floods in bore further away from the rivers are more subdued but they still reflect wet and dry years.

The bores on the northern part of the Gingham Section show no drawdown response to pumping but still have significant water level declines. This is mainly due to reduced through flow as a result of extraction to the east.

On the peripheral edges and in the south west of the water source hydrographs show stable to rising water level trends with little or no direct response to groundwater extraction. These sites also show a subdued or no response to climatic changes and major flood events.

Potentiometric surface and flow direction contour diagrams comparing pre development and 2007 water levels show that 30 years of extraction has resulted in seasonal recovered water level declines and reduced pressures in some areas. This has caused the potentiometric surface to change shape with resulting changes to groundwater flow.

During the pumping season, extraction causes significant changes to the groundwater flow directions between Moree and Ashley. This area also has a long term recovery decline of up to 8 metres (m). The recovery decline in the far west of the Lower Gwydir which is also greater than 8m, is the result of reduced through flow caused by concentrated extraction to the east and changing climatic conditions.

The findings of this 2006–2008 assessment of groundwater status were presented to the Lower Gwydir groundwater community mid 2008. The presentation included a discussion of groundwater management and acceptable impacts. As a result of the levels of impact occurring, trade restrictions were proposed for areas where drawdowns have reached 40 per cent of the saturated thickness of the alluvium and are showing recovery decline. An area of concern was identified between Moree and Ashley. The intention of these restrictions is to limit further drawdowns from additional water being traded into this area. The revised criteria for dealings assessments in the Lower Gwydir, including trade restricted areas, took effect on 21 August 2008.

1 History of groundwater management

The first groundwater volumetric allocation policy for the Lower Gwydir Valley was introduced in November 1983 culminating in the release by the (former) Water Resources Commission of the document *Licensing Policy for High Yield Bores in the Lower Gwydir Valley, NSW* in 1984. Under this policy the existing unrestricted area based licences were converted to an annual volumetric entitlement. New licences were also subsequently granted with an annual volumetric entitlement under this policy.

A moratorium on new groundwater entitlements was imposed on 18 November 1993 followed by an embargo of new entitlement and new bores in December 1993 for the whole of the Lower Gwydir Valley downstream of Gravesend. Since that time, there have been no new groundwater licences issued other than for replacement bores within the existing property allocations (Kalaitzis,1999). The embargo was current until it was replaced by the Lower Gwydir Groundwater Source Water Sharing Plan (the Plan) in October 2006.

Prior to the water sharing plan, groundwater extraction was controlled by announced allocations. These were announced at the beginning of each water year as a percentage of the entitlements. Licence holders also had access to unused allocation that was carried over from the previous year in their groundwater account as well as the potential for borrowing from the following year's allocation.

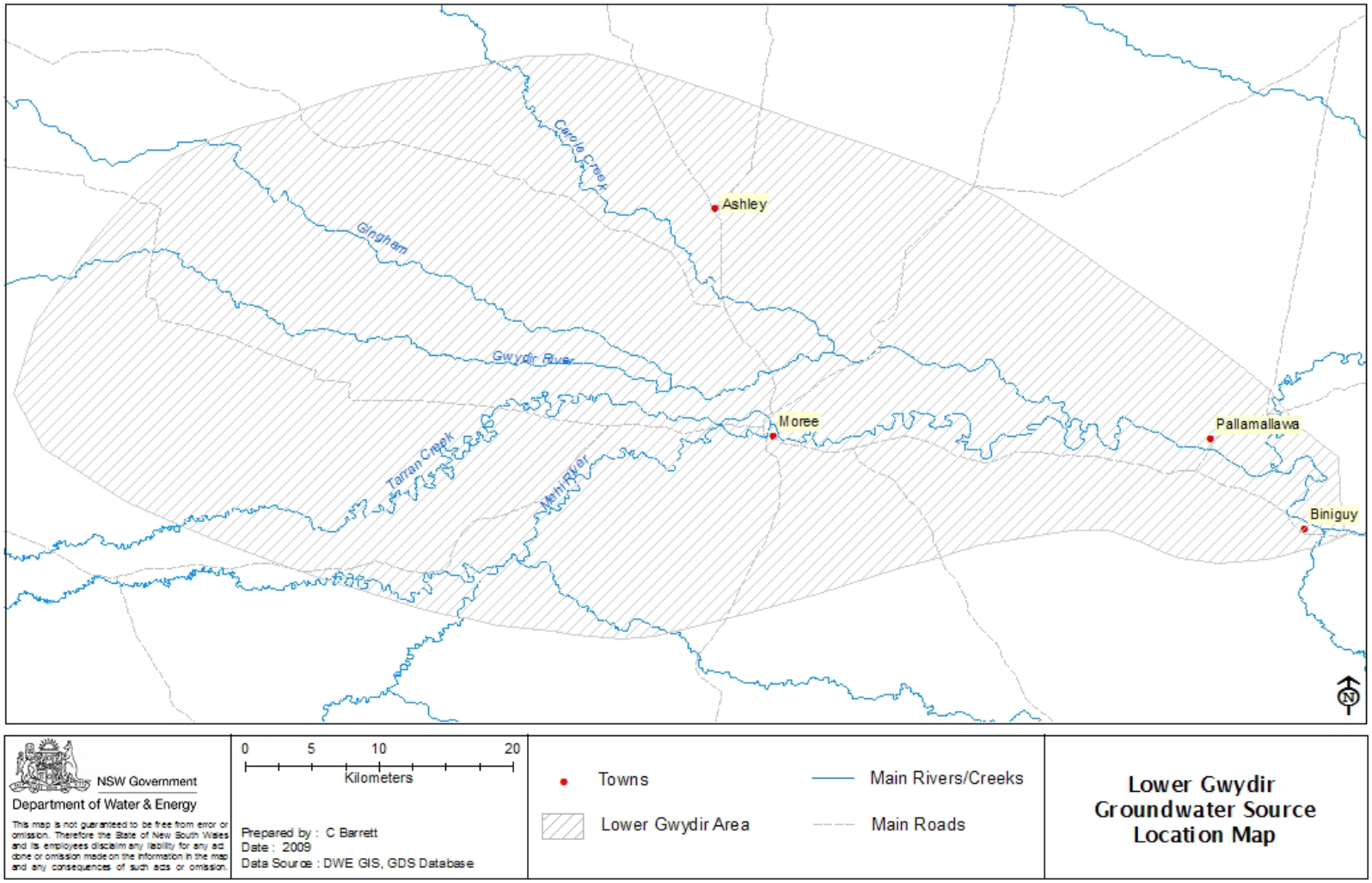
2 Water sharing plan

The water sharing plan for the Lower Gwydir Groundwater Sources commenced on 1 October 2006. Since commencement of the Plan the Lower Gwydir is being managed under the *Water Management Act 2000*. The Water Sharing Plan for the Lower Gwydir Groundwater Source covers the area shown in Figure 1. The Plan sets the framework for managing groundwater in the Lower Gwydir until 30 June 2017. The Lower Gwydir Groundwater Source includes all the groundwater contained within alluvial sediments associated with the Gwydir and Mehi Rivers and their tributaries west of Biniguy. Bores into the underlying Great Artesian Basin (GAB) are tapping a different water source and are not included in this report.

The Plan sets the rules for sharing the resource between extractive users and that which is reserved in the aquifer. The basis for water sharing is the estimated average annual recharge of 38,000 megalitres (ML) per year. Eighty-five per cent is made available for extraction (ie 32,300 ML) in conjunction with a defined volume of groundwater from aquifer storage each year. The remaining 15 per cent, 5,700 ML is reserved as 'planned environmental water'.

At the commencement of the Plan, the water requirements for holders of domestic and stock supplies extracted as landholders basic rights was estimated to be 700 ML per year. The Plan recognises that the exercise of basic landholder rights may increase during the term of the Plan.

Figure 1 Location of the Lower Gwydir Groundwater Source



3 Groundwater access licences

Three categories of groundwater access licence (WAL) are held in the Lower Gwydir water source. These are local water utility access licences (LWUAL), aquifer access licences (AAL) and supplementary water access licences (SWAL).

The local water utility access licences are held by local government and are for town water supply purposes. The share component of these licences is for a specified volume of groundwater. The share components of aquifer access licences and supplementary water access licences are issued for a specified number of unit shares. The number of licences and unit shares for each licence type at the start of the 2008–09 water year is given in Table 1.

Table 1 Number of water access licences and unit shares at start 2008–09 water year

Licence type	**July 1 2008**	
	No WALs	Total Unit Shares
Aquifer access licenses	171	28,858
Local water utility access licences	2	3,572
Supplementary access licences	41	13,930

The total number of licences may change during the term of the Plan as a result of the granting, surrender, or cancellation of access licences, and the variation of local water utility access licences.

4 Groundwater allocations

At the start of each water year an available water determination (AWD) is made which sets the allocation of groundwater for the different categories of access licences.

For supplementary water access licences, the water sharing plan has already set the available water determinations for each year of the plan. These are listed in Table 2. The available water determination for supplementary water access begins decreasing in year 2009–10.
After 2014–2015 there will be no groundwater available under supplementary water access licences.

The 2007–08 available water determination for aquifer access licences was 1 ML per unit share. The 2007–08 available water determination for local water utility access licences was 100 per cent of the share component.

Table 2 Available water determinations for supplementary water access licences

Year of the Plan	Water year	AWD for supplementary access licences (ML per unit share)	Volume available for supplementary access licences (ML)
1 (8 months)	2006–2007	1	13,930
2	2007–2008	1	13,930
3	2008–2009	1	13,930
4	2009–2010	0.857	11,938
5	2010–2011	0.714	9,946
6	2011–2012	0.571	7,954
7	2012–2013	0.429	5,957
8	2013–2014	0.286	3,983
9	2014–2015	0.143	1,992
10	2015–2016	0	0
11	2016–2017	0	0

5 Groundwater accounts

There is an account limit of 3 ML per unit share for aquifer access licence accounts. This is adjusted up or down within the water year if allocation is temporarily transferred in or out of the account. If there is a permanent transfer of shares from the access licence then the account water is adjusted down to the maximum account limit of 3 ML per unit share based on the new share component of the access licence. Any water in the account in excess of this limit is forfeited.

Unused allocation in aquifer access licence accounts may be carried over into the following water year up to a maximum of 2 ML per unit share. Any water in excess of this is forfeited. There is also a limit of 2 ML per unit share that can be debited from the account in one water year. This includes water that is traded out. A volume greater than 2 ML per unit share may be taken from the account if additional allocation is assigned to the account by a temporary transfer.

There is no carryover of allocation in local water utility and supplementary water access licence accounts. For those landholders that have both supplementary water and aquifer access licences, usage is deducted from the supplementary water account first. The volume per unit of share component that may be held, used and carried over in accounts under the water sharing plan is summarised in Table 3. Water held in accounts for the water years 2006–07, 2007–08, and 2008–09 is summarised in Table 4.

Table 3 Summary of Lower Gwydir Water Sharing Plan account rules

	ML per unit of share component that may be held in account	ML per unit of share component that may used	ML per unit of share component that may be carried over
Aquifer access licences	3	2	2
Supplementary water access licences	1	1	0
Local water utility access licences	1	1	0

Table 4 Summary of water held in accounts from 2006–2008

Account type	2006–2007 (ML)	2007–2008 (ML)	2008–2009 (ML)
Local water utility access licences	3,572	3,572	3,572
Aquifer access licences–total water in accounts (AWD + CO capped at 2 ML per unit of share component)	74,777	63,436	61,553
Aquifer access licences–water available for use (Use limit)	54,703	50,026	48,726
Supplementary access licences	13,930	13,930	13,930
Total water available for use (use limit + supplementary + local water utilities)	72,205	67,528	66,228

6 Extraction limits

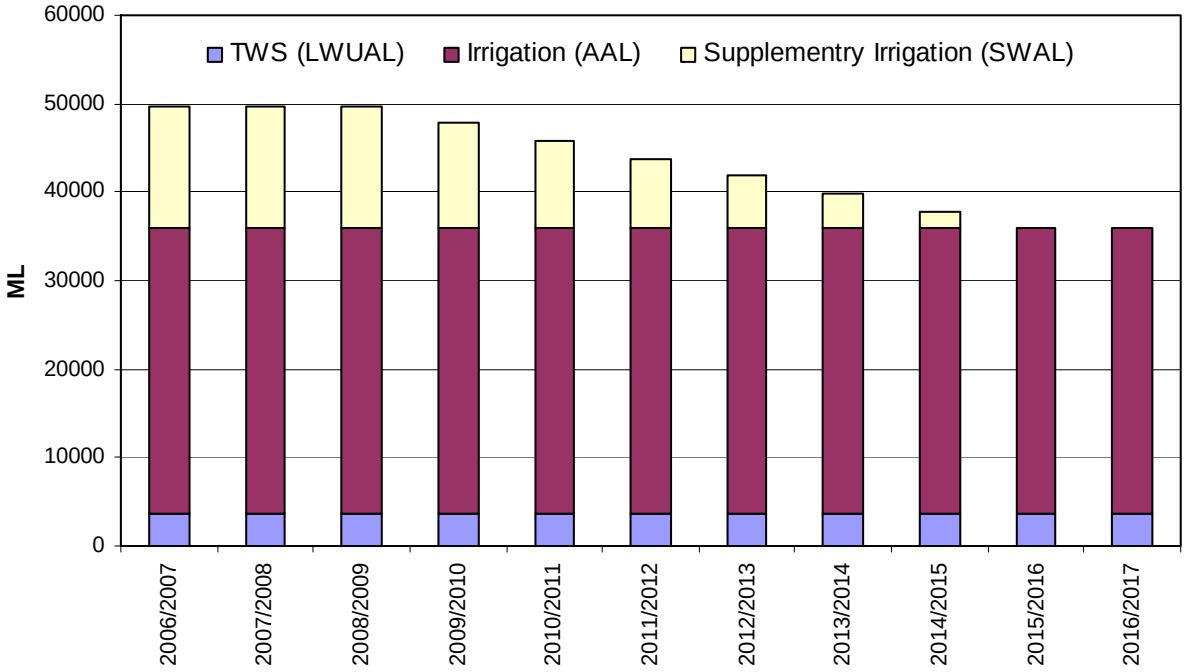
The water sharing plan sets an extraction limit for each year of the Plan which is shown in Table 5. The extraction limit is equivalent to the sum of the supplementary water access licence allocations and 85 per cent of estimated average annual recharge (i.e. 32,300 ML). As the supplementary water allocations are reduced, the extraction limit also reduces until it reaches 32,300 ML in 2015, Year 10 of the Plan.

The Plan aims to manage the overall extraction to within 5 per cent of the extraction limit over a three year period. The rolling three year average allows for some fluctuation in usage from one year to the next. If usage does exceed the three year average extraction limit then the Plan requires that an available water determination be made for aquifer access licences for the following water year to reduce the subsequent total water extraction to the extraction limit. The start of the three year rolling average period was 2006–07. Annual extraction limits and their component aquifer access licences, local water utility access licences and supplementary water access licences are shown in Figure 2.

Table 5 Annual extraction limits under the Lower Gwydir Water Sharing Plan

Year of plan	Extraction limit
2006–07	46,236 ML
2007–08	46,236 ML
2008–09	46,236 ML
2009–10	44,238 ML
2010–11	42,246 ML
2011–12	40,257 ML
2012–13	38,257 ML
2013–14	36,283 ML
2014–15	34,292 ML
2015–16	32,300 ML
2016–17	32,300 ML

Figure 2 Annual extraction limits for the Lower Gwydir Groundwater Source



7 Groundwater dealings and assignments

Under the *Water Management Act 2000*, temporary transfers are referred to as an 'Assignment of Allocation'. The transfer of allocation from supplementary water access licence accounts is not permitted. Local government may transfer allocation between their local water utility access licence accounts with Ministerial approval in certain circumstances.

Assignments of allocation applications (or temporary transfers) are received by State Water Corporation. Applications for permanent trading, subdivision and amalgamation of licences are received by the Department of Water and Energy (DWE). Permanent and temporary dealings are assessed under the operational dealings policy for the Lower Gwydir which is in Appendix A.

A summary of permanent dealings since commencement of the Plan is given in Table 6 and a summary of temporary dealings since plan commencement is given in Table 7.

Table 6 Permanent dealings since commencement of the water sharing plan

	2006–07	2007–08	2008–09
No Perm Transfers	3	15	1
Volume (ML)	149	2,705	19

Table 7 Temporary dealings since commencement of the water sharing plan

	2006–07	2007–08	2008–09
No Temp Transfers	33	32	20
Volume (ML)	5,529	7,151	4,031*

*as at 10/02/09

8 Groundwater usage

In the Lower Gwydir a combined total of 93,626 ML was pumped in the two seasons 2006–07 and 2007–08. Groundwater usage from the Lower Gwydir since commencement of the Plan is given in Table 8. Annual groundwater usage since 1994 is shown in Figure 3. The distribution of average usage for 2002–07 and property distribution is shown on Figure 4.

Table 8 Groundwater usage since commencement of the water sharing plan

Year	Usage (ML)	Annual Extraction Limit (ML)
2006–07		
Local water utility access licences	2,271	3,572
Aquifer access licences	34,705	28,858
Supplementary water access licences	12,767	13,930
Total	**49,743**	**46,360**
2007–08		
Local water utility access licences	2,216	3,572
Aquifer access licences	26,311	28,858
Supplementary water access licences	15,433	13,930
Total	**43,883**	**46,360**

Figure 3 Lower Gwydir groundwater usage since 1993–94

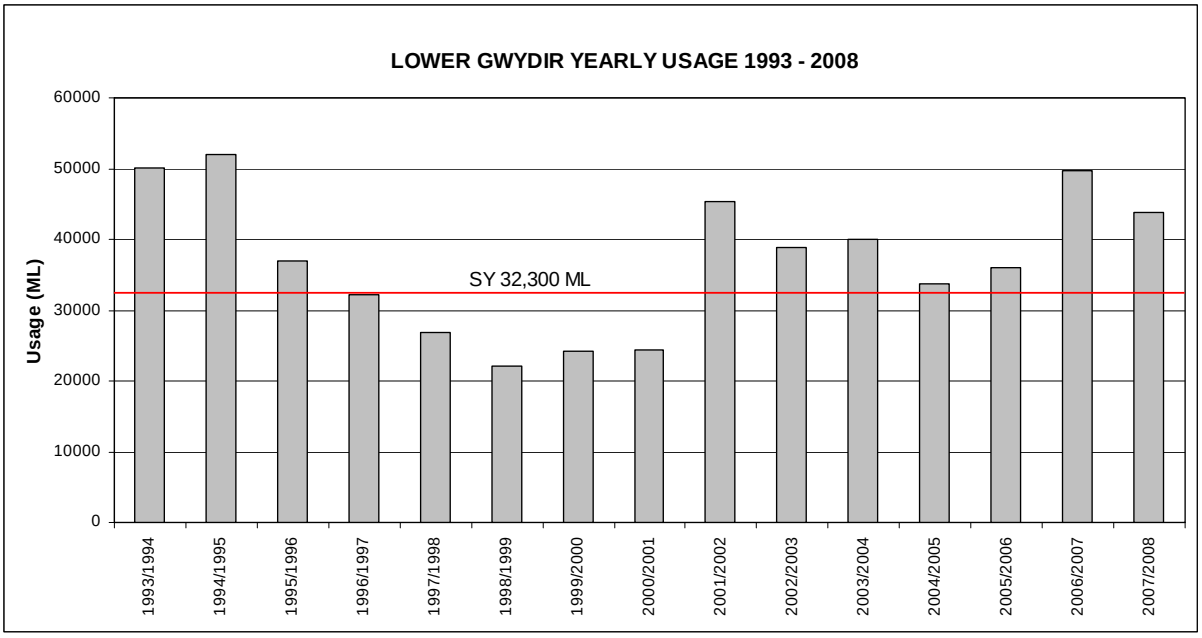
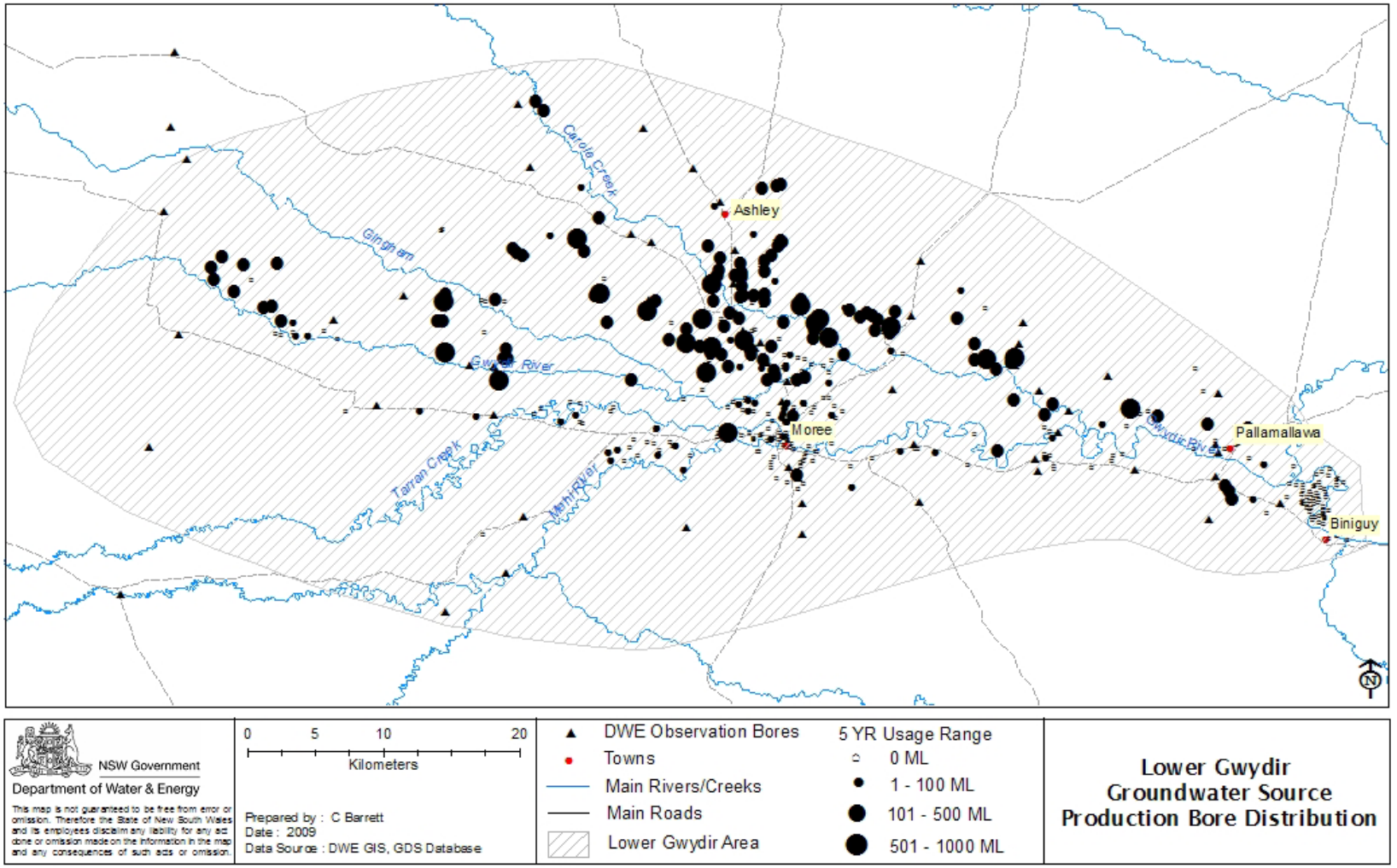


Figure 4 Production bore distribution and average groundwater usage 2002–2007 in the Lower Gwydir

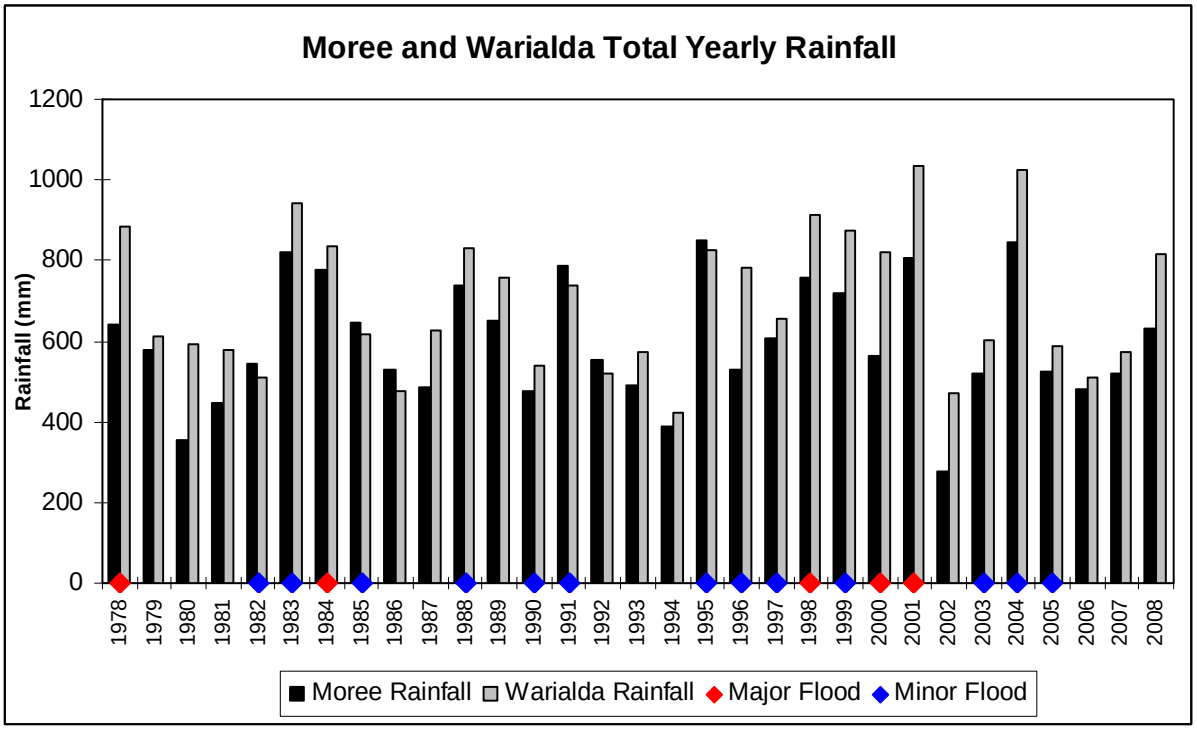


9 Rainfall

Rainfall data was available for Moree airport station 53115 and Warialda post office station 54029. These stations are monitored by the Bureau of Meteorology and the data was extracted from the SILO website (referenced). The period of record for both stations is 1890 to present. Warialda is 35km east of the water source, approximately 80km east of Moree.

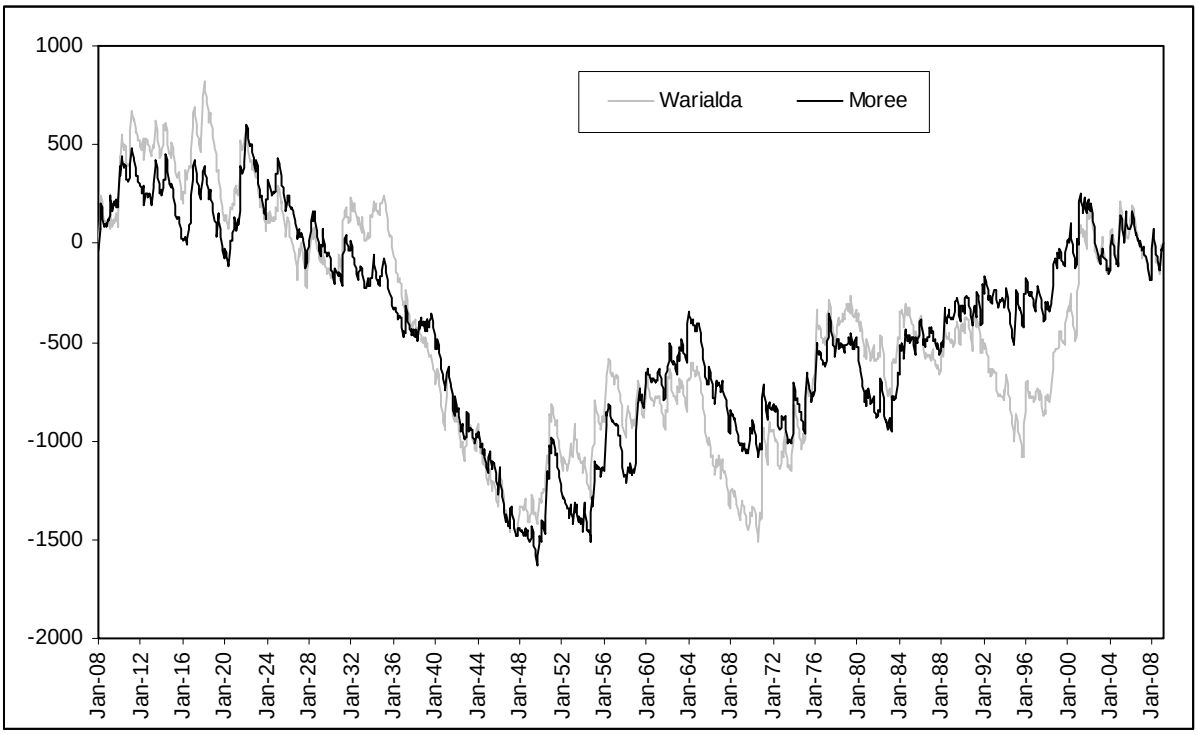
The Lower Gwydir Valley has a semi-arid climate with over 60 per cent of the annual rainfall falling during the summer months between November and March. Consequently, floods are more likely to occur during the summer months. The annual average rainfall for Moree is 496mm and for Warialda it is 642mm. In Moree, the lowest and highest annual rainfall recorded were in 1902 (202mm) and 1959 (1033mm) respectively. Flooding of the Gwydir, Mehi and Gingham Rivers have a significant impact on groundwater levels in the Lower Gwydir Valley., The majority of flooding down these rivers is driven by rainfall higher in the catchment rather than local rain events. Figure 5 shows the annual rainfall at Moree and Warialda from 1978 to 2008. Figure 5 also shows the years of major and minor flooding. There have been five major floods in the last 30 years; 1978, 1984, 1998, 2000 and 2001 (Falkenmire, 2009), during which there has been significant area of floodplain under water.

Figure 5 Annual Rainfall at Moree and Warialda 30 years 1978–2008



The residual mass curve of monthly rainfall in the last 100 years for Moree and Warialda is shown in Figure 6. This figure shows the deviation of actual monthly rainfall from the mean monthly rainfall. The slope of the curve indicates whether the area was experiencing a relatively wetter or drier time compared to the average for the last 100 years. For example the periods 1965–1971 and 1978–1983 rainfall has tended to be below average, and for the periods 1971–1977 and 1995–2000, annual rainfall has tended to be higher than the long-term average.

Figure 6 Cumulative deviation from mean monthly rainfall, Moree and Gravesend 1890–2008



10 Monitoring Bore Drilling Program

In 2007–08, 33 bores were drilling at 19 sites across the Lower Gwydir to extend the current monitoring bore network and fill in data gaps across the water source. The full drilling report is in Appendix C.

11 Geology

The Mesozoic bedrock of the Lower Gwydir Valley consists predominantly of shale and sandstone with some clay and lignite seams. A broad fan-shaped valley has been incised in the Mesozoic sediments, and in-filled by a sequence of unconsolidated deposits of Cainozoic alluvium. These unconsolidated sediments were laid down in the flood plains of the antecedent and present Gwydir River system and include a variable amount of water bearing sand and gravels particularly in the central part of the valley (Bilge, 2002). The alluvium has a maximum thickness in the area of approximately 65m. More detailed geology can be found in Kalaitzis, 1999.

12 Hydrogeology

Information collated from drilling carried out by the Department of Water and Energy and its predecessors in the 1960s and 1970s and more recently in 2006–07, show sequences of clay, sand and gravel sediments. The water bearing sands and gravels within the alluvial sediments are generally divided into two main aquifer systems, a shallow aquifer system (10–30m depth) and a deep aquifer (35–80m depth). The shallow, generally unconfined aquifer is locally known as the Narrabri Formation and the deeper and confined/semi confined aquifer is known as the Gunnedah Formation. Within each system there may be more than one aquifer which varies in thickness and in lateral and longitudinal extent. These aquifers are more extensive in thickness and lateral extent in the upstream area near Moree and consist of coarse gravels in the shallow aquifers and fine to medium sand and gravel in the deep aquifers. Further downstream the aquifers grade into finer sands and become more irregular in their occurrence.

There appears to be no laterally continuous horizon or marker layer to define a distinct boundary between the Narrabri and Gunnedah Formations. Generally, the Narrabri Formation aquifers are separated from the Gunnedah Formation aquifers by a thick and relatively impermeable layer of clay. Maximum thickness of the alluvial sediments increases from 20m in the upstream area to about 60m near Moree and 75–80m in the west (Bilge, 2002).

Bore yields

Within the Lower Gwydir suitably constructed bores in the deeper aquifers yield up to 100 litres per second (L/sec). However the majority of high yield bores produce supplies in the range of 10-40 L/s of low salinity water suitable for irrigation purposes. The highest yielding bores are located in an area between Moree and Ashley (see Figure 1). Away from this area the yields are generally less. Smaller yields suitable for stock and domestic supplies are available throughout the entire alluvial area (Kalaitzis, 1999).

Groundwater recharge

Conceptually the dominant recharge process for the Lower Gwydir alluvium is leakage from the rivers and watercourses.

Upstream of Moree, the alluvial sediments are in direct hydraulic connection with the watercourses allowing direct recharge from the river into the aquifer system. Areas upstream of Moree and those located near rivers and creeks that have regulated flow could expect minimal recharge during years of average stream flow. However in these areas, recharge pulses will occur after major flood events when large volumes of water are available to recharge the aquifer system. In average years, the greatest proportion of recharge is expected to come from direct vertical infiltration from the regulated streams (Kalaitzis, 1999).

Some additional recharge is also expected from rainfall, weir pools, on-farm storages, irrigation losses and groundwater inflows from the east. The hydrographs also indicate that leakage from the upper aquifer to the lower aquifer is occurring. Extraction from the lower aquifer will result in induced leakage from the upper aquifer, in some cases resulting in dewatering of the upper aquifer.

Groundwater quality

There is little in the way of water quality information for the Lower Gwydir alluvium. Department groundwater observation bores were sampled for water quality at the time of construction. The electrical conductivity (EC) readings from groundwater samples range from 200 microsiemens per centimetre (µs/cm) close to the rivers to >2000µs/cm in the far west of the water source and on the outer limits of the alluvium. The limited available water quality information shows no significant change in water quality with depth through the alluvium.

Cross sections

The geological cross sections for the Lower Gwydir from east to west are shown in Appendix B; Maps 1 to 6. These cross section show the gradual thickening of the alluvial sequence and the changes in the lithology of the alluvial sediments from east to west. This has a direct bearing on the hydrogeological characteristics of the valley.

The Lower Gwydir Valley is characteristic of an alluvial fan deposit. The transition between the uplifted area to the east and the much smoother topography of the Moree Plains is fairly abrupt. This transition has caused the transport capacity of the palaeo Gwydir River to decrease suddenly as it diverges as numerous channels over the plains (Kalaitzis,1999).

13 Groundwater levels

Introduction

An unconfined aquifer is a groundwater system usually near the ground surface which is in connection with atmospheric pressure and whose upper level is represented by the water table. The water table is the upper surface of groundwater or the level below which an unconfined aquifer is saturated with water. A confined aquifer is a groundwater system which is isolated from atmospheric pressure by a layer of relatively impermeable material, and whose upper pressure level is represented by the potentiometric surface.

In the Lower Gwydir the upper aquifer tends to be unconfined. Where it occurs, the deeper productive aquifer is semi-confined or confined. In some areas where the deeper aquifer is semi-confined there is limited hydraulic connection allowing vertical flow between the shallow and deeper aquifers. In areas where there is significant pumping water level responses indicate that downward leakage between the aquifers can be induced.

The potentiometric surface is a pressure surface that represents the total head of groundwater, and is defined by the level to which water will rise in a bore. The potentiometric surface indicates the pressure or head of water at a given location and depth, it does not necessarily represent the top of the saturated zone. Potentiometric surfaces are presented in this report in metres Australian Height Datum (AHD), where mean sea level is 0m. This provides a reference level for the measurement of groundwater height independent of topography (Smithson, 2009).

Groundwater levels have been monitored since the early 1970s at 65 monitoring bore locations throughout the Lower Gwydir Groundwater Source. Water level records are held for the last 30 to 40 years for most sites, 19 new sites were drilled and incorporated into the monitoring network in 2007–08.

Groundwater levels are generally shallower at the eastern upper end of the catchment where there is generally only a shallower unconfined aquifer. Groundwater levels become progressively deeper towards the west, with the occurrence of both upper and lower aquifer west of the Roydon Section; Figure 7 shows the basement contours in Australian Height Datum (AHD) for the Lower Gwydir.

The locations of all monitoring sites and key representative sites are shown in Figure 8. Hydrographs for representative monitoring bores are presented in Figures 10 to 21. For comparison, all hydrographs have been plotted at the same vertical scale. The hydrographs are displayed from east to west along the Pallamallawa, Royden, Moree/Ashley, The Raft and Gingham Sections. Figure 9 shows the location of the cross sections.

Figure 7 Lower Gwydir basement contour map

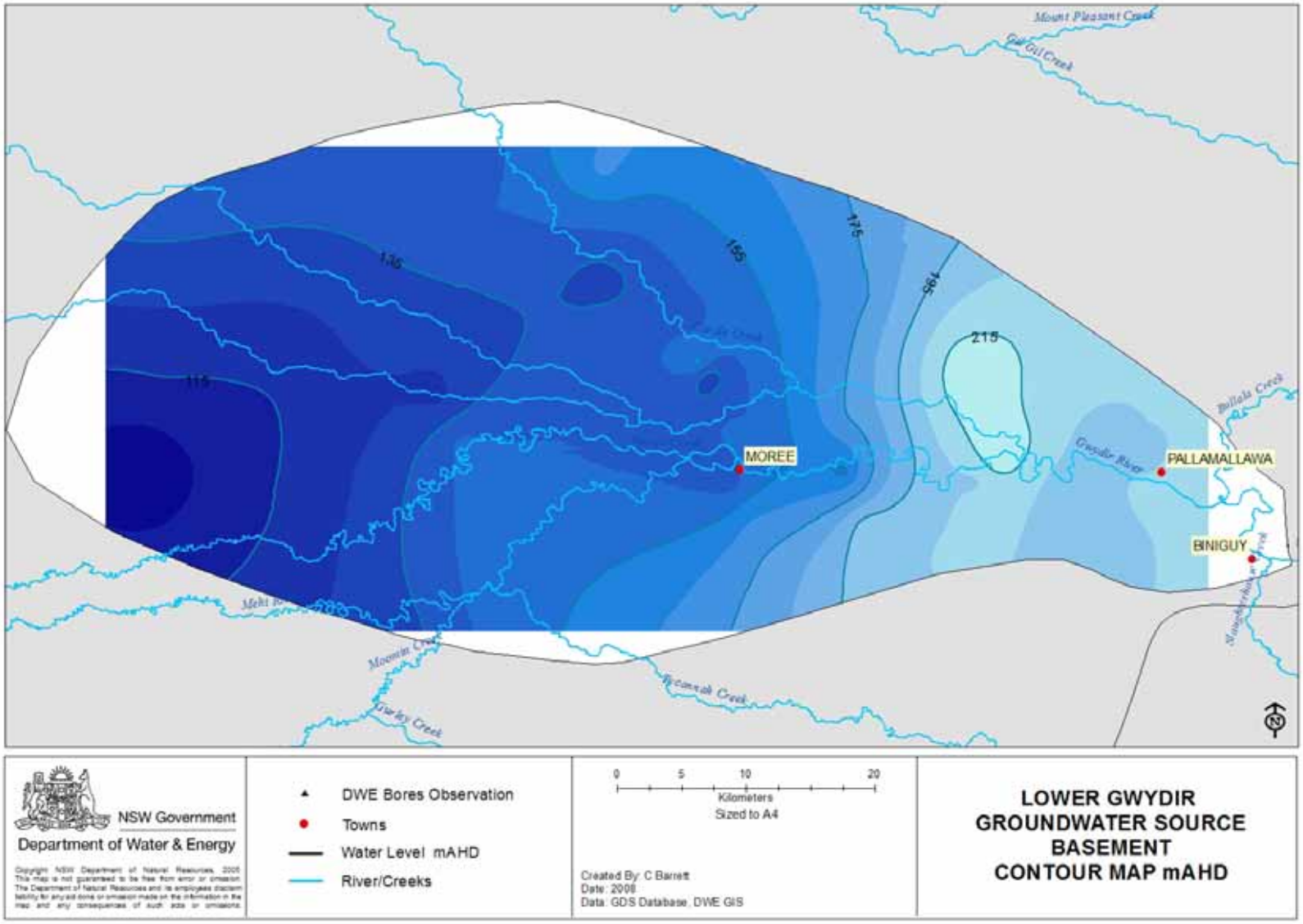


Figure 8 Location of monitoring bores and key representative sites

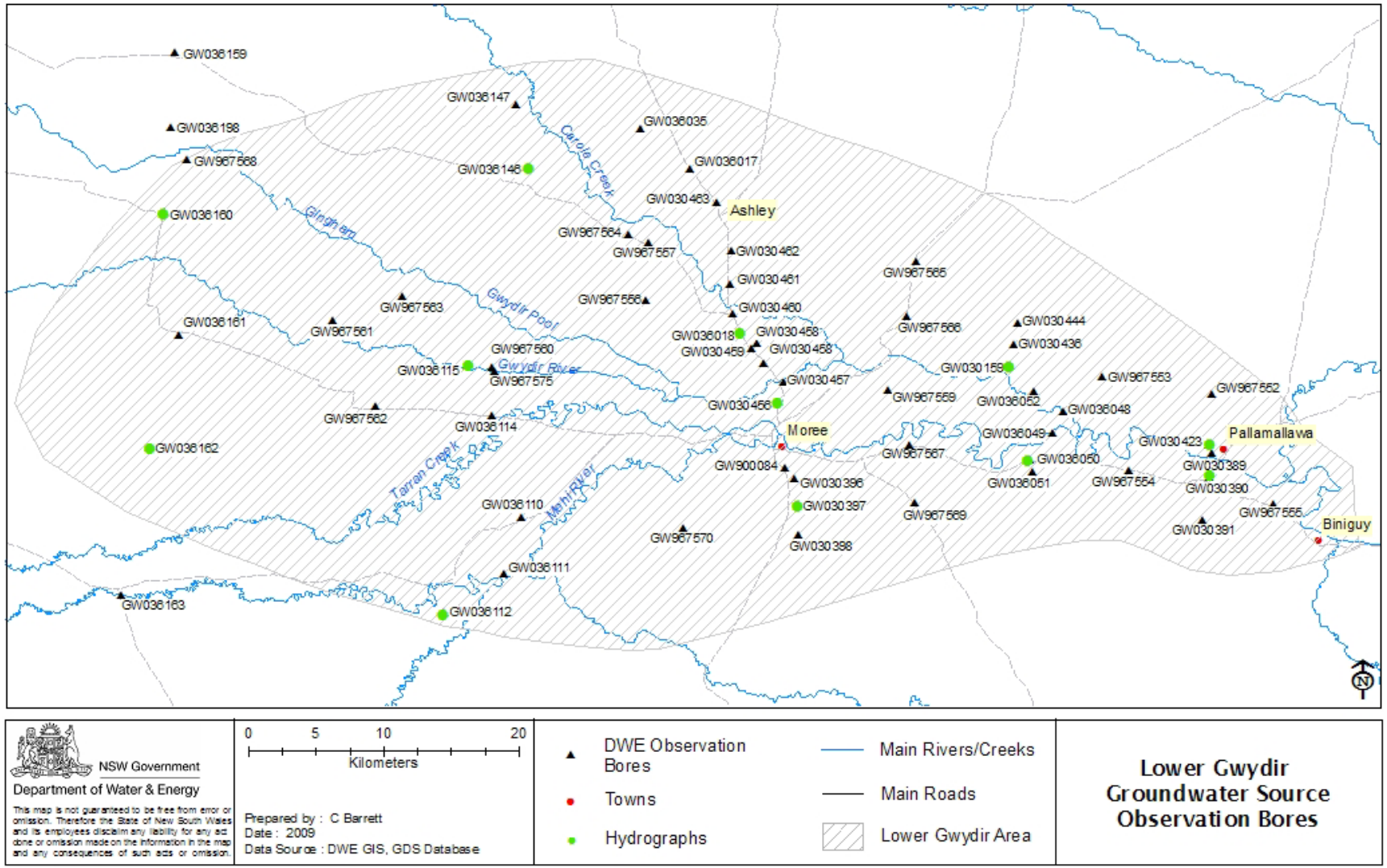
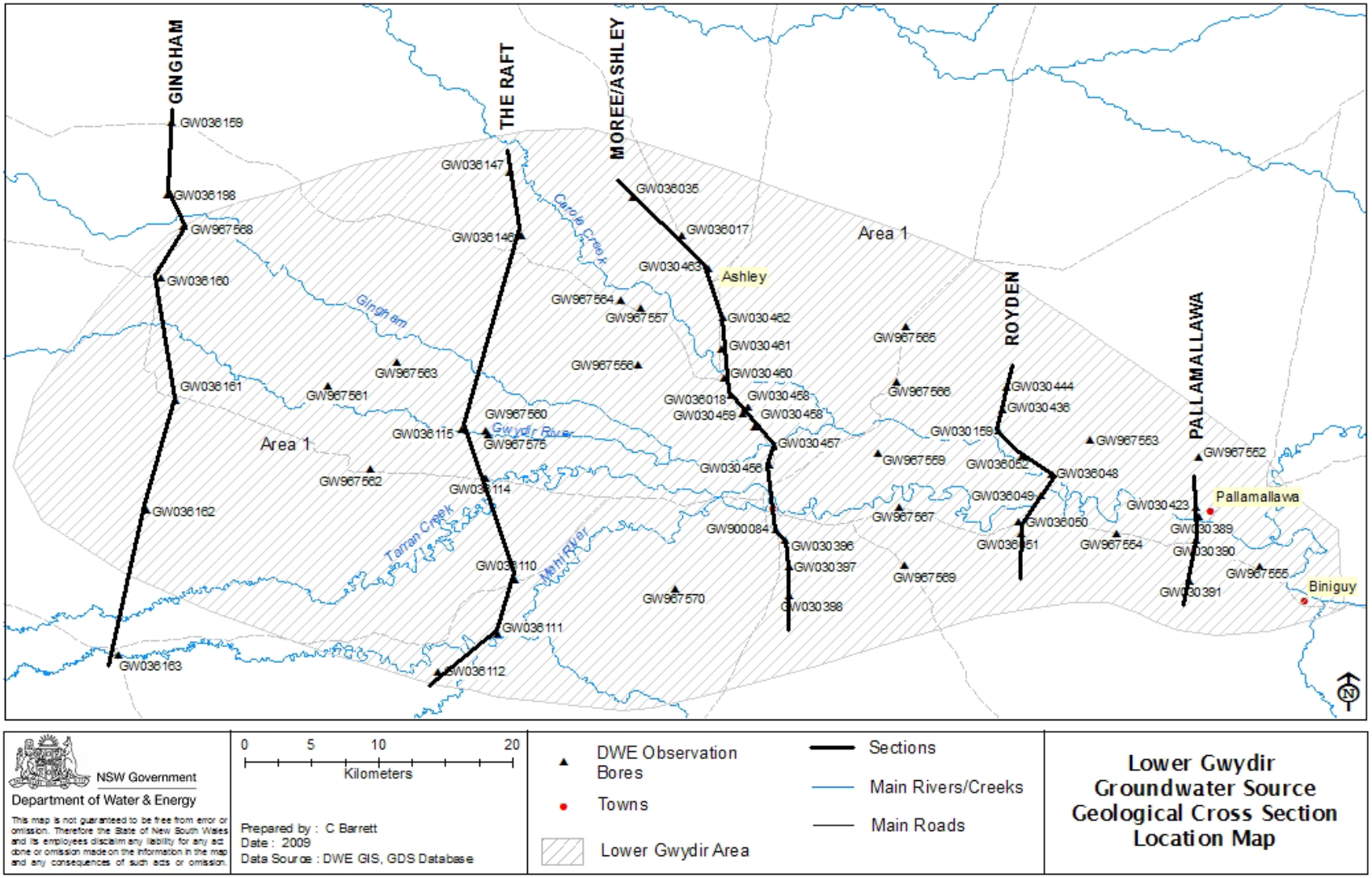


Figure 9 Location of cross sections



Hydrographs

Figures 10 and 11 show hydrographs from the Pallamallawa Section. At both sites there are two pipes screened less than 30m into the Narrabri Formation. The almost identical water level behaviour in both pipes indicates that at this location the formations are in excellent hydraulic connection and are unconfined. River recharge is rapid as shown by the sharp short lived peak in water levels in 1984 and 2001–02. Water levels in GW030423 show some response to extraction since 2002. At both sites the water levels were stable until 2003 since this time there they have been declining.

Figure 10 Hydrograph for groundwater monitoring site GW030423

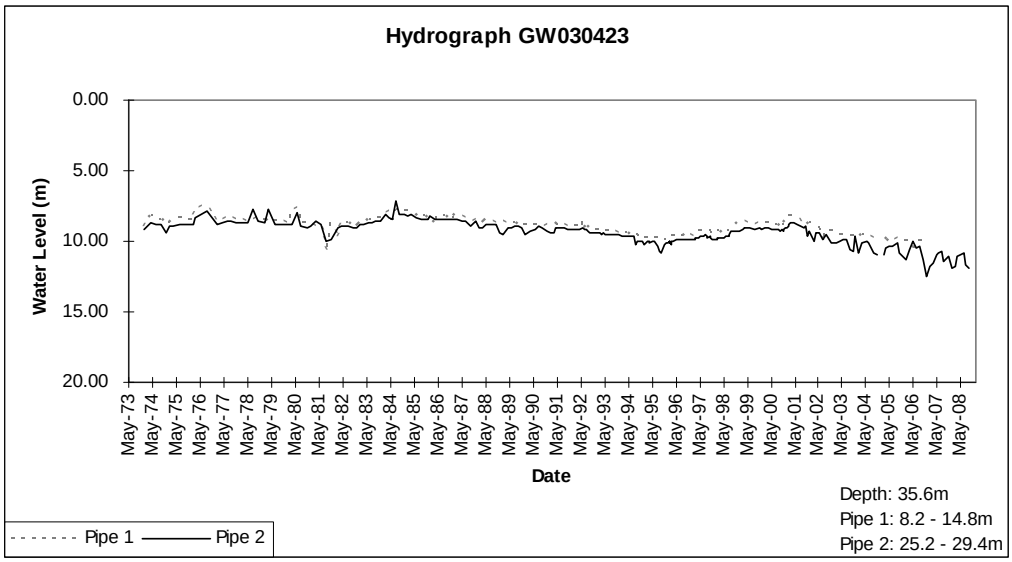


Figure 11 Hydrograph for groundwater monitoring site GW030390

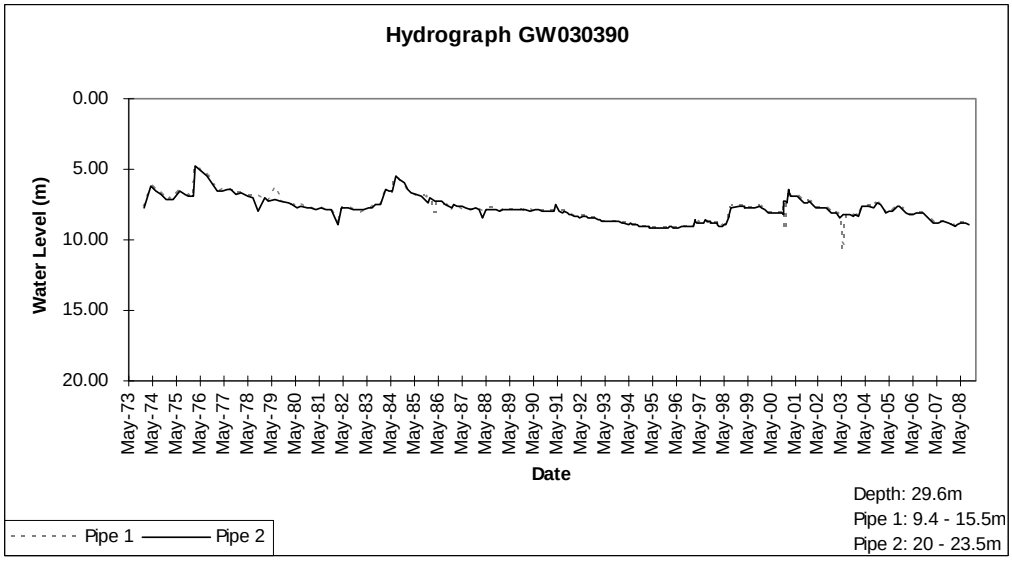
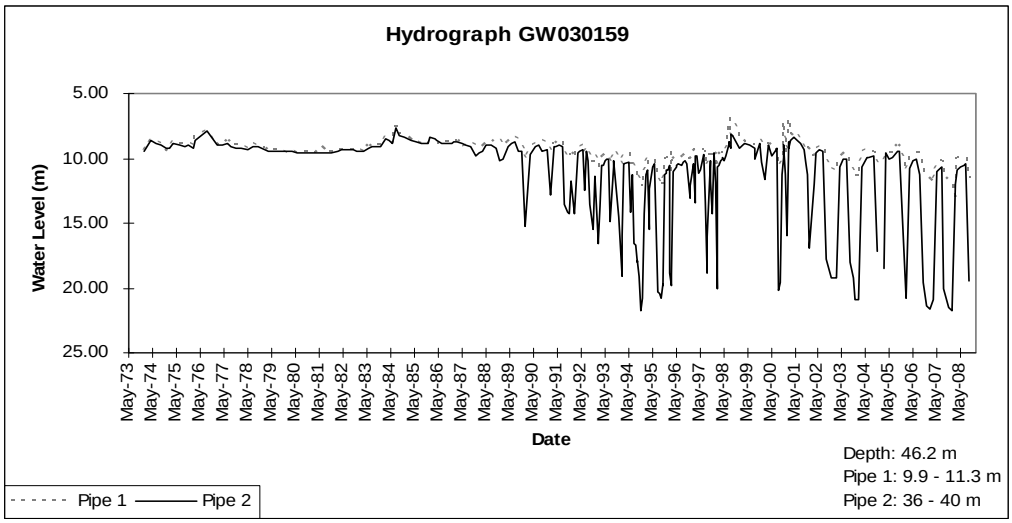


Figure 12 shows the water level data from bore GW030159 located next to the Gwydir River on the Royden Section. This bore has pipes into the unconfined Narrabri Formation and the semi confined Gunnedah Formation, the deepest screen is from 36m to 40m. The water level response in the upper aquifer indicates there is some hydraulic connection between the aquifers with extraction in the deeper aquifer impacting on the upper aquifer. The deeper aquifer has seasonal drawdowns of 10–11m.

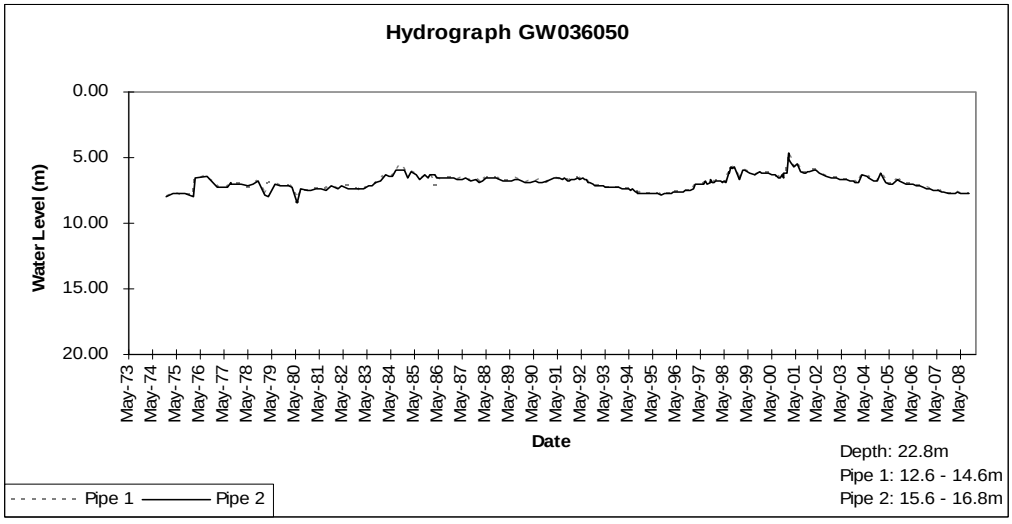
Significant peaks in water levels correspond with flood events in 1976, 1984, 1998 and 2001. Over all, water levels have been declining since 2001.

Figure 12 Hydrograph for groundwater monitoring site GW030159



The hydrograph for bore GW036050 located to the south of the Mehi River on the Royden Section is shown in Figure 13. The pipes are completed in the Narrabri Formation only with the deepest screen at 15.6m to 16.8m. The water level's response indicates there is excellent vertical hydraulic connection between the aquifers which are unconfined. The data also shows a response peak to major flooding in 1984, 1998 and 2001 and minor flooding in 2005.

Figure 13 Hydrograph for groundwater monitoring site GW036050



Bore GW036018 is located between Moree and Ashley in an area of intense cotton irrigation. There is one pipe completed in the semi-confined Narrabri Formation and two pipes in the Gunnedah Formation with the deepest screen from 42.2m to 44.7m. The hydrograph is shown in Figure 14.

The water level data from GW036018 suggests reasonably good hydraulic connection between the deeper aquifers although the shallow aquifer shows a much more subdued response to pumping. There has been significant drawdown due to extraction since the mid 1980s with drawdowns of up to 15m. The recovered water levels also show a declining trend from 1986–1996. After 1996 there is some recovery of water levels and less drawdown to 2001–02. This result is most likely due to wetter

years and reduced extraction. The water levels since have shown drawdowns up to 15m and continuing recovery decline.

Figure 14 Hydrograph for groundwater monitoring site GW036018

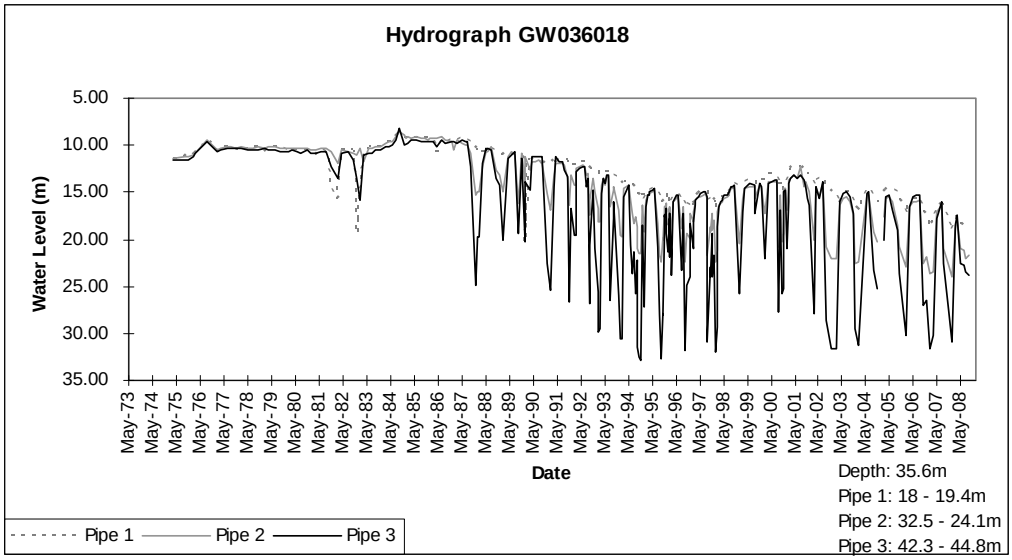


Figure 15 shows the water level data from bore GW030456 located just North of Moree. This bore is located close to a Moree town water supply bore between the Mehi and Gwydir Rivers. There is one pipe located in the unconfined Narrabri Formation and two pipes into the Gunnedah Formation, the deepest screen is from 43m to 46 m. Water levels for the shallow aquifer indicate a subdued response to extraction in the deeper aquifers suggesting limited hydraulic connection. The water levels show a response to extraction since the 1970s from the nearby town water supply bore. There are drawdowns of up to 5m with an overall declining trend in water levels at this site.

Figure 15 Hydrograph for groundwater monitoring site GW030456

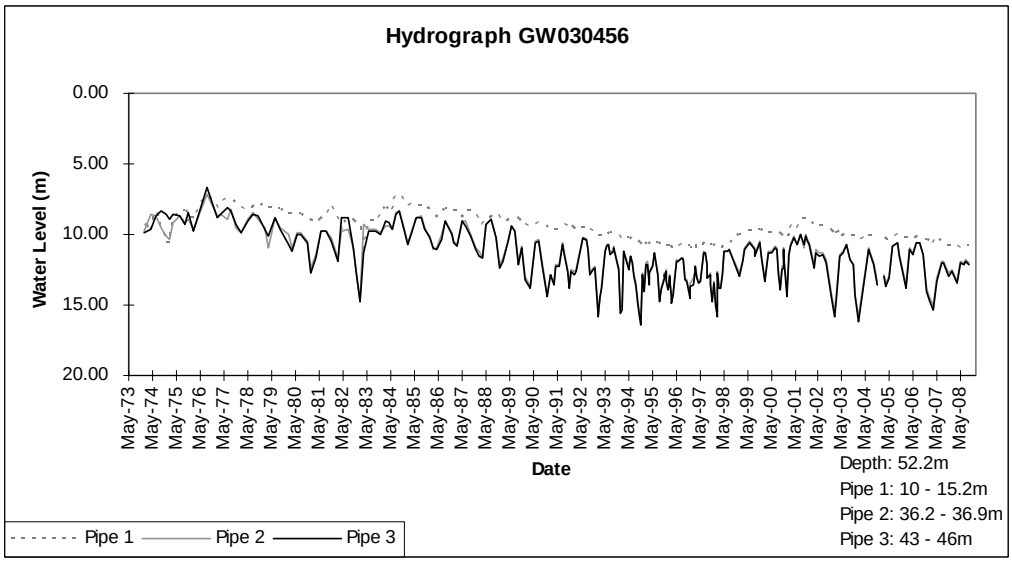


Figure 16 shows two pipes at site GW030397 which are screened in the Narrabri Formation. GW030397 is located south of Moree. At this site the aquifer is semi confined, the deepest screens are from 36.4m to 39.6m. Water level behaviour shows there is a minor response to extraction since the 1970s which is most likely due to the proximity to another town water supply bore. The data indicates an overall rising to a stable water level trend and there is no obvious response to climate.

Figure 16 Hydrograph for groundwater monitoring site GW030397

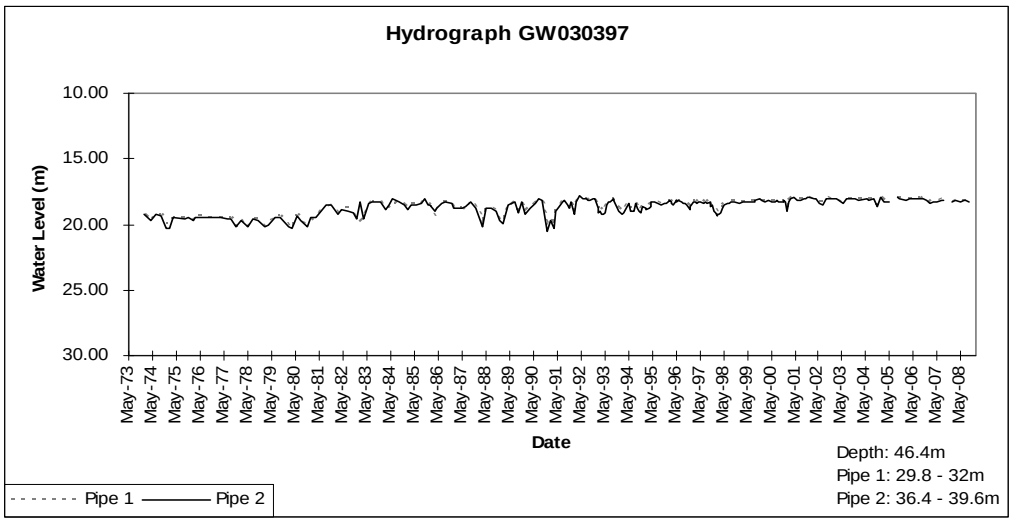


Figure 17 shows the hydrograph for GW036146 located north of Moree near Carole Creek on the Raft Section. This site has pipes in the Narrabri and Gunnedah Formations. The similar water level behaviour in both pipes indicates that at this site these formations are in good hydraulic connection. Water level response shows an overall declining trend since monitoring commenced in the 1970s. In the early 1990s a reverse in hydraulic gradient to downward leakance has been noted.

Figure 17 Hydrograph for groundwater monitoring site GW036146

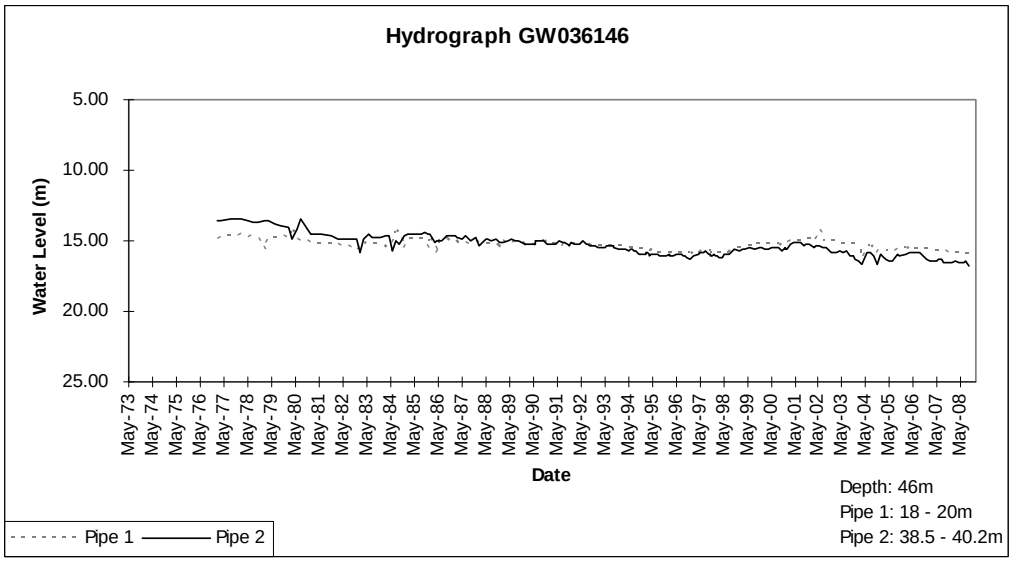
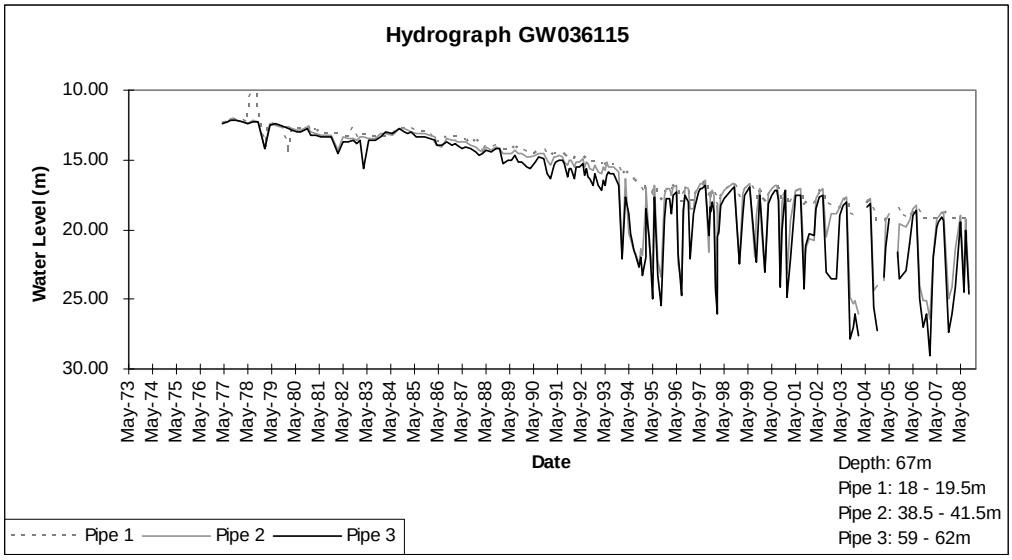


Figure 18 shows the hydrograph for bore GW036115 which is located west of Moree on the Raft Section next to the Gwydir River. There is one pipe located in the Narrabri Formation and two pipes in the Gunnedah Formation. The deepest screen is from 59m to 62 m. The shallow aquifer shows a subdued response to extraction in the deeper aquifers suggesting limited hydraulic connection. The deeper pipes show excellent hydraulic connection. Water level response in the deeper aquifers shows a response to extraction since the 1990s, with drawdowns of up to 10m. The water levels show an overall declining trend with a subdued response to wet and dry years.

Figure 18 Hydrograph for groundwater monitoring site GW036115



The hydrograph in Figure 19 is for bore GW36112 located on the edge of the water source boundary south west of Moree near the Mehi River. All pipes at this site are screened in the Narrabri Formation with the deepest screen from 28.5m to 29.7m. The water levels were rising from 1998 after a major flood and also show a pronounced response to the 2001 flood event. The water levels have been declining since 2001.

Figure 19 Hydrograph for groundwater monitoring site GW036112

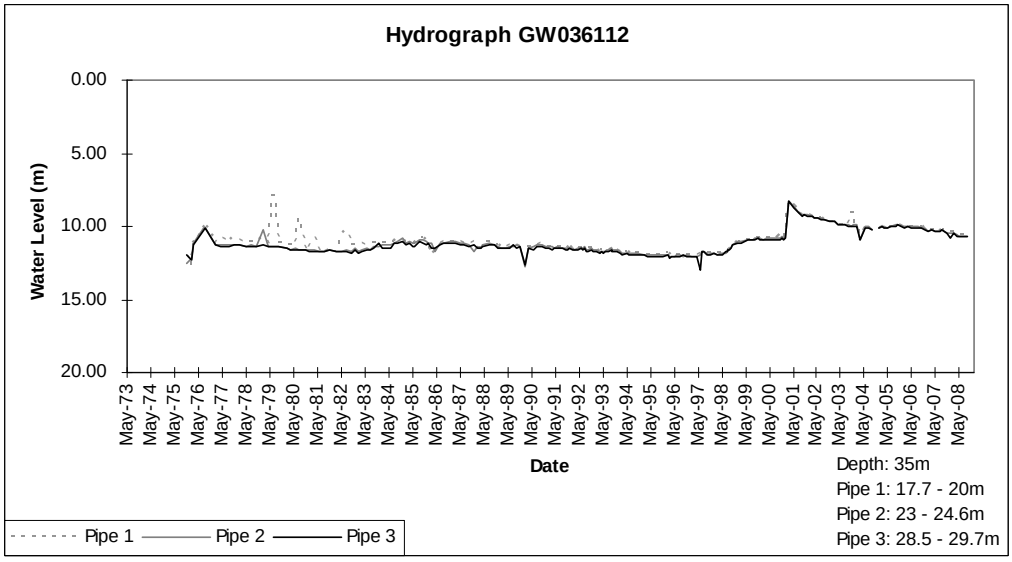
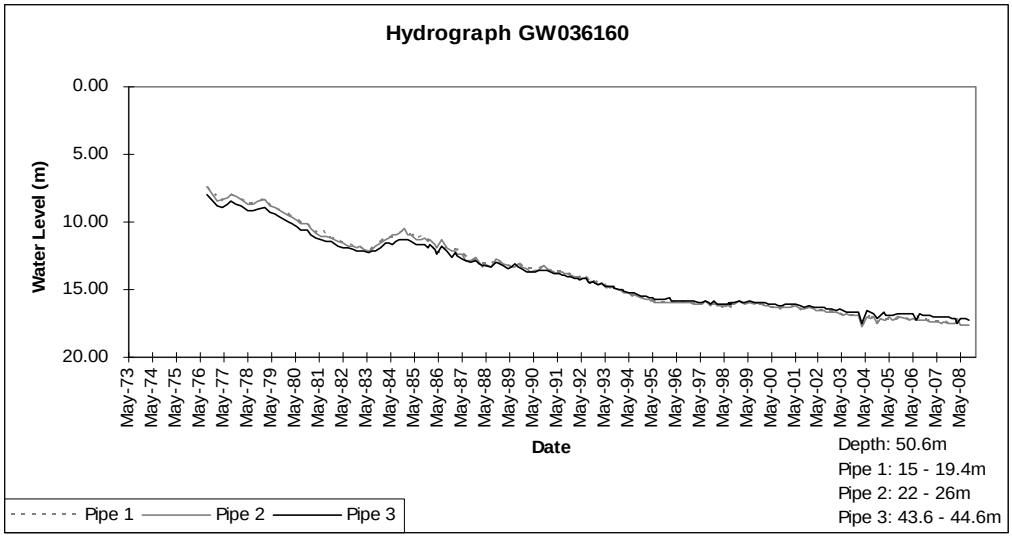


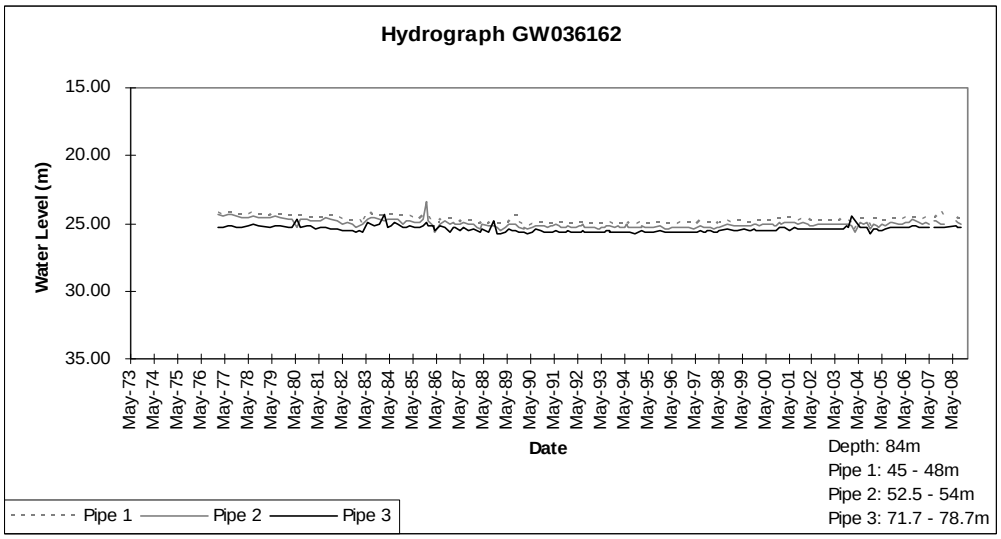
Figure 20 shows the hydrograph for bore GW36160 which is located on the Gingham Section at the western edge of the water source. There are two pipes located in the semi-confined Narrabri Formation and one pipe into the Gunnedah Formation, the deepest screen is from 43.6m to 44.6m. None of the pipes show impact from extraction however there is an overall declining trend in water levels since monitoring commenced in the 1970s and a reverse in hydraulic gradient to downward leakage in the early 1990s.

Figure 20 Hydrograph for groundwater monitoring site GW036160



The hydrograph in Figure 21 is for bore GW036162 which is located on the Gingham Section south west of Moree. There are three pipes into the Gunnedah Formation only. The deepest screen is from 71.7m to 78.7m. There is little groundwater extraction occurring in this area. Over all the water trends at this location are stable.

Figure 21 Hydrograph for groundwater monitoring site GW036162



Hydrograph summary

Large drawdowns and recovery decline occur along the Royden, Moree/Ashley and Raft Sections north of the Gwydir River where the majority of extraction occurs. The most significant drawdowns occur in the area between Moree and Ashley. With growth in groundwater usage from the deep aquifer since the 1980s, the pressure in this aquifer has fallen due to extraction. This is inducing downwards leakage from the shallow aquifer, causing a decline in water levels in the shallow aquifers and reversal in the hydraulic gradient in some bores. During the wetter years of 1996–2001 there was a period of reduced extraction and water levels in most parts of the aquifer stabilised or recovered. However, since onset of the drought in 2001 water levels have continued to decline in these areas. The bores close to the Gwydir and Gingham Rivers have water level peaks after major flood events and in the bores further away from the rivers the water levels reflect wet and dry years.

The bores on the northern part of the Gingham section show no drawdown response but have significant water level declines. This maybe in part due to reduced through flow as a result of extraction to the east. On the peripheral edges and in the south west of the water source water level responses show stable to rising water level trends and little or no direct response to groundwater extraction. These sites also show subdued or no response to climatic changes and major flood events.

Contour diagrams

In this section a number of contour diagrams are displayed, these were constructed using the GIS mapping program 'ArcGIS' and quality check against hand drawn contours of the same data.

The pre development potentiometric surface and groundwater flow directions for the deep productive aquifer is shown in Figure 22. The 2007–08 recovered potentiometric surface and groundwater flow directions for the productive aquifer are shown in Figure 23.

Prior to development of the aquifer, groundwater heads and flow directions were primarily in a westerly direction with a recharge bulge toward the west indicating river water leaking into the groundwater. Thirty years of extraction and recovery decline has reduced the pressures in some areas and caused the potentiometric surface to change shape. Comparison between the groundwater heads and flow directions in Figures 22 and 23 show the contours are flatter in the 2007–08 diagram, there is no longer obvious river bulging along the rivers.

Figure 22 Pre development potentiometric surface and groundwater flow direction in deep aquifer

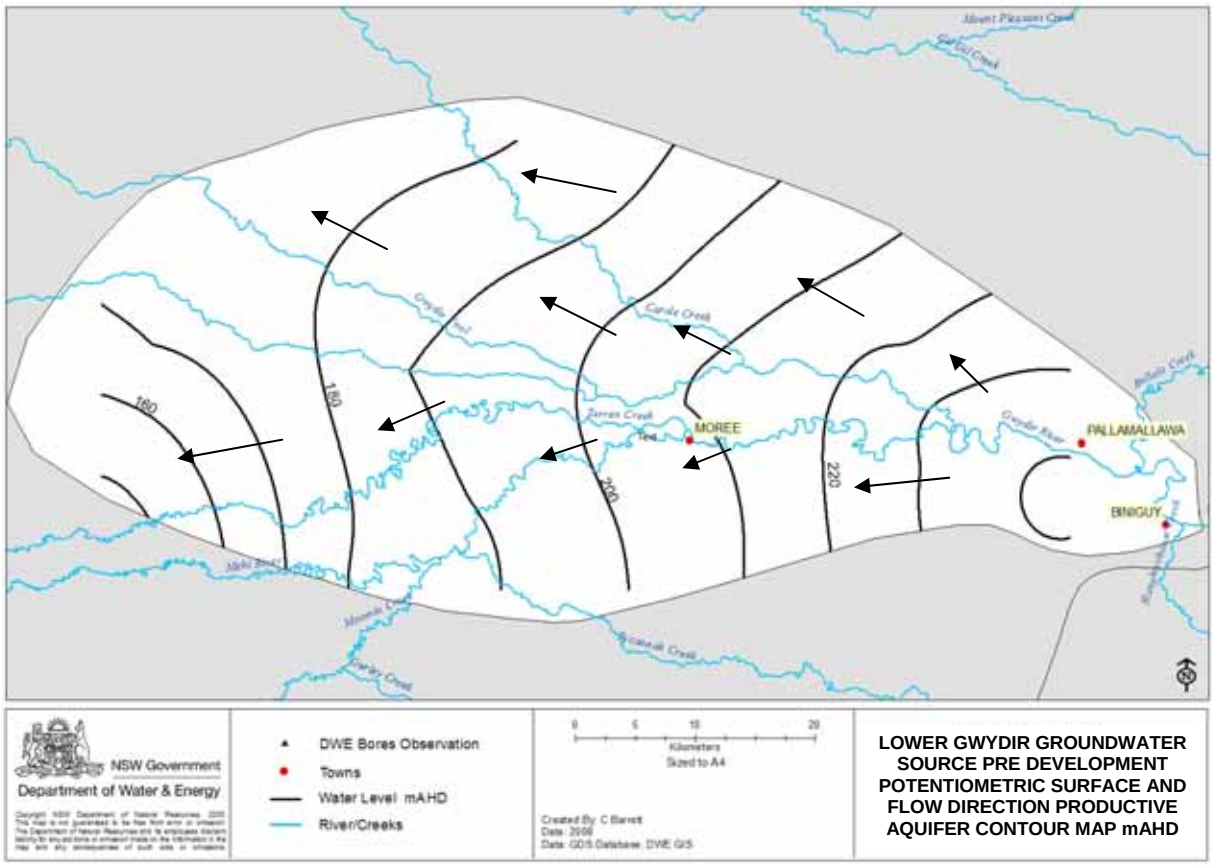


Figure 23 2007–08 Recovered potentiometric surface and groundwater flow directions in deep aquifer

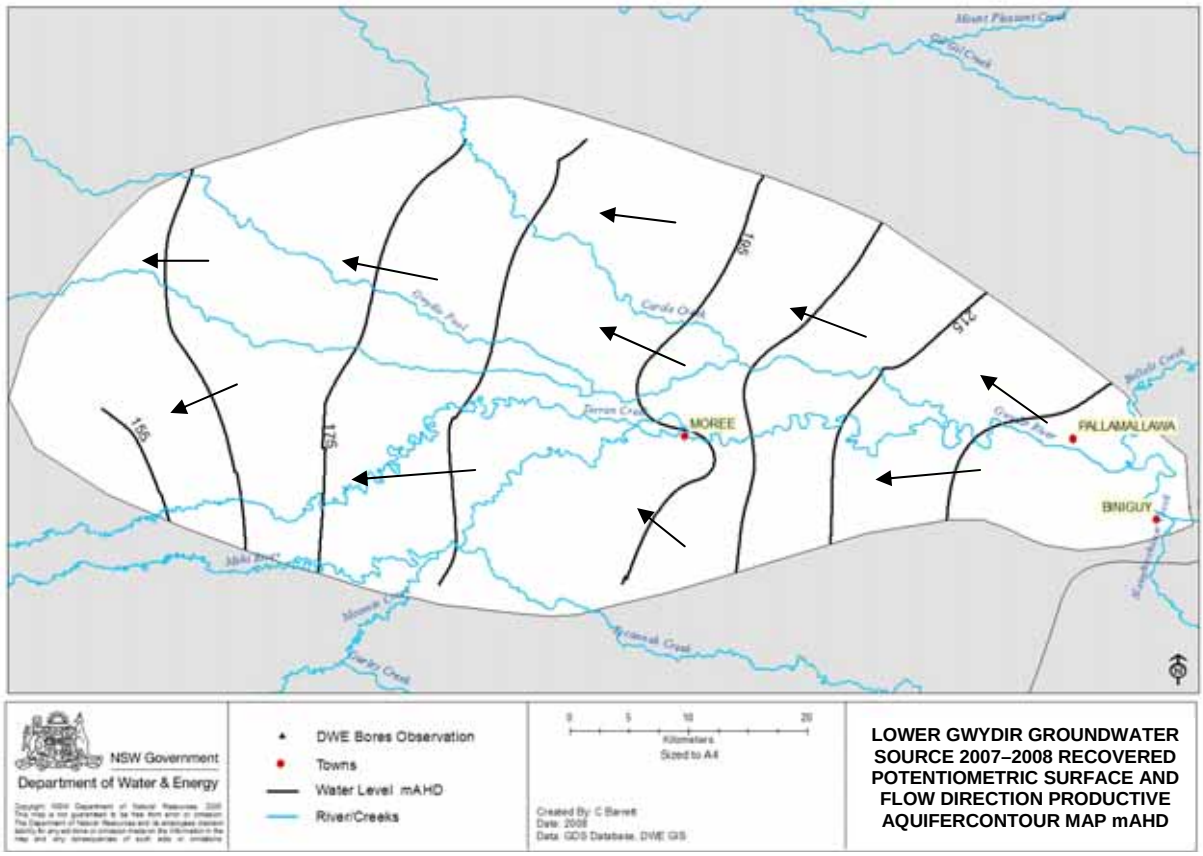
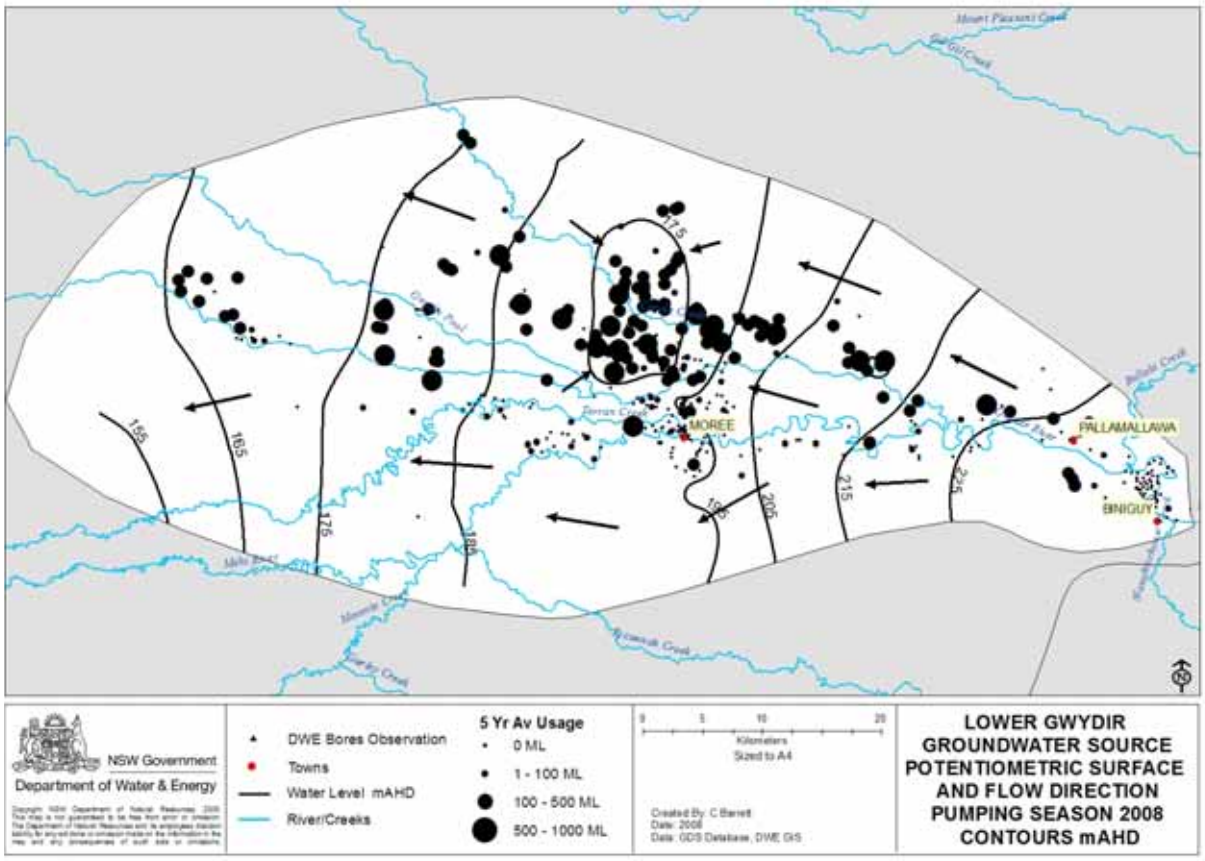


Figure 24 shows the potentiometric surface and groundwater flow directions for the productive deeper aquifer over the pumping season. Extraction reduces the groundwater pressure in areas of pumping and cause the groundwater flow direction to change. This is particularly evident north of Moree, where flow directions are changed from west to east due to the concentration of extraction.

Figure 24 Potentiometric surface and groundwater flow directions in deep aquifer (2007–08 pumping season)

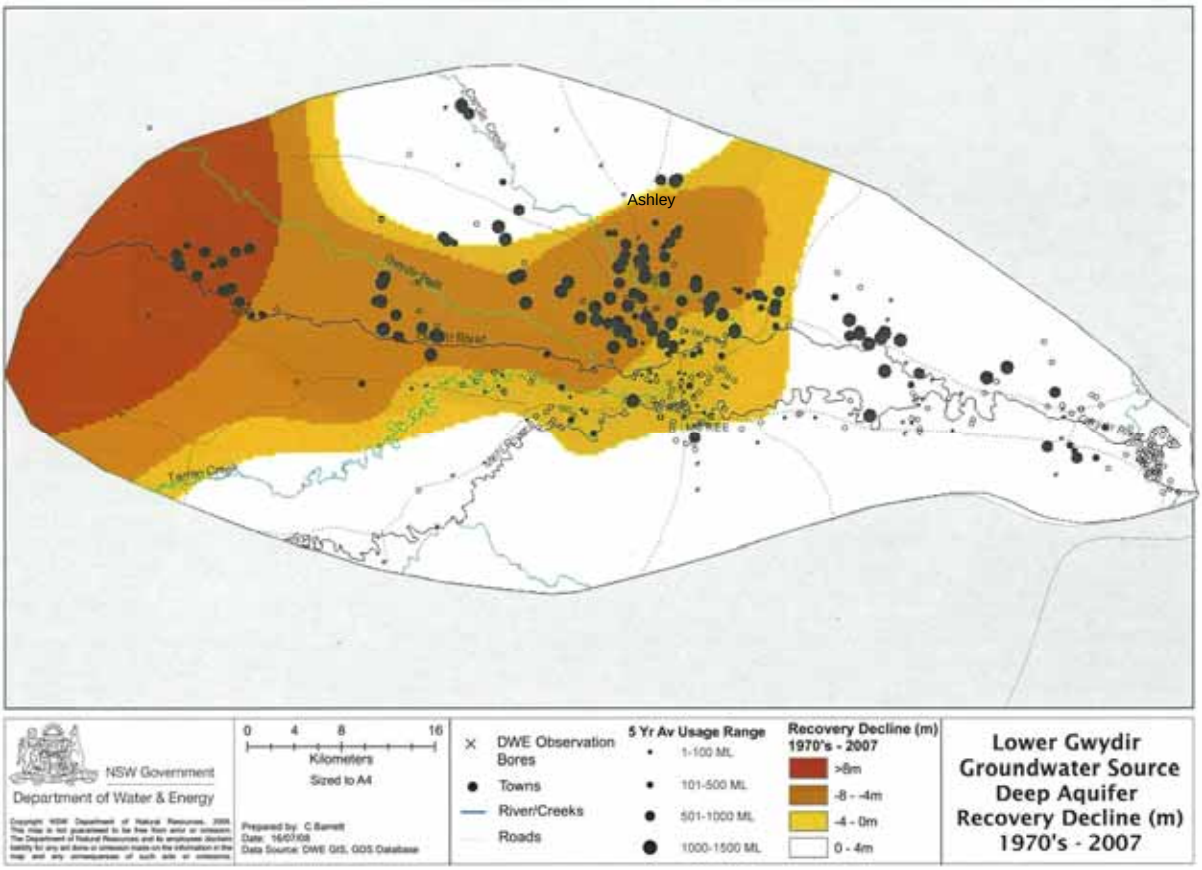


The recovered head is the level to which the potentiometric surface recovers at the end of each pumping season. Recovery of water levels is important for the health and functioning of the aquifer and for the economic benefit of its users (Smithson, 2009).

The recovery decline is the difference between the pre development potentiometric surface and the recovered potentiometric surface. When the groundwater head does not recover to the level of pre development over time, this indicates potential for a long term decline in groundwater levels. Recovery decline in the deep aquifer since development is shown on Figure 25.

Recovery decline up to 8m occurs in the area north of Moree between Moree and Ashley and in the west of the water source. These correspond closely with the areas showing significant drawdowns in Figure 24. There is recovery decline of greater than 8m in the far west of the Lower Gwydir where the hydrographs show no direct response to extraction. The large recovery decline is likely to be a result of reduced through flow caused by concentrated extraction to the east in conjunction with climatic conditions.

Figure 25 1970s to 2007 Recovery decline



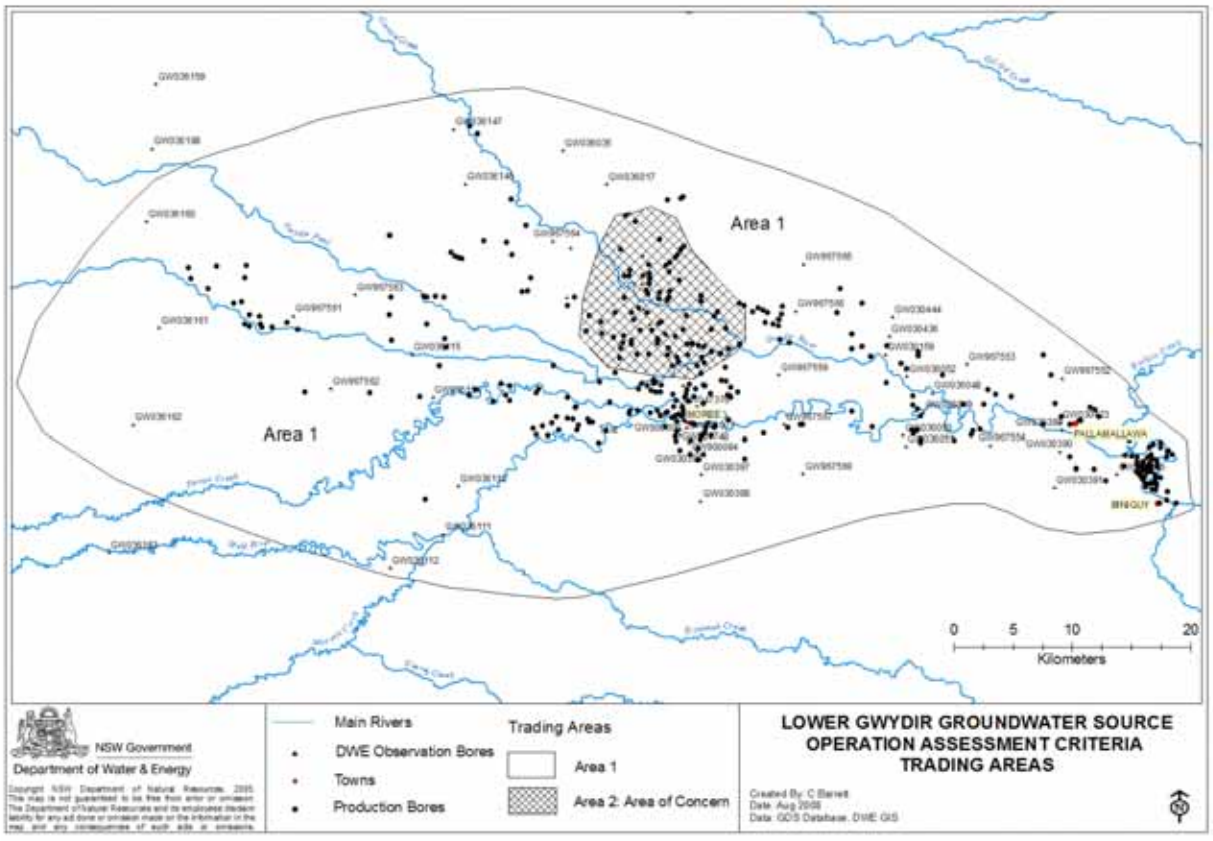
Community consultation and management of drawdown impacts

The findings of the 2006–2008 assessment of groundwater status were presented to the Lower Gwydir groundwater community on 22 July 2008 at Moree. The presentation included a discussion of groundwater management and acceptable impacts.

As a result of the levels of impact occurring, trade restricted areas were proposed for the areas where drawdowns of up to 40 per cent of saturated thickness of the alluvium have occurred and are also showing recovery decline. An area of concern was identified between Moree and Ashley. The intention of these restrictions is to limit further impacts from additional water being traded in to these areas of greater impact. The proposed trade restricted areas were presented at the community meeting for discussion and comment. A second meeting was held on the 21 August 2008 in Moree with the licence holder located within the area of concern to further discuss trade restricted areas.

The criteria for dealings assessments in the Lower Gwydir, including trade restricted areas, took effect on 21 August 2008. The trade restricted areas are shown in Figure 20. The dealings assessment criteria and an explanation of the trade restricted areas are given in Appendix A.

Figure 26 Trade restricted areas in the Lower Gwydir Groundwater Source



14 References

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Jiwan, J. and Gates, G.. (1993) *Groundwater Use and Water Level behaviour in the Lower Gwydir Valley NSW.* Status Report Number 2. NSW Department of Water Resources Sydney, NSW.

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State of Queensland (Natural Resources and Mines, on behalf of the Climate Impacts and Natural Resource Systems, 2000), 1998 (Cited 13 February 2009) *The SILO Patched Point Dataset (PPD)*, http://dlwc/silo/ppd/PPD_frameset.html

Appendix A Dealings assessment criteria

Lower Gwydir Groundwater Source dealing assessment criteria

Dealings will be assessed in accordance with the criteria set out below. Dealings that do not meet the assessment criteria will be refused because of the adverse impacts on the aquifer and its users from seasonal water level drawdowns and cumulative water level and recovery decline (over and above those impacts anticipated under the provisions of the 2003 Water Sharing Plan).

Following a review of the Lower Gwydir Groundwater Source conducted in the first half of 2008, an area between Moree and Ashley was identified as having significant drawdown and recovery decline, with drawdowns of up to 40 per cent of saturated thickness during the 2006–2007 pumping season.

This area between Moree and Ashley has become an area of concern in regard to the cumulative impacts on the aquifer and water users, and that the declining water levels above those anticipated under the Water Sharing Plan may result in a reduced economic benefit to the community.

The identification of this area of concern has lead to 2 trading areas (Figure 1) being established to assist in the management of groundwater dealings.

Area 1 – the area outside of the area of concern;

Area 2 – the area of concern between Moree and Ashley.

Permanent Dealings (71M, 71N, 71Q and 71W) Assessment Criteria

All permanent dealings will be subject to a full assessment by DWE. Permanent dealings that are assessed as having an adverse impact will be refused by DWE. All assessments for permanent trades will be done on the following criteria calculated at the end of a 10 year period:

- The calculated drawdown at 200m from any production bore will not exceed 40 per cent of the saturated thickness of the alluvium.
- The additional drawdown at the nearest neighbouring bore screened in the same aquifer will not exceed 2m.

Pending satisfaction of the above criteria, permanent dealings may be permitted if they are:

a. between properties within the same trading area,

b. from Area 2 into Area 1

Dealings may be approved subject to conditions being placed on nominated work or combined approvals such as bore extraction limits to minimise potential impact on neighbouring bores.

Permanent trading, subdivision and amalgamation of licences are received and assessed by the Department of Water and Energy, and are subject to IPART determined fees. Permanent dealings will attract a lodgement fee of $112.35 plus $356.92 for a basic hydrogeological assessment. Applications requiring a special hydrogeological assessment are levied at $16.42 per unit entitlement in excess of 20 unit entitlements. For more information contact the Department's Narrabri office on 02 6799 6625.

Temporary Dealings (71T) Assessment Criteria

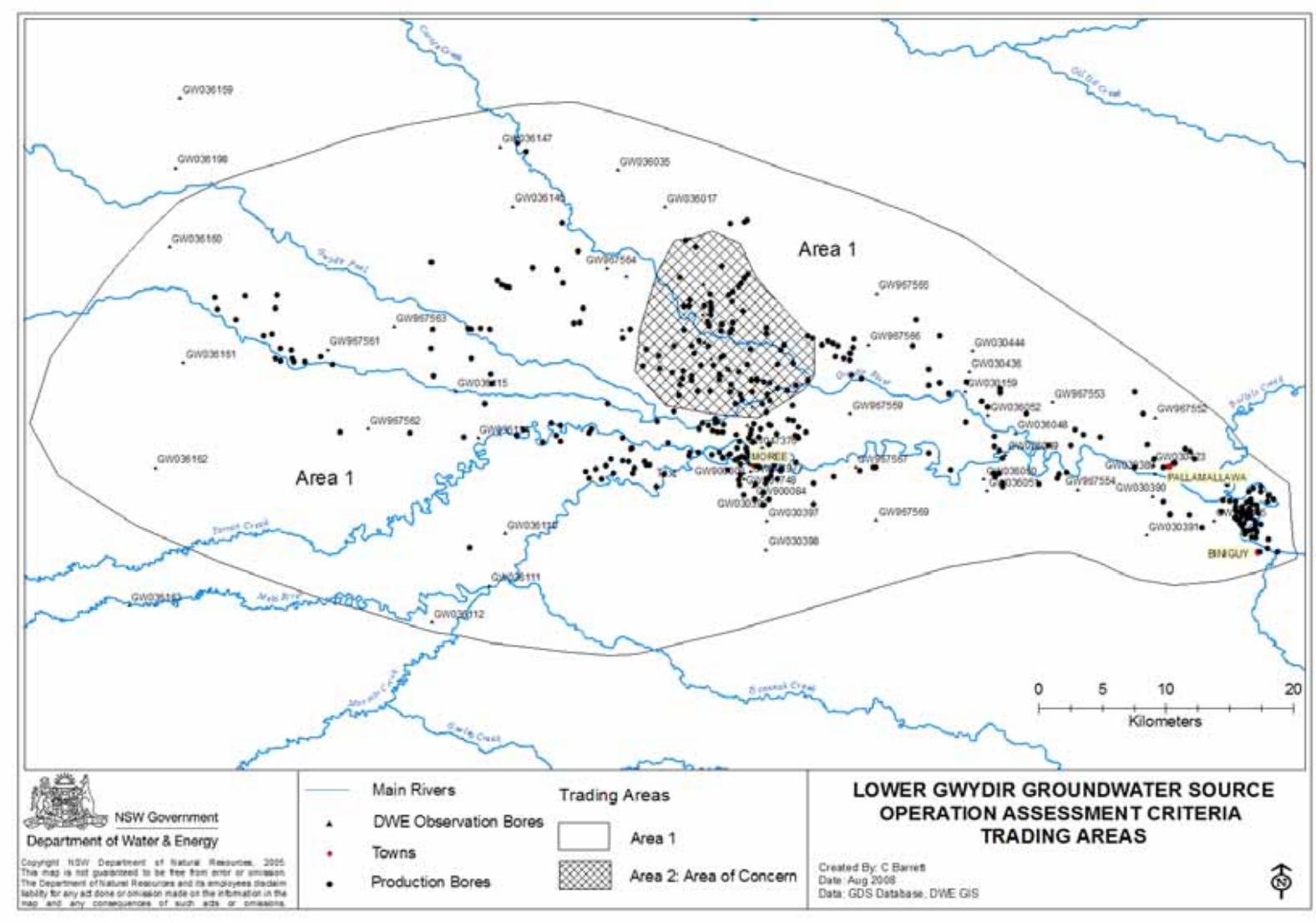
Temporary dealings will be approved without a hydrogeological assessment if they are:

a. Into Area 1 (including trades out of the Area 2).

b. Into and within Area 2 but will be capped so that the take limit and supplementary access for a year does not exceed the past maximum history of use of the buyer (i.e. temporary dealings + take limit + supplementary access is not greater than the maximum history of use of the buyer).

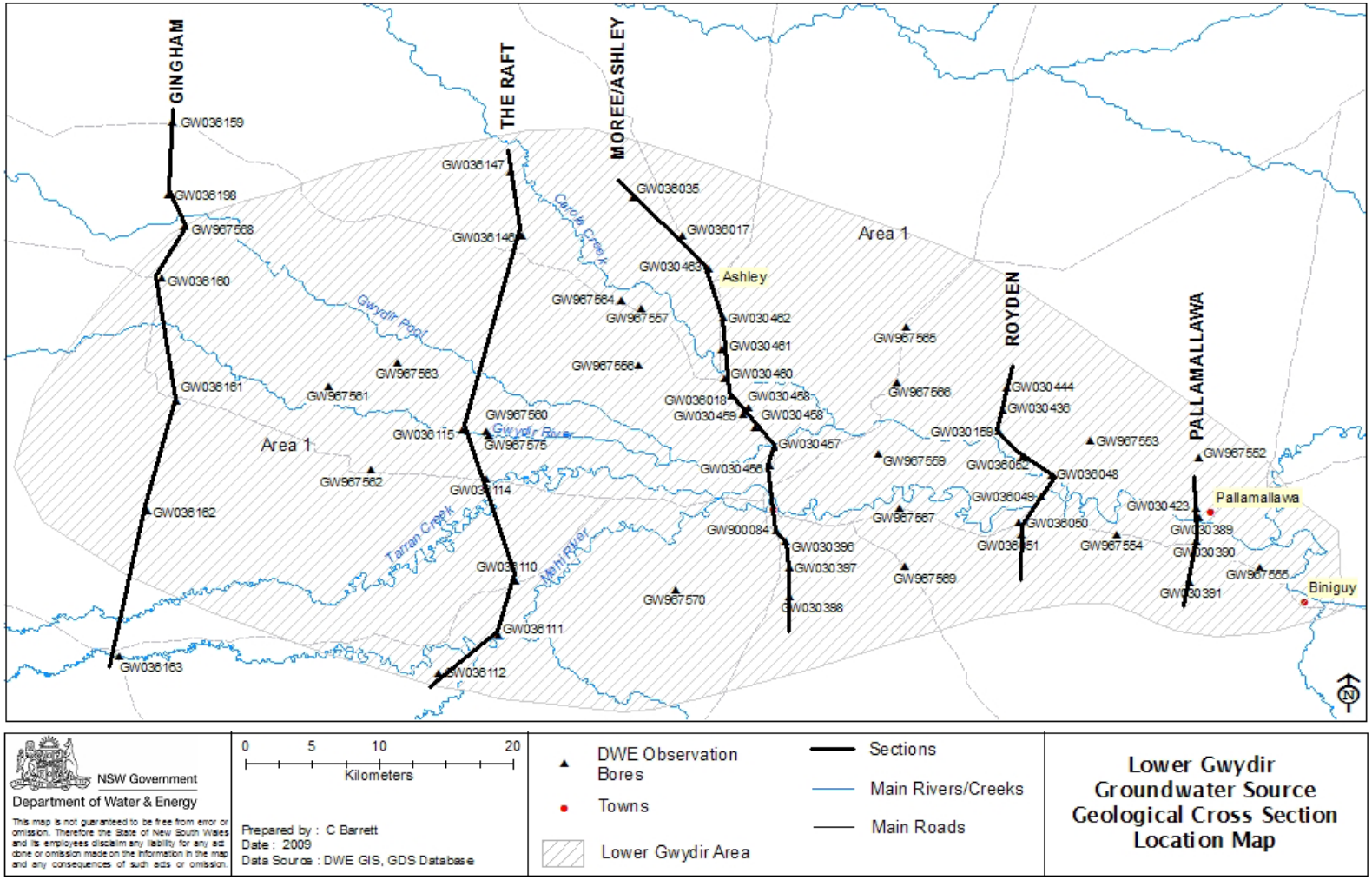
Assignments of allocation (or temporary transfers) are processed by your State Water Corporation Customer Service Officer. The fee for a temporary transfer is $50 plus $0.50 per ML up to a maximum of $150. For more information or an application form please contact your State Water Customer Service Officer.

Figure A1 Trading areas of the Lower Gwydir Groundwater Source.

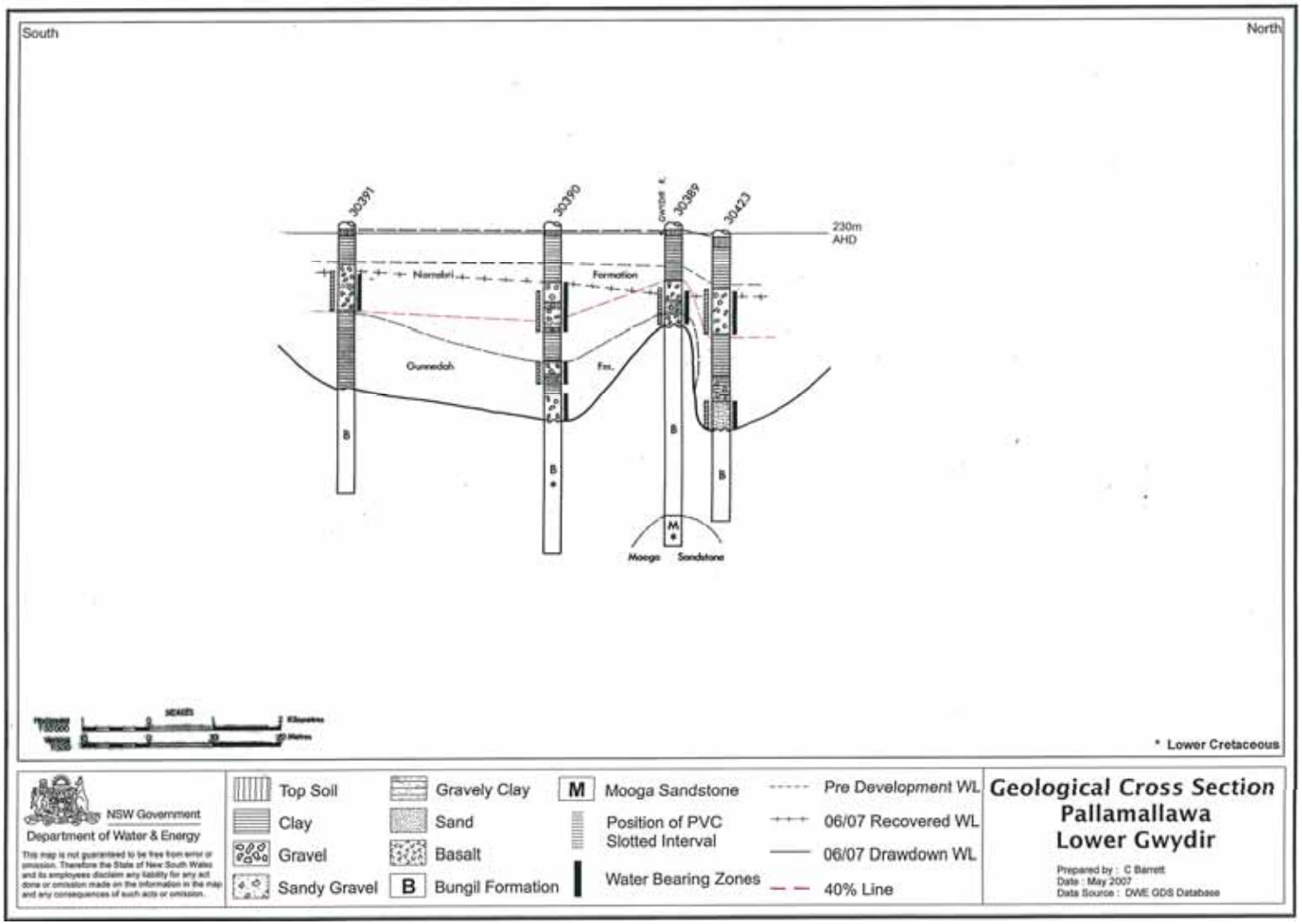


Appendix B Geological Cross Sections

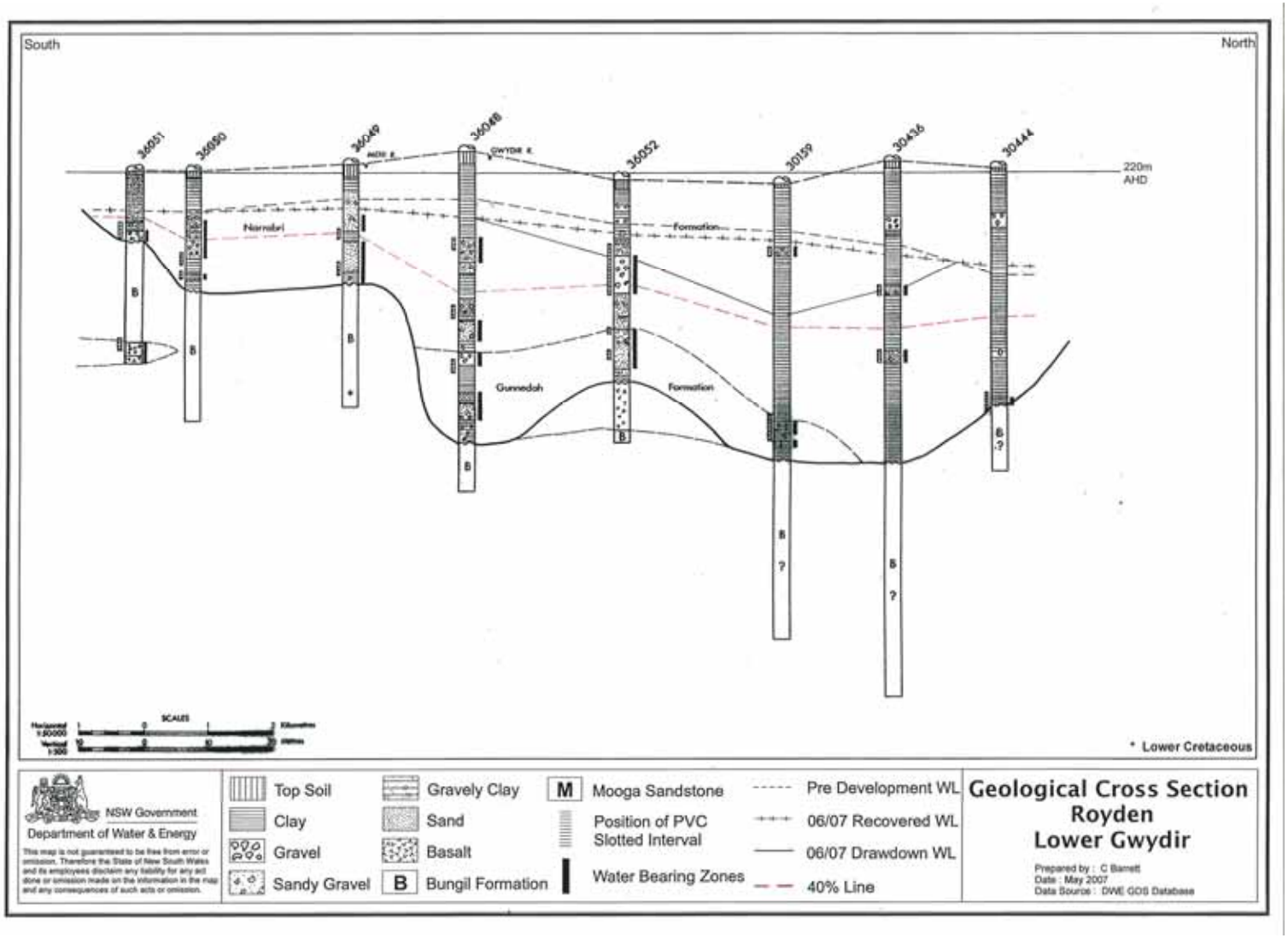
Map B1 Cross Section location map Lower Gwydir



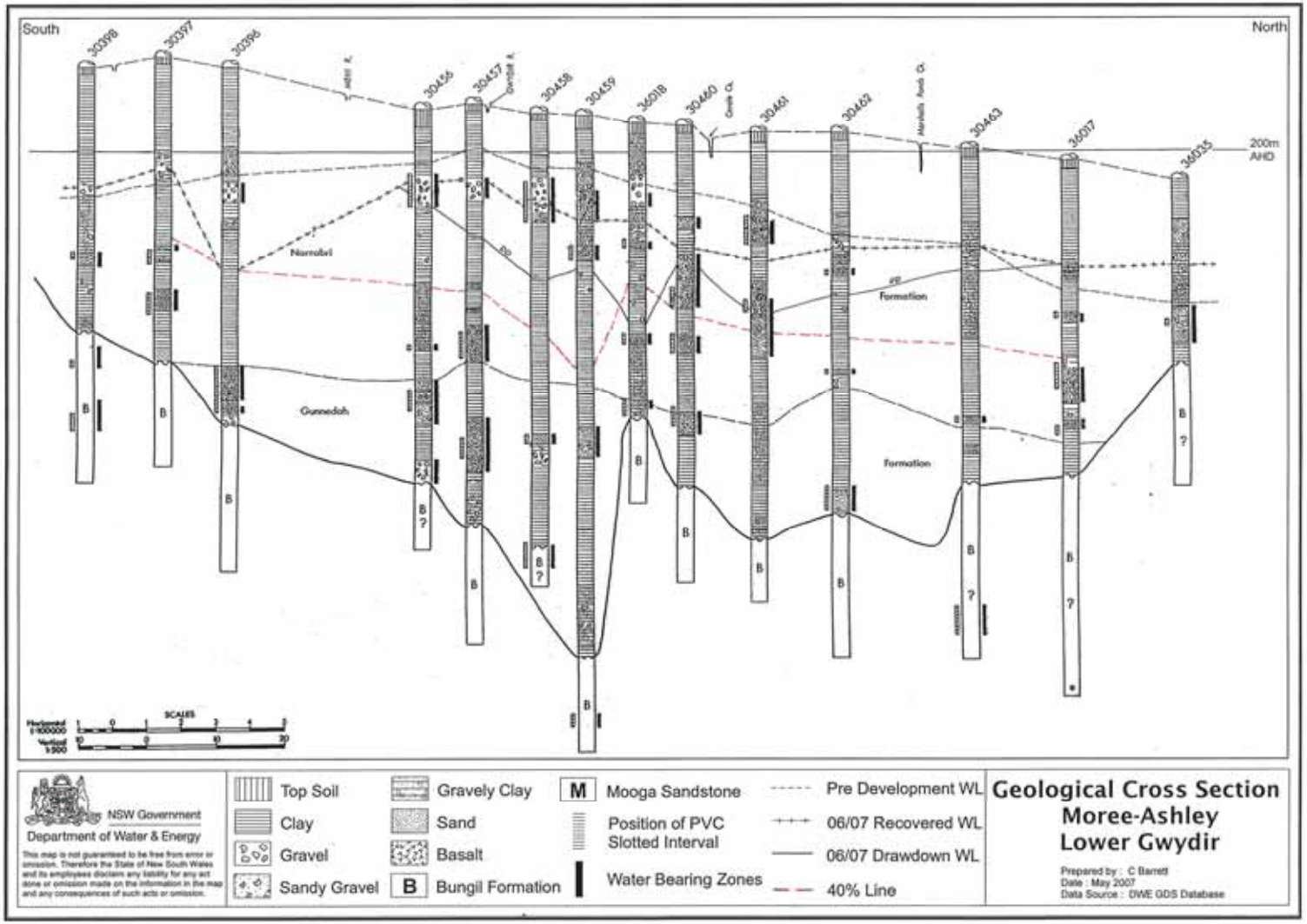
Map B2 Pallamallawa geological cross section



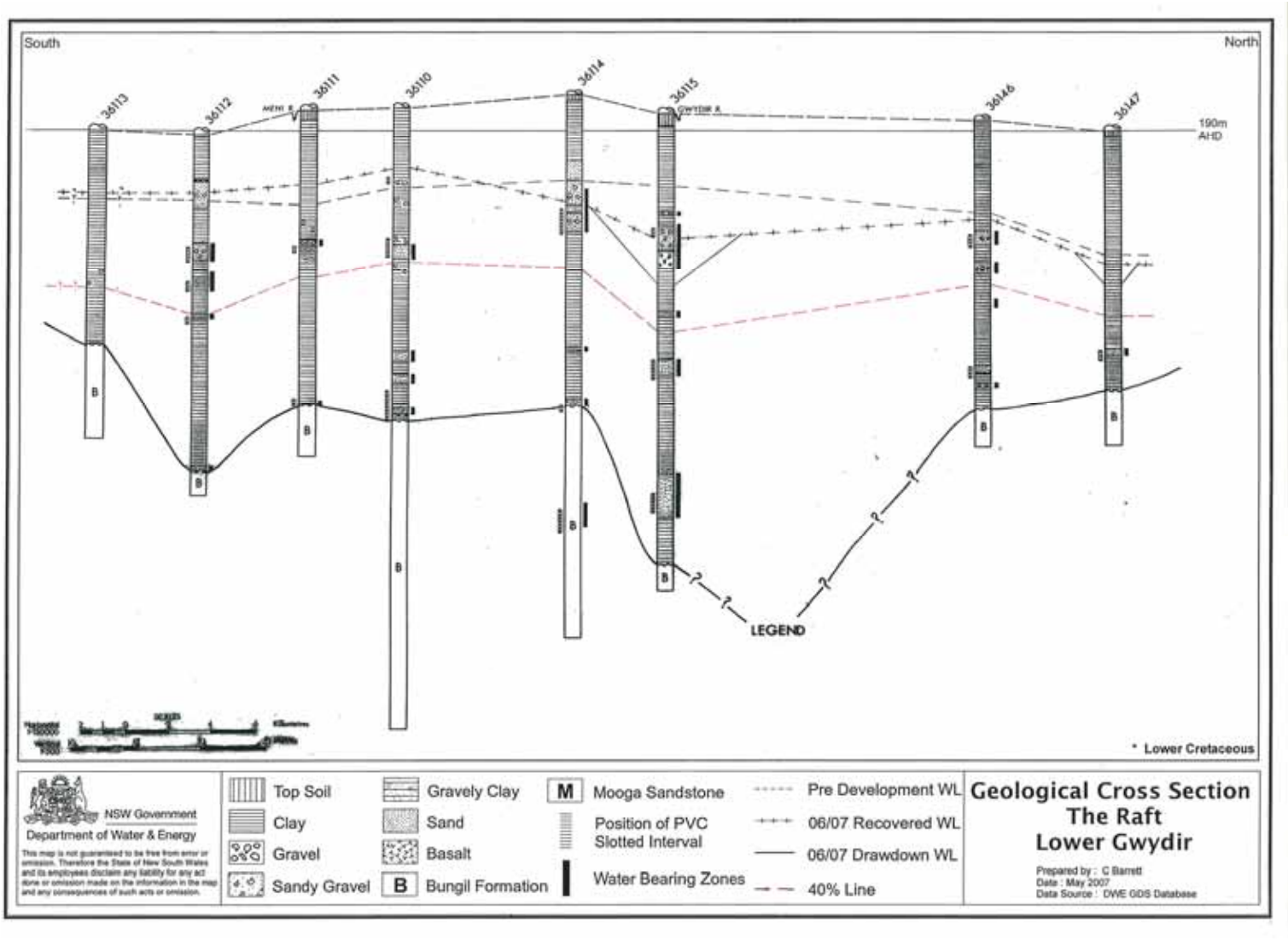
Map B3 Royden geological cross section



Map B4 Moree/Ashley geological cross section



Map B5 The Raft geological cross section



Map B6 Gingham geological cross section