Expert Report to the Land Court by Mark Stewart

1. Experts Details & Qualifications

1.1 Name

My name is Mark Stewart.

Principal Hydrogeologist at URS Australia Pty Ltd

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)

Annexure A to this report is my curriculum vitae, which sets out my professional qualifications.

2. Instructions

I have been instructed by Allens on behalf of Hancock Coal Pty Ltd to provide a report in response to the following questions:

Assessment

Question 1

Describe:

(a) the geology and stratigraphy in the area potentially impacted by the proposed Alpha Coal Mine;

The geology and the stratigraphy across the area are described in Section 5 Response 1, pages 16 to 19 of this report.

(b) the hydrogeology, condition and potential interactions of aquifers in the area potentially impacted by the proposed Alpha Coal Mine;

The description of the hydrogeology and potential aquifer interactions in the area are described in Section 5 Response 1, pages 18 to 23 of this report. Groundwater resources within the Alpha Coal Mine are associated with the confined coal seam and sandstone aquifers. These aquifers are separated from the limited intermittent perched unconfined groundwater within the alluvium and Tertiary sediments by a thick (~ 40 m) clay and laterite, as illustrated in Figure 16.

(c) the potential interactions of aquifers in the proposed Alpha Coal Mine area and the Great Artesian Basin.

The potential interactions of aquifers in the proposed Alpha Coal Mine and the Great Artesian Basin are described in Section 5 Response 1, pages 24 to 25 of this report. After consideration of geological structures across Alpha Coal Mine, no interaction between the proposed Alpha Coal Mine and the Great Artesian Basin aquifers has been identified. In particular, the proposed Alpha Coal Mine is separated from the Great Artesian Basin by the basal Great Artesian Basin aquitard, the Rewan Formation, and the clay-rich Bandanna Formation aquitard.

Question 2

What were the assessment requirements of the Terms of Reference in relation to the proposed Alpha Coal Mine's potential impacts on groundwater?

The assessment requirements of the Terms of Reference for groundwater are described in Response 2 of this report. The Terms of Reference requirements for groundwater have been compiled with, and comments regarding the consideration of potential impacts on groundwater with regards to the Terms of Reference have been included in Section 5 Response 2 pages 25 to 27 of this report.

Question 3

What work was performed to address the assessment requirements of the Terms of Reference and to undertake the groundwater impact assessment?

The groundwater study was conducted using a phased approach over a long period allowing for the correct scientific development of the study ensuring the compilation and assessment of the potential impacts, requirements of the Terms of Reference and requests for additional information raised during public comment and through discussions with the State and Federal regulatory bodies. A detailed list of studies and the methodology adopted is included in Section 5 Response 3 pages 27 to 32 of this report.

Question 4

In your opinion, was the work performed to address the assessment requirements of the Terms of Reference and to undertake the groundwater impact assessment in accordance with standard professional practice for this type of proposed project?

Yes; it is my opinion the groundwater impact assessment was conducted in accordance to standard professional practice for this type of proposed project. The reasons for my opinion are detailed on page 32 of this report.

Question 5

In your opinion, was the work performed to address the assessment requirements of the Terms of Reference and to undertake the groundwater impact assessment inadequate because of one or more of the following matters:

a) it has not adequately investigated potentially impacted bores and the importance of those bores to their owners;

No; it is my opinion that the bore survey adequately allowed for the identification of local groundwater use and the discussion of groundwater resources with the relevant bore owners. The reasons for my opinion are detailed on pages 33 to 35 of this report.

b) it has not adequately investigated the potential drawdown from the Applicant's proposed mining activities or the cumulative effect with other proposed mines nearby;

No; it is my opinion that the work conducted to assess the potential drawdown resulting from the proposed mining activities is adequate. In particular, it assesses the cumulative impacts of the Applicants' proposed Alpha and Kevin's Corner coal mines. My reasons for this opinion relate to the groundwater investigations, predictive modelling, and consideration of cumulative mining projects, as detailed on pages 36 to 37, pages 46 to 47, pages 59 to 62, and page 65 of this report.

c) baseline groundwater / bore studies of the quantity and quality of groundwater that have been done by the Applicant are inadequate to establish the likely extent of the impact of the proposed Alpha Coal Mine;

No; it is my opinion that the work performed is not inadequate on the basis of this allegation. I consider that sufficient site specific representative groundwater data was compiled, assessed, and interrogated during the Alpha Coal Mine groundwater study to allow for the description and assessment of quantity and quality of groundwater resources. The groundwater resource investigations are detailed on pages 37 to 38 of this report.

d) the impact on the Great Artesian Basin is unknown due to the insufficient modelling of recharge rates;

No; it is my opinion that the recharge mechanisms were adequately considered and evaluated during the groundwater study, allowing for recharge to be adequately included in the modelling.

Consideration of recharge, when considering groundwater impacts including the potential impacts on Great Artesian Basin units, was included in the predictive modelling. This specific objection suggests some confusion surrounding the recharge mechanisms considered across the groundwater study area (as reflected in the regional groundwater model area). The results of the modelling and additional studies indicate that any potential recharge to the confined aquifers within the proposed mine sites (Alpha and Kevin's Corner) occurs as a result of diffuse recharge along the Great Dividing Range.

My reasons for this opinion are detailed on pages 39 to 40 of this report.

e) there is insufficient information to assess the impact that the proposed Alpha Coal Mine's groundwater drawdown and potential contamination could have on the Great Artesian Basin;

No; it is my opinion that the potential impacts on the Great Artesian Basin units have been adequately assessed on the basis of sufficient information. Predictive groundwater modelling, using site specific and representative hydrogeological data, included modelling of potential groundwater level changes within the Great Artesian Basin units during and after mining. This modelling allowed for the evaluation of any potential groundwater drawdown and / or potential contamination on the Great Artesian Basin.

My reasons for this opinion are detailed in Response 1 (pages 16 to 25), pages 36 to 37, page 40, and pages 57 to 60 of this report.

f) the detail of scientific information provided on the scale and likelihood of the impacts that the mine will have on groundwater are not commensurate with the scale of the mine and the risk to environmental values. In particular, have regard to:

(i) the impacts of mine dewatering on groundwater levels, groundwater flow direction, groundwater chemistry, and recharge and discharge mechanisms described in EIS Volume 2 Section 12.9.1;

No; it is my opinion that the level of scientific investigation, allowing for the conceptualisation of the groundwater regime and model refinement over time, was sufficient to evaluate the potential groundwater impacts commensurately with the scale and risks involved. Details are included on pages 41 to 42 of this report.

(ii) the impacts on groundwater quality within the open cut pits and below and adjacent to mine infrastructure described in EIS Volume 2, Section 12.9.7;

No; it is my opinion that the potential impacts of the final void and water and waste storage infrastructure on the groundwater quality have been adequately assessed commensurately with the scale and risks involved. Details of the integrated surface water-groundwater modelling, conducted to assess these potential impacts, are included on pages 42 to 43 of this report.

(iii) the long term drawdown and water quality impacts from the final void described in EIS Volume 2, Section 12.9.8;

No; it is my opinion that the groundwater modelling, considering surface water, climatic data, and groundwater, adequately allowed for the simulation of final void water level and quality changes and long term impacts commensurately with the scale and risks involved. The reasons for my opinion are detailed on pages 43 to 44, page 66, and pages 79 to 83 of this report.

(iv) potential impacts from the tailings storage facility through leakage, movement of leachate and potential discharge into aquifers described in EIS Volume 2, Section 12.9.2;

No; it is my opinion that the potential impacts of the Tailings Storage Facility (TSF) have been adequately assessed from a groundwater perspective commensurately with the scale and risks involved. An evaluation of the potential to alter groundwater and surface water quality was conducted. The details are included in Section 5 Response 5(f) (ii) on pages 42 to 43 of this report.

(v) potential impacts to the character resilience and values of the receiving environment in relation to:

- *agricultural purposes, including stock and domestic watering;*
- *cultural and spiritual values;*
- *drinking water supply;*
- *any surface water features that may receive baseflow from groundwater described in EIS Volume 5, Appendix P, Section P.3.4.2.2; and*
- *impacts described in EIS Volume 5, Appendix P, Section P.3.4.3.2 Groundwater Impacts.*

No; it is my opinion that sufficient information has been compiled and assessed to allow for the identification and assessment of groundwater environmental values commensurately with the scale and risks involved. My reasons for this opinion are detailed in Response 5(f)(v) on pages 44 to 46 of this report.

g) the regional cumulative impacts covering groundwater impacts, has not been adequately assessed; and

No; it is my opinion that modelling of the concurrent mining of both proposed Alpha and Kevin's Corner coal mines allowed for an assessment of cumulative impacts of coal mining within the same geology along the eastern margin of the Galilee Basin. The details are included on pages 46 to 47 of this report.

h) a regional water balance has not been undertaken.

No; it is my opinion that consideration of the groundwater components of regional and local water balance has been undertaken. The groundwater modelling included the calculation of groundwater water balance results, as it is noted that the water balance is an integral part of model evaluation and was included in the modelling process. The water balance components are included on page 48 of this report.

Question 6

In your opinion, have all potential adverse impacts on groundwater have been adequately described in the EIS, SEIS and supplementary material?

Yes; it is my opinion that all potential adverse impacts on groundwater resources have been adequately considered and described in the EIS, SEIS and supplementary material.

Potential Groundwater Impacts

Questions 7

What conclusions were reached regarding the potential impacts of the proposed Alpha Coal Mine on groundwater?

Predictive groundwater modelling was conducted to assess the potential alterations to groundwater levels across the regional groundwater model area, over time and spatially. This allowed for the evaluation of possible groundwater resource reduction and alteration of groundwater quality in each of the geological units. Based on the modelling results it was concluded the proposed Alpha Coal Mine will have a marked impact on the local groundwater resources within the Permian units over the life of the mine and post closure.

Depressurisation within the target coal seams was considered to have a limited impact on groundwater resources outside of the MLA70426. For example, the proposed Alpha Coal Mine will have negligible impacts on the Great Artesian Basin, registered springs, Groundwater-Dependent Ecosystems, and surface water bodies.

Detailed conclusions are included in Response 7 on pages 51 to 59 of this report.

In answering this question, identify the extent to which the proposed Alpha Coal Mine is likely to impact on groundwater aquifers and surrounding bores, including:

- ***bores clustered around Tallarenha Creek drawing from the Colinlea Sandstone;***
- ***bores clustered to the west of Tallarenha Creek that draw from the basal, potentially lower quality Dunda Beds/Bandanna Formation; and***

- ***each objector bore identified in paragraph 2(b) in the response to request for particulars filed on behalf of objectors Paul and Janeice Anderson; and***
- ***each objector bore identified in the paragraph identified as 6(b)(i) in the response to request for particulars filed on behalf of objectors Bruce and Annette Currie.***

The predicted groundwater drawdown resulting from the Alpha Coal Mine dewatering is not predicted to impact on any of the bores identified by the objectors.

The bores clustered around Tallarenha Creek, identified in the response to request for particulars filed on behalf of objectors Paul and Janeice Anderson, are discussed on page 59 of this report. The bores, identified in the response to request for particulars filed on behalf of objectors Bruce and Annette Currie, are discussed on page 63 to 65 of this report.

In addressing the above matters, consider:

- ***the impacts of mine dewatering on groundwater levels, groundwater flow direction, groundwater chemistry, and recharge and discharge mechanisms described in EIS Volume 2 Section 12.9.1;***
- ***the impacts on groundwater quality within the open cut pits and below and adjacent to mine infrastructure described in EIS Volume 2, Section 12.9.7;***
- ***any differences in estimates of the extent of drawdown in EIS Volume 2, Section 12.9.1, Section 12.9.5, Section 12.9.8; URS (March 2012) Groundwater Modelling Report, section 10.6.2;***
- ***the statement that the proposed Alpha Coal Mine "has the potential to impact [sic] on the use of groundwater for agricultural purposes (stock watering) by causing material interference to bores (e.g. by limiting the available drawdown in the bore and hence reducing yield, or by drawing the water level down below the existing pump intake)" (EIS Volume 5, Section P.3.4.3.2);***
- ***any various springs and surface water features (e.g. Lagoon Creek) that may be fed, at least periodically, by groundwater;***
- ***the relevance of the drawdown cone of depression being predicted to be elongated in a north/south direction;***
- ***the relevance of the proposed Kevin's Corner Coal Mine being predicted to have a cumulative impact on the drawdown cone of depression in an elongated north/south direction;***
- ***whether the migration of water towards the cone of depression caused by the proposed Alpha Coal Mine may:***
    - ***cause water of lesser quality to migrate towards the cone of depression, potentially increasing salinities; and***
    - ***cause contaminants including water of lesser quality to replace supplies of groundwater;***
- ***an impacts to the character resilience and values of the receiving environment in relation to:***

- ***agricultural purposes;***
- ***cultural and spiritual values; and***
- ***drinking water supply.***

I have considered these matters. In particular, consideration of the bores identified by the objectors Paul and Janeice Anderson and Bruce and Annette Currie has been compiled in Response 7, pages 59 to 65 and when considering at-risk bores, pages 33 to 35 and 57 to 58 of this report.

Question 8

In your opinion, will the proposed Alpha Coal Mine have a significant impact on groundwater?

It is my opinion that the proposed Alpha Coal Mine will have a marked impact on the local groundwater resources within the Permian units over the life of the mine and post closure. Depressurisation within the target coal seams was considered to have a limited impact on groundwater resources outside of the MLA 70426. For example, the proposed Alpha Coal Mine will have negligible impacts on the Great Artesian Basin, registered springs, Groundwater-Dependent Ecosystems, and surface water bodies. The reasons for my opinion are detailed on page 66 of this report.

Question 9

Identify any conditions in the Coordinator-General's Report, the draft Environmental Authority and/or EPBC Act Approval relevant to the potential impacts of the proposed Alpha Coal Mine on groundwater.

Annexure B to this report contains the groundwater conditions included in the Coordinator-General's Report, the draft Environmental Authority and the EPBC Act Approval documents.

Question 10

To the extent your opinion is that there is a degree of scientific uncertainty regarding the potential impacts of the proposed Alpha Coal Mine on groundwater, to what extent (if any) do the conditions in the Coordinator-General's Report, draft Environmental Authority and/or EPBC Act Approval address that uncertainty?

It is my opinion that even allowing for model sensitivity and uncertainty analysis the groundwater model is still a simplification of the complex heterogenic multilayered groundwater system intersected within the mine area and surrounds. Thus any model can be improved and predictions verified once additional information (groundwater level monitoring and mine extraction data) is available.

It is noted that the inclusion of conditions (**Annexure B**), which allow for additional groundwater monitoring (network and program), regular groundwater modelling, third party audits, and the development of a basin model will allow for the assessment and verification of predicted impacts on the groundwater resources in this portion of the Galilee Basin. The reasons for my opinion are detailed on page 67 of this report.

Question 11

In relation to the advice of the Interim Independent Expert Scientific Committee to the Commonwealth Environment Minister, in your opinion have:

- ***any of the matters raised in that advice have already been appropriately assessed by the information in the EIS, SEIS and supplementary documentation to date?; and***
- ***the matters raised in that advice have been adequately addressed by the conditions of the Environment Protection and Biodiversity Conservation Act 1999 approval, the Coordinator-General's conditions and the conditions of the draft Environmental Authority?***

It is my opinion that the groundwater related matters raised by the Interim Independent Expert Scientific Committee (IIESC) have been considered, evaluated and included during the EIS process. I consider that there is sufficient information to date for the purpose of understanding the potential impacts and for making informed decisions.

I consider that the conditions that have been imposed on the Alpha Coal Mine (Annexure B) will allow for the provision of additional hydrogeological information regarding the potential impacts on to the Great Artesian Basin, predictive modelling validation, and the management and monitoring of groundwater, throughout the life of the mine, thus providing the IIESC with additional information as raised in their advice. The reasons for my opinion are detailed on pages 67 to 72 of this report.

Question 12

In your opinion, is there sufficient, adequate and accurate information to provide a reasonable level of scientific certainty to support your conclusions in relation to the above?

Yes; it is my opinion that sufficient site-specific, accurate and representative data was compiled, which allowed for the compilation of groundwater impact assessments, mitigation measures and management plans in the various EIS groundwater sections and technical reports. This data allowed for the development of predictive groundwater models, which accurately assess the potential impacts of the proposed mining on the groundwater resources and allowed for informed decision making. The reasons for my opinion are detailed on pages 72 to 74 of this report.

Potential Surface Water and Other Impacts

Question 13

In your opinion:

(a) ***what is the likelihood of interconnectivity between groundwater and surface water, including surface water features (e.g. springs and perched water tables)?***

In my opinion, based on the numerous groundwater level monitoring points, locations (adjacent to surface water bodies and spread across both Alpha and Kevin’s Corner mines), and water level readings over time, the likelihood of surface water-groundwater interconnectivity is low. The details are included on pages 74 to 76 of this report.

(b) ***What is the likelihood and significance of direct and indirect impacts of proposed Alpha Coal Mine dewatering on surface water, including surface water features (e.g. springs and perched water tables)?***

In my opinion, based on the effective aquitard (clay) separation between the coal seams to be mined and the perched water table and ephemeral surface water, the likelihood of indirect impacts (induced flow) of the open pit mine will be very low. The direct impacts will be limited to immediately adjacent to the open pits. The details are included on pages 76 to 78 of this report.

In answering this question, include a discussion of any contribution of 'baseflow' from groundwater and the likelihood of any contamination as a result of mining activities, and in particular consider any surface water features that may receive baseflow from groundwater described in EIS Volume 5, Appendix P, Section P.3.4.2.2).

No groundwater-surface water interaction has been recorded across MLA70426 or downstream within Kevin's Corner MLA70425. Groundwater model construction and calibration, both steady-state and transient, achieved a good correlation of groundwater levels across the whole regional model area with no simulation of groundwater loss or discharge into the surface water. The details are included on page 78 of this report.

Potential contamination of Lagoon Creek, as a result of possible poor quality seepage from the TSF was conducted and discussed in **Response 15** (pages 84 to 87).

Question 14

In your opinion, to what extent will the proposed Alpha Coal Mine's final void impact on groundwater? In answering this question, include detail regarding:

- ***the size of the final void;***
- ***when the void is expected to reach a 'steady state';***
- ***the risk of decant from the final void;***
- ***the quality of water in the final void;***
- ***the impact of the final void on groundwater equilibrium; and***
- ***the likelihood of the final void resulting in groundwater contamination.***

In particular, also consider the long term drawdown and water quality impacts from the final void described in EIS Volume 2, Section 12.9.8.

In my opinion, the final void will impact on the local groundwater resources in perpetuity. The resultant altered local groundwater flow pattern will, however, prevent poor quality water leaving the final void and migrating off site in the groundwater. The reasoning behind my opinion is included in Response 14 on pages 78 to 83 of this report.

Question 15

In your opinion, to what extent will the proposed Alpha Coal Mine's Tailings Dam impact on groundwater? In answering this question, consider the:

- ***potential impacts of the tailings storage facility through leakage, movement of leachate and potential discharge into aquifers described in EIS Volume 2, Section 12.9.2;***
- ***potential movement of leachate from the tailings storage facility down gradient at shallow depth toward Lagoon Creek where it could discharge to the Lagoon Creek alluvium, with particular consideration of EIS Volume 2, Section 12.9.2.1; and***

- ***the Objector's allegation that the proposed liner system will only "reduce" seepage to groundwater and "limit seepage of tailings water" with particular reference to EIS Volume 5, Appendix J2, p27).***

It is my opinion, based on the proposed TSF design and construction requirements and Hancock's commitments, that the potential for the TSF to act as a source of poor quality artificial recharge will be reduced. I consider that any deep drainage resulting from seepage below the TSF would, over time, flow to the final void thus reducing the potential for seepage migration off site. Long term predictive modelling does not indicate seepage from the TSF into Lagoon Creek even considering a worst case (keeping a water cover over the TSF as a constant head) scenario over 300 years. Response 15 pages 83 to 86 include the details.

Question 16

In your opinion, is there sufficient, adequate and accurate information to provide a reasonable level of scientific certainty to support your conclusions in relation to the above?

Yes; it is my opinion that sufficient site-specific and representative data was compiled during the groundwater and geotechnical studies across the TSF footprint to allow for the accurate model simulation of potential seepage. The use of a constant water level and representative permeability, within the predicted dewatered and depressurised (post mining) groundwater regime allowed for the assessment of possible seepage migration. I consider this approach to be standard professional practice. The details are included on page 87 of this report.

3. Facts and Assumptions

In producing this Court report, I have relied on the facts and assumptions contained within the following reports and the reference documents included in these reports:

- Hancock Prospecting Pty Ltd (2010), Alpha Coal Project Environmental Impact Statement Section 12 Groundwater, Volume 2;
- Hancock Prospecting Pty Ltd (2010), Alpha Coal Project Environmental Impact Statement Appendix 5G Groundwater, Volume 5;
- Hancock Prospecting Pty Ltd (2010), Alpha Coal Project Environmental Impact Statement Appendix 5P Environmental Management Plan, Volume 5;
- Hancock Prospecting Pty Ltd (2011), Alpha Coal Project Supplementary Environmental Impact Statement Appendix N Groundwater and Final Void Report, Volume 2;
- Hancock Prospecting Pty Ltd (2011), Alpha Coal Project Supplementary Environmental Impact Statement Appendix O Groundwater Bore Survey Report, Volume 2;
- Hancock Prospecting Pty Ltd (2011), Alpha Coal Project Supplementary Environmental Impact Statement Addendum Tailings Storage Facility: Hydrogeological Assessment;
- Hancock Prospecting Pty Ltd (2011), Alpha Coal Project Supplementary Environmental Impact Statement Addendum Tailings Storage Facility: Geotechnical Assessment;
- Hancock Coal Pty Ltd (2012), Alpha Coal Mine Environmental Management Plan, November 2012;
- URS (2012), Report for Hancock Coal Pty Ltd Groundwater Modelling Report – Alpha Coal Project, report ref 42626880, dated 28 March 2012;
- URS (2012b), Report for Hancock Galilee Pty Ltd Kevin's Corner SEIS Groundwater Report, report ref 42626920, dated 18 May 2012;

In addition, the following documentation was considered during the compilation of this Court report:

- JBT Consulting (2010), Great Artesian Basin – Groundwater Implications for Alpha and Kevin's Corner Projects, Letter report ref JBT01-005-015-GAB Summary, dated 3 June 2010;
- Parsons Brinckerhoff (2012), Alpha Coal Project Mine Water Structures Bridging Report, Report 2123204D-RPT001-D-mk, July 2012
- Queensland Government (2009), Terms of Reference for an Environmental Impact Statement, Alpha Coal Project, The Coordinator-General June 2009;
- Queensland Government (2012), Alpha Coal Project, The Coordinator-General Report Summary, May 2012;
- Queensland Government (2012), Alpha Coal Project, Coordinator-General's Evaluation Report on the Environmental Impact Statement, May 2012;
- Queensland Government (2012), Draft Environmental Authority (Mining Lease) Non Code Compliant Level 1 Mining Project Permit Number: MIN101017310 – Alpha Coal Mine, 17 December 2012;

- Salva Resources (2009), Summary of Galilee Regional Model (GAB), Internal Project Memorandum from Salva Resources to Hancock Coal Pty Ltd.

4. Background

It appears that the objections received regarding the groundwater assessments for the proposed Alpha Coal Mine relate largely to the adequacy of the work conducted. It should be noted in this regard that a significant amount of geological and hydrogeological data compilation, validation and assessment has been conducted over a period starting in late 2009 to 2012. The groundwater studies allowed for the construction and calibration of built-for-purpose groundwater models to simulate groundwater conditions and assess potential impacts on groundwater environmental values and resources during mining and for up to 300 years post mining.

The groundwater studies include:

- Reviewing existing data compiled from prior phases of groundwater investigations across mine lease application (MLA) 70426, including 6 long duration pump-out tests and aquifer hydraulic parameter evaluations from 1982 to 1984;
- The evaluation of 176 registered groundwater bores within a radius of 20 km of MLA70426;
- A bore survey on 14 properties within and adjacent to MLA70426, which allowed for the assessment of groundwater use and baseline groundwater quality;
- Reviewing the regulatory framework as it relates to groundwater, including discussions with the then Department of Environment and Resource Management;
- Field work, including siting and construction of a groundwater monitoring network and the installation of data loggers (water level monitoring, rain gauges). The site specific data points include the following:
    - Vibrating wire piezometer (VWP) monitoring bores have been installed at 16 sites of Alpha, monitoring 42 vertical intervals;
    - 14 monitoring bores have been installed across Alpha (monitoring the Colinlea Sandstone, Joe Joe Formation, Tertiary, and alluvium);
    - Test pumping bores have been installed at three sites. Two bores are constructed within the D-E sandstone, and one bore is constructed within the sub-E sandstone;
    - Groundwater level, yield, and chemistry data has been reviewed from over 250 groundwater exploration bores within MLA70426 and the adjacent Kevin’s Corner mining lease application area (MLA70425);
- Aquifer hydraulic parameters were estimated using pump out aquifer tests, variable head tests, laboratory permeability testing and literature data. This data plus aquifer information compiled during the Alpha Test Pit (ATP) dewatering were used in the modelling;
- Development of a Rainfall Residual Mass curve using synthetic long term climate data;
- A regional geological model to assess regional scale fold and fault structures and evaluate the geological relationship between the Galilee Basin and the Great Artesian Basin;
- A literature review and evaluation of available hydraulic conductivity (permeability) data for the Rewan Formation, the basal GAB unit which separates the GAB from the Galilee Basin. The Rewan Formation is a regional aquitard that limits the flow of water within and between basins.

An assessment of available Queensland Petroleum Exploration Data drill stem test data indicated layers of very low permeability (< 0.0009 m/day) within the Rewan Formation;

- Topography data initially included 250 m contour spacing outside of the mine areas (Alpha and Kevin's Corner) and 1 m contour spacing within the mine areas. Additional elevation data (90 m spacing) was added which allowed for a more representative evaluation of changes in groundwater level across the regional model area;
- Groundwater recharge assessment based on drilling and groundwater level and quality data, to evaluate recharge mechanisms. A review of available groundwater hydrographs, from long term monitoring points across the Alpha and Kevin's Corner MLAs, drilling results, chemistry, and groundwater flow patterns indicated diffuse recharge along the Great Dividing Range;
- Evaluation of surface water-groundwater interaction through the installation of nested bores, intersecting alluvium and Tertiary unconfined aquifers and deeper confined Permian aquifer, adjacent to Lagoon Creek and Sandy Creek;
- Baseline groundwater monitoring in the 14 monitoring bores, including the collection of water level and hydrochemistry data, has been conducted since July 2011 allowing for the compilation of datasets indicated in the table below;

Well ID	Number of Events Completed	Dates of Events
ATSF-01B	10	August 2011 – June 2012
ATSF-02	10	August 2011 – June 2012
ATSF-03	10	August 2011 – June 2012
ATSF-05B	10	August 2011 – June 2012
ATSF-06B	10	August 2011 – June 2012
ATSF-06C	10	August 2011 – June 2012
ATSF-07B	10	August 2011 – June 2012
ATSF-07C	10	August 2011 – June 2012
ATSF-08B	10	August 2011 – June 2012
ATSF-09A	9	August 2011 – June 2012
AMB-01	11	July 2011 – June 2012
AMB-02	11	July 2011 – June 2012
AMB-03	11	July 2011 – June 2012
AMB-04	11	July 2011 – June 2012

- Groundwater level data from the vibrating wire piezometers, recorded every 6 hours, was recovered from the automated readers during the monitoring events;
- A groundwater assessment of the TSF, including drilling, aquifer assessments, chemistry evaluation, and contaminant propagation (migration) modelling to evaluate risks to surface water and deeper groundwater resources;
- Seepage modelling, undertaken to predict inflow rates to the open cut mine, extent of drawdown due to passive drainage, and geotechnical requirements for mine dewatering;
- An initial Environmental Impact Statement regional numerical model, which allowed for a preliminary assessment of potential impacts of mine dewatering on the regional groundwater regime;

- A refined predictive groundwater model, to provide high confidence level estimates of groundwater flow into the open cut mine over the life of mine and facilitated mine water management and mine water balance studies;
- Predictive groundwater modelling to provide prediction of the magnitude and extent of groundwater level impacts from Alpha Coal Mine alone and with the Kevin's Corner Coal Mine (cumulative impacts);
- Assessment of at-risk bores and the compilation of make-good commitments to ensure unduly affected groundwater supplies are managed during and after mining; and
- Integrated surface water-groundwater final void modelling, to provide predictions of water levels and long-term water quality (in terms of salinity), simulated for 300 years post mining, which allowed for the assessment of potential impacts on groundwater resources, springs, and the GAB in the long term.

These studies allowed for the compilation of groundwater impact assessments, mitigation measures and management plans in the groundwater sections, Environmental Management Plans, and technical reports included in the Alpha EIS, SEIS, SEIS Appendices, and Addendums.

The data compiled, evaluated and considered allowed for the development of predictive groundwater models which accurately assess the potential impacts of the proposed mining on the groundwater resources and are sufficient to allow for informed decision making.

5. Opinion and Findings

I have prepared answers to the questions provided by Allens on behalf of Hancock Coal Pty Ltd.

ASSESSMENT

Question 1

Describe:

(a) ***the geology and stratigraphy in the area potentially impacted by the proposed Alpha Coal Mine;***

(b) ***the hydrogeology, condition and potential interactions of aquifers in the area potentially impacted by the proposed Alpha Coal Mine;***

(c) ***the potential interactions of aquifers in the proposed Alpha Coal Mine area and the Great Artesian Basin.***

Response 1

The proposed Alpha Coal Mine lies on the eastern margin of the Galilee Basin. The geology consists of gently (1 to 2 degrees) westerly dipping sediments of Permian age, unconformably overlain by younger Tertiary and Quaternary sediments. The Permian deposits include the target coal seams. No Mesozoic age GAB sediments are located within MLA70426.

Permian sedimentary deposits at site comprise the Bandanna Formation and the underlying Colinlea Sandstone, and these units contain both economic and sub-economic coal seams. The coal seams are named alphabetically A through F, with the A seam being uppermost. There are two coal seams proposed to be mined within the deposit: the C seam and D seam, which vary in thickness from 3 m to 6 m. The overlying A and B coal seams will not be mined by Hancock Coal Pty Ltd (Hancock).

Geologically the boundary between the Bandanna Formation and the Colinlea Sandstone is the sandstone unit above the C coal seam where the sandstone units grade from predominantly clay-rich to quartz-rich with depth. Therefore the Bandanna Formation hosts the A and B coal seams, while the Colinlea Sandstone hosts the C and D coal seams.

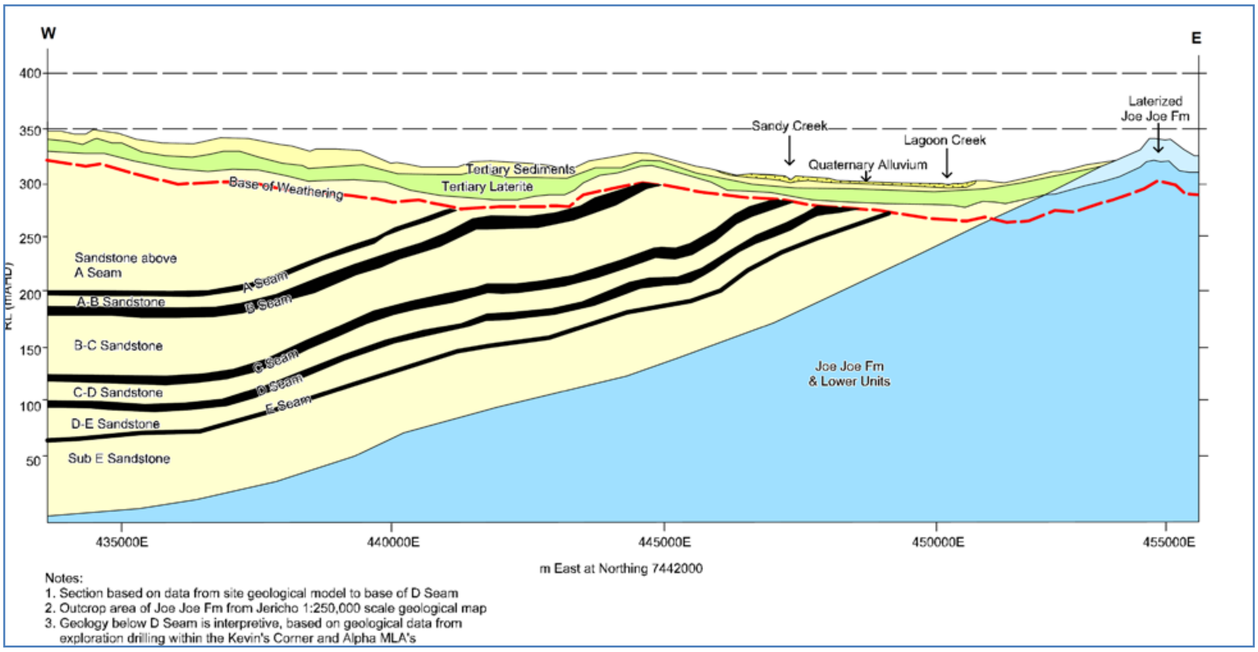
For clarity it is noted that the sandstone units are named based on the coal seams it occurs between. For example the C-D sandstone lies between the C and D coal seams.

The regional stratigraphy of the Galilee Basin, located at the Alpha Coal Mine, is described in Table 1. Figure 1 presents a cross-section through proposed Alpha Coal Mine, which illustrates the site stratigraphy.

Table 1 Project Stratigraphy

Age	Stratigraphic unit	Lithology	Thickness
Quaternary (present to 2.6 Million years)		Alluvium	15 - 20 m
Tertiary (65 to 2.6 Million years)		Argillaceous laterite and clays	~ 40 m
		Unconformity	
Late Permian (251 to 260 Million years)	Bandanna Formation	Argillaceous sandstone	10 - 30 m
		Coal – A Seam	1 – 2.5 m
		A-B Sandstone - Labile sandstone, siltstone and mudstone	~ 10 m
		Coal – B Seam	6 - 8 m
		B-C sandstone - Labile sandstone, siltstone and mudstone	70 - 90 m
Early Permian (299 to 260 Million years)	Colinlea Sandstone	Coal – C Seam – target coal seam	2 - 3 m
		C-D sandstone – Labile sandstone, siltstone and mudstone	5 - 20 m
		Coal – D Seam – target coal seam	4.5 – 6 m
		D-E sandstone	~ 15 m
		Coal – E Seam – dirty coal / carbonaceous shale – uneconomic	0.1 – 0.4 m
		Sub-E sandstone, labile sandstone, siltstone and mudstone	15 - 20 m
		Coal Seam F. Localised thick geological section, no working section	0.5 – 5 m
		Sub-F sandstone	Transition to Joe Joe Formation
	Joe Joe Formation	Labile and quartz sandstone	

Figure 1   West-East Cross-section across Alpha Coal Mine illustrating the Stratigraphy



From a groundwater perspective, major hydrostratigraphic boundaries occur within MLA70426 at the base of weathering (Figure 1), beyond which groundwater is encountered under confined conditions in the B-C and C-D sandstones, C and D coal seams, and at the base of the D coal seam (D-E sandstone).

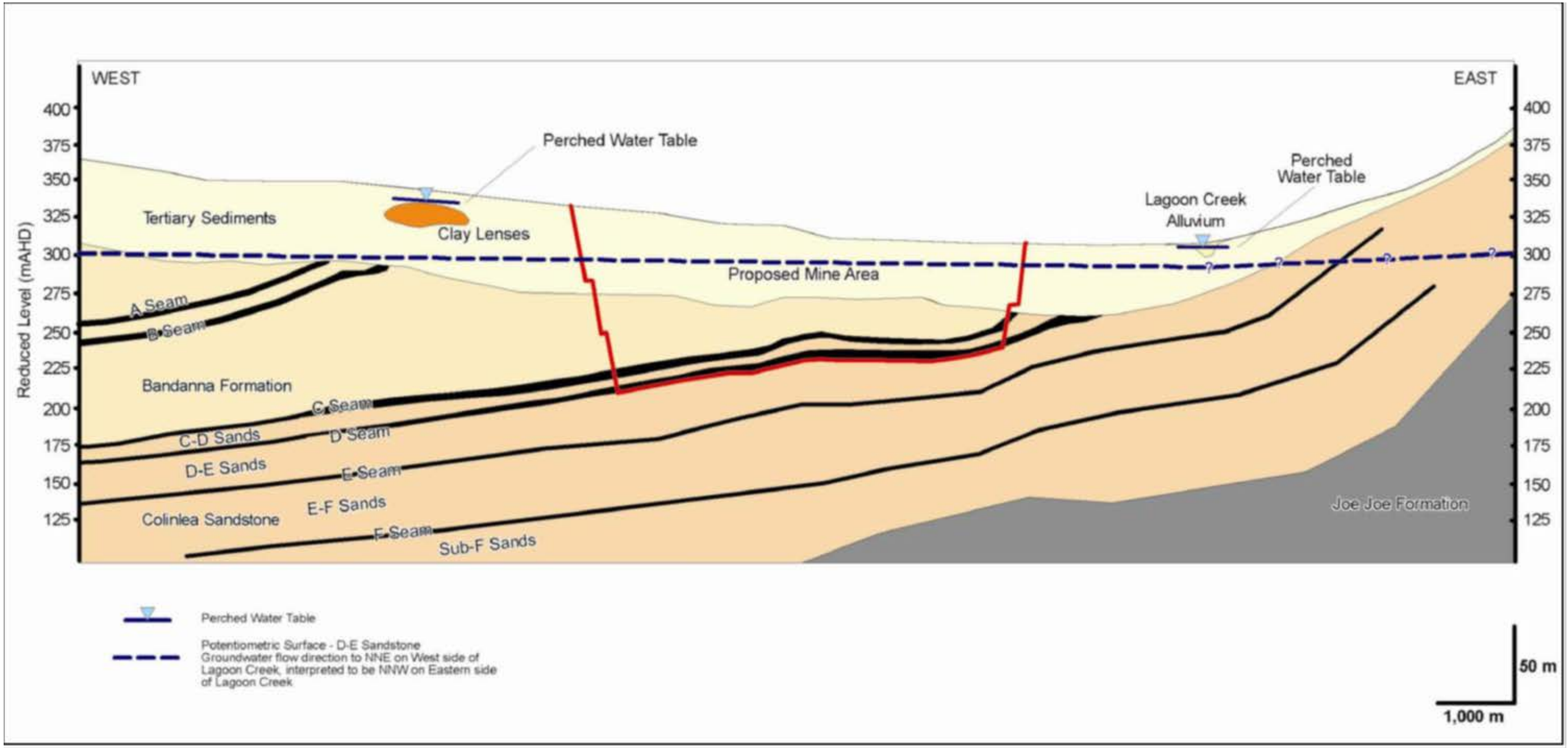
The stratigraphy and associated aquifer type, within MLA70426, is included in Table 2. The conceptualisation of groundwater resources within MLA70426 is included in Figure 2.

Table 2   Project Stratigraphy and Hydrogeology

Age	Stratigraphic unit	Lithology	Aquifer Type and Description
Quaternary		Alluvium	Quaternary alluvium associated with current surface water drainage systems may contain localised occurrences of groundwater, especially following wet season rainfall, but the alluvium is not extensive or continuous, with limited effective storage. It is therefore not regarded as a significant groundwater resource.
Tertiary		Argillaceous laterite and clays	Aquitard - Sporadic localised perched groundwater was recorded on the clay-rich laterite during exploration drilling and geotechnical studies.
Unconformity			
Late Permian	Bandanna Formation	Argillaceous sandstone	Semi-confined aquifer
		Coal – A Seam	Semi-confined aquifer
		A-B Sandstone - Labile sandstone, siltstone and mudstone	Semi-confined to confined aquifer
		Coal – B Seam	Semi-confined to confined aquifer

			B-C sandstone - Labile sandstone, siltstone and mudstone	Semi-confined to confined aquifer
Early Permian	Colinlea Sandstone			
			Coal – C Seam – target coal seam	Confined aquifer
			C-D sandstone – Labile sandstone, siltstone and mudstone	Confined aquifer
			Coal – D Seam – target coal seam	Confined aquifer
			D-E sandstone	Confined aquifer
			Coal – E Seam – dirty coal / carbonaceous shale – uneconomic	Confined aquifer
			Sub-E sandstone, labile sandstone, siltstone and mudstone	Confined aquifer
			Coal Seam F.	Confined aquifer
			Sub-F sandstone	Confined aquifer
	Joe Joe Formation		Labile and quartz sandstone	Aquitard

Figure 2 Alpha Coal Mine hydrogeological conceptualisation



Recharge – Diffuse downward recharge predominantly in the west along the Great Dividing Range where Tertiary cover is thinnest

The pre-mining groundwater resource across MLA70426 is summarised as:

- Groundwater occurs within the coal seam and sandstone aquifers. The sandstone aquifers are the main sources of groundwater in the mine area;
- The sandstone aquifers have increased quartz content and are coarser grained with depth;
- The coal seams confine the sandstone aquifers as the coal seams have low vertical permeability relative to horizontal permeability;
- Groundwater occurrence in the younger Tertiary sediments and Quaternary alluvium is intermittent, such that the limited volume of perched groundwater does not allow for useable aquifers;
- Rainfall recharge to the Permian groundwater resources occurs in topographically elevated areas to the west and flows down gradient toward the northeast. No recharge from or interaction with surface water has been identified across the groundwater study area (the regional model area). I refer to **Response 5 (d)** for additional details;
- Groundwater in the Bandanna Formation and Colinlea Sandstone is encountered under confined conditions, even adjacent to Lagoon Creek. Groundwater level measurements (potentiometric pressure readings of the confined aquifers) indicate that due to the presence of extensive confining layers (aquitards) no hydraulic connectivity between the confined groundwater resources and the surface water systems and perched water tables have been recorded.

Great Artesian Basin - Geological and Hydrogeological Considerations

Alpha Coal Mine is located to the east of the basal boundary of the GAB (Figure 3 shows a schematic cross-section through the Galilee Basin, indicating the GAB cover). The stratigraphy of the Galilee Basin to the west of the Great Dividing Range is described in Table 3.

The Rewan Formation occurs to the west of MLA70426. The geological outcrops, GAB declared subartesian boundary, and the MLA70426 boundary (and proposed Alpha Coal Mine footprint) are included in Figure 4. A cross-section (Figure 4b) through the regional 3D geological model (Salva, 2009), based on 1,201 GAB model database bores, indicates the mine exploration bores (i.e. proposed mine area) in relation to the GAB units.

The proximity to the GAB to the proposed Alpha Coal Mine was considered during the EIS as registered springs (along the Hutton outcrop) and the Clematis Sandstone (major GAB aquifer) are located to the west of MLA70426. Predictive modelling was conducted to assess the potential risk to these groundwater resources of the GAB. A detailed assessment was included in JBT Consulting (2010) report entitled, "*Great Artesian Basin – Groundwater Implications for Alpha and Kevin's Corner Projects*".

Table 3 Stratigraphy west of MLA70426 – Galilee Basin and GAB Mesozoic Age Cover

Era	Period	Basin	Unit	Rock Types
Cainozoic (65.5 mya to present)	Quaternary			Alluvium
	Tertiary			Argillaceous sandstone and clay
Mesozoic (251 to 65.5 mya)	Jurassic	Eromanga	Hutton Sandstone	Sandstone – GAB aquifer
			Moolayember Formation	Mudstone
			Clematis Sandstone	Sandstone – GAB aquifer
	Triassic	Galilee	Rewan Formation	Green-grey mudstone, siltstone, and labile sandstone
Palaeozoic (542 to 251 mya)	Permian		Bandanna Formation	Coal seams (A and B), labile sandstone, siltstone, and mudstone
			Colinlea Sandstone	Coal seams (C, D, E, and F), labile and quartz sandstone
	Late Carboniferous to Early Permian		Joe Joe Formation	Mudstone, labile sandstone, siltstone, shale and thin carbonaceous beds
	Early Carboniferous	Drummond Basin		

mya – million years ago

Figure 3 Alpha Coal Mine and Great Artesian Basin

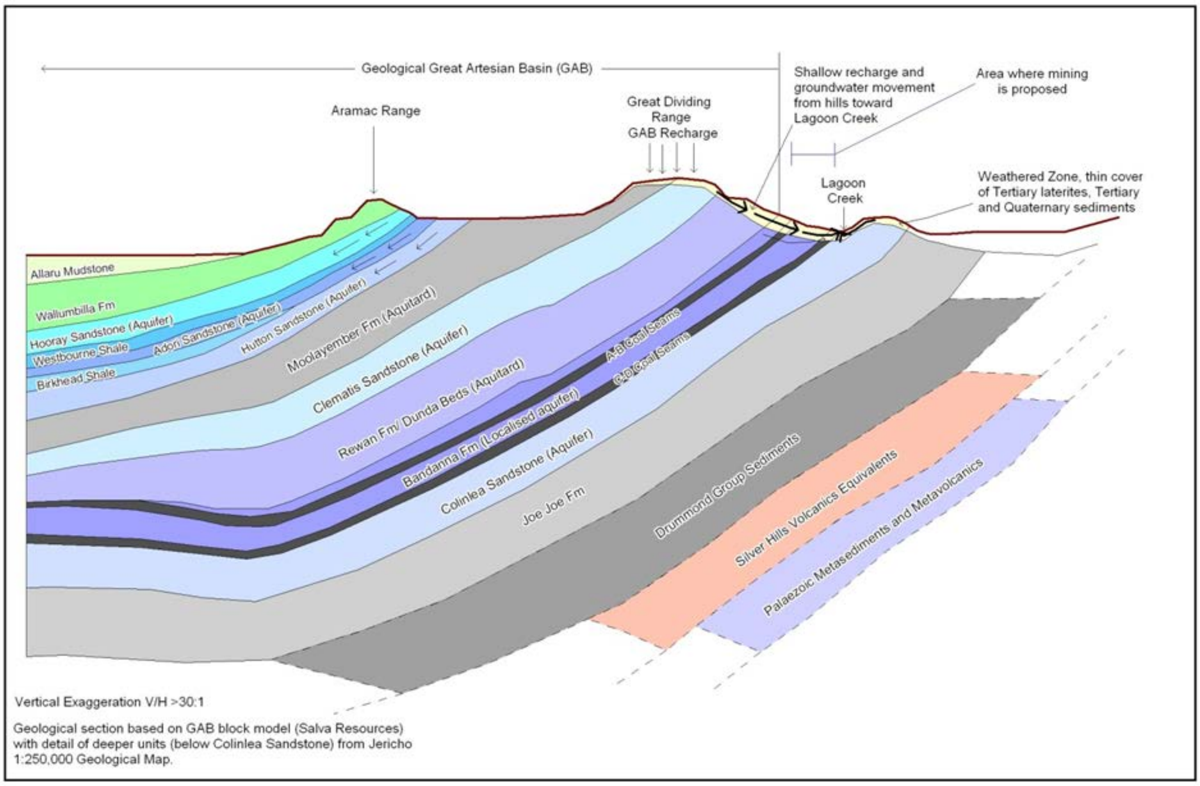


Figure 4   Alpha MLA70426 and GAB boundaries

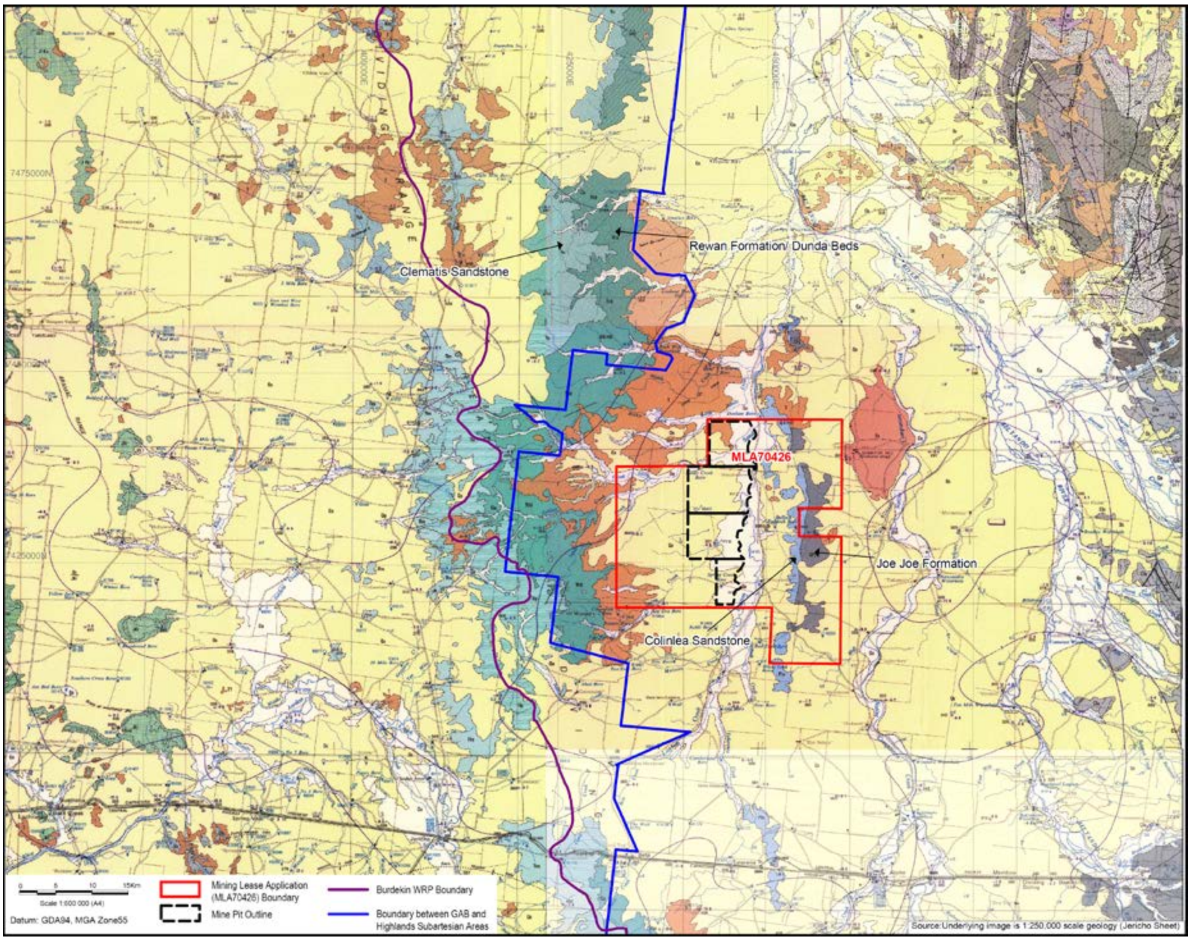
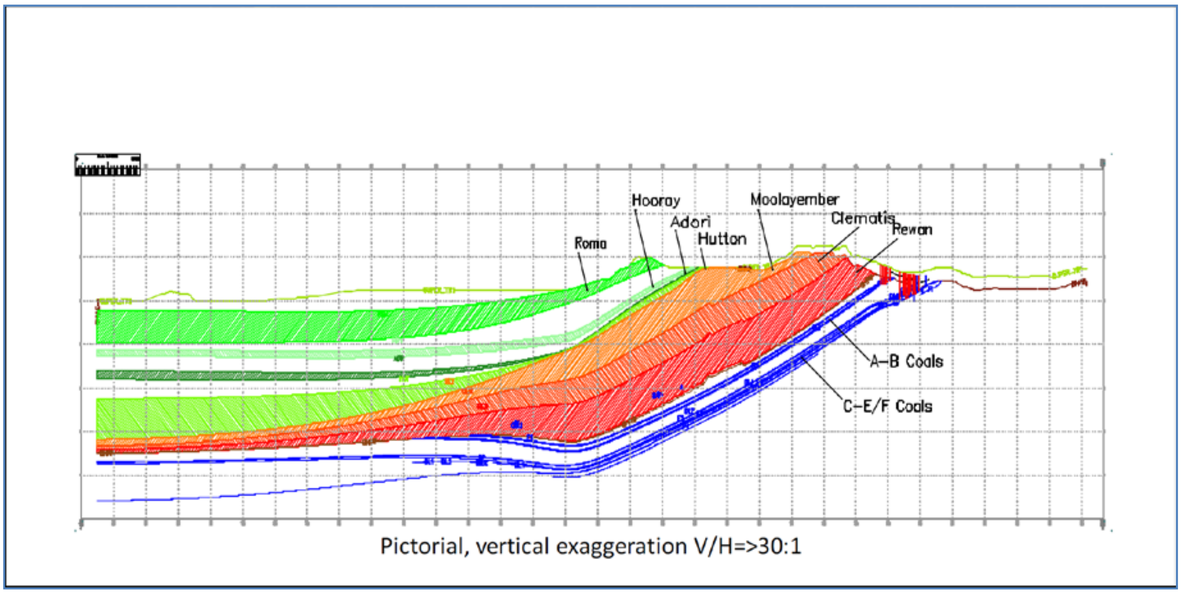


Figure 4b East-West cross-section through the Salva GAB model



The proposed Alpha Coal Mine and the GAB

The theoretical potential impacts of the proposed Alpha Coal Mine on the GAB groundwater resources could include changes to groundwater levels within the GAB units should depressurisation of the target Permian coal seams extend below the GAB to the west of MLA70426.

In order to impact on water levels in the GAB Clematis Sandstone, water levels in the Bandanna Formation and Colinlea Sandstone would need to fall to a level that created a potential for downward leakage through the Rewan Formation confining unit (i.e. induce flow). This would require leakage through the Rewan Formation, which is recorded[1] to have zones of very low permeability. Considering that the GAB aquifer, the Clematis Sandstone aquifer, has high permeability (relative to the Rewan Formation) groundwater is more likely to flow horizontally within the Clematis Sandstone aquifer, rather than downward through the Rewan Formation aquitard.

Predictive groundwater modelling was used to predict changes in groundwater levels as a result of mine dewatering and confined aquifer depressurisation. The modelling allowed for an assessment of possible risks with regard to the Clematis Sandstone and an assessment of the Rewan Formation. Observation points were included in the predictive groundwater model to allow for an assessment of the potential for groundwater level changes, through induced flow, within the GAB Clematis Sandstone and Rewan Formation.

Based on the projected groundwater levels within the observation points, there is very low risk of potential induced groundwater movement from the Clematis Sandstone aquifer towards the dewatered and depressurised mine site, during the life of mine (LOM), due to the low permeable nature of the sediments within the Bandanna and Rewan formations.

In order to further assess these predictions and to look at the potential long term impacts the observations points were included in an integrated model, which allowed for the projection of long term groundwater levels after mining (300 years post mining).

Long term groundwater levels within the Bandanna Formation, at observation points directly below both the Rewan Formation and Clematis Sandstone GAB units, were simulated in the model. Projected groundwater levels within the Bandanna Formation indicate minor, ~ 1 m changes in groundwater levels after 300 years post mining (no change at end of LOM). Based on the low vertical permeability of the Rewan Formation, between the predicted long term (slightly) depressurised Bandanna Formation (after 300 year) and the Clematis Sandstone; any induced flow impacts would be negligible within the Clematis Sandstone.

It is noted that long term groundwater levels within the Bandanna Formation, at observation points directly below the Rewan Formation (closer to proposed Alpha Coal Mine) were also simulated in the model. Projected groundwater levels within the Bandanna Formation at these observation points indicate long term changes of < 5 m after 300 years post mining. Considering the Rewan Formation directly overlies the Bandanna Formation and even though the Rewan Formation has recognised low vertical permeability, the depressurising trend within the Bandanna Formation over time indicates that there is the potential for induced flow from the Rewan Formation albeit in the long term (> 300 years).

[1] Refer to Table 10 in Response 11

The obligations of Hancock, as conditioned by the Coordinator-General, the draft Environmental Authority, and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) approval (included in **Annexure B**) include for the development of an optimum Groundwater Monitoring Program and model refinement and prediction validation (plus third party audits) on a regular basis, which will allow for monitoring of groundwater level variation over time and towards the west.

It is my opinion that the potential for induced flow from the GAB units, the Rewan Formation and Clematis Sandstone, is very low based on the available geological and hydrogeological data.

Question 2

What were the assessment requirements of the Terms of Reference in relation to the proposed Alpha Coal Mine's potential impacts on groundwater?

Response 2

The Terms of Reference assessment requirements for groundwater impacts and some comments in relation to the consideration of potential impacts on groundwater arising from those requirements are as follows:

- *An assessment of the potential environmental harm caused by the project to local groundwater resources.*

  The groundwater studies and assessments conducted during the EIS process allowed for the evaluation of potential for environmental harm to the local groundwater resources, which include:

  - Dewatering (direct) impacts on confined and unconfined aquifers;
  - Depressurisation impacts and potential for induced flow from over- and underlying aquifers towards the mine workings and depressurised confined aquifers;
  - The evaluation of possible poor quality seepage from the TSF on surface water and groundwater;
  - Conceptualisation of recharge and discharge mechanisms and an evaluation of potential alterations due to mine operations;
  - The evaluation of groundwater level decline, over time and spatially, to determine potential at-risk bores and local groundwater supplies;
  - Consideration of groundwater quality alteration and contaminant migration potential, within the groundwater;
  - Final void impacts on long term groundwater levels, local groundwater flow patterns, and final void water quality; and
  - Cumulative impacts assessing the impacts of two mines, immediately adjacent and within the same geology/hydrogeology, mining concurrently on the local and regional groundwater resources.

- *The impact assessment should define the extent of the area within which groundwater resources are likely to be affected by the proposed operations and the significance of the project to groundwater depletion or recharge.*

  The final predictive model, which was extended and refined to include the registered springs to the north of MLA70425, is a regional model covering a model area of 5,404 km^2.

- *Propose management options to monitor and mitigate these effects. In particular, proposed methods and the feasibility of those methods to 'make good' any adverse affects on the groundwater resources utilised by adjacent landholders.*

  The Groundwater Modelling Report (URS, 2012) includes groundwater monitoring network details and commitments. The report also includes details of the make-good commitment and recommended inclusions in make-good agreements.

- *The expected response of the groundwater resource to the progression and finally cessation of the project should be described, particularly in relation to the recharge potential of aquifers affected by mining.*

  Long term groundwater levels were projected using an integrated (surface water runoff – groundwater) model. This model, utilising the end of mine groundwater levels, surface water runoff, and variable recharge (backfill areas), was constructed to allow for an assessment of long term (300 years post mining) groundwater levels, flow patterns, and gradients.

- *The EIS should include mapping and a description of potential impacts for those areas where groundwater drawdown could deplete water in the root zone of vegetation with conservation value, particularly in localities with endangered regional ecosystems or threatened species.*

  An assessment of potential direct (passive drainage into open pits) and indirect (induced flow) impacts of groundwater depletion on vegetation communities was included in the Groundwater Modelling Report (URS, 2012).

- *The sensitivity of the modelling should be of sufficient precision to fully assess the extent of groundwater depletion in the root zone of vegetation with conservation value.*

  In order to best simulate mining activities on the groundwater resources to provide a more detailed assessment of potential risks to vegetation communities and springs, the predictive model was further refined and reconfigured to allow for more accurate simulations of mine dewatering and depressurisation on the younger sediments. The model refinement included:

  - Increased model area to include the registered springs north of MLA70425 and MLA70426;
  - Revision of the elevation data, outside of the MLAs, using more accurate dataset;
  - Model layer parameter change to better represent the upper layers, either GAB or Tertiary units; and
  - Revised model layer calibration, using Alpha Test Pit transient data to obtain parameter data for the Tertiary layers.

  In addition, in order to best assess the potential indirect impacts, i.e. possible induced flow from the perched water tables to the depressurised units adjacent to the mine footprint, the upper model layers were refined to allow for the representation of the Tertiary layers. These layers are not saturated based on field drilling and water level monitoring; however, for the purposes of assessing possible risks these upper Tertiary layers were assumed to be saturated across the model and have the same initial groundwater levels as those used in the steady-state calibration (the same as the D coal seam).

- *The EIS should provide an assessment of the options for the beneficial use of surplus water from dewatering of the mine pit over the life of the project, including the potential for irrigation or recharge to mitigate the impacts on areas containing vegetation with conservation value.*

The predictive groundwater model was constructed and calibrated, not only to assess potential for environmental harm, but also to provide high confidence level estimates of groundwater inflows and dewatering volumes available to the proposed Alpha and Kevin's Corner coal mines. These groundwater inflow volumes, on a year-on-year basis, were for inclusion in the mine water balance.

- *The evaluation of options for managing the surplus water should include assessment of their potential impacts and benefits and a rationale for the recommendation of a preferred option. If disposal of surplus groundwater into local waterways is an option, the EIS should include an assessment of the potential for such water to impact on fluvial processes and stream integrity.*

  All groundwater intersected during mining will be utilised in the mine operations.

- *Strategies to mitigate any negative impacts should also be described.*

  The Alpha Coal Mine Environmental Management Plan, dated November 2012, includes the proposed control strategies with regards to groundwater.

- *An assessment should be undertaken of the impact of the project on the local ground water regime caused by any land disturbance.*

  The integrated model, used to evaluate final void impacts, long term groundwater levels and flow patterns, was also utilised to assess potential long term seepage impacts from the TSF.

- *A network of observation points which would satisfactorily monitor groundwater resources both before and after commencement of operations should be developed.*

  Groundwater monitoring network details and commitments are included in the Groundwater Modelling Report and the Alpha Coal Mine Environmental Management Plan.

Question 3

What work was performed to address the assessment requirements of the Terms of Reference and to undertake the groundwater impact assessment?

Response 3

URS adopted a phased approach to allow for the assessment and evaluation of potential impacts on groundwater resources as a result of the mining at the proposed Alpha Coal Mine. The phased approach allowed for the correct scientific development of the study and allowed for the re-evaluation of impacts based on additional information over the entire groundwater study (2009 to 2012).

<u>EIS Phase</u>

The scope of work included during the EIS was groundwater investigations allowed for collation and assessment of sufficient data in order to prepare a report to satisfy the Terms of Reference in respect to groundwater resources. The work included:

- A description of the geology of the mine area, with particular reference to the physical and chemical properties of surface and sub-surface materials and geological structures within the proposed areas of disturbance;
- A review of the quality, quantity and significance of groundwater resources within and adjacent to the mine area;
- A description of the nature of the aquifers, including:

- aquifer type - such as confined, unconfined;
- depth to and thickness of the aquifer and transmissivity of the aquifer;
- potential for aquifer interconnectivity;
- depth to groundwater level and seasonal changes in levels, including response to existing extraction;
- groundwater flow directions (defined from groundwater level contours);
- interaction with surface water;
- existing and possible sources of recharge; and
- vulnerability to pollution.

- Specification of the major ionic species present in the groundwater, pH, electrical conductivity and total dissolved solids;
- A description of the environmental values of the groundwater of the affected area, in terms of:
    - values identified in the Queensland Environmental Protection Policy (Water);
    - sustainability, including both quality and quantity; and
    - physical integrity, fluvial processes and morphology of groundwater resources.
- An assessment of the potential environmental harm caused by the Alpha Coal Mine to local groundwater resources;
- Proposed management options to monitor and mitigate these effects. In particular, proposed methods and the feasibility of those methods to 'make-good' any adverse effects on the groundwater resources utilised by adjacent landholders;
- A description of the expected response of the groundwater resource to the progression and finally cessation of the Alpha Coal Mine, particularly in relation to the recharge potential of aquifers affected by mining;
- An assessment of the options for the beneficial use of surplus water from dewatering of the mine pit over the life of the mine, including the potential for irrigation or recharge to mitigate the impacts on areas containing vegetation with conservation value;
- An assessment was undertaken of the impact of the Alpha Coal Mine on the local ground water regime caused by any land disturbance; and
- A description of the development of a network of observation points which would satisfactorily monitor groundwater resources both before and after commencement of operations.

The EIS included the following:

- Reviewing existing data, prior phases of groundwater investigations, and other EIS reports that may be influenced by groundwater (e.g. surface water studies, cultural heritage studies, waste management studies);
- Reviewing the regulatory framework as it relates to groundwater, including discussions with DERM;

- Field work, including siting and construction of groundwater monitoring bores, installation of data loggers (water level monitoring, rain gauges);
- Preparing a baseline description of the groundwater environment (description of aquifer types, groundwater levels, groundwater flow directions, recharge and discharge mechanisms, water quality, sustainable yield);
- Preparing a description of the environmental values of groundwater in the region;
- Assessing mine dewatering requirements;
- Assessing the impacts of the operation on the groundwater resource in terms of groundwater levels, groundwater quality, and groundwater environmental values (i.e. impacts on existing groundwater users and the environment);
- Assessing the final void with regards to water levels and long-term water quality (in terms of salinity);
- Developing a conceptual groundwater model to describe the groundwater environment pre-mining, and the groundwater environment post-mining; and
- Developing monitoring and mitigation strategies input into the Environmental Management Plan (EMP).

Supplementary Environmental Impact Statement Phase

For the Supplementary Environmental Impact Statement (SEIS), in response to requests for additional hydrogeological information, clarification, and discussions with State and Federal regulatory bodies, allowed for the completion of additional hydrogeological studies and the further refinement of the assessment of groundwater impacts. The work for the SEIS included:

- The refinement of the EIS groundwater model, after external review and completion of additional drilling and a bore survey;
- An increased groundwater monitoring network, plan, and program;
- Further assessment of the potential impacts on the GAB, through the compilation and evaluation of Rewan Formation hydraulic parameter (hydraulic conductivity) data;
- Re-evaluation of any possible Groundwater Dependent Ecosystems (GDE), including the palustrine wetland on Lagoon Creek (a man-made water management feature) and the registered springs' spring reference no. 405, which is located just over 40 km from the boundary of the MLA70426;
- Confirmation of little or no hydraulic connection between the potentiometric surface associated with the confined Colinlea Sandstone aquifers and the perched water table, through the evaluation of groundwater level data compiled from the groundwater monitoring bores constructed adjacent and within the proposed TSF footprint;
- Further evaluation of potential impacts of mine dewatering and depressurisation on vegetation communities and GDEs based on groundwater level data;
- A geological and hydrogeological assessment of the proposed 30 year life of mine TSF footprint which allowed for:

- Mapping of the underlying geology and evaluation of the nature of the boundary between the Colinlea Sandstone and the underlying Joe Joe Formation;
  - Description of the groundwater resources within and adjacent to the TSF footprint;
  - Construction of groundwater monitoring bores to obtain groundwater data from multiple vertical zones;
  - Assessment of the suitability of the proposed TSF site from a groundwater perspective; and
  - Assessment of recharge mechanisms within the proposed TSF area.
- A bore survey of existing groundwater users and use was conducted within a ~ 10 km radius of both MLA70426 and MLA70425. The survey provided additional pre-mining ambient groundwater data. These results allowed for a revision of the groundwater environmental values.

<u>TSF Evaluation Phase</u>

A standalone groundwater report (URS, 2011) regarding the TSF was compiled to further assess the groundwater resources and potential impacts within MLA70426. Based on the compiled site specific geological and groundwater data an assessment of the potential impacts of the TSF was compiled. The assessment allowed for further consideration of:

- Recharge, where it was recognised that the recharge potential to the underlying Colinlea Sandstone is low, due to the thick clay-rich Tertiary cover, thin discontinuous Colinlea Sandstone aquifers, thick unsaturated zone, and no Colinlea Sandstone rock outcrop;
- The Joe Joe Formation aquitard and limited groundwater potential;
- Groundwater quality, poor within the intermittent perched water table, within the TSF footprint;
- Potential for poor quality seepage and seepage control measures down gradient of the proposed TSF.

The groundwater report included an assessment of potential seepage migration from the TSF towards Lagoon Creek and the mine workings, based on the groundwater model drawdown predictions.

<u>Predictive Modelling Phase</u>

URS conducted groundwater studies necessary to allow for the assessment of potential impacts of the proposed mining activities on the groundwater regime. These groundwater studies, including drilling, aquifer testing, and compilation of aquifer hydraulic parameters that allowed for the construction and calibration of several numerical groundwater models. The various “built-for-purpose” models included:

- An initial EIS regional numerical model, which allowed for a preliminary assessment of potential impacts of mine dewatering on the regional groundwater regime;
- A refined predictive groundwater model, which allowed for an accurate estimate of groundwater ingress over the LOM and facilitated mine water management and mine water budget studies; and

- An integrated surface water - groundwater model, which allowed for a more detailed and accurate simulation and assessment of potential long term groundwater impacts associated with the Alpha final void.

Again URS adopted a phased approach to the groundwater modelling, allowing for the correct scientific development of the models, as additional more accurate data became available. The initial EIS model provided an initial assessment of groundwater ingress, drawdown impacts, and final void / long term groundwater levels. These results, presented in the various EIS submissions, were superseded through ongoing model refinement based on the compilation of additional site-specific groundwater data. The data compiled for the model refinement were available from:

- The dewatering of the ATP for bulk sample collection;
- Bore construction and aquifer testing within the same geological units across the proposed Kevin's Corner Coal Mine (MLA70425);
- An independent review of the modelling; and
- Drilling and aquifer testing across the TSF.

The refinement of models allowed for more accurate assessments of possible risks associated with the proposed Alpha Coal Mine on the groundwater resources including:

- An evaluation of recharge and potential impacts on recharge mechanisms;
- Predictive inflows for both proposed Alpha and Kevin's Corner coal mines, estimated through zone budget in the model simulation, allowed for an assessment of cumulative impacts;
- The assessment of groundwater level drawdown within the different aquifers and geological model layers, over time and spatially across the model area;
- The potential for impact on the groundwater levels within the Clematis Sandstone;
- The potential for induced flow from and through the Rewan Formation, which overlies the Permian coal seams;
- The direct and indirect impacts of mine dewatering on the vegetation communities;
- An assessment of neighbouring bores, which may be at risk from Alpha Coal Mine dewatering (referred to as at-risk bores);
- Long term groundwater levels, flow patterns, and contaminant migration risks at mine closure;
- Potential for impacts on registered springs to the north of the proposed Alpha and Kevin's Corner coal mines;
- The possible induced flow impacts from sub-E sandstone, which has been identified as a source of make-good water; and
- Cumulative impacts through assessing the model predictions for Alpha Coal Mine alone and then comparing the results of simulating the proposed Alpha and Kevin's Corner coal mines.

<u>Opinion</u>

In my opinion the data compiled, evaluated and refined over the length of the study allowed for the development of predictive groundwater models, which provide an accurate evaluation of potential impacts on the groundwater resources, locally and regionally. The resultant reports provide sufficient data, assessment, and consideration to allow for informed decision making with regards to granting the mining lease and developing accompanying conditions and obligations.

Question 4

In your opinion, was the work performed to address the assessment requirements of the Terms of Reference and to undertake the groundwater impact assessment in accordance with standard professional practice for this type of proposed project?

Response 4

It is my opinion that this groundwater study was conducted in accordance to standard professional practice for this type of proposed project. The groundwater study, as discussed in **Response 3**, was conducted using a phased approach over a long period allowing for the compilation and assessment of the potential impacts, requirements of the Terms of Reference and requests for additional information raised during public comment and through discussions with the State and Federal regulatory bodies.

It is my opinion that the groundwater studies and evaluation as a whole addresses the Terms of Reference requirements and also included an evaluation of potential impacts on regional groundwater resources, which was not specifically requested in the Terms of Reference.

Question 5

In your opinion, was the work performed to address the assessment requirements of the Terms of Reference and to undertake the groundwater impact assessment inadequate because of one or more of the following matters:

(a) it has not adequately investigated potentially impacted bores and the importance of those bores to their owners;

(b) it has not adequately investigated the potential drawdown from the Applicant's proposed mining activities or the cumulative effect with other proposed mines nearby;

(c) baseline groundwater / bore studies of the quantity and quality of groundwater that have been done by the Applicant are inadequate to establish the likely extent of the impact of the proposed Alpha Coal Mine;

(d) the impact on the Great Artesian Basin is unknown due to the insufficient modelling of recharge rates;

(e) there is insufficient information to assess the impact that the proposed Alpha Coal Mine's groundwater drawdown and potential contamination could have on the Great Artesian Basin;

(f) the detail of scientific information provided on the scale and likelihood of the impacts that the mine will have on groundwater are not commensurate with the scale of the mine and the risk to environmental values. In particular, have regard to:

> ***(i) the impacts of mine dewatering on groundwater levels, groundwater flow direction, groundwater chemistry, and recharge and discharge mechanisms described in EIS Volume 2 Section 12.9.1;***

(ii) ***the impacts on groundwater quality within the open cut pits and below and adjacent to mine infrastructure described in EIS Volume 2, Section 12.9.7;***

(iii) ***the long term drawdown and water quality impacts from the final void described in EIS Volume 2, Section 12.9.8;***

(iv) ***potential impacts from the tailings storage facility through leakage, movement of leachate and potential discharge into aquifers described in EIS Volume 2, Section 12.9.2;***

(v) ***potential impacts to the character resilience and values of the receiving environment in relation to:***

- ***agricultural purposes, including stock and domestic watering;***
- ***cultural and spiritual values;***
- ***drinking water supply;***
- ***any surface water features that may receive baseflow from groundwater described in EIS Volume 5, Appendix P, Section P.3.4.2.2; and***
- ***impacts described in EIS Volume 5, Appendix P, Section P.3.4.3.2 Groundwater Impacts.***

(g) the regional cumulative impacts covering groundwater impacts, has not been adequately assessed; and

(h) a regional water balance has not been undertaken.

Response 5

(a) it has not adequately investigated potentially impacted bores and the importance of those bores to their owners;

No; it is my opinion that the bore survey adequately allowed for the identification of local groundwater use and the discussion of groundwater resources with relevant bore owners.

As detailed in SEIS Appendix O, a groundwater bore survey was conducted, within a ~ 10 km radius of Alpha Coal Mine, on properties within and immediately adjacent to MLA70426 (Alpha) and MLA70425 (Kevin's Corner). These properties and the owners who were interviewed during the bore survey are included in Table 4 below.

Table 4 Bore Survey Details

Property	Contact
Burtle	John Sparrow
Cavendish	Allan & Rhonda Coyne
Forrester	Ross & Sandy McKeering
Gadwell	Bevan & Aloma Everingham
Hobartville	Steve & Vonda Kimber
Mentmore	Bevan & Aloma Everingham
Monklands	Reid Bauman

Spring Creek	Don & Kaye Gordon
Surbiton	Elsie Dillon
Tresillian	Glen Sparrow
Glen Innes	Ian Hoch
Kia Ora	Kelvin Sypher
Surbiton South	Andrew Donaldson
Wendouree	Doug Carruthers

It is noted that the objectors, Currie and Anderson, properties were not within the bore survey as these properties (Speculation and Eureka, respectively) are not immediately adjacent to or within MLA70426 and MLA70425 (Figure 5). They are not within the zone of influence of the proposed mine.

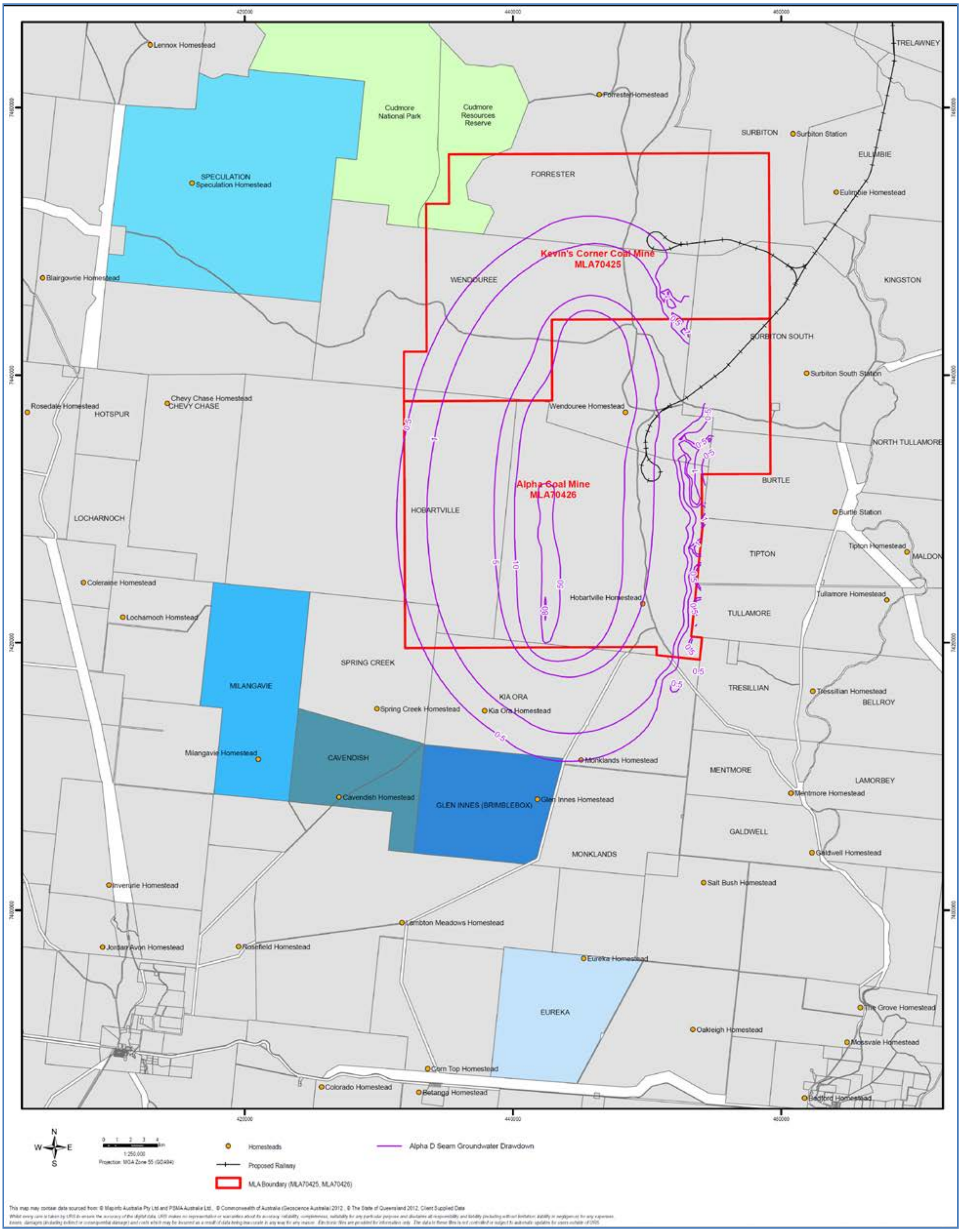
During the bore survey details regarding the operational bores were compiled and discussed with the landholders. Bores no longer in operation were discussed but not surveyed.

Drawdown predictions from the predictive model allowed for the assessment of at-risk bores, where it is assumed that any bore (recorded during the study) within the predicted 1 and 5 m drawdown contours for the target D coal seam could potentially be impacted by mine dewatering. The projected drawdown contours, resulting from Alpha Coal Mine dewatering, were projected within the D coal seam to provide the largest zone of influence at the end of mining. The drawdown contours, up to 0.5 m variation from the pre-mining groundwater level associated with the D seam, are presented in Figure 5. It is noted that the bore survey was conducted on all properties within the zone of influence.

At-risk bores identified using predictive modelling will, as part of Hancock's make-good commitment, be field verified and assessed as part of any make good agreements.

As the majority of the bores have little or no data regarding construction and aquifer, the approach to be taken is to validate and assess all existing bores within these drawdown contours prior to mining. This will allow for the compilation of all available groundwater use and develop the optimum make-good strategies (URS, 2012).

Figure 5 Projected drawdown contours at LOM and properties



(b) it has not adequately investigated the potential drawdown from the Applicant's proposed mining activities or the cumulative effect with other proposed mines nearby;

No; it is my opinion that the work conducted to assess the potential drawdown resulting from the proposed mining activities is adequate.

The predictive groundwater model (URS, 2012), based on site specific data, model sensitivity and uncertainty analyses, and model review, allowed for the assessment of projected drawdown within different aquifers and geological units across the model area and at the LOM and long term (300 years post mining).

The cumulative impact of mine dewatering at Alpha and Kevin's Corner coal mines was modelled. This allowed for the assessment and comparison of potential drawdown impacts for the proposed Alpha Coal Mine alone as well as if Kevin's Corner Coal Mine was mined simultaneously.

It is noted that drawdown cones created for Alpha Coal Mine alone and for mining both Alpha and Kevin's Corner coal mines do not indicate any additional or cumulative impact to the west, i.e. the cumulative drawdown only increases to the north where the two drawdown cones overlap. This is important as this indicates that the risk to the units to the west (i.e. the GAB units) is not increased by additional mine projects along strike of one another. The Rewan Formation and Bandanna Formation aquitards limited potential for induced flow from the GAB units along strike.

Consideration of cumulative impacts of multiple projects, all within the same Permian coal bearing sediments, was given with respect to potential impacts on the GAB units to the west and to the older units to the east (below the Joe Joe Formation).

It is noted that the same geological / hydrogeological constraints (Rewan Formation aquitard) that separate the proposed mining operations by Hancock from the GAB are the same for China First and South Galilee, thus I consider that the dewatering associated with these mining operations will not result in cumulative drawdown extending to the west rather north –south along strike.

The Joe Joe Formation aquitard reduces the potential for induced drawdown, associated with additional mining projects, in the older units to the east.

The cumulative impact of these mining operations will, however, impact over a larger area within the Permian units and affect long term groundwater flow patterns and resources.

The inclusion of other proposed coal mines, namely China First (Waratah) and South Galilee, in the regional model was considered (URS, 2012). Cumulative impacts of all proposed mining operations in the portion of the Galilee Basin containing Alpha Coal Mine raises significant issues regarding the availability and use of data, reliance on unchecked / validated data available in the public domain and limited information about other relevant matters, such as mining methods. This potentially leads to inaccurate impact assessments. This could, in the case of Waratah and South Galilee, result in disagreement if these proponents do not agree with the resultant impact evaluation or predictions based on the limited data available to Hancock. Based on the number of assumptions, differences in conceptualisation (geology and groundwater), and simplifications that would be required to obtain a preliminary high level assessment of potential drawdown using a large regional the model, 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 of mine dewatering associated with all proposed projects within this portion of the Galilee Basin.

The cumulative impact assessment of additional coal mines was, therefore, considered quantitatively and discussed in terms of possible additional impacts.

(c) baseline groundwater / bore studies of the quantity and quality of groundwater that have been done by the Applicant are inadequate to establish the likely extent of the impact of the proposed Alpha Coal Mine;

In my opinion, no, the work performed is not inadequate on the basis of this allegation. I consider that sufficient site specific representative groundwater data was compiled, assessed, and interrogated during the Alpha Coal Mine groundwater study to allow for the description and assessment of quantity and quality of groundwater resources within and adjacent to MLA70426.

The assessment of aquifer hydraulic parameters included the following:

- Composite groundwater level data was obtained from over 250 exploration bores;
- Vibrating Wire Piezometer monitoring bores have been constructed at 26 sites within the MLA70426 and MLA70425, with 72 separate intervals monitored. The majority of VWP bores are monitored using automated data loggers, which compile daily groundwater level records (6 hour intervals);
- Three sites are equipped with tipping-bucket rain gauges, with rainfall data also captured by the data loggers;
- Four long term monitoring bores, AMB-01 to AMB-04 (installed late 2010);
- Groundwater yield data for 119 DERM groundwater database bores;
- Groundwater air-lift yield data for 451 exploration bores;
- Historic aquifer hydraulic test data for Bridge Oil Limited, during 1982 to 1984, comprising 6 long duration pump out tests;
- Six site specific aquifer hydraulic test conducted across Alpha and Kevin's Corner coal mines;
- Variable head tests across the TSF;
- Core sample laboratory permeability testing;
- Transmissivity and hydraulic conductivity data for GAB aquifers from 390 government bores;
- Porosity and storage coefficient data from GAB aquifers from 39 petroleum exploration wells. A number of samples were taken from the vertical profile in each well resulting in 122 porosity values and 69 storage coefficient values;
- Vertical hydraulic conductivity data for GAB confining beds from 53 petroleum exploration wells is included. A number of samples were taken from the vertical profile in each well resulting in 259 vertical hydraulic conductivity values, and 73 weighted average values for the two confining beds considered in the regional GAB model at that time; and
- The ATP was developed pm MLA70426 between November 2010 and July 2011 to enable a bulk sample of coal (150,000 tonnes) to be extracted for product testing. The ATP was excavated to a depth of 66 m below natural surface, and required advance depressurisation to allow mining to proceed safely to depth (i.e. for prevention of floor heave and to maintain geotechnical stability of the pit walls). Monitoring of daily pumping volumes from 12 pit perimeter bores (from commencement of pumping on 21 April 2011 to cessation of pumping on

20 July 2011), and 6-hourly groundwater level monitoring of bores adjacent to the pit, provided a data set that was used for transient calibration.

The assessment of hydrochemistry included the following:

- Composite groundwater samples collected from open exploration bores, which provided an accurate indication of groundwater quality that will report to the open cut mine;
- Bore survey groundwater sampling provided baseline groundwater quality data prior to mining, which can be utilised for comparison over time to assess potential alteration off site;
- A groundwater monitoring network and program has been instigated on site. This program aims at compiling sufficient (from a statistical perspective) hydrochemical data in order to propose trigger levels and compliance limits for inclusion in the Environmental Authority conditions. The groundwater monitoring network for Alpha is summarised as follows:
    - Monthly background groundwater samples have been successfully collected from fifteen (15) of eighteen (18) on site monitoring bores in the proposed Alpha mine area. Background groundwater samples have not been collected from three bores drilled dry (ATSF-04B, ATSF-08C, and ATSF-09B) Table 5 presents the units monitored on site;
    - Most bores have completed ten (10) monthly sampling events (August 2011 through July 2012).

The draft Environmental Management Plan (November 2012) includes obligations (included in the Groundwater Monitoring Program) to amend and add to the monitoring network over time. Groundwater quality monitoring obligations have been included in the mine approval conditions, as included in **Annexure B**.

Table 5 Alpha Baseline Groundwater Monitoring Network

Well ID	Unit Monitoring
AMB-01	D-E Sandstone (Colinlea Sandstone)
AMB-02	E-F Sandstone (Colinlea Sandstone)
AMB-03	D-E Sandstone (Colinlea Sandstone)
AMB-04	C-D Sandstone (Colinlea Sandstone)
ATSF-01B	Laterite
ATSF-02	Conglomerate within Laterite
ATSF-03	Conglomerate within Laterite
ATSF-04B	Laterite
ATSF-05B	Joe- Joe Formation
ATSF-05C	Laterite
ATSF-06B	D-E Sandstone (Colinlea Sandstone)
ATSF-06C	Surficial Deposits/ Sands
ATSF-07B	Laterite
ATSF-07C	Base of Surficial Deposits/ Sands
ATSF-08B	Joe- Joe Formation
ATSF-08C	Base of Surficial Deposits/ Top of Laterite
ATSF-09A	Joe- Joe Formation
ATSF-09B	Surficial Deposits/ Sands

(d) the impact on the Great Artesian Basin is unknown due to the insufficient modelling of recharge rates;

It is my opinion that recharge mechanisms were adequately considered and evaluated throughout the groundwater impact assessment. Recharge rates were determined for inclusion in the predictive modelling to aid in assessing potential impacts. Consideration of recharge, when considering groundwater impacts including the potential impacts on GAB units, was included in the predictive modelling.

This question suggests some confusion surrounding the recharge mechanisms considered across the groundwater study area (as reflected in the regional groundwater model area). Initial EIS consideration of recharge mechanisms with regards to the Colinlea Sandstone on MLA70426 included the recharge mechanism identified to occur along the intake beds of the GAB. This mechanism is related to rainfall intensity, such that rainfall in excess of 200 mm per month on the GAB intake beds (i.e. Clematis Sandstone, Hutton Sandstone, etc.) is required before significant recharge events occur, and diffuse recharge occurs following “average” rainfall events. These recharge mechanisms were considered when assessing the Galilee Basin Permian units.

Initial consideration of recharge included:

> <u>Recharge Mechanism 1 – Direct Recharge to Outcrop Areas</u>
>
> Based on the mapped Colinlea Sandstone in the eastern portion of MLA70426 a possible recharge mechanism was considered via direct rainfall recharge to aquifer units in areas where they outcrop or subcrop (once sufficient rainfall has occurred to facilitate infiltration). This is the same mechanism by which recharge (after high rainfall intensity events) is recognised to occur within groundwater intake beds of the GAB.
>
> <u>Recharge Mechanism 2 – Diffuse recharge from the Great Dividing Range</u>
>
> This recharge mechanism considers that recharge occurs along the topographically elevated areas to the west (along the Great Dividing Range) and flows down gradient toward surface water drainage features in lower lying areas. The diffuse recharge can infiltrate the thin Tertiary cover and enter the Permian units, as the Tertiary is thinnest to the west.

To evaluate the recharge mechanisms rainfall and data from VWP and monitoring bores within the Alpha and Kevin’s Corner MLAs were assessed. It is noted that significant rainfall (above average of Bureau of Meteorology data) was recorded in site rain gauges for both the 2009-2010 and the 2010-2011 wet seasons. This data has proved valuable in assessing groundwater recharge from significant rainfall events. A review of bore water level time series graphs (hydrographs) did not indicate any obvious increase in groundwater levels that could be interpreted as aquifer recharge in response to wet season rainfall.

The exception was bore AVP-13 (closest to the Great Dividing Range) where piezometers in the shallow sandstone above the A coal seam as well as the A-B sandstone, both recorded groundwater level increases over the 2010 year. The groundwater level trend in this bore suggests a recharge potential at this site related to diffuse recharge occurs along the Great Dividing Range

A geological and groundwater assessment of the proposed TSF was undertaken. Based on the site specific geological, geotechnical, and hydrogeological data compiled during the TSF study, an assessment of the recharge within the Colinlea Sandstone / Joe Joe Formation contact area indicated:

- Restricted recharge potential to the underlying Colinlea Sandstone units due to the thick clay-rich Tertiary laterite, thin discontinuous Colinlea Sandstone aquifers (cross-sections indicate thin sub-E and sub-F sands) pinching out against the Joe Joe Formation, thick unsaturated zone (even though the site was subject to prolonged high rainfall events during 2010/2011), and no Colinlea Sandstone rock outcrop or shallow subcrop recorded in any of the 14 bores drilled during the TSF study;
- Drilling results and blow-out yields recorded during rotary-air-percussion within the TSF footprint indicate aquitards and units of limited groundwater potential; and
- The majority of the shallow perched groundwater within the TSF footprint comprises poor quality groundwater. This indicates little or no recharge with fresh rain water to reduce salinity concentrations.

The information compiled and assessed during the TSF assessment indicates that little or no recharge occurs within the Colinlea Sandstone / Joe Joe Formation contact area.

The results of the hydrographs and the TSF study indicate that any potential recharge to the confined aquifers within the proposed mine sites (Alpha and Kevin's Corner) occurs as a result of diffuse recharge along the Great Dividing Range.

(e) there is insufficient information to assess the impact that the proposed Alpha Coal Mine's groundwater drawdown and potential contamination could have on the Great Artesian Basin;

It is my opinion that the potential impacts of the mine dewatering on the GAB have been adequately assessed on the basis of sufficient information, as discussed in **Response 1**. A detailed evaluation of the Rewan Formation provides evidence of how this unit effectively separates the GAB from the Galilee Basin units.

The proposed Alpha Coal Mine open pit will impact on the groundwater levels and flow patterns adjacent to the mine. Groundwater flow will be towards the mine workings, thus any potential contaminants will report to the mine void. At closure the final void will function as a groundwater "sink" (receptor) in perpetuity, and hydraulic gradients will cause groundwater in the adjacent units to flow into the final void. Integrated surface water-groundwater modelling was conducted to assess the final void water level and the long term groundwater flow patterns (URS, 2012). This modelling indicates no real risk of decant (no potential for poor quality pit water to leave site in the surface water) and thus no potential for poor quality pit water to migrate off site within the groundwater.

I consider that the proposed Alpha Coal Mine does not pose a risk to the groundwater quality within the GAB.

(f) the detail of scientific information provided on the scale and likelihood of the impacts that the mine will have on groundwater are not commensurate with the scale of the mine and the risk to environmental values. In particular, have regard to:

(i) the impacts of mine dewatering on groundwater levels, groundwater flow direction, groundwater chemistry, and recharge and discharge mechanisms described in EIS Volume 2 Section 12.9.1;

No; it is my opinion that the level of scientific investigation, allowing for the conceptualisation of the groundwater regime and model refinement over time, was sufficient to evaluate the potential groundwater impacts commensurately with the scale and risks involved.

<u>Scale of impacts – Groundwater Level Impacts</u>

The potential impacts of the proposed 30 million tonnes per annum (Mtpa) Alpha Coal Mine was considered in detail using a regional scale numerical model. The final predictive model covered an area of 5,404 km^2 and included 11 layers, to best assess the mines impact on groundwater levels and flow patterns (groundwater level recover and long term (300 years)). The modelling included consideration of groundwater level changes, spatially and over time, with the modeled units (Table 6).

The use of steady-state and transient calibration, uncertainty and sensitivity analyses, and an independent model review allowed for model predictions at a high confidence level and of a suitable scale considering the mine scale.

Table 6 Groundwater model layers

Unit	Model Layer	Thickness (m)
GAB	1	0.1 to 266
Tertiary sediment	2	0.1 to 21 (mostly for 10)
Rewan Formation / Tertiary laterite	3	0.1 to 414 for Rewan; 0.1 to 20 for laterite
Bandanna Formation	4	0.1 to 436
C seam	5	2
C-D sandstone	6	5
D seam	7	5
D-E sandstone	8	15
E seam	9	3
Sub E sandstone	10	82
Joe Joe Formation	11	540

<u>Scale of impacts – Recharge and Discharge</u>

The recharge assessment is discussed in **Response 5 (d)**.

Discharge was considered based on an evaluation of site specific drilling and monitoring bore groundwater level data, including shallow groundwater assessments conducted during the geotechnical study at the TSF. Additional nested (shallow 10 m and deeper 30 m bores spaced 5 m apart) bores along Sandy Creek on MLA70425 (Kevin's Corner) added further information, which was used to assess groundwater–surface water interaction. **Response 13** includes additional groundwater level assessment details.

Groundwater within the Bandanna Formation and Colinlea Sandstone (the units in which groundwater is usually first intersected) is encountered under confined conditions, even adjacent to Sandy Creek. Groundwater level data for the shallow (10 m) bores constructed within the Sandy Creek alluvium range from 3.48 to 8.9 m below surface. Bores constructed below the alluvium, within the confined D-E sandstone indicate groundwater levels ranging from 12.53 to 22.34 m below surface. This groundwater level data indicates a 3 to 19 m separation between the perched alluvium water levels and the D-E sandstone potentiometric levels. This data shows distinct separation thus no hydraulic linkage between the two groundwater systems.

This data, plus no recorded springs and seeps in or adjacent to the MLAs; indicate limited potential for groundwater discharge from the Colinlea Sandstone units.

<u>Scale of impacts – Groundwater chemistry</u>

The open pit mining will result in mixing of groundwater from the different aquifers intersected during mining. This will result in a change in groundwater chemistry within the mine workings during mining. The open pit, as detailed in **Response 14**, will act as a "sink" thus preventing pit water migrating off site within the groundwater.

The integrated surface water-groundwater model, utilised to evaluate long term pit water levels and groundwater flow patterns, provides a high level of accuracy based on site specific transient data and provides an accurate assessment suitable for the scale of the model.

The potential impacts of the Alpha Coal Mine, initially considered in the EIS Volume 2 Section 12.9.1, have been further assessed over the life of the groundwater study to ensure an accurate evaluation of potential impacts and the development of mitigation measures.

(f) the detail of scientific information provided on the scale and likelihood of the impacts that the mine will have on groundwater are not commensurate with the scale of the mine and the risk to environmental values. In particular, have regard to:

> ***(ii) the impacts on groundwater quality within the open cut pits and below and adjacent to mine infrastructure described in EIS Volume 2, Section 12.9.7;***

In my opinion the potential impacts of the final void and water and waste storage infrastructure on the groundwater quality have been adequately assessed and are commensurate with the scale and risks involved.

The integrated modelling and final void predictions (URS, 2012) provide an assessment of the final void quality and levels based on various climate change conditions and considering a range of runoff water quality (salinity). The model results indicate that there is no real potential for pit water decant (and migrating off site in the surface water) or poor quality final void migration off site within the groundwater.

An evaluation of the TSF, considered the largest mine water and waste storage facility at the mine which could potentially alter groundwater quality, was conducted (Section 13.5 of the Groundwater Modelling Report (URS, 2012)).

The integrated model was utilised to consider the long term potential impacts of the TSF. The TSF was simulated as a constant source of poor quality water (assumed constant source of 1,000 mg/L total dissolved solids (TDS)) at a constant water level (340 m AHD) some 12 to 15 m above surface. The surface leakance was set at (conservative) 1 x 10^{-06} based on integrated model results and layer thickness. The model simulation allowed for the prediction of concentration propagation (similar to particle tracking) over time (300 years) assessing the risk to Lagoon Creek and to deeper aquifers.

The concentration propagation indicated an expanding plume away and with depth over time. The predicted migration did not indicate any impact to Lagoon Creek during the simulation. Deeper drainage migrates more readily within the lower, depressurised, units at depth. Concentration changes with depth are predicted below the TSF but the plume migration (vertically) is limited by the unaltered fresh Joe Joe Formation.

Limited risk to Lagoon Creek and sub-E sandstone (aquifer) units are predicted assuming the base of the TSF is sufficiently prepared to a vertical hydraulic conductivity not more than 10^{-9} m/s, as included in the report *Alpha Coal Project Mine Water Structures Bridging Report* (Parsons Brinckerhoff, 2012). Hancock has committed to designing and constructing the TSF to a standard sufficient to prevent leaching and other impacts on the surrounding environment.

(f) the detail of scientific information provided on the scale and likelihood of the impacts that the mine will have on groundwater are not commensurate with the scale of the mine and the risk to environmental values. In particular, have regard to:

> ***(iii) the long term drawdown and water quality impacts from the final void described in EIS Volume 2, Section 12.9.8;***

No; it is my opinion that the groundwater modelling, considering surface water, climatic data, and groundwater, adequately allowed for the simulation of final void water level and quality changes and long term impacts commensurately with the scale and risks involved.

Long term groundwater level predictions were evaluated using an integrated model. This model, utilising the end of mine groundwater levels, was constructed to allow for an assessment of potential long term impacts on groundwater resources, within the modelled layers, over time (300 years post mining) and spatially. The prediction of final void water levels and long term groundwater levels, flow patterns, and gradients were projected in Section 12 of the Groundwater Modelling Report (URS, 2012).

The conclusions from the final void assessment include:

- The final void modelling predicts that the final void water level reaches a pseudo steady-state after ~ 50 years, at around 37 m above pit floor (~ 250 m AHD depending on location within the final void).
- The lowest elevation point where decant could potentially occur is along the northern most portion of the final void, at an elevation of 305 m AHD. The projected final void water level in the northern portion of the final void is 249 m AHD, some 56 m below the lowest pit surface elevation. The risk of decant is, therefore, considered negligible.
- Final void quality is recognised to deteriorate over time due to the concentration of salts as a result of evaporation. The final void water could be utilised for ~ 150 years before the salinity reached 5,000 mg/L TDS, the ANZECC 2000 guidelines for cattle livestock drinking water. This water could be utilised for longer to supply sheep as the ANZEEC 2000 guideline indicates that sheep can adapt to water, without loss of production, with TDS of up to 10,000 mg/L TDS.

- Observation points within the model indicate that changes in groundwater levels and pressures, as a result of mining and final void, will permanently alter groundwater flow patterns and levels around the final void.

(f) the detail of scientific information provided on the scale and likelihood of the impacts that the mine will have on groundwater are not commensurate with the scale of the mine and the risk to environmental values. In particular, have regard to:

> ***(iv) potential impacts from the tailings storage facility through leakage, movement of leachate and potential discharge into aquifers described in EIS Volume 2, Section 12.9.2;***

No; it is my opinion that the potential impacts of the TSF have been adequately assessed from a groundwater perspective commensurately with the scale and risks involved.

An evaluation of the TSF, considered the largest mine water and waste storage facility at the mine which could potentially alter groundwater quality, was conducted (Section 13.5 of the Groundwater Modelling Report (URS, 2012)).

As detailed above (**Response 5(f)(ii)**), limited risk of long term TSF impacts on Lagoon Creek and the sub-E sands are predicted.

(f) the detail of scientific information provided on the scale and likelihood of the impacts that the mine will have on groundwater are not commensurate with the scale of the mine and the risk to environmental values. In particular, have regard to:

> ***(v) potential impacts to the character resilience and values of the receiving environment in relation to:***
>
> - ***agricultural purposes, including stock and domestic***
> - ***watering;***
> - ***cultural and spiritual values;***
> - ***drinking water supply;***
> - ***any surface water features that may receive baseflow from groundwater described in EIS Volume 5, Appendix P, Section P.3.4.2.2; and***
> - ***impacts described in EIS Volume 5, Appendix P, SectionP.3.4.3.2 Groundwater Impacts.***

No; it is my opinion that sufficient information has been compiled and assessed to allow for the identification and assessment of groundwater environmental values commensurately with the scale and risks involved. The groundwater studies, conducted during the compilation of the EIS, identified the following Environmental Values (EVs):

- Agricultural purposes - groundwater in the groundwater study (model) area is used extensively as stock watering supply and, based on current usage patterns, groundwater has an EV of agricultural purposes, specifically stock watering of beef cattle and horses;
- Cultural and spiritual values – permanent or semi-permanent surface water features that are maintained to some degree by groundwater flow may have cultural significance in an area where surface water is ephemeral;

- Drinking water supply - groundwater in the area may be regarded as potable in some instances based on TDS values, however, based on the assessment that groundwater can be above drinking water guideline values for metals and metalloids, it is considered that groundwater for potable use requires treatment; and
- Surface water features that may receive baseflow from groundwater were considered. The surface water sources within and adjacent to the mine area are generally accessed by cattle for drinking water supply and in this respect the bed and banks of surface water features have been degraded. Based on existing land use and interaction of cattle with waterways, it is interpreted that surface water features in the area would have an EV applicable to moderately disturbed waters.

The SEIS Volume 2 Appendix N (Groundwater and Final Void Report) included an assessment of possible Groundwater Dependent Ecosystems (GDEs), the review of available data, compiled during the compilation of the Alpha Coal Project EIS, did not indicate the presence of any GDEs within or adjacent to the proposed mine. Two surface water features, which were considered to potentially be groundwater related, included:

- A modified dam, identified as a palustrine wetland, which was interpreted to be a perennial water feature; and
- The registered springs to the north of MLA70426, spring reference no.405, some 40 km from the MLA boundary.

EIS Volume 2 Section 19 Non Indigenous Cultural Heritage indicates that the mapped palustrine wetland (known as Murdering Lagoon) is a man-made water management feature. This was constructed on Hobartville station in the early 20th century. Section 19.3.3.2.3 indicates that the site represents elements of a rural cultural landscape but has little heritage value. **Response 13** includes consideration of surface water – groundwater interaction based on the groundwater levels adjacent to Murdering Lagoon. Based on the depth variation (~10 m difference between water levels) Murdering Lagoon is recognised to be perched above the groundwater resources within the Lagoon Creek alluvium. No direct impact of mining, to the west of Murdering Lagoon, will occur and no potential for induced flow (from the surface water to the depressurised confined aquifers) is recognised due to the lack of hydraulic connection.

The potential impact of groundwater drawdown on the registered springs, to the north of Alpha Cola Mine and within the GAB was considered in the predictive modelling. The modelling of Alpha Coal Mine alone and Alpha and Kevin’s Corner coal mines together do not indicate groundwater drawdown impacts on the registered springs (URS, 2012). The spring, based on its location (within the Galilee Basin sediments), on a change in slope, and satellite imagery over time, is considered seasonal resulting from limited effective storage within hill wash and scree. These observations plus the groundwater level data, as discussed in **Response 13**, indicate no hydraulic connection between the confined Permian aquifers and the perched groundwater table and surface water resources, on or down gradient of Alpha MLA (within the regional model area). This indicates little or no potential for GDEs or groundwater baseflow to surface water bodies.

The post EIS studies allowed for the re-assessment of groundwater EVs, which were confirmed through the bore survey. The groundwater EVs are thus considered to only include groundwater use for stock watering and domestic use (drinking, household, and small scale gardening).

Groundwater impacts on the groundwater EVs as described in EIS Volume 5, Appendix P, Section P.3.4.3.2 Groundwater Impacts, were re-assessed and included:

- Mine dewatering impacts were assessed and at-risk bores, supplying groundwater for stock watering and domestic purposes, were identified. Commitments regarding make-good agreements were included to manage possible reduction in groundwater supplies within these bores.
- The potential for the TSF, acting as a source of poor quality artificial recharge, was assessed using an integrated surface water-groundwater model. The long term evaluation of potential contaminant recharge on Lagoon Creek and sub-E sands aquifer were conducted.
- Post mining impacts considering long term groundwater levels, flow patterns, and final void levels and quality were conducted.

The results of these studies, discussed in responses above, and included in the Groundwater Modelling Report (URS, 2012), include for the management and mitigation of possible impacts on the groundwater EVs.

(g) the regional cumulative impacts covering groundwater impacts, has not been adequately assessed.

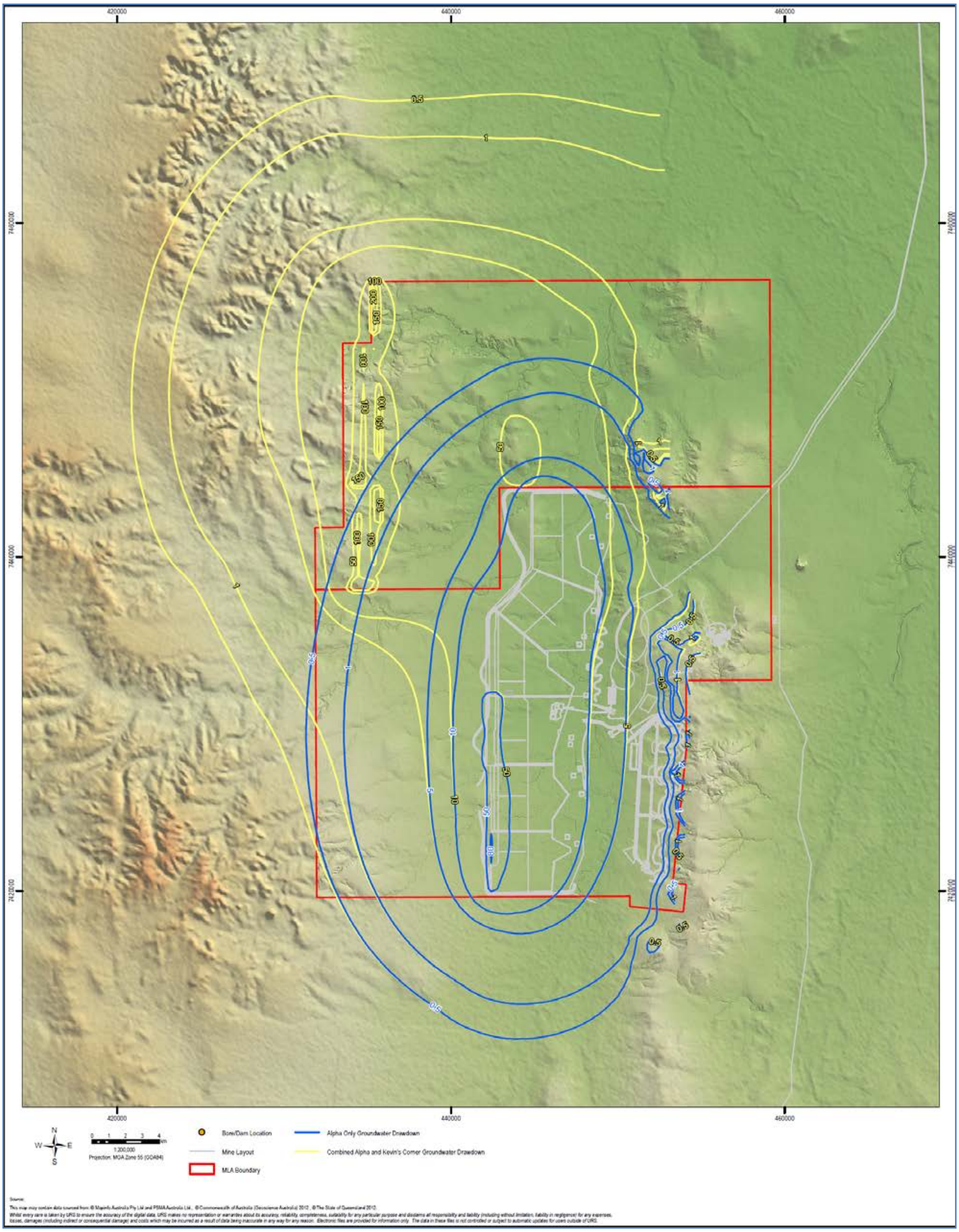
In my opinion, the consideration of modelling the concurrent mining of both Alpha and Kevin's Corner coal mines allowed for an assessment of cumulative impacts of coal mining within the same geology along the eastern margin of the Galilee Basin.

Response 5 (b) includes discussion on the cumulative impacts approach included in the EIS groundwater study.

It is noted that the resultant dewatering impacts (drawdown cones) are predicted to elongate north and south, within the more permeable sandstone units of the Colinlea Sandstone. The cumulative impact, when adding the proposed Kevin's Corner mine dewatering, results in deeper drawdown where drawdown cones overlap and further elongation along strike (Figure 6). The drawdown contours extend to the west as a result of deeper mining in MLA70425 further to the west than the Alpha Coal Mine.

Geological / groundwater constraints are recognised to govern the extent of drawdown impacts to the east and west, namely the Rewan Formation (west) aquitard and the Joe Joe Formation aquitard (east). These units are mapped across the entire portion of the Galilee Basin containing Alpha Coal Mine and thus constrain drawdown. This means that the potential for induced flow from GAB units or drawdown in the older units to the east of the Joe Joe Formation does not increase based on additional mining operations along strike of Alpha Coal Mine.

Figure 6   Groundwater drawdown contours in D seam at LOM



(h) a regional water balance has not been undertaken.

It is my opinion that consideration of the groundwater components of regional and local water balance has been undertaken. The groundwater modelling included the calculation of groundwater water balance results, as it is noted that the water balance is an integral part of model evaluation and was included in the modelling process.

The groundwater mass balance results, included in the Groundwater Modelling Report (URS, 2012), include the groundwater water balance components on a regional and site scale.

Taking into consideration the groundwater level data monitored across MLA70426, adjacent to Lagoon Creek, and MLA70425, adjacent to Sandy Creek, no groundwater–surface water interaction is recognised on or adjacent to the Alpha MLA. This is recognised in the regional (using the predictive model area size of 4,560 km^2) groundwater model water balance results for both steady-state and transient calibration (URS, 2012).

The resultant mass balance for the steady-state calibration is included in Table 7.

Table 7 Simulated mass balance for the steady state model

Budget Component	Annual Groundwater Inflow (m^3)	Annual Groundwater Outflow (m^3)
Horizontal flow	175,629	192,369
Recharge	19,149	0
Evapotranspiration	0	2,613
Total	194,778	194,982
Discrepancy (%)	-0.1%	

The mass balance for the transient calibration is shown in Table 8. Note that the outflow from the drains includes in-pit pumping and evaporation from the ATP. The component of evapotranspiration was considered in the model and was zero as groundwater levels were lower than the extinction depth (3 m).

Table 8 Mass balance for the transient model

Budget Component	Accumulated Groundwater Inflow (m^3)	Accumulated Groundwater Outflow (m^3)
Storage	59,155	17,513
Horizontal flow	5,704	2,610
Pumping	0	38,842
Recharge	1,378	0
Drains	0	6,059
Evapotranspiration	0	0
Total	66,236	65,024
Discrepancy (%)	1.8%	

Question 6

In your opinion, have all potential adverse impacts on groundwater have been adequately described in the EIS, SEIS and supplementary material?

Response 6

Yes; it is my opinion that all potential adverse impacts on groundwater resources have been adequately considered and described in the EIS, SEIS and supplementary material.

Potential Groundwater Impacts

Question 7

What conclusions were reached regarding the potential impacts of the proposed Alpha Coal Mine on groundwater?

In answering this question, identify the extent to which the proposed Alpha Coal Mine is likely to impact on groundwater aquifers and surrounding bores, including:

- ***bores clustered around Tallarenha Creek drawing from the Colinlea Sandstone;***
- ***bores clustered to the west of Tallarenha Creek that draw from the basal, potentially lower quality Dunda Beds/Bandanna Formation; and***
- ***each objector bore identified in paragraph 2(b) in the response to request for particulars filed on behalf of objectors Paul and Janeice Anderson; and***
- ***each objector bore identified in the paragraph identified as 6(b)(i) in the response to request for particulars filed on behalf of objectors Bruce and Annette Currie.***

In addressing the above matters, consider:

- ***the impacts of mine dewatering on groundwater levels, groundwater flow direction, groundwater chemistry, and recharge and discharge mechanisms described in EIS Volume 2 Section 12.9.1;***
- ***the impacts on groundwater quality within the open cut pits and below and adjacent to mine infrastructure described in EIS Volume 2, Section 12.9.7;***
- ***any differences in estimates of the extent of drawdown in EIS Volume 2, Section 12.9.1, Section 12.9.5, Section 12.9.8; URS (March 2012) Groundwater Modelling Report, section 10.6.2;***
- ***the statement that the proposed Alpha Coal Mine "has the potential to impact [sic] on the use of groundwater for agricultural purposes (stock watering) by causing material interference to bores (e.g. by limiting the available drawdown in the bore and hence reducing yield, or by drawing the water level down below the existing pump intake)" (EIS Volume 5, Section P.3.4.3.2);***
- ***any various springs and surface water features (e.g. Lagoon Creek) that may be fed, at least periodically, by groundwater;***
- ***the relevance of the drawdown cone of depression being predicted to be elongated in a north/south direction;***
- ***the relevance of the proposed Kevin's Corner Coal Mine being predicted to have a cumulative impact on the drawdown cone of depression in an elongated north/south direction;***
- ***whether the migration of water towards the cone of depression caused by the proposed Alpha Coal Mine may:***
    - ***cause water of lesser quality to migrate towards the cone of depression, potentially increasing salinities; and***

    - ***cause contaminants including water of lesser quality to replace supplies of groundwater;***
- ***an impacts to the character resilience and values of the receiving environment in relation to:***
    - ***agricultural purposes;***
    - ***cultural and spiritual values; and***
    - ***drinking water supply.***

Response 7

In order to best answer the questions I have considered each of the matters raised in Question 7 separately.

What conclusions were reached regarding the potential impacts of the proposed Alpha Coal Mine on groundwater?

In order to assess the potential impacts of mining on groundwater level, both during mining (using the results of the refined predictive model) and long-term (using the integrated final void model) several observation points were introduced at key locations across the regional model area. The observation points allowed for the projection of changes in groundwater level in different model layers / groundwater units over time and spatially.

The observation points, model layers and corresponding units assessed are included in Table 9 and indicated on Figure 7.

Table 9 Observation points for groundwater level projections

Observation point	Model layer(s) observed
OP-G1	Layer 1 – Clematis Sandstone
OP-G2	Layer 1 – Clematis Sandstone
OP-G3	Layer 1 – Clematis Sandstone
OP-G4	Layer 1 – Clematis Sandstone
OP-G5	Layer 1 – Clematis Sandstone
OP-R1	Layer 3 – Rewan Formation
OP-R2	Layer 3 – Rewan Formation
OP-R3	Layer 3 – Rewan Formation
OP-R4	Layer 3 – Rewan Formation
OP-S1	Layers 1 to 11 – South transect – Alpha
OP-S2	Layers 1 to 11 – South transect – Alpha
OP-S3	Layers 1 to 11 – South transect – Alpha
OP-S4	Layers 1 to 11 – South transect – Alpha
OP-W1	Layers 1 to 11 – West transect – Alpha
OP-W2	Layers 1 to 11 – West transect – Alpha

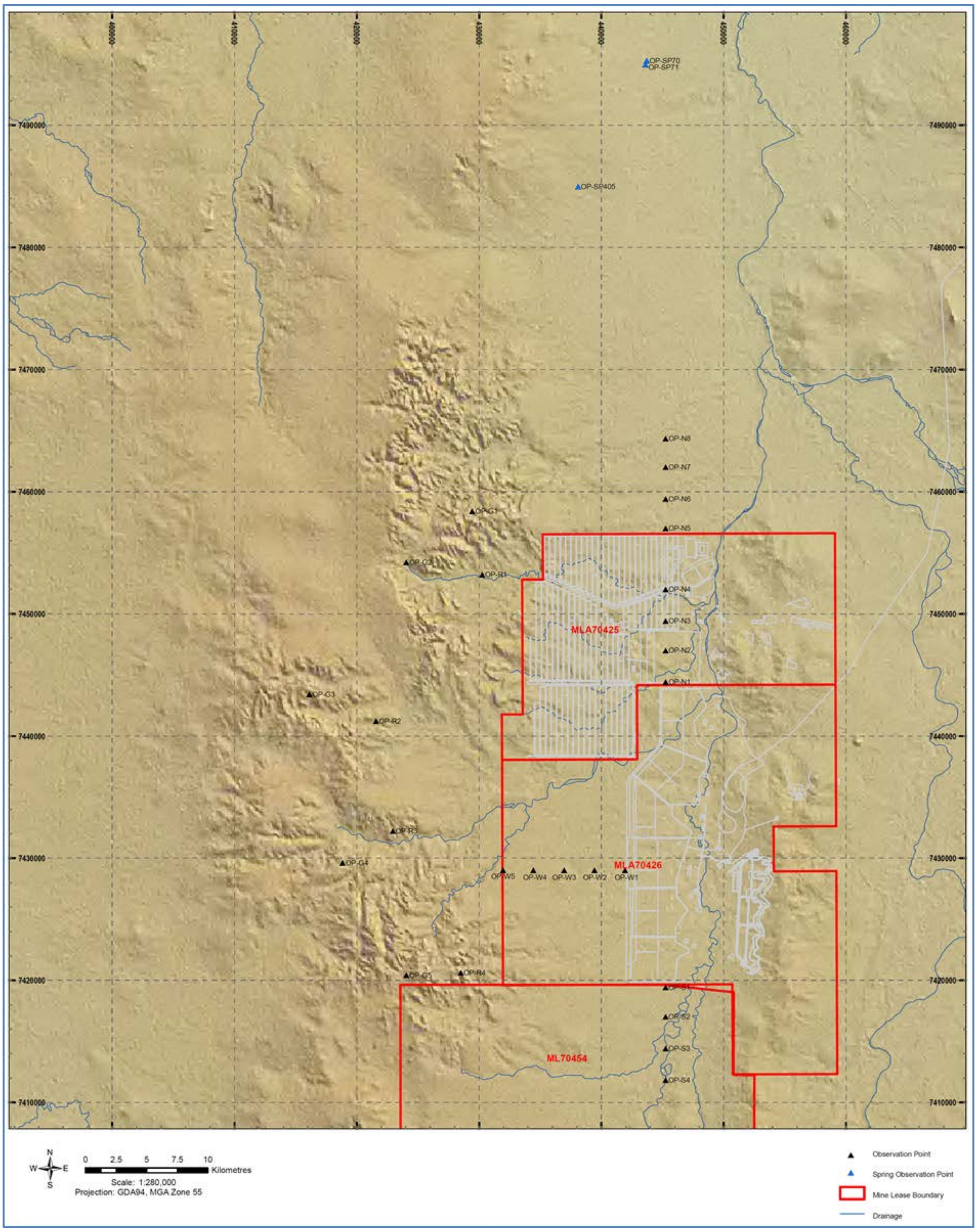
OP-W3	Layers 1 to 11 – West transect – Alpha
OP-W4	Layers 1 to 11 – West transect – Alpha
OP-W5	Layers 1 to 11 – West transect – Alpha
OP-N1	Layers 1 to 11 – North transect – Alpha
OP-N2	Layers 1 to 11 – North transect – Alpha
OP-N3	Layers 1 to 11 – North transect – Alpha
OP-N4	Layers 1 to 11 – North transect – Alpha
OP-N5	Layers 1 to 11 – North transect – Kevin's Corner
OP-N6	Layers 1 to 11 – North transect – Kevin's Corner
OP-N7	Layers 1 to 11 – North transect – Kevin's Corner
OP-N8	Layers 1 to 11 – North transect – Kevin's Corner
OP-SP70	Layer 1 - Spring 70
OP-SP71	Layer 1 - Spring 71
OP-SP405	Layer 1 - Spring 405

Groundwater level projections, compiled as time series hydrographs, were generated for each observation point. The following assessments were made:

- **Long term trends**
    - o The long term projected hydrographs for observation points adjacent to the Alpha Coal Mine indicate that groundwater levels do not stabilise once the pseudo steady-state final void water level is reached (after ~ 50 years). This is due to the model layer parameters (low vertical permeability determined from transient calibrations) and the ongoing final void evaporation (which represents a loss from the system). Model projections indicate pseudo steady-state groundwater levels and flow patterns after ~ 300 years.
    - o The long term impacts indicate that groundwater resources will be "mined" (extracted) from the Galilee Basin sediments and will be permanently lost.
    - o It is noted that the long term projected unconfined groundwater levels (simulated to be saturated and have the same groundwater levels as the D coal seam) within the Tertiary units indicate the potential for induced flow over time. This will not occur in reality as these units are unsaturated, not directly hydraulically linked to confined aquifers, and are regularly recharged by rain and flood events.
- **Clematis Sandstone**
    - o The regional predictive groundwater model was calibrated to groundwater levels derived for the D-E sandstone. Based on the elevation differences of the Clematis Sandstone (thin outcrop dipping west from the Great Dividing Range), the groundwater levels in the D-E sandstone do not reach into the Clematis Sandstone. The assessment of groundwater level changes below the Clematis Sandstone units was conducted to assess potential for induced flow. It was assumed that this approach

provides an assessment of potential for impact as this is an impact assessment model and not an aquifer performance / simulation model.

Figure 7 Groundwater level observation points relative to Alpha MLA



- Observation points within the Clematis Sandstone (to assess the saturated layers below the Clematis Sandstone) were included in the predictive groundwater model. No impact or change in groundwater level was predicted during LOM.
- In the integrated model the model cells in Layer 1 Clematis Sandstone are dry. Thus the model looked at the long term change in the groundwater levels within the first saturated layer, Layer 4, the Bandanna Formation. Projected groundwater levels within the Bandanna Formation indicate minor, ~ 1 m changes in groundwater levels, below observation points OP-G1, OP-G2, and OP-G3 after 300 years post mining. Observation points OP-G4 (~ 1.5 m) and OP-G5 (~ 2.5 m) are located closest to the Alpha Coal Mine and indicate that modelling predicts ongoing impacts of the final void as evaporation exceeds ingress and recharge.
- It is noted that these long term impacts are limited, occur below the Clematis Sandstone, are within acceptable seasonal groundwater fluctuations, and are within model uncertainty. Based on the low vertical permeability of the Rewan Formation, between the predicted long term (slightly) depressurised Bandanna Formation (after 300 year) and the Clematis Sandstone; any induced flow impacts would be negligible within the Clematis Sandstone.

In addition, an assessment of mine dewatering impacts on the Colinlea Sandstone indicates:

- The total estimated range (high, low, and expected) volumes of groundwater ingress for the Alpha Coal Mine only over the LOM were 100 gigalitres (GL), 41 GL, and 60 GL, respectively. The majority of this groundwater will be removed from the Colinlea Sandstone. The mine dewatering drawdown cones in the D coal seam were contoured to assess the largest predicted zone of influence during mining. The drawdown, up to 0.5 m change from initial groundwater levels, indicate that there will be minimal drawdown to the east along the contact with the Joe Joe Formation, elongate some 8 km north and south of the Alpha and Kevin's Corner MLA boundaries within the more permeable sandstone units of the Colinlea Sandstone, and extend to the western boundary of MLA70426 (Figure 4).
- Due to the large final void, located within the Colinlea Sandstone, groundwater levels do not stabilise once the pseudo steady-state final void water level is reached (after ~ 50 years). This is due to the model layer parameters (low vertical permeability determined from transient calibrations) and the ongoing final void evaporation (which represents a loss from the system). Model projections indicate pseudo steady-state groundwater levels and flow patterns after ~ 300 years. The long term groundwater level projections indicate that the local groundwater regime, within the Permian units, will be permanently altered. The permanent alteration of the local groundwater regime as a result of a final void is recognised to occur at all open pit mines in central Queensland, due to the climate (where evaporation exceeds rainfall and groundwater ingress into the final voids).
- An assessment of at-risk bores, resulting from Alpha Coal Mine dewatering, indicated that there are 18 neighbouring bores within the projected 1 and 5 m drawdown contours for the target D seam at the end of mining. The impact of decreased

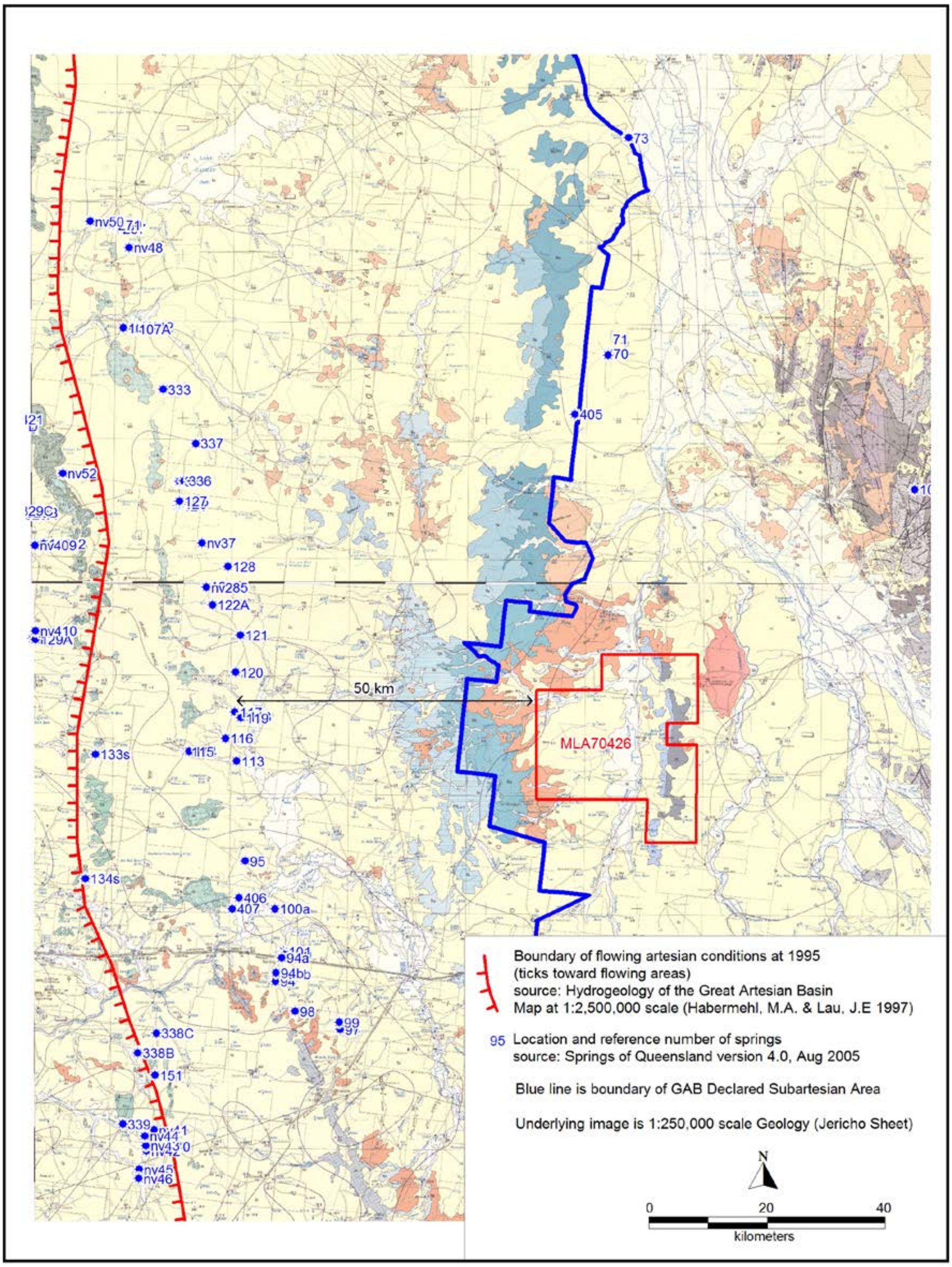
potentiometric level in these bores can result in these bores being unduly affected. These bores are to be field checked as part of the Hancock make-good commitment.

  - It is noted that not all Colinlea Sandstone groundwater resources within the Alpha MLA will be dewatered as an assessment of the sub-E sands, conducted to evaluate potential for make-good supply, indicate that the sub-E sandstone will remain fully saturated (no dewatering) but will be depressurised during mining. It is therefore considered that the sub-E sandstone can be utilised, away from the immediate mining area, as a source of make-good water.

- **Rewan Formation**
  - Observation points within the Rewan Formation were included in the predictive groundwater model. No impact or change in groundwater level was predicted during LOM.
  - As with the Clematis Sandstone, the model cells for Layer 3 Rewan Formation in the integrated model are dry. Thus the model looked at the long term change in the groundwater levels within the first saturated layer, Layer 4, the Bandanna Formation.
  - Projected groundwater levels within the Bandanna Formation indicate a dewatering trend within the Bandanna Formation post mining. Projections in groundwater levels below the Rewan Formation after 300 years post mining indicate declines in groundwater levels of < 5 m closest to Alpha Coal Mine.
  - It is noted that these long term impacts are < 5 m. It was conservatively considered that this drawdown may result in measurable impacts on available drawdown in bores within confined aquifers. Considering the Rewan Formation directly overlies the Bandanna Formation and even though the Rewan Formation has recognised low vertical permeability, the depressurising trend within the Bandanna Formation over time was considered to indicate the potential for induced flow from the Rewan Formation albeit in the long term (> 300 years). At-risk bores (reduced groundwater supplies) were identified and will be considered during make-good assessments and agreements.
- **Registered springs**
  - Registered springs SP70, SP405, and SP71, were included in the model predictions. Groundwater level data for the Tertiary overburden (Layer 1), Tertiary sediments (Layer 2), and the target D seam was projected over time (30 years LOM and 300 years post mining). The Tertiary layers were assumed to be saturated and have the same initial heads as the steady-state calibration.
  - No change in groundwater levels, in any of the model layers, was predicted.
  - The registered GAB recharge springs, along the Hutton Sandstone outcrop, are considered too far away (> 50 km) to be impacted by the Alpha Coal Mine (Figure 8).
- **Joe Joe Formation**
  - The potential impacts on this unit include poor quality artificial recharge from mine water and water storage infrastructure. Model simulations of potential seepage from the Alpha TSF indicate deeper drainage migrates more readily within the lower more depressurised layers at depth. Concentration changes with depth are predicted below

the TSF but are limited by the fresh Joe Joe Formation. Limited risk of long term TSF impacts on Lagoon Creek was also predicted.

Figure 8 Registered springs within the GAB



- **Bandanna Formation**
  - o Direct and indirect flow from the Bandanna Formation will occur resulting in decreased groundwater levels within this unit. Neighbouring bores which utilise groundwater within the Bandanna Formation, within the drawdown contours generated for the D coal seam (Figure 9) will be subject to the make-good assessments and agreements.
- **Groundwater Table**
  - o The perched unconfined groundwater resources associated with the Tertiary and alluvium units overlying the confined Permian units (Figure 10 conceptualisation) form the groundwater table.
  - o An assessment of the direct and indirect impacts of mine dewatering on the vegetation communities indicates that there is limited potential for induced flow from the isolated (non-continuous) perched water down into the depressurised deeper aquifers.

    The dewatering groundwater monitoring data compiled during the construction of the bulk sample pit at Alpha have shown that there is no hydraulic link between the deeper aquifers and the perched aquifers. This is due to the presence of the laterisation of Permian sediments, which resulted in a thick clay confining layer. Monitoring data from a 20 m and a 40 m bore show that minor induced flow occurred at the base of the Permian laterite (40 m) over time, however, there was no impact of induced flow on the water level within the 20 m bore. The implications of this mean is that as groundwater is extracted during mine dewatering and depressurisation occurs, there will be limited potential for induced flow from impacts on the isolated (non-continuous) perched water aquifers because water will not be induced to flow down into the mine pit through the depressurised deeper aquifers.

    It is also noted that these perched water tables are regularly recharged through rain and flood events and not reliant on upward groundwater movement.

    Direct impacts to the perched water table(s) can occur as a result of direct drainage into the open mine voids, considered to occur within a 10 to 100 m zone around the mine voids based on low gradients and permeability. The impacts are limited as mine infrastructure (roads, bunds, and piping) are considered to be located within this buffer around the open pits.

Figure 9 Alpha coal mine At-Risk bores

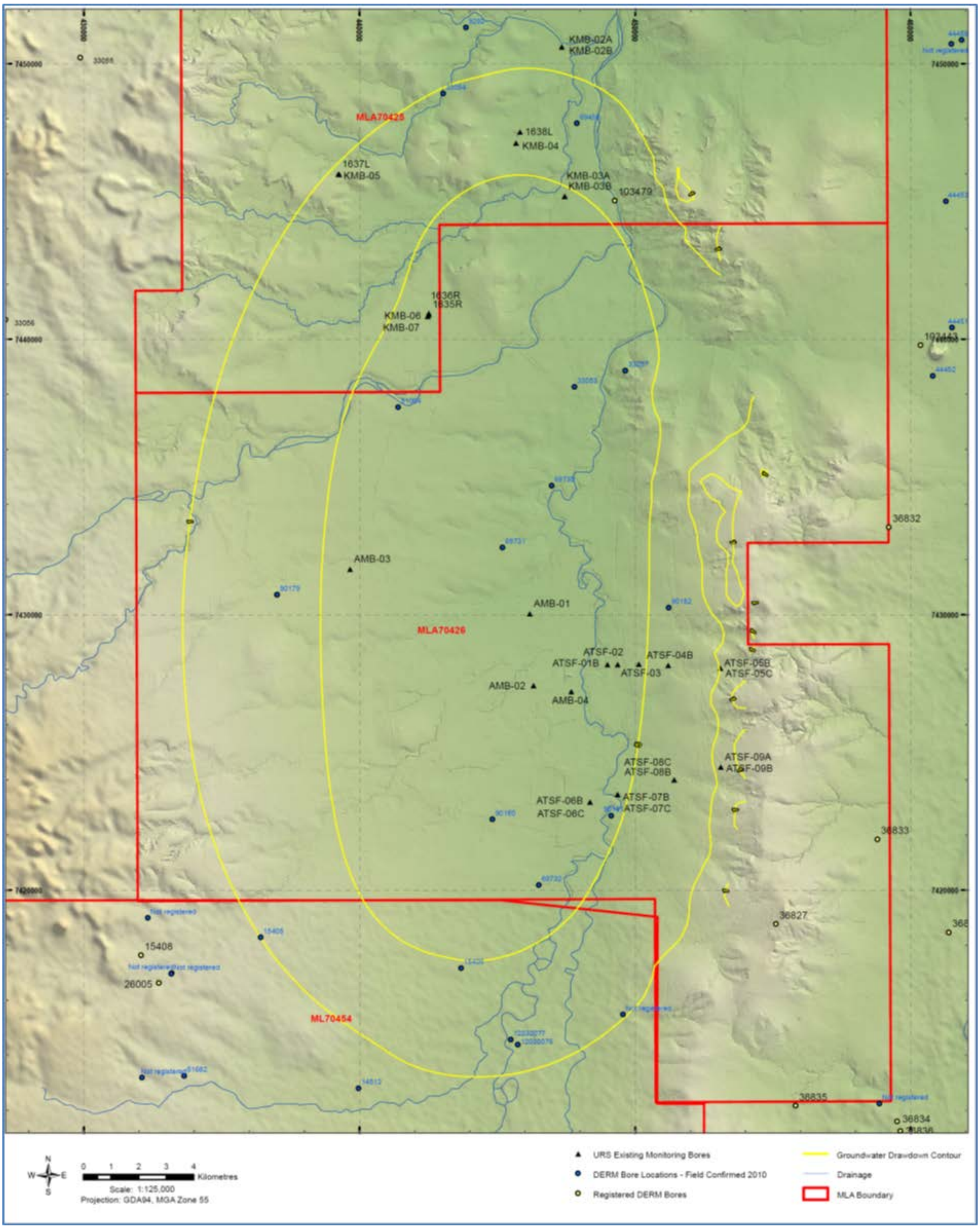
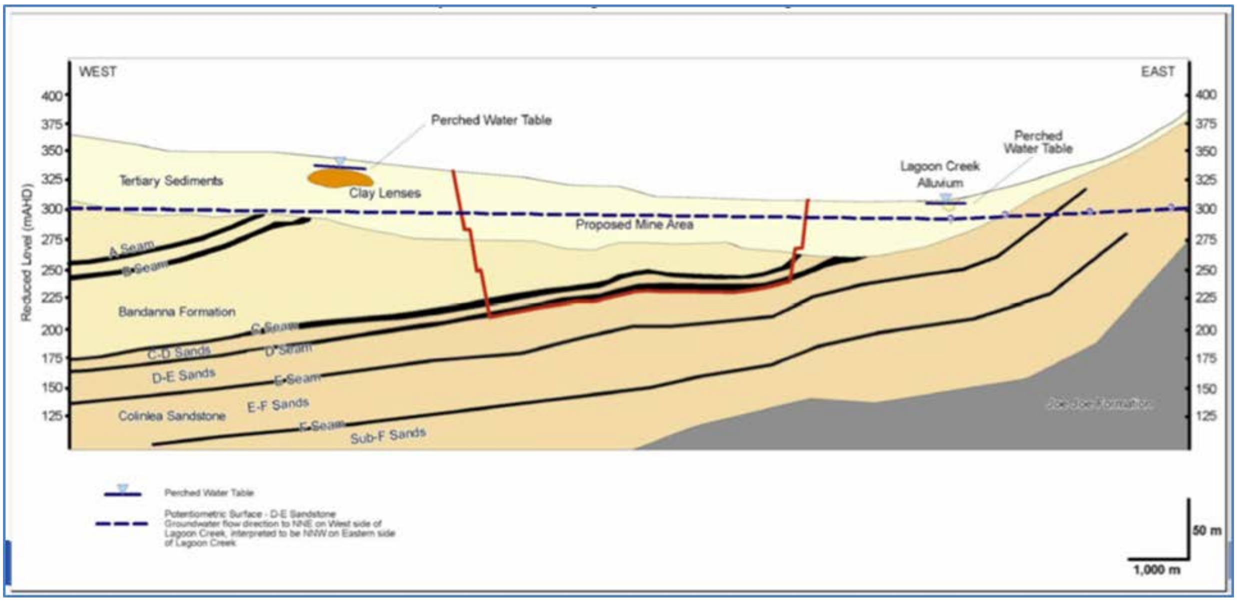


Figure 10 Perched groundwater table separate from confined potentiometric surface



In addition, the likely consequences of the changes to the groundwater table were considered.

- o Vegetation communities (depending on root depth) may utilise the isolated (non-continuous) perched water aquifers or the seasonal alluvium. Reduction in these water sources can lead to plant stress.

  It is, however, considered that the direct impact of the open pit mining on the groundwater table would be limited to a 10 to 100 m zone around the mine voids, based on permeability and gradient. These potentially impacted vegetation communities in the 10 to 100 m zone around the mine voids would need to be cleared as well to facilitate mining activities.

In answering this question, identify the extent to which the proposed Alpha Coal Mine is likely to impact on groundwater aquifers and surrounding bores, including:

- ***bores clustered around Tallarenha Creek drawing from the Colinlea Sandstone;***
- ***bores clustered to the west of Tallarenha Creek that draw from the basal, potentially lower quality Dunda Beds/Bandanna Formation; and***
- ***each objector bore identified in paragraph 2(b) in the response to request for particulars filed on behalf of objectors Paul and Janeice Anderson; and***
- ***each objector bore identified in the paragraph identified as 6(b)(i) in the response to request for particulars filed on behalf of objectors Bruce and Annette Currie.***

The bores clustered around Tallarenha Creek, identified in the response to request for particulars filed on behalf of objectors Paul and Janeice Anderson, are included on Figure 11. This figure includes the projected drawdown within the target D coal seam at the LOM as well as the cumulative drawdown contours generated when considering the Alpha and Kevin’s Corner coal mines.

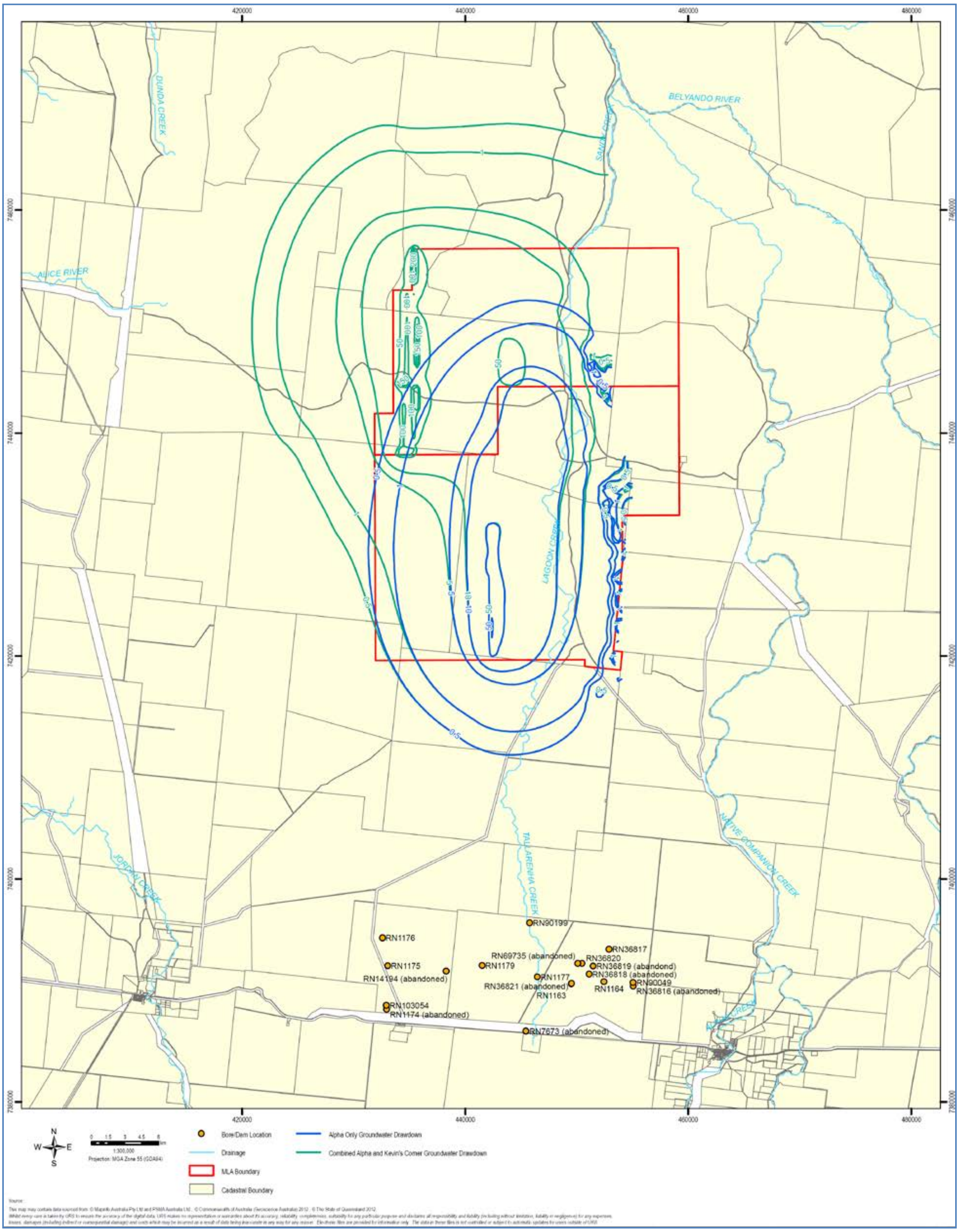
The projected change in D seam potentiometric surface of 0.5 m extends southwards, some 8 km from MLA70426. This is approximately 14 km from the nearest bore identified along the Tallarenha Creek.

The predictive modelling indicates that the proposed mining activities at Alpha Coal Mine, and cumulatively with Alpha and Kevin's Corner coal mines, will not result in any alteration of groundwater levels in any of these bores.

The proposed Alpha Coal Mine mining operations are, therefore, not predicted to:

- Impact on groundwater levels, flow patterns, hydrochemistry, or recharge and discharge mechanisms;
- Result in any long term impacts as a result of final void water quality and long term flow patterns;
- Impact on the capacity of the bores for agricultural purposes (stock watering);
- Impact on groundwater contribution to Lagoon Creek and Tallarenha Creek; and
- Impact on the groundwater EVs within the area containing these bores.

Figure 11 Tallarenha Creek bores and projected drawdown



The predictive modelling included in the Groundwater Modelling Report (URS, 2012), based on steady state and transient model calibration, using the base case (most suitable model parameters) is considered to provide an accurate prediction of the drawdown and interaction between units. It is recognised, however, that groundwater conditions (**Annexure B**) include:

- Groundwater Monitoring Program;
- Model validation and verification of predictions based on monitoring and mine extraction data (on a regular basis); and
- Third party model audits and data validation.

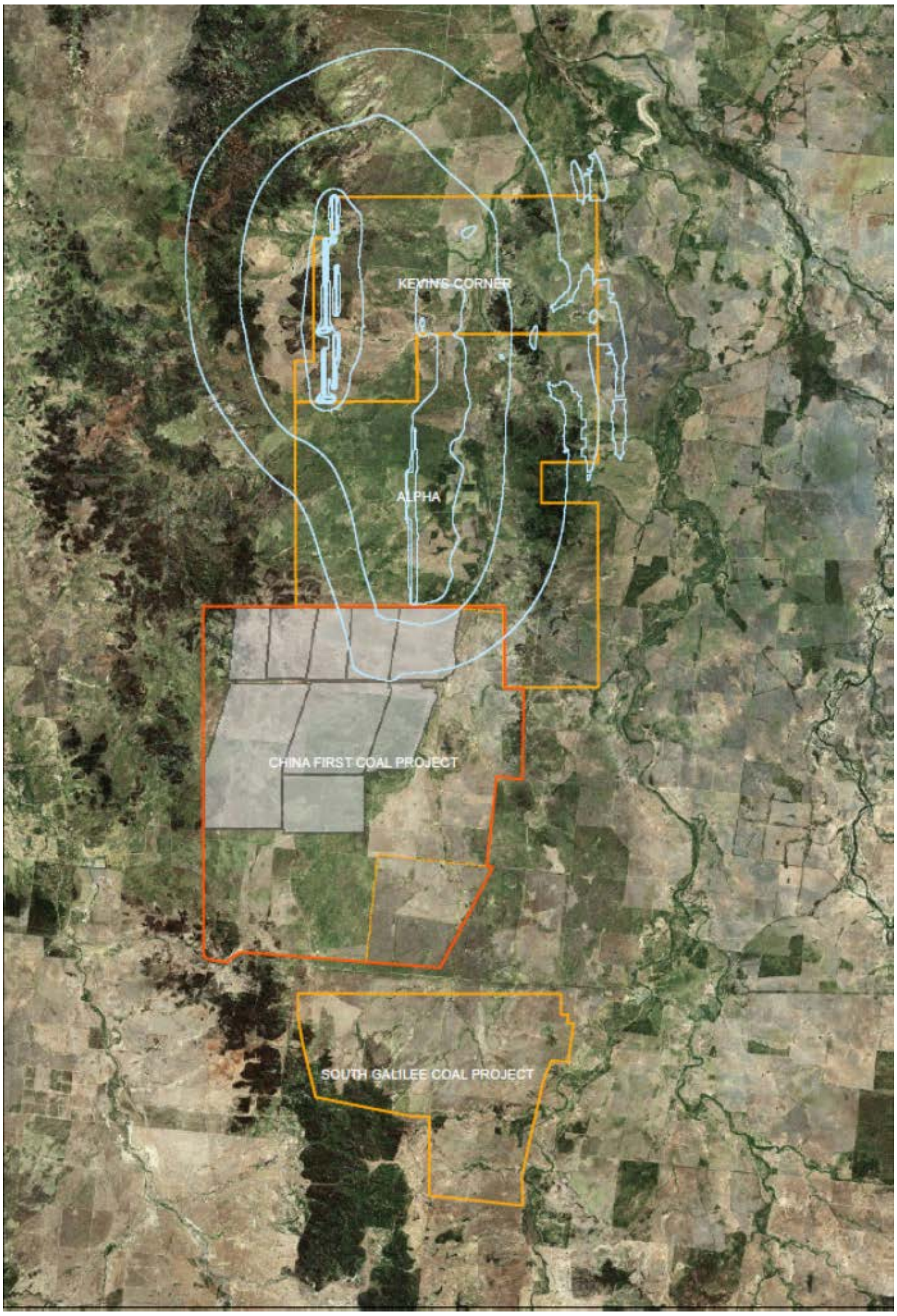
This will allow for the model refinement and prediction validation, to ensure optimum management and mitigation of groundwater impacts as a result of Alpha Coal Mine mining operations.

Cumulative impacts of multiple mines along strike will result in the elongation of drawdown impacts. The inclusion of mining operations south of the proposed Alpha Coal Mine, which currently includes the proposed China First Coal Project and South Galilee Coal Project (Figure 12), are considered to result in the elongation of the drawdown impacts to the south.

The conditions in **Annexure B**, from the Coordinator-General, include for Alpha Coal Mine to contribute to any basin wide collaborative project established by the administering authority to develop a basin groundwater model, including pro-rata funding.

This will allow for an assessment of the coal mining operations along the eastern basin margin (targeting shallow coal subcrop).

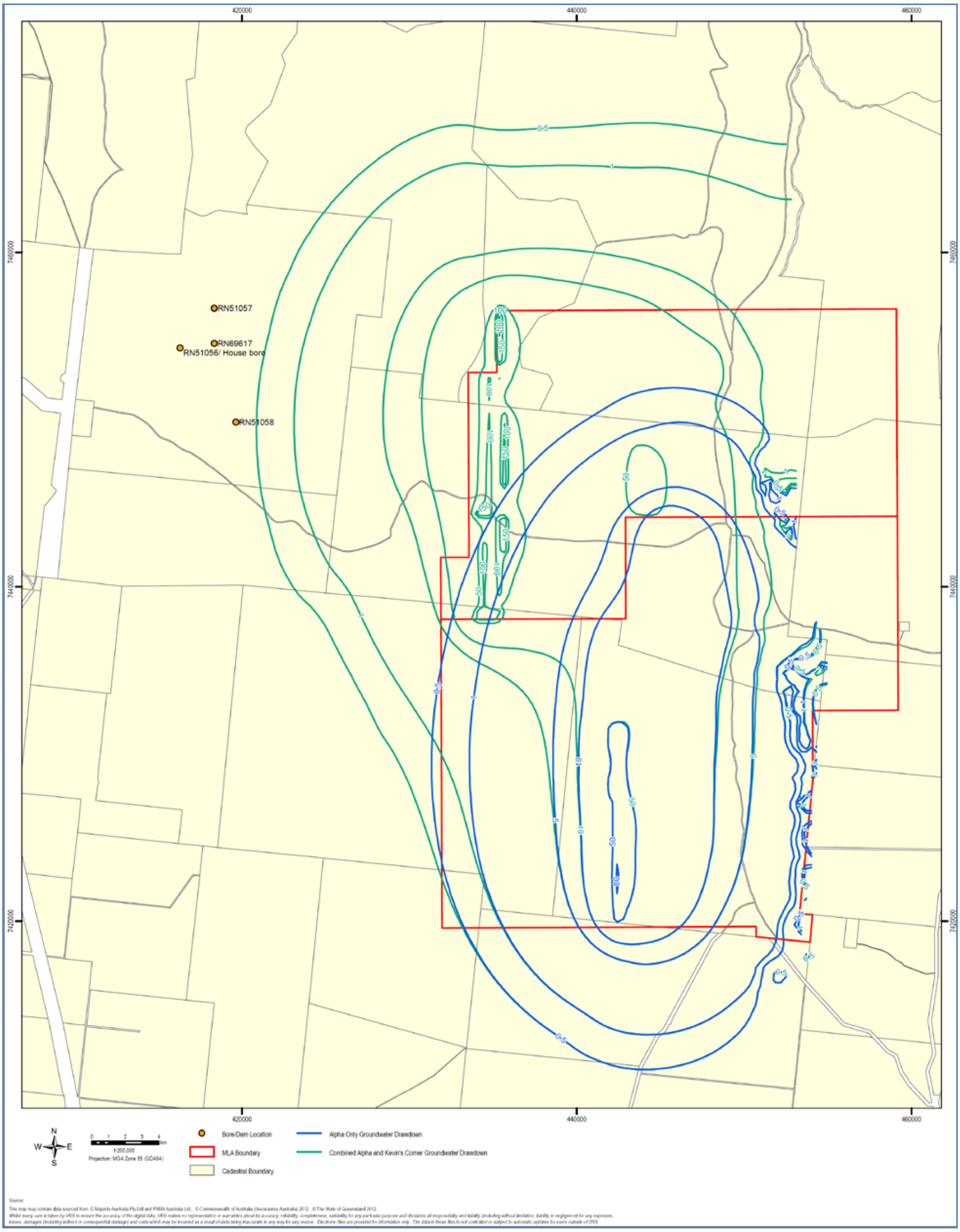
Figure 12 Proposed mining projects south of Alpha MLA70426



The bores, identified in the response to request for particulars filed on behalf of objectors Bruce and Annette Currie, are included on Figure 13. Figure 13 includes the projected drawdown within the target D coal seam at the LOM as well as the cumulative drawdown contours generated when considering the Alpha and Kevin’s Corner coal mines.

The projected change in D seam potentiometric surface of 0.5 m, resulting from the Alpha Coal Mine, extends westwards, to the western boundary of MLA70426. This is approximately 16 km from the nearest bore identified within the Speculation property.

Figure 13 Speculation bores and projected drawdown



The cumulative drawdown of both Alpha and Kevin's Corner (simulated to mine concurrently) results in the 0.5 m change (in D seam potentiometric surface) extending to within 1 km from the nearest bore.

The predictive modelling indicates that the proposed mining activities at Alpha Coal Mine will not result in any alteration of groundwater levels in any of these bores.

The proposed Alpha Coal Mine operations are, therefore, not predicted to:

- Impact on groundwater levels, flow patterns, hydrochemistry, or recharge and discharge mechanisms;
- Result in any long term impacts as a result of final void water quality and long term flow patterns;
- Impact on the capacity of the bores for agricultural purposes (stock watering);
- Impact on groundwater contribution to surface water bodies within Speculation; and
- Impact on the groundwater EVs within the area containing these bores.

The predictive modelling included in the Groundwater Modelling Report (URS, 2012), based on steady state and transient model calibration, using the base case (most suitable model parameters) is considered to provide an accurate prediction of the drawdown. It is recognised, however, that groundwater conditions (**Annexure B**) include:

- Groundwater Monitoring Program;
- Model validation and verification of predictions based on monitoring and mine extraction data (on a regular basis); and
- Third party model audits and data validation.

This will allow for the model refinement and prediction validation, to ensure optimum management and mitigation of groundwater impacts as a result of the proposed Alpha Coal Mine operations.

The cumulative impact of adding the Kevin's Corner dewatering, used to assess at-risk bores in the Groundwater Modelling Report (URS, 2012), results in deeper drawdown where drawdown cones overlap and further elongation along strike. The elongation to the north within the Colinlea Sandstone D coal seam (Figure 13) is not projected to impact on the Speculation bores. The drawdown is, however, more pronounced to the west as a result of deeper mining further to the west than the Alpha open pits. The same geological / hydrogeological constraints, which limit drawdown impacts to the east and west, are recognised when considering Kevin's Corner coal mining. It is considered that the potential for induced flow from the GAB Clematis Sandstone aquifer does not increase due to the nature (aquitard) of the Rewan and Bandanna formations.

The conditions in **Annexure B**, from the Coordinator-General, include for the proposed Alpha Coal Mine to contribute to any basin wide collaborative project established by the administering authority to develop a basin groundwater model, including pro-rata funding.

This will allow for an assessment of the coal mining operations along the eastern basin margin (targeting shallow coal subcrop).

Question 8

In your opinion, will the proposed Alpha Coal Mine have a significant impact on groundwater?

Response 8

It is my opinion that the Alpha Coal Mine will have a marked impact on the local groundwater resources within the Permian units over the life of the mine and post closure. However, depressurisation within the target coal seams is considered to have a limited impact on groundwater resources outside of the Alpha MLA70426.

Due to the large scale of the open cut mining, 30 Mtpa for 30 years, the volume of groundwater to be removed has been estimated at ~ 60 GL[2]. This will result in a zone of influence (depleted or reduced groundwater resources) within an area of ~35 km x 18 km, extending some 8 km north and south outside of the MLA70426.

This removal of groundwater during the 30 year LOM will have a marked impact on the local groundwater resources. The deepest coal seam to be mined as part of the Alpha Coal Mine will be the D coal seam. Consequently the groundwater resources below the D seam, located within the D-E sandstone, E-F sandstone, and sub-F sandstone, will still be available for use and is a suitable supply to make-good unduly affected groundwater supplies. An assessment of the model zone budget for the sub-E sandstone was undertaken to quantify the potential impacts of mine dewatering on the sub-E sandstone groundwater supply. The mine dewatering and long term alterations to potentiometric pressures in the sub-E sandstone indicate that the unit will not be dewatered during mining, only depressurised (10 to 20 m reduction in the sub-E sandstone potentiometric surface). Thus the aquifer remains fully saturated during and after mining. It is therefore considered that the sub-E sandstone can be utilised, away from the immediate mining area, as a source of make-good water.

The long term impacts of the proposed Alpha Coal Mine, due to the large scale of the final void and the climate in the area (evaporation exceeding rainfall plus groundwater ingress) will result in a permanent impact on the local Permian age aquifers as the final void will act as a sink in perpetuity. The permanent alteration of the local groundwater regime as a result of a final void is recognised to occur at all open pit mines within in central Queensland, due to the climate (evaporation exceeding rainfall plus groundwater ingress).

Thus, in the long term groundwater resources will be “mined” from the Colinlea Sandstone C-D and D-E sandstone aquifers and will be permanently lost. Make-good alternative supplies will have to ensure replacement over the long term.

The proposed Alpha Coal Mine will, however, have negligible impacts on the GAB, registered springs, GDEs, and surface water bodies.

Question 9

Identify any conditions in the Coordinator-General's Report, the draft Environmental Authority and/or EPBC Act Approval relevant to the potential impacts of the proposed Alpha Coal Mine on groundwater.

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[2] 1 Gigalitre = 1 x 10^9 litres

Response 9

Annexure B to this report contains the groundwater conditions included in the three documents included in the question.

Question 10

To the extent your opinion is that there is a degree of scientific uncertainty regarding the potential impacts of the proposed Alpha Coal Mine on groundwater, to what extent (if any) do the conditions in the Coordinator-General's Report, draft Environmental Authority and/or EPBC Act Approval address that uncertainty?

Response 10

It is my opinion that even allowing for model sensitivity and uncertainty analysis the groundwater model is still a simplification of the heterogenic multilayered groundwater system intersected within the Alpha Coal Mine MLA and surrounds. Thus any model can be improved and predictions verified once additional information (groundwater level monitoring and mine extraction data) is available.

The approval conditions (**Annexure B**) adequately allow for the compilation and validation of data, these conditions include for:

- The augmentation of groundwater monitoring (network and program);
- Regular groundwater modelling and prediction comparison and verification;
- Third party model review audits; and
- The development of a basin (or part-basin) model to best manage and assess cumulative impacts of multiple coal mines.

These conditions will allow for the confirmation and optimum management of groundwater resources in this portion of the Galilee Basin into the future.

Question 11

In relation to the advice of the Interim Independent Expert Scientific Committee to the Commonwealth Environment Minister, in your opinion have:

- ***any of the matters raised in that advice have already been appropriately assessed by the information in the EIS, SEIS and supplementary documentation to date?; and***
- ***the matters raised in that advice have been adequately addressed by the conditions of the Environment Protection and Biodiversity Conservation Act 1999 approval, the Coordinator-General's conditions and the conditions of the draft Environmental Authority?***

Response 11

In the Interim Independent Expert Scientific Committee's (IIESC) response to the request from the Federal Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) regarding whether the proposed conditions in the Queensland Coordinator-General's Assessment Evaluation Report were sufficient to mitigate the water related impacts to:

- The Great Artesian Basin;
- Regional surface water resources of the Galilee Basin;
- The Caley Valley Wetland, including potential acid sulphate soil issues; and

- Habitat for listed species, through water course alteration.

The IIESC's advice stated that the information presented to it could be improved by:

- Further details of the measured hydrogeological data, model parameters, uncertainties, confidence and transparency;
- A site and regional water balance (comment assumed to include groundwater components);
- Associated risk assessments; and
- Mitigation measures to appropriately address risk.

I consider that the:

- Groundwater Modelling Report (URS, 2012); and
- The EIS submission documentation provided during the EIS process,

contain the details of the hydrogeological data, the modelling parameters (refined over time), uncertainty and sensitivity analyses, high confidence level modelling (which has been subject to independent review). I consider that they ensure confidence and transparency in the assessment to date.

The groundwater mass balance results, included in the Groundwater Modelling Report (URS, 2012) and presented above (**Response 5 (h)**), include the groundwater water balance components on a regional and site scale.

Impact evaluation and risks to groundwater EVs have been considered, initially in the EIS and then again after additional post EIS groundwater studies had been complete. The risk assessment of the potential impacts on groundwater resources, in terms of possibility and likely outcomes, was further evaluated during the predictive modelling. Sensitivity and uncertainty analyses included in the modelling allowed for the evaluation of model parameters to ensure the representativeness of model input, thus reducing the risk of incorrect impact evaluation.

The potential risk of groundwater reduction allowed for the compilation of environmental protection commitments (groundwater specific), control strategies, and monitoring recommendations in the Alpha Coal Mine Environmental Management Plan 2012.

The control strategies include for:

- Water level impacts;
- Impacts on GDEs or Vegetation Communities;
- Reduced recharge;
- Seepage mitigation;
- Groundwater quality impacts; and
- Post mining mitigation

Cumulative groundwater impacts, as detailed in the Groundwater Modelling Report (URS, 2012), have been conducted for the proposed Alpha and Kevin's Corner coal mines, being mined concurrently and within the same groundwater and geological units.

Cumulative impacts of the four proposed mining operations (Alpha, Kevin's Corner, China First (Waratah), and South Galilee coal mines[3]) raises significant issues regarding the availability and use of data, reliance on unchecked / validated data available in the public domain and limited information about other relevant matters, such as mining methods. This potentially leads to inaccurate impact assessments. This could, in the case of Waratah and South Galilee, result in disagreement if these proponents do not agree with the resultant impact evaluation, or predictions based on the limited data available to Hancock.

The number of assumptions, differences in conceptualisation (geology and hydrogeology), and simplifications that would be required to construct and calibrate a preliminary high level regional model would lead to an assessment of potential drawdown with limited confidence. 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 of mine dewatering associated with all proposed projects within this portion of the Galilee Basin. The cumulative impact assessment (for the projects other than Kevin's Corner) was, therefore, considered quantitatively and discussed in terms of possible additional impacts. The basis for this assessment was the results of the predictive modelling considering both Alpha and Kevin's Corner coal mines mining concurrently.

I consider that the Alpha Coal Mine model and data could be included in a larger regional model, similar to the approach adopted in the Surat Basin; once more detailed groundwater models are available across the eastern portion of the Galilee Basin. Conditions to this affect have been imposed on the project (**Annexure B**). In particular:

- Condition 2 in Appendix 2, Part B of the Coordinator-General's Report – The condition states that it has been imposed *"To address the potential cumulative impacts on groundwater quality and availability in the Galilee basin..."* The proponent must:

  "(i) before commencing mining activities prepare to the satisfaction of the administering authority and implement a groundwater monitoring and reporting program for aquifers impacted by the project off the mining lease

  (ii) design the program to complement the environmental authority requirements and other groundwater management programs in the Galilee basin. The program should aim to enable a basin groundwater model to be developed to predict, verify and monitor groundwater impacts.

  (iii) make monitoring results from the program publicly available on the proponent's web site updated at least annually

  (iv) contribute to any basin wide collaborative project established by the administering authority to develop a basin groundwater model, including pro-rata funding

  (v) contribute to development of a basin wide groundwater model for determining the capacity of aquifers and acceptable extraction rates, including pro-rata funding"

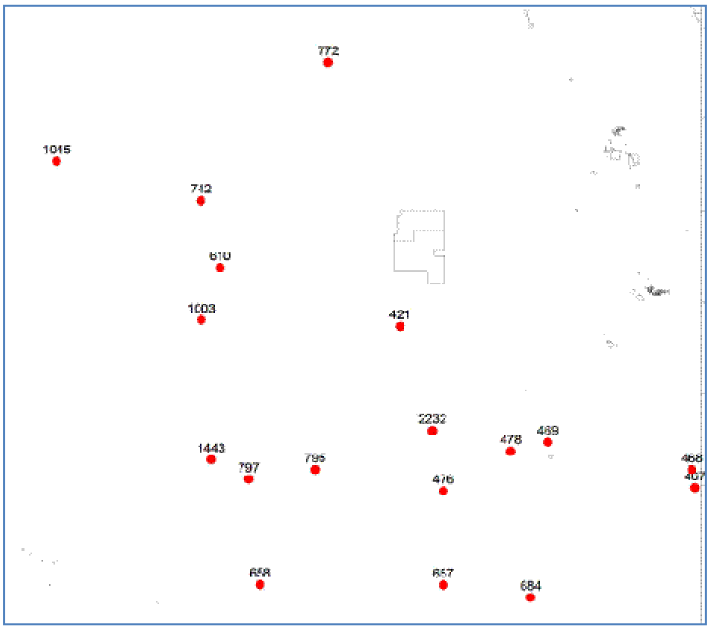
- Condition 11 of the EPBC Act approval for the project states that the proponent must submit a Regional Water Management Plan to the Minister for Approval. The plan must include a regional groundwater monitoring program with reference to groundwater dependent habitat for listed threatened species and ecological communities, and listed migratory species. The proponent cannot commence construction activities until the Minister approvals the Regional Water Plan in writing.

[3] Refer to Figure 12, which indicates the four coal mines

The SEIS Appendix N (Groundwater and Final Void Report) include the results of literature review regarding the Rewan Formation, which includes several references discussing the regional aquitard nature of the Rewan Formation. On a local scale there is no evidence, based on the exploration data compiled by Salva (2009) during the generation of the regional geological model, of any large scale geological structures (faults, etc.), within the proposed mine areas that could promote inter-aquifer or inter-basin hydraulic connection.

In order to obtain representative permeability data, both horizontal and vertical, for the Rewan Group, an assessment of the Queensland Petroleum Exploration Data (QPED) database was conducted. Eighteen (18) bores were recorded containing permeability data across an area of ~ 290 x ~340 km (98,600 km^2), obtained from drill stem tests during exploration drilling, within the study area (Figure 14).

Figure 14 Rewan Formation Permeability Data Sources relative to MLA70426



The available QPED records are summarised in Table 10. The permeability (hydraulic conductivity) was determined for different depths within the bores. Several tests did not result in a response during the drill stem tests, indicating very low permeability (lower than the lowest permeability measured in Table 6, 0.0009 m/day).

The permeability data, both vertically and spatially, indicates that the Rewan Formation acts as a continuous regional scale aquitard.

Table 10 Rewan Formation Hydraulic Conductivity Data

Bore No	Test Depth (m)	Porosity (%)	Horizontal Hydraulic Conductivity (m/day)	Vertical Hydraulic Conductivity (m/day)
476	575.46	23.3	0.014	0.0014
476	578.82	12.2	0[4]	0
476	588.87	17.1	0	0
476	593.14	12	0	0
476	597.41	30	0.79	0.47
476	601.98	25.9	0.86	0.011
476	619.35	28.2	0.13	0.012
476	623.62	26.4	4.44	0.14
476	629.11	23.5	0.016	0.015
476	636.42	23.4	0.055	0.036
476	645.26	28.3	0.43	1.18
476	651.05	27.3	2.07	0.05
476	657.15	27.6	0.83	0.34
478	40.2	23.3	0.28	0.015
772	541.9	23	0	0
772	641.6	13.5	0	0
772	734.3	16	0	0
1045	906.37	18.2	0.07	0.006
1045	919	17.2	0.44	0.07
1045	929.3	20.3	0.28	0.028
1443	1149.43	20	0.02	0.005
1443	1158.28	25	0.099	0.07
1443	1169.02	25	0.099	0.07
1443	1179.57	25	0.13	0.055
1443	1193.63	22	0.029	0.005
1443	1203.21	21	0.029	0.0048
1443	1212.34	18	0.027	0.004
1443	1221.69	18 0	0.0048	0.003
1443	1234.57	23	0.0039	0.001
1443	1241.97	24	0.055	0.002
1443	1251.97	21	0.06	0.004
1443	1266.85	19	0.17	0.002
2232	22.4	27	0.001	0
2232	22.8	26	0.0009	0

[4] No response during drill stem test, very low permeability

2232	64	26	0.014	0

These results indicate heterogeneity within the Rewan Group, with zones of very low vertical permeability identified over a large area. These zones provide the confining pressures required for artesian and sub-artesian conditions recorded in the GAB (the confining layer below the aquifers) and reduce the potential for vertical induced flow. The results validate the conceptualisation of the Rewan Formation acting as a regional aquitard, which prevents inter-aquifer and inter-basin flow.

The impacts of mine dewatering on the Rewan Formation and ultimately to the Clematis Sandstone are, therefore, recognised as negligible. Groundwater model predictions, as discussed in the Groundwater Modelling Report (URS, 2012) provide verification of this impact evaluation.

The Alpha Project groundwater modelling – Independent due diligence assessment compiled by Parsons Brinckerhoff was included as an appendix to the Groundwater Modelling Report (URS, 2012), which was provided as part of the Alpha Coal Mine EIS submission.

The Alpha Coal Mine model and data could be included in a larger basin scale model, similar to the approach adopted in the Surat Basin; once more detailed groundwater models are available across the eastern portion of the Galilee Basin. As detailed above conditions regarding a regional model have been imposed on the Alpha Coal Mine.

I acknowledge the IIESC advice that the information presented could be improved. I agree that it is always possible to undertake further studies, and recognising that there are conditions and obligations on the project to obtain additional data and conduct further refinements, I consider that there is sufficient information to date for the purpose of understanding the potential impacts and for making informed decisions. It is my opinion that the groundwater related matters raised by the IIESC have been adequately considered, evaluated and included during the EIS process.

Question 12

In your opinion, is there sufficient, adequate and accurate information to provide a reasonable level of scientific certainty to support your conclusions in relation to the above?

Response 12

In my opinion, yes, sufficient site-specific, accurate and representative data was collated, which allowed for the compilation of groundwater impact assessments, mitigation measures and management plans in the various EIS groundwater sections and technical reports. This data allowed for the development of predictive groundwater models, which accurately assess the potential impacts of the proposed mining on the groundwater resources is sufficient to allow for informed decision making.

The approach adopted, as detailed in **Response 3**, to collate, refine and re-assess groundwater data over the entire hydrogeological study, was successful in addressing the Terms of Reference in respect to groundwater resources. The various groundwater related documents and reports provide:

- A detailed description of the regional and local geology, and provide an assessment of the geological structures and the groundwater occurrence associated with the geological units;
- A detailed baseline description of the groundwater resources and an evaluation of groundwater environmental values, within and adjacent to the Alpha MLA70426;
- A description of the nature of the aquifers, including:

- Identified confined and unconfined aquifers, heterogeneity, and resource potential;
- Aquifer thickness, stratigraphy, and aquifer hydraulic parameters (site specific and modelled);
- An evaluation and identification of aquifer interconnectivity (primarily from site specific aquifer hydraulic testing including the ATP dewatering);
- Transient groundwater level data, long term fluctuation hydrographs, and aquifer test and ATP dewatering response;
- Regional and local groundwater level contours, flow patterns and gradients (steady-state model calibration to groundwater levels and transient model calibration to groundwater level variation);
- Evaluation of nested groundwater level data and the assessment of groundwater – surface water interaction;
- Recharge and discharge studies; and
- Contaminant propagation modelling to assess groundwater and surface water vulnerability to pollution.

- Details of baseline hydrochemistry for different aquifers envisaged to be impacted by mining operations, composite groundwater (resulting from blending within the open pit, and compilation of a hydrochemistry database, which includes major anions and cations, selected dissolved metals, pH, electrical conductivity, total dissolved solids, and organic compounds;
- An initial evaluation of groundwater environmental values was compiled in the EIS; this was further revised based on additional site specific data, bore survey, and groundwater data evaluation and conceptualisation.
- An assessment of the potential environmental harm caused by the Alpha Coal Mine to local groundwater resources, as detailed in **Responses 3 and 4**;
- The Groundwater Modelling Report (URS, 2012) includes groundwater monitoring network details and commitments. The report also includes details of the Hancock make-good commitment and recommended inclusions in make-good agreements required to ensure ‘make-good’ any adverse effects on the groundwater resources utilised by adjacent landholders;
- An integrated model allowed for the description of the expected response of the groundwater resource to the progression and finally cessation of the Alpha Coal Mine mining operations. This model allowed for an assessment of long term (300 years post mining) groundwater levels, flow patterns, and gradients;
- An assessment of the groundwater volumes generated from dewatering over the life of the mine, was conducted to estimate groundwater inflows, on a year-on-year basis, for inclusion in the mine water balance. It is recognised that all groundwater intersected during mining will be utilised in the mine operations;
- An assessment was undertaken of the impact of the Alpha Coal Mine on the local ground water regime caused by any land disturbance. The integrated model, used to evaluate final void

impacts, long term groundwater levels and flow patterns, was also utilised to assess potential long term seepage impacts from the TSF; and

- Groundwater monitoring network details and commitments were included in the Groundwater Modelling Report and the Alpha Coal Mine Environmental Management Plan.

The data compiled, evaluated and considered which allowed for the development of predictive groundwater models, which accurately assess the potential impacts of the proposed mining on the groundwater resources, is sufficient to allow for the consideration of severity and long term nature of groundwater impacts, as considered in **Response 8**.

POTENTIAL SURFACE WATER AND OTHER IMPACTS

Question 13

In your opinion:

(a) what is the likelihood of interconnectivity between groundwater and surface water, including surface water features (e.g. springs and perched water tables)?

(b) What is the likelihood and significance of direct and indirect impacts of proposed Alpha Coal Mine dewatering on surface water, including surface water features (e.g. springs and perched water tables)?

In answering this question, include a discussion of any contribution of 'baseflow' from groundwater and the likelihood of any contamination as a result of mining activities, and in particular consider any surface water features that may receive baseflow from groundwater described in EIS Volume 5, Appendix P, Section P.3.4.2.2).

Response 13

What is the likelihood of interconnectivity between groundwater and surface water, including surface water features? (e.g. springs and perched water tables).

In my opinion, based on the numerous groundwater level monitoring points, locations (next to surface water bodies and spatially across Alpha and Kevin's Corner coal mines), and water level readings over time, the likelihood of surface water-groundwater interconnectivity is low.

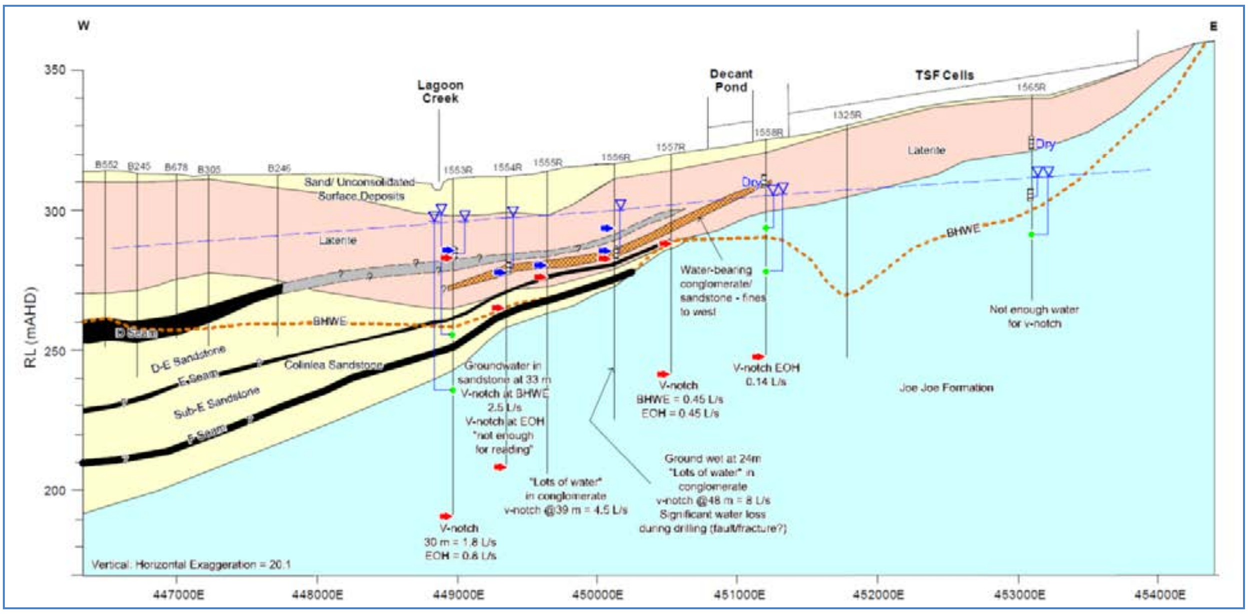
Based on drilling and field measurements recorded across the site it was conceptualised that isolated perched water tables occur within the clay-rich Tertiary overburden (Figure 10). The data compiled for the basis of this conceptualisation includes:

- Nested bores adjacent to Sandy Creek on MLA70425;
- The assessment of the TSF, which included the drilling and construction of multiple monitoring points (SEIS Addendum Alpha Tailings Storage Facility: Hydrogeological Assessment, 2011); and
- The assessment of the palustrine wetland (SEIS Appendix N Groundwater and Final Void Report, Volume 2).

Groundwater level data for the shallow (10 m) bores constructed within the Sandy Creek alluvium range from 3.48 to 8.9 m below surface. Bores constructed below the alluvium, within the confined D-E sandstone indicate groundwater levels ranging from 12.53 to 22.34 m below surface. This groundwater level data indicates a 3 to 19 m separation between the perched alluvium water levels and the D-E sandstone potentiometric levels. This data shows distinct separation thus no hydraulic linkage between the two groundwater systems. This data, plus no recorded springs and seeps in or adjacent to the MLAs; indicate limited potential for groundwater discharge from the Colinlea Sandstone units.

Groundwater levels across and adjacent to the Alpha TSF from 22 monitoring bores, 14 geotechnical bores, and 52 test pits allowed for the evaluation of unconfined and confined (potentiometric) groundwater levels (Figure 15). The nested bores at drill targets 1564R (bores 1621R and 1622R), 1561R (bores 1618R and 1617R), 1563R (bores 1619R and 1620R), 1565R (bores 1614R and 1615R), and 1566R (bores 1616R and 1566R) all indicate differences and separation between the water level measurements indicating no hydraulic linkage.

Figure 15 Potentiometric surface relative to Lagoon Creek (Alpha TSF Footprint)



I make the following observations with respect to groundwater levels in the area of the proposed TSF:

- Geological units of the Colinlea Sandstone are restricted east of Lagoon Creek due to Tertiary processes and more resistive (to alteration than Colinlea Sandstone units) Joe Joe Formation, thus groundwater levels associated with the Colinlea Sandstone do not extend under the TSF footprint;
- Beneath the TSF footprint most bores were relatively dry during drilling, and current levels suggest groundwater levels between 25 and 30 m below ground level (e.g. 1563R);
- No groundwater levels were measured in any of the 14 geotechnical bores (drilled to 10 m and 20 m) after 1 month of installation (Alpha SEIS Addendum Appendix C);
- Perched groundwater was only recorded in two of the 52 test pits, at depths of 2.1 m and 1.2 m. These data indicate localised perched water table;
- Hydraulic head differences (separation) between the groundwater table and the potentiometric levels, associated with the confined aquifers, in all the multiple piezometer bores indicate no evidence of hydraulic connection; and

- All groundwater level data, recorded in the shallow monitoring bores within different aquifers, adjacent to Lagoon Creek and the TSF are ~ 10 m below surface, significantly deeper than the likely root depth of plants or the depth of surface water bodies.

In the assessment of the palustrine wetland (a man-made water feature) the groundwater levels in a monitoring bore AMB04, some 800 m northwest of Murdering Lagoon, was compared to the water levels in the palustrine wetland. Piezometeric levels, associated with the underlying C-D sands aquifer intersected in AMB04 have groundwater level records at 300.8 m AHD. The elevation of the palustrine wetland is at 311 m AHD. Based on the depth variation (~10 m difference between water levels) the wetland is considered to be perched above the confined groundwater resources and within the Lagoon Creek alluvium.

In addition, groundwater levels for multiple aquifers within one bore (such as drill target 1561R, 100 m from Lagoon Creek) indicate that the piezometeric levels in the shallower aquifers are higher than the deeper aquifers in this area. This suggests a downward potential for groundwater flow in the area of the palustrine wetland, and supports a view that water levels in Murdering Lagoon are recharged by surface water flow rather than groundwater.

Groundwater occurrence in the Tertiary sediments and Quaternary alluvium occurs as intermittent unconfined perched groundwater, and are not regarded as significant regional aquifers. Figure 10 presents a conceptualisation of the pre-mining hydrogeology, indicating the potentiometric surface associated with the confined D-E sands and the perched water tables (associated with Lagoon Creek alluvium and clay lenses within the Tertiary and Quaternary units).

Groundwater level data (over time) for the confined and unconfined monitoring bores across the Alpha and Kevin’s Corner MLAs indicate no hydraulic connection between the confined potentiometric levels and the water tables.

What is the assessment of the likelihood and significance of direct and indirect impacts of Alpha Coal Mine dewatering on surface water, including surface water features (e.g. springs and perched water tables).

In my opinion, based on the effective aquitard (clay) separation between the target coal seams and the perched water table and ephemeral surface water, the likelihood of indirect impacts (induced flow) of the open pit mine will be very low (this was recognised during the ATP bulk sample pit dewatering). The direct impacts will be limited to the area immediately adjacent to the open pits based on low gradients and low permeability (based on Darcy’s Law).

<u>Springs</u>

An assessment of the potential impact of the required mine dewatering, both Alpha and Kevin’s Corner coal mines, on the registered springs within the GAB and to the north of MLA70425, was conducted during the predictive modelling.

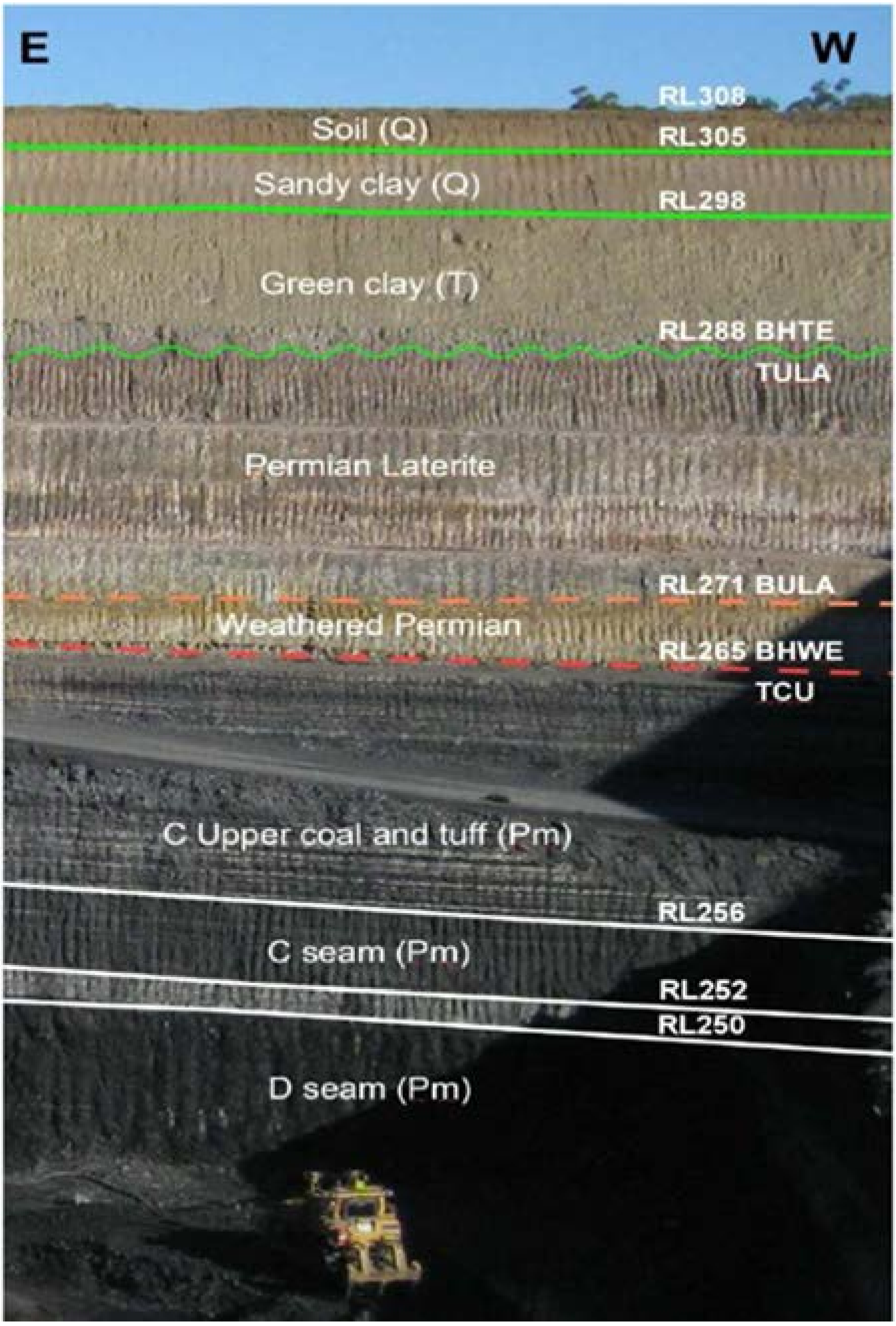
Drawdown predictions over 300 years post mining do not indicate any potential for impacting on the GAB springs.

Registered springs SP70, SP405, and SP71 (Figure 8), were included in the model predictions. Groundwater level data for the Tertiary overburden (Layer 1), Tertiary sediments (Layer 2), and the target D seam was projected over time (30 years LOM and 300 years post mining). The Tertiary layers were assumed to be saturated and have the same initial groundwater levels as the confined Permian units utilised in the steady-state calibration (a “worst-case” scenario as exploration drilling and geotechnical studies indicate intermittent localised perched groundwater within the clay-rich laterite). No change in groundwater levels in any of the model layers, and hence no impact on these springs, was predicted.

Perched Water Table

An assessment of mine dewatering indicates limited potential for induced flow from the isolated (non-continuous) perched water down into the depressurised deeper aquifers. The dewatering monitoring conducted during the bulk sample pit (ATP) dewatering indicates that there is no hydraulic link between the deeper aquifers and the perched aquifers. This is due to the laterisation of Permian sediments, which resulted in a thick clay confining layer (Figure 16).

Figure 16 Alpha Test Pit lithology



Monitoring data from a 20 m (bottom of green clay) and a 40 m (bottom of weathered Permian) bore show that minor induced flow occurred at the base of the Permian laterite (40 m) over time, however, there was no impact of induced flow on the water level within the 20 m bore. The implications of this is that as groundwater is extracted during mine dewatering and depressurisation occurs, there will be limited potential for induced flow from impacts on the isolated (non-continuous) perched water aquifers because water will not be induced to flow down into the depressurised units.

It is also noted that these perched water tables are regular recharged through rain and flood events and not reliant on upward groundwater movement.

Direct impacts to the perched water table can occur as a result of direct drainage into the open mine voids, considered to occur within a 10 to 100 m zone around the mine voids based on low gradients and permeability (Darcy's Law). The impacts are limited as mine infrastructure (roads, bunds, and piping) are considered to be located within this buffer around the open pits.

Please include a discussion of any contribution of 'baseflow' from groundwater and the likelihood of any contamination as a result of mining activities, and in particular consider any surface water features that may receive baseflow from groundwater described in EIS Volume 5, Appendix P, Section P.3.4.2.2).

No groundwater-surface water interaction has been recorded across Alpha MLA70426 or downstream within Kevin's Corner MLA70425.

Model construction and calibration, both steady-state and transient, achieved good correlation to groundwater levels across the model area with no simulation of groundwater loss or discharge into the surface water.

Potential contamination of Lagoon Creek, as a result of possible poor quality artificial recharge from the TSF was conducted and discussed in **Response 15**.

Question 14

In your opinion, to what extent will the proposed Alpha Coal Mine's final void impact on groundwater? In answering this question, include detail regarding:

- ***the size of the final void;***
- ***when the void is expected to reach a 'steady state';***
- ***the risk of decant from the final void;***
- ***the quality of water in the final void;***
- ***the impact of the final void on groundwater equilibrium; and***
- ***the likelihood of the final void resulting in groundwater contamination.***

In particular, also consider the long term drawdown and water quality impacts from the final void described in EIS Volume 2, Section 12.9.8.

Response 14

In my opinion, the final void will impact on the local groundwater resources in perpetuity. The resultant altered local groundwater flow pattern will, however, prevent poor quality water leaving the final void and migrating off site in the groundwater.

Long term groundwater level predictions considering the impacts of the final void were evaluated using an integrated (surface water runoff – groundwater) model. This model, utilising the end of mine groundwater heads, was constructed to allow for an assessment of potential long term impacts on groundwater resources, within the modelled layers, over time (~ 300 years post mining) and spatially.

The integrated model was constructed based on the refined predictive groundwater model with an additional model layer created to represent the overland flow surface. The overland flow area included only the disturbed mining area, as it was assumed that secondary containment (bunds) will be constructed around the mine footprint such that it will not have external surface runoff interactions.

Based on projected mine activities, resulting in a final void and rehabilitated backfilled areas over the life of mine, the land surface in the integrated model was updated to an envisaged final mine layout and surface, compiled by Hancock (Figure 17). A west-east cross section, at a selected location, indicates the final void and out-of-pit spoil dump elevations included in the integrated model (Figure 18).

Figure 17 Land surface and final void

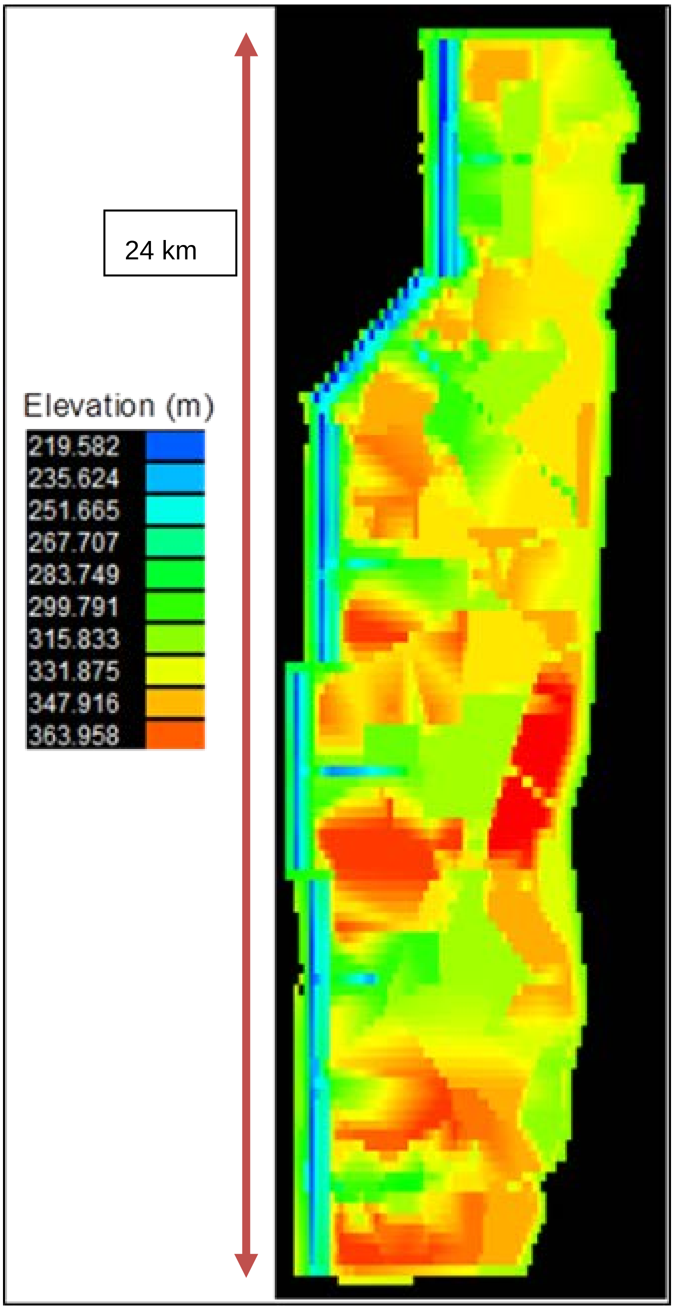
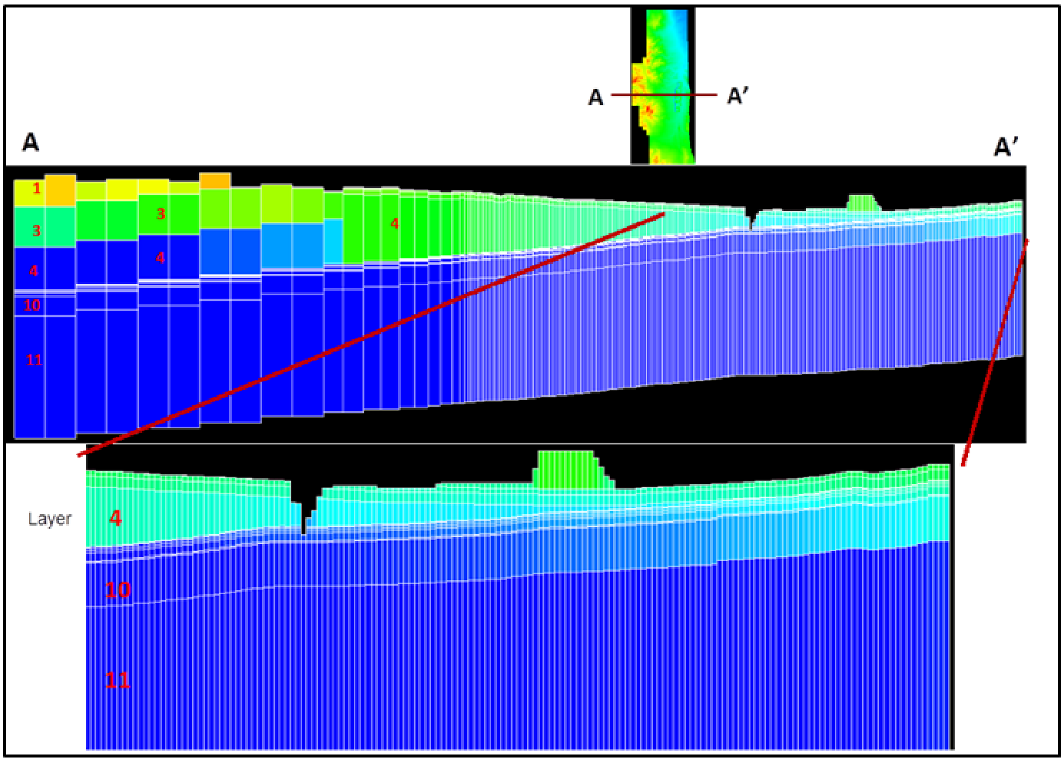


Figure 18 Cross-section through the groundwater flow area (showing final void)



The final void was modelled to extend the length of MLA70426, some 24 km in length and approximately 100 m wide at the bottom. The final void disturbed area footprint covers an approximate 144 km^2.

The integrated model was used to obtain an estimate of where the water level will rise to and stabilise over time based on in (rainfall recharge and runoff) and out (evaporation) flux components. The predicted final void water level change with time, based on an observation point in the middle of the final void, indicates the final void water level reaches a pseudo steady-state after ~ 50 years, at around 37 m above pit floor.

<u>Final Void Decant Potential</u>

The lowest elevation point where decant could potentially occur is along the northern most portion of the final void, ~ 305 m AHD. The projected final void water level in the northern portion of the final void is 249 m AHD, some 56 m below the lowest pit surface elevation. The risk of decant, of final void water, is therefore negligible as the volume of water required to fill the remaining void space would be in excess of 750 GL.

The potential additional rainfall ingress, using 1:100 year rainfall event volumes ~ 400 mm (based on the high rainfall data which resulted in flooding in 2011), over the disturbed mine footprint and assuming all the water entered the final void would result in ~ 52 GL entering the void. This would increase the final void water level to 257 m AHD. This increase does not increase the risk of decant.

<u>Final Void Water Quality Assessment</u>

An assessment of final void water quality over time was conducted using the integrated model. The modelling allowed for the following salinity (in terms of TDS) input:

- Composite groundwater quality with a TDS of 1,200 mg/L[5]; and
- Variable runoff quality based on surface conditions including TDS of 50 mg/L for rehabilitated areas, 100 mg/L for partially rehabilitated areas, and 200 mg/L for disturbed areas.

The projected increase in salinity indicates that the final void water could, when compared to the ANZECC 2000 guidelines for cattle livestock drinking water, be utilised for ~ 150 years (using the worst case 200 mg/L runoff value). The TDS (salinity) guidelines for beef cattle are:

- TDS 0 to 4,000 mg/L – No adverse effects on animals;
- TDS 4,000 to 5,000 mg/L – Stock should adapt without loss of production; and
- TDS 5,000 to 10,000 mg/L – Loss of production and decline in animal condition.

The final void water could, therefore, be utilised for a significantly long time before salinity exceeds the 5,000 mg/L guideline.

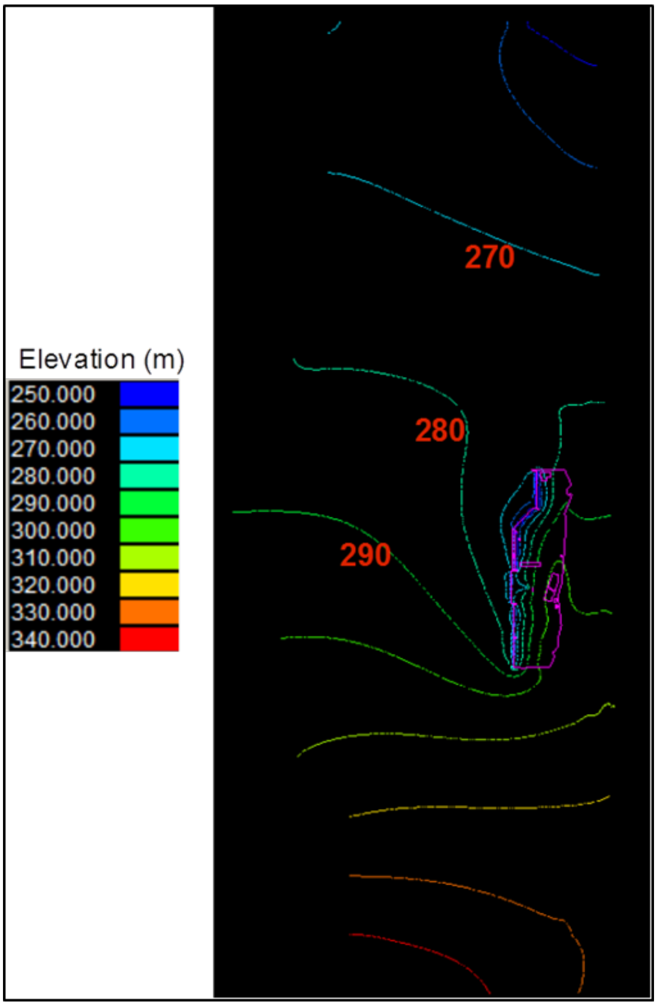
This water could be utilised for longer to supply sheep as the ANZEEC 2000 guideline indicates that sheep can adapt to water, without loss of production, with TDS of up to 10,000 mg/L TDS.

Long term groundwater level equilibrium

The recovery simulation was conducted for 300 years. The simulated head contours for the D seam after 300 years is presented in Figure 19. The long term changes in groundwater flow patterns occur mainly around the northern and western sides of the final void.

[5] The mean groundwater TDS value for composite groundwater samples collected from 313 open exploration bores across the MLAs.

Figure 19 Simulated water levels in D seam after 300 years



At closure the final void will function as a groundwater sink (receptor) in perpetuity, and groundwater gradients will cause groundwater in the adjacent units to flow into the final void. The final void modelling indicates no risk of decant (and no risk of final void water leaving site in the surface water) and no potential for poor quality water to migrate off site within the groundwater.

Question 15

In your opinion, to what extent will the proposed Alpha Coal Mine's Tailings Dam impact on groundwater? In answering this question, consider the:

- ***potential impacts of the tailings storage facility through leakage, movement of leachate and potential discharge into aquifers described in EIS Volume 2, Section 12.9.2;***
- ***potential movement of leachate from the tailings storage facility down gradient at shallow depth toward Lagoon Creek where it could discharge to the Lagoon Creek alluvium, with particular consideration of EIS Volume 2, Section 12.9.2.1; and***

- ***the Objector's allegation that the proposed liner system will only "reduce" seepage to groundwater and "limit seepage of tailings water" with particular reference to EIS Volume 5, Appendix J2, p27).***

Response 15

It is my opinion, based on the proposed TSF design and construction requirements and Hancock's commitments, that the potential risks for the TSF to act as a source of poor quality artificial recharge will be reduced. I consider that any deep drainage below the TSF would, over time, flow to the final void thus reducing the potential for seepage migration off site.

An integrated (surface water-groundwater) model, utilising the end of mine groundwater levels, was constructed to allow for an assessment of potential long term impacts on groundwater resources, within the modelled layers, over time (~ 300 years post mining) and spatially.

The integrated model was utilised to consider the long term potential impacts of the TSF, providing additional information to facilitate the assessment of potential impacts on the underlying groundwater resources and adjacent Lagoon Creek.

The TSF was simulated as a constant source of poor quality water (assumed constant source of 1,000 mg/L TDS) at a constant head of 340 m AHD, some 12 to 15 m above surface and no self-sealing (decrease in permeability) over time was included. This approach is conservative as it assumes the head of water in the TSF will remain constant over the 300 year simulation period. The surface leakance[6] was set at (conservative) 1x 10^{-06} based on integrated model results and layer thickness (Table 11 and Table 12, respectively).

Table 11 Refined model parameters

Model Layer	Unit	Kx (m/d)	Kz (m/d)	Sc	Sy
1	GAB	5.60E+00	5.60E-01	6.00E-04	5.01E-02
2	Tertiary sediment	1.00E-01	1.00E-02	6.00E-04	5.01E-02
3	Rewan	1.00E-04	1.00E-05	4.56E-04	8.41E-03
3	Tertiary laterite	1.00E-03	1.00E-05	4.56E-04	8.41E-03
4	Bandanna Formation	1.76E-03	1.76E-04	4.56E-04	8.41E-03
5	C seam	1.00E-02	1.00E-05	9.77E-06	8.02E-03
6	C-D sandstone	1.00E-01	1.00E-04	6.23E-06	8.03E-03
7	D seam	1.00E-02	1.00E-05	9.77E-06	8.02E-03
8	D-E sandstone	5.00E-02	5.00E-05	4.56E-04	8.41E-03
9	E seam	1.00E-02	1.00E-05	9.77E-06	8.02E-03
10	Sub E sandstone	5.00E-02	5.00E-05	4.56E-04	8.41E-03
11	Joe Joe Formation	1.00E-04	1.00E-05	4.56E-04	8.41E-03

Where: Kx – Horizontal hydraulic conductivity, Kz – Vertical hydraulic conductivity, Sc – storativity (confined aquifer storage), Sy – specific yield (unconfined aquifer storage)

[6] Vertical leakance is based on the half-thickness of model layers and the vertical hydraulic conductivity of the layers. Note that overland flow, which has an unlimited vertical hydraulic conductivity, is taken into consideration when estimating leakance.

Table 12 Refined model layers

Unit	Model Layer	Thickness (m)
GAB	1	0.1 to 266
Tertiary sediment	2	0.1 to 21 (mostly for 10)
Rewan/Tertiary laterite	3	0.1 to 414 for Rewan; 0.1 to 20 for laterite
Bandanna Formation	4	0.1 to 436
C seam	5	2
C-D sandstone	6	5
D seam	7	5
D-E sandstone	8	15
E seam	9	3
Sub E sandstone	10	82
Joe Joe Formation	11	540

The model simulation allowed for the prediction of concentration propagation (similar to particle tracking) over time (300 years) assessing risk to Lagoon Creek and to deeper aquifers.

Figure 20 presents the TSF footprint, drainage lines, and transect where the cross-section through the model was assessed. Figure 21 indicates the model cross-section, simulated TSF footprint which acts as a constant source (and head), and Lagoon Creek, which was simulated as a drain in the integrated model.

Figure 20 TSF footprint and drainage

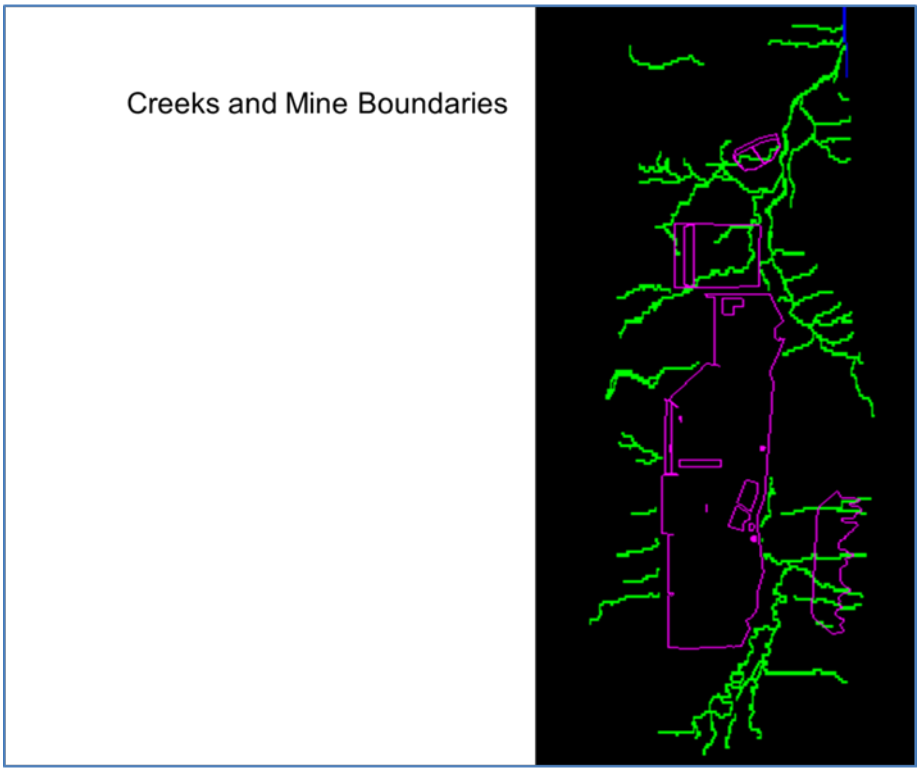
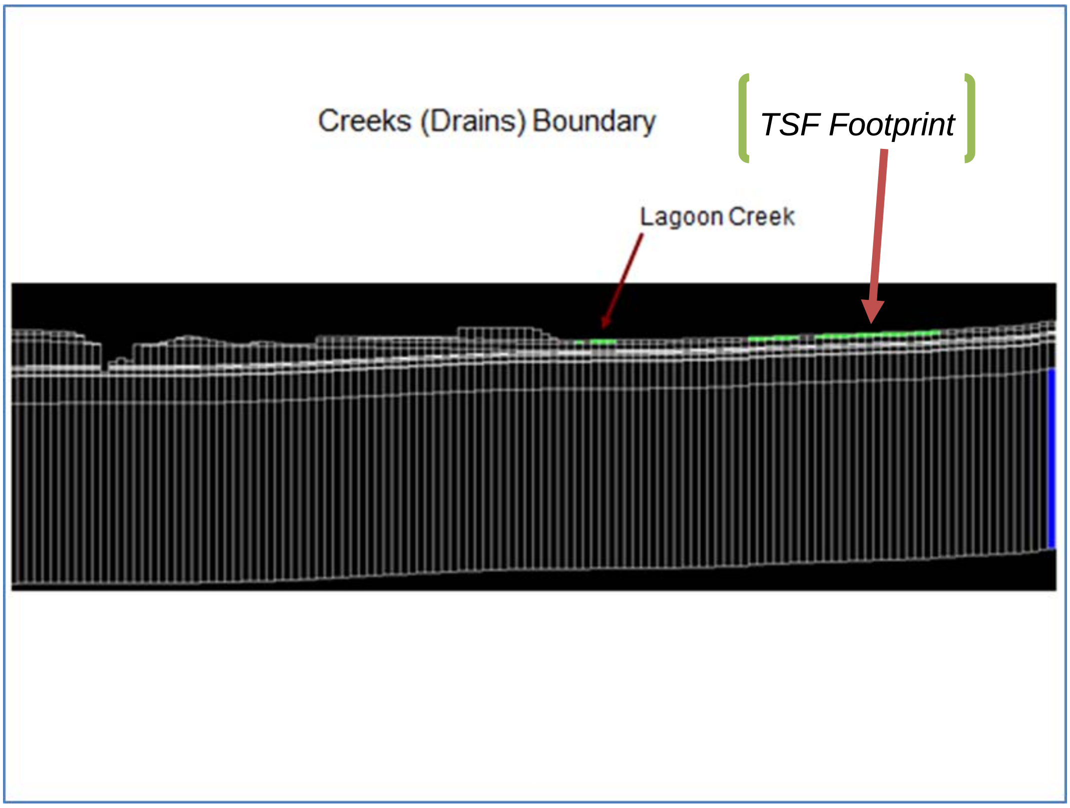


Figure 21 Model cross-section



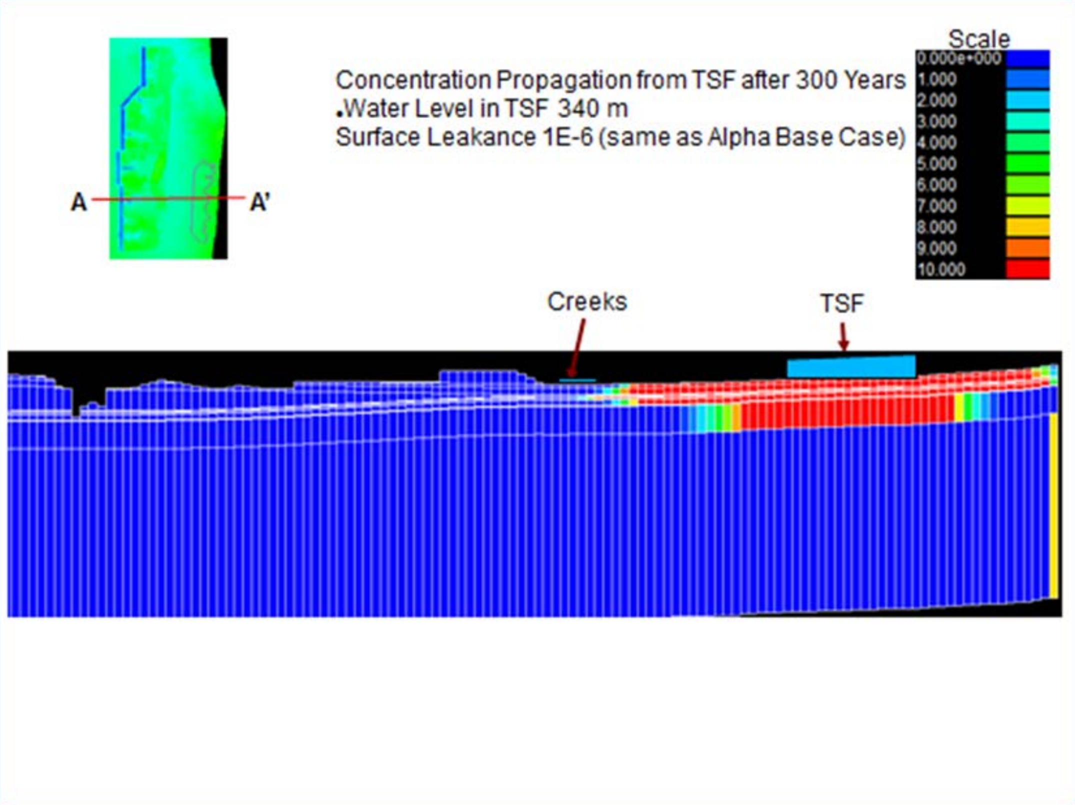
The concentration propagation indicates expanding contaminant plume away and with depth over time. The predicted propagation indicates that no impact to Lagoon Creek is predicted during the simulation. Deeper drainage migrates more readily within the lower depressurised layers at depth. Concentration changes with depth are predicted below the TSF; however, vertical plume migration is curtailed by the fresh Joe Joe Formation aquitard.

Figure 22 presents the predicted concentration propagation after 300 years post mining assuming a constant head within the TSF.

Limited risk to Lagoon Creek and sub-E sandstone (aquifer) units are predicted assuming the base of the TSF is sufficiently prepared to a permeability of not more than 10^{-9} m/s. The vertical hydraulic conductivity utilised in the modelling was $1x10^{-05}$ m/day, as determined for Tertiary laterite during calibration (Table 11).

Should poor quality seepage migrate within the groundwater below the TSF it will finally report to the final void, as the final void will act as a sink in perpetuity and influence local groundwater flow patterns (as detailed in **Response 14**).

Figure 22 Predicted concentration propagation



Question 16

In your opinion, is there sufficient, adequate and accurate information to provide a reasonable level of scientific certainty to support your conclusions in relation to the above?

Yes; it is my opinion that sufficient site-specific and representative data was compiled during the groundwater and geotechnical studies across the TSF footprint to allow for accurate model simulation of potential seepage. The use of a constant water level and representative permeability, within the predicted dewatered and depressurised (post mining) groundwater regime allowed for the assessment of possible seepage migration. I consider this approach to be standard professional practice.

6. Summary of Conclusions

It is my opinion that a significant amount of site specific and representative hydrogeological and geological data has been compiled over the four year groundwater study, which cumulated in the construction and calibration of predictive groundwater models that allowed for the evaluation of potential impacts to groundwater resources as a result of proposed mine operations.

The adopted phased approach to the EIS groundwater study, which allowed for the compilation, evaluation and refinement of data and concepts, ensured the correct scientific development of the study. This approach allowed for collation of spatial and transient groundwater data (across both MLA70426 and MLA70425), which resulted in the development and refinement of predictive groundwater models, which provide an accurate evaluation of potential impacts on the groundwater resources, locally and regionally.

Predictive modelling, including sensitivity analysis, model parameter uncertainty evaluations, and an independent review, provided an assessment of groundwater level alteration over time and within the different groundwater units mapped within the model area. The modelling allowed for an assessment of potential impacts on the unconfined perched water resources; springs, perched water tables, and creeks. This impact evaluation plus the assessment of potential impacts on the confined Permian and GAB units (including neighbouring bores) allowed for the compilation of EIS groundwater reports and sections.

The resultant reports provided sufficient information and evaluation to:

- Address the Terms of Reference requirements from a groundwater perspective;
- Assess the potential impacts of groundwater drawdown over time and spatially (including the GAB);
- Evaluate the final void impacts and possible contaminant migration;
- Consider cumulative impacts and develop a regional groundwater model which could be used as input into a basin model; and
- Allow for informed decision making with regards to granting the mining lease and developing accompanying conditions and obligations.

It is considered that the data compiled, evaluated and considered which allowed for the development of predictive groundwater models, which accurately assess the potential impacts of the proposed mining on the groundwater resources was sufficient to allow for informed decision making when considering approvals and the compilation of project obligations and conditions.

7. Additional Information Required

I do not consider that any additional information is required in order to address the questions identified in this report.

8. Expert's Statement

I confirm the following:

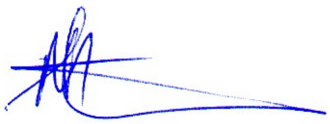
(b) the factual matters stated in this report are, as far as I know, true;

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

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

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

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



Mark Stewart

30 May 2013

GLOSSARY

ALLUVIUM - Sediments (days, sands, gravels and other materials) deposited by flowing water. Deposits can be made by streams on river beds, floodplains, and alluvial fans.

ALLUVIUM AQUIFER - A deposit of detrital material- mostly sediment- formed by river, stream and floodplain processes that store and transmit water in spaces between sediments grains. Stored water can be extracted and used.

AQUICLUDE - A low-permeability unit that forms either the upper or lower boundary of a groundwater flow system.

AQUITARD – These are geologic units that are of low permeability. Aquitards usually form a layer in a geologic sequence. They may contain water, but would not yield reasonable volumes of water to bores or wells. An example of an aquitard would be a saturated clay layer that is overlying a saturated sandy aquifer.

AQUIFER - A geological structure of formation or part thereof, permeated with water or capable of- (a) being permeated permanently or intermittently with water; and (b) transmitting water.

AQUIFER, CONFINED - An aquifer that is overlain and underlain by impervious layers. The water level in bores tapping confined aquifers rises within the bore to a level above the top of the aquifer, and may result in an artesian or sub artesian bore. Confined aquifers tend to occur in the central and deeper parts of the Basin.

AQUIFER, PERCHED - Perched Aquifers occur in the upper catchments. They sit over a thick layer of clayey weathered sediments and have no connection to the fractured rock aquifers beneath the clay. This lack of connection means that their ecosystems are highly dependent on rainfall runoff, lateral subflow, from unconsolidated sediments overlying the clay or upstream flow contributions. These systems are more sensitive to surface water changes. Development of surface water resources or disruptions to subsurface flow will have the greatest impact on flora and fauna in this setting.

AQUIFER, SEMICONFINED - An aquifer confined by a low-permeability layer that permits water to slowly flow through it. During pumping of the aquifer, recharge to the aquifer can occur across the confining layer. Also known as a leaky artesian or leaky confined aquifer.

AQUIFER TEST - A hydrological test performed on a well, aimed to increase the understanding of the aquifer properties, including any interference between wells, and to more accurately estimate the sustainable use of the water resource available for development from the well.

AQUIFER, UNCONFINED - An aquifer which has the water table as its upper surface which may be recharged directly by infiltration from the groundwater surface.

ARTESIAN - Groundwater which rises above the surface of the ground under its own pressure by way of a spring or when accessed by a bore. An artesian well, including all associated works, from which water flows, or has flowed, naturally to the surface.

AUSTRALIAN HEIGHT DATUM (AHD) - The Australian height datum, adopted by the National Mapping Council of Australia, for referencing a level or height back to a standard base level.

BORE (WELL) - Any bore, well or excavation or any artificially constructed or improved underground cavity used or to be used for the purpose of—(a) the interception, collection, storage or extraction of groundwater; or (b) groundwater observation or the collection of data concerning groundwater; or (c) the drainage or desalination of any land; or (d) in the case of a bore that does not form part of a septic tank system, the disposal of any matter below the surface of the ground; or (e) the recharge of an aquifer— but does not include a bore that is used solely for purposes other than those specified in paragraphs (a), (b) and (d).

CALIBRATION - Calibration of a model is the process where parameters in the model are fine tuned to get the best possible match between actual and modelled data over a defined period.

CALIBRATION, INITIAL CONDITIONS - The initial hydrologic conditions for a flow system that are represented by its aquifer head distribution at some particular time corresponding to the antecedent hydrologic conditions in that system. Initial conditions provide a starting point for transient simulations.

CALIBRATION, STEADY STATE - The calibration of a model to a set of hydrologic conditions that represent (approximately) an equilibrium condition, with no accounting for aquifer storage changes.

CALIBRATION, TRANSIENT - The calibration of a model to hydrologic conditions that vary dynamically with time, including consideration of aquifer storage changes in the mathematical model.

CONCEPTUAL MODEL (CONCEPTUALISATION) - A simplified representation of the physical hydrogeologic setting and understanding of the essential flow processes of the system. This includes the identification and description of the geologic and hydrologic framework, media type, hydraulic properties, sources and sinks, and important aquifer flow and surface-groundwater interaction processes.

CONE OF DEPRESSION - The radial decline of potentiometric levels or underground water levels around a point of water extraction from an aquifer.

DARCY'S LAW - An empirical equation developed to compute the quantity of water flowing through an aquifer. Usually expressed as Q=kiA, where Q=flow, k=hydraulic conductivity, I=hydraulic gradient, A=aquifer cross-sectional area.

DEWATERING - Removing underground water for construction or other activity. It is often used as a safety measure in mining below the water table or as a preliminary step to development in an area

DIFFUSE RECHARGE – Recharge that is distributed over large areas in response to precipitation infiltrating the soil surface and percolating through the unsaturated zone to the water table.

DRAWDOWN - Refers to a lowering of the surface that represents the level to which water will rise in cased bores. Natural drawdown may occur due to seasonal climatic changes. Groundwater pumping may also result in seasonal and long-term drawdown.

EPHEMERAL – Lasting for a very short time; short-lived.

EXTRACTION - In relation to any bore includes withdrawing, taking, using or permitting the withdrawing, taking or using of water from that bore.

EVAPOTRANSPIRATION - The sum of evaporation and transpiration.

FINAL VOID – That open pit remaining when an open cut mine has ceased to be mined.

Gigalitre (GL) - A volumetric measure equal to one million kilolitres or one billion litres.

GREAT ARTESIAN BASIN - Is a ‘confined’ groundwater basin comprised of a complex multi-layered system of water bearing strata (porous sandstone aquifers) separated by largely impervious rock units, underlying largely arid and semi-arid landscapes to the west of the Great Dividing Range, and extending from Queensland through New South Wales and the Northern Territory, to South Australia.

GROUNDWATER - (a) Water occurring naturally below ground level (whether in an aquifer or otherwise); or (b) water occurring at a place below ground that has been pumped, diverted or released to that place for the purpose of being stored there; but does not include water held in underground tanks, pipes or other works.

GROUNDWATER FLOW MODEL - An application of a mathematical model to represent a site-specific groundwater flow system.

GROUNDWATER-DEPENDENT ECOSYSTEMS (GDE) - Ecosystems which have their species composition and natural ecological processes wholly or partially determined by groundwater.

HETEROGENEOUS - A medium which consists of different (non-uniform) characteristics in different locations.

HOMOGENEOUS - A medium with identical (uniform) characteristics regardless of location.

HYDRAULICS – The science that deals with water and other liquids in motion.

HYDRAULIC CONDUCTANCE - A term which incorporates model geometry and hydraulic conductivity into a single value for simplification purposes. Controls rate of flow to or from a given model cell, river reach, etc.

HYDRAULIC CONDUCTIVITY - A measure of the ease of flow through a pore space or fractures. Hydraulic conductivity has units with dimensions of length per time (e.g. m/s, m/min, or m/d).

HYDRAULIC GRADIENT - Spatial variation in the effective elevation of water table and/or potentiometric level, which drives lateral flow of underground water.

HYDRAULICALLY LINKED - In relation to sub artesian water, means there is a direct connection between the sub artesian water and surface water to the extent that— (a) if the aquifer is full and surface water is removed, sub artesian water begins, within approximately 1 day, to flow to the surface, replacing the surface water removed; and (b) if the aquifer is not full, surface water begins, within approximately 1 day, to seep into the aquifer causing the water level in the aquifer to rise.

HYDROGRAPH - A graph that shows some property of groundwater or surface water (usually head or flow) as a function of time.

INFILTRATION - The flow of water downward from the land surface into and through the upper soil layers.

INTEGRATED MODEL – Model that integrates both the surface water runoff and groundwater hydrological systems to provide a more accurate assessment based on a complete hydrologic simulation.

LATERITE – Soil layer that is rich in iron oxide and derived from a wide variety of rocks weathering under strongly oxidising and leaching conditions.

LEAKANCE - Controls vertical flow in a model between cells in adjacent layers. Equivalent to effective vertical hydraulic conductivity divided by the vertical distance between layer midpoints.

MODEL CALIBRATION - The process by which the independent variables (parameters) of a numerical model are adjusted, within realistic limits, to produce the best match between simulated and observed data (usually water-level values). This process involves refining the model representation of the hydrogeologic framework, hydraulic properties, and boundary conditions to achieve the desired degree of correspondence between the model simulations and observations of the groundwater flow system.

MULTI-LAYERED AQUIFER - Is a succession of leaky aquifers sandwiched between aquitards; systems of interbedded permeable and less permeable layers.

NESTED BORES – A bore with more than one pipe or a group of nearby bores, open at different levels in aquifers/aquitards used to evaluate the vertical variation in groundwater pressure head or chemistry.

NUMERICAL MODEL - Refers to a mathematical representation of a physical system intended to mimic the behaviour of a real system, allowing description about empirical data and prediction about untested states of the system.

OBSERVATION WELL - A non-pumping well used to observe the elevation of the water table or the potentiometric surface. An observation well is generally of larger diameter than a piezometer and typically is screened or slotted throughout the thickness of the aquifer.

PALUSTRINE WETLAND – Relating to a system of inland, nontidal wetlands characterised by the presence of trees, shrubs, and emergent vegetation (vegetation that is rooted below water but grows above the surface). Palustrine wetlands range from permanently saturated or flooded land (as in marshes, swamps, and lake shores) to land that is wet only seasonally (as in vernal pools).

PERPETUITY – Forever; endless.

PERCHED AQUIFER – A type of unconfined aquifer that sits above another unconfined aquifer because water infiltrating from the surface is trapped or 'perched' on a shallow aquitard.

PIEZOMETER - A non-pumping well, generally of small diameter, that is used to measure the elevation of the water table or potentiometric surface. A piezometer generally has a short well screen through which water can enter.

POROSITY - The ratio of the aggregate volume of the spaces between grains or fractures in a rock, sediment or soil to its total volume, generally expressed as a percentage.

POTENTIOMETERIC SURFACE - Is a surface that represents the level to which groundwater will rise in cased bores intersecting confined aquifers. Also known as PIEZOMETERIC SURFACE

RECHARGE - Is the addition of water, usually by infiltration, to an aquifer.

RECHARGE BOUNDARY - An aquifer system boundary that adds water to the aquifer. Streams and lakes are typically recharge boundaries.

SAMPLING EVENT – Refers to a specific point in time (i.e. calendar day) when water samples are collected from monitoring points for water quality analysis

SATURATED ZONE - The zone in which the voids in the rock or soil are filled with water at a pressure greater than atmospheric. The water table is the top of the saturated zone in an unconfined aquifer.

SEDIMENTARY AQUIFERS - These occur in consolidated sediments such as porous sandstones and conglomerates, in which water is stored in the intergranular pores, and limestone, in which water is stored in solution cavities and joints. These aquifers are generally located in sedimentary basins that are continuous over large areas *and* may be tens or hundreds of metres thick. In terms of quantity, they contain the largest groundwater resources.

SPECIFIC YIELD - The ratio of the volume of water that a given mass of saturated soil or rock will yield by gravity to the volume of that mass.

SPRING - A spring of water naturally rising to and flowing over the surface of land, but does not include the discharge of underground water directly into a watercourse, wetland, reservoir or other body of water.

STORAGE COEFFICIENT (STORATIVITY) Is the volume of water released or taken into storage per unit plan area of aquifer per unit change of head. It is a dimensionless value. In an unconfined aquifer, it is equal to specific yield.

STRATIGRAPHY – The branch of geology concerned with the order and relative position of strata and their relationship to the geological time scale.

SUB-ARTESIAN - Groundwater that does not rise above the surface of the ground when accessed by a bore and must be pumped to the surface.

TOPOGRAPHIC DIVIDE - The boundary between adjacent surface water boundaries. It is represented by a topographically high area.

TOTAL DISSOLVED SOLIDS – total concentration of dissolved substances, useful parameter in describing the quality of water.

TRANSMISSIVITY - Aquifer hydraulic parameter used to indicate the ease of groundwater flow through a metre width of aquifer section.

UNCONFORMABLE – Of rock strata consisting of a series of younger strata that do not succeed the underlying older rock in age or in parallel position, as a result of a long period of erosion or nondeposition.

VIBRATING WIRE PIEZOMETER – A device which measures the pressure or more precisely the piezometeric head of groundwater at a specific point.

WATER BUDGET - An evaluation of all the sources of supply and the corresponding discharges with respect to an aquifer or a drainage basin.

WATER TABLE - Is the upper surface of an unconfined aquifer.

YIELD, SAFE - The amount of naturally occurring groundwater that can be economically and legally withdrawn from an aquifer on a sustained basis without impairing the native groundwater quality or creating an undesirable effect such as environmental damage. It cannot exceed the increase in recharge or leakage from adjacent strata plus the reduction in discharge that is due to the decline in head caused by pumping.

YIELD, SUSTAINABLE - An accepted working definition of sustainable yield is (Kalaitzis et al, 1999): "*Sustainable yield is that proportion of the long term average annual recharge which can be extracted each year without causing unacceptable impacts on groundwater users or the environment*".

ANNEXURE A

Curriculum Vitae

Qualifications

Bachelor of Science (Geology), Rhodes University, South Africa, 1990

Mark Stewart

Principal Hydrogeologist

Areas of Experience

- Hydrogeology and Mining Project Team Management
- Mine related hydrogeology
- Environmental impact assessments
- Hydrogeological conceptualisation, design input and decision making
- Groundwater impact assessments and mitigation and management plan
- Project Management of entire EIS studies and Groundwater Study Lead
- Environmental, Compliance and Due Diligence audits
- Aquifer assessments, management and protection plans
- Long term water level and final void predictions
- Risk assessments with regard to groundwater contamination
- Groundwater monitoring programs – design and implementation

Career Summary

Mark is a Principal Hydrogeologist with 20 years professional and project management hydrogeological experience across Africa and now in Australia. He has been actively involved all aspects of groundwater resource assessment (quantity and quality) in varying climatic (sub-tropical-to-arid) and land-use settings (irrigated agriculture to deep-level gold mines).

Recent experience includes the assessment and management of potential impacts of coal mining on groundwater resources within artesian and sub-artesian sedimentary basins. Groundwater resource evaluation and impact assessment of coal surface mining on shallow weathered and alluvial aquifers for the compilation of an EIS, Wandoan Queensland. Expert witness for objections to the Wandoan mining project in the Queensland land court.

Experience in the mining industry includes evaluation of groundwater impact assessments, data validation and interrogation, and the compilation of an expert report for the Queensland land court. Mark is currently undertaking an expert witness role for a base metal mine in north western Queensland, which requires the review and discussion of groundwater related objections.

Mark has assessed and developed appropriate and practical groundwater resource management strategies, compiled and discussed site specific and appropriate groundwater Environmental Authority Conditions, developed groundwater monitoring programs for all phases of mining projects, including baseline, construction, operations, and post closure. Mark has implemented continuous dewatering and water supply borefields and schemes, designed and implemented monitoring systems, and evaluated resultant data to ensure optimisation of resources and achieve environmental compliance.

Mark Stewart.*Principal Hydrogeologist*

Key Experience

- Expert witness roles for Queensland Land Court
- Groundwater study lead on Alpha Coal Project EIS
- Groundwater study lead on Kevin's Corner EIS
- Project Management of Red Hill EIS
- Compilation of groundwater EIS technical reports and chapters
- Hydrogeological conceptualisation, predictive modelling, and plume migration
- Impact assessments and mitigation and management plans
- Groundwater management plans
- Liaison and presentation of hydrogeological data to State and Federal regulatory bodies

Selected Projects

Groundwater and Mining

- Assessment to the geology and groundwater resources within the Galilee Basin, including conceptualisation, predictive modelling, and impact assessment for two proposed coal projects within the eastern limb of the Galilee Basin
- Review of proposed open cut mine expansion, compilation of expert witness report to address land court objections.
- Groundwater resource evaluation and impact assessment of coal surface mining on shallow weathered and alluvial aquifers for the compilation of an EIS, Wandoan Queensland. Expert witness for objections to the Wandoan mining project in the Queensland land court.
- The evaluation of surface mining at Weipa with regards to alterations to groundwater recharge and surface water runoff, including an assessment of the impacts on springs and Groundwater Dependent Ecosystems.
- Evaluation of groundwater resources associated with brownfields mine site to determine current environmental values and develop appropriate Environmental Authority conditions.
- Groundwater technical report for inclusion in the Goonyella Expansion EIS submission, considering long wall coal mining, subsidence, and groundwater resource impacts.
- Groundwater components of EIS studies for coal mines and coal seam gas projects in Queensland.
- An assessment of oil shale mining activities, groundwater resources and impacts, ASS, and rehabilitation proposals in order to evaluate risks to the groundwater regime, Queensland.
- Risk assessment of water security for mines in the Bowen Basin and feasibility study regarding alternative raw water sources.
- An impact assessment of surface mining on shallow groundwater resources through the assessment of altered runoff and recharge, Brisbane.
- Seepage evaluation of water control dams at Collinsville.
- Assessment of existing dewatering data, hydrochemical, isotope, and geotechnical data in order to conceptualise the groundwater resources and interaction, conduct groundwater model simulations to develop optimum dewatering strategy for the Navachab Gold Mine expansion, Namibia
- Evaluate hydrogeological conditions through drilling and packer tests, assess dewatering requirements and propose strategy and timing for the Shituru Copper Project, Democratic Republic of Congo (DRC)
- The compilation of the hydrogeological impact assessment for the KOV pit dewatering and discharge at Kolwezi, DRC
- The preliminary assessment of the groundwater resources at the proposed Kisanfu Copper and Cobalt Mine, using artesian boreholes, DRC
- The development of a groundwater strategy for the Mwambashi Copper Project using large diameter perimeter boreholes, Zambia

- Project Manager and hydrogeological specialist for the compilation of the Environmental and Social Impact Assessment (ESIA) for the Kalumines Copper Project as required for the lenders / IFC, DRC
- Development of a well field in the Continental Terminal Aquifer for the new Tasiast Gold Mine, Mauritania
- Groundwater characterisation, water supply, dewatering assessment for DFS and BFS at the Essakane Gold Project, Burkina Faso
- Groundwater resource and vulnerability assessment for the Samira Hill Gold Project, assessing the vadose zone and possible seepage from the proposed TSF, Niger

Coal and Coal Seam Gas Studies

- Study lead for the geological and hydrogeological input, technical reporting and EIS chapters, into the Arrow Energy CSG Project EIS across the Bowen Basin
- Study lead for the geological and hydrogeological input into the Bow Energy CSG Project EIS in the Bowen Basin.
- Technical input into the Santos groundwater and springs census and monitoring programs.
- Evaluation of potential deep drainage resulting from irrigation of associated water for beneficial use.
- Drilling and aquifer test programs to evaluate Condamine Alluvium areas to assess potential impacts and suitability of irrigation with associated water.
- Evaluation of available geological and hydrogeological data or the compilation of baseline data and conceptualisation of hydrogeological resources and surface water – groundwater interactions for EIS studies including; Santos GLNG in Surat Basin, Wandoan Coal Project in Surat Basin, Bow Energy in Bowen Basin, Red Hill Project in Bowen Basin, Alpha and Kevin's Corner coal projects in Galilee Basin.
- The review and evaluation of Coal Seam Gas associated water management options, specifically suitable target units and methodologies of Managed Aquifer Recharge for Santos, including consideration of aquifer injection of brine, associated water, and treated water.
- A groundwater technical report for inclusion in the GLNG EIS which included an assessment of the impacts of CSG operations on shallow (surface infrastructure) and deep (GAB) aquifers due to coal seam depressurisation and the management of associated water.
- The development and implementation of a groundwater monitoring network with coal seam gas fields to determine the impact on the coal seam aquifers, neighbouring bores, and GAB aquifers (through induced flow).
- Evaluation of the use of associated water, from Coal Seam Gas production, at proposed open pit coal mine, Queensland.
- Geophysical surveys, drilling target selection, and monitoring bore construction adjacent to associated water evaporation ponds to evaluate impacts of possible seepage on shallow groundwater, Queensland.
- Evaluation of on-shore candidate sites for disposal of marine dredge material from a groundwater perspective for a LNG plant, Gladstone.
- The technical review of groundwater, geology, subsidence, and waste management studies compiled for Xstrata Coal projects within the Bowen Basin to ensure compliance and suitability for EIS submission.
- The evaluation of impacts on groundwater resource due to Underground Coal Gasification, considering alterations in groundwater both quantity and quality.

Groundwater Modelling Studies

- Predictive groundwater modelling of mine dewatering and depressurisation of Permian coal measures within the Galilee Basin, impact evaluation on the Great Artesian Basin, Threatened Ecological Communities, Groundwater Dependent Ecosystems, and vegetation communities.
- Integrated surface water – groundwater modelling to assess final void (quality and water levels) impacts, long term groundwater flow patterns, and direct and indirect impacts on groundwater resources.
- Groundwater modelling to estimate, to BFS level, groundwater ingress into open-cut and underground mines within the Galilee Basin. Range of predictions, using sensitivity and uncertainty, allowed for decision making regarding mine water management.
- Independent peer review of the Adani Mining Carmichael Coal Project numerical groundwater model.
- Seepage modelling to assess the possible impacts of a proposed dredge placement facility on the underlying shallow groundwater resources, Gladstone Queensland.
- Integrated surface water – groundwater modelling to evaluate impact of surface mining at Weipa on groundwater recharge and surface water runoff, including an assessment of the impacts on springs and Groundwater Dependent Ecosystems.
- Contaminant fate and transport modelling study to assess risks to sensitive receptors at a former refinery site, Brisbane
- Predictive modelling with regards to groundwater ingress and drawdown within aquifers intersected during tunnel construction and operation, Brisbane.
- Final void prediction modelling to assess three possible final void configurations, long term pit water levels, using groundwater ingress and rainfall runoff modelling, and quality predictions. The model utilised 100 year synthetic (daily) rainfall and evaporation data and allowed for the evaluation of changing climate conditions, Queensland.
- Impact assessment and compilation of mitigation measures based on a finite difference groundwater transport model, constructed and calibrated to simulate CSG activities within Fairview and Arcadia Valley, Queensland.
- The evaluation of modelled tunnel groundwater ingress predictions, and the development of optimum monitoring points to assess model predictions, subsidence, Acid Sulfate Soils, and impacts on neighbouring bores and surface water resources in Brisbane.
- The conceptualisation and determination of suitable dataset for the construction and calibration of a finite element groundwater model of the Roma area, to assess possible impacts of CSG activities and allow for the evaluation of injection of treated associated water into shallow GAB aquifers.
- Seepage modelling to assess the possible impacts of a proposed dredge placement facility on the underlying shallow groundwater resources, Gladstone Queensland.
- The evaluation of groundwater ingress predictions into a proposed underground coal mine in Central Queensland. A review and validation of the assumptions, calibration, sensitivity and uncertainty analyses included in the modelling.

Hydrochemical Evaluations

- The impact and assessment of contaminated water storage and runoff on groundwater and baseflow into creeks within an industrial area, Brisbane.
- A due diligence study assessing possible impacts associated with the management of water on tailings dams at an ore refinery, Queensland.
- Evaluation and assessment of soil and groundwater alteration due to an oil spill, Brisbane.
- Assessment of contamination threat through metal mobilisation from explosives waste residue using TCLP and leach tests, groundwater vulnerability assessment and development of remediation strategies, South Africa

- Manage and conduct several Phase I and Phase II Environmental Site Assessments (ESA) for petroleum hydrocarbon contamination, plume identification, and develop remediation and mitigation plans, assessment of Natural Attenuation, South Africa
- Assessment of dissolved NAPL plume from fuel line leak, evaluate SVE remediation and soil contamination, compile and implement monitoring program for natural attenuation, South Africa
- Conduct a Phase I and Phase II ESA for an industrial site, identify organic contamination and develop remediation and monitoring program, assessed risk to down gradient users, South Africa
- Conduct a peer review of a remediation plan to clean up a Cr^{6+} contamination from a chrome plating facility. Evaluate the use of iron Fe reactive barrier and pilot studies, South Africa
- The development and implementation of a soil and groundwater remediation plan for an industrial site with solvent (TCE, PCE) contaminants
- Assessment of PAH and DNAPL contamination associated with defunct gas works in Johannesburg

Professional History

Principal Hydrogeologist, URS Australia Pty Ltd, Brisbane, August 2008 - present

Principal Hydrogeologist, SRK Consulting, Johannesburg, April 2007 - July 2008

Senior and Principal Hydrogeologist, GCS Pty Ltd, Johannesburg, July 1995 - March 2007

Groundwater Specialist, Aquatan Synthetic Linings, January 1995 - June 1995

Hydrogeologist, GCS Pty Ltd, Johannesburg, August 1992 - December 1994

Registration

Member, International Association of Hydrogeologists (IAH)

South African Council of Natural Scientific Professions - Professional Natural Scientist (Reg. No. 1400072/98)

Office and Contact Details

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Principal Hydrogeologist

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ANNEXURE B

1. Coordinator – General Conditions

A. <u>Current Obligations (Section 5.7 of main text):</u>

- project design to ensure the minimum possible impacts on the groundwater resource;
- mitigate any adverse effects that may occur such as changes to water quality in groundwater resources;
- compliance with the terms of any water licence conditions issued by DEHP;
- establish an integrated groundwater and surface water monitoring program;
- the determination and approval by DEHP of water quality and trigger levels before the commencement of mine operations;
- The proponent has made a commitment to 'make-good' affected groundwater supplies and I have recommended conditions for the enforcement of this through the provisions of the *Water Act 2000*;
- The proponent will be required to undertake periodic audits of its groundwater model, and re-calibrate and re-predict future impacts during the mining phase of the project.

These obligations are further detailed below:

B. <u>Appendix 1: Stated Conditions – Mine EA (mining lease):</u>

Condition 17: Groundwater

(a) A groundwater monitoring program must be developed and submitted to the administering authority for approval before the commencement of mining activities. The monitoring program must:

(i) allow for the compilation of representative groundwater samples from the aquifers identified as potentially affected by mining activities. The geological units monitored include alluvium, Bandanna Formation, Colinlea Sandstone, Clematis Sandstone, Rewan Formation, and Joe Joe Formation;
(ii) include at least twelve sampling events, no more than two months apart over a two year period, to determine background groundwater quality;
(iii) obtain background groundwater quality in hydraulically isolated background bore(s), and
(iv) allow for the identification of natural groundwater level trends, hydrochemical trigger levels, and contaminant limits.

(b) In addition to Condition 17(a) groundwater quality and levels must be monitored at the locations and frequencies specified in Table A2: Groundwater monitoring network locations and frequency. Tables are listed below and attached:

Table A2: Groundwater monitoring network locations and frequency

Monitoring Sites*	Parameter	Frequency
AMB-01, AMB-02, AMB-03, AMB-04	Water level	At least one reading every 12 hours – electronic loggers
	pH, EC, TDS (lab), cations, anions, selected dissolved metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn), nutrients	Monthly until sufficient data is compiled
TSF standpipe bores ATSF-01B ATSF-02, ATSF-03, ATSF-04B, ATSF-07B, ATSF-07C, ATSF-08B, ATSF-08C, ATSF-06B, ATSF-06C, ATSF-05B, ATSF-05C, ATSF-09A, ATSF-09B	Water level	At least one reading every 12 hours – electronic loggers
	pH, EC, TDS (lab), cations, anions, selected dissolved metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn), nutrients	Monthly until sufficient data is compiled
Proposed monitoring bores adjacent infrastructure AlphaWest1, AlphaWest2, AlphaWest3, Landfill1, Landfill2, Landfill3, MIA, CHPP1, CHPP2, EWT, TLO1, RWD1, ROMSouth, ROMNorth	Water level	At least one reading every 12 hours – electronic loggers
	pH, EC, TDS (lab), cations, anions, selected dissolved metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn), nutrients, TPH (selected bores only)	Every 2 months (for at least two years)
VWP bores AVP_11, AVP_01, AVP_14, AVP_03, AVP_05, AVP_04, AVP_06, AVP_07, AVP_08, AVP_13, AVP_09, AVP_10	Water level only	At least one reading every 12 hours – electronic data readers
New TSF VWP bores ATSF-01A, ATSF-04A, ATSF-05A, ATSF-06A, ATSF-07A, ATSF-08A	Water level only	At least one reading every 12 hours – electronic data readers
New GAB bores AlphaWest4, AlphaWest5, and AlphaWest6	Water level only	At least one reading every 12 hours – electronic data readers
All monitoring bores	Al, As, Sb, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn.	Annually

(c) If groundwater monitoring results greater than the trigger levels (or outside the trigger levels range for pH) specified for the relevant aquifer in Table A3 to Table A7 (inclusive) are recorded, then the following must be conducted:

(i) the relevant monitoring point(s) will be re-sampled and the samples analysed for major cations and anions, and selected dissolved metals, including Al, As, Sb, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn;

(ii) if elevated concentrations (above trigger) are recorded on two consecutive sampling events then an investigation into cause, optimum response, and the potential for environmental harm must be conducted; and

(iii) if elevated concentrations are recorded on two consecutive sampling events then the administering authority will be notified within 1 month of receiving the analysis results.

(d) If groundwater monitoring results greater than the contaminant limits (or outside the contaminant limits range for pH) specified for the relevant aquifer in Table A3 to Table A7 (inclusive) are recorded, then an investigation into cause, optimum response, and the potential for environmental harm must be conducted.

Table A3: Groundwater contaminant limits and trigger levels – Alluvium Aquifers (wet season)

Parameter	Units	Trigger Levels	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	µg/L	80^{th} per centile of background data	99^{th} per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	µS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

Table A4: Groundwater contaminant limits and trigger levels – Alluvium Aquifers (dry season)

Parameter	Units	Trigger Levels	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	µg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Parameter	Units		
Electrical Conductivity	□S/cm		
Major anions and cations	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH	unit		
Groundwater level	For interpretational purpose only		

Table A 5: Groundwater contaminant limits and trigger levels – Colinlea Sandstone Aquifers

Parameter	Units	Trigger Levels	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	µg/L	80^{th} per centile of background data	99^{th} per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	µS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

Table A6: Groundwater contaminant limits and trigger levels – Bandanna Formation Aquifers

Parameter	Units	Trigger Levels	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	µg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	µS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

Table A7: Groundwater contaminant limits and trigger levels – Joe Joe Formation

Parameter	Units	Trigger Levels	Contaminant limits
JOE JOE FORMATION			
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	μg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	μS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

Notes for all tables Table A3 to Table A7 inclusive
Baseline value ±1.0 for pH, means the corresponding variation allowed is 1.0 pH unit above and below average and maximum/minimum pH values determined for the site.
Parameters and sampling frequency will be revised at the end of background sampling, based on results compiled at each monitoring point and proposed land use.
The administering authority and the holder will agree to suitable trigger levels and contaminant limits (per aquifer and season) once sufficient hydrochemical data has been compiled.

(e) Groundwater contaminant trigger levels for Table A3 to Table A7 (inclusive) must be finalised based on the Groundwater Monitoring Program approved under Condition 17(a) and submitted to the administering authority 28 days prior to commencing coal extraction.

(f) Groundwater monitoring bores must be constructed in accordance with methods prescribed in the Minimum Construction Requirements for Water Bores in Australia – 3rd Edition (LWBC), or equivalent.

(g) The monitored data must be reported to the administering authority, and must satisfy the following criteria:

(i) Data collected under the monitoring program will be forwarded to the administering authority on a quarterly basis within 30 business days of the end of each quarter and compiled in an annual monitoring report in a format approved by the administering authority;

(ii) The proponent shall undertake an assessment of the impacts of mining on groundwater after the first 12 months of dewatering commencing and thereafter every subsequent calendar year;

(iii) The annual monitoring report will be forwarded to the relevant authority by the first of March each calendar year; and

(iv) The annual monitoring report will include an assessment of impacts, any mitigation strategies as wells as any recommendations for changes to the approved monitoring program.

(v) If there is a requirement to submit a similar groundwater report as part of any condition issued under a water licence under the *Water Act 2000* then the proponent and the relevant administering authorities may agree for the reports to be combined.

C. <u>Appendix 2: Part B: Imposed Conditions - mine</u>

Imposed Conditions to Address Cumulative Impacts:

Regional groundwater monitoring and reporting program (Condition 2):
To address the potential cumulative impacts on groundwater quality and availability in the Galilee basin, the Coordinator-General has imposed the following condition for the Alpha project that will be similarly imposed for other projects in the basin. DEHP is designated as the agency responsible for this condition.

(a) The proponent must:

(i) before commencing mining activities prepare to the satisfaction of the administering authority and implement a groundwater monitoring and reporting program for aquifers impacted by the project off the mining lease

(ii) design the program to complement the environmental authority requirements and other groundwater management programs in the Galilee basin. The program should aim to enable a basin groundwater model to be developed to predict, verify and monitor groundwater impacts.

(iii) make monitoring results from the program publicly available on the proponent's web site updated at least annually

(iv) contribute to any basin wide collaborative project established by the administering authority to develop a basin groundwater model, including pro-rata funding

(v) contribute to development of a basin wide groundwater model for determining the capacity of aquifers and acceptable extraction rates, including pro-rata funding

Imposed condition 2, Part B, Appendix 2 would be complemented by DEHP/DNRM as the lead agencies for developing a coordinated basin wide monitoring and assessment program, to organise and collate basin wide monitoring programs, data and reports, and to ensure such outcomes influence the ongoing management of groundwater resources.

D. <u>Appendix 3 Part B: Coordinator- General's recommendations relating to approvals for the extraction and use of groundwater under the *Water Act 2000:*</u>

Recommendation 1. Water Security
(a) Before the commencement of mining activities, the proponent must develop to the satisfaction of the administering authority for the Water Act 2000, a plan to address the short and long term implications for groundwater users of dewatering the following:

(i) Alluvium aquifers

(ii) Colinlea sandstone

(iii) Bandanna Formation

(iv) Joe Joe Formation; and

(b) the plan in (a) must provide for actions to assure the long term security of water for all current groundwater users affected by the project.

Recommendation 2. Groundwater Modelling
(a) The proponent must recalibrate the groundwater model referred to in the Groundwater Modelling Report – Alpha Coal Project (Hancock Coal Pty Ltd, 28 March 2012) initially at a minimum of 3-yearly intervals, and subsequently with the approval of the administering authority for the *Water Act 2000*, at 5-yearly intervals throughout the mining phase of the project; and
(b) The proponent must provide a report on each recalibration to the administering authority for the *Water Act 2000* within 6 weeks of completion of the recalibration.

Recommendation 3. Monitoring
(a) The proponent must:
(i) Monitor and record groundwater levels at representative monitoring bores agreed to by the administering authority for the *Water Act 2000*, at frequencies determined on the basis of the results of baseline monitoring and trigger values (monthly/quarterly/continuous);
(ii) Monitor and record groundwater inflows and dewatering volumes pumped (monthly/continuous);
(iii) Compare water level changes with model-predicted water level changes, to verify the reliability of model predictions, for input to Condition 25;
(iv) Report annually to the administering authority for the *Water Act 2000*, the results of monitoring and comparison of observed impacts with predicted impacts.

Recommendation 4. Water License Terms (attached)

E. <u>Appendix 5 Proponent Commitments – Mine</u>

GROUNDWATER
HCPL will:

☐ Develop and implement a Groundwater Monitoring Program detailing the location and frequency of groundwater monitoring activities, as well as trigger levels and response actions,

☐ Expand the existing groundwater monitoring network over time to enable ongoing groundwater impact evaluations,

☐ Install groundwater monitoring bores a minimum six months prior to mining in an area,

☐ Undertake groundwater monitoring and sampling via a suitably qualified and experienced professional in accordance with recognised procedures and guidelines,

☐ Conduct an annual review of the monitoring data, using suitably qualified expert,

☐ Include in the review an assessment of groundwater level and water quality data, and the suitability of the monitoring network,

☐ Undertake groundwater modelling audits on a regular basis (intervals not exceeding three years) and provide the modelling results to the administering authority for review,

☐ Investigate all groundwater-based complaints, including the maintenance of a complaints register. The register will be made available to the regulating authority upon request, and

☐ Implement make-good agreements with land holders affected by groundwater drawdown.

2. Draft Environmental Authority Conditions

Schedule A - General

Third Party Audit:

A16: The holder of the environmental authority must nominate an appropriate third party auditor to audit compliance with the conditions of this environmental authority within one year of the commencement of this environmental authority, and then at regular intervals not to ex exceed 3 years.

A17: the holder must, at its cost, arrange for independent certification by a third party auditor of findings of the audit report required under condition A16.

A18: Within ninety days of completing the audit, provide a written report to the administering authority detailing any non-compliance issues that were found (if no non-compliance issues were found this should be stated in the report). If non-compliance issues were found the report must also address:

a) Actions taken by the holder of this environmental authority to ensure compliance with this environmental authority, and
b) Actions taken to prevent a recurrence of non-compliance.

A19: Where a condition of this environmental authority requires compliance with a standard published externally to this environmental authority and the standard is amended or changed subsequent to the issues of this environmental authority the holder of this environmental authority must:

a) Comply with the amended or changed standard within 2 years of the amendment or change being made, unless a different period is specified in the amended standard or relevant legislation; and
b) Until compliance with the amended or changed standard is achieved, continue to remain in compliance with the standard that was current immediately prior to the relevant amendment or change.

Schedule C – Water

C3: The release of mine affected water to internal water management infrastructure that is installed and operated in accordance with the water management plan that complies with conditions C33- C38 inclusive is permitted.

C50: Groundwater: A groundwater monitoring program must be developed and submitted to the administering authority for approval before the commencement of mining activities. The monitoring program must:

a) Allow for the compilation of representative groundwater samples from the aquifers identified as potentially affected by mining activities. The geological units monitoring include alluvium, Bandanna Formation, Colinlea Sandstone, Clematis Sandstone, Rewan Formation and Joe Joe Formation;

b) Include at least 12 sampling events, no more than 2 months apart over a 2 year period, to determine background groundwater quality;
c) Obtain background groundwater quality in hydraulically isolated background bore(s), and
d) Allow for the identification of natural groundwater level trends, hydrochemcial trigger levels, and contaminant limits.

C51: In addition to condition C50 groundwater quality and levels must be monitored at the locations and frequencies specified in *Table 15: Groundwater monitoring network locations and frequency* and *Figure 4: Groundwater Monitoring Locations*

Table 15: Groundwater monitoring network locations and frequency

Monitoring Sites*	Parameter	Frequency
AMB-01, AMB-02, AMB-03, AMB-04	Water level	At least one reading every 12 hours – electronic loggers
	pH, EC, TDS (lab), cations, anions, selected dissolved metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn), nutrients	Monthly until sufficient data is compiled
TSF standpipe bores ATSF-01B ATSF-02, ATSF-03, ATSF-04B, ATSF-07B, ATSF-07C, ATSF-08B, ATSF-08C, ATSF-06B, ATSF-06C, ATSF-05B, ATSF-05C, ATSF-09A, ATSF-09B	Water level	At least one reading every 12 hours – electronic loggers
	pH, EC, TDS (lab), cations, anions, selected dissolved metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn), nutrients	Monthly until sufficient data is compiled
Proposed monitoring bores adjacent infrastructure AlphaWest1, AlphaWest2, AlphaWest3, Landfill1, Landfill2, Landfill3, MIA, CHPP1, CHPP2, EWT, TLO1, RWD1, ROMSouth, ROMNorth	Water level	At least one reading every 12 hours – electronic loggers
	pH, EC, TDS (lab), cations, anions, selected dissolved metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn), nutrients, TPH (selected bores only)	Every 2 months (for at least two years)
VWP bores AVP_11, AVP_01, AVP_14, AVP_03, AVP_05, AVP_04, AVP_06, AVP_07, AVP_08, AVP_13, AVP_09, AVP_10	Water level only	At least one reading every 12 hours – electronic data readers
New TSF VWP bores ATSF-01A, ATSF-04A, ATSF-05A, ATSF-06A, ATSF-07A, ATSF-08A	Water level only	At least one reading every 12 hours – electronic data readers

New GAB bores AlphaWest4, AlphaWest5, and AlphaWest6	Water level only	At least one reading every 12 hours – electronic data readers
All monitoring bores	Al, As, Sb, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn.	Annually

C52: If groundwater monitoring results in greater than the trigger levels (or outside the trigger levels range for pH) specified for the relevant aquifer in *Table 16: Groundwater contaminant limits and trigger levels – Alluvium Aquifers (wet season)* to *Table 20: Groundwater contaminant limits and trigger levels – Joe Joe Formation* (inclusive) are recorded, then the following must be conducted:

a) The relevant monitoring point(s) will be resampled and the samples analysed for major cations and anions, and selected dissolved metals including Al, As, Sb, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, Zn;
b) If elevated concentrations (above trigger) are recorded on two consecutive sampling events then an investigation into cause, optimum response, and the potential for environmental harm must be conducted; and
c) If elevated concentrations are recorded on two consecutive sampling events then the administering authority will be notified within 1 month of receiving the analysis results.

C53: If groundwater monitoring results greater than the contaminant limits (or outside the contaminant limits range for pH) specified for the relevant aquifer in *Table 16: Groundwater contaminant limits and trigger levels – Alluvium Aquifers (wet season)* to *Table 20: Groundwater contaminant limits and trigger levels – Joe Joe Formation* (inclusive) are recorded, then an investigation into cause, optimum response, and the potential for environmental harm must be conducted.

Table 16: Groundwater contaminant limits and trigger levels- Alluvium Aquifers (wet season)

Parameter[2]	Units	Trigger Levels[3]	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	μg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	μS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH[1]	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

[1]Baseline value ±1.0 for pH, means the corresponding variation allowed is 1.0 pH unit above and below average and maximum / minimum pH values determined for the site.
[2]Parameters and sampling frequency will be revised at the end of background sampling, based on results compiled at each monitoring point and proposed land use.
[3] The administering authority and the holder will agree to suitable trigger levels and contaminant limits (per aquifer and season) once sufficient hydrochemical data has been compiled.

Table 17 Groundwater contaminant limits and trigger levels – Alluvium Aquifers (dry season)

Parameter[2]	Units	Trigger Levels[3]	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	μg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	μS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH[1]	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

[1]Baseline value ±1.0 for pH, means the corresponding variation allowed is 1.0 pH unit above and below average and maximum / minimum pH values determined for the site.

[2]Parameters and sampling frequency will be revised at the end of background sampling, based on results compiled at each monitoring point and proposed land use.

[3] The administering authority and the holder will agree to suitable trigger levels and contaminant limits (per aquifer and season) once sufficient hydrochemical data has been compiled.

Table 18: Groundwater contaminant limits and trigger levels – Colinlea Sandstone Aquifers

Parameter[2]	Units	Trigger Levels[3]	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	μg/L	80th per centile of background data	99th per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	μS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH[1]	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

[1]Baseline value ±1.0 for pH, means the corresponding variation allowed is 1.0 pH unit above and below average and maximum / minimum pH values determined for the site.
[2]Parameters and sampling frequency will be revised at the end of background sampling, based on results compiled at each monitoring point and proposed land use.
[3] The administering authority and the holder will agree to suitable trigger levels and contaminant limits (per aquifer and season) once sufficient hydrochemical data has been compiled.

Table 19 Groundwater contaminant limits and trigger levels – Bandanna Formation Aquifers

Parameter[2]	Units	Trigger Levels[3]	Contaminant limits
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	μg/L	80^{th} per centile of background data	99^{th} per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	μS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH[1]	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

[1]Baseline value ±1.0 for pH, means the corresponding variation allowed is 1.0 pH unit above and below average and maximum / minimum pH values determined for the site.
[2]Parameters and sampling frequency will be revised at the end of background sampling, based on results compiled at each monitoring point and proposed land use.
[3] The administering authority and the holder will agree to suitable trigger levels and contaminant limits (per aquifer and season) once sufficient hydrochemical data has been compiled.

Table 20 Groundwater contaminant limits and trigger levels – Joe Joe Formation

Parameter[2]	Units	Trigger Levels[3]	Contaminant limits
JOE JOE FORMATION			
Dissolved metals Aluminium (Al) Antimony (Sb) Arsenic (As) Iron (Fe) Molybdenum (Mo) Selenium (Se) Silver (Ag)	μg/L	80^{th} per centile of background data	99^{th} per centile of background data
Total Dissolved Solids	mg/L		
Electrical Conductivity	μS/cm		
Major anions and cations Sulfate Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate	mg/L		
Total Petroleum Hydrocarbons	ppb		
pH[1]	unit	6.5 – 8.5	Note: ± 1 pH unit from highest/lowest readings
Groundwater level	For interpretational purpose only		

[1]Baseline value ±1.0 for pH, means the corresponding variation allowed is 1.0 pH unit above and below average and maximum / minimum pH values determined for the site.
[2]Parameters and sampling frequency will be revised at the end of background sampling, based on results compiled at each monitoring point and proposed land use.
[3] The administering authority and the holder will agree to suitable trigger levels and contaminant limits (per aquifer and season) once sufficient hydrochemical data has been compiled.

C54: Groundwater contaminant trigger levels for *Table 16: Groundwater contaminant limits and trigger levels – Alluvium Aquifers (wet season)* to *Table 20: Groundwater contaminant limits and trigger levels – Joe Joe Formation* (inclusive) must be finalise based on the Groundwater Monitoring Program approved under condition C50 and submitted to the administering authority 28 days prior to commencing coal extraction.

C55: Groundwater monitoring bores must be constructed in accordance with methods prescribed in the Minimum Construction Requirements for Water Bores in Australia -3rd Edition (LWBC), or equivalent.

C56: The monitored data must be reported to the administering authority, and must satisfy the following criteria:

a) Data collected under the monitoring program will be forwarded to the administering authority on a quarterly basis within 30 business days of the end of each quarter and compiled in an annual motioning report in a format approved by the administering authority;
b) The proponent shall undertake an assessment of the impacts of mining on groundwater after the first 12 months of dewatering commencing and thereafter every subsequent calendar year;
c) The annual monitoring report will be forwarded to the relevant authority by the fist of March each calendar year; and
d) The annual monitoring report will include an assessment of impacts, any mitigation strategies as well as any recommendations for changes to the approved monitoring program.
e) If there is a requirement to submit a similar groundwater report as part of any condition issued under a water license under the *Water Act 2000* then the proponent and the relevant administering authorities may agree for the reports to be combined.

Schedule F – Land

F51: Residual Void: The holder of this environmental authority must complete an investigation into residual voids and submit a report to the administering authority by (Date 5 years from grant of EA). The investigation must include:

a) A study of options available for minimising final void area and volume;
b) A void hydrology study, addressing the long-term water balance in the voids, connections to groundwater resources and water quality parameters in the long term;
c) A study of the measured to protect the residual voids, uncompacted overburden and workings from the probable maximum flood (PMF) level;
d) A pit wall stability study, considering the effects for long-term soil erosion and weathering of the pit wall and the effects of significant hydrological events; and
e) A study of void capability to support native flora and fauna.

F52: Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself and subject to any other condition of this environmental authority.

F55: The Post Closure Management Plan must include the following elements:

a) Operation and maintenance of:
    i. wastewater collection and reticulation systems;
    ii. wastewater treatment systems;
    iii. the groundwater monitoring network;
    iv. final cover systems of spoil dumps and
    v. vegetative cover; and
b) monitoring of:
    i. Surface water quality;
    ii. Groundwater quality;
    iii. Seepage rates;
    iv. Erosion rates;

v. Integrity and stability of all slopes, ramps, and voids; and
vi. The health and resilience of native vegetation cover.

3. *Environmental Protection and Biodiversity Conservation Act 1999* Conditions (T Burke, 23 August 2012)

<u>Water Quality</u>

Condition 11 - Regional Water Plan:

The person taking the action must submit a Regional Water Plan to the Minister for approval. The plan must address the following requirements:

a) a regional surface water and a regional groundwater water monitoring program with reference to groundwater dependent habitat for listed threatened species and ecological communities, and listed migratory species:
b) the monitoring identified in condition 11 (a) must include identification of linkages between the formations, and likely movement of water into and out of the aquifers;
c) address the potential for impacts to groundwater dependent habitat for listed species and ecological communities, and listed migratory species:
d) Include an ongoing monitoring program to be undertaken to:
   (i) ensure no drawdown impacts result from mining operations on groundwater dependent communities in the Great Artesian Basin;
   (ii) measure the success of management measures to inform an adaptive management approach that must be implemented;
   (iii) report on milestones and compliance with this plan;
   (iv) identify measures of success; and
   (v) identify thresholds for intervention, where rehabilitation and vegetation management measures are exceeded.

The person taking the action cannot commence construction activities until the Minister approves the Regional Water Plan in writing.

The approved Regional Water Plan must be implemented.