

# Underground Water Impact Report

For Authority to  
Prospect 644



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## EXECUTIVE SUMMARY

The registered holders of Authority to Prospect (ATP) 644 are B.N.G. Pty Ltd ACN 081 690 691 (70%) and Arrow CSG (Australia) Pty Ltd ACN 054 260 650 (30%). The Underground Water Impact Report (UWIR) for the Authority to Prospect (ATP) 644 has been updated and is a follow on from the UWIR's approved on 6 March 2013 (the 2012 UWIR) and 10 June 2016 (the 2016 UWIR). Annual Reviews of the 2016 UWIR have been completed, submitted and approved by Department of Environment and Science (DES) This report forms the third UWIR for ATP 644.

This report will be reviewed annually and will consider:

- If new hydrogeological data that significantly alters the conceptual model exists;
- whether new production testing has been undertaken or is planned; and
- whether the predictions made have materially changed.

There has been no further production testing and monitoring data collection on ATP 644 since the original production testing completed in 2010 as reported in the UWIR's and subsequent Annual Reviews. All production testing wells in ATP 644 were plugged and abandoned in 2015.

As indicated in the 2012 UWIR for ATP 644, it is expected that significant recovery of the water pressures in the area of the production tests would have occurred in the eight years since testing. An assessment of the potential recovery indicates pressure recovery to within 87% of initial pressures within the affected aquifers/coal units may have occurred. Based on this, there are likely to be minimal impacts remaining from the production test. Any Immediately Affected Area (IAA) remaining, if present, is unlikely to be significant based on the results of the analytical calculation.

# 1 INTRODUCTION

The registered holders of Authority to Prospect (ATP) 644 are B.N.G. Pty Ltd ACN 081 690 691 (70%) and Arrow CSG (Australia) Pty Ltd ACN 054 260 650 (30%). The first Underground Water Impact Report (UWIR) for ATP 644 was completed in 2012 and approved by the Chief Executive of the then Department of Environment and Heritage Protection (DEHP) on 6 March 2013. A second UWIR was submitted and approved by the then DEHP on the 10<sup>th</sup> June 2016 and Annual Reviews of the 2016 UWIR have been completed, submitted and approved. As previously indicated in the UWIR (2016), no new production or production testing has been undertaken.

Pursuant to s. 370(2)(c) of the Water Act 2000, this report forms the UWIR for ATP 644. There is no production or production testing currently forecast in ATP 644 and therefore, there are no changes to the predictions made in the 2012 UWIR for ATP 644.

The purpose of this report is to address Chapter 3, and in particular, s376 of the Water Act (Qld) 2000 which stipulates that the UWIR must include:

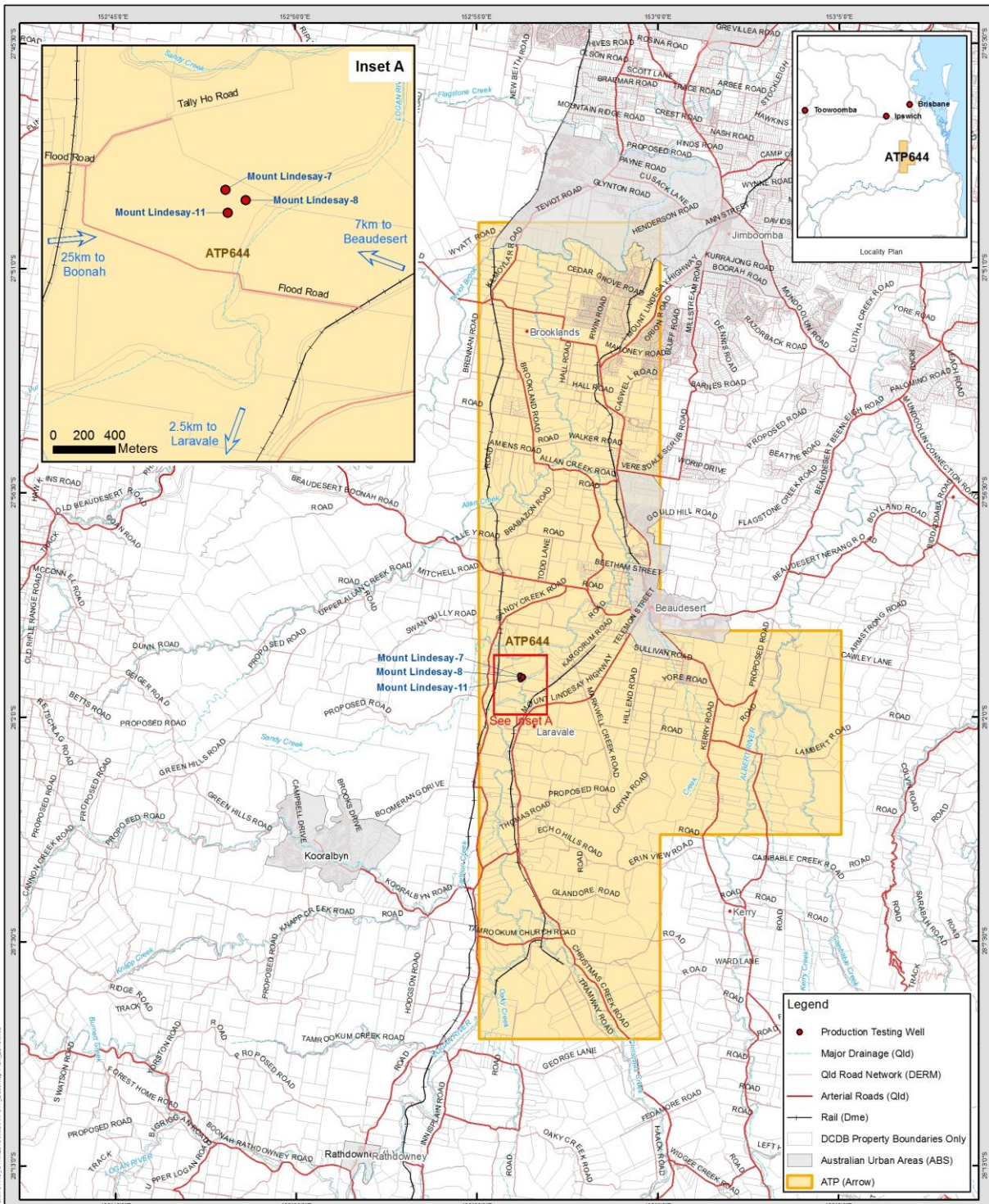
- a. for the area to which the report relates-
  - i. the quantity of water produced or taken from the area because of the exercise of any previous relevant underground water rights; and
  - ii. an estimate of the quantity of water to be produced or taken because of the exercise of the relevant underground water rights for a 3 year period starting on the consultation day for the report;
- b. for each aquifer affected, or likely to be affected, by the exercise of the relevant underground water rights-
  - i. a description of the aquifer; and
  - ii. an analysis of the movement of underground water to and from the aquifer, including how the aquifer interacts with other aquifers; and
  - iii. an analysis of the trends in water level change for the aquifer because of the exercise of the rights mentioned in paragraph (a)(i); and
  - iv. a map showing the area of the aquifer where the water level is predicted to decline, because of the taking of the quantities of water mentioned in paragraph (a), by more than the bore trigger threshold within 3 years after the consultation day for the report; and
  - v. a map showing the area of the aquifer where the water level is predicted to decline, because of the exercise of relevant underground water rights, by more than the bore trigger threshold at any time;
- c. a description of the methods and techniques used to obtain the information and predictions under paragraph (b);
- d. a summary of information about all water bores in the area shown on a map mentioned in paragraph (b)(iv), including the number of bores, and the location and authorised use or purpose of each bore;
- e. a program for-
  - i. conducting an annual review of the accuracy of each map prepared under paragraph (b)(iv) and (v); and
  - ii. giving the chief executive a summary of the outcome of each review, including a statement of whether there has been a material change in the information or predictions used to prepare the maps;
- f. a water monitoring strategy;
- g. a spring impact management strategy;
- h. if the responsible entity is the office—
  - i. a proposed responsible tenure holder for each report obligation mentioned in the report; and
  - ii. for each immediately affected area—the proposed responsible tenure holder or holders who must comply with any make good obligations for water bores within the immediately affected area.

- i. other information or matters prescribed under a regulation.

## 1.1 Project Area

ATP 644 is located within the Clarence-Moreton Basin as is shown in **Figure 1**. Production testing historically undertaken on this tenement is located approximately 7km south west of Beaudesert.





**Figure 1: ATP644 - Location and Production Testing Wells**

Source: Arrow Energy Pty Ltd  
Geosciences Australia  
Dept. Envir. and Resource Mgmt.  
Date: 11/10/2018  
Author: tstringer

0 5 10  
Kilometres  
Scale: 1:160,000 @ A3  
Coordinate System: GDA 1994 MGA Zone 56



Based on or contains data provided by the State of Queensland (Department of Environment and Resource Management) [2013]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.

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The dimensions, areas, number of lots, size & location of corridor information are approximate only and may vary.

**Disclaimer:** While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no warranty is given that the information contained on this map is free from error or omission. Any reliance placed on such information shall be at the sole risk of the user. Please verify the accuracy of all information prior to using it.

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**Figure 1 Location of ATP 644**

## 1.2 Summary of Methods

Production testing has not been undertaken since the 2012 UWIR. In addition to this, production testing is currently not forecast for ATP 644 and therefore, where relevant, the UWIR provides a summary of information presented in the previous UWIR's for ATP 644.



## 2 WATER PRODUCTION SCHEDULE

The production wells have been plugged and abandoned and no production testing has been undertaken since October 2010. This is as described in the 2012 and 2016 UWIRs. As a result, the predictions made including the IAA in the UWIR have not materially changed. There are no current plans for further production testing in ATP 644.

Historical production testing undertaken on ATP 644 comprised:

- Mount Lindesay-7, a total of approximately 0.694 ML of water taken over 7 months;
- Mount Lindesay-8, a total of approximately 0.55 ML of water taken over 7 months; and
- Mount Lindesay-11, a total of approximately 0.54 ML of water taken over 5 months.

### 3 EXISTING HYDROGEOLOGICAL REGIME

There is no update to the hydrogeological data and conceptual model presented in the previous UWIR. A summary of this is provided for reference below.

#### 3.1 Local Geology

The 2010 Mount Lindesay production tests are located in the Logan sub-basin. A cross section across the Logan subbasin is shown in **Figure 2**, showing the stratigraphic and structural relationship between the alluvial Grafton Formation and Kangaroo Creek Sandstone overlying the WCM, which in turn overlies the Koukandowie Formation. As can be seen in **Figure 2**, the Logan Sub-basin is offset by a number of faults which generally strike north-south across the basin

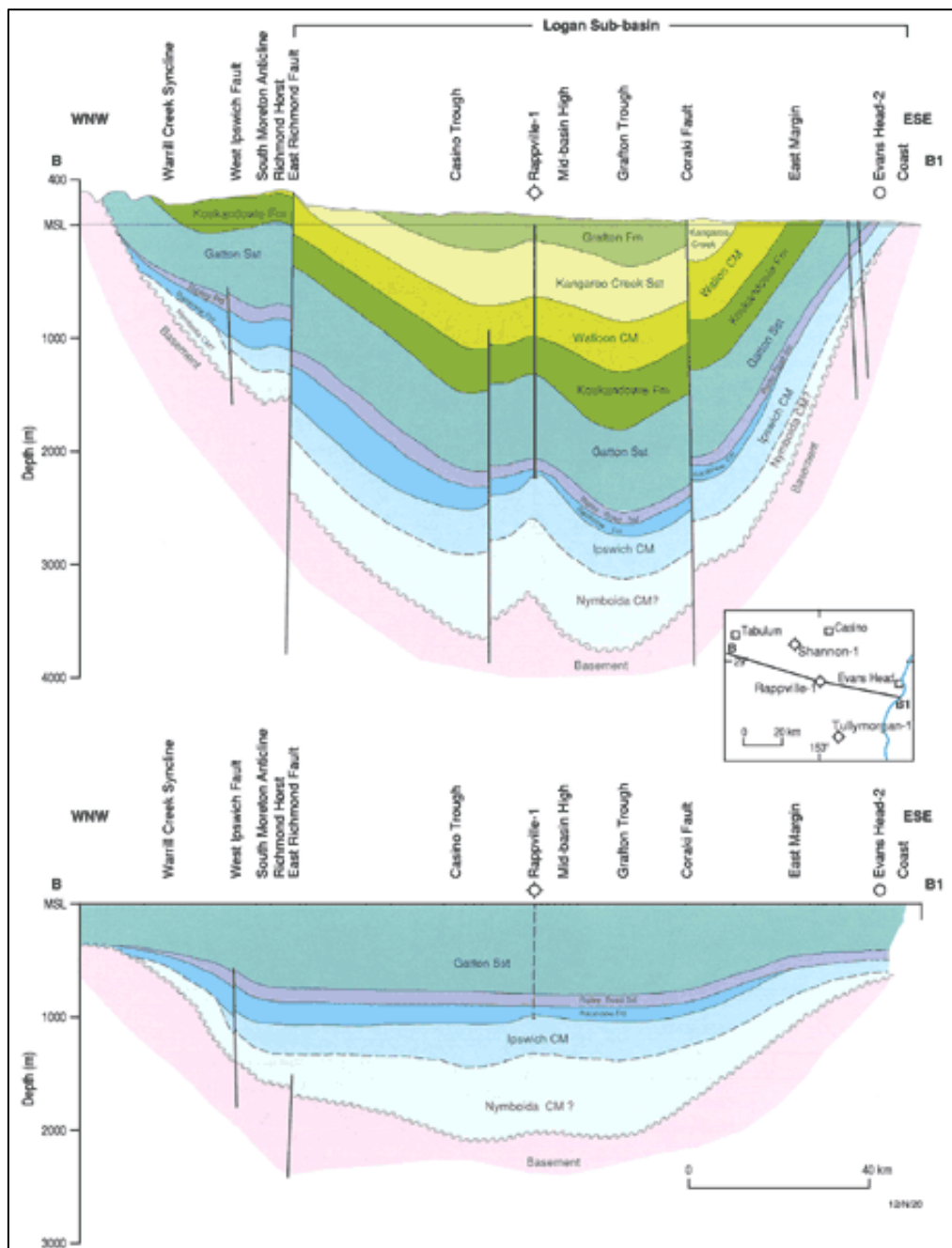


Figure 2 Geological Cross Sections

## 3.2 Aquifers

### 3.2.1 Alluvium

The Logan Basin Draft Water Resource Plan Environmental Investigations Report: Volume I – Summary Report (DEHP, 2010) describes the groundwater resources in the Logan Basin as follows:

“Most of the groundwater resources in the study area are found in the alluvial aquifers of the Logan and Albert Rivers. The groundwater baseflow component is likely to be chemically variable, depending on local aquifer material. Long and Lloyd (1996) established that the Logan/Albert system follows a relatively simple model of recharge in the southern sector, with regional groundwater flowing northward with an associated increase in total dissolved salts, which is partly the result of evaporative concentration. As reported by Please et al. (1996), to the north the water gets ‘older’, suggesting that direct recharge to the aquifer in this region is either a very slow process through the unsaturated zone or it is negligible. Horn and Wong (1998) reported almost all groundwater in the catchment is abstracted from depths of between 5 m and 25 m. The primary use for this groundwater is for irrigation and private supplies on farms (Please et al., 1996).”

Data from the Department of Natural Resources, Mines and Energy (DNRME) Groundwater Database indicates that a number of bores within 20 km of the historical production tests are screened in the alluvial strata. The alluvial aquifers are comprised of alluvium including clay, silt, sand and gravel and exist predominantly around creeks, rivers and associated flood plains. The alluvial aquifers are classed as porous media aquifers where groundwater occurs within the voids between individual grain particles. The unconsolidated alluvial aquifers in the Logan sub-basin are expected to be unconfined or semi-confined.

A summary of registered bores within 2 km of the historical production testing wells and a description of the deepest strata they intersect is provided in **Table 1**.

**Figure 3** shows the locations of these bores. No formal description of the aquifer/formations intersected by these bores was available from the DNRME Groundwater Database.



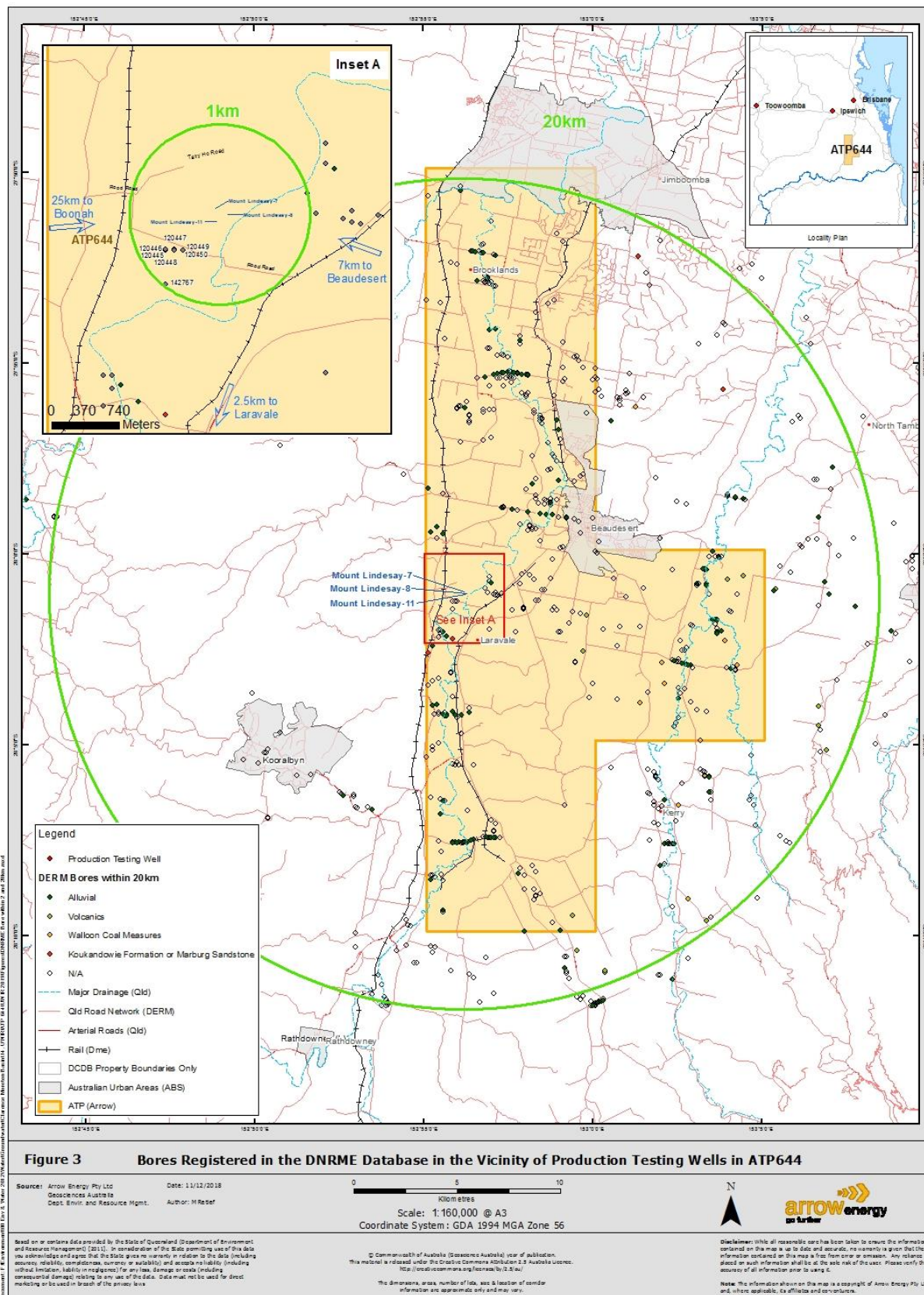
**Table 1 Summary of bore data from DNRME Groundwater Database (Note: NR – no reliable data)**

Bore ID	Deepest Lithological Description	Depth Lithological Description was Encountered (m below natural surface)	Bore Casing Depth (m below natural surface)
120450	Brown clay	42.7	NR
120449	Brown and grey sandy gravel and clay	15.5	21.6
120448	Brown sandy gravel and clay	21.9	NR
120447	Brown sandy gravel and clay	21.3	NR
120446	Brown sandy gravel and clay	21.0	NR
120445	Brown sandy gravel and clay, soft sandstone	20.7	NR
124604	Clay	27.5	29.5
138595	Gravel and silty clay	24	27
138596	Sand and gravel	19.5	28.5
138594	Sand and Clay	13	23.5
145571	Gravel	23.5	28
145572	Gravel	22.5	55
145573	NR	NR	27
145574	Gravel	19.5	22
142767	NR	NR	NR
145575	Brown/grey sandy clay and mudstone	28.5	30
145576	Brown sandy gravel and clay	25	26
14500262	Tan sandstone	17.8	20

### 3.2.2 Walloon Coal Measures

Data from the DNRME Groundwater Database indicates that a limited number of bores within 20 km are screened in the WCM aquifer. Strata descriptions from the DNRME Groundwater Database show that these bores intersect strata comprised of interbedded coal, shale, clay, mudstone and sandstone of varying grain size and induration. For reference, in the Surat Basin, the percentage of coal within the WCM is approximately 10 %, the remainder being low permeability interburden. It is expected that the WCM in the Clarence Moreton Basin display a similar coal to interburden percentage as that in the Surat Basin.

There are no bores intersecting the WCM within 2 km of the historical production test bores and **Figure 3** provides an overview of bores within the vicinity. The nearest WCM bore is located 9.7 km from the production testing wells.



NOT FOR CONSTRUCTION

Figure 3 Bores Registered in the DNRME Database

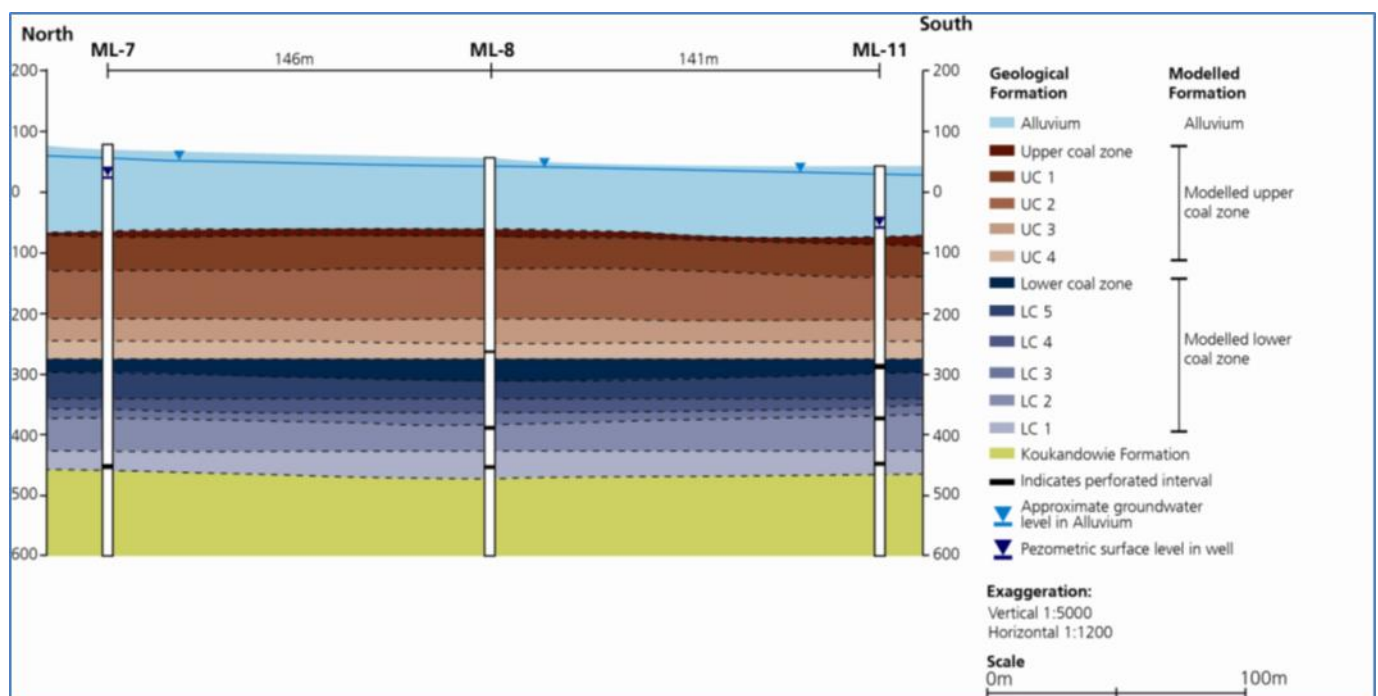
Further information relating to the WCM was available from production test well drilling. The production test well Mount Lindesay-7 was drilled as part of an appraisal program by the registered holders in August 2009. A total of 43.9 m of coal was intersected. A thickness of 16.4 m was intersected in the Upper Coal Zone and 20.1 m was intersected in the Lower Coal Zone. The bore log for Mount Lindesay-7 indicated an alluvium that persists to approximately 140 m, while in Mount Lindesay-8 alluvium extends to about 118 m depth. In Mount Lindesay-11, the alluvium extends to 149 m. The alluvium overlies the WCM which persist to about 520 m below which lies the Koukandowie formation. Individual zones of coal were identified throughout the extent of the WCM as can be seen from the cross section of the production test area shown in **Figure 4**.

The production testing wells were perforated as follows

- Mount Lindesay-7 (ML-7); in the WCM from 521 m to 527 m;
- Mount Lindesay-8 (ML-8); in the WCM from 339 m to 354 m, 433 m to 445 m and 510 m to 514 m; and
- Mount Lindesay-11 (ML-11); in the WCM from 344 m to 357 m, 434 m to 446 m and 511 m to 515.3 m.

These wells were cased and cemented so that water is only accessed at these perforated intervals, indicating a vertical separation distance between the perforated interval of these wells and the overlying alluvium of approximately 195 m to 380 m.

Drill Stem Test (DSTs) of the units failed due to very low water yields which indicated low permeability coals.



**Figure 4 Cross-Section of Well Locations**

### 3.2.3 Koukandowie Formation

The Koukandowie Formation is described as being a fine to coarse grained, quartz to quartz-lithic sandstone with interbedded conglomerates, sands, and shales. As discussed above, the main resource aquifers used in the area are the alluvial aquifers. While the Koukandowie formation unit underlying the WCM has the potential for groundwater use, the likelihood of current and future use in the area is considered low due to the depth of the formation in this area and presence of shallower and more readily accessible water resources.



### 3.3 Groundwater Levels

#### 3.3.1 Alluvium

Groundwater levels in the alluvial aquifer in the vicinity of the production test wells are in the order of 10.5 m to 12.8 m below ground surface (based on available information from DNRME Groundwater Database data. The only available groundwater level data was from Bore RN 142767 , obtained from the DNRME Groundwater Database, within 2km from the production testing wells. The bore is located approximately 880m from the production test wells and is plotted in **Figure 5**. The water level data in this bore has been collected from the year 2000 to 2011 and has not been recorded since 2011.

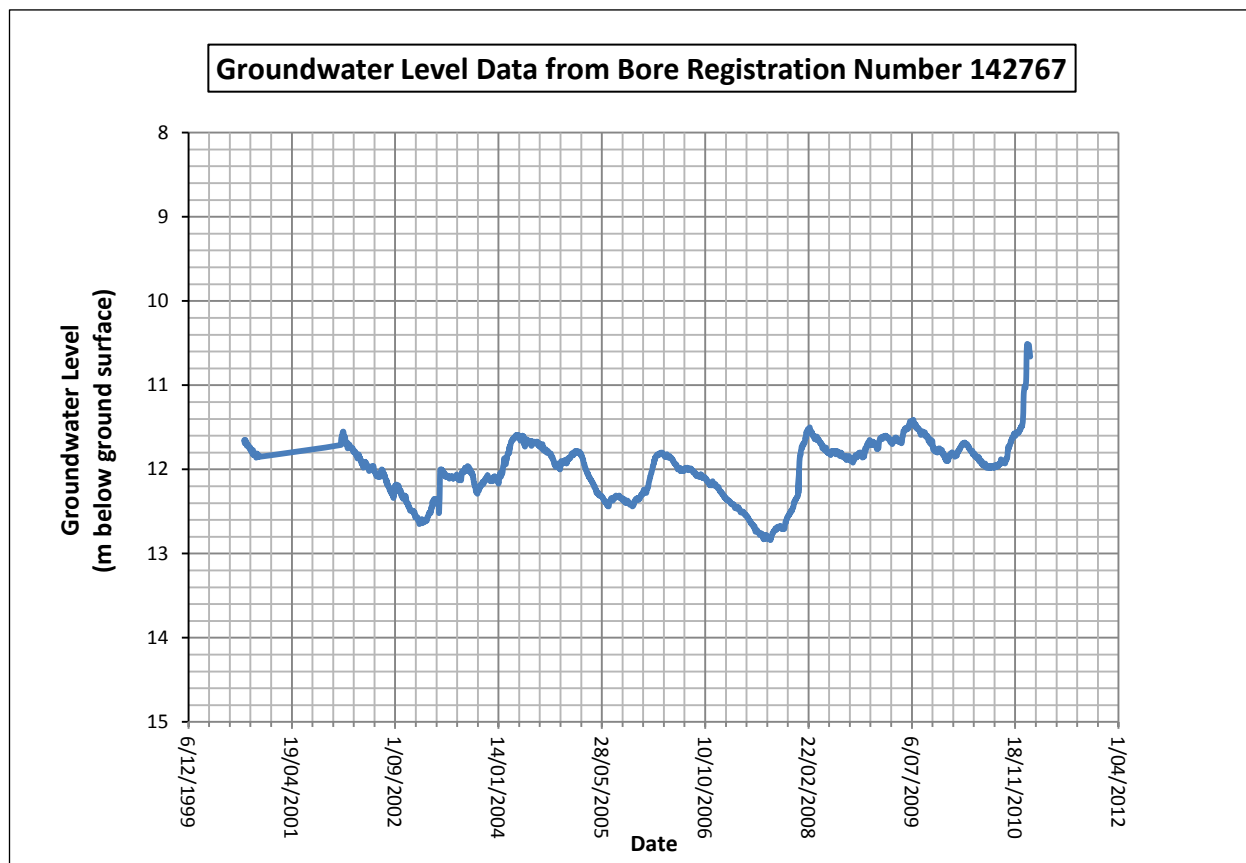


Figure 5 Hydrograph based on Groundwater Level Data from DEHP Groundwater Database

#### 3.3.2 Walloon Coal Measures

There is no groundwater level data available from the DNRME Groundwater Database for bores intersecting the Walloon Coal Measures within 20 km of the site so local groundwater levels for this formation are taken from information gathered during the production test.

Groundwater levels in the WCM ranged from 45 m below wellhead (ML-7) to a maximum of 108 m below wellhead (ML-11). This suggests that the pressure in the WCM is lower than in the alluvial aquifers and that downward vertical gradients may exist from the alluvial aquifers to the WCM. The variability in groundwater levels within the WCM may indicate very low hydraulic conductivities and/or lack of interconnectedness between layers within this unit.

### 3.3.3 Koukandowie Formation

There are a number of Landholder bores which are described in the DNRME Groundwater Database as intersecting the Koukandowie Formation within 20 km of the production test site. These bores are shallow bores (maximum depth is 54 m) so these are unlikely to be representative of the Koukandowie Formation in the vicinity of the production test wells which is present at several hundred metres depth. Groundwater levels for these bores are in the order of 13.8 m to 15.0 m below ground surface. These are similar to the values seen for the alluvial aquifer which may indicate these bores are screened within the alluvial aquifer rather than the Koukandowie Formation.

## 3.4 Groundwater Flow

### 3.4.1 Alluvium

As indicated in Section 3.2.1, the general flow direction in the alluvial aquifers is anticipated to be northwards in the direction of the Logan River.

### 3.4.2 Walloon Coal Measures

Due to the lack to available data, the flow direction in the WCM is not apparent from the available water level data. It is anticipated that these units have low permeability and a lack of horizontal and vertical connection.

## 3.5 Groundwater Quality

### 3.5.1 Alluvium

The only available water quality data from bores in the alluvial aquifers recorded in the DNRME Groundwater Database indicates electrical conductivity of 1,430  $\mu\text{s}/\text{cm}$  to 3,500  $\mu\text{s}/\text{cm}$ , indicating fresh to brackish groundwater.

### 3.5.2 Walloon Coal Measures

Total dissolved solids concentrations of groundwater in the coal measures ranged from 2,000 mg/L (Mount Lindesay-8 & Mount Lindesay-11) to 5,870 mg/L (Mount Lindesay-7). For comparison to alluvial aquifer water quality data this is approximately equivalent to 3,130  $\mu\text{s}/\text{cm}$  to 9,170  $\mu\text{s}/\text{cm}$ . This indicates that the water in the coal measures is generally more saline than the alluvial groundwater although it may have a similar salinity to the more saline alluvial groundwater. Water samples from the WCM collected from flow during the production tests or development of wells are summarised in **Figure 6**. Data on major cation/anion analysis indicated that the groundwater was generally a sodium-bicarbonate ( $\text{Na-HCO}_3$ ) dominated with lesser amounts of chloride. The data also indicates that the pH of water in the WCM is variable and ranged from near neutral (6.55) to slightly alkaline 8.85.

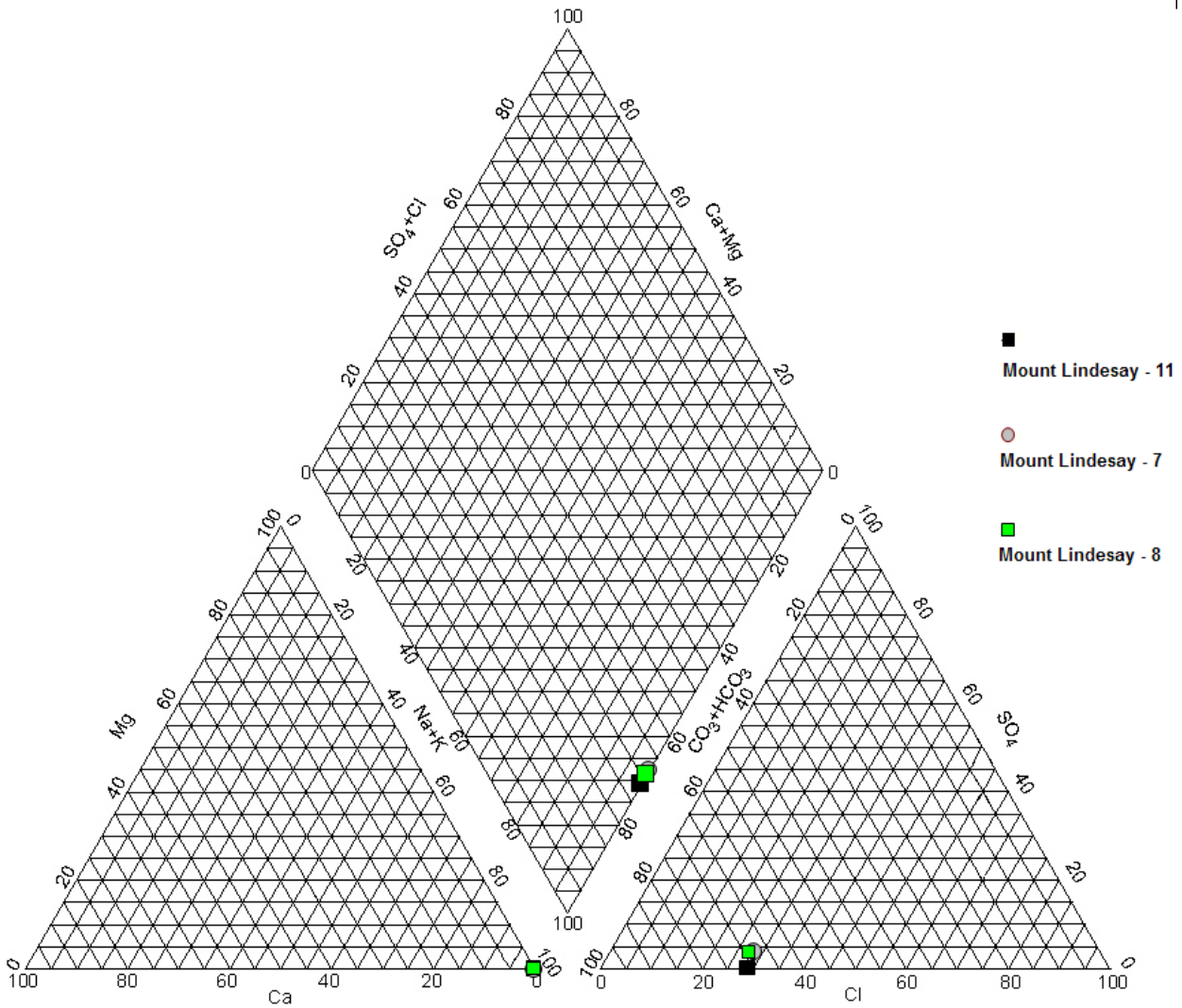


Figure 6 Trilinear Plot of Water Quality in the Walloon Coal Measures

### 3.6 Springs

A review of the Queensland Government Springs database found no documented springs within 20 km of the site. The nearest springs are understood to be springs on the basalts of the Lamington Volcanics to the south, south east and east. These springs are understood to be fed by rainfall discharge, referred to as recharge springs, from the basalts volcanics and not from underlying units. The recharge springs are generally located on the basalt contacts with underlying formations, gravity fed and not been indicated to be impacted by the production testing. Therefore, there is no requirement for a Spring Impact Management Strategy (SIMS). A SIMS will not be considered further in this UWIR.



## 4 CONCEPTUAL HYDROGEOLOGICAL MODEL

The conceptual hydrogeological model comprises an alluvial aquifer of 118 m to 140 m thickness overlying a thick sequence of several hundred metres of low permeability shales, siltstones, claystones, greywackes, sandstones and coals comprising the WCM.

The volume of groundwater stored within the alluvial aquifers and the ability of the aquifers to transmit groundwater is largely a function of the particle size of the material comprising the aquifers and the saturated thickness of the sediments. Aquifer properties are variable depending on the nature of the sediments. The alluvial groundwater is anticipated to be hydraulically connected to the surface water systems. Recharge processes in the alluvial aquifers are likely to be via:

- direct infiltration of rainfall and overland flow where no substantial clay barriers exist in the subsurface; and
- direct infiltration from surface water flow and/or flooding (losing stream).

Primary discharge mechanisms in the alluvial aquifers are likely to be:

- through flow into adjacent or underlying aquifers (in particular the WCM);
- evapotranspiration;
- discharge to surface water systems (gaining stream); and
- groundwater extraction.

The WCM is interpreted to be recharged through vertical leakage from the overlying alluvial aquifer and rainfall runoff on the eastern flank of the Logan Sub-basin with potential for some groundwater exchange between underlying Koukandowie Formation. The WCM are very low permeability units as indicated by the failed DSTs carried out during production test well drilling; where insufficient flow was available for a successful test (i.e. fluid was unable to be recovered from the coals). The perforated intervals of the production test wells are between 195 m and 380 m below the alluvial aquifers and the wells are fully cased and cemented. The 195 m to 380 m thickness of low permeability intervening units are likely to act as an aquitard or series of aquitards between the zones tested by the production tests and the overlying alluvial aquifers.

The stratigraphic sequence in the area of the production testing wells, comprising the permeable alluvium aquifer overlying a thick sequence of Walloons Coal Measures, is considered to be non-complex with little evidence of unconformity or significant structural variation. Groundwater flow is likely to be northward in the alluvium with a component of flow into the WCM (recharge) due to a lower groundwater pressure within these units (indicated in by the higher water level in the alluvial aquifer relative to the WCM shown in Figure 6). The connectivity between the Alluvial aquifer and the WCM is interpreted to be low based on groundwater elevation data and thickness of intervening aquitard.

Groundwater flow within the WCM is likely to be structurally down dip. The non-complex nature and interpreted low connectivity of the formations local to the production test area justifies a simple conceptual model.

## 5 GROUNDWATER MODELLING AND ASSESSMENT

No new production or production testing has been undertaken on ATP 644 since the last UWIR. Resultantly, there are no changes to the predictions made in the UWIR as approved 6 March 2013.

- There is no IAA (predicted drawdown greater than the 2 m trigger threshold) for the Alluvial aquifer.
- There is a localised IAA (predicted drawdown greater than 5 m trigger threshold) for the WCM aquifer. There are no existing or useable bores in the IAA (WCM).

As indicated in the last UWIR it was concluded that the impacts of extraction of underground water during and after production testing within ATP 644 are extremely low given that:

- Groundwater modelling indicates:
  - A limited extent (approximately 550 m) and duration (less than three years) of water level decline in excess of the bore trigger threshold within the WCM;
  - Absence of water level decline in excess of the bore trigger threshold within the alluvial aquifers;
- Limited volumes of water (0.54 ML to 0.69 ML per production test) were abstracted during the production tests;
- A total of 1.8ML was extracted from the 3 wells over the seven month production testing period;
- The alluvial aquifer (the main resource aquifer used in the area) is separated from the perforated interval of the wells by a 195 m to 380 m thickness of low permeability units for the 3 production test wells;
- The intervening low permeability units have the potential to act as an aquitard or series of aquitards between the zones tested by the production tests and the overlying alluvial aquifer;
- The production test wells are fully cased and cemented between different hydrogeological units. Groundwater behaviour at each unit in the production wells was observed to be significant difference; and
- The nearest landholder bore (within the alluvium) is located approximately 500 m away from the production testing wells

Data from monitoring of the production testing indicated drawdown of groundwater levels of approximately 350 m to 400 m within the WCM. An IAA of limited extent (extending approximately 550 m from the production testing wells) was predicted for the WCM. No IAA was predicted in the overlying alluvium. A cross-section of the test production site is shown in **Figure 4**.

No new production or production tests are currently forecast on ATP 644. As a result, there are no predicted impacts to aquifers by more than the bore trigger threshold and a water level recovery analysis was carried out and is discussed in more detail below.

The assessment of the IAA in the 2016 UWIR indicated that the IAA would be transient and likely to reduce as recovery occurred. An analytical calculation of the amount of recovery of groundwater levels in ATP 644 has been carried out as part of this UWIR. This takes into consideration 8 years since production testing was completed to evaluate the amount of recovery likely to have occurred to date. The results are presented in more detail in the following sections of the report.

### 5.1 Analysis of groundwater recovery

#### 5.1.1 Background

ATP 644 was subject to production testing which was undertaken using three wells. As indicated above, a total 1.8 ML of groundwater was extracted in 2010 over a period of 7 months as part of this production testing. An UWIR was prepared in 2012 to assess the impacts from the production testing in this tenement and the well locations are shown in Figure 1.

### 5.1.2 Method

An analytical solution was used to assess the potential recovery of water pressures using the Theis (1935) solution that determines transmissivity and storage based on observed drawdown. This also predicted a likely recovery rate based on the parameters that match the observed data. The rate of decline of head in a well penetrating an extensive confined aquifer can be estimated because the rate of decline of head, allowing for storativity and summed over an area is related to the discharge from the well.

This method assumes that drawdown is not negligible and the hydraulic gradient varies with time. In addition, in common with most analytical solutions, it assumes the aquifer:

- is confined,
- is homogeneous,
- has infinite areal extent,
- antecedent conditions are homogenous,
- pumping is at a constant rate, and
- flow to the well is horizontal.

As such this provides an approximate analytical calculation of potential recovery.

The analytical calculation used observed data from well ML-007 which recorded a drawdown of 344.73 m over 224 days of monitoring (Figure 7) and the values for storage ( $9 \times 10^{-5}$  to  $9 \times 10^{-6}$ ) and transmissivity ( $0.001 \text{ m}^2/\text{day}$ ) for the WCM determined by the numerical model used in the UWIR. The analytical calculation is therefore based on:

- Observation data over 224 days during production testing (calculated drawdown), extracting 1.8 ML of water over 9 months between 4 March 2010 and 14 October 2010;
- Water levels continued to draw down up to day 304 before recovery commenced up to day 3224, representing the period 2 January 2011 to 31 December 2018.

### 5.1.3 Results

The analytical calculations of recovery at the production test site as shown in **Figure 7** indicate:

- Observed drawdown of 274.86 m (day 224) during production testing between 4 March 2010 and 14 October 2010 (day 0 to day 224)
- Water level continued to draw down up to day 304 (January 2011) where after recovery started from 344.73 m and was calculated to have reduced to 44.01 m by 31 December 2018 (day 3224). The calculated recovery is 87.23% of the initial water level measured prior to the production testing commencing.

The analytical calculation also indicates that recovery is likely to have occurred and it is therefore likely that the current IAA will be smaller than that shown in **Figure 8**.

**Drawdown predictions and analysis of pumping tests in unconfined or confined aquifers using the Theis 1935 solution**

Hover mouse over to see more details [Back to Intro sheet](#)  
 Hover mouse over to see instructions

<b>Q (m<sup>3</sup>/day)</b>	<b>r (m)</b>
8.035	250

<b>Duration of Pumping (days)</b>
224

<b>Automatic (slider bars)</b>	
<b>T (m<sup>2</sup>/day)</b>	<b>S</b>
0.001	0.000009

<b>Manually defined (leave blank to use slider bars)</b>	
<b>T (m<sup>2</sup>/day)</b>	<b>S</b>
0.001	0.000009

<b>L (m)</b>
1

Measured Drawdown and Recovery		Calculated Drawdown		Calculated Recovery	
t(days)	s(m)	t(days)	s(m)	t(days)	s(m)
0.001	0.00	0	0.00	224	274.86
30.000	0.00	1	0.00	224	274.86
60.000	48.00	2	0.00	225	276.38
90.000	140.00	3	0.00	226	277.90
120.000	230.00	5	0.00	227	279.42
150.000	312.00	10	0.00	229	282.45
180.000	323.00	20	0.07	234	289.97
210.000	347.00	40	4.37	244	304.75
240.000	334.00	50	10.61	264	329.40
		60	19.60	274	337.25
		70	30.88	284	342.10
		80	43.94	294	344.42
		90	58.31	304	344.73
		100	73.61	314	343.49
		110	89.56	324	341.08
		120	105.92	334	337.81
		130	122.52	344	333.91
		140	139.23	354	329.55
		150	155.95	364	324.88
		160	172.59	374	320.00
		170	189.12	384	314.99
		180	205.48	394	309.92
		190	221.64	404	304.83
		200	237.58	414	299.75
		220	268.75	424	294.72
		224	274.86	444	284.86
				448	282.93
				500	259.31
				600	221.82
				1000	138.18
				1826	77.07
				2000	70.49
				2500	56.58
				3000	47.26
				3224	44.01
				5000	28.48
				6000	23.75
				7000	20.38
				9000	15.86

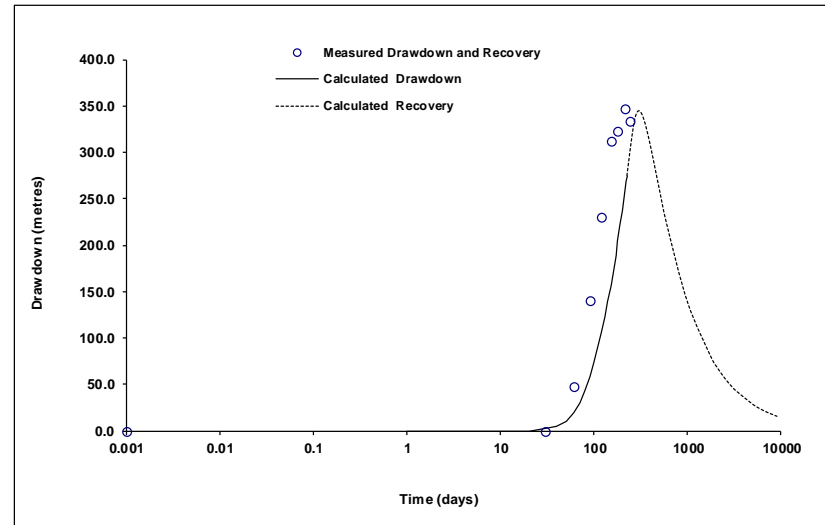
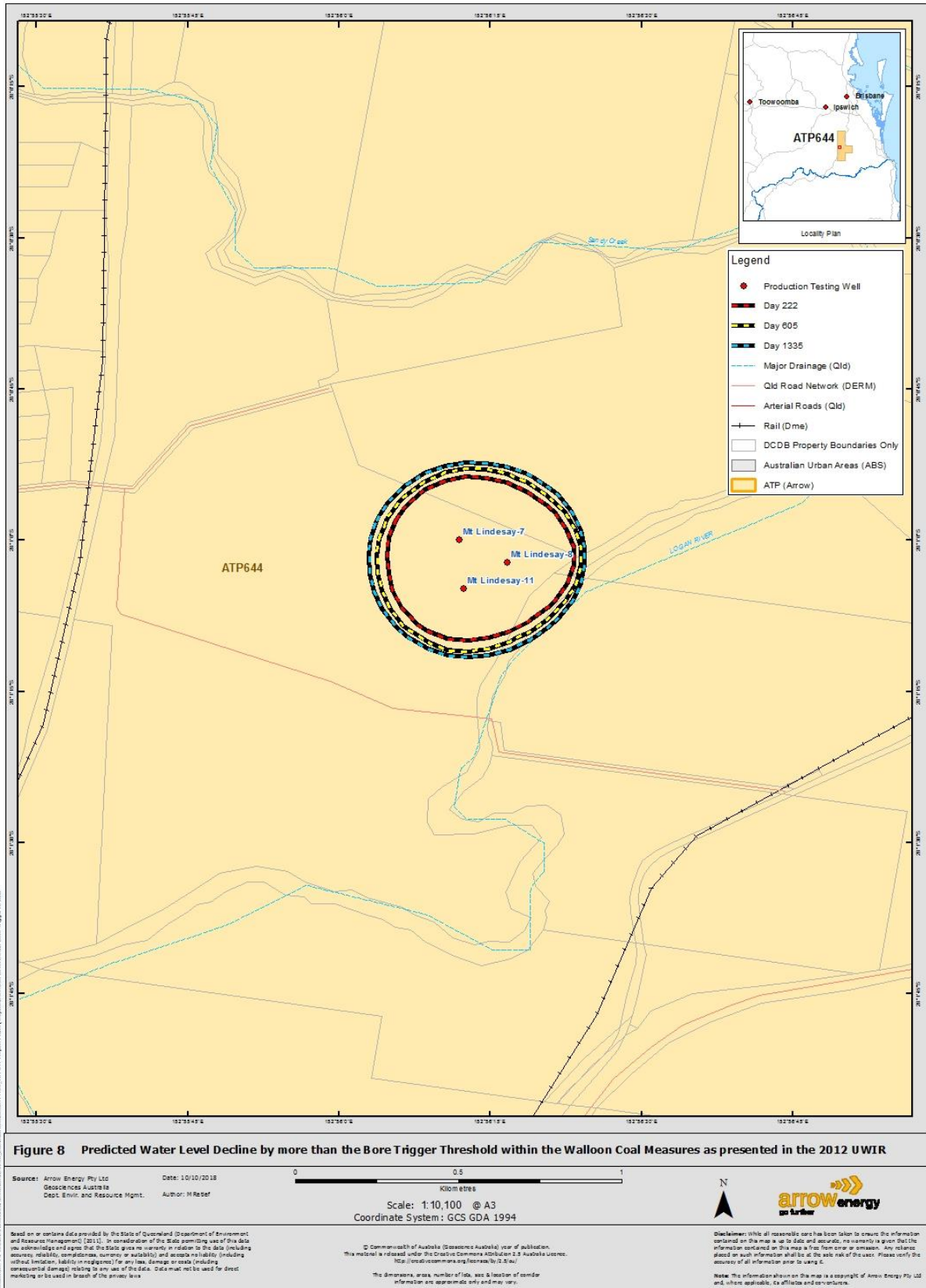


Figure 7 Analytical Calculation of Recovery





NOT FOR CONSTRUCTION

Figure 8 Predicted Water Level Decline

## 6 GROUNDWATER MANAGEMENT

There are no changes to the Water Monitoring Strategy (WMS) since the previous UWIR. A summary is provided below.

### 6.1 Water Monitoring Strategy

The following WMS is proposed.

- If at any time in the future a bore is identified within the immediately affected area and within 2 Km of the pilot bores then a bore assessment will be undertaken.
- This would include a baseline bore assessment based upon the Water Act (2000) requirements for baseline bore assessments.

Should further production testing take place at any time in the future, then the proposed water monitoring strategy includes:

- The quantity of water produced will be assessed.
- A baseline assessment of identified bores within a 2 Km radius of the proposed production test will be undertaken. The pilot bores will be monitored and sampled to assess the change in water level in the affected aquifer.
- The underground water impact report will be updated at the review date to include the impacts of new production testing in its predictions.

## 7 ANNUAL REVIEW

This report will be reviewed annually. The review will consider:

- new hydrogeological data that significantly alters the conceptual model;
- whether new production testing or production has been undertaken or is planned; and
- whether the predictions made in Section 5 have materially changed.

The program for the implementation of the strategy will be reported to DES on an annual basis as part of the annual review. The annual review will provide an update on the implementation of the WMS. In addition to the annual review, the UWIR will be updated every three years.

## 8 SUMMARY AND CONCLUSION

As described in the first and second UWIRs, the production wells have been plugged and abandoned and no production testing has been undertaken since 2010 and there are no current plans for further production testing in ATP 644.

Any Immediately Affected Area (IAA) remaining, if present, is unlikely to be significant as indicated from the analytical calculation carried out.