# Expert Response Report to the Land Court by Mark Stewart

## 1. Experts Details & Qualifications

### 1.1 Name

My name is Mark Stewart.

### 1.2 Address

My business address is:

Level 17, 240 Queen Street

Brisbane

Queensland, 4000

### 1.3 Qualifications

I hold the following qualifications:

(a) Bachelor of Science (Geology)

My curriculum vitae is included in my Expert Witness Report dated 30 May 2013.

## 2. Instructions

I have been instructed by Allens on behalf of Hancock Coal Pty Ltd to prepare a supplementary expert report in response to the key groundwater issues raised in:

(a) The Points of Disagreement compiled in the Joint Experts Report (dated 02 August 2013);

(b) Affidavit of Janeice Marie Anderson, sworn on 11 July 2013;

(c) Affidavit of Bruce Bede Currie (undated);

(d) Affidavit of Fiorella Paola Cassoni (undated);

(e) Ecology Joint Experts Report compiled by Dr David Dique and Robert Friend; and

(f) Supplementary Expert Report to the Land Court of Dr John Webb, dated 13 August 2013.

## 3. Facts and Assumptions

In producing this Response Report, I have relied on the following facts and assumptions:

(a) Contained with my Expert Report, dated 30 May 2013 and the reports referenced in that report;

(b) Included in my comments included in the Joint Experts Report, dated 02 August 2013; and

(c) Contained in the reports and documents referenced in the Joint Experts Report, dated 02 August 2013.

# 4. Opinion and Findings

**SUMMARY**

**Opinions of Dr Webb and Dr Mudd – Key areas of disagreement**

The main points of disagreement were based on the geological conceptualisation included in the groundwater conceptual model. The conceptualisation was used in the construction and calibration of a groundwater model used for impact predictions. The approach adopted by URS, where limited data was available, was to consider the worst case scenario. This approach allowed for consideration of the largest potential impact on the groundwater resources over a 30 year mine life and for 300 years post-mining.

A key area of disagreement between the groundwater experts is the cause of the flow of groundwater across the Alpha Mine Lease (MLA70426) to the northeast, which is contrary to the dip of the strata (to the west). Dr Webb and Dr Mudd consider that the reason for this flow is related to geological structures more specifically, folding within the units that make up the Great Dividing Range.

I consider that there are no readily recognisable structural complexities, such as beds dipping to the east, which would be evident if anticline folding was present either in the literature or on site. Thus the geological units were considered to dip uniformly to the west. All data available supports the URS modelled geological conceptualisation.

I consider the groundwater flow pattern recorded on site is a result of:

- The hydraulic connection of the confined Permian coal bearing units across the Galilee Basin, i.e. continuous from east to west below the Great Dividing Range;
- The potentiometric pressures within these Permian units have equalised across the basin, resulting in the potentiometric pressures recorded in monitoring bores across the Alpha Coal Mine;
- The Permian units within the Alpha coal mine are near horizontal (dip 1 to 2 degrees) and include permeable (sandstone) units which plunge to the north; and
- Elevated topography to the west and south of the proposed mine were recharge occurs.

Limited groundwater recharge in the topographic high areas and discharge in the topographic lows results in localised (across the portion of the Galilee Basin containing the Alpha Coal Mine) groundwater flow to the north east through the more permeable near horizontal beds.

The geological conceptualisation of all other projects proposed in the area and a third party review is consistent with the URS geological conceptualisation. There is no data that supports the geological conceptualisation of Dr Mudd and Dr Webb.

All available data and literature shows that either side of the Great Dividing Range the beds dip uniformly to the west. This means the folding conceptualised by Dr Webb and Dr Mudd must be within a narrow area (under the Great Dividing Range) and dip sharply either side of the anticline. No such folding was evident in the rock outcrop across the site.

If such folding existed it would not only be reflected in data and literature, it would be observable on the ground, and in the air (by helicopter, plane or otherwise). No such observations were made. Rather the field data and literature are all consistent with the URS conceptual model.

All available field data and literature supports the URS modelled conceptualisation.

Even if Dr Webb and Dr Mudd are correct, the modelled output (the resultant zone of impact around the mine) would be the same as this is based on the geology to be directly disturbed during mining.

I consider that the conditions are appropriate and sufficient to:

- Assess and address identified potential impacts;
- Allow for the validation of predictions;
- Assess cumulative impacts of multiple coal mines;
- Ensure water security; and
- Provide a suitable framework to address potential impacts and make-good on water resources.

Although there are other areas of disagreement between the experts, these areas of disagreement either stem from the different geological conceptualisation described above, or in my opinion are otherwise more academic disagreements with regards to groundwater systems and controls.

**Concerns of Landholders**

The concerns of the landholders (Anderson, Currie, and Cassoni) mainly relate to concerns regarding cumulative impacts of other proposed mining projects, water security, and the proposed conditions for the project.

I consider that the concerns regarding water security are addressed in the Alpha Coal Mine's proposed conditions. Proposed make good conditions, in the water licence (required for dewatering) will provide water security should mine dewatering impact on the landholders bores.

<u>Anderson:</u>

- The Andersons' properties are not predicted to be impacted by the groundwater drawdown of the Alpha Coal Mine;
- Considering the location of the Andersons' properties, located within the Waratah Galilee Coal Project and immediately adjacent to the proposed South Galilee Coal Project, I consider that the groundwater drawdown during mining of these two coal projects will have a marked impact on the groundwater resources of the Andersons' properties. The Anderson's properties are not predicted to be impacted by the Alpha and Kevin's Corner coal projects; and
- Based on the prediction that groundwater quality will not be impacted (final void drawdown), and the Andersons' bores are located far from the Alpha (well outside the drawdown cone) I consider that groundwater monitoring of the Andersons' supply bores is not suitable or necessary and should not be included as an approval condition.

  The Alpha Coal Mine conditions include for the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the south of the Alpha

Mine lease. These monitoring points will be located between the Alpha Coal Mine and the Andersons' properties. These monitoring points will be used to validate modelling predictions and provide "early warning" should groundwater levels decrease quicker and deeper than predicted.

Currie:

- The Curries' properties are not predicted to be impacted by the groundwater drawdown of the Alpha Coal Mine;
- Mr Currie suggests that the Curries' bores be included for monitoring as well as an additional three monitoring bores to provide early warning of impacts on the Clematis Sandstone.

  I consider that the proposed conditions for the Alpha Coal Mine, including for the monitoring of the Clematis Sandstone, are adequate and sufficient to assess potential groundwater impacts to the west of Alpha Coal Mine.

  I also consider that there is no need to condition an additional (three) monitoring bores between Alpha and the property of Speculation, as the Kevin's Corner Coal Mine proposed conditions include for monitoring bores to the west of Kevin's Corner Coal Mine similar to Alpha Coal Mine's conditions.

Cassoni

- No groundwater quality impacts are predicted to occur based on the final void acting as a sink. In addition, as groundwater flow is from south to north across Bimblebox, even during mine dewatering and post-mining, any possible migration of poor quality will not migrate southwards in the groundwater.
- The predictive groundwater model drawdown in the D coal seam at the end of mining, both for Alpha Coal Mine alone and Alpha and Kevin's Corner cumulative mining, is predicted to extend to the boundary of Kia Ora and Glen Innes;
- Considering that the Bimblebox property is located within the proposed location of the Waratah Galilee Coal Project, the Waratah Galilee Coal Project will have a marked impact on the groundwater resources within the Bimblebox property.
- The proposed approval conditions allow for the review and refinement of the existing groundwater model over time and includes the development of a regional groundwater model to consider cumulative impacts.

## 4.1 Points of Disagreements compiled in the Joint Experts Report (02 August 2013)

### 4.1.1 Geological conceptualisation (structures) below the Great Dividing Range and influence on potentiometric surfaces of the confined Permian units and flow mechanics.

Issue

Based on groundwater level data compiled from the confined Permian units, specifically the C-D sandstone and D-E sandstone units, the groundwater flow across the Alpha mine lease is to the northeast. This flow pattern is recognised to be contrary to the dip of the strata (from east to west).

Dr Webb and Dr Mudd agree that the groundwater flow across the Alpha Mine lease is to the northeast. However, they disagree as the cause of this flow.

Dr Webb and Dr Mudd consider that the reason for this flow is related to geological structures. More specifically folding, within the units making up the Great Dividing Range where the folding allows for a higher potentiometric pressure (elevated units to the west compared to those mapped within Alpha Coal Mine footprint) within the units which facilitate groundwater movement.

The URS conceptual model (Figure 1) and the conceptual models included in the Waratah SEIS Galilee Coal Project Groundwater Assessment (Heritage Computing Report, 2013) (Figure 1b) and South Galilee Coal Project Groundwater Assessment and Modelling (RPS Aquaterra, 2012) (Figure 1c) all include westward dipping beds with no recognised structural complexity (coal generally dip 1-2 degrees to the west) and no major structural features (such as folding below the Great Dividing Range).

It is noted that the independent due diligence assessment of the groundwater model, conducted by Parsons Brinckerhoff (Appendix D of the Groundwater Model Report, URS 2012) remarked that a sound regional and mine scale conceptual model had been developed, which was revised over time. The conceptualisation of the hydrogeological system was considered appropriate and adequate for the design of the model.

In addition, the Waratah SEIS Galilee Coal Project Groundwater Assessment (Heritage Computing Report, 2013) report also includes in (Section 3.4.3) a comment of no recognised structural complexity (coal generally dip 1-2 degrees to the west) and regional geological mapping has detected no major structural features.

No geological structures are identified in the South Galilee groundwater report (RPS Aquaterra, 2012). The report includes a comment that the Galilee Basin strata are essentially flat lying and dip to the west and south west at less than one degree.

*Figure 1 Conceptual Groundwater Model*

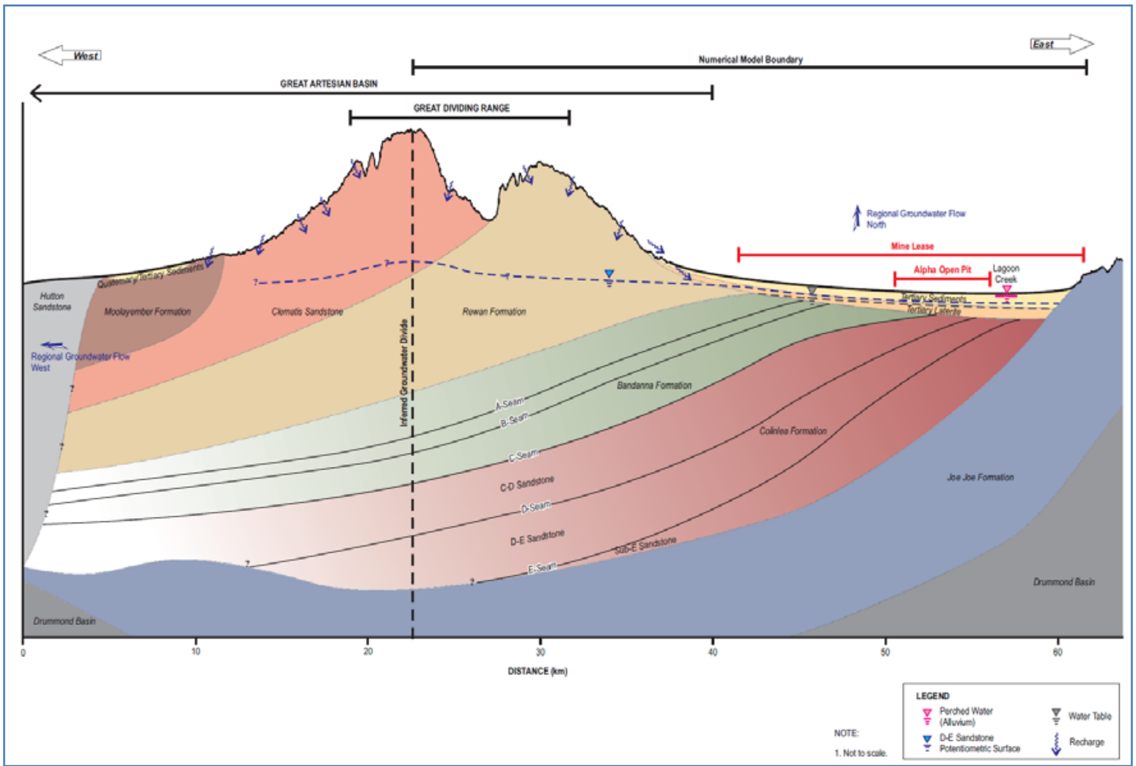



*Figure 1a Conceptual Groundwater Model – Galilee Coal Project (Heritage Computing Report, 2013)*

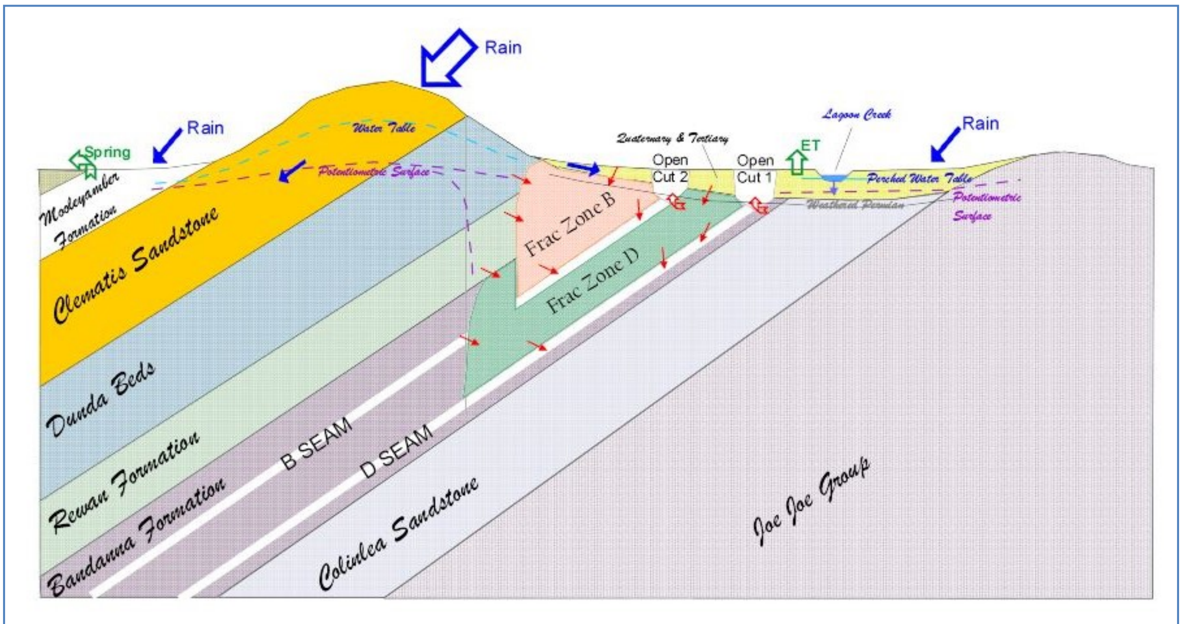
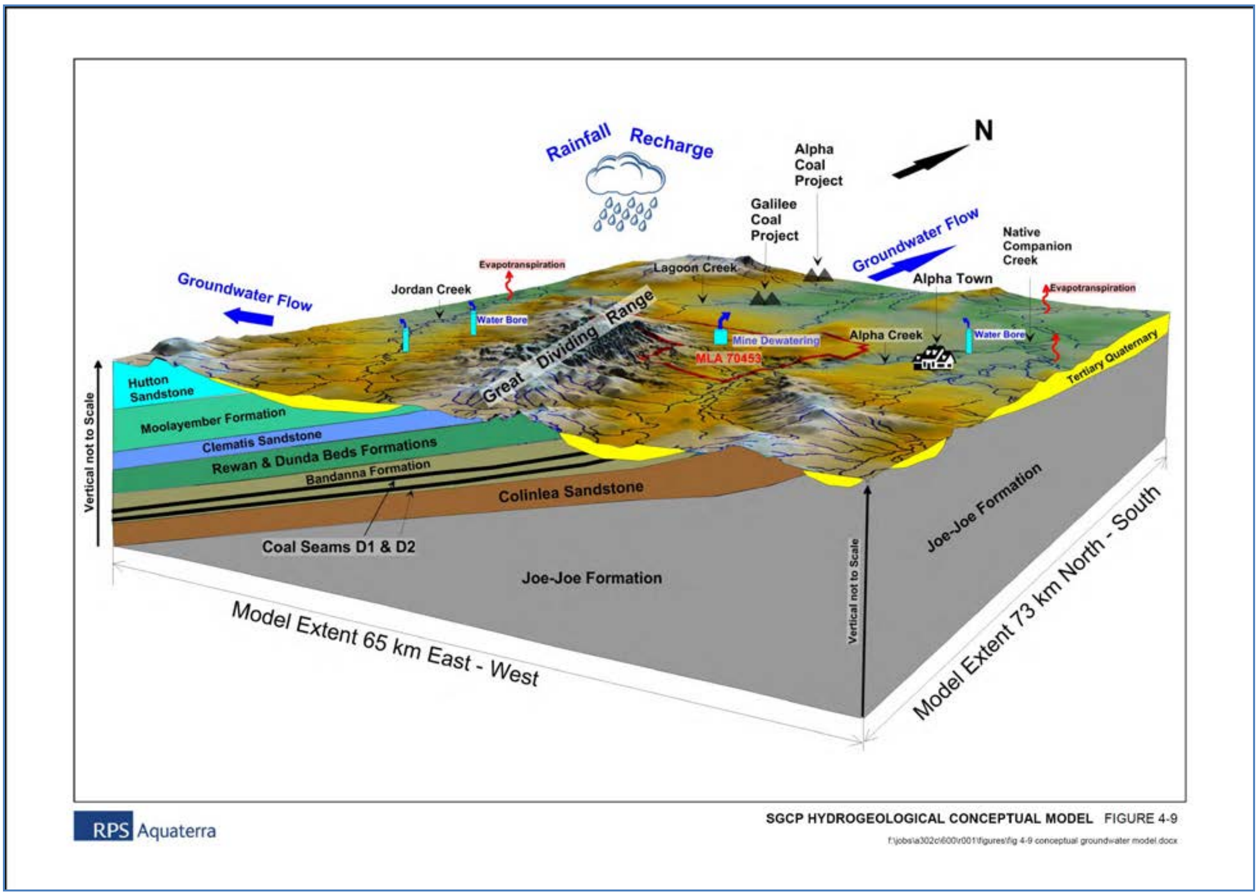



Figure 3.6 Conceptual Hydrogeological Model

*Figure 1b Conceptual Groundwater Model – South Galilee Coal Project (RPS Aquaterra, 2012)*



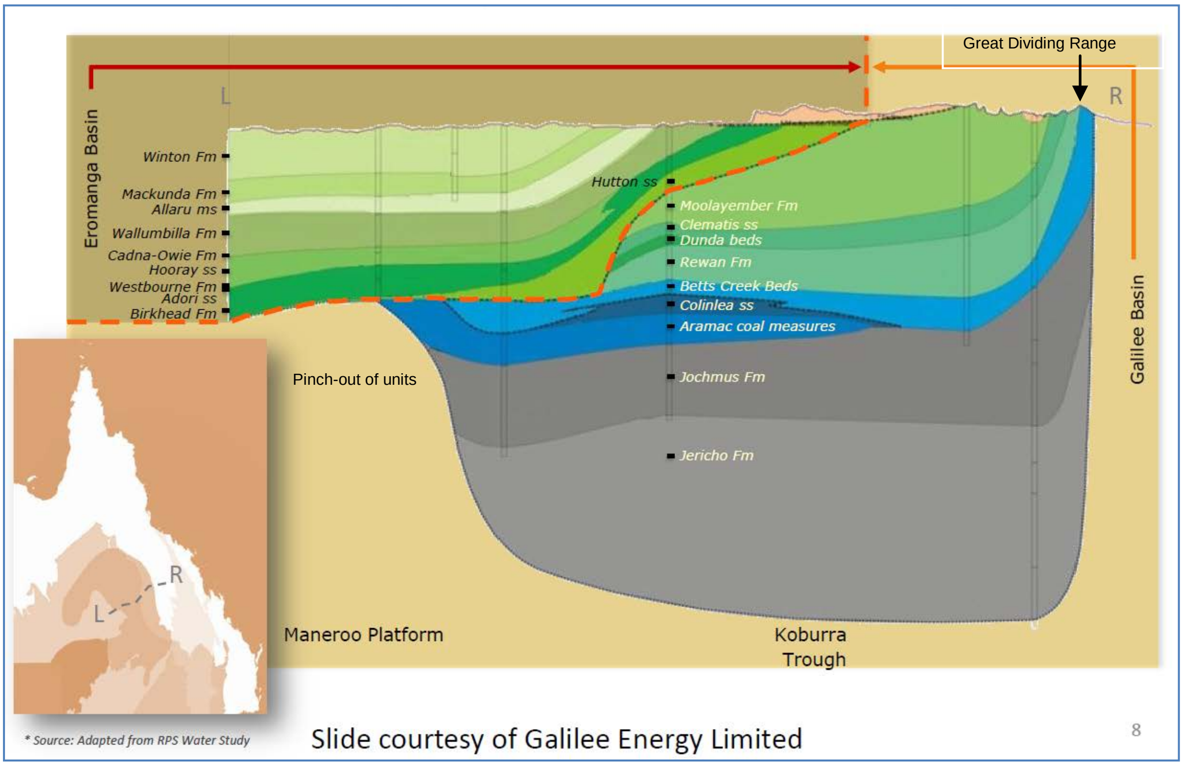

<u>Conceptualisation</u>

I consider that the groundwater flow pattern recorded on site is a result of:

- The Permian units (Bandanna Formation and Colinlea Sandstone) being hydraulically connected (east to west) across the Great Dividing Range (Figure 1 shows the continuity of the units);
- The Permian coal bearing units are confined on three sides, above by the Rewan Formation and Tertiary saprolite, below by the Joe Joe Formation and to the west where the units pinch-out (Figure 1 and Figure 2, a regional cross-section derived from the Galilee Basin Operators Forum bore database);
- The potentiometric pressures within these Permian units have equalised across the basin, resulting in the potentiometric pressures recorded in monitoring bores across the Alpha Coal Mine;
- The Permian units within the Alpha coal mine are near horizontal (dip 1 to 2 degrees) and include permeable (sandstone) units which plunge to the north; and
- Elevated topography to the west and south of the proposed mine were recharge occurs.

Limited groundwater recharge in the topographic high areas and discharge in the topographic lows results in localised (across the portion of the Galilee Basin containing the Alpha Coal Mine) groundwater flow to the north east through the more permeable near horizontal beds.

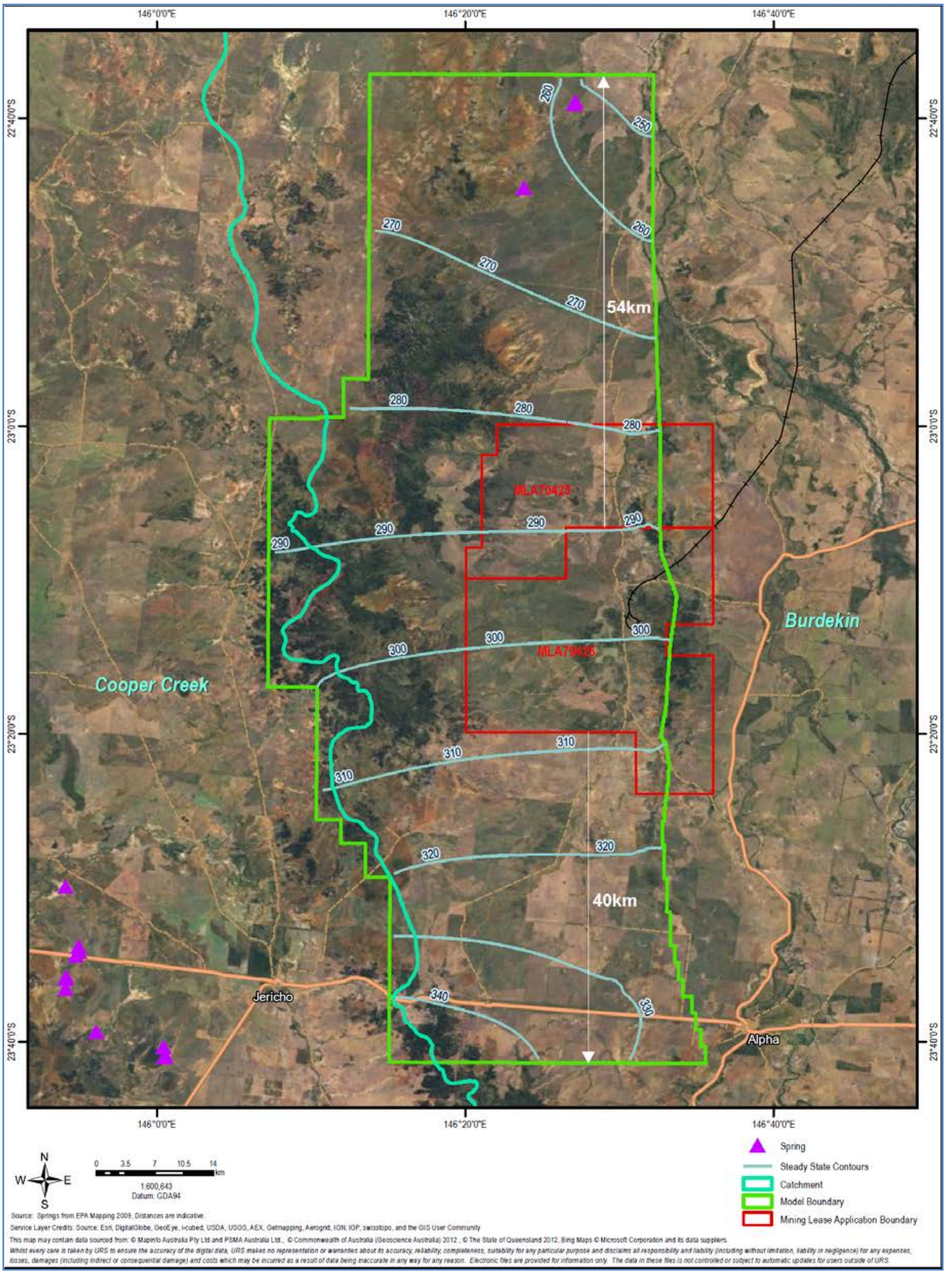
*Figure 2 Stratigraphic Relationship (source: Galilee Basin Operators Forum)*




The potentiometric pressure within the confined Permian units have equalised across the basin, resulting in the groundwater contours as presented in Figure 3 (Figure 4 Appendix A of the Joint Experts Report).

The groundwater flow across the Alpha Mine Lease is considered to occur due to groundwater recharge in the topographic high areas and discharge in the topographic lows through the more permeable near horizontal beds within the portion of the Galilee Basin containing the Alpha Coal Mine. The conceptualised recharge mechanisms are included in Section 4.1.7 of this report.

*Figure 3 Steady-state groundwater (D seam) contours*



Evidence

Available geological data does not indicate any evidence of folding within the Great Dividing Range in the portion of Galilee Basin containing the Alpha Coal Mine. The data considered includes:

- A regional scale geological cross-section derived from 1,201 bore logs (Salva Resources, 2009).

  No folding was mapped within the constructed cross-section showing the general geological trend across the Galilee and Great Artesian basins, as included in the URS conceptualisation. The bore logs from holes from east to west across the Great Dividing Range allowed for the generation of the fence diagram (cross-section), which did not necessitate the inclusion of folds to generate the uniform dipping beds.

- Site specific geological cross-sections, based on exploration drilling across the Alpha and Kevin's Corner coal mine leases, which indicate westward dipping beds with no recognised structural complexity.

  The geological cross-sections, generated from the exploration drilling across both Alpha and Kevin's Corner mine leases, indicate shallow westward dipping Permian units across both Alpha and Kevin's Corner lease areas. No marked folding was present in any of the multiple cross-sections. This is inconsistent with Dr Webb's conceptualisation of a syncline[1] within these mine lease areas, adjacent to Lagoon Creek.

- Galilee Basin Exploratory Coal Drilling – Wendouree Area drilling report, bore logs, and fence diagram (Carr, 1973).

  The report presents four coal exploration bore logs from Wendouree homestead to Greentree Creek along the northern boundary of the Kevin's Corner mine lease. The bore logs and resultant fence diagram generated from exploration drilling across the Farm Wendouree, immediately north of Kevin's Corner mine lease, indicate shallow dipping coal seams to the west and no folding. These logs are similar to the geology mapped across Alpha Coal Mine.

- 1:250 000 scale geological map Jericho (Bureau of Mineral Resources, Geology and Geophysics, 1972).

  No folds, anticlines[2] or synclines, are mapped or annotated on the local geological map. The cross-section generated through the Great Dividing Range, some 25 to 30 km south of Alpha Township, indicates uniform dipping strata within and adjacent to the Great Dividing Range. No anticline or syncline features are mapped along the Great Dividing Range on the Jericho map.

  The cross-section produced for the Groundwater Conceptual Model (Figure 1), which does not include folding, was generating using geological outcrop data from the 1:250 000 geological sheet Jericho, thus agreeing with known outcrop.

[1] Syncline – A fold of rock layers that slope upward on both sides of a common low point (see Sketch 1)

[2] Anticline – A fold of rock layers that slope downward on both sides of a common crest (see Sketch 1)

- The Galilee Basin Operators Forum cross-sections, which present the westward dipping Permian units, the pinching out of these units against the Maneroo Platform (Figure 2), and the Great Artesian Basin (GAB) units to the west of the Great Dividing Range (RPS, 2012).

  Figure 2 shows the dip of the units to the west of the Great Dividing Range, based on bore logs recorded in the Department of Natural Resources and Mines (NRM) database. No evidence of folding at the Great Dividing Range was recorded on the cross-section. This is the same as considered in the URS conceptual model.

- The CSIRO Water resource assessment for the Central Eromanga region, which provides the tectonic and depositional history of the Eromanga Basin, including the GAB units along the Great Dividing Range (CSIRO, 2012).

  The CSIRO study provides a conceptualisation of the tectonic and depositional history of the Eromanga Basin (located to the west of the Alpha Coal Mine study area), which does not include any folding in the Great Dividing Range. The study indicates uplift on the eastern boundary of the Eromanga Basin, which resulted in the formation of the Great Dividing Range.

- The Structure, Sedimentology, Sequence Stratigraphy and Tectonics of the Northern Drummond and Galilee Basins, Central Queensland, Australia, (Van Heeswijck, 2006).

  No details of folding within the Great Dividing Range are included in the geological thesis. The structural elements within the Galilee Basin, presented in the thesis, do not indicate any anticline or syncline structures in the portion of the Galilee Basin containing the Alpha Coal Mine.

- Queensland Carbon Dioxide Geological Storage Atlas (Queensland Government, 2009).

  All cross-sections across the Galilee Basin presented in this atlas do not indicate any folding on the eastern edge of the Galilee Basin, west of the Great Dividing Range.

- Geology of Queensland (NRM, 2013).

  The details of the Galilee Basin presented in the Geology of Queensland textbook do not include folding within the Great Dividing Range.

None of these data sources indicate any major structural features required to elevate the Permian units in the west above those mapped to the east within the Alpha mine lease (i.e. the folding suggested by Dr Mudd and Dr Webb). Rather, the data supports and is consistent with the URS modelled conceptualisation.

A site inspection, conducted by Mr Hair and myself, across the Rewan Formation and Clematis Sandstone units within the Great Dividing Range (within the Cudmore National Park and Cudmore Resources Reserve) did not indicate any evidence of folding or dipping beds. Beds dipping to the east, required if folding occurs within these units, were not evident. The geological outcrop, assessed from the air and on the ground within the Great Dividing Range, was near horizontal and not folded as would be required to result in higher potentiometric pressure and facilitate groundwater movement.

Dr Webb and Dr Mudd have suggested in their Expert Reports that the folding they conceptualise resembles that in the Waratah Coal's China First EIS (Volume 5 Appendix 14 Groundwater). (Figure 4).

*Sketch 1 – Anticline and syncline (www.yourdictionary.com)*

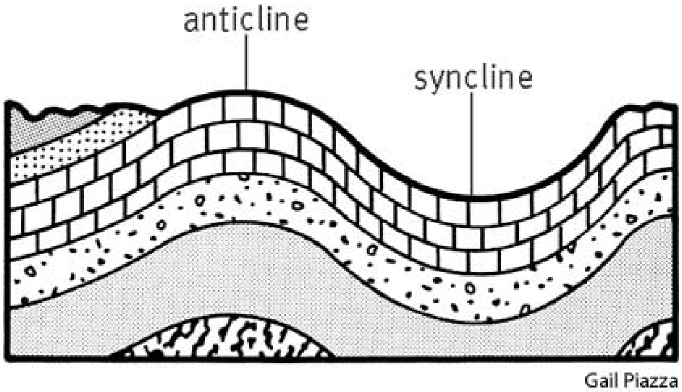
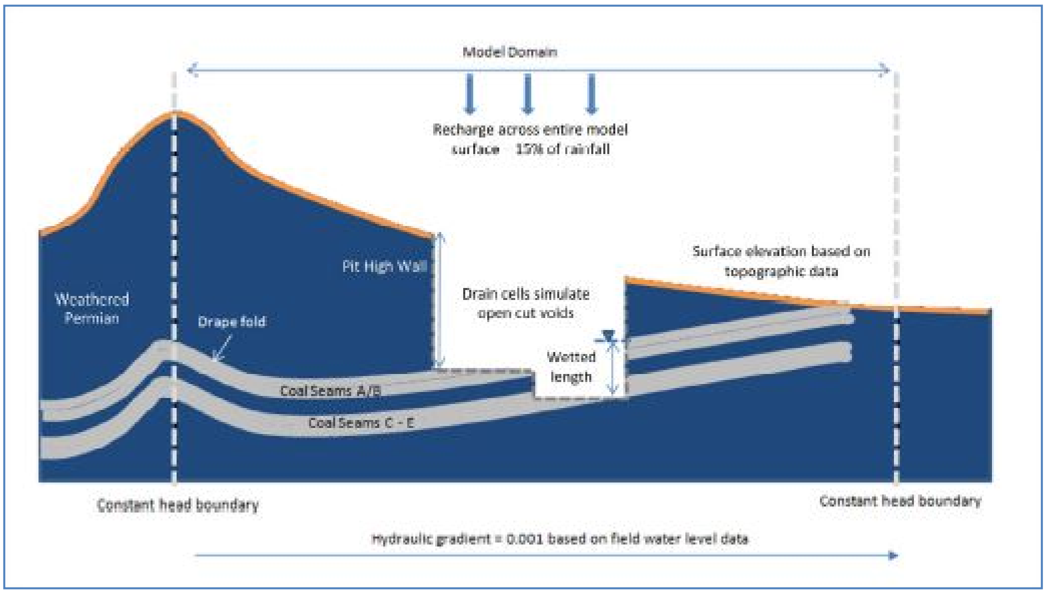



*Figure 4 Waratah Coal's China First EIS Conceptual Model (Source: E3 Consult, 2010)*




However, as identified, there is no field data or literature that supports the existence of such folding. The Waratah SEIS Galilee Coal Project Groundwater Assessment (Heritage Computing Report, 2013) includes a revised conceptual model, which replaced the EIS model, that is consistent with the URS conceptual model and all other data and literature (see Figure 1b above).

It is noted that the groundwater modelling presented in the Waratah EIS was criticised by the Office of the Coordinator General for a number of issues, one being the geometry of the coal seams. Additional information (including a monitoring bore LP01, which was drilled through the Clematis Sandstone to the B seam) and consideration, by Heritage Computing, allowed for the development of a new hydrogeological model, which did not include the folding.

All available data and literature shows that either side of the Great Dividing Range indicates Permian units dipping uniformly to the west. This means the folding conceptualised by Dr Webb and Dr Mudd would have to occur within a narrow area (i.e. within the Great Dividing Range) and thus need to dip sharply to the east (on the eastern side of the Great Dividing Range). It is noted that no east dipping beds were identified in the outcrop geology.

If such folding existed it would not only be reflected in data and literature, it would be easily observable on the ground, and in the air (by helicopter, plane or otherwise). No such observation was made. Rather the topography, data and literature are all consistent with the URS conceptual model.

I acknowledge that there is limited local scale bore log data immediately below the Great Dividing Range. However, all geological data, either side of the Great Dividing Range, has no recognised structural complexity, such as beds dipping to the east, which would be evident if anticline folding to the extent required to support Dr Webb's and Dr Mudd's conceptualisation was present (either in the literature or on site).

Therefore, although there is no direct data to completely disprove that folding exists, all available evidence (i.e. literature and field data) suggests that folding of the nature suggested by Dr Webb and Dr Mudd does not exist and supports the conceptualisation of the URS modelling.

Influence on impact evaluation

The modelling approach adopted by URS during the Environmental Impact Statement (EIS) process was to consider worst case scenarios when evaluating the potential impacts of mining on the groundwater resources. To this end no artificial folds or geological structures were included in the model. The inclusion of folds or similar geological structures would limit the assessment of possible dewatering impacts on the Great Artesian Basin.

Should folds occur, as suggested by Dr Webb and Dr Mudd, then this folding would limit any potential drawdown extension to the west. Dr Webb agrees that an anticline would prevent further migration to the west (see Fig 8 in Dr Webb's report).

Considerations

The model simulations of Alpha Coal Mine based on aquifer hydraulic parameters (hydraulic conductivity and storage) and the predicted drawdown (0.5 m drawdown in the D coal seam) only extends to the western mine lease boundary at the end of mine life (Figure 5). The predictive modelling indicates that groundwater drawdown at the end of mining and post-closure (300 years) does not result in drawdown at the Great Dividing Range. The predicted drawdown contours in the D seam after 300 years, associated with the final void, is presented in Figure 6.

Therefore, in my opinion the inclusion of geological structures (or not) does not interfere with the model predictions, as the western boundary is sufficiently far from the mining so as not to have an influence and predicted groundwater drawdown does not extend to the Great Dividing Range.

Summary

All data available supports the URS geological conceptualisation. The geological conceptualisation of all other projects proposed in the area and a third party review is consistent with the URS modelled conceptualisation. I do not consider that the available data supports the geological conceptualisation of Dr Mudd and Dr Webb.

The Alpha Coal Mine conditions (Appendix C) included for the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the west of Alpha mine lease. It is considered that these bores will provide additional geological data, which will be used in the regular model audits (Coordinator-General's Evaluation Report Appendix 3, Part B).

*Figure 5 Drawdown contours in the D seam at Life of Mine*

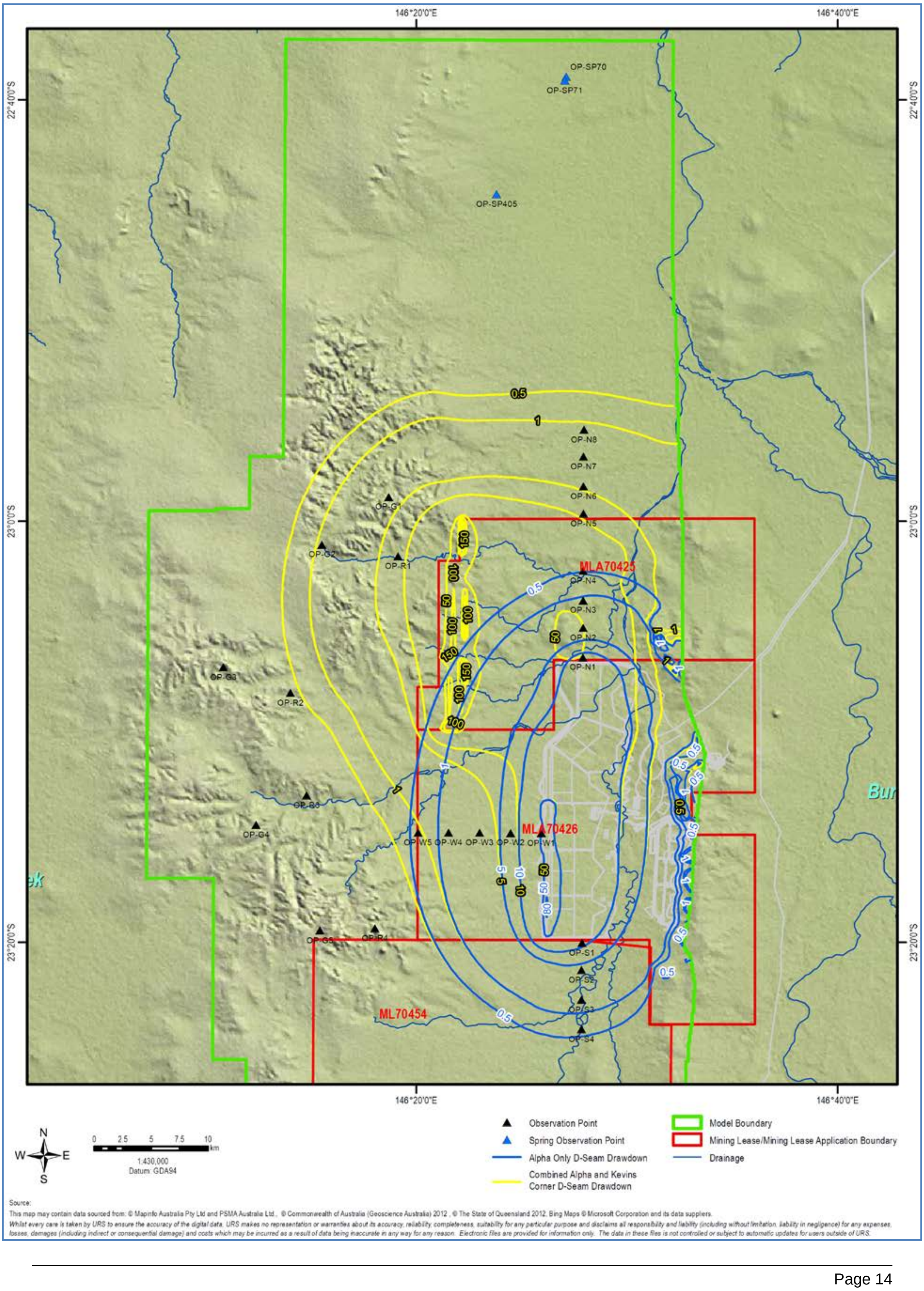
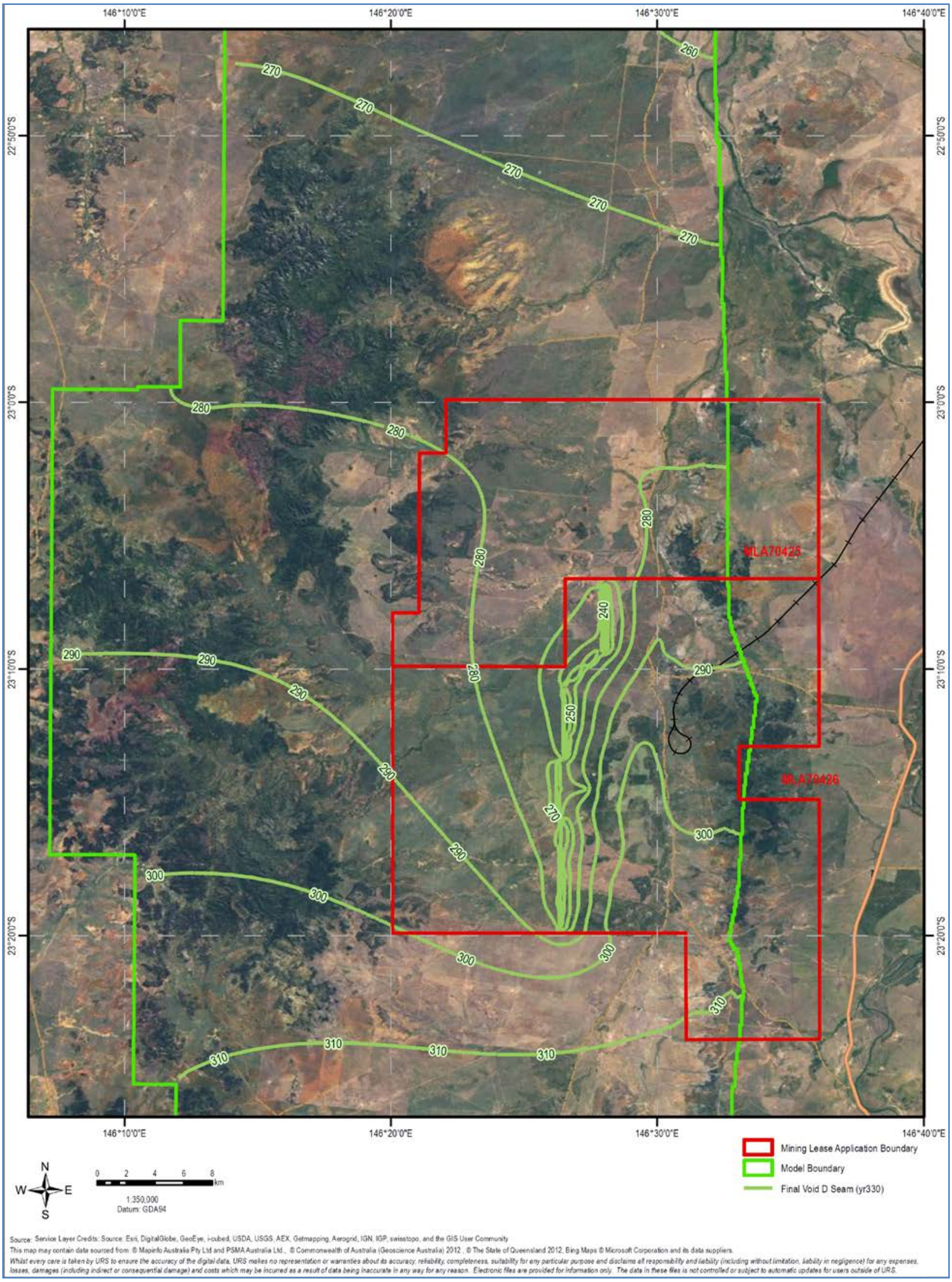


*Figure 6 Final void D seam groundwater contours after 300 years*



### 4.1.2 A point of disagreement was the regional geology based on differences in the Salva Resources regional geology and Dr Webb's data sets.

Issue

Some of the geological boundaries in the Salva Resources GAB Model, particularly the upper and lower boundaries of the Rewan Formation, differ from those mapped by Dr Webb using remote sensing and also from those depicted on the Jericho 1:250,000 geological map.

During the Joint Experts Meeting it was discussed that the subcrops matched the outcrops mapped on the Jericho 1: 250 000 geological map as well as the coal seam subcrops. Dr Webb provided data for comparison which he said showed the Rewan Formation subcrop contours did not match (See paragraph 76 of the Joint Experts Report).

Evidence

Dr Webb, in his comments on this Point of Disagreement (Point 26) in the Joint Experts Report, identified the source of the Rewan Formation subcrop to be Figure 4-6 in the Alpha Coal Project EIS volume 2, section 04 Geology, page 4-9.

Data Sets

For the purposes of clarity, it is noted that there are two geological models that were generated by Salva Resources. These are:

- A site specific model, which was based on the exploration data across the mine lease application area, which was generated specifically for project purposes (mine planning, resource estimation, etc.). This model is referred to as the Salva Resources geological model of the Alpha and Kevin's Corner mines; and
- The Salva Resources GAB Model, which took the existing information (from the site specific model) and added data from additional sources outside the lease application area (petroleum wells, geological survey stratigraphic wells, etc.) to produce a GAB geological model. The GAB geological model was put together specifically for the purpose of providing a schematic cross-section indicating the broad trend of dips and strike of the Galilee Basin and Great Artesian Basin stratigraphy.

Figure 4-6 of the Geology EIS section was compiled to provide coal seam subcrop information for consideration of possible sterilisation of coal resources (Figure 7). The Rewan Formation subcrop was included, from the Salva Resources geological model of the Alpha and Kevin's Corner mines, to indicate the extent of coal resources across the mine lease application areas.

The difference in geological boundaries was as a result of the Rewan Formation mapped by Salva Resources (Figure 8) was the upper (western) edge of the Rewan Formation (the outcrop of the Rewan Formation as shown on cross-section Figure 12) and the Figure 4-6 of the Geology EIS section provided the eastern subcrop location (i.e. the contact between the Rewan and Bandanna formations below the Tertiary). It is noted that this boundary is the most reliable based on site specific exploration data and smaller scale accuracy.

*Figure 7 Geology subcrops as mapped from the Salva Resources geological model of the Alpha and Kevin's Corner mineral leases – showing the eastern Rewan Formation subcrop*

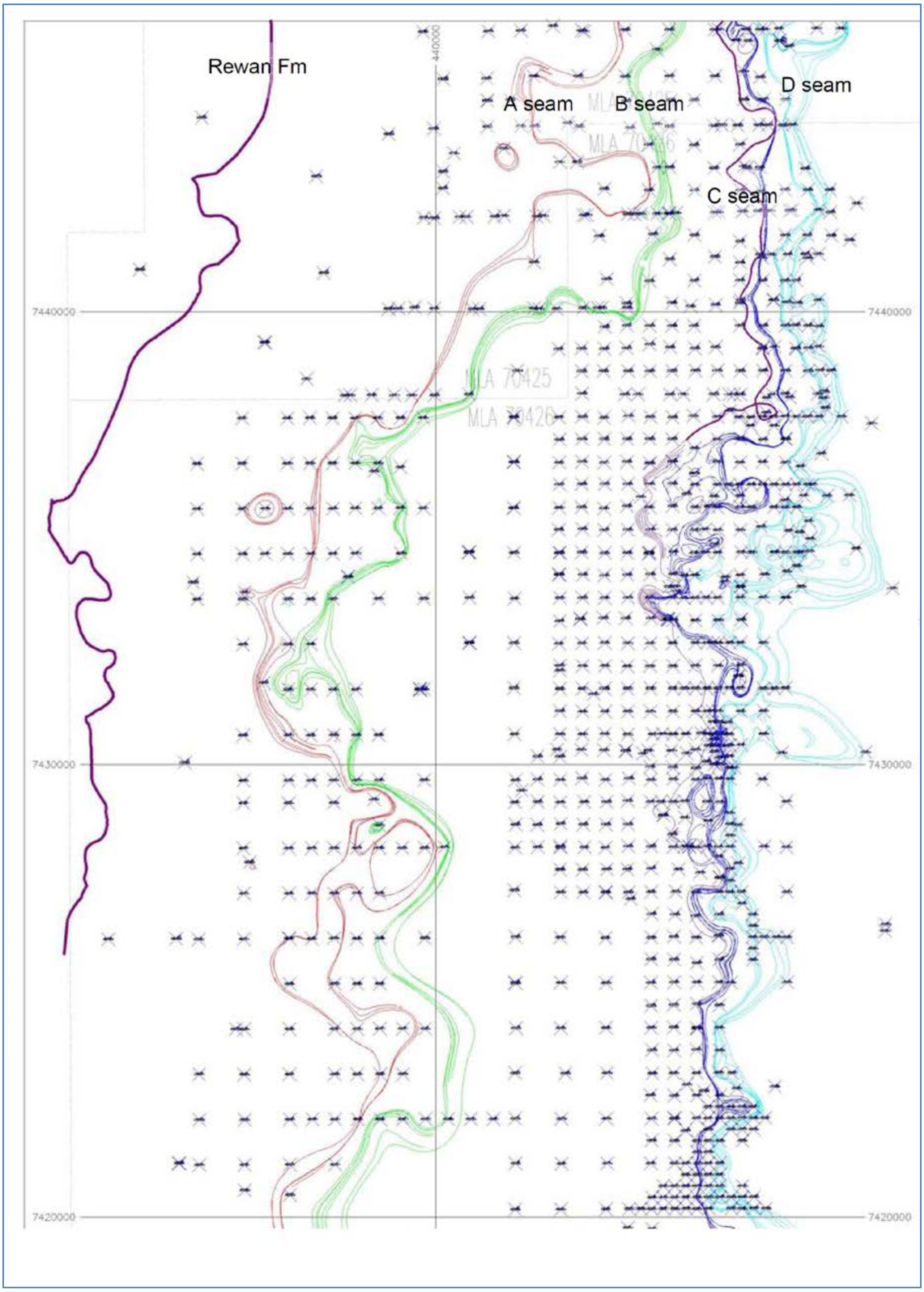
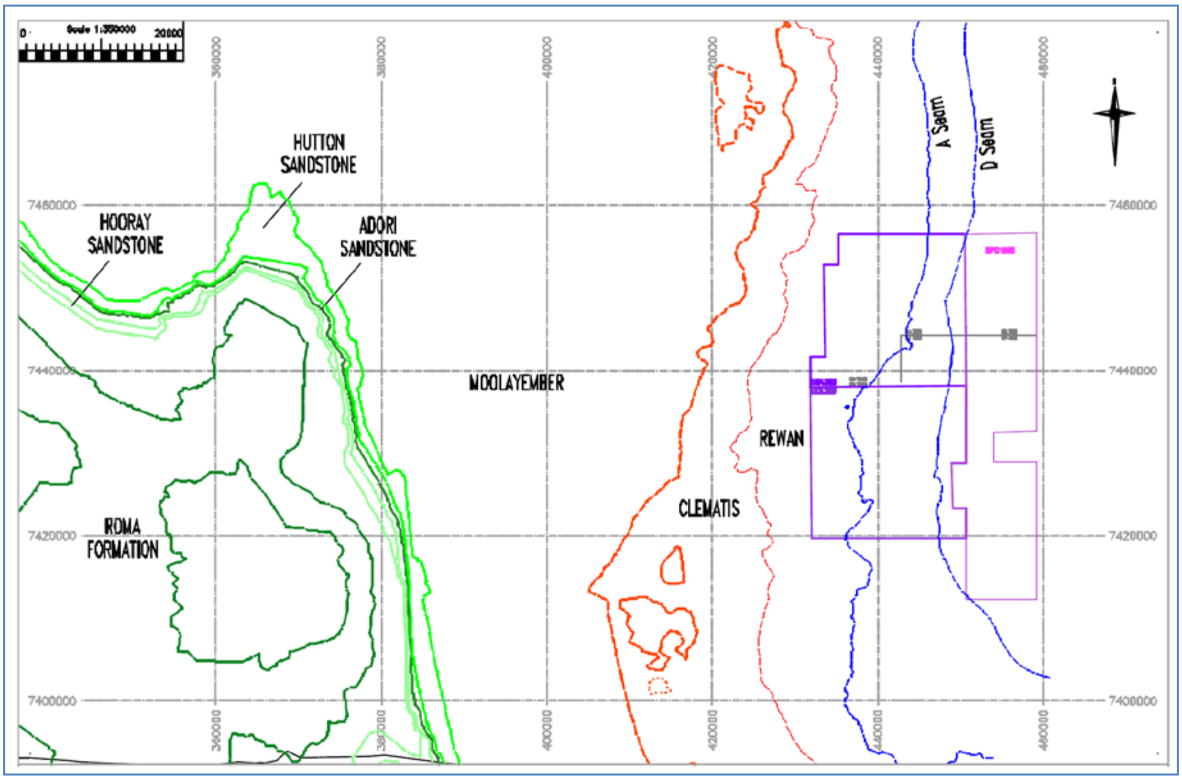


*Figure 8 Geological subcrops as mapped from the Salva Resources GAB Model –showing the western Rewan Formation outcrop*




Considerations

The groundwater model layer elevations, units, and thickness were created from the Salva Resources geological model of the Alpha and Kevin's Corner mines. It was agreed in the Joint Experts Report that the local geology, within the mine footprint, has adequately been represented in the Environmental Impact Statement reports in terms of units, strata thickness, dip, and strike (Point 9, paragraph 21 of the Joint Experts Report).

I therefore consider that the geological units included in the groundwater model, based on the Salva Resources geological model of the Alpha and Kevin's Corner mines were suitable to assess potential groundwater impacts.

I note that the geology to be disturbed during mining controls the groundwater inflow and impacts of the proposed workings, both directly and indirectly. Having a good understanding of the geology, and associated groundwater properties, based on detailed drilling allowed for the construction and design of a suitable groundwater model.

I also considered that Dr Mudd's comment on this Point of Disagreement (Point 26 paragraph 83 of the Joint Experts Report) is not relevant to the geological subcrop mapping under discussion, which is based on extensive exploration drilling, bore logs, and geological modelling (Salva Resources geological model of the Alpha and Kevin's Corner mines).

Summary

I consider that this disagreement point is largely academic and arose from a lack of clarity regarding data sources, and does not impact or influence the resultant modelling.

#### 4.1.3 A water table, unconfined and semi-confined, occurs within the Tertiary saprolite

Issue

Dr Webb commented that the water table data presented in the Out-of-Pit Tailings Storage Facility: Hydrogeological Assessment; Alpha Coal Project Supplementary EIS, ADDENDUM C shows that the water table within the Tertiary saprolite has essentially the same elevation as the potentiometric surface of the Colinlea Sandstone, suggesting that in this area the Colinlea Sandstone may be unconfined.

I maintain that the Permian units, the Bandanna Formation and the Colinlea Sandstone, are confined and hydraulically separate from the unconfined overlying units and water tables.

Evidence

Figure 5-2 of the Out-of-Pit Tailings Storage Facility: Hydrogeological Assessment; Alpha Coal Project Supplementary EIS, ADDENDUM C, does not include any water table or potentiometric surface levels, and does not include comment on the groundwater level data results included in Table 5-2 of the same report (Figure 9). The reason for the figure was to illustrate the geological units below the proposed Tailings Storage Facility and illustrate the groundwater resources are located at depth below the alluvium associated with Lagoon Creek.

I refer to the groundwater monitoring data compiled in Appendix A of the Groundwater Model Report (URS, 2012), which provides groundwater elevation data for five (5) standpipe monitoring bores in the Tertiary saprolite. The groundwater level data, for six monitoring events between 2011 and 2012, from these bores indicate an average groundwater elevation of ~ 300 mAHD. The monitoring bore ASTF-06B, screened within the D-E sandstone has an average groundwater elevation of ~ 304.5 mAHD. This indicates a difference of ~ 4 m.

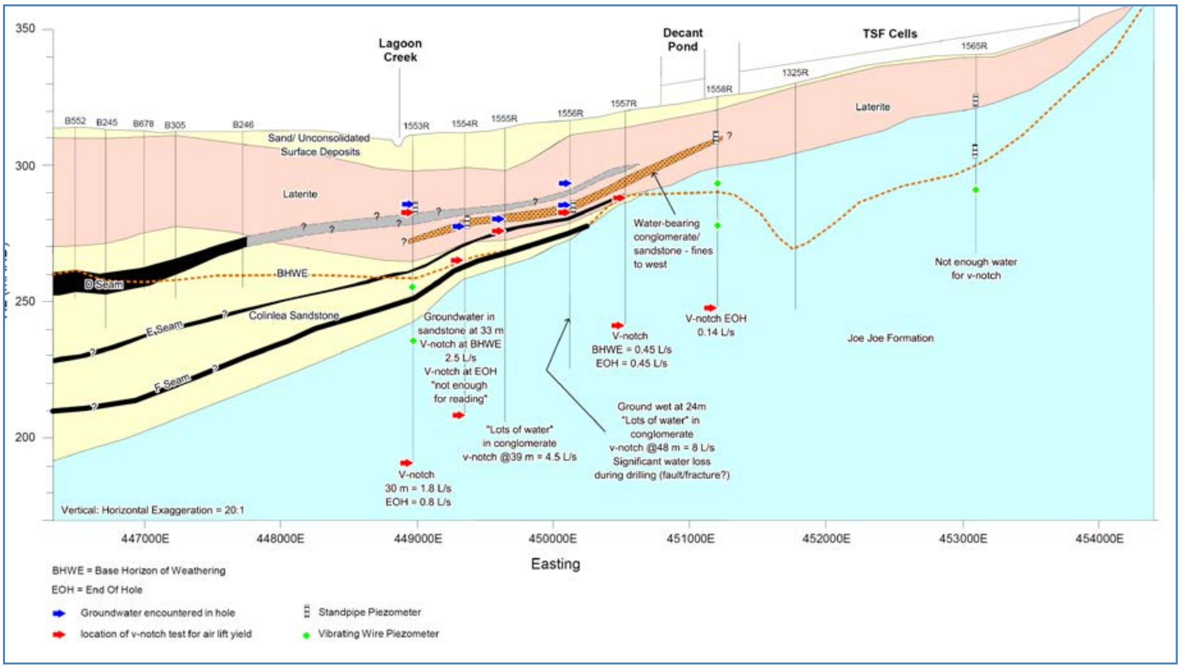
Considerations

I consider that the unconfined water table and the confined potentiometric surface are separate based on groundwater monitoring data and groundwater drawdown results recorded during the Alpha Test Pit dewatering (Groundwater Model, 2012). The separation confirms no hydraulic connection between the confined Permian aquifers and the perched groundwater table and surface water resources, on or down gradient of Alpha mine lease (as per Response 13 of my Expert Witness Report).

I considered that the difference of 4 m is not “*essentially the same elevation*” as stated by Dr Webb. This measurable separation confirms the confined nature of the Permian units and does not result in uncertainty.

This recognition of the separation and no hydraulic connection between the different groundwater resources allowed for the assessment of potential impacts of induced flow, from the overlying water table to the depressurised and dewatered Permian units during mining, in the groundwater model.

*Figure 9 Cross-section below the proposed Tailings Storage Facility*




## Summary

Based on the available groundwater level data I consider that the evidence supports URS understanding of the groundwater and modelling.

### 4.1.4 The use of a no-flow boundary along the western boundary of the groundwater model to simulate a groundwater divide

Issue

It was agreed by Dr Webb, Mr Hair, and myself that it was appropriate to simulate a no-flow boundary along the western boundary of the groundwater model to simulate a groundwater divide.

Dr Mudd considers his model simulates a constant head boundary to the west.

Conceptualisation

A groundwater divide is recognised within the Great Dividing Range and a no flow boundary is considered the most appropriate boundary condition to represent the groundwater divide in the groundwater model.

Dr Mudd considers, based on his conceptual geological model which includes folding, that the Great Dividing Range is effectively a constant head boundary, and refers to the information presented in the Galilee Coal Project Groundwater Assessment (Heritage Computing Report, 2013).

Evidence

URS recognised that a groundwater divide is likely to exist within the Great Dividing Range based on available groundwater level data from the Department of Natural Resources and Mines (NRM) groundwater database. The database includes one observed groundwater level to the west of the Great Dividing Range being lower than an observed groundwater level east of the range (Section 7.4.1 Groundwater Model Report, URS 2012). As groundwater flow is recognised to flow northeast on the eastern side of the divide it was interpreted that a likely groundwater divide exists. Thus a no-flow boundary was assumed in the model to represent the groundwater divide.

In the Joint Expert Report Dr Mudd adopts the Galilee Coal Project Groundwater Assessment (Heritage Computing Report, 2013), stating at paragraph 73 that "I maintain the view that the GDR is effectively a constant head boundary, as presented in the Waratah Galilee SEIS and shown in Appendix B Figure 1".

I have reviewed the groundwater model included in the Galilee Coal Project Groundwater Assessment (Heritage Computing Report, 2013). The model is a MODFLOW model constructed as a rectangle 120 km North-South and 130 km West-East. This approach, making a large model area, was conducted to prevent boundary effects on the model outcomes. It is noted that URS adopted the same approach when selecting their model boundaries sufficiently far away from the mine area.

The model uses General-Head boundaries (which allow for the variation of flux with head across the boundary, even if the area on the other side of the boundary has been designated non-active) on the north, west and south boundaries. This allowed for lateral inflow/outflow to/from the model area, which facilitated in the steady-state model calibration.

The model boundaries are presented on Figure 4-4 (Figure 10), not on Figure 3-6 (the conceptual model (Figure 11)) and not Figure 3-8 as written in the Galilee Coal Project Groundwater Assessment report (this is a figure showing groundwater levels).

*Figure 10 Galilee Coal Project Groundwater Assessment model boundaries (Figure 4-4)*

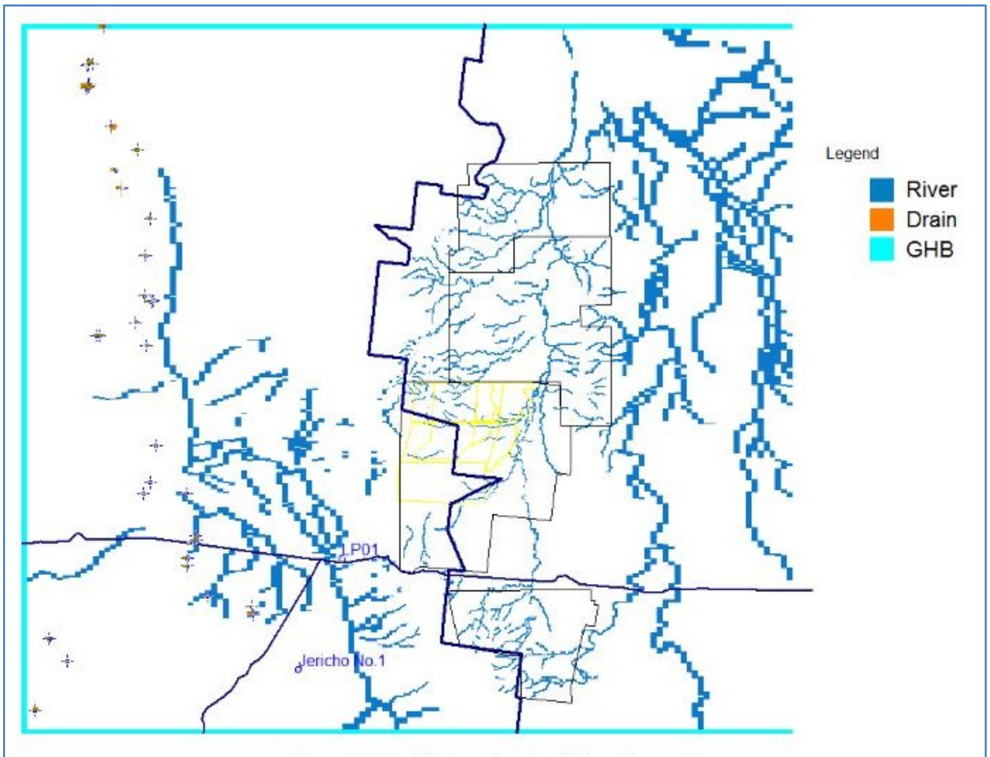



Figure 4.4 Model Boundary Conditions [Layer 1]

*Figure 11 Galilee Coal Project Groundwater Assessment conceptual model*

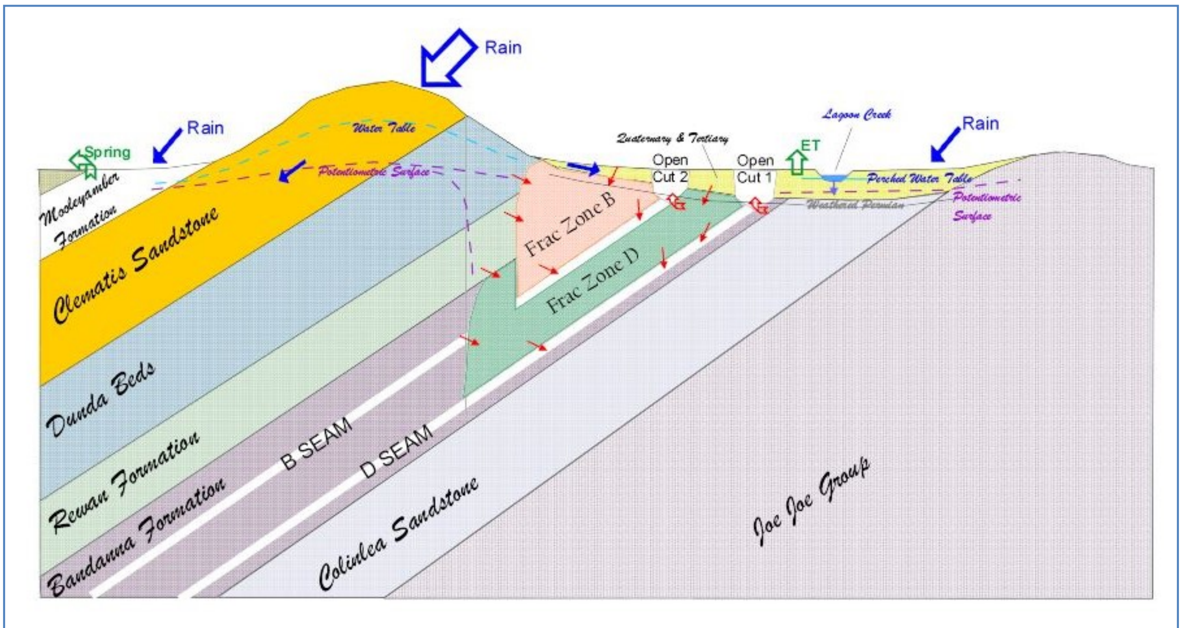



Figure 3.6 Conceptual Hydrogeological Model

Therefore, the revised Galilee Coal Project Groundwater Assessment model does not include constant head boundaries within the Great Dividing Range

The Waratah SEIS Galilee Coal Project Groundwater Assessment conceptual model (Section 3.10 of the SEIS report) recognises that local groundwater tends to mound beneath hills, which is consistent with the URS conceptualisation groundwater model (Figure 1 and Figure 11).

Considerations and Summary

I consider that there is no positive evidence to support Dr Mudd's view that the western model boundary, adopted by URS in their modelling, is incorrect and requires revision. This consideration is based on:

- The consensus of Iain Hair, Dr Webb and myself that a no-flow boundary is appropriate;
- The Waratah SEIS Galilee Coal Project Groundwater Assessment (Heritage Computing Report, 2013) includes a revision of the original EIS conceptualisation, which does not include a constant head boundary or geological structure within the Great Dividing Range;
- The independent model review, conducted by Parsons Brinckerhoff (Appendix D Groundwater Model Report, URS 2012), which indicates the boundary is reasonable based on the conceptualisation; and
- The groundwater level data evidence that supports the URS conceptualisation.

All positive evidence available, including the Galilee Coal Project Groundwater Assessment (Heritage Computing Report, 2013) (on which Dr Mudd has identified he relies upon in the Joint Experts Report), supports the URS conceptualisation.

#### 4.1.5 The western No-Flow boundary

Issue

I formed the opinion that the use of a no-flow boundary (not allowing water to enter from the west into the model) was a worst case (higher drawdown could result if dewatering reached the boundary) approach.

Dr Webb considers that his conceptualisation of the no-flow boundary is very different to Mr Hair and Mr Stewart, and considered it a Point of Disagreement.

It is noted that as groundwater drawdown predictions do not reach the western model boundary thus this issue is rather more academic than of direct consequence to the Alpha Coal Mine groundwater impact assessment.

Conceptualisation

URS included a no-flow boundary in the groundwater model within the Great Dividing Range as it was recognised that a groundwater divide was likely to exist based on groundwater level data (on either side of the Great Dividing Range near Alpha Coal Mine).

My opinion was that the use of a no-flow boundary was a worst case approach, in keeping with URS impact assessment approach, as it assumes no groundwater flow from the western side of the Great Dividing Range, even though the strata are hydraulically connected. I consider that, as the geological units are lateral equivalents and are continuous, that they are hydraulic connected.

Dr Webb does not consider the no-flow boundary to be conservative and disagrees with the possibility that groundwater could be induced across the groundwater divide (Paragraph 94).

<u>Evidence</u>

URS conceptual model is based on the Mott and Associates (1990) cross-section and discussion of the Colinlea Sandstone on a regional scale (Section 4.4.2 of the Groundwater Model Report, URS, 2012) and the Galilee Basin Operators Forum west-east cross-section (reproduced in Figure 2 of this report). These cross-sections indicate the pinching out of the Permian units and the continuous nature of the units.

<u>Considerations</u>

The schematic section through the Galilee Basin and GAB was constructed based on the Salva Resources GAB Model (Figure 12), which was compiled to provide a broad trend of dip and strike and provide a visual representation of the different geological units and stratigraphy to illustrate the target coal seams in relation to the GAB units, i.e. shows the Rewan Formation aquitard which forms the base of the Great Artesian Basin separates the older target coal seams. This figure, like the geology and groundwater data compiled over the life of the study, was superseded as new groundwater information became available, i.e. the groundwater concepts were refined over time.

In Paragraph 96 Dr Webb considers that if drawdown at Alpha Coal Mine extended across the groundwater divide then this would cause inflow from the west. He then considers that this could impact on the GAB as the Permian strata pinch out well within the GAB.

This was the approach adopted by URS in the modelling to allow for the assessment of potential impact on the GAB; the modelling considered the potential impact of coal seam depressurisation extending to the west and the potential for induced flow from the overlying and underlying units.

The Groundwater Model Report (URS, 2012) includes observation points within the model to consider the potential drawdown at these locations during mining and for a period of 300 years post mining. The resultant projected drawdown was then considered in terms of potential for induced flow from the Rewan Formation and the Clematis Sandstone (Section 13 of the Groundwater Model Report, URS 2012).

It is noted that the Permian units (equivalents of the Bandanna Formation and Colinlea Sandstone) to the west are below the Great Artesian Basin and not included in the Great Artesian Basin as considered by Dr Webb, and that these units are confined above and below by the Rewan Formation and Joe Joe Formation.

The western boundary the target coal seams are considered to pinch out against the Drummond Basement, based on Figure 4-7 (Mott and Associates 1990) of the Groundwater Model Report (URS, 2012) (Figure 13). However, it is agreed with Dr Webb that the Galilee Basin Operators Forum cross-section (Figure 2 of this report) shows the potential for the Permian units to be in contact with the Hutton Sandstone (a GAB aquifer).

I consider that the drawdown associated with the Alpha Coal Mine, as modelled, is sufficiently far from the groundwater divide in the Great Dividing Range that the projected drawdown, based on aquifer parameters and mine depth and location, will not reach the groundwater divide and induced flow across the divide.

*Figure 12 Cross-section through the Salva Resources GAB regional model*

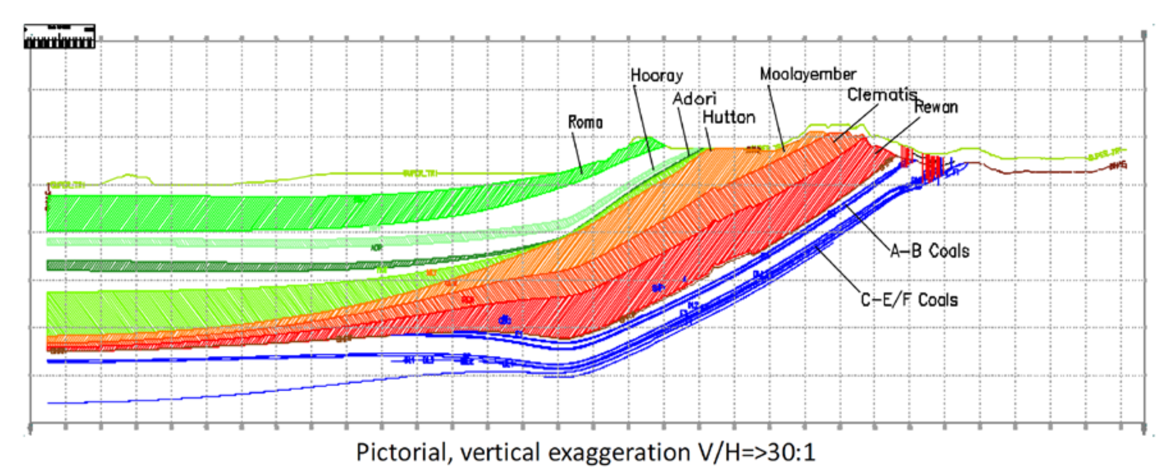
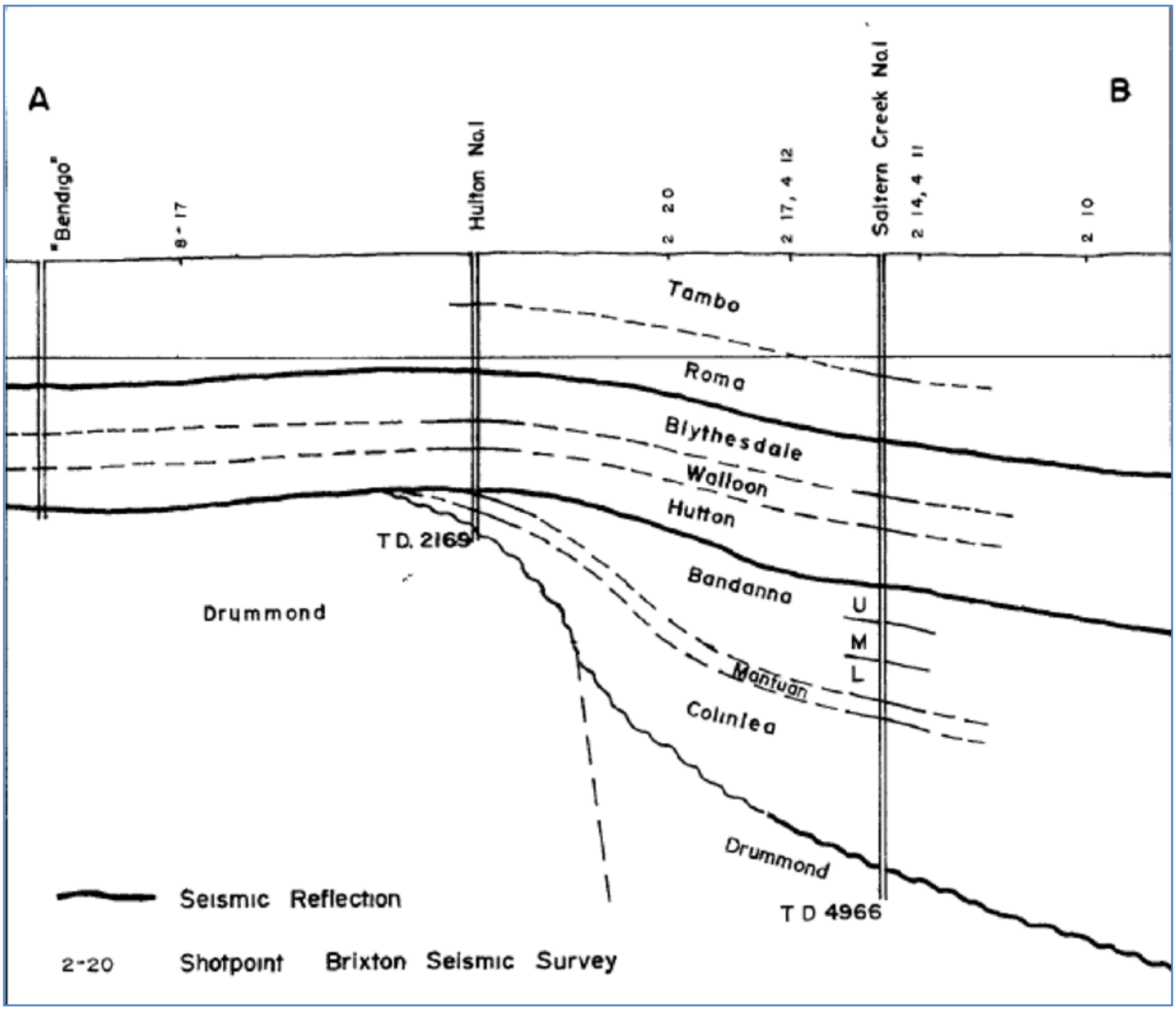



*Figure 13 Geological cross-section from Mott and Associates, 1990*



A regional groundwater model considering the Galilee Basin, as conditioned by the Coordinator-General, will need to consider this boundary and impacts should other mining operations occur within or below the Great Dividing Range.

Impact Assessment

Using the no-flow boundary approach model simulations of Alpha Coal Mine predicted drawdown (0.5 m change in the steady-state potentiometric pressure associated with the D coal seam) only extends as far west as the western Alpha mine lease boundary at the end of mine life (Figure 5).

The predictive modelling indicates that groundwater drawdown at the end of mining and post-closure (300 years) does not result in drawdown extending any further westward as post-mining groundwater levels stabilise. The predicted long term groundwater contours in the D seam after 300 years, associated with the final void, is presented in Figure 6.

It is noted that the inclusion of folds and associated elevated potentiometric heads, as conceptualised by Dr Webb and Dr Mudd would prevent drawdown migration to the west. Due to the lack of data a more cautious approach was employed.

Summary

With regards to Point of Agreement (Point 21) of the Joint Experts Report, Dr Webb and I agree that the Great Dividing Range represents a no-flow boundary and model predictions indicate will be no impact of dewatering within the Alpha Coal Mine on the Great Artesian Basin (in terms of groundwater quality or quantity). I, therefore, consider that this point of disagreement is largely academic.

#### 4.1.6 Zone of influence (drawdown impacts) and propagation of drawdown cone to the north over time due to removal of recharge

Issue

Dr Webb considers that the drawdown cone will propagate to the north over time due to interception of recharge and northwards groundwater flow (referred to as through flow).

I consider that the groundwater modelling already includes (i.e. models for) the inception of through flow and the inception of recharge.

Further based on the low hydraulic conductivity of the units, the drawdown impacts (zone of influence) have been correctly projected for the simulation periods (30 years life of mine and 300 years post-mining).

Dr Mudd would have been preferred if the model was run for longer, say up to 500 years post-mining to ensure steady state conditions were achieved across the whole Alpha model region to address this issue.

Conceptualisation

The purpose of the groundwater modelling was to assess the extent of impact due to the mine dewatering and the impacts of ongoing groundwater loss (through evaporation from the final void).

URS considered that using the low calibrated recharge allowed for an assessment of a “worst-case” simulation of head decrease and drawdown propagation. The model allowed for the simulation of mine dewatering using drains (Groundwater Model Report URS 2012) which removed groundwater from storage (i.e. the groundwater held within the aquifers), through flow, and induced flow from over- and under-lying units.

Dr Webb considered that the groundwater system is “dynamic” and that the drawdown cone will propagate to the north over time, due to interception of recharge and northwards groundwater flow (paragraph 148 of the Joint Experts Report).

In response to my consideration of the assessment of the Theim-Dupuit Steady-State Equation (Paragraph 125 of the Joint Experts Report) that considers the zone of influence around an open mine pit to reach equilibrium (i.e. stop projecting once a pseudo steady-state arises based on the final void extraction and the aquifer parameters) Dr Mudd considers the equation to be relevant to unconfined aquifers and suggests a revised Theim-Dupuit Equation for confined aquifers.

I note that due to printing / formatting issues in the Joint Experts Report the Theim-Dupuit Steady-State Equation (Equation 1 on page 34, paragraph 125) is incorrect. The equation should read:

$$Q = \frac{\pi k (h_o^2 - h_w^2)}{\ln(R / r_e)}$$

Evidence

The extent of drawdown (zone of influence) associated with groundwater extraction is determined by the aquifer hydraulic properties; hydraulic conductivity (k). The k values for inclusion in the model were determined through model calibration corresponding to field test values in this case, including the transient groundwater (level and volume) data obtained from the Alpha Test Pit dewatering. All the experts agree that the aquifer hydraulic parameters included in the model are representative, including the hydraulic conductivity of the units.

Modelling indicates that drawdown propagates slowly due to low hydraulic conductivity in the system. Head decrease does not propagate to the constant-head boundary during the evaluation period of 330 years.

Groundwater flow within the model domain is very low, based on groundwater gradients and k values, thus the system is considered “static”, in the terms of measurable changes in groundwater conditions. Darcy’s Law provides an indication of the groundwater flow rate (referred to as Darcy velocity or flux) across the site using the modelled data for the D coal seam, using v = ki, where

- k = 0.01 m/day for D coal seam (Table 11-4 Groundwater Model Report, URS 2012)
- i = hydraulic gradient, 90 m change in groundwater level over the model length of 118.5 km, 0.00076

Darcy velocity = $7.6 \times 10^{-6}$ m/day or 0.0028 m/year

Dr Webb states in his Expert Report (paragraph 62) that following Darcy’s Law any decrease in groundwater flow will cause a corresponding decrease in hydraulic gradient, thus the interception of recharge and reduction of northwards groundwater flow will result in potentiometric surface drop to the north.

I am not aware that any calculations or mathematical assessment, based on provided aquifer hydraulic parameter data, was used by Dr Webb to assess his assessment or consider the possibility of a static groundwater system.

Consideration

Based on the limited (calibrated) recharge and slow groundwater movement on site the mine dewatering simulated in the model allows for the assessment of removing the majority of groundwater from storage allowing for an assessment of the extent of drawdown. The inception of recharge and through flow, albeit small, occurs during the 30 year mining simulation.

Groundwater recovery occurs post mining and post-mining groundwater flow patterns were projected considering the impacts of the final void. The water level in the final void achieves a pseudo steady-state, which in turn influences the radius of influence around the final void. The residual zone of influence is maintained based on the relative steady extraction based on evaporation from the final void (as discussed in paragraphs 120 to 128 in the Joint Experts Report). Thus the zone of drawdown remains relatively constant during the model simulation and is not considered to extend measurably further north as a result of diminished through flow.

I consider that either of the two Theim-Dupuit equations can be considered as the open pit results in unconfined aquifers and aquifers away from the mine void are confined. These equations both allow for the consideration of the controlling factors when assessing the zone of influence as a result of groundwater extraction. In both these equations once the groundwater inflow effectively equals the effective discharge (pit evaporation), as the other factors are constant, the radius of influence (R) is determined. R is the distance to negligible drawdown.

Dr Mudd recognises that a pseudo steady-state, when discharge from the final void (due to evaporative loss) effectively equals groundwater inflow, will occur (paragraph 135 in the Joint Experts Report).

Modelled simulations of groundwater ingress after mining ceases resulting in continued groundwater extraction of ~ 600 $m^3$/day which reduces to ~ 450 $m^3$/day (7 to 5 L/s) after 300 years. The majority of this groundwater is considered to be derived from enhanced recharge across the backfilled mine footprint, an area of ~ 185 $km^2$. This does not appear to be considered by Dr Webb when he considered the removal of groundwater from the catchment (paragraph 151) or in his revised assessment (paragraph 6 of Dr Webb’s Supplementary Expert Report, dated 13 August 2013).

Impact Assessment

I consider that the groundwater system is relatively “static” rather than “dynamic” because groundwater moves slowly due to low hydraulic conductivity, slow groundwater through flow, limited recharge, and discharge.

The modelled predictions, within the model simulation, adequately consider:

- Recharge and through flow capture during the mining and post-mining;
- The extent of drawdown cone development over time;
- The effects of the final void extraction, aquifer hydraulic parameters, and the long term groundwater levels (flow patterns, contours, and gradients); and

- The post-mining water balance, considering inflows and outflows associated with the final void.

Summary

I consider the site specific data, which indicates a static groundwater system, supports the URS modelling and the predictions of the drawdown and groundwater ingress over time.

Based on the site information regarding aquifer parameters and the final void, acting as a "sink" providing a constant extraction, I consider the zone of influence to reach a steady-state and not continually extend northwards in the modelled time frame.

This assessment of groundwater impacts is considered valid based on groundwater monitoring conducted at coal mines in the Bowen Basin, which have been operational for 10s of years. Groundwater monitoring indicates groundwater levels are not readily impacted by mining based on the aquifer hydraulic parameters.

I consider that the conditions included in the Coordinator-General's report, Appendix C of the Joint Experts Report included for the development of a groundwater monitoring program, which will allow for the verification and assessment of the model drawdown predictions. These data will also allow for the refinement of the Alpha Model (Coordinator-General's report Appendix 3 Part B Recommendation 2) and the development of a basin wide groundwater model (Coordinator-General's report Appendix 2 Part B Condition 2).

#### 4.1.7 Constant head boundaries

Issue

Dr Webb in his Expert Report indicates that decreasing head boundaries should be simulated in the model rather than constant head boundaries, which are included in the URS groundwater model.

Dr Mudd in his Expert Report indicates, in his view, that the incorrect boundary conditions are assumed in the URS groundwater model (URS, 2012). However, it is not clear which boundaries or what type of boundaries Dr Mudd is referring to. He does comment on the western boundary which is discussed in Section 4.1.4 above.

URS have selected the constant head boundaries, incorporated in the model to allow for the calibration of the groundwater model, sufficiently far from the mining areas so the head boundary can remain the same even after the 30-year mining operation period and not affect model predictions of groundwater drawdown and groundwater ingress volumes.

Conceptualisation

Dr Webb comments that because the drawdown cone will propagate to the north over time, due to interception of recharge and northwards groundwater flow, the assumption in the model of a constant head boundary on the northern boundary needs revision. The southern boundary, according to Dr Webb, would probably have been better if it were extended to the drainage divide and defined as a no-flow boundary (paragraph 154 of the Joint Experts Report).

Dr Mudd considers that the southern boundary should be reassessed when considering cumulative drawdown from multiple proposed coal mines in the region.

URS included the constant head boundaries some 40 km from the south MLA40726 Alpha boundary and ~ 50 km north of the northern MLA40726 Alpha boundary (Figure 3). These distances plus an assessment of the inflow and outflow across the constant head boundary before and after the mining operations (which indicated negligible difference) indicates that north and south boundaries do not influence mine predictions and are used correctly in the predictive groundwater modelling.

Evidence

Dr Webb quotes several literature comments regarding the influence of constant head boundaries on models, with regards to flow and influence on results. He does not, however, indicate how the location of the boundaries relates to the influence on results.

Dr Webb includes a simple catchment water balance analysis to illustrate the possible loss of groundwater through flow if all the groundwater was captured and that this would result in the propagation of drawdown within the dynamic system, which would eventually affect the constant head boundary (paragraph 151 of the Joint Experts Report).

The groundwater modelling drawdown predictions at the end of mining at Alpha Coal Mine indicate the 0.5 m drawdown contour (0.5 m difference in pre-mining levels) extends ~ 8 km south and north of the MLA40726 Alpha boundary (Figure 5), some 32 to 46 km from the constant head boundaries. These distances are sufficiently far not to have an influence on the drawdown predictions.

The groundwater model simulation used calibrated recharge values, considered through flow capture, and removal of groundwater from storage to allow for an assessment of a “worst-case” simulation of head decrease and propagation. Modelling indicates that drawdown propagates slowly due to low hydraulic conductivity in the system. Head decrease does not propagate to the constant-head boundaries during the evaluation period of 330 years.

It is noted that the independent due diligence assessment of the groundwater model, conducted by Parsons Brinckerhoff (Appendix D Groundwater Model Report, URS 2012) consider that the applied boundary conditions (north and south) are plausible and unrestrictive based on conceptualisation and likely to have minimal impact on model output.

Influence on Impacts

It is considered that in a groundwater modelling simulation, a head boundary is usually specified as constant head boundary or general head boundary, where both can be changing with a given time step (or stress period).

In this relatively “static” groundwater system using either a constant head boundary or a general head boundary does not make a difference to the modelling predictions as the drawdown does not extend to the boundary.

It is noted that a constant head boundary is a step function with time, where the head is set at a constant value (depth to groundwater) for a specified period of time (referred to as a time step). The difference when considering which type of head boundary is more suitable for this model was the consideration of the length of the time step (i.e. how long the head remains constant during the model simulation). Dr Webb considers that the time step should be smaller (allowing for the head to decrease with each time step) based on his concept of a “dynamic” system; whilst the model approach adopted by URS, considering a relatively static system, included the use of a constant head over the entire simulation period (i.e. the time step was the 30 years of mining and the 300 years post mining, 330 years).

This constant head for the entire model simulation (time step) approach is supported by site specific low hydraulic conductivity data (obtained during aquifer tests and the long duration Alpha Test Pit dewatering) and an assessment of the inflow and outflow (in terms of a calculated mass balance) across the constant head boundary before and after the mining operations. The calculated mass balance indicated negligible difference between the pre- and post-mining model simulations indicating that the flux across the constant head boundary had not changed (which would occur if the drawdown extends to the edge of the model, resulting in a different gradient between the model boundary and the adjacent model cell such that the flux would change).

Summary

I consider that based on the model boundaries being sufficient far from the simulated mine dewatering that they do not impact on model output. The discussion of whether to use a constant head boundary or general head boundary is largely academic in terms of assessing potential groundwater impacts.

Considerations

I consider that the conditions (Appendix C) included in the Coordinator-General's report, allowing for the refinement of the Alpha Model (Appendix 3 Part B Recommendation 2) and the development of a basin wide groundwater model (Appendix 2 Part B Condition 2) will, over time, allow for the validation and assessment of model boundaries.

#### 4.1.8 Recharge mechanisms, rates and influence on model

Issue

The groundwater experts could not agree on a recharge mechanism(s) or rate within the model domain. In addition, URS considered that the use of a low recharge rate, based on model calibration, allowed for a more rigorous evaluation of the predicted cone of depression in the impact assessment (i.e. using the lowest recharge rates considered allowed for the consideration of a worst case scenario).

Dr Webb agrees that negligible recharge could in one sense be regarded as a worst-case scenario, because the resultant reduced groundwater inflow would cause a larger modelled drawdown cone compared to a model with higher recharge. However, he considers the reduced groundwater flow means that the impact of mining through intercepting this groundwater flow will be underestimated (paragraph 175 of the Joint Experts Report).

Dr Mudd considers that the groundwater level monitoring conducted to date is limited to the immediate environs of the proposed mine areas (Alpha and Kevin's Corner coal mines) and there are none in sandstone outcrop or subcrop areas. He considers this limits any understanding of the potential for higher recharge rates in localised areas, which he considers is also crucial to understanding hydrogeological boundary conditions and groundwater behaviour for the region (paragraph 176 of the Joint Experts Report).

Conceptualisation

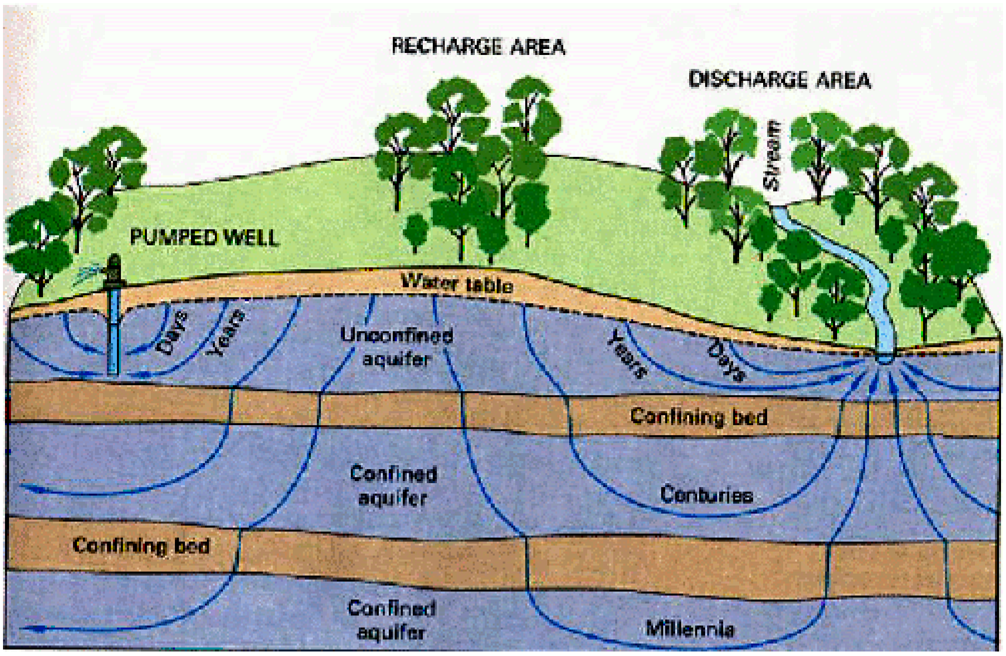
*Recharge mechanism(s)*

Dr Webb considers the main recharge areas for the Bandanna/Colinlea aquifer in the proposed mine area are along the crest of the Great Dividing Range, based on his conceptualised geological model, i.e. where the anticline axes are located.

Dr Mudd considers episodic recharge is likely to occur in areas where there is either direct sandstone outcrop (such as the Great Dividing Range, or the small range east of the Alpha project and Lagoon Creek), or shallow sandstone subcrop.

URS considered, based on site geology and groundwater and rainfall hydrographs that recharge to the confined Permian aquifers occurs as result of diffuse recharge along the Great Dividing Range, where the Tertiary cover is thinnest. This mechanism allows rainfall recharge to enter the Bandanna Formation and migrate downwards to the Colinlea Sandstone over a considerable length of time (based on low permeability in the Bandanna Formation and through the various interbeds within the Colinlea Sandstone). Sketch 2 shows the typical timeframes associated with rainfall recharge to confined aquifers.

*Sketch 2 Groundwater recharge delays (www.guts4u.com)*




*Recharge rates*

Dr Webb agrees that recharge across the area of the mine lease is probably very small, but believes that recharge along the Great Dividing Range is small but significant. Based on the chloride mass balance method, using average groundwater salinity data, Dr Webb derived a recharge figure of ≤1% of rainfall.

Dr Mudd commented that it is reasonable to expect that overall average groundwater recharge rates are low, based on the various EIS and SEIS studies, the arid climate and other studies (e.g. Smerdon and Ransley, 2012). In his Expert Witness Report, Dr Mudd indicates that he does not believe, based on climatic conditions that high recharge rates occur within the Great Diving Range (paragraph 4.4.3). Dr Mudd considers that the average recharge rates would be very low, probably in the order of 1% of rainfall, but individual major rainfall or flood events may lead to important recharge events.

In the groundwater model, a recharge rate of < 0.1% of rainfall was applied. This rate was obtained through model calibration, considering groundwater level data, aquifer hydraulic parameters, and discharge mechanisms.

*Influence on the Model*

Dr Webb agrees that negligible recharge could in one sense be regarded as a worst-case scenario, because the resultant reduced groundwater inflow would cause a larger modelled drawdown cone compared to a model with higher recharge. However, he considers the reduced groundwater flow means that the impact of mining through intercepting this groundwater flow will be underestimated.

The impact assessment for the EIS adopted a worst-case scenario approach to allow for a rigorous evaluation of possible impacts on the groundwater resources. Simulating the low calibrated recharge to the confined Permian aquifers, to be impacted during mining, was considered a worst-case scenario as the cone of depression simulated at the end of 30 year life of mine would extend over the larger area based on the model removing the majority of groundwater from storage (i.e. minor recharge input over the 30 years of mine dewatering). Additional recharge (assuming the model would remain calibrated) would result in a smaller cone of depression.

Evidence

Dr Webb considers the rate of recharge based on the chloride mass balance method using average salinity data ((~2000-3000 µS/cm; 1200 mg/L TDS[3]) and the salinity of rainfall (~10-20 µS/cm) recharge should average around 0.5-1% of rainfall.

I consider that this approach is a simplification and based on the groundwater monitoring data, provided in Appendix A of the Groundwater Model Report (URS, 2012) the rates of recharge would vary markedly using this approach. Table 1 below provides the average salinity data for the different units compiled to date.

[3] TDS – Total dissolved solids

*Table 1 Groundwater monitoring data*

**Baseline Groundwater Monitoring Data**

| Units | | EC | Sodium | Chloride | TDS |
|---|---|---|---|---|---|
| | | µS/cm | mg/L Na | mg/L Ca | mg/L |
| **Surficial Deposits** | **Minimum** | 18500 | 3570 | 5850 | 11000 |
| | **Maximum** | 53300 | 12400 | 20100 | 36700 |
| | **Average** | 41543 | 9116 | 14742 | 28150 |
| | **Median** | 46000 | 9960 | 15900 | 30000 |
| **Tertiary** | **Minimum** | 900 | 178 | 192 | 520 |
| | **Maximum** | 54100 | 12700 | 20500 | 38600 |
| | **Average** | 36333 | 7573 | 12751 | 25188 |
| | **Median** | 27900 | 5100 | 9450 | 21700 |
| **Conglomerate with Laterite** | **Minimum** | 6950 | 1160 | 1940 | 4090 |
| | **Maximum** | 8840 | 1420 | 2920 | 6270 |
| | **Average** | 7884 | 1326 | 2505 | 5303 |
| | **Median** | 7780 | 1355 | 2550 | 5475 |
| **C-D Sandstone** | **Minimum** | 4590 | 764 | 1120 | 2330 |
| | **Maximum** | 5260 | 965 | 1460 | 3370 |
| | **Average** | 4851 | 889 | 1346 | 2759 |
| | **Median** | 4795 | 913.5 | 1370 | 2720 |
| **D-E Sandstone** | **Minimum** | 1380 | 247 | 352 | 729 |
| | **Maximum** | 47500 | 9340 | 16800 | 33500 |
| | **Average** | 12597 | 2637 | 4324 | 8663 |
| | **Median** | 1580 | 308 | 442 | 845 |
| **Sub-E Sandstone** | **Minimum** | 1580 | 312 | 456 | 831 |
| | **Maximum** | 1820 | 360 | 511 | 1070 |
| | **Average** | 1689 | 330 | 482 | 910 |
| | **Median** | 1685 | 327 | 482.5 | 879.5 |

These data indicate that the chloride method is not valid as the near surface units, which receive regular rainfall recharge have the highest salinity. The deepest confined units (the sub-E sandstone) have the lowest salinity. This occurs due to the climate (evaporitic salt build up in the near surface aquifers) and aquifer composition (the deeper aquifers are associated with coarse quartz-rich sandstone which has limited salt contribution to the groundwater). Thus I do not consider that Dr Webb's statement that it is not possible, based on the groundwater composition, to have a recharge of only 0.1% of rainfall recharge is valid (paragraph 174 of the Joint Experts Report).

The magnitude of recharge applied in the model was obtained through model calibration, taking into account:

- Site specific groundwater levels measured across the site;
- Site specific aquifer hydraulic parameters (based on field tests); and
- The limited mechanisms and volumes of groundwater discharge (no baseflow to rivers and streams and evapotranspiration due to groundwater depth[4]).

The addition of increased recharge would require;

- Altering groundwater levels (model would not be calibrated);
- Changing the model aquifer parameters (resulting in these parameters to be outside the range recognised for the units); and/or
- Increasing discharge from the model (no readily explainable mechanism).

Thus the volume of recharge cannot simply be increased based on assumed recharge mechanisms but rather needs to be considered holistically across the model domain, which is based on data.

Dr Mudd comments that major rainfall or flood events may lead to important recharge events but does not refer to any assumptions on possible recharge mechanisms which would facilitate the recharge. It is noted that the groundwater level data compiled since late 2008 was conducted during the 2009 – 2010 and 2010 – 2011 flood events. No marked increase in groundwater levels were recorded (Figures 4-15 to 4-20, Groundwater Model Report URS, 2012) and it was agreed by all (Agreement Point 13) that little or no groundwater level response to seasonal rainfall variation was due to slow recharge rates. Figure 14 presents an example of the hydrographs included in the Groundwater Model Report.

Dr Mudd considered that there was no monitoring in the sandstone subcrop. Agreement Point 15 of the Joint Experts Report provides the monitoring data, which was included in the Groundwater Model Report (URS, 2012) that confirms monitoring within the Colinlea Sandstone.

<u>Influence on Impacts</u>

Simulating the low calibrated recharge to the confined Permian aquifers, to be impacted during mining, was considered a worst-case scenario as the cone of depression simulated at the end of 30 year life of mine would extend over the larger area based on the model removing the majority of groundwater from storage (i.e. minor recharge input over the 30 years of mine dewatering). The resultant drawdown cone simulated after 30 years of mine dewatering with limited recharge resulted in the removal of through flow from south to north across a larger area than if higher recharge was applied.

It is noted that the independent due diligence assessment (Appendix D of the Groundwater Model Report (URS, 2012)), conducted by Parsons Brinckerhoff, recognised that recharge was relatively insensitive in the model and as such variation in recharge has limited impact on model output.

[4] The model includes evapotranspiration as a discharge from the model using a root depth of 3 m. This occurs in the topographic low lying areas within the model domain, along the creeks.

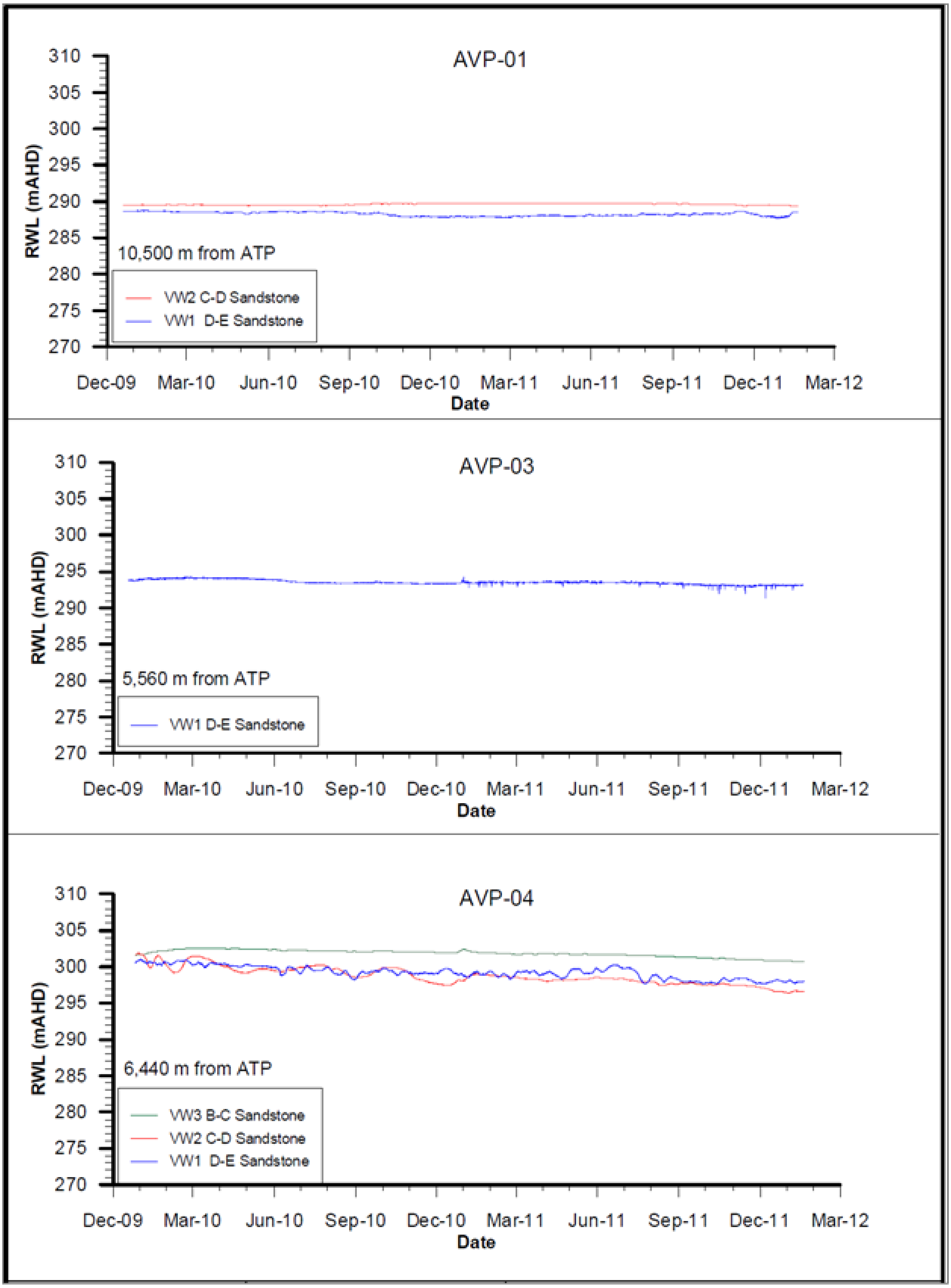
Considerations

I consider that the conditions included in the Coordinator-General's report, allowing for the refinement of the Alpha Model (Appendix 3 Part B Recommendation 2) and the development of a basin wide groundwater model (Appendix 2 Part B Condition 2) will, over time, allow for the refinement of recharge rates over time and validation of model predictions.

Summary

The use of low recharge rates is based on available site specific data and derived from the calibration of the model, to match measured groundwater levels and aquifer parameters. This evidence supports the URS modelling. The consideration of higher recharge rates and preferential recharge flow paths considered by Dr Webb are not supported by site specific evidence.

*Figure 14 Bore hydrographs for monitoring points AVP-01, AVP-03, and AVP-04*



### 4.1.9 The Rewan Formation Aquitard

Issue

URS, based on available literature data, consider the Rewan Formation acts as regional aquitard. Dr Webb considers that the Rewan Formation is largely an aquitard but contains zones of high hydraulic conductivity that allow significant recharge in places. Dr Mudd agrees and supports Dr Webb's view of the Rewan Formation.

Conceptualisation

Dr Webb considers that it is likely that recharge is occurring through the Rewan Formation, particularly where it has been partly removed by erosion. Dr Webb considers that extensional fractures on the folds could facilitate significant recharge.

I consider that the Rewan Formation in its pristine state has limited primary permeability, thus forming an effective aquitard. The Rewan Formation aquitard is recognised to form the basal seal across the entire GAB as the confined GAB aquifers of the Great Artesian Basin are bounded by the Rewan Group (Habermehl, 1997).

Evidence

Dr Webb considers the table of hydraulic conductivity values provided for the Rewan Formation in my Expert Report (Table 10) shows substantial variability, and includes a number of quite high values (up to 1.18 m/day), showing that parts of the Rewan Formation are transmissive. However, these transmissive zones are located within zones of very low permeability as these data were derived from drill stem test conducted at regular intervals down several bores. These very low permeability zones influence the vertical migration of groundwater above and below zones of increased permeability.

Dr Webb considers that recharge occurs through the Rewan Formation based on the conceptual groundwater model preferred by Mr Stewart and Mr Hair (paragraph 189 of the Joint Experts Report) as he considers recharge must be occurring into the Bandanna/Colinlea aquifer through the Rewan Formation. I consider that any potential recharge to the confined Permian aquifers within the proposed Alpha Coal Mine occurs as a result of diffuse recharge along the Great Dividing Range, where the Tertiary cover is thinnest (as discussed in Section 4.1.7 above).

I consider that the weathering and laterisation within the Rewan Group will limit the transmissivity of any extensional fractures and that the extent (depth) of the fractures would be limited based on the limited deformation considered by Dr Webb (broad folds). Consideration of vertical deep drainage based on the available hydrogeological data was conducted to assess the aquitard nature of the Rewan Group (paragraph 182 of the Joint Experts Report). It was estimated that vertical migration would be slow, ~ 1 m every 60 years. This reinforces the concept that URS adopted that the groundwater system in the model domain is relatively static.

Influence on Impacts

As considered in Section 4.1.8 regarding limited rainfall recharge entering the confined Permian units during the model simulation. The nature of the Rewan Formation is considered the same as for slow recharge rates, which:

- Provides a worst-case scenario as the cone of depression simulated at the end of 30 year life of mine would extend over the larger area based on the model removing the majority of groundwater from storage (i.e. minor recharge input over the 30 years of mine dewatering);
- The resultant drawdown cone simulated after 30 years of mine dewatering with limited recharge resulted in the removal of through flow from south to north across a larger area than if higher recharge was applied; and
- Recharge was recognised as being relatively insensitive in the model and as such variation in recharge has limited impact on model output.

Considerations

The Alpha Coal Mine conditions (Appendix C of the Joint Experts Report) include for the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the west of Alpha mine lease, within the Rewan Formation.

These bores plus additional groundwater data compiled from at-risk bore assessments (to be conducted for make-good agreements) will allow will allow for additional assessment of the Rewan Formation in terms of groundwater level variation over time and an assessment of rainfall recharge to the Rewan Formation.

Summary

Literature and field data (from the drill stem tests) indicate very low permeability within the Rewan Formation. These data support the URS conceptualisation of the Rewan Formation acting as an aquitard. No site specific data is available to support the theory of significant recharge through the Rewan Formation.

#### 4.1.10 Impacts on and source of springs, including Degulla Lagoon

Issue

Three registered springs, 405, 70 and 71, and a lagoon (Degulla Lagoon) are located to the north of Alpha Coal Mine (Figure 15 and Figure 16).

Dr Webb considers two of these springs, the Albro Springs (70 and 71) to be permanent and artesian. Dr Webb also considers Degulla Lagoon to be groundwater fed.

The issue raised by Dr Webb was that if these springs and lagoon are groundwater fed then they could be impacted by mine dewatering if the drawdown cone propagates to the north (as discussed in Section 4.1.6).

Conceptualisation

Dr Webb considers that the Albro Springs are permanent springs, which are fed by groundwater. Spring 405 is not considered or discussed by Dr Webb. Dr Mudd agrees with and supports Dr Webb's view of the Albro Springs (70 and 71) being artesian.

I consider the springs to be seasonal based on topography and satellite imagery. It is considered that these springs coincides with the area to the north of Alpha Coal Mine where groundwater levels are at or approaching surface, so there is an upward discharge potential from the deeper confined (semi-confined) groundwater units, as envisaged by Dr Webb.

Evidence

Dr Webb comments that the appearance of the springs, with extensive surrounding cemented sediments and apparently permanent swamp vegetation around the edges of the adjacent pool, strongly suggests that they are permanent.

Dr Mudd agrees with and supports Dr Webb's view of the Albro Springs (70 and 71) being artesian.

I consider that the three springs could be seasonal and flow due to limited effective storage within the colluvium cover at the slope break, based on:

- The location of the springs, along a north-south direction, adjacent to a change in slope (Figure 17 and Figure 18);
- The springs appear to emanate at the topographic break of slope, where shallow groundwater is moving west to east from recharge areas on the Great Dividing Range, and discharging at the break of slope;
- Satellite imagery indicated that were no perennial surface water flows associated with the three registered springs.

Dr Webb agrees that the Degulla Lagoon is filled by the Belyando River during flood events, but as it is (considered by the owner) permanent, even during extended periods of drought, that it may be groundwater fed from confined Permian aquifers. I am not aware of any hydrochemistry or other data to support this conclusion.

URS assessed the potential impact of mining, during the Kevin's Corner Supplementary EIS, on the flow of water down Native Companion Creek and Sandy Creek, as these tributaries were considered by the owner of Degulla Lake (Lagoon) to contribute large volumes of water to the Belyando River which cause the inflow into Degulla Lake during flood events.

*Figure 15 Spring locations north of Alpha mine lease*

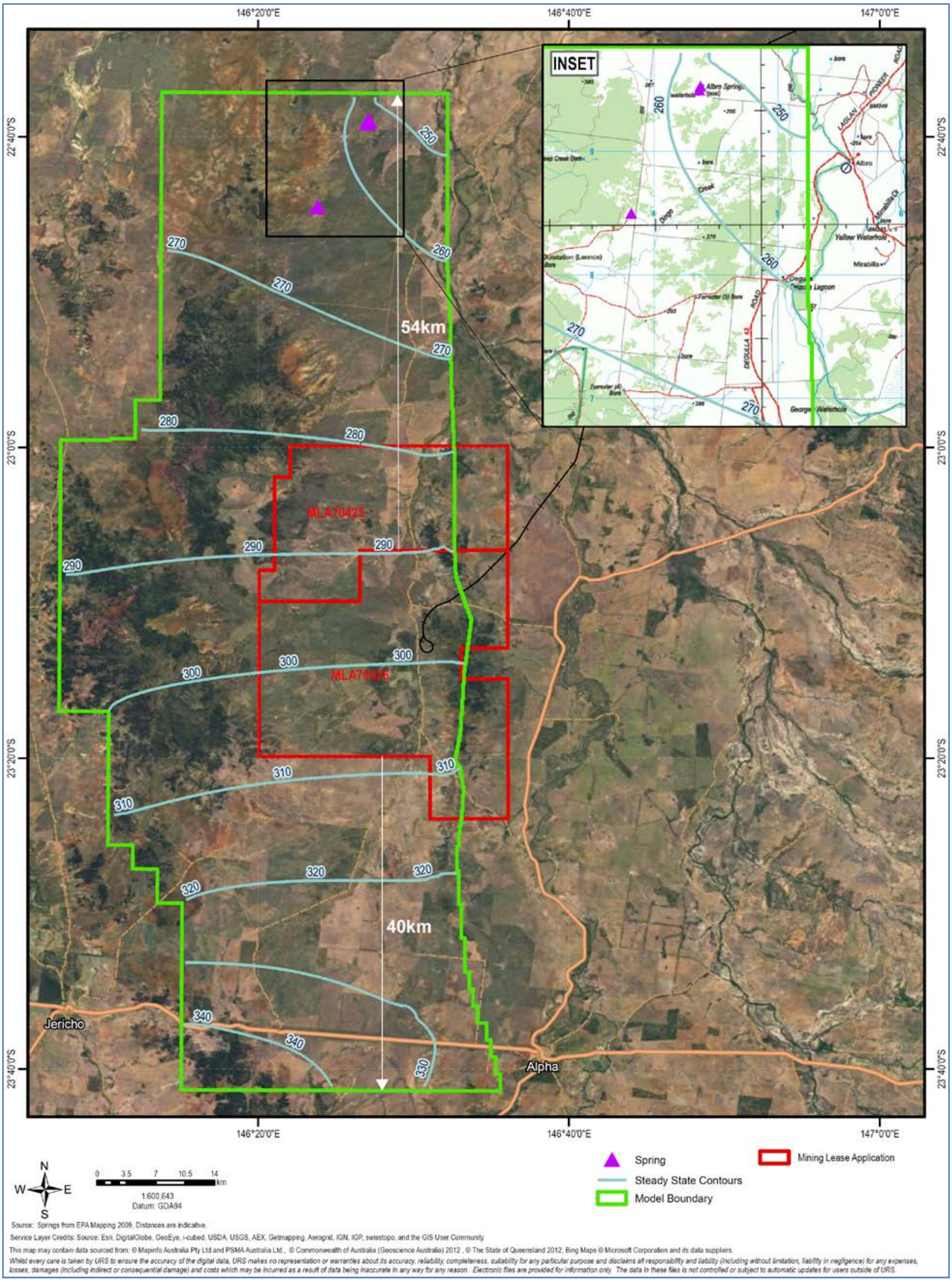
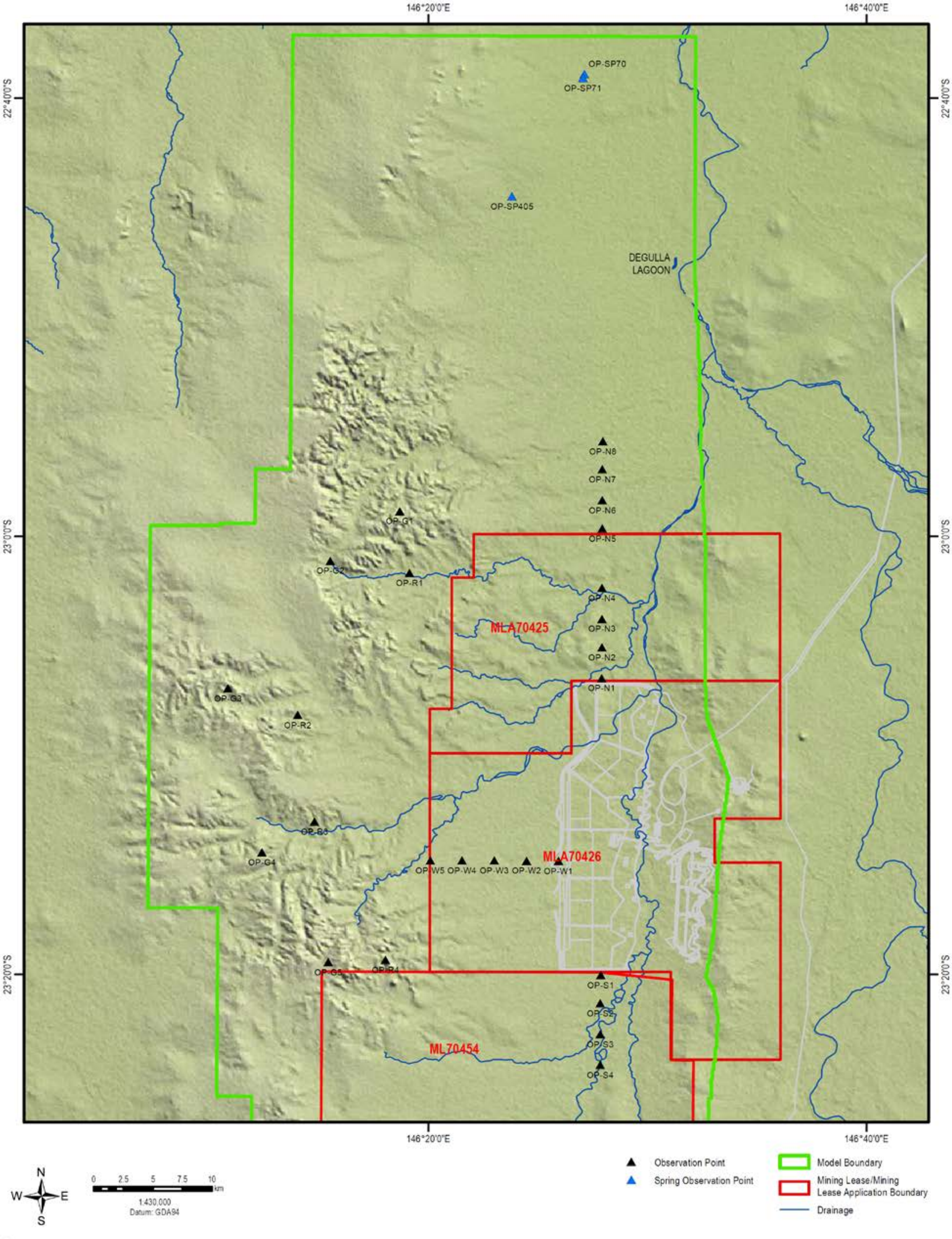


*Figure 16 Model observation points and Degulla Lagoon*




Source:
This map may contain data sourced from: © Mapinfo Australia Pty Ltd and PSMA Australia Ltd., © Commonwealth of Australia (Geoscience Australia) 2012, © The State of Queensland 2012, Bing Maps © Microsoft Corporation and its data suppliers.
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*Figure 17 Springs 70 and 71 cross-section*

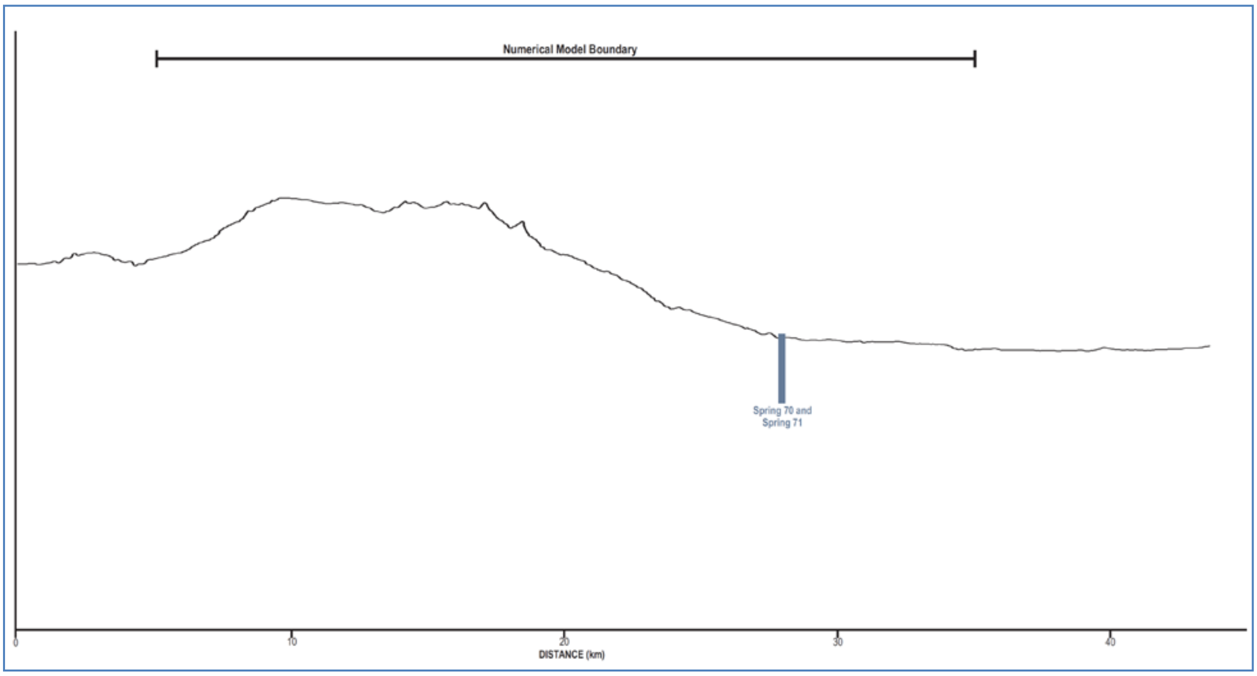
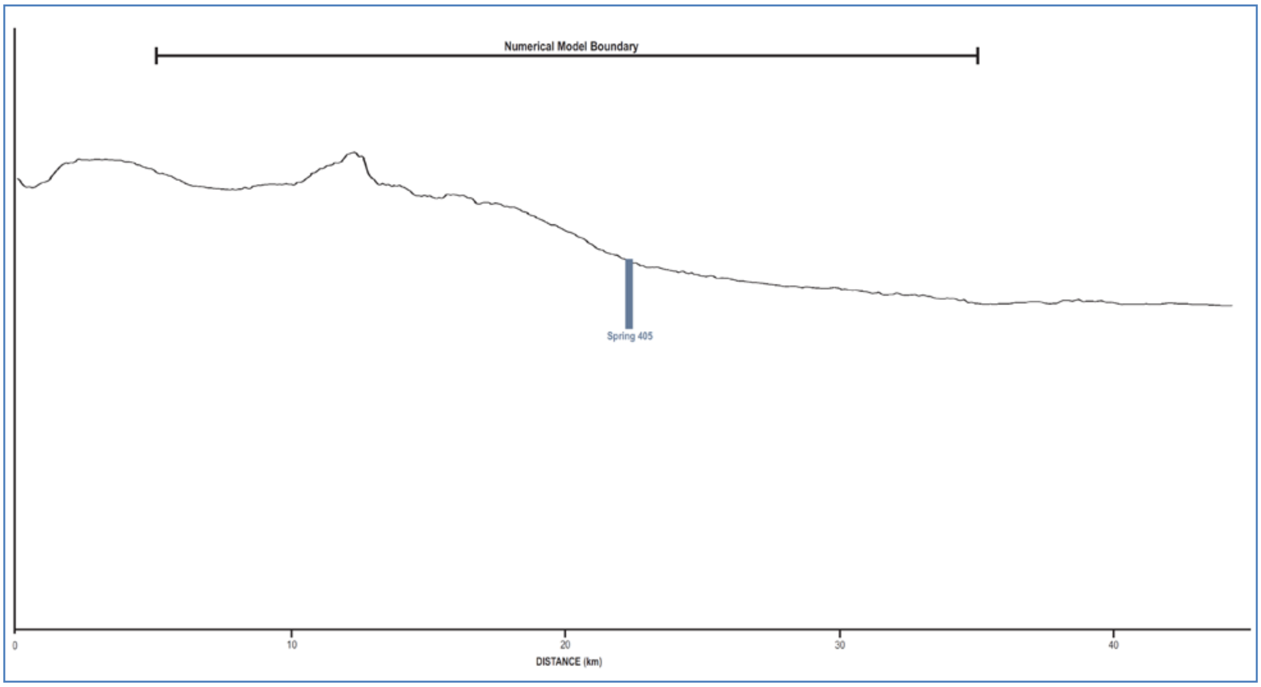



*Figure 18 Spring 405 cross-section*



I consider that Degulla Lagoon is a surface water feature based on:

- Its location within a ~ 24 km length ox-bow, cut-off from the Belyando River;
- Wet season aerial photographic images indicate that the lagoon is located within a large flood plain, which is recharged through surface water overflow;
- Large (spatial) alluvium is considered to provide storage for the lagoon; and
- Degulla Lagoon is located on or near the geological contact between the Colinlea Sandstone and the Joe Joe Formation; these units were intersected during drilling on the Alpha mine lease and indicated limited groundwater resources.

Comments

Dr Webb considers that as there are no bores north of Kevin's Corner then the model does not assess accurately the impacts to the north. I am not clear why this is considered or why Dr Webb suggests additional bores (3 sets of nested bores) adjacent to Sandy Creek would assist. It is noted that URS had installed three sets of shallow (10 m) and deep (30 m) monitoring bore along Sandy Creek and these data are included in the model (Appendix A of the Groundwater Model Report, URS 2012).

Dr Webb considers that the groundwater source for the springs and Degulla Lagoon are from the confined Permian aquifers. I am not aware of any evidence to support this assumption. The mine dewatering, according to Dr Webb, could result in reduced groundwater potentiometric pressure in the Permian units thus affecting the groundwater supply to the springs and / or lagoon.

I consider that if these springs and lagoon are groundwater fed then the Tertiary units could also provide the source of groundwater. As the unconfined groundwater resources in the Tertiary units (as discussed in Section 4.1.3 above) are hydraulically separate from the confined aquifer, the potential for induced flow from the Tertiary to the Permian is limited especially significant distance from the mine.

Influence on Model

The discharge mechanism included in the Groundwater Model Report (URS, 2012) includes evapotranspiration using a root depth of 3 m. This occurs in the topographic low lying areas within the model domain, along the creeks. This approach uses an average annual volume ignoring seasonal vegetation changes thus the discharge could be overestimated. This approach to groundwater discharge near surface has the same effect as modelling surface discharge (springs or groundwater fed lagoons).

Considerations

During the groundwater modelling, in order to assess the potential impacts of mining on groundwater levels north of Alpha (the model domain is sufficiently large to include the three registered springs and Degulla Lagoon) observation points, to consider both during mining activities and long-term (post closure), were included in the model (Figure 16). The observation points allowed for the estimation of changes in groundwater level in different model layers / hydrogeological units over time. As the source of the groundwater to the springs and possibly the lagoon was not known, the observation points allowed for an assessment of the confined D seam potentiometric surface and the unconfined Tertiary model layers.

Groundwater level data for the Tertiary and the target D seam was projected over time (30 years life of mine and 300 years post mining). No change in groundwater levels in any of the model layers was predicted.

I consider that the status of the springs (artesian / non-artesian; seasonal / perennial) is immaterial to the question of whether they will be impacted or not

Summary

The discussion of the source of the springs and Degulla Lagoon is considered largely academic as the groundwater modelling indicates that the groundwater drawdown will not extend to these water bodies.

I consider that the Alpha Coal Mine proposed conditions (Appendix C of the Joint Experts Report) included for the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the north of Alpha mine lease, which will provide groundwater level data for regular model prediction validation. These bores will provide an “early warning” system should groundwater levels decrease quicker and deeper than predicted. Mitigation measures, such as artificial recharge, could then be considered to address possible impacts on springs or groundwater fed lagoons.

#### 4.1.11 Regional impact on the Burdekin River Catchment

Issue

Dr Webb states that because the interception of recharge and groundwater flow is permanent, this will have a regional impact on the Burdekin River Catchment.

I consider that the mine dewatering will remove ~ 60 GL of groundwater during the life of the mine (30 year) and the resultant impact has been predicted within the model. Post mining, allowing for the final void, will result in permanent removal of groundwater.

The issue to consider is the magnitude of the on-going extraction (through evaporation from the final void) on the Burdekin River Catchment.

Conceptualisation

Dr Webb is concerned that the permanent removal of groundwater as a result of mining will impact on the Burdekin River Catchment in terms of reducing baseflow to the upper Belyando River.

I consider that mine dewatering, at the rate of 2 GL per year, will reduce groundwater resources within the drawdown cone. I consider that as the reduced groundwater resources do not have an impact on baseflow (ephemeral creeks and rivers) and are not predicted to impact on the possible groundwater discharge features (Albro Springs and Degulla Lagoon) as considered in Section 4.1.9 above; it is considered that the proposed groundwater extraction of 2 GL per year will have limited impact on surface water resources, which provide the main contribution to water resources in the Burdekin River Catchment.

Evidence

Dr Webb considers that 60 GL (2 GL/year) will be permanently withdrawn from the groundwater system during mining and that the 2 GL/year represents ~0.2% of the current annual groundwater extraction in the Burdekin River Catchment.

Dr Webb considers that the final void will largely intercept groundwater flow from the headwaters region of the Lagoon Creek catchment, an area of ~2,800 $km^2$ (~2% of the area of the Burdekin River Catchment). He also considers, in his Supplementary Expert Witness Report, that the total catchment for the Colinlea Sandstone and Bandanna Formation units at the northern boundary of the model is ~ 3,860 $km^2$. He considers that should all groundwater be captured in the of ~2,800 $km^2$ then ~ 75% of the groundwater in the Colinlea Sandstone and Bandanna Formation model area will be captured.

Figure 19 includes the Alpha mine lease (MLA70426) within the Burdekin River Catchment, it is noted that Lagoon Creek is the creek mapped to drain through MLA70426.

The URS modelling simulates a temporary dewatering of the mine over a 30 year period after which groundwater recovery was simulated for 300 years. It is estimated that a total of 60 GL will be removed from the Alpha Coal Mine. The resultant impact on the groundwater resources, in terms of groundwater level drawdown, has been assessed (Figure 5).

Modelled simulations of groundwater ingress after mining ceases resulted in continued groundwater extraction of ~ 600 $m^3$/day which reduces to ~ 450 $m^3$/day (7 to 5 L/s) after 300 years. This equates to a groundwater extraction volume of 0.22 to 0.16 GL/year. Based on the annual groundwater extraction from the Burdekin River Catchment estimated of 913 GL/year (SKM, 2012[5]), the long term impact of extraction would increase the current annual groundwater extraction volume by ~ 0.018%.

It is noted that the removal of groundwater in the long term is limited by the enhanced recharge in the backfill of the mined area, which covers an area of some 185 $km^2$. This recharge plus a small amount of surface run-off into the final void results in only ~ 5 L/s being extracted from groundwater.

The final void area of ~ 24 km long by 270 m wide (~ 6.5 $km^2$) is considered to have a limited impact on the regional groundwater resources within the 132,000 $km^2$ Burdekin River Catchment.

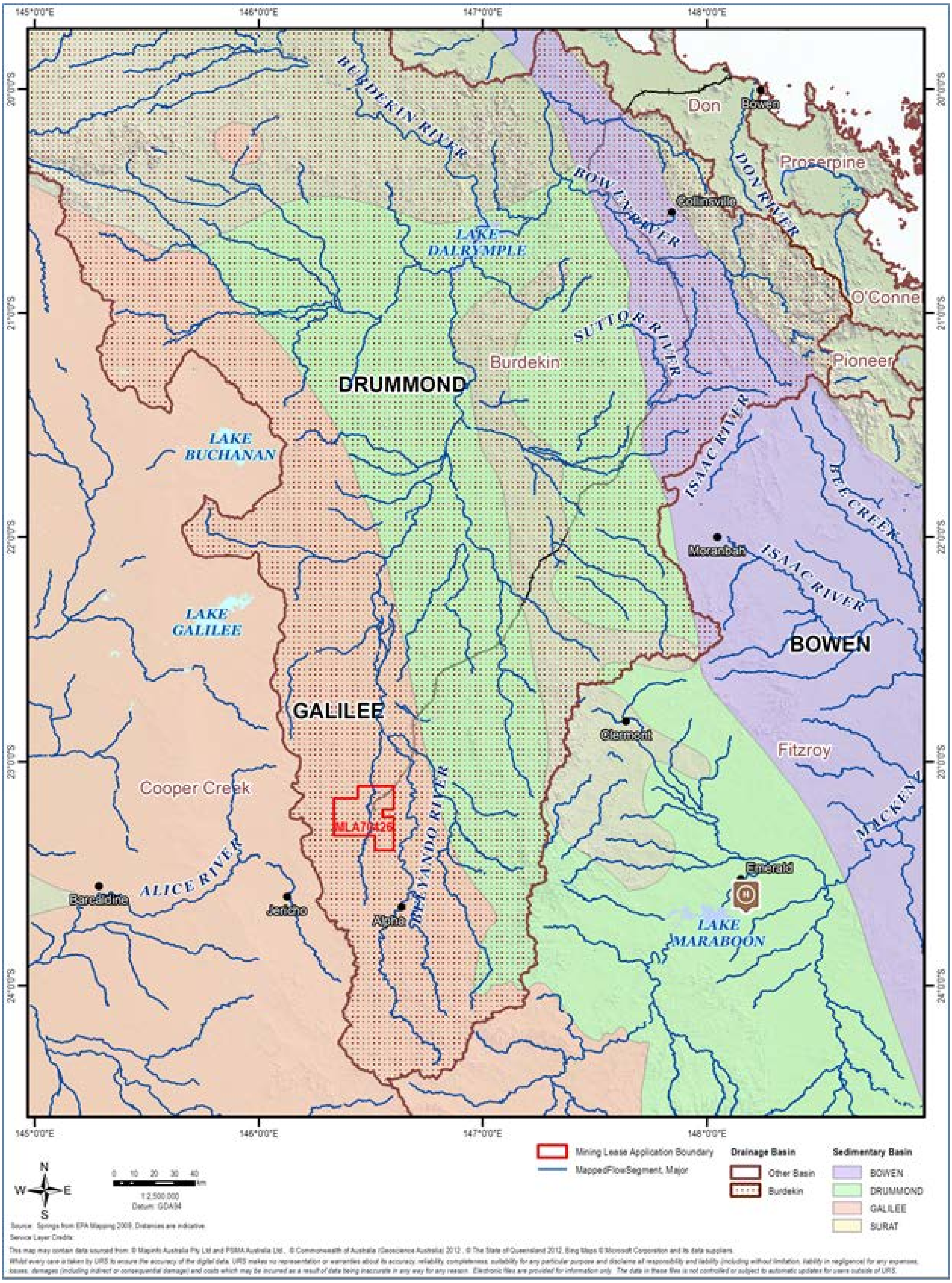
<u>Estimations</u>

Dr Webb considers that the final void will intercept groundwater flow within a catchment area of 2,800 $km^2$ and that this is likely to reduce baseflow in the Belyando River. This includes areas outside the localised cone of drawdown predicted to result at the end of the model simulation once a pseudo steady-state (allowing for climate variation) has been reached. This also does not consider the enhanced recharge into the backfill.

Dr Webb then considers, in his Supplementary Expert Report, that this interception of groundwater flow in the Permian units will impact on the Albro Springs and the Degulla Lagoon, even though as discussed in Section 4.1.10 that the source of the springs is not proven and that the mine dewatering (allowing for the capture of through flow) does not extend sufficiently north to impact on unconfined and confined aquifers in the area of the springs and lagoon.

[5] Sinclair Knight Merz, 2012. Impacts of groundwater extraction on streamflow in selected catchments throughout Australia, Waterlines Report Series No 84, June 2012

*Figure 19 Burdekin River Catchment*



It is noted that the Lagoon Creek catchment (to the Greentree Creek and Sandy Creek confluence) is only ~ 1,763 $km^2$ and not 2,800 $km^2$ as estimated by Dr Webb (this catchment is shown in Figure 19a). This catchment includes units and drainage areas to the east of Lagoon Creek, which are predicted to not be impacted by mining (i.e. Tertiary units and the Joe Joe Formation aquitard).

The area of Permian units, Colinlea Sandstone and Bandanna Formation, within the Lagoon Creek is estimated at 5,404 $km^2$ based on the Permian geological units included across the entire model domain. The Lagoon Creek catchment would, therefore, only cover ~ 30% of the Permian units included to the northern boundary of the model.

I consider, however, that these simple water balance calculations do not provide an accurate assessment of the impact of groundwater removed from the Lagoon Creek on the Burdekin River Catchment, as this water balance approach only considers the possible capture of all through flow within the final void. As discussed above, the groundwater flow model predicts a long term removal of groundwater at a rate of ~ 5 L/s due to evaporation from the final void. This volume considers enhanced recharge through the backfill (rehabilitated section of the mine), direct rainfall and rainfall runoff within the ~ 185 $km^2$ Alpha Coal Mine area, and groundwater inflow compared to evaporation losses from the final void (this was modelled in the integrated surface water-groundwater model).

The resultant long term groundwater flow patterns, Figure 6, indicates a localised alteration to the groundwater flow across the model area, such that not all groundwater sourced to the south of the Alpha Coal Mine is captured as it flows from south to north. The capture area is estimated at around 4 km x 4 km around the final void, ~ 16 $km^2$, i.e. an estimated capture diameter of 8 km.

Groundwater through flow, at a rate of 0.0028 m/year, indicates that the groundwater captured in the final void localised drawdown cone would be ~ 22,4 $m^3$/year from the D seam, which is 0.01 % of the long term 5 L/s extraction.

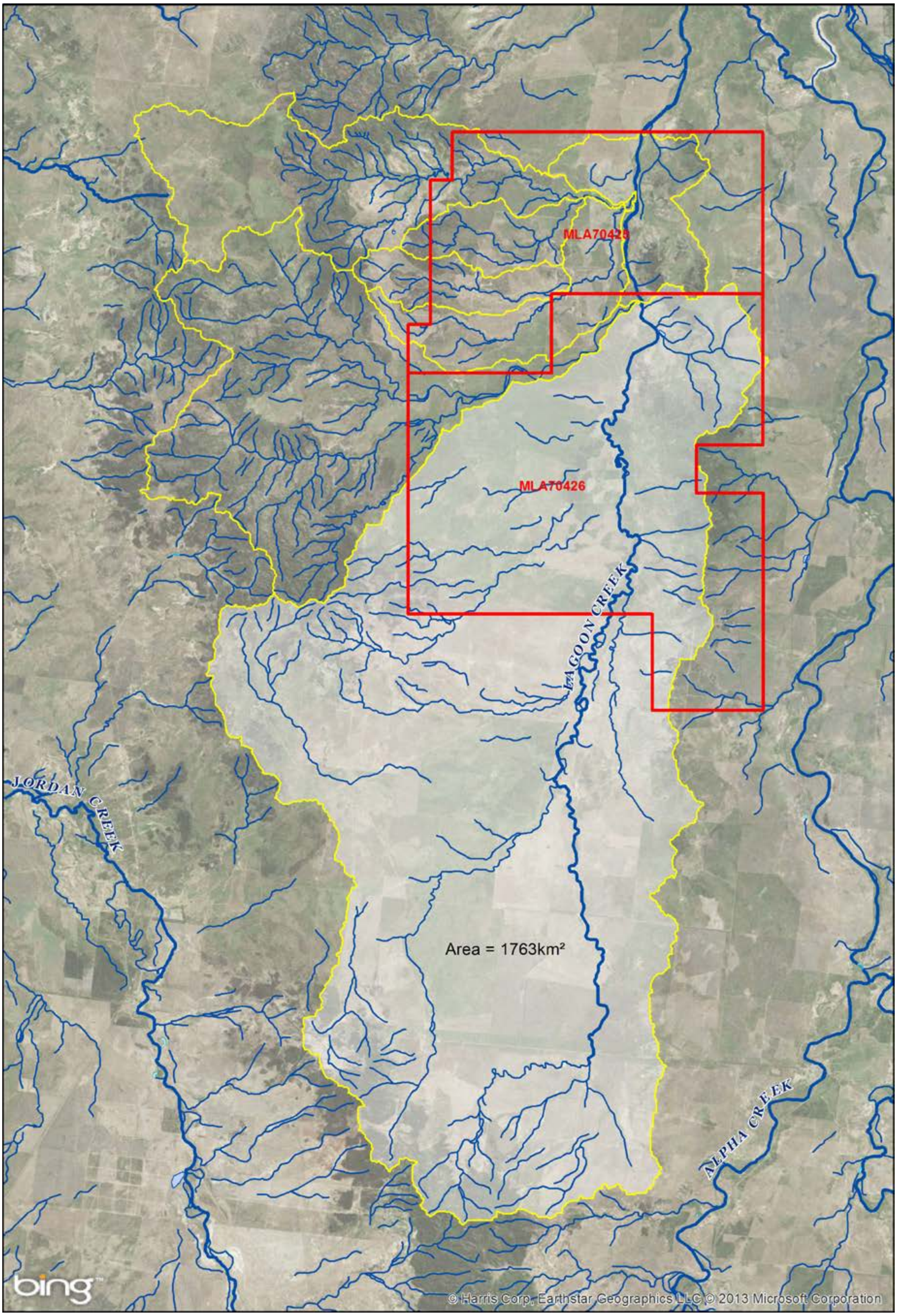
Influence on Model

This consideration of impacts does not impact on the model approach or predictions.

The modelling, as discussed in Section 4.16 above, considers the capture of recharge and through flow during the mining and post-mining and provides a projection of the extent of drawdown cone development over time. Observation points to the north (as discussed in Section 4.1.9) do not indicate groundwater drawdown within the areas where groundwater levels are close to or discharge to surface water features, thus baseflow impacts are not predicted.

The effects of the final void extraction, some 5 L/s, is considered to have limited impact on the Lagoon Creek catchment, as recognised in the long term groundwater contours.

*Figure 19a Lagoon Creek catchment*



Considerations

It was agreed by all that the final void will act as a permanent groundwater sink, such that no pit water can migrate off site within the groundwater (Agreement Point 1 of the Joint Experts Report). This prevents poor quality groundwater impacts (long term salinity plume migration) based on the groundwater extraction through evaporation from the final void (paragraph 38 of the Joint Experts Report).

It was agreed (Agreement Point 21 of the Joint Experts Report) that the local groundwater flow patterns and resources will be impacted in perpetuity due to the final void acting as a “sink”. It was agreed that the potential impacts of the final void on groundwater resources can be addressed through the provision of alternative water supply, as per the Applicant’s make-good commitment and enforcement through the provisions of the *Water Act 2000*.

In addition, as the mine’s water demand is greater than available water (groundwater from mine dewatering and surface water flood harvesting) water will have to be imported into the area to facilitate mining. The provision of bulk water, from external sources, will offset the diminished groundwater resources and can be used for make-good and water security to the area.

Summary

The mining will reduce groundwater resources within the Lagoon Creek catchment. Make-good conditions will provide for the replacement of reduced groundwater resources. Based on the envisaged water demand from the mine it is considered water will be imported. This external water source will provide water security to the area.

For the reasons described above I maintain my view that the mine dewatering, allowing for the capture of through flow, will not extend to the area containing Degulla Lagoon and the Albro Springs.

I consider that the Alpha Coal Mine proposed conditions (Appendix C) include the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the north, south, and west of Alpha mine lease. Regular groundwater monitoring data collection and analyses coupled with regular model audits will allow for the verification of groundwater impacts on local and regional groundwater resources.

#### 4.1.12 Groundwater approval conditions

Issue

I consider that the conditions are appropriate and sufficient to:

- Assess and address identified potential impacts;
- Allow for the validation of predictions;
- Assess cumulative impacts of multiple coal mines;
- Ensure water security; and
- Provide a suitable framework to address potential impacts and make-good on water resources.

Dr Webb agrees with all the Coordinator-Generals conditions but has included additional recommendations, as detailed in paragraphs 26 to 31 of his Expert Witness Report.

Dr Mudd is in general agreement with all the conditions but requires more precise definition to ensure they achieve the objective of groundwater protection. Dr Mudd has included additional recommendations, as detailed in paragraphs 5.1.1 to 5,1,6 of his Expert Witness Report.

Comments

Dr Webb's considerations were included in the Joint Experts Report, and included below, as all were in agreement that additional specifics were added to several of the conditions.

Dr Mudd's comments on modelling updates, monitoring network, and regional model were in agreement that additional specifics were added to several of the conditions detailed below.

Considerations

During the Joint Experts Meeting it was discussed that several of the conditions required additional consideration and the agreed recommendations included ("Agreed Recommendations" on page 61 of the Joint Experts Report):

- It was agreed that clarity is required with regards to the conditioned Galilee Basin regional groundwater model in regard to extent. That is, the regional model should focus only on the eastern central limb of the Galilee Basin where coal mining is proposed to occur.
- The Groundwater Monitoring Program must include a groundwater monitoring network that allows for the monitoring of potential drawdown to the north, south, and west of the Alpha Coal Mine. Groundwater monitoring network is to include locations to the east, adjacent to mine water and waste infrastructure.
- It is recommended that the audits of the groundwater model should occur at intervals of no longer than 3 years during the life of mine and post-closure.

## 4.2 Affidavit of Janeice Marie Anderson

Key Groundwater Issues

Ms Anderson's affidavit raises the following key groundwater issues for consideration:

- Long term impacts of Alpha Coal Mine on the groundwater resources within the properties; Eureka, Oakleigh, and Corntop;
- Cumulative impact of the proposed South Galilee and Alpha Coal Mine;
- Lack of baseline monitoring by Hancock GVK on the properties; Eureka, Oakleigh, and Corntop;
- Waratah Coal's statement that Alpha Coal Mine's groundwater model did not include a fracture zone;
- Reliability of the modelling;
- Make-good agreement; and
- Suggested conditions.

Response Comments

### 4.2.1 Long term impacts the groundwater within the properties; Eureka, Oakleigh, and Corntop

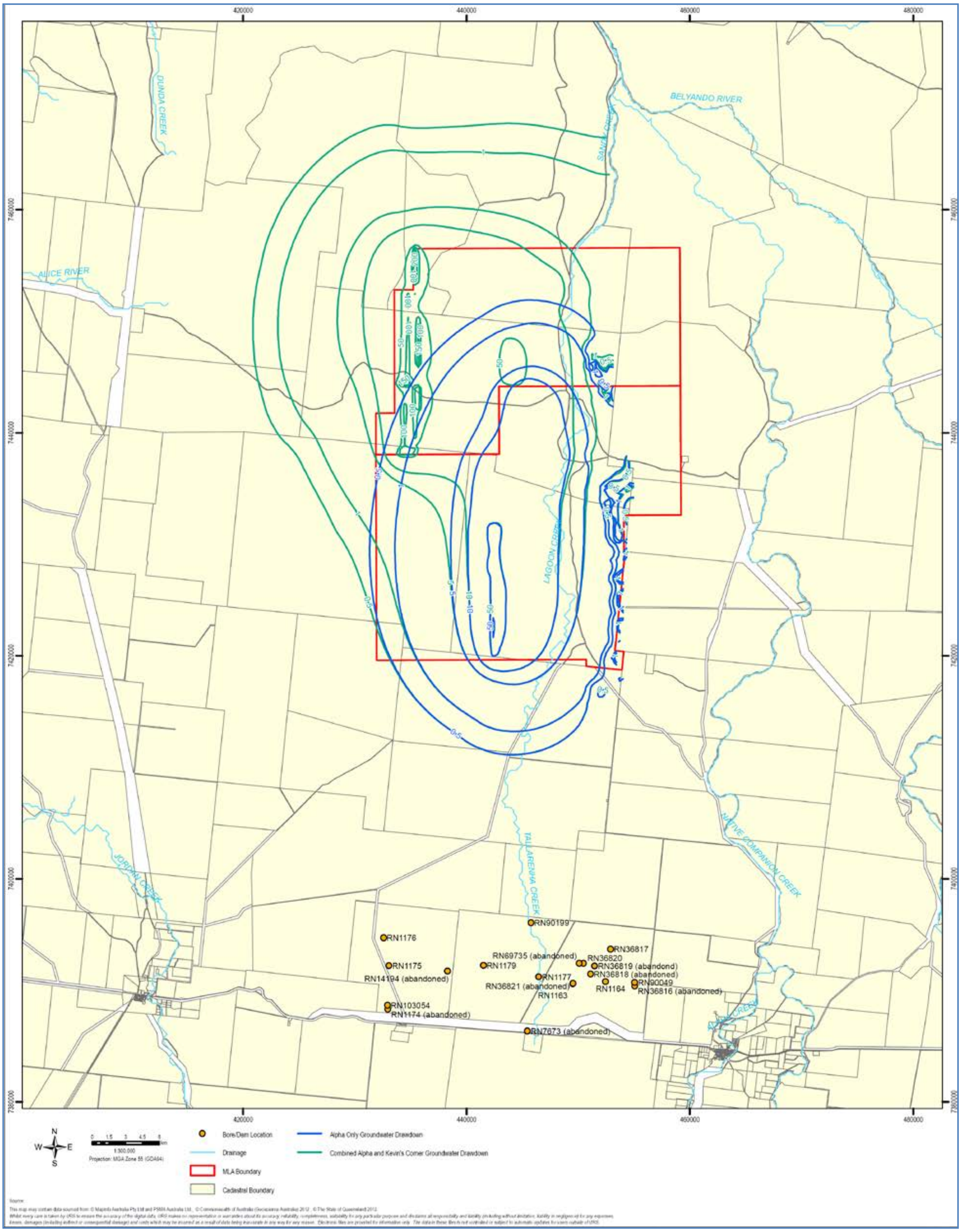
No long term impacts on the Anderson's properties are predicted.

Groundwater modelling using accurate aquifer parameters allowed for the prediction of groundwater drawdown as a result of mine dewatering over a period of 30 years. The geology (and associated groundwater properties) to be mined controls the inflow and thus the extent of drawdown.

Comments in Section 4.1.6 provide details of the modelling approach undertaken by URS to consider worst case scenarios when assessing potential impacts. This approach (limited recharge and model boundary selections) allowed for the assessment of drawdown within all of the geological layers to be intersected during mining. Through flow and recharge as well as groundwater storage was removed from the mine, using drains, to determine estimates of groundwater ingress (estimated to be ~ 60 GL for Alpha Coal Mine) over the life of the mine and the resultant drawdown.

The projected drawdown within the D coal seam is presented in Figure 5 and is recognised to extend some 8 km south of the southern Alpha Coal Mine boundary. The closest bore located on the Anderson properties is bore RN90199, located some 23 km south of the southern Alpha Coal Mine boundary. This is ~ 15 km from the 0.5 m contour. It is noted that the default "bore trigger threshold" for petroleum activities in the *Queensland Water Act 2000* is a decline in groundwater levels of 5 m for confined aquifers. The 5 m drawdown contour is predicted even further from the Anderson properties (Figure 20).

*Figure 20 Groundwater drawdown and the Anderson bores*



The groundwater drawdown associated with the mine dewatering is not predicted to impact on any of the Anderson bores. On completion of mining the predicted drawdown contours in the D seam after 300 years, associated with the final void, is presented Figure 6. These long term groundwater contours do not extend to the south and impact on the Anderson properties.

#### 4.2.2 Cumulative impact of the proposed South Galilee and Alpha Coal Mine

It is acknowledged that the groundwater modelling conducted by URS did not include the South Galilee Coal Project as at the time of modelling there was little or no information, other than the Initial Advice Statement, on this project.

A quantitative impact assessment was included in the Groundwater Model Report (URS, 2012), which based on the cumulative modelling assessment of Alpha and Kevin's Corner coal projects indicated that dewatering impacts are predicted to elongate north and south within the more permeable sandstone units.

The concept of superposition was considered for multiple coal mines, where mining occurs along strike and within the same geology. This concept considers that where the drawdown cone from each mining operation overlaps then the drawdown will be deeper than for a single mine. It is noted, however, that this would depend on timing and schedule of the mines as some areas may already be dewatered.

Considering the location of the Andersons' properties, located within the Waratah Galilee Coal Project and immediately adjacent to the proposed South Galilee Coal Project, I consider that groundwater drawdown during mining of these two projects will have a marked impact on the groundwater resources on the Andersons' properties.

Alpha and Kevin's Corner coal projects are not predicted to impact on the Andersons' properties.

#### 4.2.3 Lack of baseline monitoring on Eureka, Oakleigh, and Corntop;

During the EIS a bore survey was conducted of groundwater use within a radius of ~ 10 km around the Alpha and Kevin's Corner mine leases. This 10 km is industry standard and allows for the compilation of baseline data regarding:

- Groundwater bore depths;
- Groundwater levels;
- Groundwater quality;
- Groundwater use; and
- Estimates of groundwater extraction.

These data are used in the EIS to help in the description of groundwater resources and values prior to any mining activities.

The Anderson properties are located ~ 23 km south of the southern Alpha Coal Mine boundary, outside of the 10 km survey area and as such were not included in the baseline bore survey.

It is noted that all the registered bores within the model area were included for consideration when assessing at-risk bores (i.e. bores located within the project 1 m drawdown contours). As discussed in Section 10.6.4 of the Groundwater Model Report (URS, 2012) the approach to be taken is to assess all existing bores within the predicted 1 m drawdown contour (using the D coal seam which will have the largest zone of influence) regardless of unit the bore intersects.

#### 4.2.4 Waratah Coal's statement that Alpha Coal Mine's groundwater model did not include a fracture zone

The fracture zone referred to in the Galilee Coal Project Groundwater Assessment (Heritage Computing Report, 2013) relates to the alteration of the units above the target coal seam(s) after longwall underground mining. The collapse of the units, known as goaf, occurs and fractures the units above the removed coal.

As Alpha Coal Mine is an open cut coal mine, it will not include alteration due to goaf, and there is no fracture zone associated with the Alpha Coal Mine mining.

The fracture zone was included for the underground mining at Kevin's Corner. This is discussed in Section 12.1.1 of the Kevin's Corner SEIS Appendix L.

I can confirm that the predictive modelling, providing estimates of groundwater ingress, included varying aquifer properties (in response to longwall mining goaf) over the life of the mine. The groundwater software, MODHMS, was selected as it allows for time-varying properties of hydraulic conductivity and storage.

It is noted that Heritage Computing model (Galilee Coal Project Groundwater Assessment Heritage Computing Report, 2013) was unable to assess the cumulative impacts due to a difference in conceptualisation and differences in model software.

A regional model, using one agreed modelling software package, appropriate regional model boundaries, uniform number of model layers, and conceptualisation plus accurate mine plans and schedules, is required to assess accurately model cumulative impacts. This regional model is included in the Alpha approval proposed conditions (Appendix C of the Joint Experts Report).

#### 4.2.5 Reliability of the modelling

The affidavit of Ms Anderson refers to paragraph 10 on page 36 of my expert report dated 30 May 2013. In the paragraph I state that I consider that a cumulative model, at this stage without all the proponents buy-in and data, would not provide a very accurate assessment of potential impacts. The cumulative impact assessment of the Alpha and Kevin's Corner projects is accurate because the cumulative modelling of Alpha and Kevin's Corner used the same modelling software package, model boundaries, number of model layers, and included accurate mine plans and schedules. The proposed conditions for the Alpha Mine require contribution towards a regional model.

Ms Anderson also refers to paragraph 5 on page 34 of my expert report dated 30 May 2013. For clarity, this statement relates to the approach required during the make-good agreement process. It recommends the assessment of neighbouring (at-risk) bores regardless of the aquifers intersected in these bores.

Little data is known or documented on the registered bore database thus using a worst case approach all bores within the 1 m drawdown contour of the D coal seam were considered to be potentially unduly affected by mine dewatering by the end of mining.

This is a precautionary approach as:

- A drawdown of 1 m was used, whereas (as discussed above), the default 'bore trigger threshold for petroleum activities in the *Queensland Water Act 2000* is a decline of 5 m for confined aquifers; and
- The majority of neighbouring production bores would not target the D coal seam for groundwater supply rather over or underlying sandstone units where the drawdown will be less than in the D seam.

### 4.2.6 Make-good agreement

I consider that the Alpha Coal Mine proposed conditions (Appendix C of the Joint Experts Report) will allow for the construction of monitoring bores to the south of Alpha mine lease, which will provide groundwater level data for regular model prediction validation (also an approval condition).

These bores will provide an “early warning” system should groundwater levels decrease quicker and deeper than predicted in all the groundwater / model units envisaged to be affected by mine dewatering.

Should groundwater supplies be unduly affected the recommended water licence (which Alpha Coal Mine will have to obtain before mining) conditions plus in my experience will ensure water security.

Appendix 3, Part B, Recommendation 4 of the Coordinator-General’s report includes a copy of the standard Water Licence conditions;

- Condition SPEC6 – Urgent Restoration provides that the Chief Executive may issue notice requiring the licensee to commence an appropriate program for implementation of restoration measures within 48 hours of receipt of notice.
- If, in the Chief Executive’s opinion, the Licensee fails to adequately comply with the notice, the Chief Executive will carry out the necessary restoration measures and the Licensee must pay the Chief Executive the costs of carrying out the restoration measures.

### 4.2.7 Suggested conditions

I note that Ms Anderson has listed a series of monitoring requests, including a baseline monitoring program, annual monitoring (including quality) and an annual report.

Based on the fact that groundwater quality will not be impacted, and the Anderson’s bores are located far from Alpha (well outside the predicted drawdown cone) I consider that groundwater monitoring of the Anderson’s supply bores is not suitable or necessary and should not be included as an approval condition.

The Alpha Coal Mine conditions (Appendix C of the Joint Experts Report) include for the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the south of Alpha mine lease, which will be between Alpha and the Anderson properties. As mentioned in Section 4.2.6 these monitoring points will be used to validate monitoring predictions and provide “early warning” should groundwater levels decrease quicker and deeper than predicted.

No active production bores are to be used for monitoring due to impacts of extraction on the groundwater levels.

I consider that these bores will provide groundwater data, which will be used in the regular model audits (Coordinator-General's Evaluation Report Appendix 3, Part B).

## 4.3 Affidavit of Bruce Bede Currie

Key Groundwater Issues

Mr Currie's affidavit raises the following key groundwater issues for consideration:

- Cumulative impact of Alpha and Kevin's Corner mine dewatering on groundwater resources within the property Speculation;
- Bore monitoring program and the Clematis Sandstone;
- Drawdown contours across Speculation;
- Assessment of the Rewan Formation (between the Great Artesian Basin and the Alpha Coal Mine units);
- Bore census for baseline data;
- Conditions.

Comments

### 4.3.1 Cumulative impacts of mine dewatering

It should be recognised that the worst case modelling does not predict an impact on the Curries' bores from the Alpha Coal Mine alone.

The predictive groundwater modelling considering the cumulative impact of Alpha and Kevin's Corner mining concurrently allowed for the assessment of drawdown in the D coal seam at the end of mining (Figure 21). The 0.5 m contour, change in the pre-mining groundwater level associated with the D coal seam, is projected to extend below the eastern portion of the property Speculation.

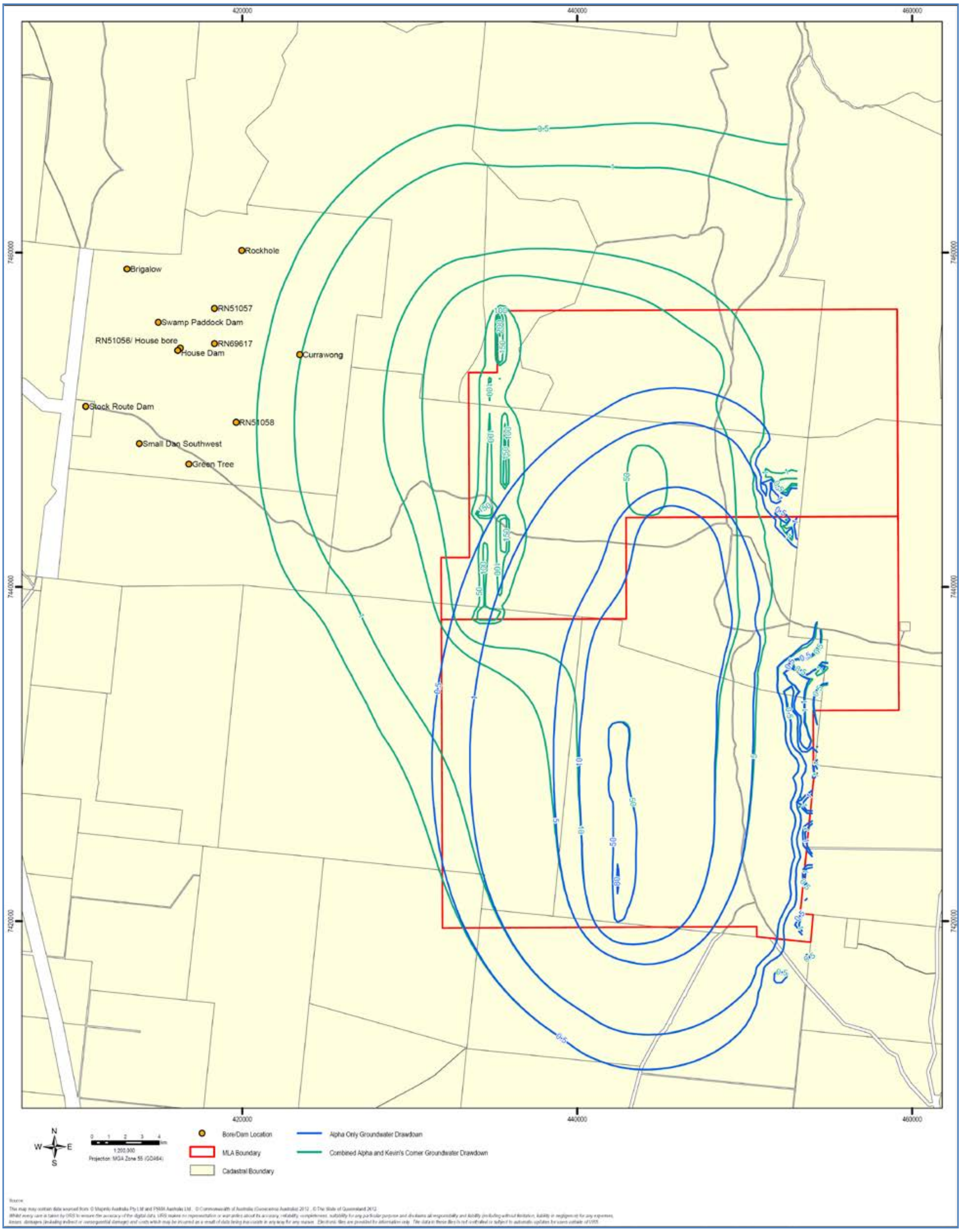
It is noted that the default 'bore trigger threshold for petroleum activities in the Queensland Water Act is a decline in groundwater levels of 5 m for confined aquifers. The 5 m drawdown contour is not predicted to extend onto the Speculation property (Figure 21).

The groundwater modelling included observation points within the Rewan Formation and the Clematis Sandstone to the west of Alpha and Kevin's Corner (Section 13 of the Groundwater Model Report, URS 2012). This allowed for the evaluation of groundwater level changes, in the different units, over time and spatially. Observation points OP-G1, OP-G2, and OP-R1 (Figure 16) were located within the area containing the property Speculation.

For Alpha and Kevin's Corner cumulatively, no impacts or change in groundwater levels were predicted in any of the 5 observation points (OP-G1 to OP-G5) during the mining. ~ 1 m drawdown was predicted in the Bandanna Formation in observation points OP-G1 and OP-G2 after 300 years post mining. Based on the low vertical permeability of the Rewan Formation (as discussed in Section 4.1.8 above) it is considered that any induced flow from the Clematis Sandstone (through the Rewan Formation) as a result of the ~ 1 m drawdown in the Bandanna Formation would be negligible.

The groundwater modelling took into account the possible cumulative impacts of Alpha and Kevin's Corner mine dewatering on groundwater resources within the Clematis Sandstone, utilised within Speculation.

*Figure 21 Groundwater drawdown and the Currie bores*



### 4.3.2 Bore monitoring program

Mr Currie suggests that his bores “come under the monitoring program” to allow for the assessment and validation of groundwater modelling.

The Alpha Coal Mine proposed conditions (Appendix C of the Joint Experts Report) include for the development of a groundwater monitoring program, which will allow for the construction of monitoring bores to the west of Alpha mine lease, which will be between Alpha and the Speculation properties.

These monitoring points will be used to validate monitoring predictions and provide “early warning” should groundwater levels decrease quicker and deeper than predicted.

No active production bores will be used for monitoring for model validation purposes as these data will be subject to dewatering stresses associated with the landholder’s groundwater extraction.

Should groundwater supplies be unduly affected then the approval conditions plus the Water Licence conditions (which Alpha Coal Mine will have to obtain before mining) will ensure water security (as detailed in Section 4.2.6 above).

The monitoring program is to include groundwater monitoring bores within the Clematis Sandstone, as conditioned in the approval conditions (Appendix C of the Joint Experts Report).

Kevin’s Corner Coal Mine has its own approval conditions, which include a groundwater monitoring network with monitoring bores to the west of Kevin’s Corner (Kevin’s Corner project: Coordinator-General’s evaluation report on the environmental impact statement, dated May 2013).

### 4.3.3 Drawdown contours across Speculation

The groundwater contours are projected to occur, as presented in Figure 21, within the D coal seam at the end of mining. The drawdown contours will extend to the west as mining moves westward over the life of the mine. The drawdown cone, as a result of mining, is governed by the units mined in terms of their permeability.

The groundwater model and predictions will be validated and reassessed as per the recommended conditions included in the Coordinator-General’s report, allowing for the refinement of the Alpha Model (Appendix 3 Part B Recommendation 2) and the development of a basin wide groundwater model (Appendix 2 Part B Condition 2).

The inclusion of monitoring bores to the west of Alpha, as discussed in Section 4.3.2 above, and the refinement of the modelling over time will allow for validation of the drawdown contours projected adjacent to the property Speculation (i.e. the drawdown contours for Alpha Coal Mine alone)

I also consider that the regional model will aid in verifying the cumulative drawdown contours projected within the D coal seam at the end of mining at Alpha and Kevin’s Corner coal projects below the property Speculation.

### 4.3.4 Assessment of the Rewan Formation

Mr Currie considers the potential interaction between the Permian confined aquifers to be directly impacted by mining and the Clematis Sandstone Great Artesian Basin as an area of concern.

Figure 1 presents the conceptualisation of the geology and groundwater within the study area. This figure shows the separation between the target C and D coal seams in the Colinlea Sandstone and the Clematis Sandstone. The units in between comprise the clay-rich Bandanna Formation and the Rewan Formation aquitard.

Consideration of the possible interaction between these two units, the Colinlea Sandstone and Clematis Sandstone, was given in the terms of considering faults providing preferential flow paths (interaction) between the units.

Faults

No faulting was identified on the 1:250 000 geological map within the Clematis Sandstone unit adjacent to MLA70426 (Alpha) or MLA40725 (Kevin's Corner). A single fault is mapped, on the Jericho geological map, within the Rewan Formation to the west of MLA70425. This fault could potentially be within the cumulative (Alpha and Kevin's Corner) 5 m drawdown contour. The only faults identified are within the Permian units based on geophysical surveys across the MLA70425.

Based on the dip of the units resulting in separation distances of ~ 50 km between the Colinlea Sandstone and the Clematis Sandstone, any faults of sufficient extent to connect these two units would have been identified on the geological map or during the geophysical survey.

Potential interconnection

In addition to the faults having to be significant in length the potential for faults to act as preferential flow paths would depend upon the nature of the faults, i.e. the transmissivity of the faults. It would require that the faults remain open along the length and depth of the fault. Similar to the discussions in Section 4.1.8 above, the effects of weathering and laterisation within the Rewan Group would limit the transmissivity of faults; these secondary processes will fill the faults reducing the flow potential along the fault.

There would have to be a direct hydraulic connection between the target coal seams being dewatered, through the Bandanna Formation and Rewan Formation and into the saturated portion of the Clematis Sandstone to the west of MLA70426.

Impact

Assuming a fault could extend and remain open between the two units this discrete preferential flow path would have limited impacts on the model predictions based on the limited size within the large regional model domain.

### 4.3.5 Speculation bore census and make-good commitment

A bore survey was conducted of groundwater use within a radius of ~ 10 km around the Alpha and Kevin's Corner mine leases during the EIS. This 10 km is considered industry standard and allows for the compilation of baseline data for the description of groundwater resources and values prior to any mining activities (as detailed in Section 4.2.3 above).

The property Speculation was not included in the EIS baseline bore census. However the registered bores on the property (RN51057 and 51058) were included in the assessment of at-risk bores.

It is, however, noted that the 1 m drawdown contour, considered as providing the initial assessment of at-risk bores, predicted for the Kevin's Corner coal mine extends to the within the property Speculation (Kevin's Corner Supplementary EIS Appendix L, URS 2012). Based on predicted drawdown and the methodology detailed in the Groundwater Model Report (URS, 2012) as part of the Proponent's make-good commitment an assessment of bores on the properties potentially at-risk will be conducted. This will include field verification of bores and an assessment as part of any make-good agreements.

#### 4.3.6 Suggested conditions

Mr Currie suggests that their bores be included for monitoring as well as an additional three monitoring bores to provide early warning of impacts on the Clematis Sandstone.

I consider that the proposed conditions in relation to the Alpha Coal Mine, as discussed in Section 4.3.2 above, are adequate and sufficient to assess potential groundwater impacts to the west of Alpha Coal Mine.

Based on the worst case modelling I also consider that there is no need to condition an additional (three) monitoring bores between Alpha and the property of Speculation, as the Kevin's Corner Coal Mine proposed conditions include for monitoring bores to the west of Kevin's Corner Coal Mine similar to Alpha Coal Mine's conditions

### 4.4 Affidavit of Fiorella Paola Cassoni

Key Groundwater Issues

Ms Cassoni's affidavit raises the following key groundwater issues for consideration:

- Groundwater model deficiency;
- Cumulative impacts;
- Aquifer drawdown and quality impacts on Bimblebox;
- Bore census for baseline data;
- Make-good agreement; and
- Suggested conditions.

Comments

#### 4.4.1 Groundwater model deficiency

Ms Cassoni considers, based on expert evidence that the groundwater modelling is deficient so as not to include the impacts on Bimblebox and where the model is deficient, inadequate or incorrect then no reliance can be placed on the resultant assessment.

I consider that the groundwater modelling is not inadequate or incorrect based on:

- The use of recognised industry practice;
- Adopting an approach that allowed for the consideration of worst case scenarios;
- The fact that the model was developed on site specific groundwater data and simulated transient data (groundwater extraction and water level changes recorded during the Alpha Test Pit dewatering, to a high degree of accuracy;
- The model having been assessed by independent experienced groundwater modelling practitioners;
- The model having been reviewed by experienced regulatory authorities; and
- The point of agreement (18 of the Joint Experts Report) where it was agreed that the groundwater model construction and calibration, specifically with regard to model layers and hydrogeological parameters (hydraulic conductivity and storage parameters) are appropriate.

I also note that the groundwater modelling allowed for the assessment of the impacts of Alpha Coal Mine dewatering to the south of Alpha Coal Mine, an area which includes Bimblebox.

The points of disagreement, as detailed in Section 4.1 of this report, when considered relate more to the conceptualisation and understanding of recharge, groundwater system dynamics (static or dynamic), and groundwater through flow, which have limited impacts on the groundwater model results (as the model included sensitivity and uncertainty analyses and adopted a worst case scenario approach). Thus I do not consider that a concern that the model results cannot be relied upon is well founded.

### 4.4.2 Cumulative impacts

It is acknowledged that the groundwater modelling conducted by URS did not include the South Galilee Coal Project as at the time of modelling there was little or no information, other than the Initial Advice Statement, on this project.

URS considered the initial groundwater model presented in the Waratah EIS[6], which was available during the Alpha Coal Mine modelling. This preliminary model, based on limited information and incompatibility of conceptualisation, geological layer nomenclature, and model construction (it is noted that this model has been superseded by the modelling completed by Heritage Computing Report, 2013), could not be relied on to provide an accurate assessment of cumulative impacts. URS were, however, able to model and assess the impacts of two projects being mined simultaneously to allow for the assessment of how groundwater resources would be affected by multiple coal mining projects.

The resultant quantitative impact assessment was included in the Groundwater Model Report (URS, 2012), which indicated that dewatering impacts are predicted to elongate north and south within the more permeable sandstone units. The quantitative impact assessment considered the concept of superposition where by multiple mine-dewatering activities would result in deeper drawdown where each mine related drawdown cone overlaps with another. The extent and impact of additional dewatering does, however, depend on timing and the schedule of the mines as some areas may already be dewatered.

Considering that the Bimblebox property is located above the coal bearing Permian units, within the proposed Waratah Galilee Coal Project, it is considered that groundwater drawdown during this mining will have the predominant impact on the Bimblebox property.

Thus the drawdown will be the most severe (depth of drawdown > 5 m) within and immediately adjacent to the Waratah Galilee Coal Project. I consider that this impact will not be significantly larger when considering any potential cumulative impact of Alpha Coal Mine.

It is recognised that a regional model is included in the Alpha Coal Mine conditions (Appendix C of the Joint Experts Report). The regional model will allow for buy-in from all of the proponents as it is envisaged that all proposed coal mines in the area will have the same approval condition. The regional model will include:

- An agreed conceptualisation;
- Agreed modelling software package;
- Model construction;
- Appropriate regional model boundaries;
- Uniform number of model layers;
- All available groundwater, baseline, bore census, and monitoring data; and
- Mine schedules and plans to simulate drawdown and groundwater extraction and recovery over time.

[6] Waratah Coal China First: Groundwater Assessment by E3 Consult, dated September 2010

This approach has been adopted in the Surat Basin where four large Coal Seam Gas operators have undertaken a regional groundwater model to assess groundwater impacts.

#### 4.4.3 Aquifer drawdown and quality impacts on Bimblebox

Ms Cassoni considers that the Alpha Coal Mine dewatering will have a negative impact on the quantity and quality of the groundwater on Glen Innes (Bimblebox Nature Reserve).

No groundwater quality impacts are predicted to occur based on the final void acting as a sink; refer to comments included in the Joint Experts Report, Point 1 and Point 21.

In addition, groundwater flow is from south to north across Bimblebox, even during mine dewatering and post-mining, such that any possible migration of poor quality would not migrate southwards in the groundwater.

The predictive groundwater model drawdown in the D coal seam at the end of mining is presented in Figures 20 and 21 of this report. The 0.5 m drawdown contour, both for Alpha alone and Alpha and Kevin’s Corner cumulative mining, is projected to extend to the boundary of Kia Ora and Glen Innes (Figure 22). It is noted that the default 'bore trigger threshold for petroleum activities in the *Queensland Water Act 2000* is a decline in groundwater levels of 5 m for confined aquifers. The 5 m drawdown contour is predicted even further from the Bimblebox / Glen Innes property.

The consideration by Ms Cassoni is therefore considered to be made without any scientific consideration of the aquifer parameters and groundwater flow, which are well understood and control the inflows and resultant dewatering impacts at the Alpha Coal Mine.

#### 4.4.4 Bore census for baseline data

Ms Cassoni incorrectly assumes that URS have only assessed groundwater resources within the 10 km radius based on the baseline bore census, which was conducted during the EIS to assist in describing the groundwater resources and values.

The groundwater modelling considered an area of 5,404 $km^2$ (118.5 km x 45.6 km).

It is noted that the bore census included the bores located on Glen Innes.

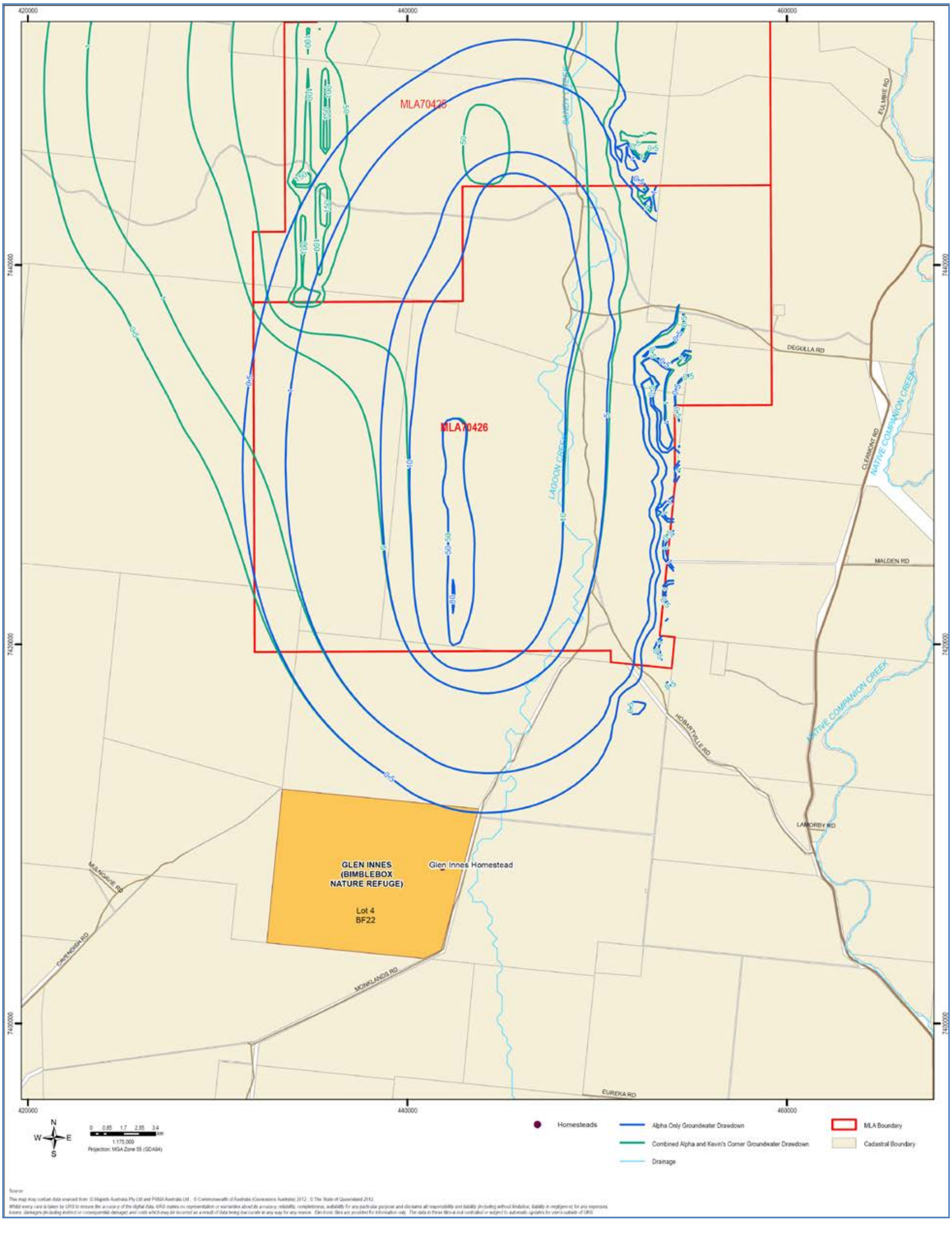
#### 4.4.5 Make-good agreement

There appears to be some confusion between the make-good commitment, which I refer to in the Groundwater Model Report and other groundwater sections of the EIS reports, and the actual make-good agreements.

Ms Cassoni states that no make-good agreement has been entered into with the proponent. This, however, does not mean that my statement that the proponent is committed to make-good unduly affected groundwater supplies is false.

I note, as detailed in Section 4.2.6 above, that should groundwater supplies be unduly affected then the recommended approval conditions plus the Water Licence conditions (which Alpha Coal Mine will have to obtain before mining) will ensure water security.

*Figure 22 Projected drawdown contours and the Glen Innes property*



### 4.4.6 Suggested conditions

Ms Cassoni considers that additional approval conditions are required, these include:

- A true and correct groundwater model;
- Baseline monitoring of bores within or adjacent to Bimblebox;
- Monitoring overtime (12 months) to compile representative pre-mining data;
- A DERM supervised regional model to be updated every 3 years;
- A mutually suitable make-good agreement with Bimblebox;
- Monitoring of neighbouring production bores; and
- Publically available monitoring data.

The proposed conditions allow for the review and refinement of the exiting groundwater model over time and includes for the development of a regional groundwater model to consider cumulative impacts. As the two models will be assessing possible groundwater impacts I consider that there is no need to undertake a new groundwater model study.

Baseline monitoring, during which groundwater levels and quality are compiled, are subject to the make-good agreement. It is considered that these data will be compiled as part of any make-good agreements that will be mutually agreed between Alpha Coal Mine, Waratah Galilee Coal Project, or both with Bimblebox, based on the location of this property within the Waratah Galilee Coal Project

I consider that the suggestion of the Department of Natural Resources and Mines (the former DERM) taking custodianship of the regional model is a good idea. It is noted that the Office of Groundwater Impact Assessment within the Department of Natural Resources and Mines undertakes this role to assess and manage the impacts of Coal Seam Gas water extraction.

As previously stated in this report, no active production bores will be used for monitoring for model validation purposes as these data will be subject to dewatering stresses associated with the landholder's groundwater extraction. Specific monitoring points, within the different groundwater units and spatially located adjacent to the Alpha Coal Mine will be incorporated into the conditioned groundwater monitoring program.

These monitoring points will be used to validate monitoring predictions and provide "early warning" should groundwater levels decrease quicker and deeper than predicted.

The location and depth of these bores will be critical in obtaining ambient groundwater data, as these need to be located sufficiently far from existing (and possible future) groundwater extraction so as not to be influenced. These monitoring points will allow for the collection of groundwater level and quality data.

I consider that the existing approval conditions are appropriate and sufficient to:

- Assess and address identified potential impacts;
- Allow for the validation of predictions;
- Assess cumulative impacts of multiple coal mines;
- Ensure water security; and

- Provide a suitable framework to address potential impacts and make-good on water resources.

I, therefore, consider that these suggested conditions are unnecessary.

## 4.5 Ecology Joint Experts Report compiled by Dr David Dique and Robert Friend

Issue

Mr Friend included comment on the potential impacts of mine dewatering based on his interpretation of the test pit lithology (paragraph 5.3.12 of the Ecology Joint Experts Report).

Comment

Mr Friend incorrectly assumes the Tertiary saprolite mapped across the mine lease and detailed within the test pit is a soil (i.e. permeable). In fact this saprolite is logged within numerous exploration bores and within the Alpha Test pit to comprise low permeable thick clay material, as annotated on Table 10-10 (Figure 23).

Mr Friend considers, without evidence, that the near surface or perched water tables are in hydraulic connection with the "deep soil" aquifers. The nature of the separation of perched water table and the confined potentiometric surface was considered in the Groundwater Model Report (URS, 2012) and evaluated during the Alpha Test Pit dewatering.

The assessment of direct impacts of the pit, which include the near surface unconfined (water table) aquifers is included in Section 10.6.3 of the Groundwater Model Report and queried by Mr Friend in paragraph 5.3.13 of the Ecology Joint Experts Report. The extent of direct drainage into the void is related to the head (groundwater level and thickness of the unit) and hydraulic conductivity (permeability) of the unconfined Tertiary and Quaternary cover intersected during mining. Based on the low permeability the direct drainage around the void would range between 10 and 100 m. It is noted that this is not in dispute with any of the groundwater experts considering the EIS groundwater information.

Indirect impacts can occur where induced flow to the coal seams, which are dewatered and depressurised, results in drainage from the overlying units. The low permeability of the thick Tertiary clay limits (as recognised in the groundwater level monitoring during the Alpha Test Pit (Figure 11-7 of the Groundwater Model Report) (Figure 24) any induced flow from the shallow water tables.

Consideration of the drawdown contour (0.5 m from the pre-mining level) for the target D coal seam is projected to extend some 8 km south of the southern Alpha Coal Mine lease boundary, approximately to the Glen Innes property. The potential of induced flow from the overlying perched and unconfined water tables, through the Tertiary saprolite mapped above the Permian (Bandanna Formation and Colinlea Sandstone) units is considered to be negligible.

*Figure 23 Alpha Test Pit lithology*

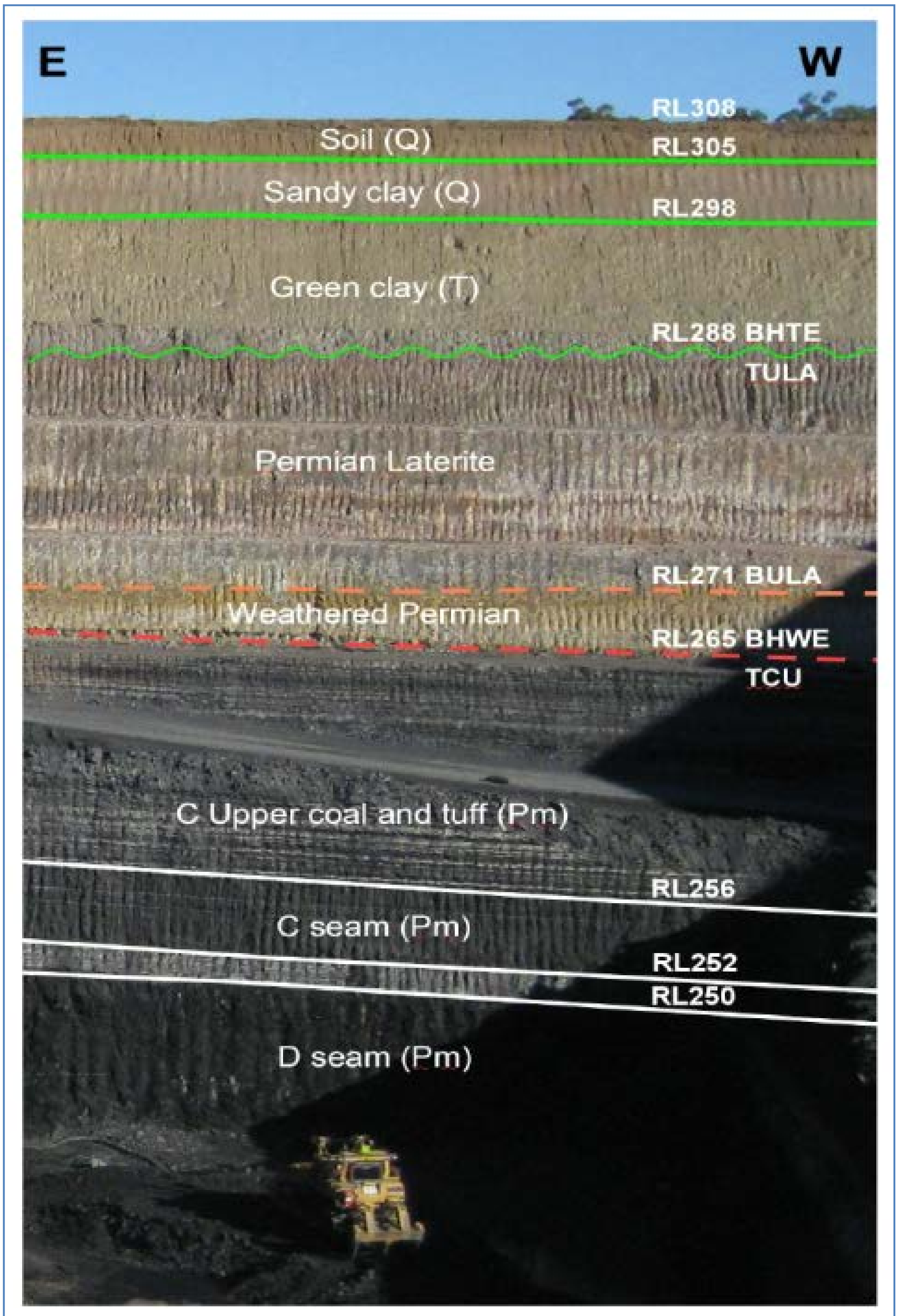
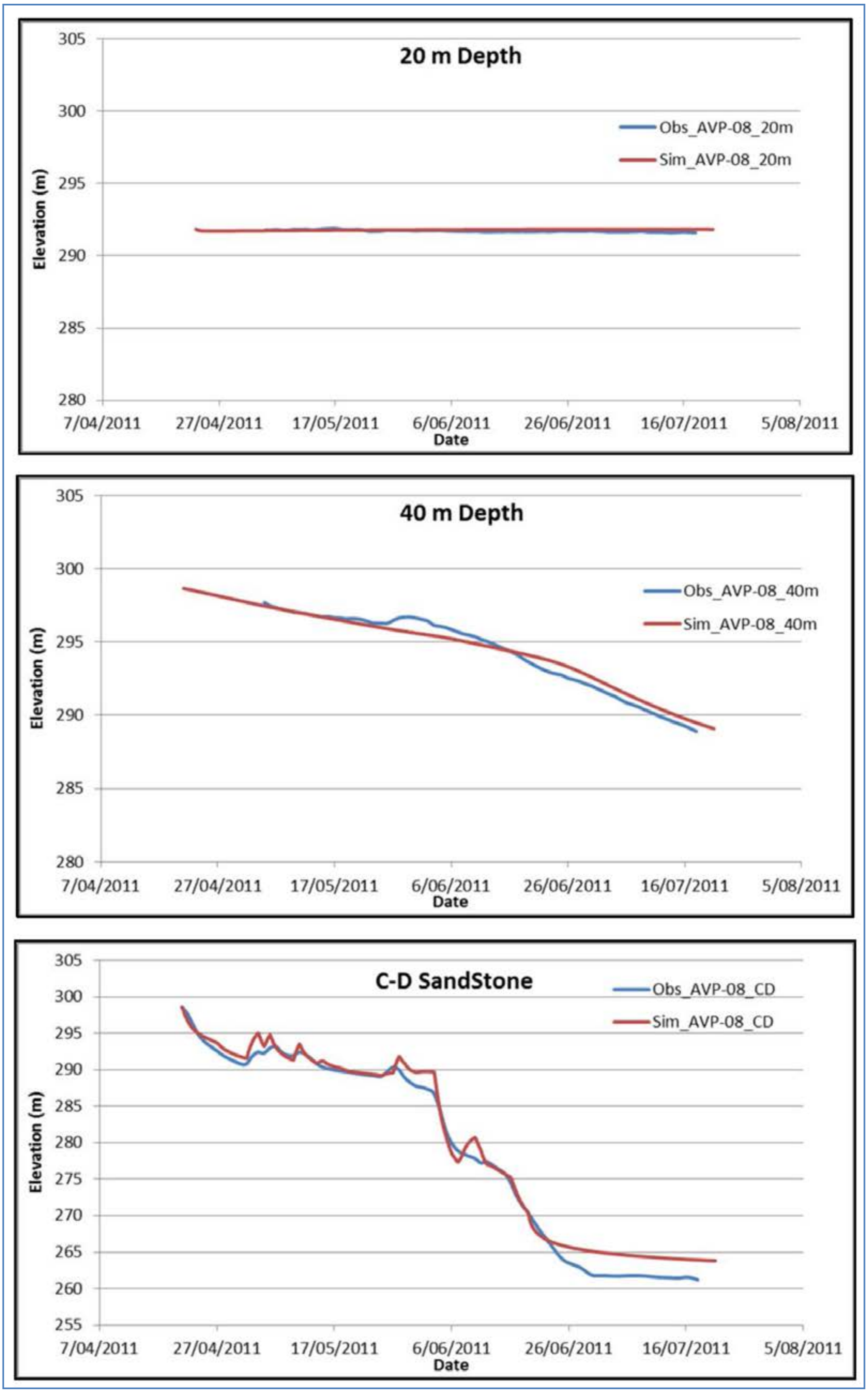


*Figure 24 Simulated versus field measured drawdown curves*



# 5. Summary of Conclusions

- Points of disagreement were based largely on the geological conceptualisation included in the groundwater conceptual model, used for the construction and calibration of a groundwater model used for impact predictions. The approach adopted by URS was to consider the worst case scenario, thus allowing for the largest potential impact on the groundwater resources over a 30 year mine life and for 300 years post-mining.
- The key area of disagreement was the conceptualisation of the cause or mechanism to facilitate groundwater flow patterns, to the northeast, recorded across the Alpha Coal Mine, which are contrary to the dip of the geological units and aquifers which dip to the west. Dr Webb and Dr Mudd consider geological structures to facilitate the groundwater flow, whereas I considered the potentiometric surface, equalised within the Permian units across the Galilee Basin, mimicked topography and plunge of the units within the Alpha Coal Mine area allowing for flow through the more permeable near horizontal units.
- No recognised structural complexity, such as beds dipping to the east, which would be evident if anticline folding to the extent required to support Dr Webb's and Dr Mudd's conceptualisation was present either in the literature or on site. All data and literature considered supports the URS modelled geological conceptualisation. The geological conceptualisation of all other projects proposed in the area and a third party review is consistent with the URS modelled geological conceptualisation.
- Available regional and local geological datasets provide a comprehensive description of the geological units on and adjacent to the Alpha Coal Mine. Agreement was reached that the local geology is representative of the geological units, strata thickness, dip, and strike. Thus the geology to be mined, which controls the inflow and drawdown impacts associated with the proposed mine dewatering, is well understood (Point 9 paragraph 21 of the Joint Experts Report).
- Recorded groundwater level data from monitoring bores within the Permian Bandanna Formation and the Colinlea Sandstone are consistently measured at elevations different to the unconfined Tertiary and Quaternary units. This indicates no hydraulic connection between the two, such that the Permian units are confined by the Tertiary clay rich material and the water table is perched and separate from the confined potentiometric surface.
- A groundwater divide is recognised within the Great Dividing Range and a no flow boundary is considered the most appropriate boundary condition to represent the groundwater divide in the groundwater model. This is the view shared by Dr Webb, Mr Hair, Heritage Computing, Parsons Brinckerhoff, and I.
- URS included a no-flow boundary in the groundwater model within the Great Dividing Range as it was recognised that a groundwater divide was likely to exist based on limited groundwater level data within the registered bore database. The use of a no-flow boundary, I considered, was a worst case approach as it assumes no groundwater flow from the western side of the Great Dividing Range, even though the strata are hydraulically connected. This meant that no flow was available from the continued units to the west of the Great Dividing Range to limit the extent of drawdown predicted in the model.

It is noted that the inclusion of folds and associated elevated potentiometric heads, as conceptualised by Dr Webb and Dr Mudd would prevent drawdown migration to the west. Due to the limited data available off site within the Great Dividing Range, URS adopted a more cautious approach. This means the zone of impact of the mine could be smaller than modelled by URS.

- The groundwater system is relatively static due to low hydraulic conductivity, slow groundwater through flow (groundwater flow through the D coal seam is at ~ 0.0028 m per year), limited recharge, and discharge. Modelling, considering the majority of groundwater extracted is from storage and that through flow and recharge is captured, allowed for the extent of drawdown cone development to be accurately projected over time. A pseudo steady-state, when discharge from the final void (due to evaporative loss) effectively equals groundwater inflow, will occur. The zone of drawdown remains relatively constant during the model simulation and is not considered to extend measurably further north as a result of diminished through flow.
- Constant head boundaries, incorporated in the model, sufficiently far from the mining areas do not affect model predictions of groundwater drawdown and groundwater ingress volumes. In this relatively static groundwater system using either a constant head boundary or a general head boundary (as considered by Dr Webb) would not make any difference to the modelling predictions as the drawdown does not extend to the boundaries. I consider that the model predictions would not change if the model boundaries were changed to general head boundaries.
- The impact assessment adopted a worst-case scenario approach allowing for a rigorous evaluation of potential impacts on the groundwater resources. Simulating the calibrated recharge to the confined Permian aquifers, to be impacted during mining, was considered a worst-case scenario as the cone of depression simulated at the end of 30 year life of mine would extend over a larger area than if more recharge was included. This in turn allowed for a larger capture zone, to intercept the recharge and through flow, providing an assessment of potential groundwater impacts. It is noted that additional recharge would result in a smaller cone of depression.
- The Rewan Formation acts as an effective regional aquitard, which limits rainfall recharge to the confined Permian Bandanna Formation and Colinlea Sandstone units targeted during mining.
- The potential impact of mine dewatering on the springs, regardless of source, was considered during modelling. The modelling predictions do not indicate a change in groundwater levels within the units below the springs or Degulla Lagoon over the 330 year modelling scenario. The inclusion of groundwater discharge at surface or close to surface (as simulated in the model) will not have an impact on the model predictions.
- The mine dewatering will remove ~ 60 GL of groundwater during the life of the mine (30 year) and the resultant impact has been predicted within the model. Post mining, allowing for the final void, will result in permanent removal of groundwater. The reduced groundwater resources do not have an impact on baseflow (ephemeral creeks and rivers) and are not predicted to impact on the possible groundwater discharge. The proposed groundwater extraction of 2 GL per year will have limited impact on surface water

resources, which provide the main contribution to water resources in the ephemeral upper reaches of the Burdekin River Catchment.

Groundwater ingress into the final void over the long term is estimated at ~ 5 L/s, an increase of ~0.018% of groundwater extraction in the Burdekin River Catchment. This continued pumping, resulting from evaporation, will prevent saline plume migration from the final void in the groundwater. Water will need to be imported (external water supply) in order to undertake the mining. This provision of external water will provide water security to the area replacing lost groundwater resources.

- The concerns of the neighbouring landholders (Anderson, Currie, and Cassoni) were considered to largely relate to concerns of groundwater supply security considering the cumulative impacts of other proposed mine projects within the same portion of the Galilee Basin as the Alpha Coal Mine.

  It is considered that the concerns regarding water security are addressed in the proposed conditions. Furthermore all required water licences, such as for mine dewatering, will include conditions regarding make-good of unduly affected neighbouring bores, which I consider will provide water security should mine dewatering impact on the landholders bores.

## 6. Expert's Statement

I confirm the following:

(d) the factual matters stated in this report are, as far as I know, true;

(e) I have made all enquiries that I consider appropriate;

(f) the opinions stated in this report are genuinely held by me;

(g) the report contains reference to all matters I consider significant; and

(h) I understand my duty to the court and have complied with the duty.

Mark Stewart

20 August 2013