Australasian
Groundwater
and Environmental
Consultants Pty Ltd
(AGE)

Report on

Underground Water Investigation Report for ATP769

Paranui Pilot Project

Prepared for
Westside Corporation

Project No. G1631A October 2015
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Executive Summary

Westside in joint venture with QGC and Mitsui E&P Australia, are assessing development of the Paranui Pilot Project on ATP769, located 10 km south of Moura, and 5 km to the west of the Meridian Coal Seam Gas (CSG) fields. The Project targets the Baralaba Coal Measures which contain gas-bearing coal in up to 14 seams that occur between 550 m and 950 m depth. This report presents the Underground Water Impact Report (UWIR) for Westside and has been prepared in accordance with the requirements detailed in the Water Act 2000.

The Paranui Pilot Project initially included production testing of three appraisal wells with three additional wells completed in 2010. Production testing of these wells was not completed and was subsequently suspended as a result of the protracted wet season in late 2010. Westside have not undertaken any production testing from the Paranui wells since 2010. However a development plan for the period 2014 to 2017 includes production testing of only two wells over a two year period between May 2016 and July 2017.

This assessment has included reviews of published and unpublished reports (in the public domain), registered bore operation, available groundwater level and (baseline) water quality data. Three aquifers were identified within the study area, these being:

- a shallow alluvial aquifer mainly associated with the Dawson River;
- the eastern extents of the GAB Mimosa Management Area along the western margins of ATP769; and
- a deeper confined aquifer within the Permian coal sequences that host the CSG resource.

Twenty six registered bores have been identified within ATP769. Only four of the 13 located within Quaternary alluvium appear suitable for water supply. The other 13 bores intersect the underlying Triassic and Permian sediments of which the majority are located within the Great Artesian Basin sediments, where more reliable yields and better water quality is available.

Numerical modelling undertaken to assess the likely extents of impact on these aquifers has identified that the Permian coal seam aquifer will be the only aquifer impacted by the proposed CSG operations for ATP769. Depressurisation of this aquifer does not extend upwards or laterally into the other two aquifers. The predicted extent of the Immediately Affected Area (IAA) as defined by drawdown exceeding 5 m is contained within a 90 m to 130 m radius of the proposed extraction wells. This increases slightly up to 50 m further for the Long Term Affected Area (LTAA) to between 140 m and 180 m of the proposed extraction wells. During the period of operation there are no impacted registered bores located within either the IAA or the LTAA. The nearest registered bore is a petroleum or gas exploration bore is located approximately 4 km to the northeast, and the nearest water supply bore approximately 11 km to the west. During this period, there is no cumulative impact as a result of the groundwater abstraction for the two wells. There is also no groundwater drawdown predicted in the Quaternary Alluvium (i.e. Dawson River Alluvium). Sensitivity analysis of the aquifer parameters has identified that the model is most sensitive to changes in the coal seam hydraulic conductivity value.

A groundwater monitoring program has been established to assess the changes in groundwater levels and quality on re-commencement of operation and during the CSG operations. This includes sampling and monitoring undertaken on a quarterly basis for the first 12 months of operation. Thereafter, the monitoring frequency will be reviewed to determine whether variation to the sampling frequency is warranted (i.e., biannually or annually). A review of performance of the numerical model will also be undertaken to confirm the predicted level and extents of impact on the aquifer(s), update the model, and decrease the level of uncertainty with the current model parameters. The results of the monitoring program and outcome of the model review will be presented in annual reviews of the Project to Westside and an update of this UWIR in three years.

Document details and history

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Report on

Underground Water Investigation Report for ATP769 Paranui Pilot Project

1 Introduction

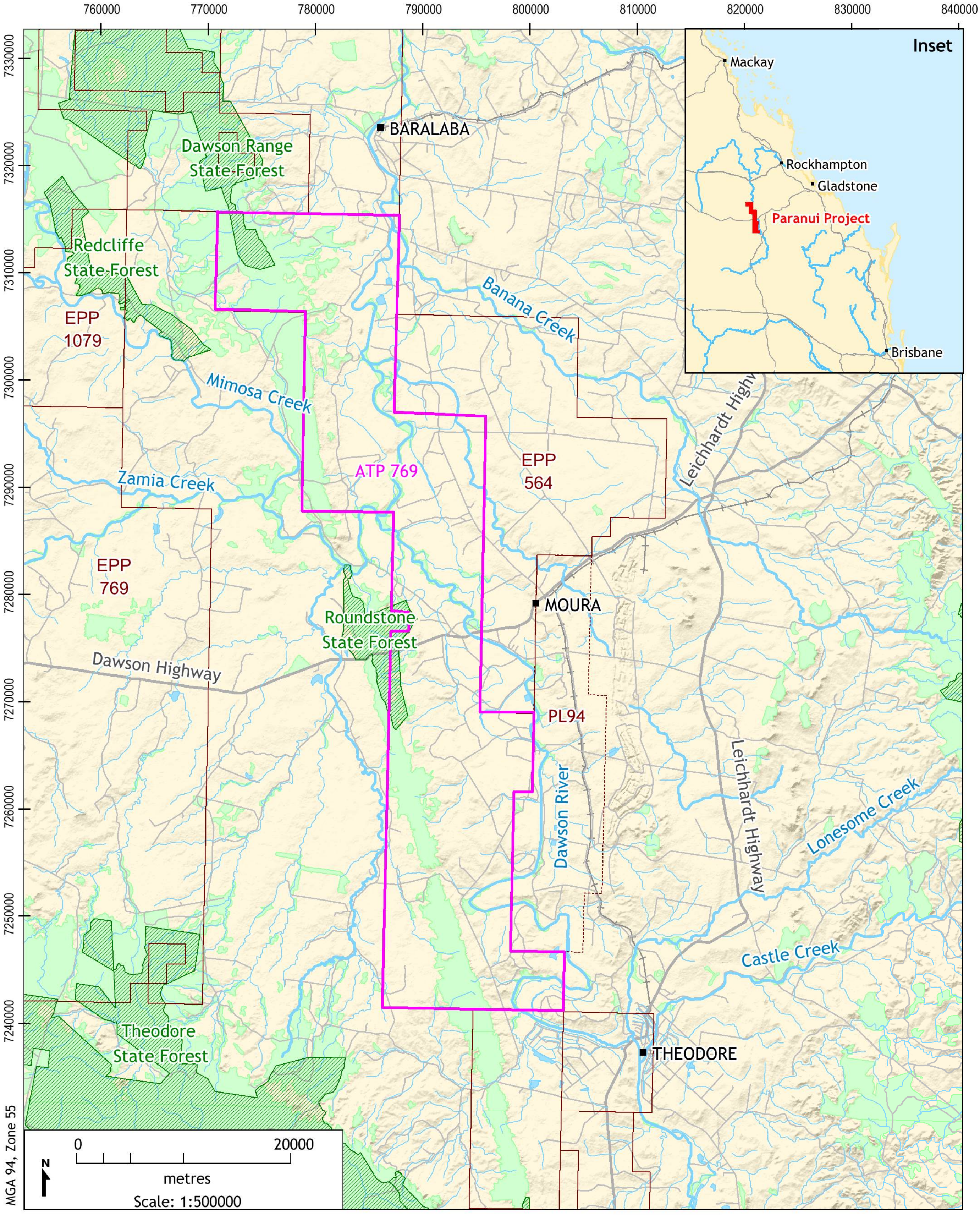
Westside Corporation (Westside) in joint venture with QGC and Mitsui E&P Australia, are operating under an authority to prospect (ATP) for development of the Paranui Pilot Project (the Project) on ATP769, located 10 km south of Moura, and 5 km to the west of the Meridian Coal Seam Gas (CSG) fields. The Project targets the Baralaba Coal Measures which occur between 550 m and 950 m depth and generally contain 21 m to 25 m of gas-bearing coal in up to 14 seams.

The Paranui Pilot Project initially included six appraisal wells (P-1, P-2, P-3, P-5R, P-6R and P-8), two observation wells (P-4 and P-7) and one core well (P-10). Three additional wells (P-11, P-12 and P-13) were completed in 2010. Production testing of these wells commenced in late 2010 but was subsequently suspended due to the protracted wet season. The pilot production testing identified an initial reserve of 135 petajoules (PJ) of CSG, with an additional 183 billion cubic feet of CSG (estimated) available to a depth of 1,000 m within the remainder of the ATP769 tenement.

Prior to commencing operation, the Pilot Project must comply with the requirements of the Water Act 2000, which includes the requirement to prepare an Underground Water Impact Report (UWIR). This report presents the results of the UWIR for the ATP769 tenement within the Paranui Pilot Project area. This UWIR has been undertaken by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) at the request of Westside.

1.1 Project area

The Project is currently operating within the Paranui property which is located roughly centrally along the eastern side of ATP769. It is understood that up to six gas bores will be put into operation. Following completion of prospecting, it is likely that the Paranui portion of the ATP769 area will be developed into a CSG production site. The ATP769 encompasses a number of adjoining and discrete properties, and extends north, south and west of the Paranui site. The combined area of ATP769 is 3,265 km^2 whilst the portion of ATP769 that Westside are focusing their exploration covers an area of approximately 910 km^2 as shown in Figure 1.1. The Paranui site which includes the Pilot Project has an area of 2.12 km^2 (2,121 ha).



LEGEND:

- ATP 769
- Petroleum Lease (PL 94)
- Exploration Permit for Petroleum (EPP)
- Watercourse
- Road
- Rail
- Reserve
- Vegetation
- Populated Place

Paranui UWIR (G1631)

Site Location

DATE: 9/9/2013

FIGURE No: **1.1**

1.2 Legislation

The following sections summarise Queensland Government legislation and policy for groundwater that applies to the management of groundwater affected by petroleum or coal seam gas (CSG) projects.

1.3 Petroleum and Gas Act 2004 (QLD)

The authority to prospect ATP769 was granted under the *Petroleum and Gas Act 2004* (Qld).

Under the *Petroleum and Gas Act 2004* (Qld), the petroleum tenure holder may *take or interfere with the water if taking or interference happens during the course of, or results from, the carrying out of another authorised activity for the tenure*. The Act requires tenure holders to comply with underground water obligations specified in the *Water Act 2000* (Qld).

1.4 Water Act 2000 (QLD)

Management of underground water as a result of the exercise of underground water rights by petroleum tenure holders for petroleum or CSG projects is detailed in Chapter 3 of the Water Act 2000. It provides a framework that requires the petroleum tenure holder to prepare an Underground Water Impact Report (UWIR) which establishes underground water obligations for monitoring and managing impacts on aquifers and springs. More specifically it provides for trigger levels for establishing impact on an aquifer in the event of a decline in water levels. The trigger levels are:

- a 5 m decline in water levels within a consolidated aquifer;
- a 2 m decline in water levels within an unconsolidated aquifer; and
- a 0.2 m decline in water levels associated with active springs.

The extent of declines in groundwater levels in aquifers greater than the trigger level, within the three-year period time structure are defined as Immediately Affected Areas or IAA. This includes those aquifers that are hosted in the coal seam measures. Predicted declines the water level by more than the bore trigger threshold at any time is defined as Long Term Affected Areas or LTAA.

1.5 Report structure

The structure of this UWIR is in accordance with that outlined in the *Guideline: (Water Act 2000) Underground Water Impact Reports and Final Reports*, (DEHP, 2013[a]), and include the following sections:

- Part A: Information about underground water extractions resulting from the exercise of underground water rights (Section 2);
- Part B: Information about aquifers affected, or likely to be affected (Section 3);
- Part C: Maps showing the area of the affected aquifer(s) where underground water levels are expected to decline (Section 4);
- Part D: A water monitoring strategy (Section 5);
- Part E: A spring impact management strategy (Section 6); and
- Conclusion (Section 7).

2 Underground water extractions

2.1 Quantity of water already produced

The Pilot Project by Westside has included production testing of three appraisal wells (P-5R, P-6R and P-8) at the Paranui site. Whilst the three additional wells (P-11, P-12 and P-13) were completed in 2010, production testing of these wells was not completed and subsequently suspended as a result of the protracted wet season in late 2010.

An overall total of 5,670 kL of water was produced from the three wells. No water production has occurred since that time.

Monthly totals for water production over the three-year period are shown in Table 2.1 and Figure 2.1. This historical production has been included in the transient groundwater model described in Section 4.

Table 2.1 Historical water production by well at ATP769

Date	Water production (kL/month)		
	P-5R	P-6R	P-8
June 2008	0	330	0
July 2008	0	518	0
August 2008	0	368	0
September 2008	243	238	5
October 2008	566	124	37
November 2008	385	105	2
December 2008	0	114	0
January 2009	173	115	0
February 2009	257	87	0
March 2009	177	19	50
April 2009	150	0	36
May 2009	125	0	0
June 2009	113	0	0
July 2009	120	0	0
August 2009	117	0	0
September 2009	138	0	0
October 2009	139	0	0
November 2009	91	0	0
December 2009	121	0	0

Date	Water production (kL/month)		
	P-5R	P-6R	P-8
January 2010	98	0	0
February 2010	71	0	0
March 2010	81	0	0
April 2010	91	0	0
May 2010	101	0	0
June 2010	78	0	0
July 2010	83	0	0
August 2010	6	0	0
Total	**3,524**	**2,017**	**129**

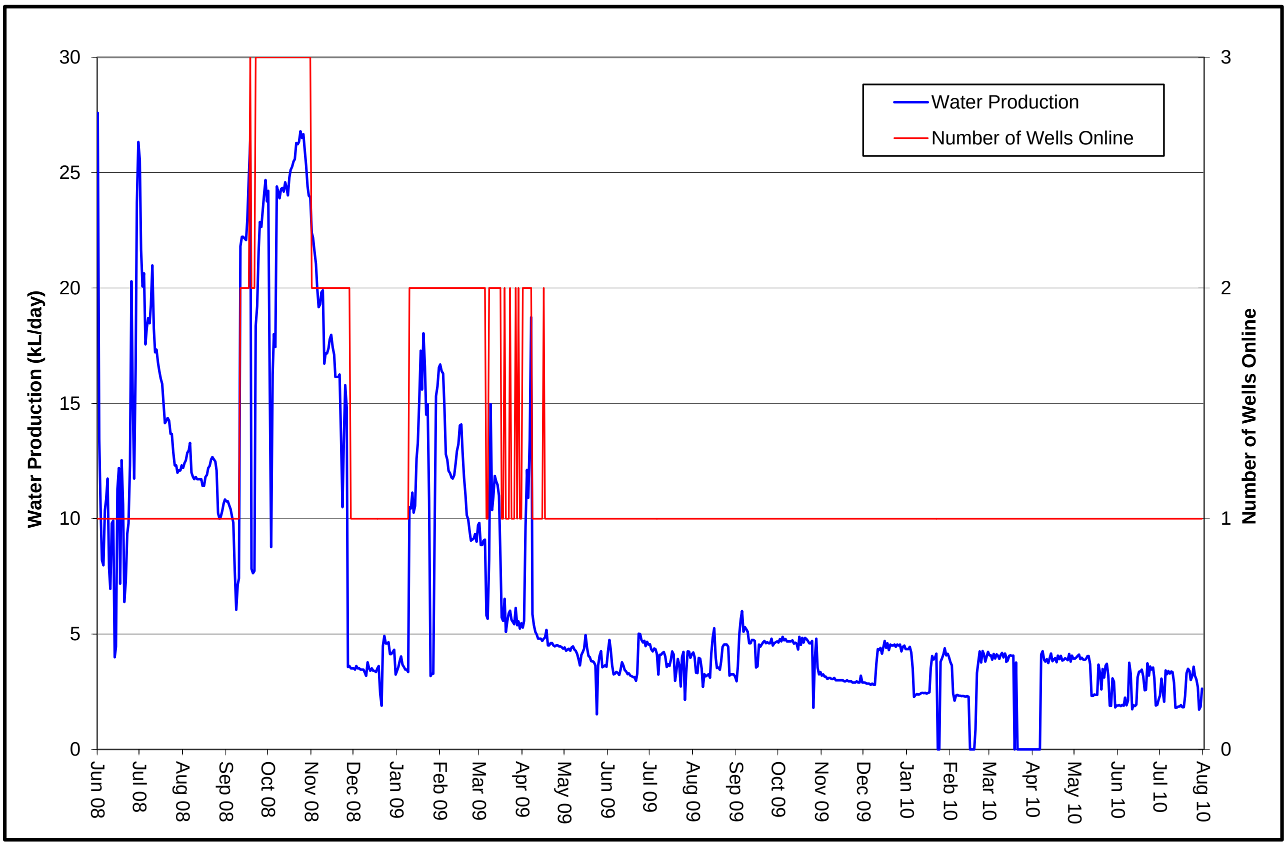


Figure 2.1 Historical water production at ATP769

2.2 Estimated water produced for three year simulation run

Westside have not undertaken any production testing from the Paranui wells since 2010. Water production rates from future planed testing are provide below in Table 2.2; based on a development plan for the three year period from May 2014 to May 2017. These production rates are based on abstraction from only two wells with production rates listed in kilolitres per year.

The wells currently anticipated to be tested are P-1 and P-12, although this may be subject to change during finalisation of the development plan prior to the planned commencement of testing in 2016. Total extraction over the three year period up to mid-2017 is estimated to be 1,088 kL. The period of production currently anticipated for each well is from May to October 2016 for P-1, and February to July 2017 for P-12.

The numerical model (see Section 5) utilises these projected pumping rates.

Table 2.2 ATP769 Theoretical development plan

Field	Well	Water production estimate (kL/Annum)			
		2014	2015	2016	2017
Paranui	P-1	0	0	544	0
Paranui	P-12	0	0	0	544
Totals (kL)		-	-	**544**	**544**

3 Geological and hydrogeological regime (Part B)

A review of the geological and hydrogeological features that occur beneath ATP769 are described below and have been used to develop the hydrogeological conceptualisation of the groundwater regime beneath the Project area and surrounds. This understanding forms the basis for the numerical groundwater flow model. Geological information reviewed as part of this assessment has included:

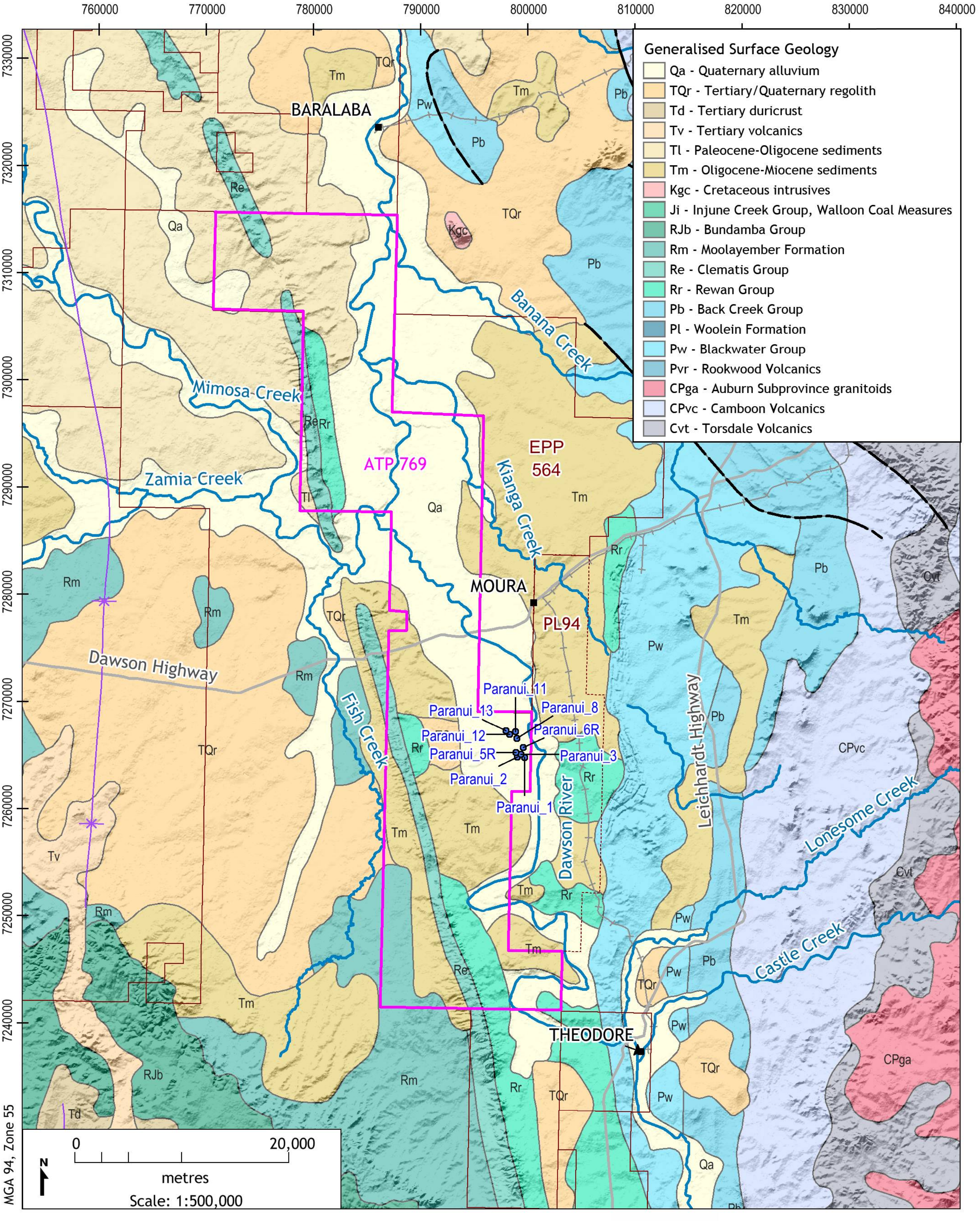
- 1:250,000 Geological Series – Baralaba sheet SG55-4 (GSQ, 1964);
- 1:250,000 Geological Series - Monto sheet SG56-1 (GSQ, 1981); and
- Bowen Basin Structural Geology 2008 (CSIRO & DEM, 2008).

The target for coal seam gas exploration at ATP769 is the Baralaba Sub-Group which comprises the Baralaba Coal Measures and Kaloola Formation.

3.1 Stratigraphy

The stratigraphic sequence across the site comprises two distinct units; a Permian sequence which is unconformably overlain by the Triassic Rewan Formation. Unconsolidated Tertiary sediments unconformably overlie both formations along the Dawson River. The Permian and Triassic rocks form a regular layered, westerly dipping sedimentary sequence while the Tertiary and Quaternary sediments are more complex and irregular. Localised linear deposits of Quaternary alluvium are associated with most of the creeks that traverse the site. These creeks enter a large flat alluvial plain associated with the Dawson River. The floodplain is up to 10 km wide around in the northern area of the lease, and decreases to about 1 km at the southern extremity.

The surface geology is shown in Figure 3.1. The coal seam gas wells are shown on the geology map in Figure 3.2, and a general stratigraphic section as provided by Westside for the Paranui Project is given in Figure 3.3.



LEGEND:

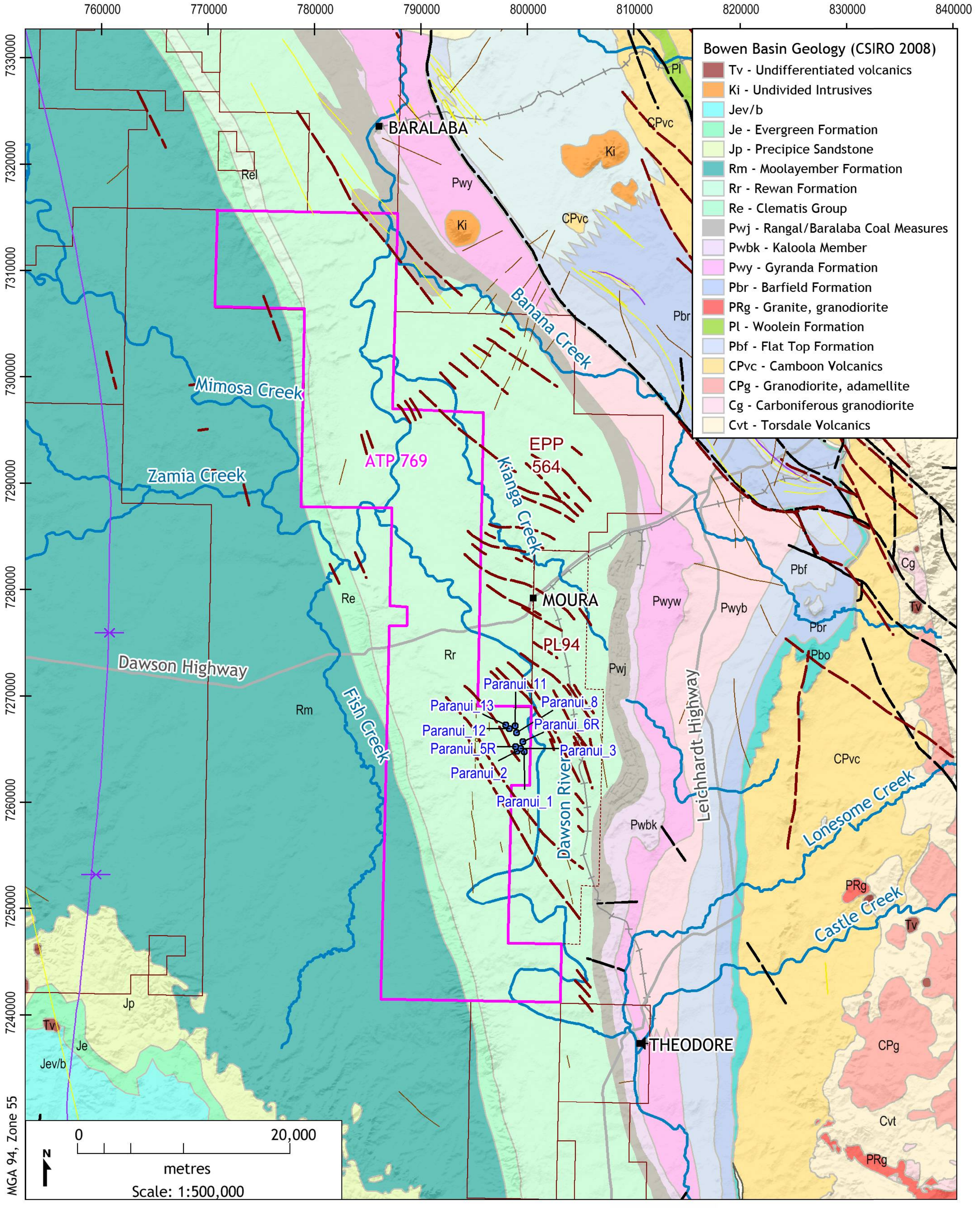
- ATP 769
- Petroleum Lease (PL 94)
- Exploration Permit for Petroleum (EPP)
- Existing Paranui Well
- Syncline
- Fault
- Watercourse
- Road
- Rail
- Populated Place

Paranui UWIR (G1631)

Surface Geology

DATE: 9/9/2013

FIGURE No: 3.1



LEGEND:

- ATP 769
- Petroleum Lease (PL 94)
- Exploration Permit for Petroleum (EPP)
- Existing Paranui Well
- Watercourse
- Road
- Rail

Structural Geology

- Fault (Bowen Basin Geology)
- Anticline (Bowen Basin Geology)
- Dykes (CSIRO 2008)
- Fault (CSIRO 2008)
- Fold (CSIRO 2008)
- Populated Place

Paranui UWIR (G1631)

Basement Geology

DATE: 9/9/2013

FIGURE No: 3.2

Paranui Well P-12						
Age	Formation	Geology	Depth to Top (mRT[1])	Depth to Base (mRT[1])	Gross Thickness (m)	Net Coal Thickness (m)
Quaternary	Alluvium	Clay, sand	0	18.82	18.82	-
Triassic	Rewan Formation	Dark grey-green sandstone, siltstone	18.82	626.8	607.98	-
Upper Permian	Baralaba Coal Measures	Dark grey-green sandstone, siltstone	626.8	632	5.2	-
		Un-named - Stoney Coal	632	634.58	2.58	0
		Dark grey siltstone, sandstone	634.58	657.12	22.54	-
		PC1 - Coal	657.12	661.42	4.3	2.2
		Grey-dark grey sandstone, siltstone	661.42	676.61	15.19	-
		PC2 - Coal	676.61	678.32	1.71	1.12
		Dark grey siltstone	678.32	696.1	17.78	-
		PC3 - Coal	696.1	699	2.9	1.72
		Dark grey siltstone, sandstone	699	713.12	14.12	-
		PC4 - Coal	713.12	715.44	2.32	2.11
		Dark grey siltstone	715.44	726.98	11.54	-
		Un-named - Coal	726.98	727.63	0.65	0
		Grey-dark grey sandstone, siltstone	727.63	754.05	26.42	-
		PC5 - Coal	754.05	757.28	3.23	3.11
		Dark grey siltstone	757.28	792.4	35.12	-
		PC6-7 - Coal	792.4	796.8	4.4	4.4
		Dark grey siltstone	796.8	827.05	30.21	-
		PC8 - Coal	827.05	830.37	3.32	3.12
		Dark grey siltstone	830.37	854.11	23.74	-
		PC9 - Coal	854.11	856.38	2.27	1.74
		Dark grey siltstone	856.38	874.06	17.68	-
		PC10 - Coal	874.06	876.12	2.06	2
		Dark grey siltstone	876.12	883.46	7.34	-
		Un-named - Stoney Coal	883.46	885.38	1.92	0
		Dark grey siltstone	885.38	905	19.62	-
		PC11 - Coal	905	908.74	3.74	1.63
		Dark grey siltstone	908.74	916.62	7.88	-
		PC12 - Coal	916.6	918.0	1.4	1.3
		Dark grey siltstone	918	932.6	14.6	-
		PC13 - Coal	932.6	933.21	0.61	0.52
		Dark grey siltstone	933.21	941.83	8.62	-
		Un-named - Coal	941.83	942.06	0.23	0
		Dark grey siltstone	942.06	949.29	7.23	-
		PC14 - Coal	949.29	949.62	0.33	0
	Yarrabee Tuff Bed	Tuff, stoney at base	949.62	955.06	5.44	-
	Kaloola Member	Grey siltstone, mudstone	955.06	-	-	-
		End of hole	-	1045.82	-	-
Notes: 1 - mRT, metres below rotary table				Source: Westside Corporation Limited		

Figure 3.3 Generalised stratigraphy of the Paranui project site area

A typical east-west cross section through ATP769 in relation to the Paranui Project Site area is presented in Figure 3.4.

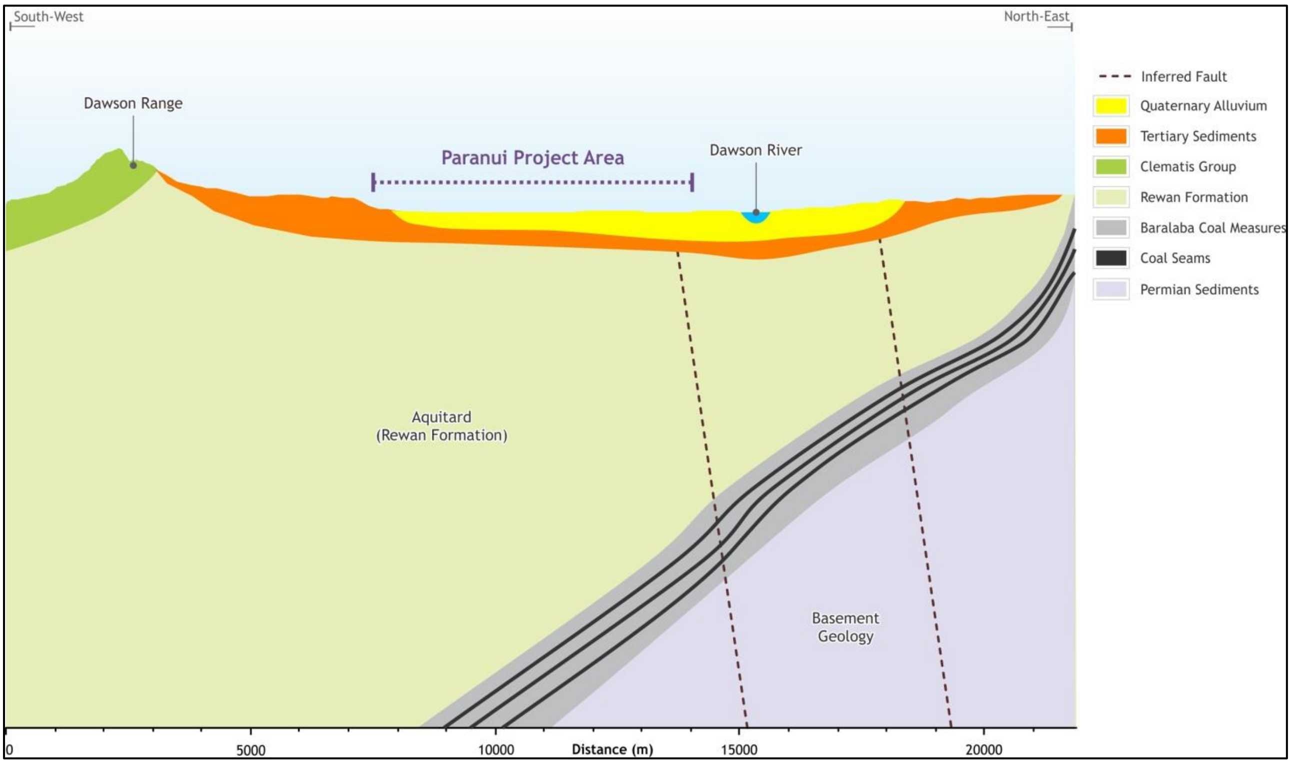


Figure 3.4 Typical geological cross section

3.2 Permian Strata – Baralaba coal measures

The gas resources targeted in ATP769 are contained within a sequence of coal seams denoted numerically from PC1 to PC14 in sequential order from top of the Upper Permian Baralaba Coal Measures. The Baralaba Coal Measures are up to 320 m thick striking north-south and dipping to the west at between 5° and 16°. The westerly dip of the sequence indicates the upper coal seams are about 650 m below ground level in the eastern area of ATP679, and up to 900 m below surface in the western areas.

The Baralaba Coal Measures consist of fine to medium grained, feldspathic and lithic sandstone and interbedded units of siltstone, mudstone, shale and coal seams. Sandstone occurs as thick beds of typically massive, channel sandstone that is extensively cross bedded. Carbonaceous mudstone and tuff are common towards the base of the production sequence. The coal beds are black, vitreous, thinly laminated to very thinly bedded.

3.3 Triassic Strata

Triassic aged sediment overlies the Permian strata within most of ATP769. These sediments include Rewan Formation which are the dominant Triassic sediments, and Great Artesian Basin [GAB] (Clematis Group and Moolayember Formation) outcropping along the western margins of the ATP769.

3.3.1 Rewan Formation

The Rewan Formation is typically comprised of brown / green siltstone and shale with minor interbedded lithic sandstones. The Rewan Formation has limited outcrop over much of ATP769, as it is obscured by a blanket of unconsolidated Tertiary and Quaternary sediments over much of the Project area, as is the case within the Paranui site (refer Figure 3.1).

3.3.2 Great Artesian Basin - Mimosa management area

The eastern boundary of the Great Artesian Basin (GAB) Mimosa Management Area occurs 8 km west of the Paranui Project area (Figure 3.2). The Mimosa Management Area is comprised largely of the Triassic Clematis Group and Moolayember Formation which are considered a recharge area for the GAB. These sediments dip towards the west and are separated from the Permian coal measures by the Rewan Formation.

3.4 Weathered strata and unconsolidated alluvium

The Baralaba Coal Measures are typically weathered to a depth of between 2 m and 25 m below surface (AGE, 2011). As the rocks which form the Coal Measures consist primarily of minerals that weather to clays, the residual soils developed over these rocks are therefore high in clay content.

Thin zones of alluvial deposits of sand, gravel and clay are associated with the creek systems that traverse ATP679. Extensive alluvial deposits up to 10 km wide occur adjacent to the Dawson River between Theodore and Baralaba. Six lines of investigation holes were drilled across the alluvium at a spacing of 20-25 km by the former Water Resources Commission 1991. The alluvium consists of soil, sandy clay and clay overlying widespread and generally thick deposits of fine to medium silty sand which is normally underlain by clay bound and silty sand and gravel. The alluvium varies between 10 m and 26 m in thickness. In places, the alluvial deposits are separated from the underlying bedrock by Tertiary sediments.

3.5 Structures

ATP769 is located on the eastern limb of the Mimosa Syncline in the south-eastern Bowen Basin. The area has been affected by a series of compression events, resulting in multiple north-westerly striking reverse faults. Extension is also evident in the form of sporadic north-easterly striking normal faults.

4 Hydrogeological regime

The hydrogeology of the Project area and surrounds comprises two distinct aquifers that occur within the study area, these being:

- the Quaternary age alluvium; and
- the Permian to Triassic age fractured rocks.

These aquifers are described in more detail below.

4.1 Quaternary alluvial aquifers

Quaternary deposits within the ATP769 consist of unconsolidated alluvium comprising soil, silt, clay, sand, and gravel associated with the rivers and creeks that traverse the study area. More specifically these are dominated by the Dawson River alignment.

The nature of the alluvium associated with the Dawson River in the area of ATP769 was investigated by the Water Resources Commission in 1991. The investigation included drilling a line of bores across the floodplain known as the Moura Line. The line of bores was drilled adjacent to the Dawson Highway to the west of the township of Moura. The lithological units intersected in each borehole across the floodplain as prepared by Water Resources Commission are shown in Figure 4.1

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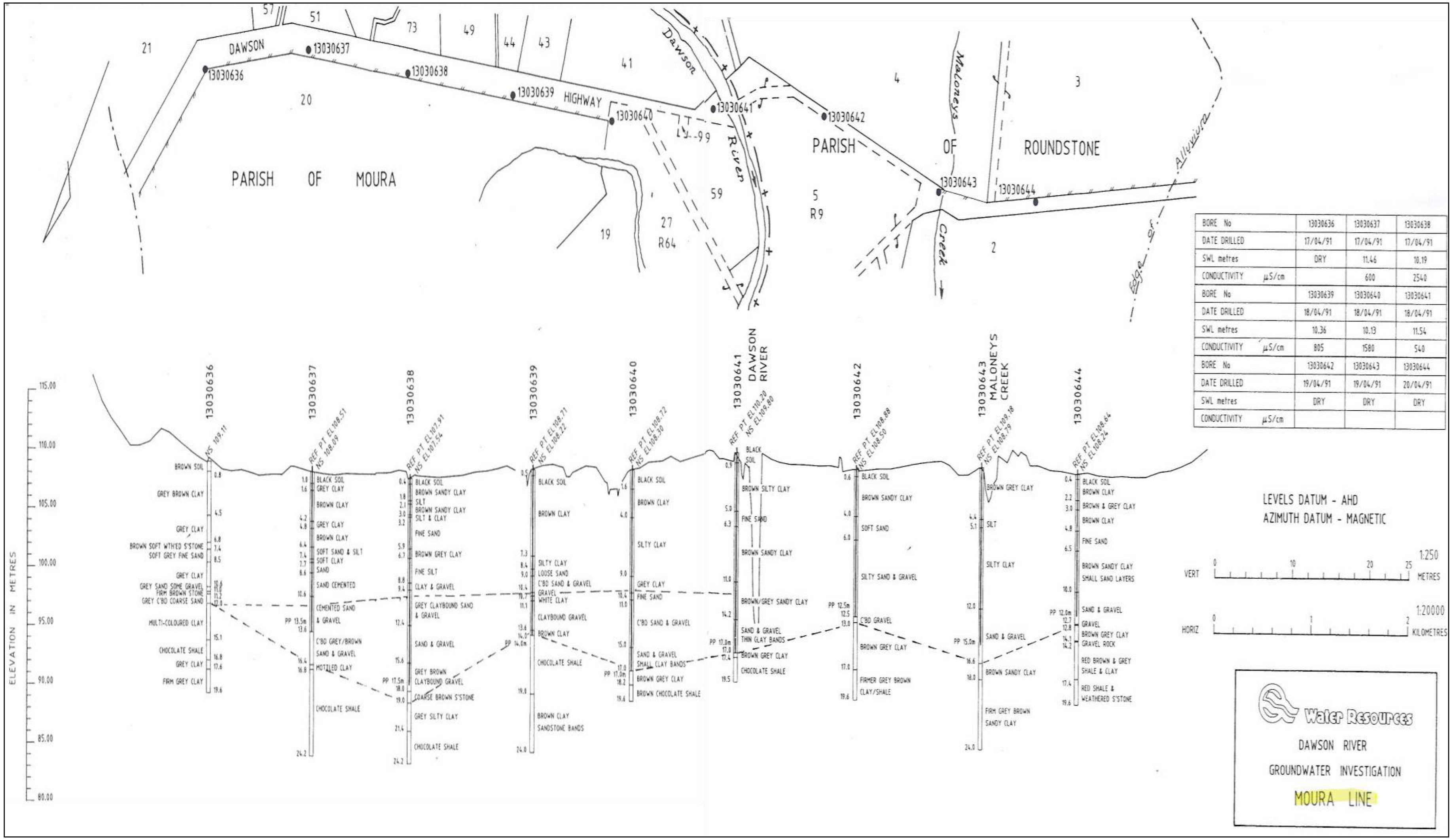


Figure 4.1 Cross section – Moura Line

The drilling indicated the unconsolidated alluvial sediments are between 15 m and 20 m in thickness and are generally comprised of silty and clayey sediments in the upper 10 m, with the potential for clay bound or clean sands and gravels in the basal 5 m. The alluvial sediments were underlain by brown silty clays and chocolate shales.

Groundwater levels at the time of drilling in 1991 were between 10 m and 11 m below ground level. Groundwater levels in the Moura area indicated the Dawson River was a gaining river, but further upstream as the elevation of the river bed rises, groundwater levels are close to the bed of the river indicating a losing stream in this area.

4.1.1 Distribution and users

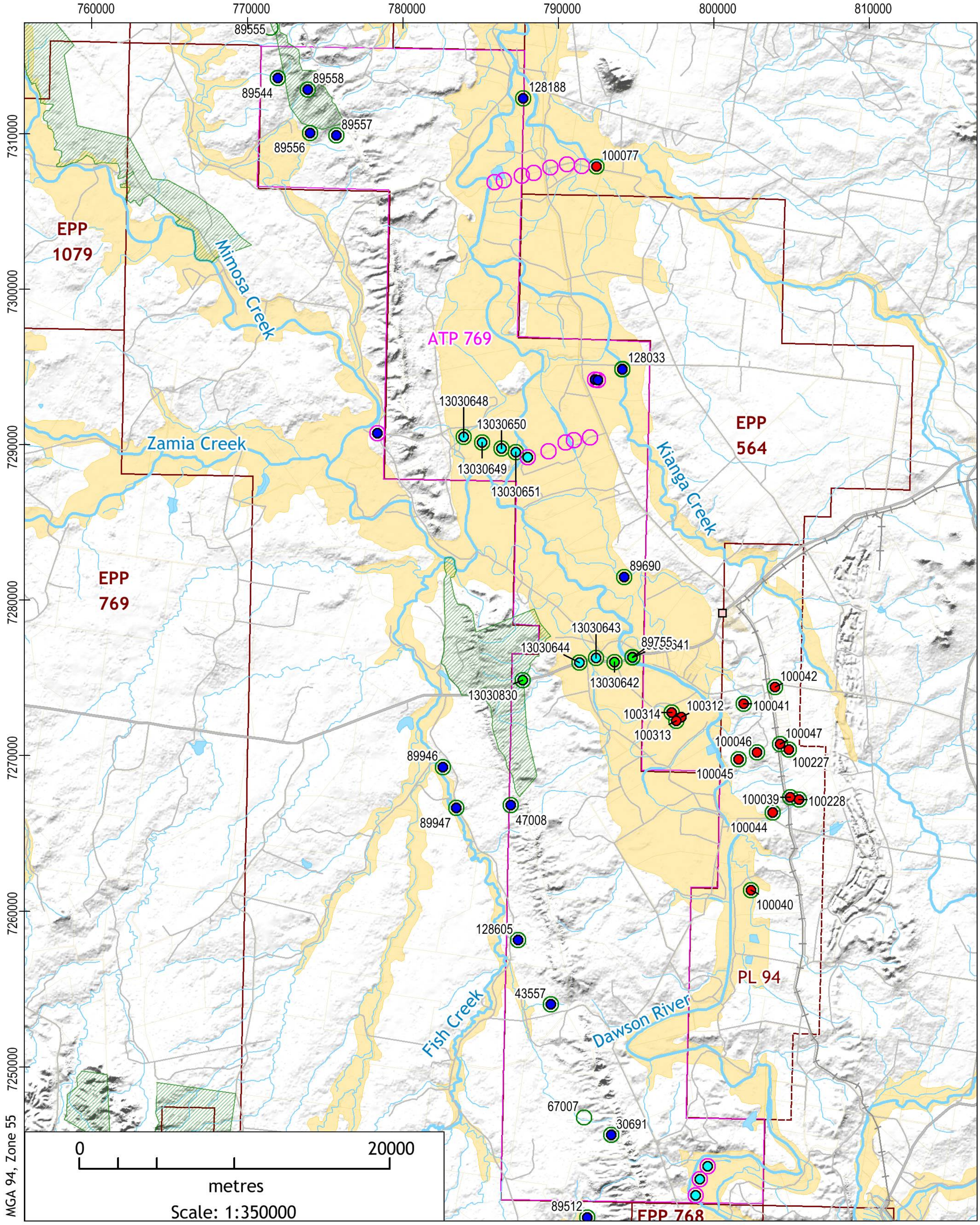
The Quaternary alluvium associated with the Dawson River covers an area of about 240 km^2 which extends across much of the ATP769. Data from the Department of Natural Resources and Mining (DNRM) Groundwater Database was reviewed to assess groundwater usage in the alluvium within this portion of ATP769. The locations of the bores within the DNRM database are shown in Figure 4.2. Details of these registered bores and summarised in Table 4.1 and Appendix A.

Table 4.1 Registered bores in Dawson river alluvium within ATP769

Registered number	Date drilled	Easting	Northing	Purpose	Status	Depth (m)	Screen (m)
89690	-	794,221	7,281,500	Water Supply	Existing	19	14.2-18.9
89755	2001	794,738	7,276,353	Water Supply	Existing	24	15-24
128033	2007	794,105	7,294,871	Water Supply	Existing	18	14.5-17.5
128034	-	794,104	7,294,843	Water Supply	Existing	-	16.5-22.5
128188	2006	787,733	7,312,273	Water Supply	Existing	15.5	14.5-15.5
13030641	1991	794,755	7,276,316	WR Monitoring Bore	A/U	17	4-17
13030642	-	793,588	7,276,030	WR Investigation Bore	A/U	13	10.5-12.5
13030643	-	792,407	7,276,301	WR Investigation Bore	A/U	16.6	13-15
13030644	-	791,331	7,276,008	WR Investigation Bore	A/U	12.8	9-12
13030648	-	783,892	7,290,497	WR Investigation Bore	A/U	16.6	14-16
13030649	-	785,071	7,290,131	WR Investigation Bore	A/U	19.7	17.2-19.7
13030650	-	786,338	7,289,754	WR Investigation Bore	A/U	23.9	21-23
13030651	-	787,244	7,289,537	WR Investigation Bore	A/U	15.4	13-15

Note: *Projection is MGA94, Zone 55*

A total of 11 registered bores are located on the alluvial aquifer. Only four of the registered boreholes (RN89690, RN89755, RN128033 and RN128188) appear to be designed for the extraction of groundwater from the alluvium. These bores are constructed in the alluvial aquifers with screens in the basal sands and gravels and were installed between 2001 and 2007. It is uncertain if they all remain in use.



LEGEND:

Registered Bore

- Water Supply
- Water Resource Investigation
- Sub-artesian Monitoring
- Petroleum or Gas Exploration
- Registered Bore - Existing
- Registered Bore - Destroyed
- Rail
- Road
- Watercourse
- ATP 769
- Petroleum Lease (PL 94)
- Exploration Permit for Petroleum (EPP)
- Quaternary Alluvium
- Reserve / State Forest
- Cadastre

Paranui UWIR (G1631)

Registered Bores

DATE: 9/9/2013

FIGURE No: 4.2

4.1.2 Groundwater levels

Groundwater levels have been monitored intermittently in the monitoring bores along the Moura Line between 1991 and 2000. The groundwater levels are presented below in Figure 4.3.

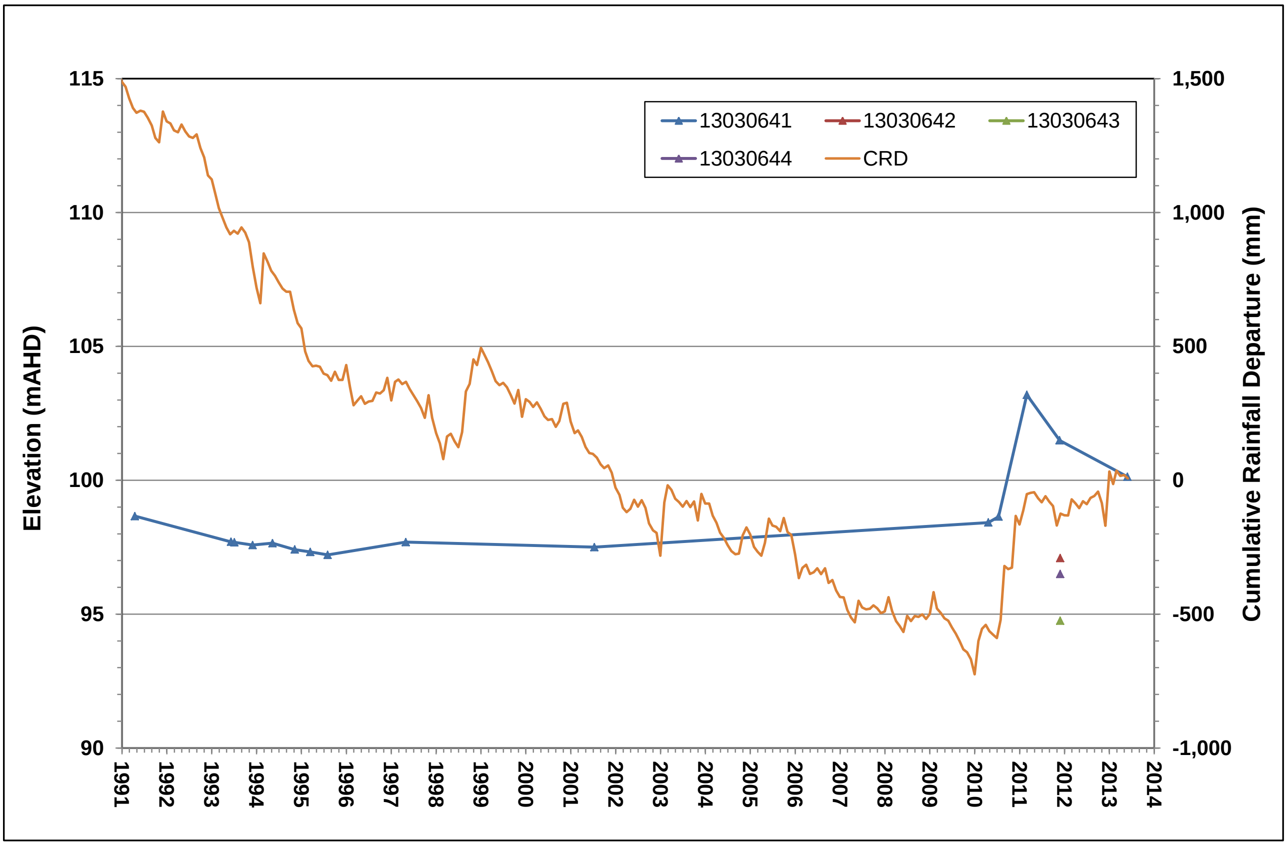


Figure 4.3 Moura Line monitoring bore water level hydrographs

Continuous water level data over the period of monitoring is only available for bore RN13030641 and RN13030830. Bores RN13030642, RN13030643 and RN13030644 only have one water level measurement recorded. At the time of this assessment, these bores were located and were either dry (RN13030643 and RN13030644) or destroyed (RN13030642). It is therefore assumed that these bores did not intersect or connect with the alluvial aquifer. Water levels in bore RN13131641 remained generally static from 1991 to 2010 but responded to the above average rainfall indicated by the rising Cumulative Rainfall Departure (CRD) value in 2010 and 2011. This response was not observed Bore RN 13030830 which is constructed within Rewan Formation sediments. These sediments are typically tight and of low permeability (i.e. they are clay bound) and would not be expected to respond to recharge from rainfall.

4.1.3 Groundwater flow and yields

Groundwater flow is from the alluvium to the Dawson River when the alluvium is recharged by good rainfall and water levels are high and above the river water level. Conversely when rainfall is low and water levels are below the bed of the river, groundwater flow is likely to remain within the alluvium and be to the north.

There is no information available on yields from bores constructed in the alluvial aquifer. Yields from bores are expected to be good where clean basal gravels are present and water levels and sufficiently high. When the basal gravels are clay bound, yields would be poor.

4.1.4 Hydraulic parameters

No testing of the hydraulic properties of the alluvium is known to have been undertaken. The drilling undertaken along the Moura Line suggests zones of clean basal sands would have a very high hydraulic conductivity. However, these zones are not likely to be laterally extensive with clay bound sand and gravel commonly encountered in the investigation. In the absence of any hydraulic parameters for this alluvial aquifer, typical values were sourced from relevant literature and other EIS coal projects in the Bowen Basin and are provided in Table 4.2.

Table 4.2 Alluvium hydraulic parameters

Parameter	Value
Hydraulic Conductivity	0.1 – 100 m/day (Bowen Basin alluvial aquifers)[a] 20 – 100 m/day (coarse sand)[b]
Specific Yield	0.05 – 0.25[a] 0.27[b] 0.25[c]
Specific Storage	1×10^{-3} (c)

Source of data: *a – CDM Smith, 2013.*
b – Kruseman & de Ridder, 1992.
c – AGE, 2006.

4.1.5 Recharge and discharge processes

Recharge to the alluvial aquifer is expected to occur through direct diffuse rainfall infiltration, and also via seepage from the Dawson River into the alluvium during high flow and flood events.

The Dawson River alluvial floodplain covers an area of about 780 km^2 within the vicinity of ATP769. The average long term recharge to the aquifer from rainfall is estimated to be about 4 ML/day, assuming 0.25% of the rainfall infiltrates the aquifer. The estimated rainfall recharge rate is approximately 1.7 mm/year based on an average annual rainfall of 685 mm (Station Number 39071, Moura Post Office).

4.2 Bedrock Triassic / Permian Aquifers

4.2.1 Description

The Triassic sediments within the Mimosa Management Area are considered a recharge area for the GAB. The aquifers associated with these sediments are separated from the underlying Permian coal measures by a thick sequence (~600 m) of "tight", very low yielding, low permeability sediments that make up the Rewan Formation. Permeability testing elsewhere in the Bowen Basin indicates very low permeability values around 1×10^{-5} m/day for the Rewan Formation (AGE, 2010).

The Permian coal seams comprise confined aquifers which generally exhibit relatively low permeability and recharge rates. Groundwater storage and movement occurs within the coal seam cleats and fissures, and within fractures associated with faults intersecting the seams. The sediments of the interburden and overburden sequence are typically relatively impermeable and form aquitards.

The Permian strata can be categorised into the following hydrogeological units:

- generally hydrogeologically "tight" and hence very low yielding sandstone, siltstone and shales that comprise the majority of the Permian interburden / overburden;
- low to moderately permeable coal seams which are the prime water bearing strata within the Permian sequence; and
- potentially higher yielding fracture zones associated with faulting and open joints.

4.2.2 Distribution and users

Data from the DNRM Groundwater Database identifies there are 13 registered monitoring bores within these sediments in this portion of ATP769. Seven are recorded as being constructed within either the Clematis Group or Moolayember Formation sediments, and one with the Rewan Formation. The locations of these bores within the NRM database are shown in Figure 4.2. Details of these registered bores and summarised in Table 4.3 and Appendix A.

Table 4.3 Registered bores in Triassic / Permian sediments within ATP769

Registered number	Date	Easting	Northing	Purpose	Status	Depth (m)	Screen (m)
30691	1968	793,380	7,245,647	Water Supply	Existing	64	Open
43557	1974	789,514	7,254,015	Water Supply	Existing	538	Open
47008	1974	786,935	7,266,841	Water Supply	Existing	525	Open
89512	-	791,848	7,240,340	Water Supply	Existing	-	36-42
89544	-	771,954	7,313,557	Water Supply	Existing	-	-
89556	1991	774,018	7,310,055	Water Supply	Existing	54	42-48
89557	1991	775,712	7,309,890	Water Supply	Existing	60	24-54
89558	1991	773,869	7,312,837	Water Supply	Existing	54	42-54
89946	-	782,567	7,269,271	Water Supply	Existing	-	-
89947	-	783,414	7,266,667	Water Supply	Existing	-	-
100077	-	792,431	7,307,891	Petroleum / Gas Bore	Existing	-	-
128605	2009	787,401	7,258,147	Water Supply	Existing	560	290-560
13030830	-	787,697	7,274,857	WR Monitoring Bore	Existing	48	46.5-47.5

The majority of these bores are located within the GAB sediments where more reliable yields and better water quality is available.

4.2.3 Aquifer properties

Measurement of coal seam permeability has only been undertaken in pilot well P-1 with estimates of permeability provided for wells P-5R and P-6R (IPT, 2010). These are summarised in Table 4.4. The intrinsic permeability of the coal seams, measured in millidarcies (md) was converted to a hydraulic conductivity, with the units of meter / day by a multiplication factor of 8 x 10^{-4}.

Table 4.4 Summary of permeability testing data

Well / Seam	Depth	Intrinsic permeability (md)	Hydraulic conductivity (m/day)	Field
P-1/Y	688.95	0.13	0.0001	unknown
P-1/B	762.20	0.27	0.0002	unknown
P-1/Bl+C	786.21	1.01	0.0008	unknown
P-5R	-	0.065	0.00005	unknown
P-6R	-	0.305	0.0002	unknown

The test data indicates the hydraulic conductivity / permeability of the coal seams is relatively low for coal. The coal permeability ranges from 8 x 10^{-4} m/day to 5 x 10^{-5} m/day.

These are lower than the permeability values for the Meridian Seam Gas Fields (AGE, 2011) which is consistent with these coal seams being deeper. The permeability of coal seams typically decline with depth as overburden pressure closes the cleats.

The hydraulic conductivity of the interburden and overburden units has not been measured within ATP769. In the absence of any hydraulic parameters for the interburden and overburden units, typical values were sourced from relevant literature and other EIS coal projects in the Bowen Basin and are provided in Table 4.5.

Table 4.5 Overburden, interburden and coal seam hydraulic parameters

Geological Unit	Parameter	Value
Rewan Formation / Interburden	Hydraulic Conductivity	0.1 – 10^{-6} m/day [a] 10^{-4} - 10^{-5} m/day [b, c]
	Specific Storage	5 x 10^{-5} - 5 x 10^{-6} (a) 1 x 10^{-6} (b) 1 x 10^{-5} (c)
Bowen Basin Coal Seams	Hydraulic Conductivity	5 – 10^{-6} m/day [a] 1 m/day for less than 100 m depth, declining to 10^{-6} m/day for greater than 400 m depth [b] 5 x 10^{-2} m/day for less than 100 m depth [c]
	Specific Storage	4 x 10^{-4} to 2 x 10^{-7} (a) 1 x 10^{-6} (b) 1 x 10^{-4} to 1 x 10^{-5} (c)

Source of data: *a – CDM Smith, 2013.*
b – AGE, 2006
c – AGE, 2010

The referenced data in Table 4.5 indicates that the hydraulic conductivity values for the overburden / interburden sediments in the Bowen Basin can be as much as one to two orders of magnitude lower than the coal seams. Based on the cyclic sequence of sandstones, siltstones and shales that comprise the overburden and interburden sediments, these sequences as a whole are considered to have a poor capacity to transmit water.

4.2.4 Water level fluctuations and piezometric elevation

Monitoring of groundwater levels / pressures in the overburden and coal seams is not undertaken routinely on ATP769. Outside the lease DNRM constructed a monitoring bore into the consolidated bedrock in 2003 as part of the "National Action Plan for Salinity". This bore (RN13030830) is located north of the Paranui Project area within the Rewan Formation along the Dawson Highway and west of the Dawson River Alluvium. Groundwater levels have been monitored in these bores since installation, with hydrographs shown in Figure 4.4. The water levels in this monitoring bore are for groundwater associated with the overburden and show only very limited fluctuation with rainfall.

Groundwater level determined from water level measurements for the Moura Mine to the east, indicate a hydraulic gradient of 0.01 (1 in 100) in the Dawson South Stage 2 area grading from RL 150m in the east to RL 120m in the west (AGE, 2011). Based on this, it is considered that the potentiometric surface in the bedrock is expected to be a subdued reflection of the topography indicating groundwater flow from the east, towards the Dawson River in the west.

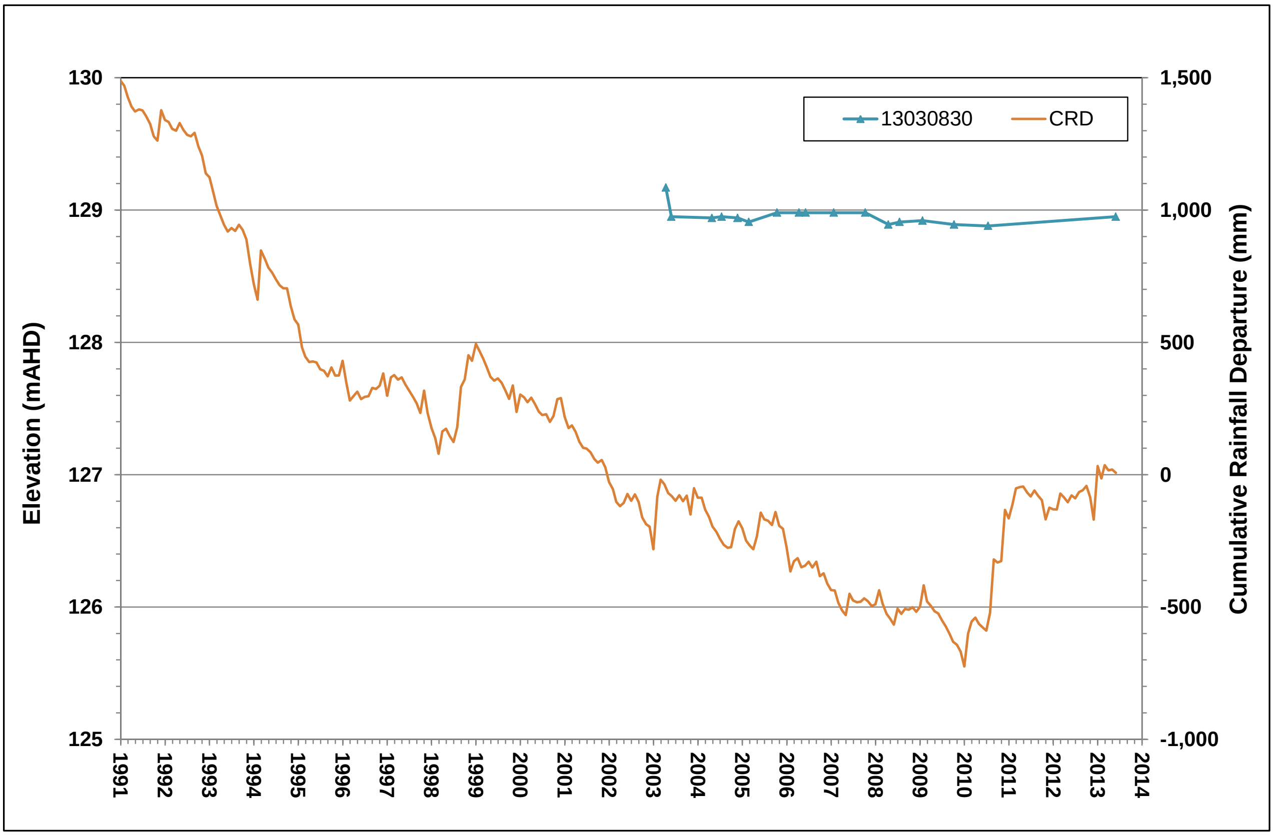


Figure 4.4 Hydrograph - Rewan Formation

4.2.5 Groundwater flow (Yield)

The coal seam gas wells within the Paranui Project area (in ATP769) were drilled using the rotary mud method and therefore no observations of groundwater flows from different stratigraphic units can be made. There are 13 existing, registered landholder bores within ATP769 that have been constructed in the bedrock for stock and domestic purposes. These are mostly located towards the western side of the ATP769 into the GAB Triassic sediments.

It is understood that drilling undertaken at the adjacent Dawson Mine does not typically intersect large volumes of groundwater, with dry holes being common (AGE, 2011). The exception is where the hydraulic conductivity has been locally enhanced by closely spaced open joints or broken fault zones which can have higher yields. These zones do not generally produce high yields long-term as the fractures are readily drained of water due to the less transmissive surrounding rocks.

The coal seams are considered to be the only laterally extensive aquifer within the coal measures.

4.2.6 Recharge and discharge processes

Recharge to the coal seams is expected to be primarily via the outcrop and subcrop areas which occur to the east of ATP769 particularly within the Dawson Mine lease. The recharge rates are expected to be relatively low in comparison to the alluvial aquifer.

The Triassic / Permian outcrop is recharged by diffuse areal recharge and potentially also from the overlying Quaternary / Tertiary unconsolidated sediments where these are present. Again the rates of recharge are considered to be relatively low, compared to the alluvial aquifer.

4.3 Groundwater quality

Part of this review has included initiating the baseline groundwater monitoring of accessible registered bores listed in Table 4.1 and Table 4.3. Nine bores were sampled which included:

- RN89755, RN89947, RN128033, RN13030641, and unregistered bore next to RN89690 located within the Quaternary Alluvium;
- RN47008, RN43557, RN128605 located within the Clematis Sandstone (GAB); and
- RN13030830 located within the Rewan Formation.

Grab samples were collected from each bore using either a bailer or from an outlet for those bores equipped with pumps (RN47008, RN43557, RN89947, RN128605) between 29 May and 28 June 2013. The results of this sampling are provided in Appendix B.

The salinity of the water samples can be categorised based on the following total dissolved solids concentrations (FAO, 2013) for groundwater:

Fresh water	<500 mg/L
Brackish (slightly saline)	500 to 1,500 mg/L
Moderately saline	1,500 to 7,000 mg/L
Saline	7,000 to 15,000 mg/L
Highly saline	15,000 to 35,000 mg/L
Brine	>35,000 mg/L[1]

[1] The Department of Environment and Heritage (DEHP) define a brine as saline water with a total dissolved solids concentrations greater than 40,000 mg/L.

In summary, the analysis results indicate:

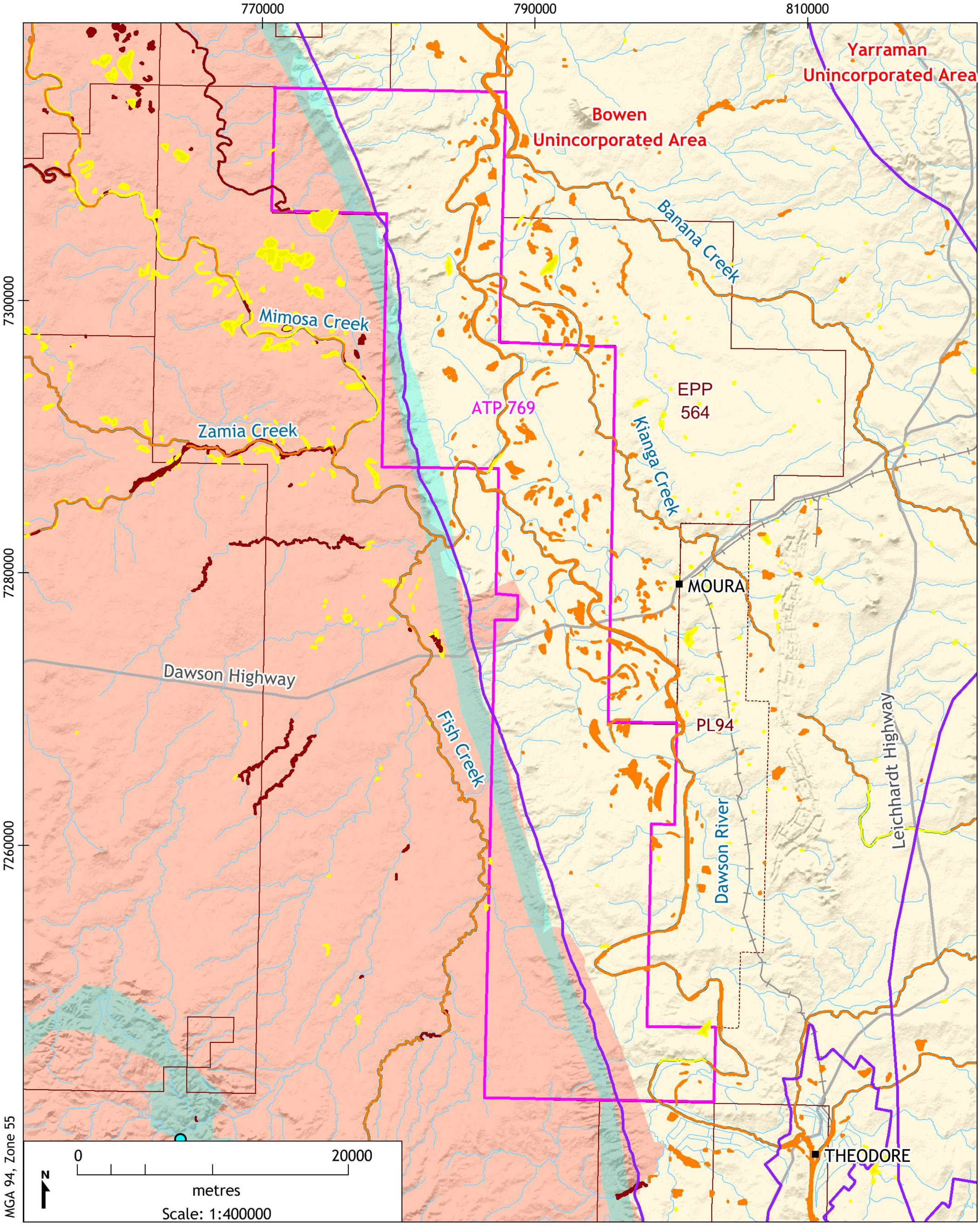
- Groundwater within the alluvial aquifer is neutral to slightly alkaline and fresh (286 mg/L) to brackish (1,290 mg/L) dominated by calcium, sodium and chloride ions.
- Groundwater within the GAB sediments is alkaline and fresh (365 mg/L) to slightly brackish (564 mg/L) also dominated by calcium, sodium and chloride ions.
- Groundwater within the Rewan Formation sediments is slightly alkaline and highly saline (17,700 mg/L) also dominated by calcium, sodium and chloride ions.
- Detectable levels of metals for barium, manganese, nickel, strontium, boron, iron, zinc in most bores, with detectable levels of arsenic in RN89755 and RN128033, and cobalt and copper in RN 89755.
- Detectable levels of nutrients in all bores sampled.
- Levels below the laboratory detection limits for all bores sampled for total petroleum hydrocarbons (TPH), benzene, toluene, ethyl benzene and xylenes (BTEX), and polycyclic aromatic hydrocarbons (PAH).
- No detectable levels for gross alpha and beta radionuclides for all bores sampled.
- Detectable levels for dissolved methane between 15 μg/L and 128 μg/L in four of the bores sampled.

4.4 Springs and wetlands

The location of wetlands within ATP769 was determined by consulting 1:100,000 scale mapping published by DEHP (2013[b]). The mapping is shown in Figure 4.5.

The mapping documents the presence of a number of lacustrine and palustrine water bodies occurring in drainage channels within ATP769. Lacustrine wetlands are defined by DERM as *"wetlands and deepwater habitats situated in a topographic depression or a dammed river channel. Includes areas where emergent perennial vegetation has less than 30 percent areal coverage and total waterbody area exceeds 8ha"*. Palustrine wetlands are *"dominated by persistent emergent vegetation or where water in deepest part of the basin is less than 2m, active wave formed shores or bedrock features are lacking"*.

Examination of the wetlands indicates that some are farm dams. The remaining wetlands are naturally occurring features, but it is not known to what extent they are fed by groundwater or surface water. If the wetlands are reliant on groundwater, they would be classified as groundwater dependent ecosystems. The palustrine wetlands located on the Paranui property are considered to be ephemeral surface water bodies or lakes that exist only after significant rainfall events or overland flows (flooding) from the Dawson River breaching its banks. At the time of this assessment, whilst some of these features contained shallow water which would be consistent with the end of wet season, the largest on the Paranui property was dry and was being cropped. Based on these observations, it is doubtful these features are groundwater dependent, rather they are a function of surface water flow events.



LEGEND:

- Groundwater Management Unit Boundary
- Mimosa GMU (Area 22 of the GABWRP)
- GAB Intake Area
- Spring

GDE Atlas - Surface Expression

- High potential for GW interaction
- Moderate potential for GW interaction
- Low potential for GW interaction
- Identified in previous study: fieldwork
- Identified in previous study: desktop

- ATP 769
- Petroleum Lease (PL 94)
- EPP

- Populated Place
- Rail
- Watercourse
- Road

Paranui UWIR (G1631)

Groundwater Dependent Ecosystems & Springs

DATE: 9/9/2013

FIGURE No: **4.5**

4.5 Conceptual hydrogeological model

As standard practice, every numerical groundwater model has as its foundation a conceptual model. Details of the groundwater regime for this project described in this section form the basis of the numerical model. The conceptual model is an understanding of how the groundwater system operates and is an idealised and simplified representation of the natural system.

Figure 3.4 presents a generalised east-west section showing the location of the Paranui project area in relation to the regional geological setting. Hydrogeologically, the data used to develop this conceptualisation indicates the area supports two distinct aquifers that occur within the study area, these being:

- the Quaternary age alluvium; and
- the Permian to Triassic age fractured rocks.

Figure 4.6 shows the hydrogeological conceptualisation on a local scale.

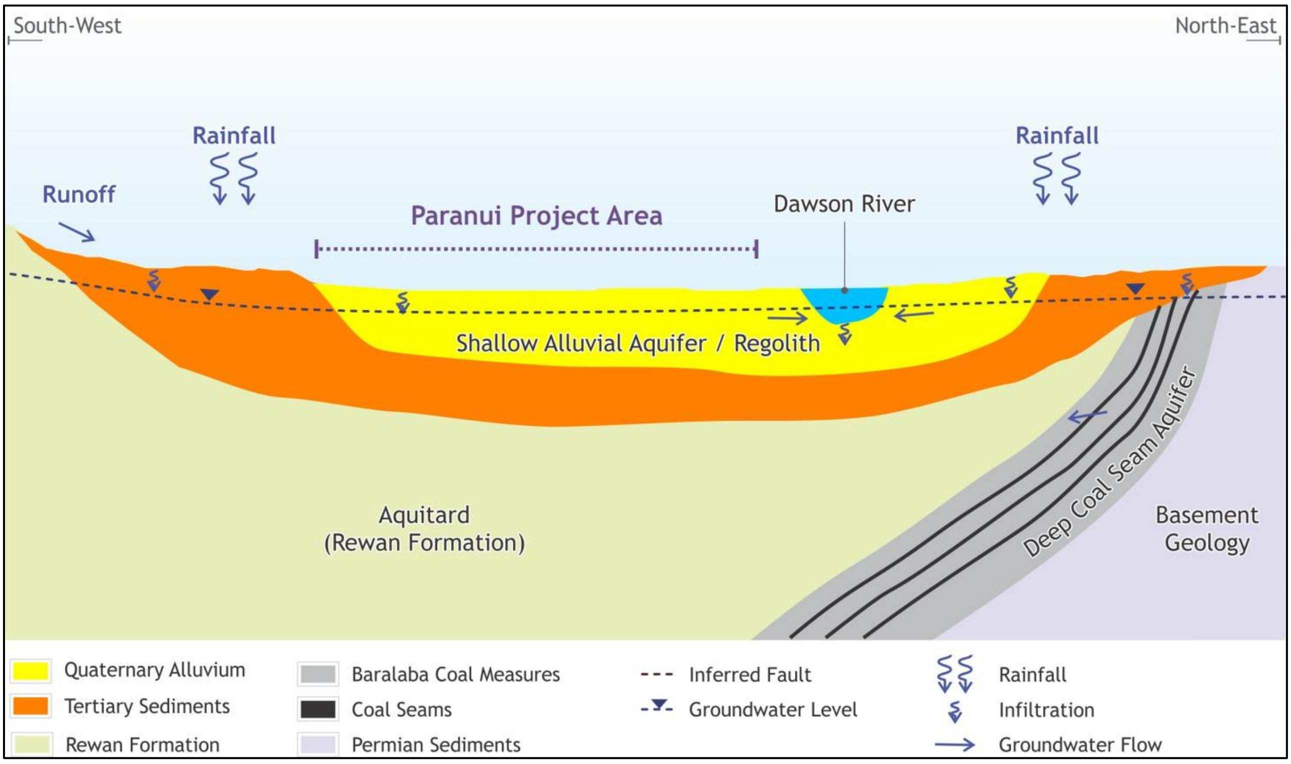


Figure 4.6 Conceptual hydrogeological model

This conceptualisation shows groundwater occurs:

- locally within the base of the Quaternary sediments where more permeable sediments occur; and
- regionally where it effectively includes the combined hydraulic heads of the deeper saline aquifers hosted within the Permian Baralaba Coal Measures, which include coal seams that will be targeted for this CSG project.

These aquifers are separated by a thick sequence of Triassic (Rewan Formation) sediments which comprise "tight", low permeability sediments or aquitards. As such, these aquifers are unlikely to be hydraulically interconnected.

Recharge would principally be in the form of infiltration from rainfall and creek flow into the Quaternary, and to a lesser extent within the Permian aquifer sub-crop areas west of the Paranui site. However, this would be significantly reduced where predominantly clayey Tertiary sequences overlie the Permian coal measures.

Regionally, groundwater flow will be more pronounced within the more permeable Quaternary aquifer which is likely to be to the north. However on a local scale, groundwater movement within the alluvium will be towards the Dawson River, particularly when groundwater levels are high and above the river water level. The regional groundwater levels within the bedrock are expected to be a subdued reflection of the topography indicating groundwater flow from the east towards the Dawson River.

4.6 Summary of hydrogeological investigation

The results of the hydrogeological investigation for ATP769 can be summarised with the following key points:

- The consolidated geology across the site comprises two distinct units which include a basement Permian sequence unconformably overlain by Triassic Rewan Formation. Unconsolidated Tertiary sediments unconformably overlie both formations along the Dawson River. The Permian and Triassic rocks form a regular layered, westerly dipping sedimentary sequence while the Tertiary and Quaternary sediments are more complex and irregular.
- The study area is bound to the east where the Permian geology outcrops roughly along the line of open cut coal mines. The eastern boundary of the GAB Mimosa Management Area is located along the western extents of ATP769, some 8 km west of the Paranui Project area.
- The hydrogeology of the Project area and surrounds comprises two distinct aquifers within the study area, which include the Quaternary age alluvium and the Permian to Triassic age fractured rocks.
- Groundwater associated with the unconsolidated alluvial sediments occurs within the sands and gravels in the basal 5 m. These are overlain by a thicker unit of clay sediments between 15 m and 20 m in thickness. Recharge to this aquifer is expected to occur from rainfall infiltration and seepage from the Dawson River into the alluvium during high flow and flood events.
- The Triassic sediments within the Mimosa Management Area are considered a recharge area for the GAB. Aquifers associated with these sediments are separated from the underlying Permian coal measures by a thick sequence (~600 m) of "tight", very low yielding and low permeability sediments that make up the Rewan Formation.
- The Permian coal seams comprise confined aquifers which generally exhibit relatively low permeability and recharge rates. The sediments of the interburden and overburden sequence are typically relatively impermeable and form aquitards. Recharge to the coal seams is expected to be relatively low, occurring where the coal seam sub-crop / outcrop, particularly within the Dawson Mine lease.
- Groundwater flow is typically from the alluvium to the Dawson River when water levels are high and above the river water level. When there is no rainfall and water levels are below the bed of the river, groundwater flow is likely to remain within the alluvium and be to the north.
- Groundwater levels within the bedrock are expected to be a subdued reflection of the topography indicating groundwater flow from the east towards the Dawson River.
- Groundwater usage is limited within the study area to shallow bores within the Dawson River alluvium and deeper bores into the GAB sediments in the west. Groundwater quality in these aquifers is typically neutral to alkaline and fresh. Groundwater in the deeper Rewan Formation is slightly alkaline and saline.

5 Predictions of groundwater impacts (Part C)

Predicted impact on the groundwater regime as a result of groundwater abstraction in relation to CSG production in ATP769 has been undertaken through development and simulation of a numerical groundwater model. The focus of this part of the assessment has been identification of impact above the trigger drawdown levels in the Immediately Affected Area (IAA) and the Long Term Affected Area (LTAA).

5.1 Model code

Simulation of groundwater flow for the Project site was undertaken using the MODFLOW-SURFACT code (referred to as SURFACT for the remainder of the report). SURFACT is a commercial derivative of the standard MODFLOW code, and is distributed by Hydrogeologic Inc. It has distinct advantages over MODFLOW that are critical for the simulation of groundwater flow in the Project area.

The MODFLOW code (on which SURFACT is based) is the most widely used code for groundwater modelling and is presently considered an industry standard. Use of the SURFACT modelling package is widespread, particularly in mining applications where groundwater dewatering and recovery are simulated.

SURFACT is capable of simulating unsaturated conditions. This is critical for the requirements of the proposed extended operations where the coal seam and overburden progressively dewater with time until the end of CSG operation when active pumping will cease and groundwater recovery will re-wet these units. SURFACT is also supplied with more robust numerical solution schemes to handle the more complex numerical problem resulting from the unsaturated flow formulation. Added to the more robust numerical solvers is an adaptive time-step function that aide the progression of the solution past difficult and complex numerical situations such as oscillations.

The MODFLOW pre- and post- processor PMWIN (Chaing & Kinzelbach, 1996) generated some of the input files for the SURFACT model. Where the files differ to allow for the additional capabilities of SURFACT, these model files were manually edited.

5.2 Model domain

The numerical groundwater model has focussed on the Paranui site where CSG production has been proposed. The extent of the model includes those aquifers that will potentially be affected from the proposed operation.

The extents of the numerical model have been set to minimise the size of the model on the basis that the predicted impacts are considered to be minimal. They extend from the Baralaba Coal Seam subcrop/outcrop to the east which is coincident with the location of the Moura Mine which is approximately 7 km to the west. Similarly the northern and southern boundaries are located approximately 10 km from the Project site along the Dawson River alignment. The constructed model is three-dimensional, and includes a multi-layered geological system that vertically comprises 13 layers, these being:

- Layer 1 – regolith / topsoil and alluvium (two zones);
- Layers 2 to 11 – Rewan formation;
- Layer 12 – Baralaba Coal Seam; and
- Layer 13 – bedrock which include the model base with an arbitrary thickness of 150 m.

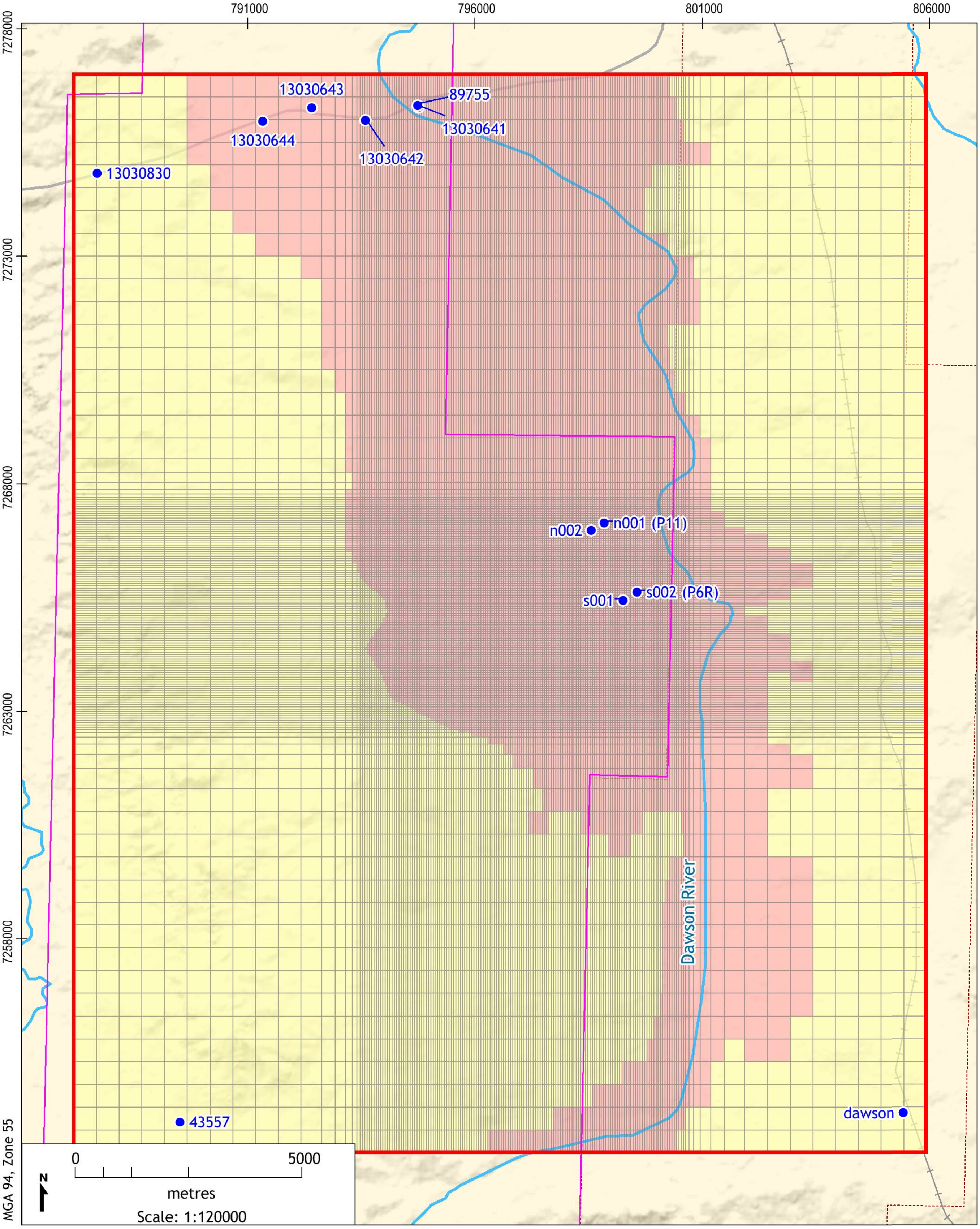
Layer 12 is the target layer for simulation of all pumping from model and it represents a combined thickness of the individual coal seams.

Where the geologic units subcrop or outcrop the layer was 'wrapped' under the overlying layer, the thickness fixed at 0.5 m and the hydraulic properties of the underlying material adopted.

Figure 5.1 shows the model grid overlain on the regional surface geology. The model domain was discretised into 146 rows and 173 columns forming 25,258 rectangular cells. The dimensions of the model cells vary from 50 m by 50 m within the mining area to up to 500 m by 500 m at the model extents.

The north-west corner of the model grid is located at 787180 mE and 7277000 mN (MGA 94, Zone 55). The model extent is about 18.8 km x 23.7 km covering an area of approximately 444 km^2.

Publicly available SRTM digital elevation data was used to define the ground topographic surface in the model.



LEGEND:

Model Recharge Zones

- Alluvium (1.69 mm/yr)
- Regolith (0.068 mm/yr)
- Model Observation Bore
- ATP 769
- Petroleum Lease (PL 94)
- EPP
- Watercourse

Paranui UWIR (G1631)

Model Domain

DATE: 9/9/2013

FIGURE No: **5.1**

5.3 Model boundary conditions

The model domain is rectangular with all cells set as active and surrounded by "no flow" boundaries with the exception of the inlet and outlet points of the main Dawson River waterway. The base of the model was also assumed to be a "no flow" boundary. A "no flow" boundary does not allow any exchange of water between the model domain and the surrounding areas.

Recharge

The model distributed recharge across Layer 1 according to geology, with two zones of recharge. The zones represented the Quaternary alluvium and weathered regolith material Triassic / Permian Formations. The proportion of incident rainfall that infiltrates was calibrated for each recharge zone.

Rivers

Watercourses (including minor creeks) were incorporated into the model, using the SURFACT River (RIV) package. Within the model domain the Dawson River has been assumed to contain water for the duration of the simulation with a minimum water depth of 0.5 m. Conversely, the other "minor" creeks and gullies are considered ephemeral and are simulated as drains. All creeks and rivers were given high conductance and their parameters were not subject to calibration in PEST. Figure 5.2 shows the location of the river cells.

Constant heads

In order to simulate a hydraulic gradient in the Dawson River Alluvium, constant head boundaries were set in cells at the northern and southern edges of the model domain within the alluvium and were based on extrapolation of recorded groundwater head elevations to the model boundaries. Figure 5.2 shows the location of the constant head cells.

5.4 Hydraulic parameters

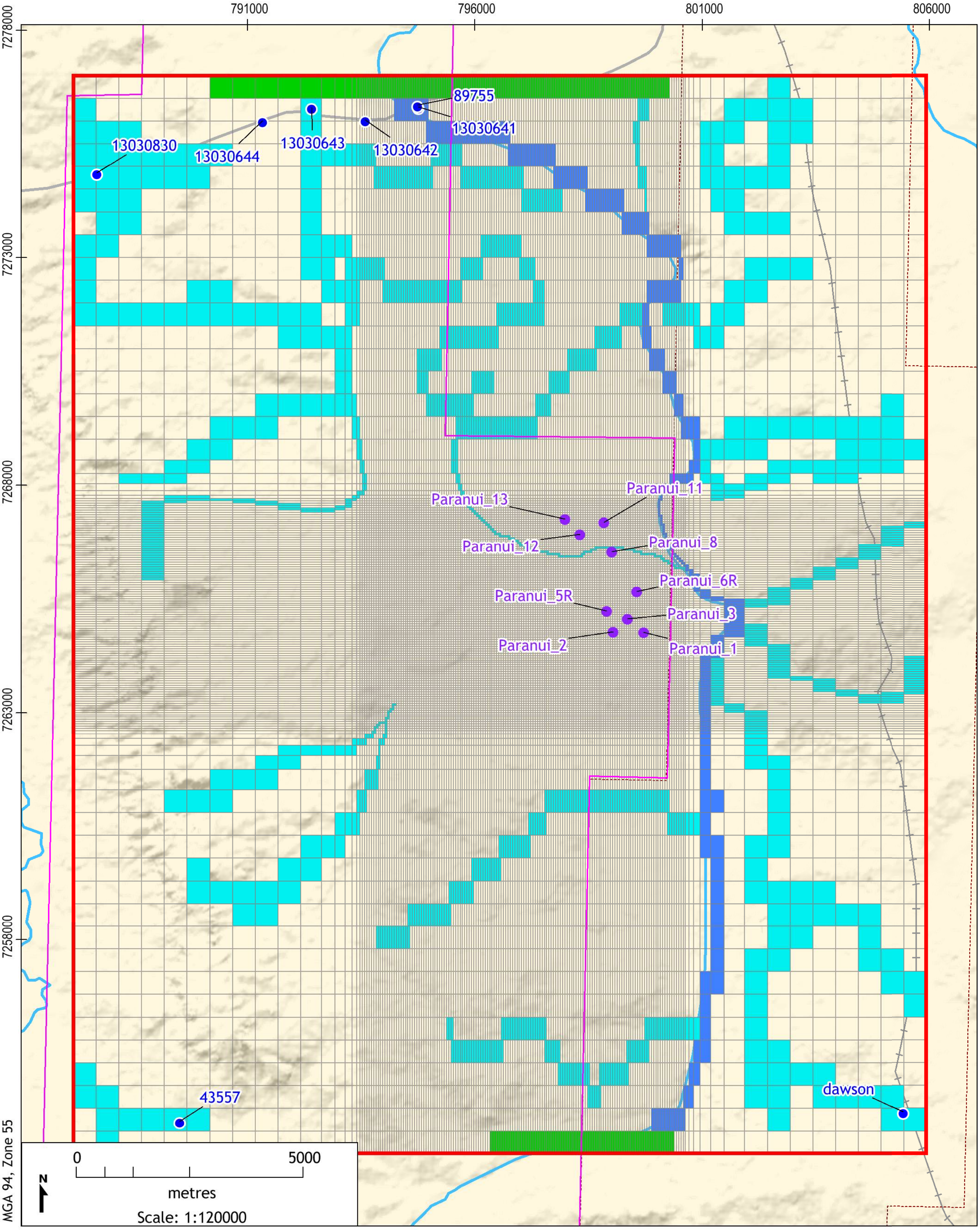
Hydraulic conductivity (Kh), Specific Yield (S_y) and Specific Storage (S_s) parameters have been based on typical values sourced from relevant literature and other EIS coal projects in the Bowen Basin (refer Section 4).

Values for Kh within the coal seams were not subject to calibration and have been based on available data for coal seams sourced from the CSG investigations and previous coal seam gas investigations (IPT, 2010 and AGE, 2011).

5.5 Calibration results

Anderson and Woessner, (1992) note, *"calibration of a groundwater flow model refers to a demonstration that the model is capable of producing field measured heads and flows which are the calibration values. Calibration is accomplished by finding a set of parameters, boundary conditions and stresses that produce simulated heads and fluxes that match field measured values within an acceptable range of error".*

During the calibration, hydraulic conductivity in the coal seam remained fixed. The recharge rates and permeability of other geologic units were altered to obtain a closer match between predicted and observed water levels. The main objective of model calibration was to reproduce and match the observed water levels, reproduce the general pattern of the groundwater contours, and keep recharge rates within the expected low range.



LEGEND:

- River Cell - Dawson River
- Drain Cell
- Constant Head
- Model Observation Bore
- Existing Paranui Well
- ATP 769
- Petroleum Lease (PL 94)
- EPP
- Watercourse

Paranui UWIR (G1631)

River Cells & Boundary Conditions

DATE: 9/9/2013

FIGURE No: **5.2**

5.6 Hydraulic heads

Groundwater levels measured in registered water bores (details sourced from the DEHP Groundwater Database) were used as the calibration targets for the steady state model. The objective of the steady state modelling was to simulate current conditions prior to commencement of CSG operations. A total of eight data points were used to calibrate the model which include seven registered bores identified from the DEHP water bore data base. Table 5.1 shows the predicted and observed water levels for the monitoring bores within the Project site and from registered private bores.

Table 5.1 Calibration targets and simulated water levels – steady state model

Bore ID	Easting (m)	Northing (m)	Measured water level (mAHD)	Modelled water level (mAHD)	Residual (m)	Source
43557	789,514.0	7,254,015.0	139.70	111.36	28.34	Registered bore
89755	794,738.0	7,276,353.0	97.44	99.25	-1.81	Registered bore
13030641	794,755.0	7,276,316.0	97.92	99.25	-1.33	Registered bore
13030642	793,588.5	7,276,030.1	97.26	97.22	0.04	Registered bore
13030643	792,406.7	7,276,300.8	93.50	97.86	-4.36	Registered bore
13030644	791,330.7	7,276,007.4	98.18	98.50	-0.32	Registered bore
13030830	787,691.5	7,274,862.7	106.00	103.72	2.28	Registered bore
Dawson	805,418.7	7,254,218.7	132.79	125.13	7.66	River

Figure 5.3 compares the observed and simulated groundwater levels.

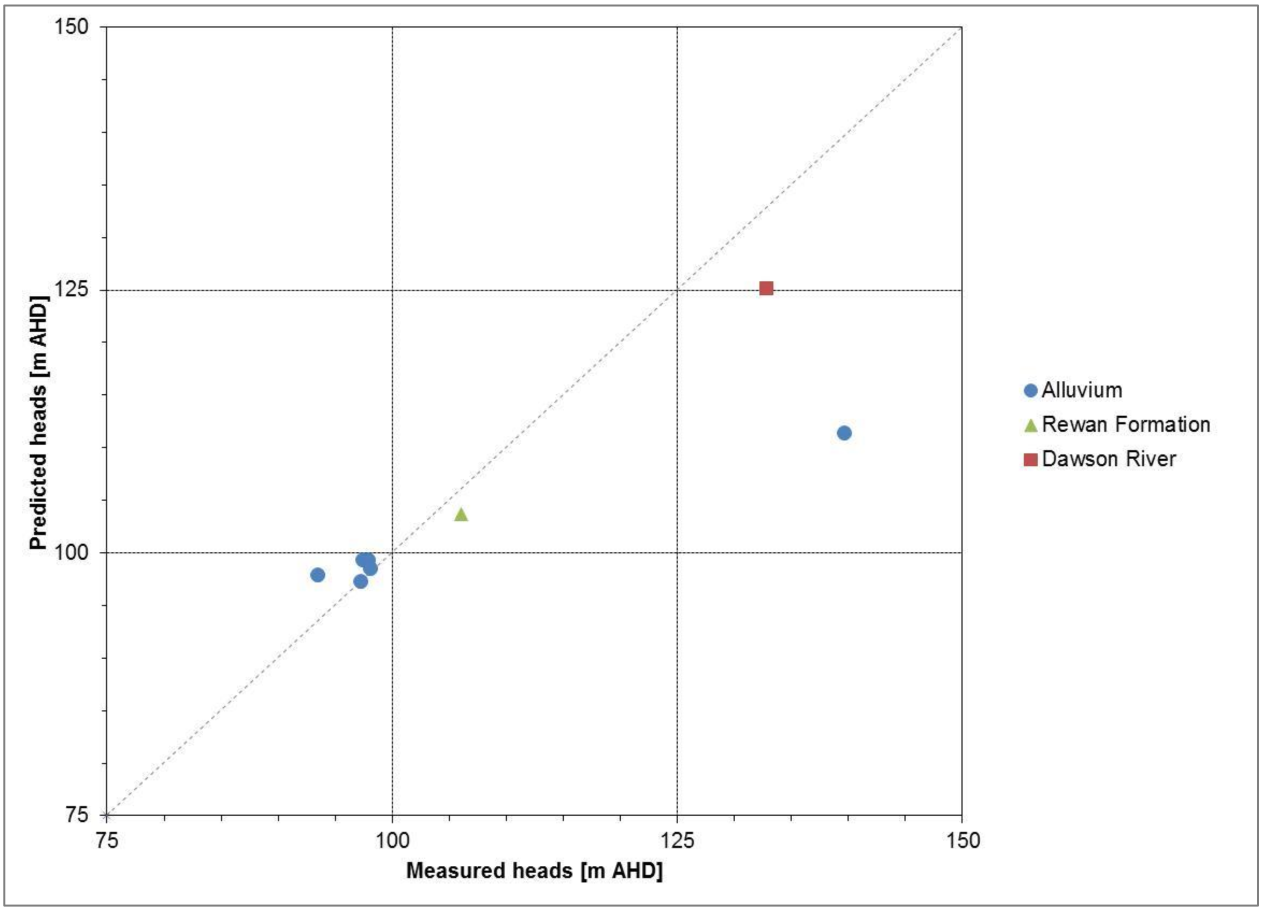


Figure 5.3 Predicted versus observed groundwater levels from the steady state model

The simulated steady state groundwater level elevations for selected layers are presented in Figure 5.4.

An objective method to evaluate the calibration of a model is to examine the statistical parameters associated with the calibration. One such method is by measurement of the difference between the modelled and observed (measured) water levels. The root mean square (RMS) difference is expressed as follows:

$$RMS = \left[1/n \sum (h_o - h_m)_i^2\right]^{0.5}$$

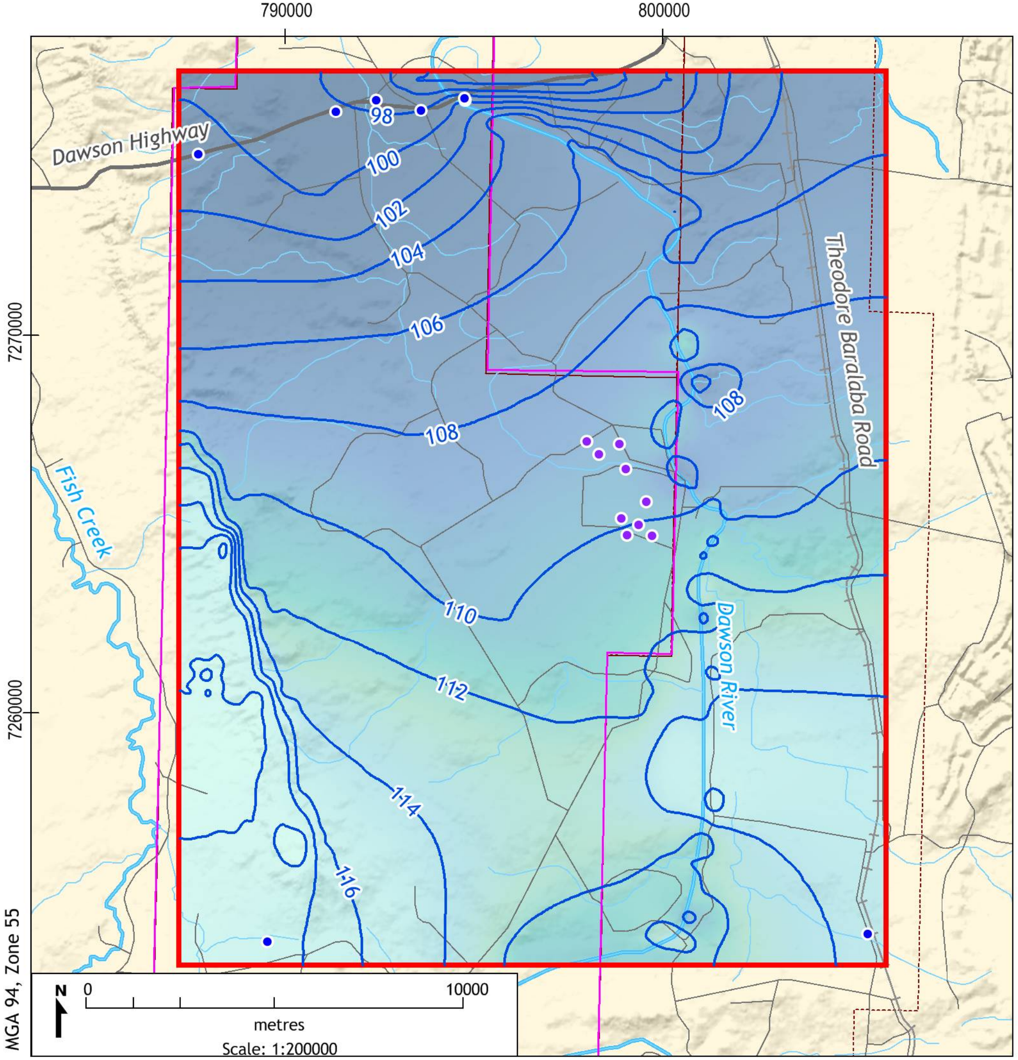
where: n = number of measurements

h_o = observed water level

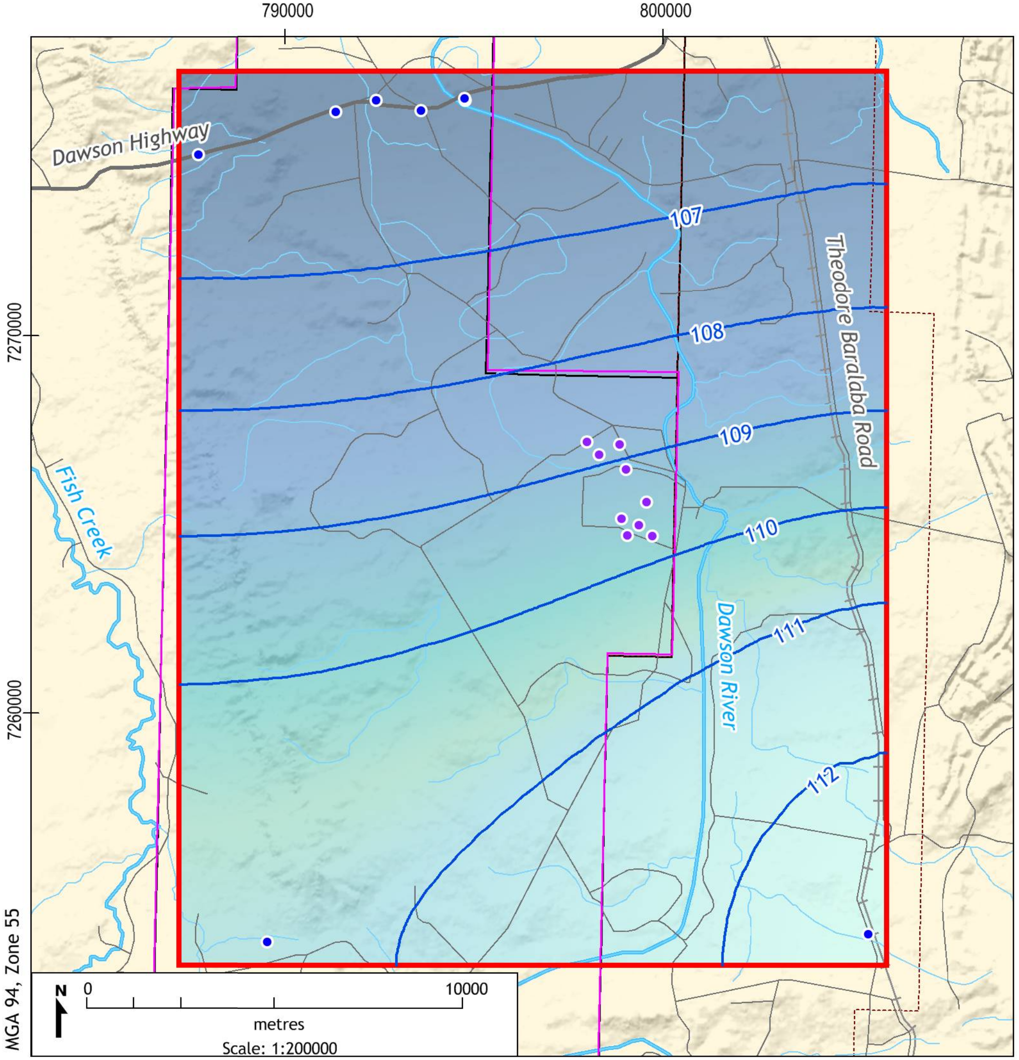
h_m = simulated water level

The RMS calculated for the calibrated model was 10.55 m. The maximum acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS to the total change is small, known as the Scaled RMS (SRMS), the differences are only a small part of the overall model response (Anderson and Woessner, 1992).

Steady State Heads - Layer 1 (Unconsolidated)



Steady State Heads - Layer 12 (Coal Seams)



LEGEND:

- Groundwater Contour (mRL)
- Existing Paranui Well
- Model Observation Bore
- Model Extent
- ATP 769
- Petroleum Lease (PL 94)
- EPP
- Road
- Rail
- Watercourse

Paranui UWIR (G1631)

Steady State Heads
Layer 1 and Layer 12

DATE: 9/9/2013

FIGURE No: **5.4**

Scaled RMS was calculated by dividing the RMS by the range of observed values, as shown below:

$$RMS_{scaled} = [RMS / (\max h_o - \min h_o)] \left[\frac{1}{100} \right]$$

The ratio of RMS (10.6 m) to the total head change across the calibration points (46.2 m) indicated a SRMS of 22.84% which is considered a poor calibration. The acceptable target for SRMS varies between models but is typically between 5% and 10% (Barnett *et al,* 2012). However when the following points are taken into account, the calibration is considered to be the best achievable based on the available data:

- the steady state model used a simplified uniform representation of permeability based on limited data to represent a complex heterogeneous fractured rock system;
- the calibration points are mostly clustered along the northern model boundary with limited coverage across the remainder of the model domain; and
- the available observations are from different time periods, which may not be representative of steady state conditions.

5.7 Hydraulic properties

Table 5.2 presents the hydraulic parameters adopted for the model following calibration process.

Table 5.2 Hydraulic parameters

Layer	Parameter	Value
Layer 1 Alluvium Weathered Material (Regolith)	Horizontal Hydraulic Conductivity [kh]	Alluvium 20 m/day Regolith 0.1 m/day
	Vertical Hydraulic Conductivity [kv]	Alluvium and Regolith 10% of k_h
	Specific Yield [S_y]	Alluvium 0.1 Regolith 1 x 10^{-3}
	Specific Storage [S_s]	Alluvium 1 x 10^{-3} Regolith 1 x 10^{-4}
Layers 2 to 11 Rewan Formation	Horizontal Hydraulic Conductivity [kh]	1 x 10^{-4} m/day
	Vertical Hydraulic Conductivity [kv]	1% of k_h
	Specific Yield [S_y]	1 x 10^{-3}
	Specific Storage [S_s]	1 x 10^{-5}
Layer 12 Baralaba Coal Seams (combined)	Horizontal Hydraulic Conductivity [kh]	3.5 x 10^{-4} m/day
	Vertical Hydraulic Conductivity [kv]	10% of k_h
	Specific Yield [S_y]	5 x 10^{-2}
	Specific Storage [S_s]	5 x 10^{-5}
Layer 13 Kaloola Formation (Model Base)	Horizontal Hydraulic Conductivity [kh]	1 x 10^{-4} m/day
	Vertical Hydraulic Conductivity [kv]	1% of kh
	Specific Yield [S_y]	1 x 10^{-3}
	Specific Storage [S_s]	1 x 10^{-5}

Note: *See Section 4 for likely range and sources for aquifer storage parameters*

5.8 Water budgets

The differences between calculated model inflows and outflows at the completion of the calibration run, expressed as percent of discrepancy was 0.1%, indicating an accurate numerical solution and overall stability of the model. Table 5.3 presents the water budget inputs and outputs.

Table 5.3 Groundwater budget – steady state model (ML/day)

Parameter	Input	Output
Rainfall recharge	0.7	0
Constant heads	24.7	53.0
River leakage	64.4	36.9
Totals	**89.8**	**89.9**

Table 5.4 presents the calibrated rates of recharge to Layer 1 for each geological zone defined in the model.

Table 5.4 Rainfall recharge

Geology	Recharge - Percentage of Rainfall (%)	Recharge (mm/year)
Alluvium	0.25	1.69
Weathered material (Regolith)	0.01	0.07

5.9 Model Setup for Impact Assessment

The predictive simulation required the steady state model to be converted to transient flow conditions to predict the zone of depressurization induced by dewatering of the coal seams. This transient simulation includes the period from 2008 onwards with the initial starting conditions being those determined from the steady state analysis. The historical water production is as described in Section 2.1 with the predicted simulation as per that described in Section 2.2. Abstraction of groundwater from the numerical model is simulated using MODFLOW well package (WEL) in conjunction with the assigned well production rates. The wells are assumed to be fully penetrating across the entire depth of the coal seams assigned to Layer 12. No details of horizontal wells have been provided and hence have not been included in this simulation. Similarly, inclusion of any induced hydraulic (lateral) fracturing (or fracking) has not been specifically simulated as it is considered its impacts are on a much smaller scale than the resolution of the model grid.

The transient simulation therefore includes a two year period during which production testing takes place between 2016 and 2017 where there is predicted to be water produced from the two pilot wells. This was continued for a further 100 years to investigate any long-term effect from the proposed CSG extraction and groundwater abstraction. This part of the simulation does not have any CSG extraction or groundwater abstraction and represents the period of groundwater recovery post CSG operation within the Baralaba Coal Seams.

The extent of the drawdown responses from CSG extraction and groundwater abstraction are presented in terms of the trigger thresholds defined in the Water Act. These include a water decline in excess of 5m for consolidated aquifers and 2 m for unconsolidated aquifers. As detailed in Section 5.7, the alluvium and regolith in Layer 1 represents the unconsolidated aquifers, whilst the other underlying Layers 2 to 13 represent consolidated aquifers. More specifically the Baralaba Coal Seams are represented as a consolidated unit in Layer 12. That is, the CSG extraction and groundwater abstraction from Layer 12 has therefore simulated the period May 2014 to July 2017, with the predicted extraction not anticipated or modelled prior to the proposed commencement of testing in May 2016, whilst also incorporating the Pilot Project between 2008 and 2010.

5.9.1 Immediately affected area

For the duration of groundwater abstraction associated with CSG production for the period May 2014 to July 2017, groundwater drawdown is only observed in Baralaba Coal Seams (Layer 12). The extent of this drawdown is shown in Figure 5.5. It should be noted that this predictive simulation included the pilot well testing on wells P-5R, P-6R and P-8 between 2008 and 2010, resulting in the cumulative impact from the two periods of CSG production. This shows that at the end of Year three in 2017, the extents of groundwater impact for the individual wells is contained within a 150 m to 200 m radius of the proposed extraction wells.

Due to the distance between the two wells there is no interference and hence no cumulative impact from the pilot well testing. The extents of the IAA as defined by drawdown exceeding 5 m is contained within a 90 m to 130 m radius of the proposed extraction wells. There is no cumulative impact as a result of the groundwater abstraction for the two wells. There is no groundwater drawdown predicted in the Quaternary Alluvium (i.e. Dawson River Alluvium). During this period, there are no impacted registered bores (Figure 4.2) within the IAA. The nearest registered bore is a petroleum or gas exploration bore (RN100045) located approximately 4 km northeast of well P-12. The nearest registered water supply is RN47008 which is located approximately 11 km west of well P-12.

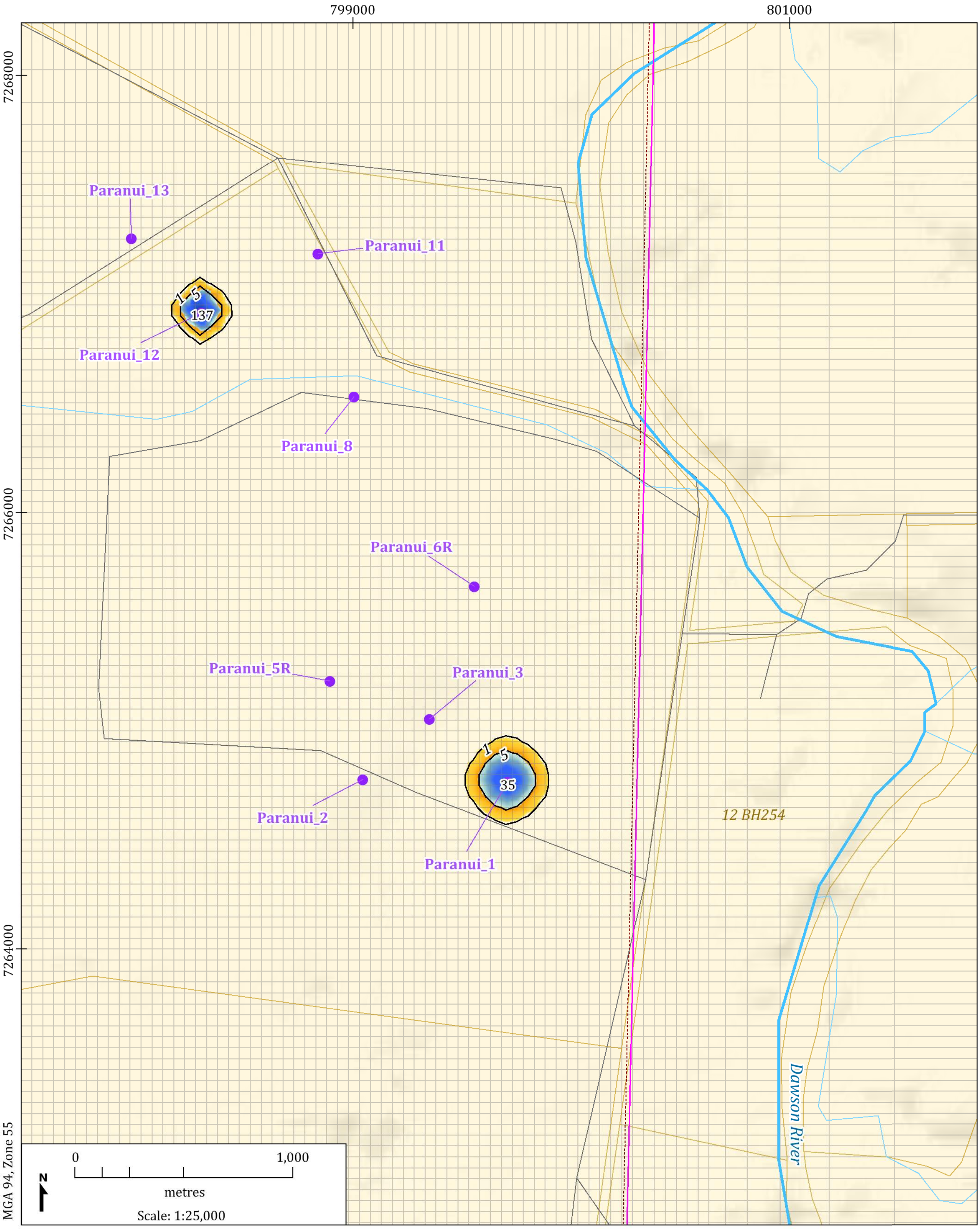
5.9.2 Long term affected area

The model has assessed the LTAA by simulating recovery of the groundwater system for 100 years post CSG extraction. The simulation utilised the predicted groundwater levels and hydraulic properties at the end of the three-year period of CSG operation. The well boundary condition used to simulate dewatering from the coal seam was removed, allowing the groundwater levels in geological units above and beneath the coal seams to recover (gradually return to pre CSG extraction conditions).

The LTAA showing the predicted water level declines by more than 5 m (water level trigger) at any time is shown in Figure 5.6. This shows a generally similar response to that predicted at the end of 2017 (IAA), with the extent of the 5 m groundwater drawdown contour increasing slightly up to 50 m beyond that predicted at the end of 2017 for the two wells. This drawdown was generated by assessing the entire transient model output and identifying the maximum drawdown predicted at all the model cells in the coal seam layer. Similar to the IAA, there are no impacted registered bores (Figure 4.2) within the LTAA. The nearest registered bores are the same as for the IAA, that is petroleum or gas exploration bore (RN100045) and water supply bore (RN47008) located approximately 4 km northeast 11 km west respectively from well P-12.

Figure 5.7 presents the predicted drawdown and recovery in the groundwater levels with respect to the proposed CSG wells P-1and P-12 in relation to the combined Baralaba Coal Seams in Layer 12.

These show groundwater level recovers quickly once CSG operations cease in Year 3, with recovery to < 5m drawdown predicted in approximately 5.5 years in both P-1 and P-12. Thereafter the time taken for full recovery to less than 1 m drawdown (i.e. within 1%) of the pre-CSG operations is predicted to take around between 19 years (P-12) and 22 years (P-1).



LEGEND:

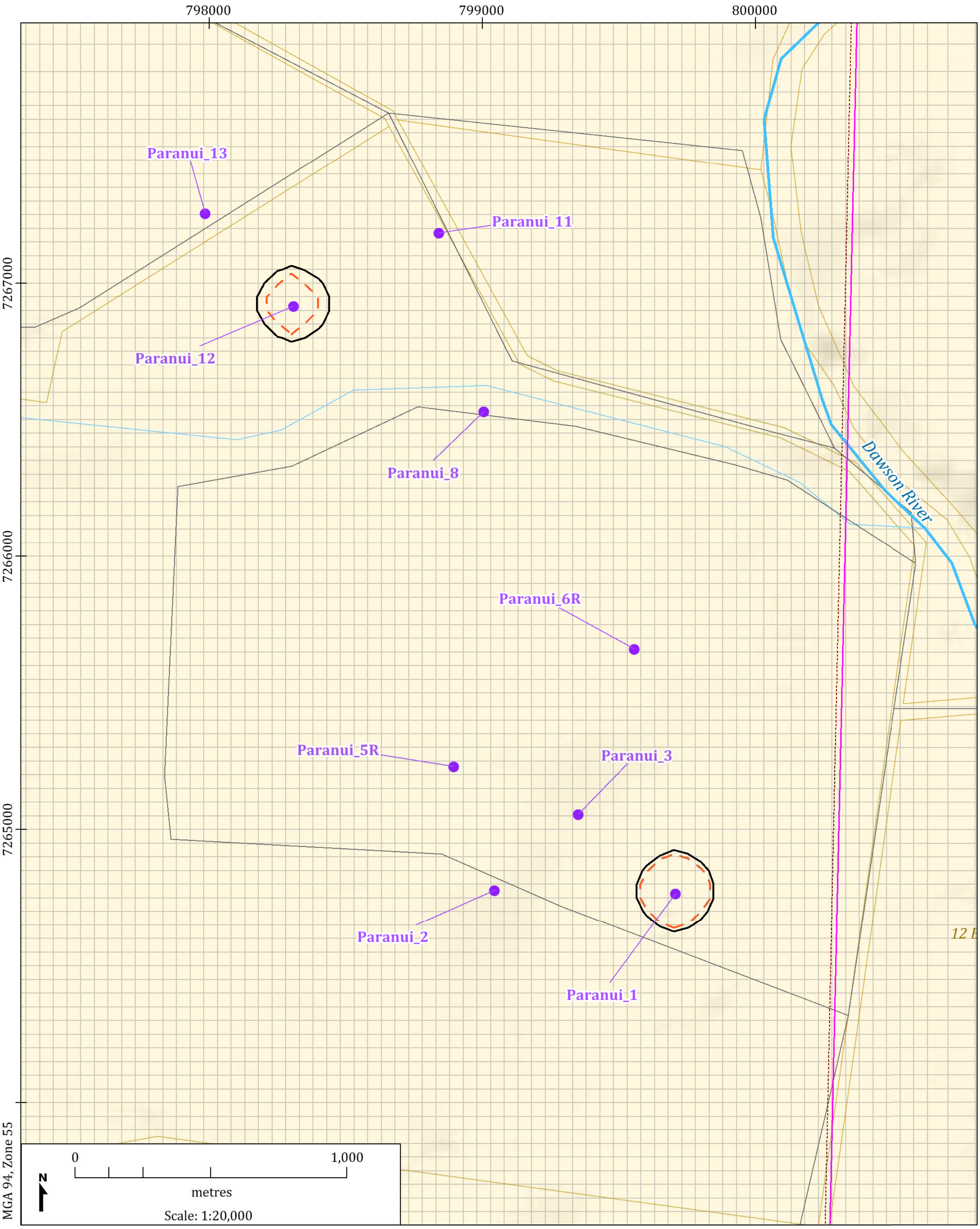
- Existing Paranui Well
- ATP 769
- Petroleum Lease (PL 94)
- Drawdown contour (m)
- Model Grid
- Cadastre (Lot Plan)
- Watercourse
- Road

Paranui UWIR (G1631A)

Predicted Groundwater Drawdown - End of 2017 Combined Baralaba Coal Seam (Layer 12)

DATE: 31/7/2015

FIGURE No: **5.5**



LEGEND:

- Existing Paranui Well
- ATP 769
- Petroleum Lease (PL 94)
- Long Term Affected Area - 5m contour
- End of 2017 - 5m contour
- Model Grid
- Cadastre (Lot Plan)
- Watercourse
- Road

Paranui UWIR (G1631A)

Predicted Groundwater Drawdown - Long term Affected Area Combined Baralaba Coal Seam (Layer 12)

DATE: 31/7/2015

FIGURE No: **5.6**

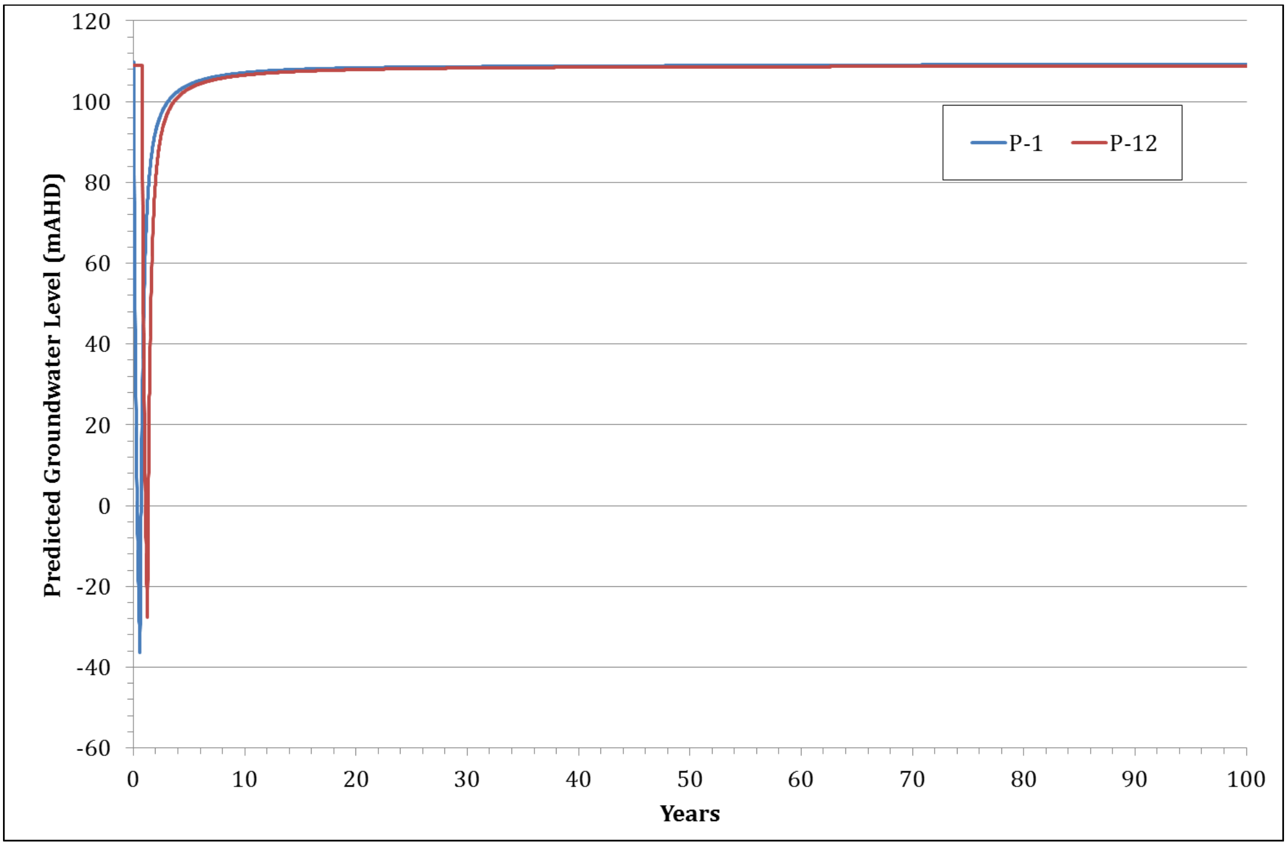


Figure 5.7 Predicted duration for drawdown and recovery of groundwater levels for each CSG production well

5.10 Sensitivity

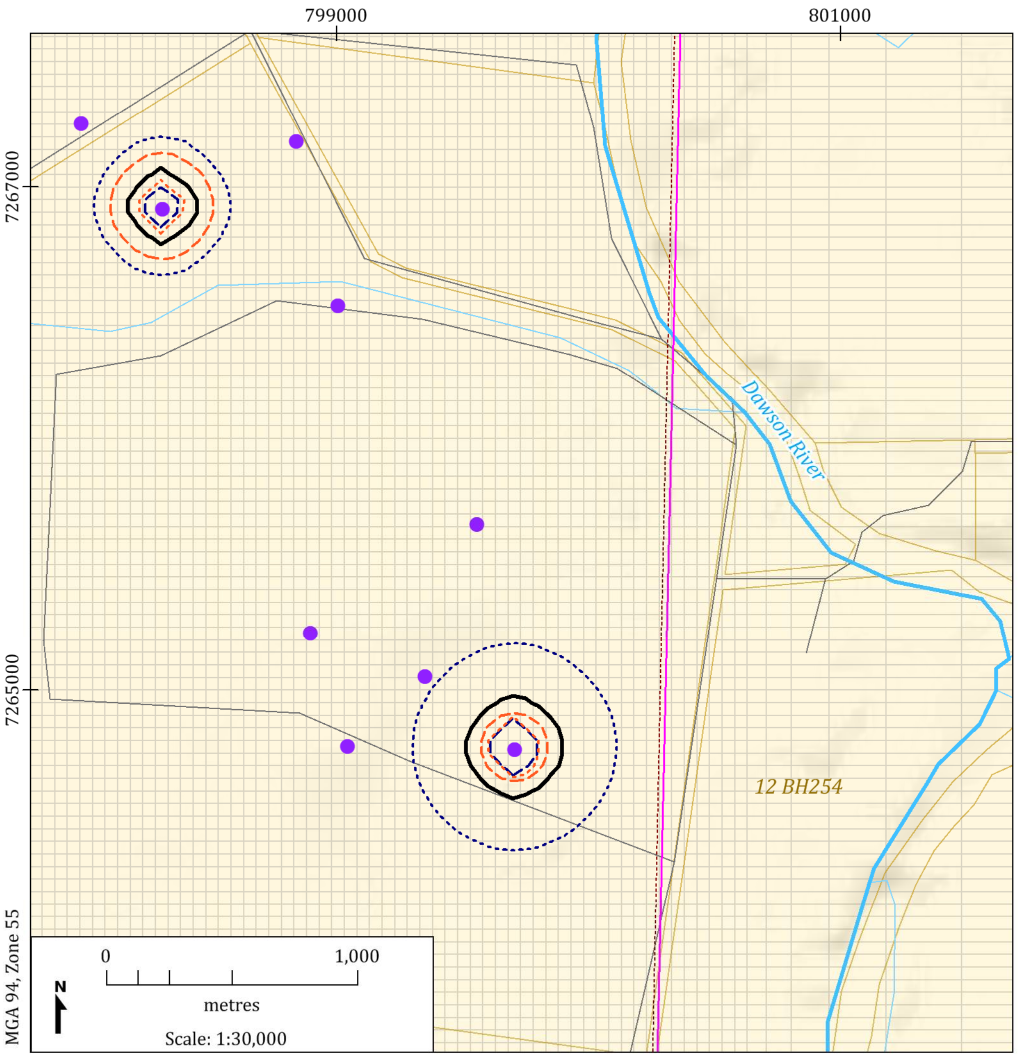
The predicted drawdown extents are fully dependent on the hydraulic properties of the geological units adopted in the model. These have been based on calibrated aquifer parameters determined from permeability testing undertaken for the Project. The sensitivity of the predicted drawdown extents to changes in the adopted hydraulic properties in the model was assessed. The sensitivity analysis adjusted the hydraulic properties as follows:

- horizontal and vertical hydraulic conductivity (k) + 10 x in Layer 12;specific storage (Ss) ± 5 x in Layer 12; and
- specific yield (Sy) ± 5 x in Layer 12.

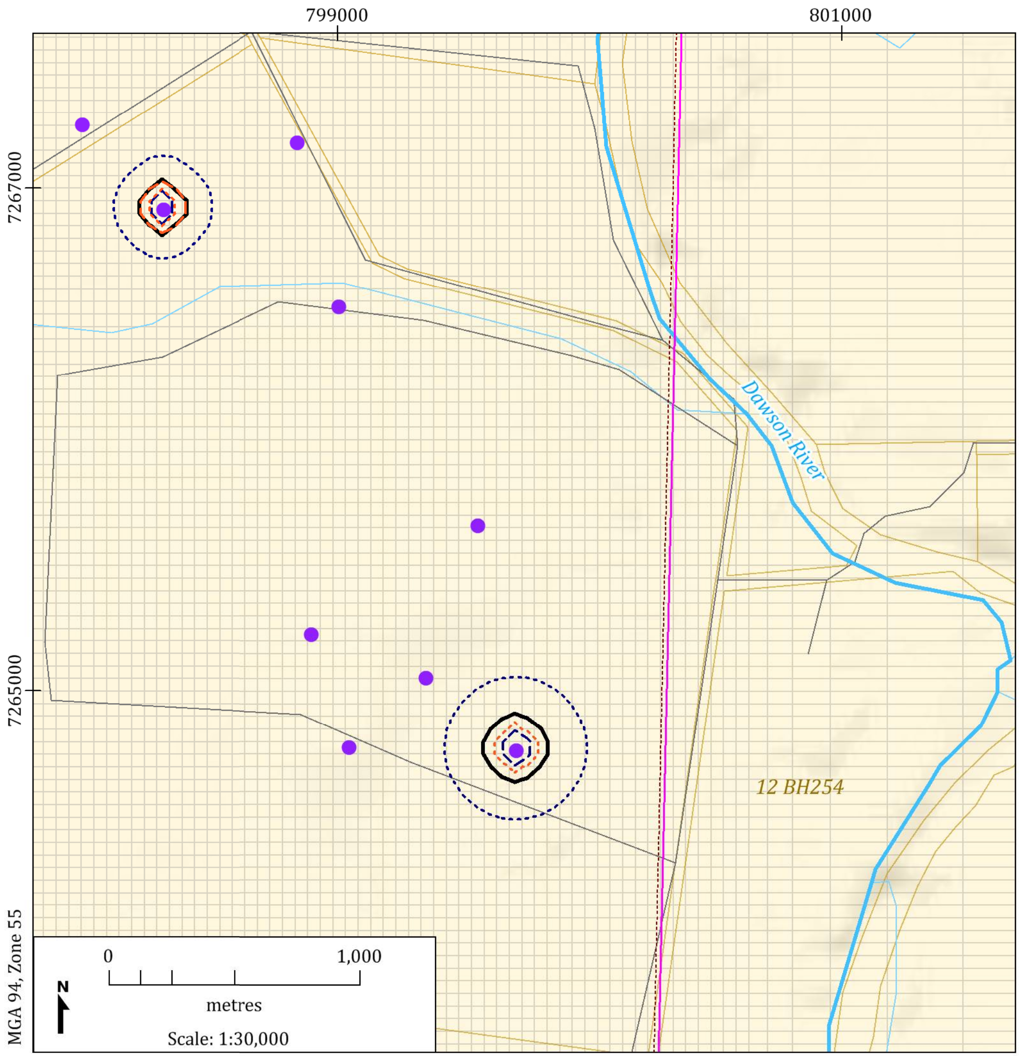
Sensitivity testing was carried out to determine a 'best case' and a 'worst case' scenario for the drawdown extents. It focused on the predicted impact on the coal seams since only this layer is predicted to be impacted from the proposed CSG operation. The tests evaluated the response of the model to variability in input parameters.

The results of the sensitivity analyses run are summarised in Table 5.5. Figure 5.8 provides a comparison of the extent of drawdown for each sensitivity run. This shows the model is most sensitive to specific storage and hydraulic conductivity, with no change in drawdown extents observed for specific yield. This is due to the aquifer remaining confined and not becoming extensively depressurised and unconfined during the simulation.

Sensitivity Analysis - 1m Drawdown Contours



Sensitivity Analysis - 5m Drawdown Contours



LEGEND:

- Existing Pumping Well
- Watercourse
- Model Grid
- Road
- Cadastre (Lot Plan)
- ATP 769

Drawdown Contour

- Basecase
- HC +1 OM
- HC -1 OM
- Ss +50 Percent
- Ss -50 Percent

Paranui UWIR (G1631A)

Sensitivity Analysis
Layer 12 Drawdown Contours

DATE:
31/7/2015

FIGURE No:
5.8

Table 5.5 Summary of sensitivity runs

Run	Condition assessed	CSG Well	
		P-1	P-12
Base case	Maximum drawdown	146 m	137 m
	Recovery time for < 5m drawdown	5.5 years	5.5 years
	Recovery time for < 1m drawdown	22 years	19 years
Hydraulic conductivity (k) + 10x	Maximum drawdown	24 m	23 m
	Recovery time for < 5m drawdown	0.75 years	1.4 years
	Recovery time for < 1m drawdown	1.4 years	2 years
Hydraulic conductivity (k) - 10x	Maximum drawdown	308 m	268 m
	Recovery time for < 5m drawdown	63 years	55 years
	Recovery time for < 1m drawdown	>100 years	>100 years
Specific yield (Ss) +5x	Maximum drawdown	54 m	48 m
	Recovery time for < 5m drawdown	6.3 years	6.3 years
	Recovery time for < 1m drawdown	54 years	48 years
Specific yield (Ss) -5x	Maximum drawdown	229 m	222 m
	Recovery time for < 5m drawdown	4.5 years	5 years
	Recovery time for < 1m drawdown	229 years	222 years

5.10.1 Best case scenario

The best case scenario is depicted when the hydraulic conductivity values are increased by an order of magnitude. This scenario creates a slightly larger zone of impact as defined by the increased extents of the 1 m drawdown in the coal seam aquifer. However, it corresponds with significantly lesser maximum drawdown at the end of CSG operations in 2017 within each CSG well. The extents of these simulated conditions for each CSG well at the Paranui site are shown in Figure 5.9 and Figure 5.10.

5.10.2 Worst case scenario

The worst case scenario is depicted when the specific storage is decreased by half an order of magnitude. This scenario creates the largest zone of impact at the end of CSG operations in 2017 as defined by the extents of the 1 m drawdown in the coal seam aquifer. However, the order of magnitude reduction in hydraulic conductivity scenario results in the greatest maximum drawdown within each CSG well at the end of CSG operations. The extents of these simulated conditions for each CSG well at the Paranui site are shown in Figure 5.9 and Figure 5.10.

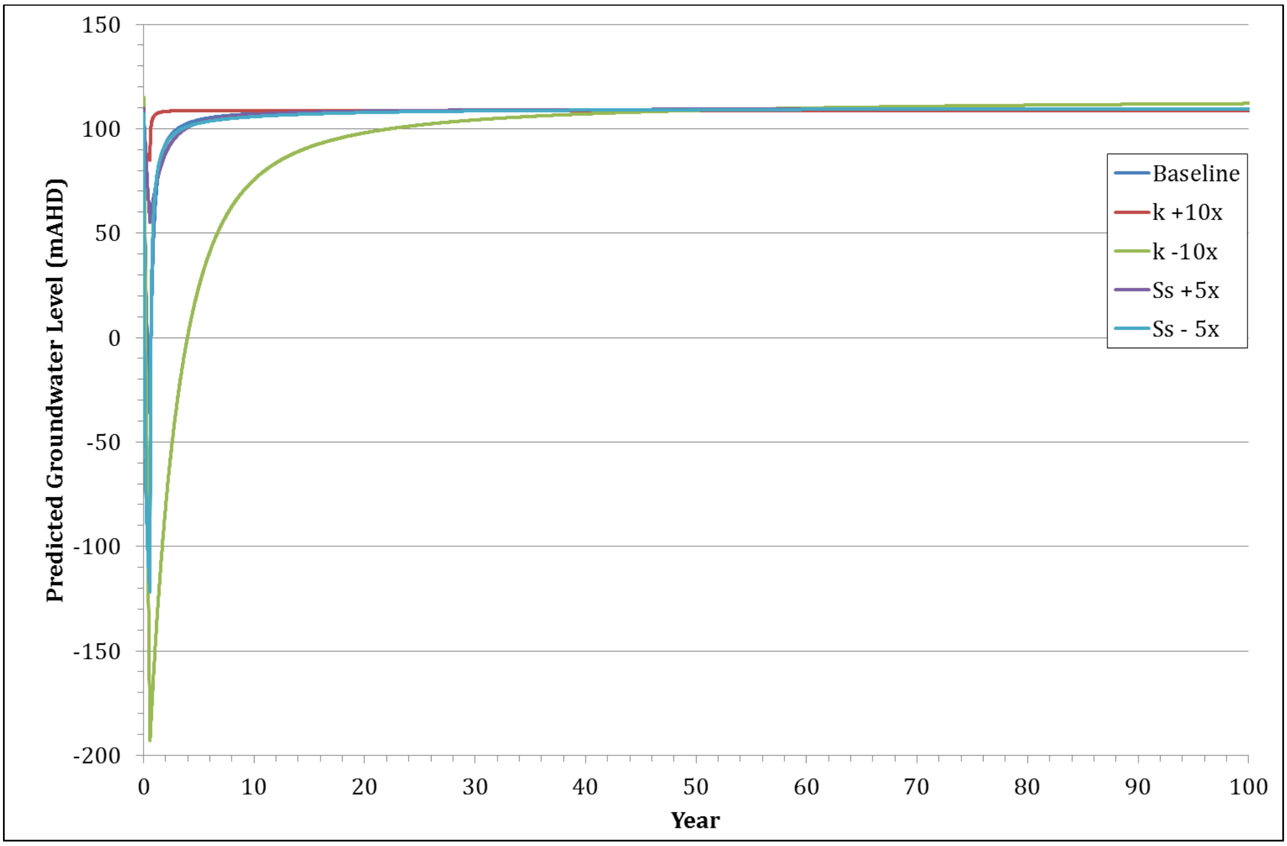


Figure 5.9 Sensitivity analysis Layer 12 drawdown and recovery for P-1

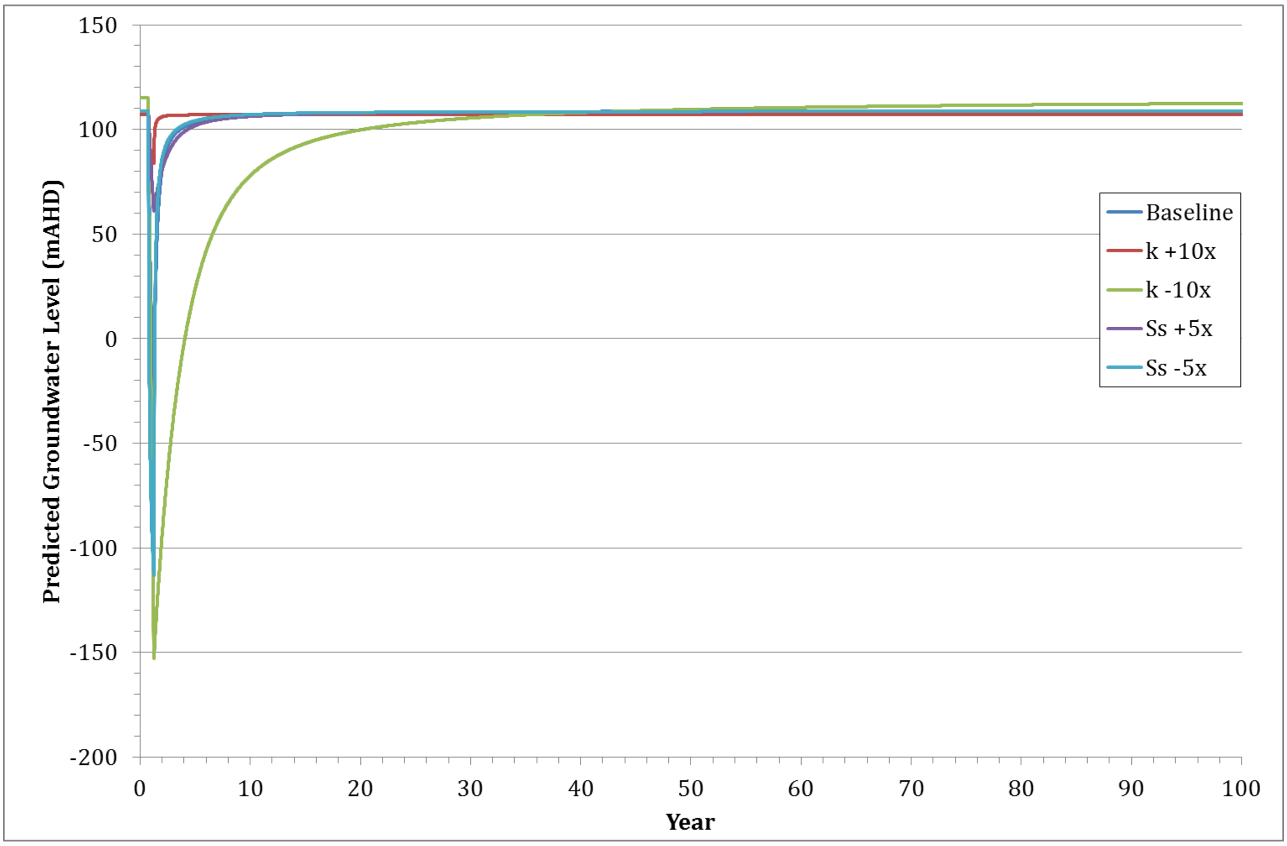


Figure 5.10 Sensitivity analysis Layer 12 drawdown and recovery for P-12

5.11 Review of maps produced

This modelling has identified the areas defined as the IAA and LTAA are contained within the Permian coal sequences and do not propagate upwards into the overlying shallow alluvial aquifer. Neither do they extend laterally nor impact on other adjacent aquifers such as those within the GAB located along the western margins of ATP769. After CSG operations and pumping cease, groundwater levels slowly recover and there are no long term affected areas. No registered or identified bores are anticipated to be located with these predicted IAA and LTAA areas.

Development, calibration and the results of predictive simulations from this groundwater model have been based on available data characterising the groundwater system under investigation. More specifically this model has used available data for aquifer parameters and groundwater levels to predict the impacts from the proposed CSG operations. The assumptions on the geology, hydrogeology and hydraulic properties of the model will be reviewed annually to determine the accuracy of the predictions made. Where new data indicates substantial differences (previously unrecognised information) to those originally interpreted, these data will be incorporated into the model and revised predictions made and reported. The principal objective of this will be to validate the model predictions and identify if the data indicates significant divergence from the model predictions. Where identified, the groundwater model should be an updated for revised simulation of CSG operations and assessment of the IAA and LTAA.

Based on the above, an annual review is proposed to allow comparison of model predictions to field observations to ensure the model and its underlying assumptions are correct and 'fit for purpose'. Where commencement of production testing and associated water extraction has not occurred prior to the review period it is proposed that the model will not be reviewed or updated. The model will be updated at annual reviews where new data is available that would likely result in appreciable divergence from the original model predictions. Data that would likely result in such changes in model predictions include:

- geological and hydrogeological data such as structural features that behave as hydraulic barriers or modify the aquifer extents;
- changes to proposed CSG extraction and hence groundwater pump rates;
- significant variations in drawdown prediction of any well given the conservative nature of the model construction;
- changes in aquifer properties from further aquifer testing that produce aquifer parameter values that vary by more than an order on magnitude (for hydraulic conductivity) or are outside the variation observed in the sensitivity analysis; and
- variations in the model domain where drawdowns do not match those predicted.

6 Water monitoring strategy (Part D)

6.1 Rationale

This Water Monitoring Strategy has been developed to detect any changes in water levels and water quality as a result of the exercise of underground water rights at ATP769.

Water supplies near the Project area are mostly sourced from the Dawson River. As such, dependence on groundwater in this area is limited to a small number of water supply bores which mostly intersect the upper alluvial aquifer. Nearby registered bores that intersect the Baralaba Coal Seam aquifer are mainly CSG bores that are not used for water supply. The numerical modelling shows that there will be no impact on the shallower alluvial aquifer.

Similarly, no springs have been identified within this portion of the ATP769 or the zone of influence for the proposed CSG operation. This being the case, there is no provision for monitoring springs in this monitoring strategy.

The numerical modelling does predict the Baralaba Coal Seams will be impacted from groundwater abstraction from the proposed CSG operation, but the IAA will be contained within the boundary of the Paranui Property in which the Project is located. The extent of this impact reduces on cessation of CSG operations with no long term affected areas after 22 years post CSG extraction.

6.2 Monitoring threshold criteria

It is proposed that the following criteria be implemented for this Project to identify adverse impacts on significant changes in water quality and quantity:

- **Adverse chemical impacts:** Compare concentrations of following analytes to previous monitoring rounds – if either (a) value exceeds highest previous measurement by >25% or (b) three subsequent monitoring events record an increase in one or more analyte concentrations then a potential adverse impact has been identified.
- **Adverse Water Level Impacts:** Compare measured water level to previous monitoring rounds – if either (a) water level is lower than previous lowest measurement by >5m or (b) three subsequent monitoring events record a fall in water level >1m then a potential adverse impact has been identified.

6.3 Critical data gaps

The results of the predictive modelling have been based on the results of available data on parameters used. In order to provide future confidence on the parameters identified in this report and used for the numerical modelling, it is proposed that additional detail be obtained. Possible sources of this data include:

- development of a better understanding of the geological structure and hence conceptual hydrogeological model using geophysical mapping techniques;
- determination of aquifer parameters for horizontal and vertical hydraulic conductivity values, and storage coefficient for the Baralaba Coal Seams and surrounding interburden and overburden; and
- regular measurement of groundwater levels in selected boreholes.

6.4 Monitoring strategy and timetable

The monitoring strategy for CGS operations at ATP769 will cover water extracted from the coal seams and impacts within the IAA. This monitoring is proposed to commence at the start of production testing. Baseline sampling outside of ATP769 is not proposed on the basis the predicted LTAA does not extend outside these boundaries.

6.4.1 Extracted underground water

Westside maintained records of the volumes of underground water extracted during the pilot testing program between 2008 and 2010. The same monitoring and recording program will be implemented for the proposed CGS Operation. This will include maintaining monthly records for reporting annually.

6.4.2 Monitoring locations

As there are no registered bores with the IAA, it is proposed that a dedicated monitoring network be established proximal to the Project area within the Paranui Property. Since the simulated area of impact is predicted to be no more than 1.1 km from the CSG operation, it is proposed to use the existing observation wells P-4 and P-7 as Permian aquifer monitoring bores. The locations of these observation / monitoring wells is shown in Figure 6.1. Consideration for inclusion of an adjacent, shallow monitoring bore constructed within the Quaternary alluvial sediments adjacent to each observation well will be assessed based on the response to the Permian aquifer water levels at these locations.

In the event of the Permian aquifer water level monitoring results indicating a potential impact, an assessment will be made with regard to the construction of additional monitoring bores as stated within one month such an event. Full details of any additional monitoring bore construction will be provided to DNRM for inclusion in the Groundwater Database, in the subsequent annual report. Details will include the Westside identification number, registered bore number, location, and property details (tenure).

6.4.3 Water level monitoring

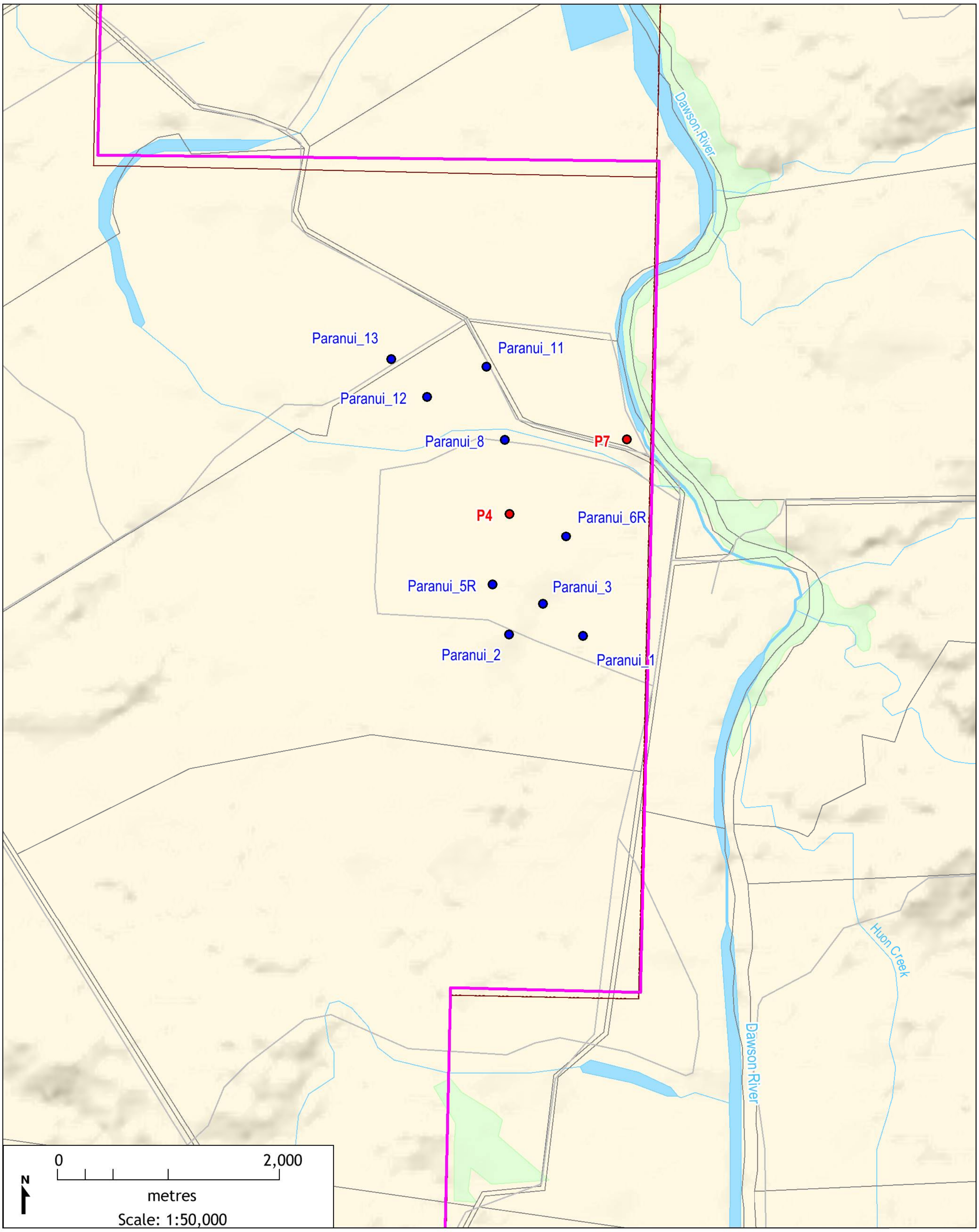
Monitoring of groundwater levels is required to identify actual impact from CSG production and to verify the aquifer drawdown predicted by the numerical modelling. A reference point such as bore collar will be established, and surveyed to a known height datum (i.e. Australian Height Datum). Manual measurements for water levels will be made monthly for the duration of pumping (whilst production testing is occurring). The data will be reviewed after the initial 12-month monitoring period to determine any seasonal variations that need to be taken into consideration. After this period, the monitoring frequency will also be reviewed. The threshold criteria detailed in Section 6.2 will be used to determine whether changes in water levels are significant.

6.4.4 Water quality monitoring

Water quality monitoring will be undertaken to determine whether CSG production is impacting on groundwater quality over the duration of the proposed CSG operation. The parameters suite for laboratory analysis will be in accordance with that undertaken for the baseline sampling and monitoring requirements, which are listed below. All samples will be submitted to a NATA registered laboratory for analysis.

Ongoing sampling will be undertaken on a quarterly basis for the first 12 months of operation (post re-commencement of the production testing) and reviewed to determine whether a reduced sampling frequency is warranted (i.e., biannually or annually). Collected samples will be analysed for the following:

- pH, electrical conductivity and total dissolved solids;
- major anions (bicarbonate, carbonate, chloride, sulphate) and cations (calcium, magnesium, sodium, potassium);
- nutrients (ammonia, nitrite, nitrate, total phosphorus);
- dissolved and total metals (aluminium, arsenic, barium, cadmium, copper, cobalt, lead, nickel, zinc, boron, strontium); and
- total petroleum hydrocarbons, BTEX, PAHs.



LEGEND:

- Proposed Paranui Monitoring Well
- Existing Paranui Well
- ATP 769
- Petroleum Lease (PL 94)
- Exploration Permit for Petroleum (EPP)
- Cadastre
- Vegetation
- Watercourse
- Road
- Rail

Paranui UWIR (G1631)

Proposed Groundwater Monitoring Network

DATE: 6/12/2013

FIGURE No: 6.1

Groundwater samples will be collected from the monitoring bores in accordance with procedures specified in DEHP Monitoring and Sampling Manual 2009, Environmental Protection (Water) Policy 2009 (Version 2, September 2010), and Australian Standards *Water Quality - Sampling* AS 5667 (1998). That is the groundwater sampling will need to conform to applicable procedures for sampling equipment decontamination, preservation and transport, documentation and chain of custody protocol, and quality assurance / quality control.

6.4.5 Reporting

The results of the Water Management Strategy as detailed in this section will be reported annually by Westside in a standalone report for the duration production testing. This will include a summary of the monitoring data recorded to date which will document changes in water quality and groundwater levels. The report will provide a review of the extents of the IAA as shown in Figure 5.5. Similarly information and details relating to the status of monitoring associated with this UWIR will be included in the annual report. This UWIR is to be updated in three years (from the anniversary of this report) to include:

- the annual reviews;
- monitoring data collected;
- the quantity of water produced; and
- other relevant information on the hydrogeological regime.

Where applicable, the groundwater model will be updated to reflect the new data obtained for each annual review.

The details for the proposed Water Management Strategy are summarised below in Table 6.1.

Table 6.1 Summary of proposed Water Management Strategy

<table>
<tr><th>Site</th><th>Parameters</th><th>Frequency</th><th>Reporting</th></tr>
<tr><td rowspan="2">Observation wells:
• P-4 and P-7, and
• any monitoring bore(s) constructed in the Quaternary Alluvium for the Project</td><td>• water level</td><td>Monthly (for the first 12 months of operation)</td><td rowspan="2">Results of quarterly sampling to be included in an Annual Report and submitted to DNRM prior to the annual return date</td></tr>
<tr><td>• pH,
• electrical conductivity,
• total dissolved solids, cations / anions,
• nutrients,
• dissolved and total metals,
• total petroleum hydrocarbons</td><td>3 monthly (for the first 12 months of operation)</td></tr>
</table>

7 Spring impact management (Part E)

This part of the UWIR details the requirements for a spring management strategy for springs identified within areas where the source aquifer is predicted to decline by more than 0.2 m.

7.1 Spring inventory

A desktop review of the spring inventories has been undertaken as part of this assessment within 10 km of the ATP769 boundaries. This has included a review of the following publicly available data sources:

- Queensland Government Information Service (Queensland Wetland Data – Springs);
- The *WetlandInfo* Website; and
- The Great Artesian Basin Resource Operation Plan Spring Register.

No springs have been identified with the 10 km boundary of the ATP769. On this basis there is no information available regarding either potential connection between springs and aquifers or spring values as required for an UWIR.

7.2 Management of springs

On the basis there are no known springs within the Project area or the predicted area of drawdown resulting from the proposed CSG operation associated with ATP769, it is considered that there is no requirement for a spring management strategy for this Project.

8 Conclusions

Westside in joint venture with QGC and Mitsui E&P Australia, are assessing development of the Paranui Pilot Project on ATP769. This report presents the Underground Water Impact Report for Westside and has been prepared in accordance with the requirements detailed in the Water Act 2000.

It includes a review of published and unpublished reports (in the public domain), registered bore operation, available groundwater level and (baseline) water quality data. Three aquifers were identified within the study area, these being:

- a shallow alluvial aquifer mainly associated with the Dawson River;
- the eastern extents of the GAB Mimosa Management Area along the western margins of ATP769; and
- a deeper confined aquifer within the Permian coal sequences that host the CSG resource.

Numerical modelling was undertaken to assess the likely extents of impact on these aquifers. This has identified that the Permian coal seam aquifer will be the only aquifer impacted by the proposed CSG operations for ATP769. Depressurisation of this aquifer does not extend upwards or laterally into the other two aquifers. Sensitivity analysis of the aquifer parameters has identified that the model is most sensitive to changes in the coal seam hydraulic conductivity value.

During this period there are no impacted registered bores within either the IAA or the LTAA. The nearest registered bore is a petroleum or gas exploration bore located approximately 4 km to the northeast, and the nearest water supply bore is located approximately 11 km to the west.

The predicted extent of the IAA as defined by drawdown exceeding 5 m is contained within a 90 m to 130 m radius of the proposed extraction wells. This increases slightly up to 50 m further for the LTAA to between 140 m and 180 m of the proposed extraction wells. During this period, there is no cumulative impact as a result of the groundwater abstraction for the two wells. There is also no groundwater drawdown predicted in the Quaternary Alluvium (i.e. Dawson River Alluvium).

A groundwater monitoring program has been established to assess the changes in groundwater levels and quality on commencement of operation and during the CSG operations. This includes a review of performance of the numerical model to confirm the predicted level and extents of impact on the aquifer(s), update the model, and decrease the level of uncertainty with the current model parameters.

The results of the monitoring program and outcome of the model review will be presented in annual reviews of the Project to Westside and an update of this UWIR in three years.

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Appendix A Summary details of Registered Bores in ATP769

Appendix A – Registered Water Bores (Project No. G1631)

RN	Easting	Northing	Facility Type	Status	Lot	Plan	Formation Type	Top	Bottom	Flow	Quality	Yield	Water Level	Registered Date	Formation Name
30691	793,380	7,245,647	Water Supply	Existing	-	-	Consolidated	47.2	64	N		0.2	33.8	29/08/1968	Moolayemba Formation
43557	789,514	7,254,015	Water Supply	Existing	21	BH148	Consolidated	61	538	Y	570 mS/cm	0.4	27.6	10/03/1974	Clematis Group
47008	786,935	7,266,841	Water Supply	Existing	18	BH147	Consolidated	49.8	525	Y	900 mS/cm	0.1	5.6	3/06/1974	Clematis Group
89512	791,848	7,240,340	Water Supply	Existing	70	LE275	-	-	-	-	-	-	-	-	-
89544	771,954	7,313,557	Water Supply	Existing	1	KM291	-	-	-	-	-	-	-	-	-
89556	774,018	7,310,055	Water Supply	Existing	2	KM292	Fractured	42	54	N	SALTY	0.5	20.0	18/09/1991	Moolayemba Formation
89557	775,712	7,309,890	Water Supply	Existing	2	KM292	Consolidated	42	60	N	POTABLE	1.9	8.0	24/09/1991	Clematis Group
89558	773,869	7,312,837	Water Supply	Existing	212	FTY1332	Consolidated	26	54	N	POTABLE	4.6	22.0	2/10/1991	Clematis Group
89690	794,221	7,281,500	Water Supply	Existing	11	FN200	Unconsolidated	8.23	15.2	N		0.0	0.0		Dawson River Alluvium
89755	794,738	7,276,353	Water Supply	Existing	-	-	Unconsolidated	14.6	16.7	N	POTABLE	0.5	12.3	24/06/2001	Dawson River Alluvium
89946	782,567	7,269,271	Water Supply	Existing	18	BH147	-	-	-	-	-	-	-	-	-
89947	783,414	7,266,667	Water Supply	Existing	18	BH147	-	-	-	-	-	-	-	-	-
100077	792,431	7,307,891	Petroleum/Gas Bore	Existing	35	FN141	-	-	-	-	-	-	-	-	-
128033	794,105	7,294,871	Water Supply	Existing	38	FN506	Consolidated	14	18	N	POTABLE	0.2	11.6	3/06/2007	Tertiary - undefined
128034	794,104	7,294,843	Water Supply	Existing	38	FN506	-	-	-	-	-	-	-	-	-
128188	787,733	7,312,273	Water Supply	Existing	4	FN514	Unconsolidated	14.5	15.5	N	350 mg/L	2.0	12.5	1/05/2006	Dawson River Alluvium
128605	787,401	7,258,147	Water Supply	Existing	20	BH150	Consolidated	315	457	N	POTABLE	1.4	0.0	20/07/2009	Clematis Group
13030830	787,697	7,274,857	Sub-artesian Monitoring Bore	Existing	-	-	Consolidated	44	47		-	0.0	0.0	-	Rewan Formation
13030641	794,755	7,276,316	Sub-artesian Monitoring Bore	Abandoned/Usable	-	-	Unconsolidated	14.2	17	N	528 mS/cm	0.0	11.5	18/04/1991	Dawson River Alluvium
13030642	793,588	7,276,030	WR Investigation Bore	Abandoned/Usable	-	-	Unconsolidated	4	13	N	-	0.0	0.0	-	Dawson River Alluvium
13030643	792,407	7,276,301	WR Investigation Bore	Abandoned/Usable	-	-	Unconsolidated	12	16.6	N	-	0.0	0.0	-	Dawson River Alluvium
13030644	791,331	7,276,008	WR Investigation Bore	Abandoned/Usable	-	-	Unconsolidated	10	12.8	N	-	0.0	0.0	-	Dawson River Alluvium
13030648	783,892	7,290,497	WR Investigation Bore	Abandoned/Usable	-	-	Unconsolidated	10.4	16.6	N	-	0.0	0.0	-	Dawson River Alluvium
13030649	785,071	7,290,131	WR Investigation Bore	Abandoned/Usable	8	KM87	Unconsolidated	17.4	19.7	N	-	0.0	0.0	-	Dawson River Alluvium
13030650	786,338	7,289,754	WR Investigation Bore	Abandoned/Usable	8	KM87	Unconsolidated	5.9	23.9	N	-	0.0	0.0	-	Dawson River Alluvium
13030651	787,244	7,289,537	WR Investigation Bore	Abandoned/Usable	12	KM87	Unconsolidated	11.2	15.4	N	-	0.0	0.0	-	Dawson River Alluvium

Datum: MGA94 Zone 55

Appendix B Baseline assessment laboratory analysis results

Sample ID / Sample date			47008	43557	89755	89947	128033
Analyte	**Units**	**LOR**	12/06/2013	27/06/2013	29/05/2013	12/06/2013	30/05/2013
Water Quality Indicators							
pH Value	pH Unit	0.01	7.88	8.41	7.59	7.98	8.14
Electrical Conductivity @ 25°C	µS/cm	1	868	562	440	1320	1980
Total Dissolved Solids (Calc.)	mg/L	1	564	365	286	858	1290
Total Hardness as $CaCO_3$	mg/L	1	109	10	167	262	345
Sodium Adsorption Ratio	-	0.01	5.63	18.7	1.04	5.1	6.98
Alkalinity							
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	<1	9	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	127	185	197	470	821
Total Alkalinity as $CaCO_3$	mg/L	1	127	194	197	470	821
Dissolved Major Ions							
Calcium	mg/L	1	32	4	42	39	82
Magnesium	mg/L	1	7	<1	15	40	34
Sodium	mg/L	1	135	136	31	190	298
Potassium	mg/L	1	10	<1	4	<1	11
Chloride	mg/L	1	194	70	24	174	193
Sulfate as SO_4 - Turbidimetric	mg/L	1	30	4	1	15	9
Ionic Balance							
Total Anions	meq/L	0.01	8.63	5.93	4.63	14.6	22
Total Cations	meq/L	0.01	8.3	6.12	4.78	13.5	20.1
Ionic Balance	%	0.01	1.98	1.45	1.56	3.97	4.54
Dissolved Metals							
Aluminium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	mg/L	0.001	0.001	<0.001	<0.001	<0.001	0.007
Beryllium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	mg/L	0.001	0.111	0.022	0.068	0.059	0.085
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	<0.001	<0.001	0.004	<0.001	0.001
Copper	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	0.177	0.001	2.74	0.106	1.09
Molybdenum	mg/L	0.001	<0.001	<0.001	0.002	<0.001	<0.001
Nickel	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.002
Selenium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	mg/L	0.001	0.249	0.166	0.584	0.818	1.49
Tin	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	0.01
Zinc	mg/L	0.005	0.011	<0.005	0.013	<0.005	0.005
Boron	mg/L	0.05	0.16	0.26	<0.05	0.06	0.13
Iron	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	0.07

Sample ID / Sample date			47008	43557	89755	89947	128033
Analyte	Units	LOR	12/06/2013	27/06/2013	29/05/2013	12/06/2013	30/05/2013
Total Metals							
Aluminium	mg/L	0.01	<0.01	<0.01	0.04	<0.01	0.07
Arsenic	mg/L	0.001	<0.001	<0.001	0.042	<0.001	0.006
Beryllium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	mg/L	0.001	0.115	0.024	0.123	0.061	0.107
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	<0.001	<0.001	0.004	<0.001	<0.001
Copper	mg/L	0.001	<0.001	<0.001	0.002	<0.001	0.001
Lead	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.002
Manganese	mg/L	0.001	0.179	0.001	3.58	0.119	0.954
Molybdenum	mg/L	0.001	<0.001	<0.001	0.003	<0.001	<0.001
Nickel	mg/L	0.001	<0.001	<0.001	0.001	<0.001	0.002
Selenium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	mg/L	0.001	0.252	0.168	0.632	0.825	1.52
Tin	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	0.001	<0.001	<0.001	<0.001	0.002	<0.001
Vanadium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	0.02	0.006	0.03	0.008	0.009
Boron	mg/L	0.05	0.18	0.24	<0.05	0.07	0.08
Iron	mg/L	0.05	0.2	<0.05	7.03	<0.05	0.43
Mercury / Chromium							
Mercury, dissolved	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Mercury, total recoverable	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Trivalent Chromium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hexavalent Chromium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nutrients - N and P							
Ammonia as N	mg/L	0.01	0.09	0.06	1.6	0.05	46.5
Nitrite as N	mg/L	0.01	<0.01	<0.01	0.37	0.01	0.08
Nitrate as N	mg/L	0.01	<0.01	0.07	1.46	3.57	0.25
Nitrite + Nitrate as N	mg/L	0.01	<0.01	0.07	1.83	3.58	0.33
Total Kjeldahl Nitrogen as N	mg/L	0.1	<0.1	0.3	1.7	0.5	47.3
Total Nitrogen as N	mg/L	0.1	<0.1	0.4	3.5	4.1	47.6
Total Phosphorus as P	mg/L	0.01	<0.01	0.14	0.86	<0.01	6.54
PAH							
Naphthalene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b)fluoranthene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sum of PAH	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ (WHO)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Sample ID / Sample date			**47008**	**43557**	**89755**	**89947**	**128033**
Analyte	**Units**	**LOR**	12/06/2013	27/06/2013	29/05/2013	12/06/2013	30/05/2013
BTEXN							
Benzene	µg/L	1	<1	<1	<1	<1	<1
Toluene	µg/L	2	<2	<2	<2	<2	<2
Ethylbenzene	µg/L	2	<2	<2	<2	<2	<2
meta- & para-Xylene	µg/L	2	<2	<2	<2	<2	<2
ortho-Xylene	µg/L	2	<2	<2	<2	<2	<2
Total Xylenes	µg/L	2	<2	<2	<2	<2	<2
Sum of BTEX	µg/L	1	<1	<1	<1	<1	<1
Naphthalene	µg/L	5	<5	<5	<5	<5	<5
Total Petroleum Hydrocarbons							
C6 - C9 Fraction	µg/L	20	<20	<20	<20	<20	<20
C10 - C14 Fraction	µg/L	50	<50	<50	<50	<50	<50
C15 - C28 Fraction	µg/L	100	<100	<100	<100	<100	<100
C29 - C36 Fraction	µg/L	50	<50	<50	<50	<50	<50
C10 - C36 Fraction (sum)	µg/L	50	<50	<50	<50	<50	<50
Total Recoverable Hydro-carbons / NEPM 2010 Draft							
C6 - C10 Fraction	µg/L	20	<20	<20	<20	<20	<20
C6 - C10 Fraction minus BTEX	µg/L	20	<20	<20	<20	<20	<20
>C10 - C16 Fraction	µg/L	100	<100	<100	<100	<100	<100
>C16 - C34 Fraction	µg/L	100	<100	<100	<100	<100	<100
>C34 - C40 Fraction	µg/L	100	<100	<100	<100	<100	<100
>C10 - C40 Fraction (sum)	µg/L	100	<100	<100	<100	<100	<100
Gases							
Dissolved Oxygen	mg/L	0.1	8.8	13.8	5.3	8.4	5.4
Free Carbon Dioxide as CO_2	mg/L	1	3	1	10	10	12
Total Carbon Dioxide as CO_2	mg/L	1	115	168	183	423	734
Methane	µg/L	10	<10	<10	126	<10	1420
Miscellaneous							
Silicon as SiO_2	mg/L	0.1	21.2	20.5	35.4	39	27.4
Fluoride	mg/L	0.1	0.4	<0.1	0.4	0.5	0.3
Bromide	mg/L	0.010	0.468	0.248	0.161	0.595	0.59
Unionized Hydrogen Sulfide	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfide as S^{2-}	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Gross Alpha and Beta Activity							
Gross alpha	Bq/L	0.05	<0.25	-	<0.14	<0.40	<0.50
Gross beta activity - 40K	Bq/L	0.10	<0.50	-	<0.29	<0.80	<1.00

Sample ID / Sample date			128605	13030641	13030830	Beaufoy Standpipe
Analyte	**Units**	**LOR**	27/06/2013	29/05/2013	30/05/2013	28/06/2013
Water Quality Indicators						
pH Value	pH Unit	0.01	8.13	7.66	7.71	7.41
Electrical Conductivity @ 25°C	µS/cm	1	573	440	27200	988
Total Dissolved Solids (Calc.)	mg/L	1	372	286	17700	642
Total Hardness as $CaCO_3$	mg/L	1	99	152	4730	132
Sodium Adsorption Ratio	-	0.01	3.37	1.34	34.9	6.61
Alkalinity						
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	116	191	439	231
Total Alkalinity as $CaCO_3$	mg/L	1	116	191	439	231
Dissolved Major Ions						
Calcium	mg/L	1	23	38	537	30
Magnesium	mg/L	1	10	14	823	14
Sodium	mg/L	1	77	38	5520	175
Potassium	mg/L	1	8	4	87	3
Chloride	mg/L	1	111	31	11600	194
Sulfate as SO_4 - Turbidimetric	mg/L	1	1	4	118	11
Ionic Balance						
Total Anions	meq/L	0.01	5.47	4.77	338	10.3
Total Cations	meq/L	0.01	5.52	4.8	337	10.3
Ionic Balance	%	0.01	0.49	0.3	0.24	0.08
Dissolved Metals						
Aluminium	mg/L	0.01	<0.01	<0.01	<0.05	<0.01
Arsenic	mg/L	0.001	<0.001	0.002	<0.005	0.002
Beryllium	mg/L	0.001	<0.001	<0.001	<0.005	<0.001
Barium	mg/L	0.001	0.088	0.025	0.574	0.103
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0005	<0.0001
Chromium	mg/L	0.001	<0.001	<0.001	<0.005	<0.001
Cobalt	mg/L	0.001	<0.001	<0.001	0.008	<0.001
Copper	mg/L	0.001	<0.001	<0.001	<0.005	<0.001
Lead	mg/L	0.001	<0.001	<0.001	0.036	<0.001
Manganese	mg/L	0.001	0.229	0.002	0.88	<0.001
Molybdenum	mg/L	0.001	<0.001	0.004	<0.005	<0.001
Nickel	mg/L	0.001	<0.001	0.003	0.019	<0.001
Selenium	mg/L	0.01	<0.01	<0.01	<0.05	<0.01
Silver	mg/L	0.001	<0.001	<0.001	<0.005	<0.001
Strontium	mg/L	0.001	0.169	0.16	23.8	0.632
Tin	mg/L	0.001	<0.001	<0.001	<0.005	<0.001
Uranium	mg/L	0.001	<0.001	<0.001	<0.005	<0.001
Vanadium	mg/L	0.01	<0.01	<0.01	<0.05	<0.01
Zinc	mg/L	0.005	<0.005	<0.005	0.148	<0.005
Boron	mg/L	0.05	0.18	0.05	1.5	0.05
Iron	mg/L	0.05	0.05	<0.05	<0.25	<0.05

Sample ID / Sample date			128605	13030641	13030830	Beaufoy Standpipe
Analyte	**Units**	**LOR**	27/06/2013	29/05/2013	30/05/2013	28/06/2013
Total Metals						
Aluminium	mg/L	0.01	0.01	0.38	1	0.14
Arsenic	mg/L	0.001	<0.001	0.003	<0.005	0.002
Beryllium	mg/L	0.001	<0.001	<0.001	<0.005	<0.001
Barium	mg/L	0.001	0.099	0.192	0.612	0.105
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0005	<0.0001
Chromium	mg/L	0.001	<0.001	0.002	<0.005	<0.001
Cobalt	mg/L	0.001	<0.001	0.001	0.009	<0.001
Copper	mg/L	0.001	<0.001	0.008	0.006	<0.001
Lead	mg/L	0.001	0.001	0.042	0.113	<0.001
Manganese	mg/L	0.001	0.24	0.638	0.89	0.005
Molybdenum	mg/L	0.001	<0.001	0.004	<0.005	<0.001
Nickel	mg/L	0.001	<0.001	0.028	0.021	<0.001
Selenium	mg/L	0.01	<0.01	<0.01	<0.05	<0.01
Silver	mg/L	0.001	<0.001	<0.001	<0.005	<0.001
Strontium	mg/L	0.001	0.173	0.539	25.2	0.635
Tin	mg/L	0.001	<0.001	<0.001	<0.005	<0.001
Uranium	mg/L	0.001	<0.001	<0.001	0.007	<0.001
Vanadium	mg/L	0.01	<0.01	<0.01	<0.05	<0.01
Zinc	mg/L	0.005	0.013	0.06	0.169	<0.005
Boron	mg/L	0.05	0.14	0.05	1.66	<0.05
Iron	mg/L	0.05	1.94	2.71	0.78	0.1
Mercury / Chromium						
Mercury, dissolved	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Mercury, total recoverable	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Trivalent Chromium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01
Hexavalent Chromium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01
Nutrients - N and P						
Ammonia as N	mg/L	0.01	0.11	0.2	0.15	0.03
Nitrite as N	mg/L	0.01	<0.01	<0.01	0.02	<0.01
Nitrate as N	mg/L	0.01	0.01	0.12	0.1	0.14
Nitrite + Nitrate as N	mg/L	0.01	0.01	0.12	0.12	0.14
Total Kjeldahl Nitrogen as N	mg/L	0.1	0.3	1.4	0.4	<0.1
Total Nitrogen as N	mg/L	0.1	0.3	1.5	0.5	0.1
Total Phosphorus as P	mg/L	0.01	0.01	0.17	0.09	0.76
PAH						
Naphthalene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b)fluoranthene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	µg/L	0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Sum of PAH	µg/L	0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ (WHO)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5

Sample ID / Sample date			128605	13030641	13030830	Beaufoy Standpipe
Analyte	**Units**	**LOR**	27/06/2013	29/05/2013	30/05/2013	28/06/2013
BTEXN						
Benzene	µg/L	1	<1	<1	<1	<1
Toluene	µg/L	2	<2	<2	<2	<2
Ethylbenzene	µg/L	2	<2	<2	<2	<2
meta- & para-Xylene	µg/L	2	<2	<2	<2	<2
ortho-Xylene	µg/L	2	<2	<2	<2	<2
Total Xylenes	µg/L	2	<2	<2	<2	<2
Sum of BTEX	µg/L	1	<1	<1	<1	<1
Naphthalene	µg/L	5	<5	<5	<5	<5
Total Petroleum Hydrocarbons						
C6 - C9 Fraction	µg/L	20	<20	<20	<20	<20
C10 - C14 Fraction	µg/L	50	<50	<50	<50	<50
C15 - C28 Fraction	µg/L	100	<100	<100	<100	<100
C29 - C36 Fraction	µg/L	50	<50	<50	<50	<50
C10 - C36 Fraction (sum)	µg/L	50	<50	<50	<50	<50
Total Recoverable Hydro-carbons / NEPM 2010 Draft						
C6 - C10 Fraction	µg/L	20	<20	<20	<20	<20
C6 - C10 Fraction minus BTEX	µg/L	20	<20	<20	<20	<20
>C10 - C16 Fraction	µg/L	100	<100	<100	<100	<100
>C16 - C34 Fraction	µg/L	100	<100	<100	<100	<100
>C34 - C40 Fraction	µg/L	100	<100	<100	<100	<100
>C10 - C40 Fraction (sum)	µg/L	100	<100	<100	<100	<100
Gases						
Dissolved Oxygen	mg/L	0.1	16.2	6.1	6	13
Free Carbon Dioxide as CO_2	mg/L	1	2	8	17	18
Total Carbon Dioxide as CO_2	mg/L	1	104	176	403	221
Methane	µg/L	10	88	23	15	<10
Miscellaneous						
Silicon as SiO_2	mg/L	0.1	10.6	34.1	17.2	82.3
Fluoride	mg/L	0.1	0.2	0.2	0.1	0.5
Bromide	mg/L	0.010	0.35	0.182	22.3	0.705
Unionized Hydrogen Sulfide	mg/L	0.1	<0.1	<0.1	<0.1	<0.1
Sulfide as S^{2-}	mg/L	0.1	<0.1	<0.1	<0.1	<0.1
Gross Alpha and Beta Activity						
Gross alpha	Bq/L	0.05	-	<0.12	<10.0	-
Gross beta activity - 40K	Bq/L	0.10	-	<0.25	<20.0	-