G

Review of Groundwater Impacts

BYLONG COAL PROJECT
Supplementary Information

Hansen Bailey
ENVIRONMENTAL CONSULTANTS

Australasian Groundwater and
Environmental Consultants Pty Ltd

Report on

Bylong Coal Project

Mine Plan Update

Groundwater Impact Assessment

Prepared for
Hansen Bailey Pty Ltd

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Australasian Groundwater and Environmental Consultants Pty Ltd

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Report on

Bylong Coal Project – Revision to Project Mine Plan

Groundwater Impact Assessment

1 Introduction

KEPCO Bylong Australia Pty Ltd (KEPCO) proposes to develop an open cut and underground coal mine in the Bylong Valley (the Project), which is located in the Mid-Western Region of New South Wales (NSW). The impact of the Project on groundwater resources has been assessed according to the NSW regulatory regime and is documented in reports prepared for:

- Dec 2013 NSW Gateway Certificate (AGE 2013).
- Jul 2015 Environmental Impact Statement (EIS) (AGE 2015).
- Mar 2016 Response to submissions (RTS) (AGE 2016a).
- Jun 2016 Supplementary RTS (AGE 2016b).
- Dec 2017 Response to Planning Assessment Commission (PAC) (AGE 2017).

This report should be read in conjunction with Section 2 of the Response to PAC Report (AGE 2017). AGE (2017) which contains a simplified summary of the numerical groundwater flow modelling process and the modelling undertaken for the Project.

In light of the advice received from the PAC and the Heritage Council of NSW, Department of Planning and Environment (DPE) has requested information from KEPCO concerning the potential impacts of contracting the mining footprint within the Eastern Open Cut to remain off Tarwyn Park and other minor concessions. DPE's correspondence dated 28 May 2018 requested a high level review to confirm that the groundwater impacts for the Revised Mine Plan would be equal to or less than that provided within the environmental assessment documentation provided to date.

Hansen Bailey Pty Ltd (Hansen Bailey) engaged Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to address DPE's request and assess the impact of contracting the open cut footprint on the groundwater regime. This report describes the results of additional groundwater modelling which has been undertaken to assess the potential impact of the Revised Mine Plan for the Project. It also provides contextual comments on the numerical modelling conducted for the Hunter subregion Bioregional Assessment and relevant information to address concerns about the potential for the Project to remove surface flow in the Bylong River.

2 Updates to numerical model

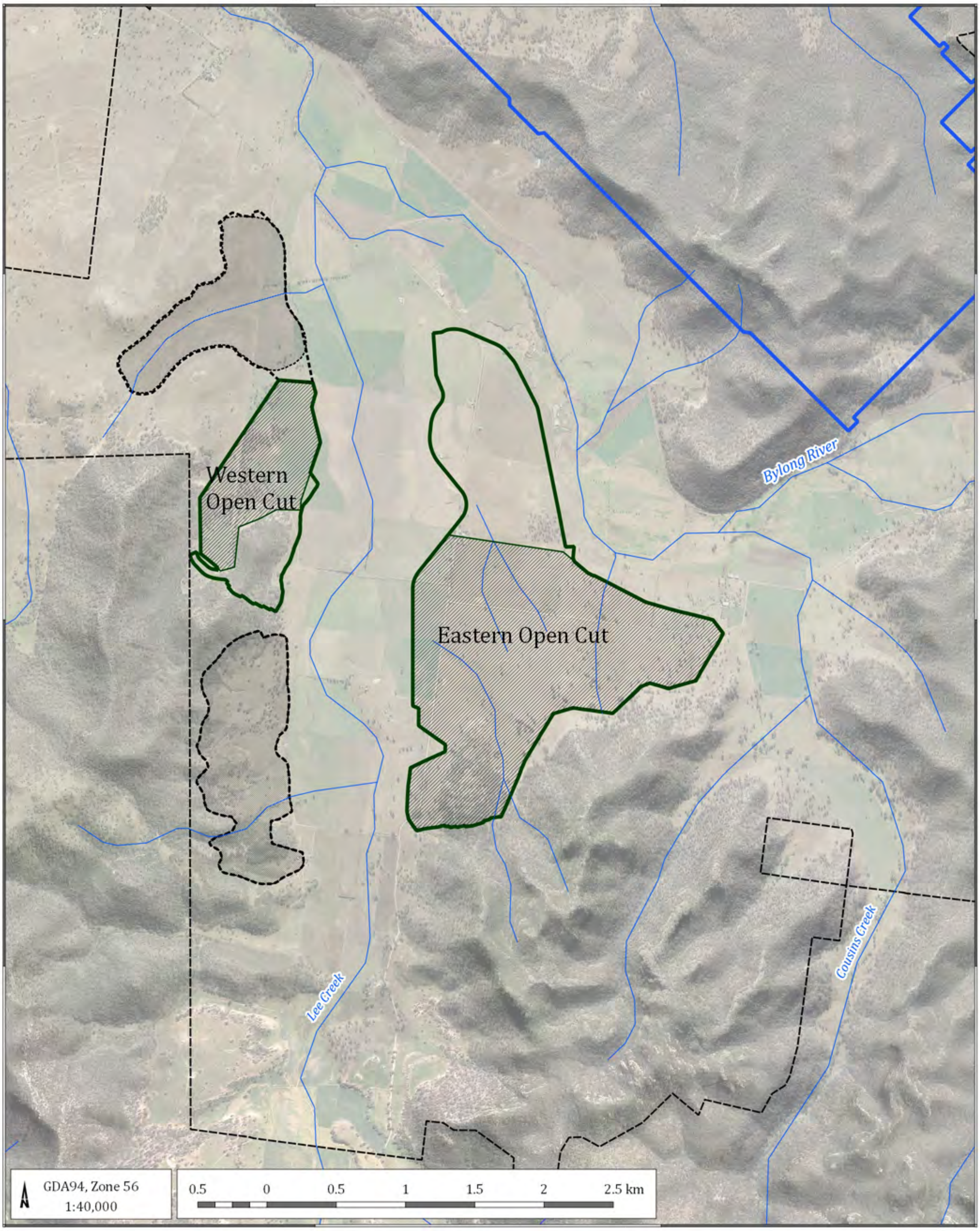
The Supplementary RTS (AGE 2016b) describes the most recent numerical modelling including model calibration and predictions for the Project. This is the most recently calibrated version of the numerical model and included the results of pump testing trials within the alluvial aquifer. A simplified explanation of the Supplementary RTS modelling results along with a further validation of the numerical model using recent water level data was undertaken as part of the Response to PAC Review Report. However, no revised calibration or predictions were required. The numerical model described within the Supplementary RTS has been updated to represent the reduced open cut mining footprint for the Eastern and Western Open Cut mining areas for the Revised Mine Plan. Figure 2-1 shows the Project mine plan which has been assessed in the previous stages of the approval process compared with the Revised Mine Plan with the reduced open cut mining footprint as required by DPE.

The Revised Mine Plan with reduced open cut mining footprint does not affect the underground mining activities previously assessed. The southern overburden emplacement area remains essentially unchanged while the northern overburden emplacement area has been reduced slightly.

The approach to modelling the Revised Mine Plan remained consistent with the assumptions described within the Supplementary RTS. The calibrated Supplementary RTS model represented the open cut mining process using the MODFLOW drain package. The model applied drain cells to the base of each model layer within the open cut mining area down to Layer 8 which represented the Coggan coal seam. Once applied, the drain boundary condition remained actively dewatering for one year. After one year, the drain cells were then removed from the area where open cut mining had been completed and the hydraulic properties changed to represent in-pit spoils using the Time Variant Materials (TVM) package. Figure 2-2 shows the progression of the pit floor for the mine plan assessed in previous approvals documents and the Revised Mine Plan.

The influence of the Revised Mine Plan on the post mining impacts was also investigated using the numerical model. The model was used to assess post closure impacts from the end of mining for a simulation period of 500 years. The post closure model used the end of mining groundwater levels as the starting water levels and removed all drain cells simulating the proposed mining areas to allow groundwater levels to equilibrate. The hydraulic properties of the spoils remained unchanged from those previously described (AGE 2015). The recharge rate and evapotranspiration surfaces were adjusted to represent the updated final landform for the Revised Mine Plan footprint.

The scope of work did not include updating the predictive uncertainty analysis described within the Supplementary RTS. Predictive uncertainty analysis was not repeated for the contracted open cut mine plan because the uncertainty is influenced by the variability in model parameters (e.g. hydraulic conductivity and recharge), and these parameter ranges remain unchanged from the Supplementary RTS.



LEGEND

- Open Cut mining area (Reduced footprint)
- Overburden Emplacement area (Reduced footprint)
- Open Cut mining area
- Overburden Emplacement area
- Underground Extraction area
- Minor drainage
- Project Boundary

Bylong Coal Project (G1606T)

Mine plan

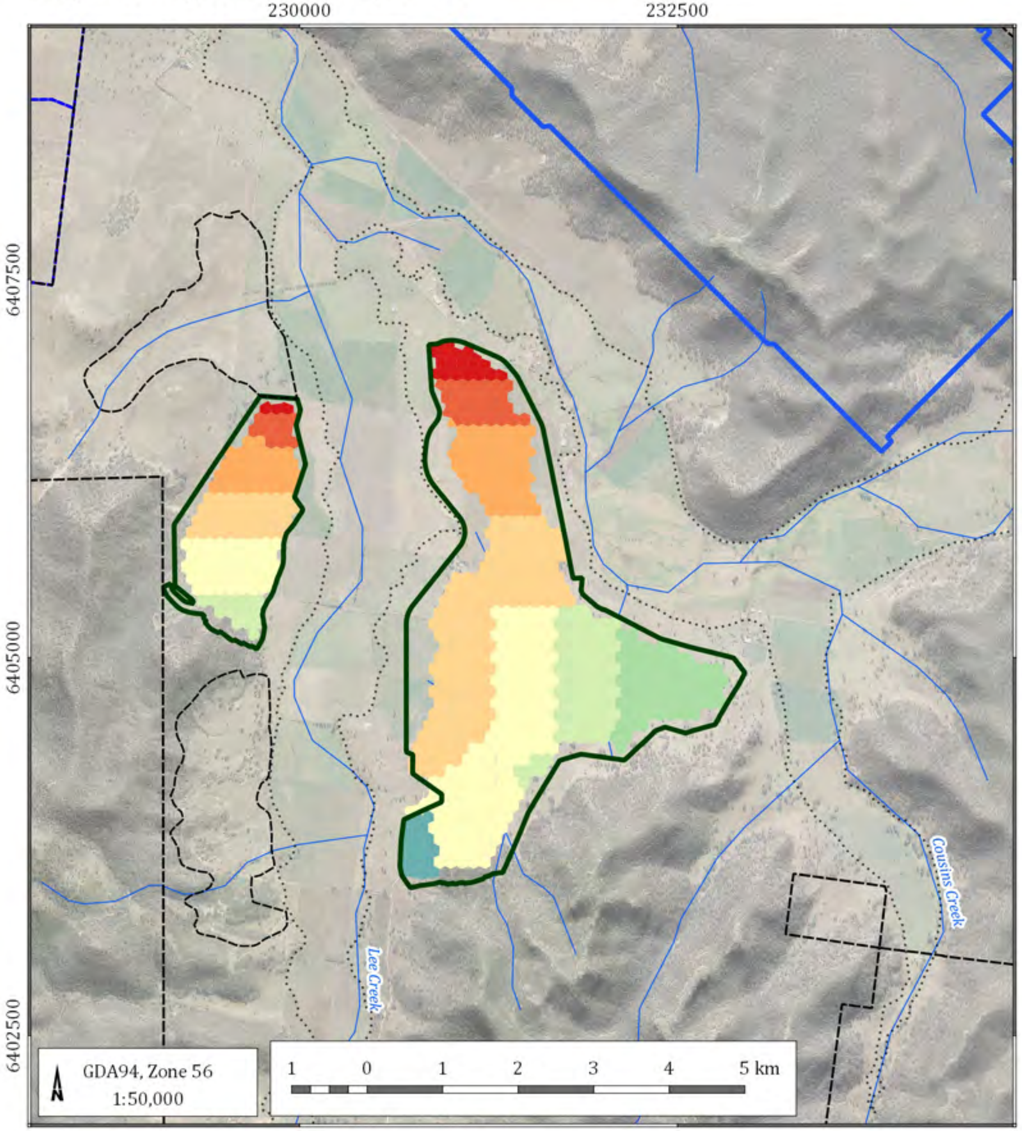
AGE

DATE 27/06/2018

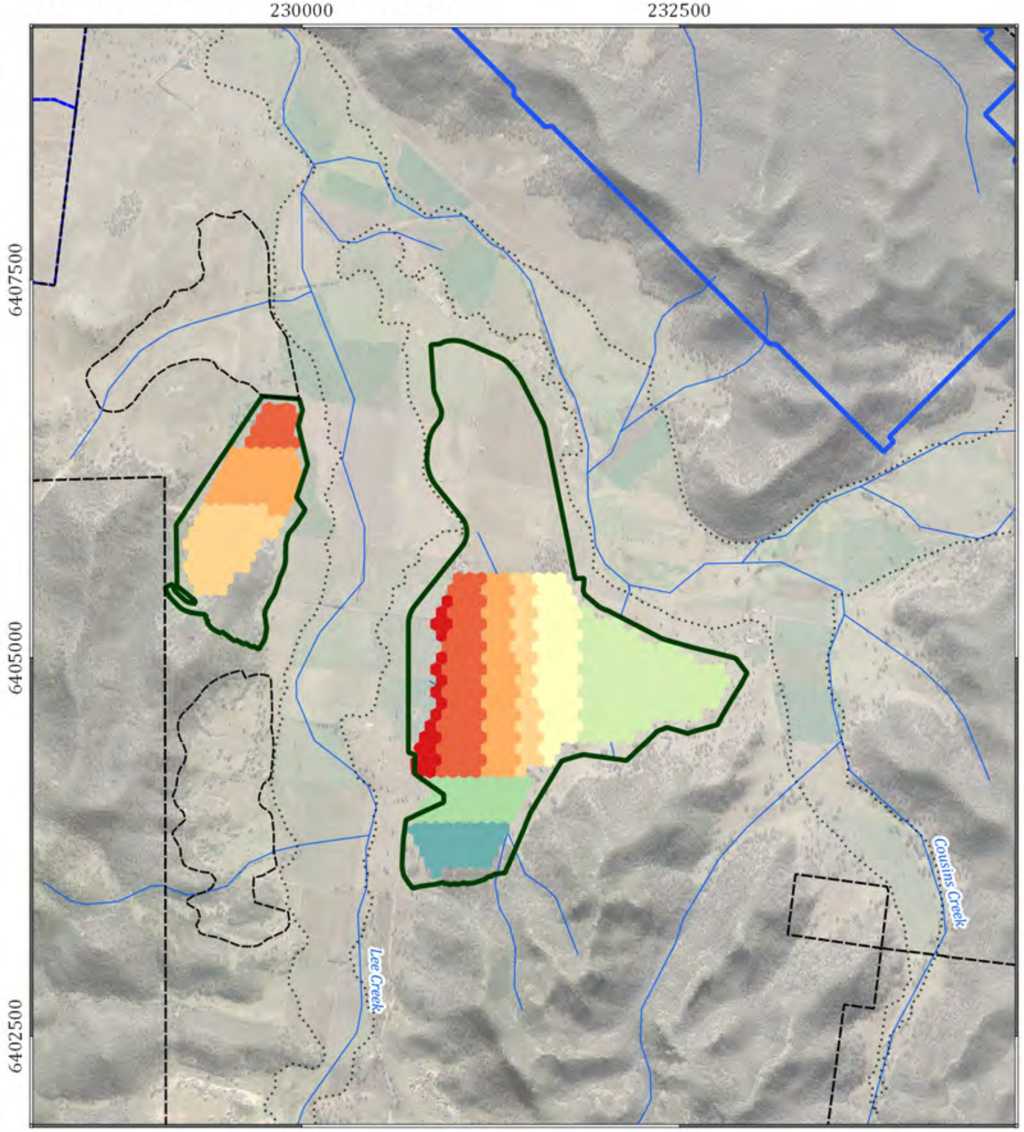
FIGURE No: **2-1**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
//bne01dc/Shared/Projects/G1606.Bylong Coal Project/3_GIS/Workspaces_QGIS/G1606T_new_mine_plan_20180508/02.01_G1606T_Proposed_Mine_plan.qgs

Supplementary RTS2 mine progression



Mine progression with reduced footprint



LEGEND

- Project Boundary
- Open Cut mining area
- Overburden Emplacement Area
- Underground Extraction Area
- Eagle Hill property
- Quaternary alluvium
- Minor drainage
- Private alluvium bores

Mine start year

- 2017
- 2018
- 2019
- 2020
- 2021
- 2022
- 2023
- 2024

Bylong Coal Project (G1606T)

AGE

Mine progression

DATE
27/06/2018

FIGURE No:
2-2

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1606.Bylong Coal Project/3_GIS/Workspaces_QGIS/G1606T_new_mine_plan_20180508/02-02_Mine_progression.qgs

3 Model predictions

The sections below describe the influence of the Revised Mine Plan on the impacts predicted for the operational and post closure phases of the Project.

3.1 Operational impacts

3.1.1 Direct interception of groundwater

The updated numerical model was used to estimate the volume of groundwater directly intercepted by the revised open cut and underground mining areas from the Permian coal measures. Figure 3-1 compares the volume of groundwater predicted to be directly intercepted by the Revised Mine Plan with the predictions previously presented in the Supplementary RTS (AGE 2016b). The groundwater inflow is included in the summary table within Appendix A. The table within Appendix A is an updated version that was included with Supplementary RTS and summarised the model water budgets and water licensing requirements.

To enable interpretation of the results, it should be noted that:

- Project Year 1 first year of construction;
- Project Year 2 completion of construction, including boxcut construction;
- Project Year 3 first year of open cut mining;
- Project Year 9 last year of open cut mining/first year of longwall underground mining; and
- Project Year 25 end of underground mining and Project life.

Figure 3-1 shows that, as expected, reducing the footprint of the open cut mining area, reduces the inflow of groundwater to the open cut mining areas. During the life of the open cut mine, the groundwater inflow reduces from a peak of 106 ML/year in Project Year 5 reported by AGE (2016b) to a peak of 76 ML/year in Project Year 7, which is a reduction of about 30 percent during the open cut mine life. The cumulative volume of groundwater intercepted during the open cut mining reduces by 163 ML due to the reduced mining footprint and reduced year of open cut mining operations.

Figure 3-1 also shows that reducing the footprint of open cut mining does not influence the groundwater inflow rate experienced during the underground mine period. This is an expected outcome as no changes to the underground mining footprint/production rates are proposed. Therefore, the peak take of groundwater from the Permian/Triassic strata due to the Project remains unchanged as it is predicted to be a function of underground, not open cut mining.

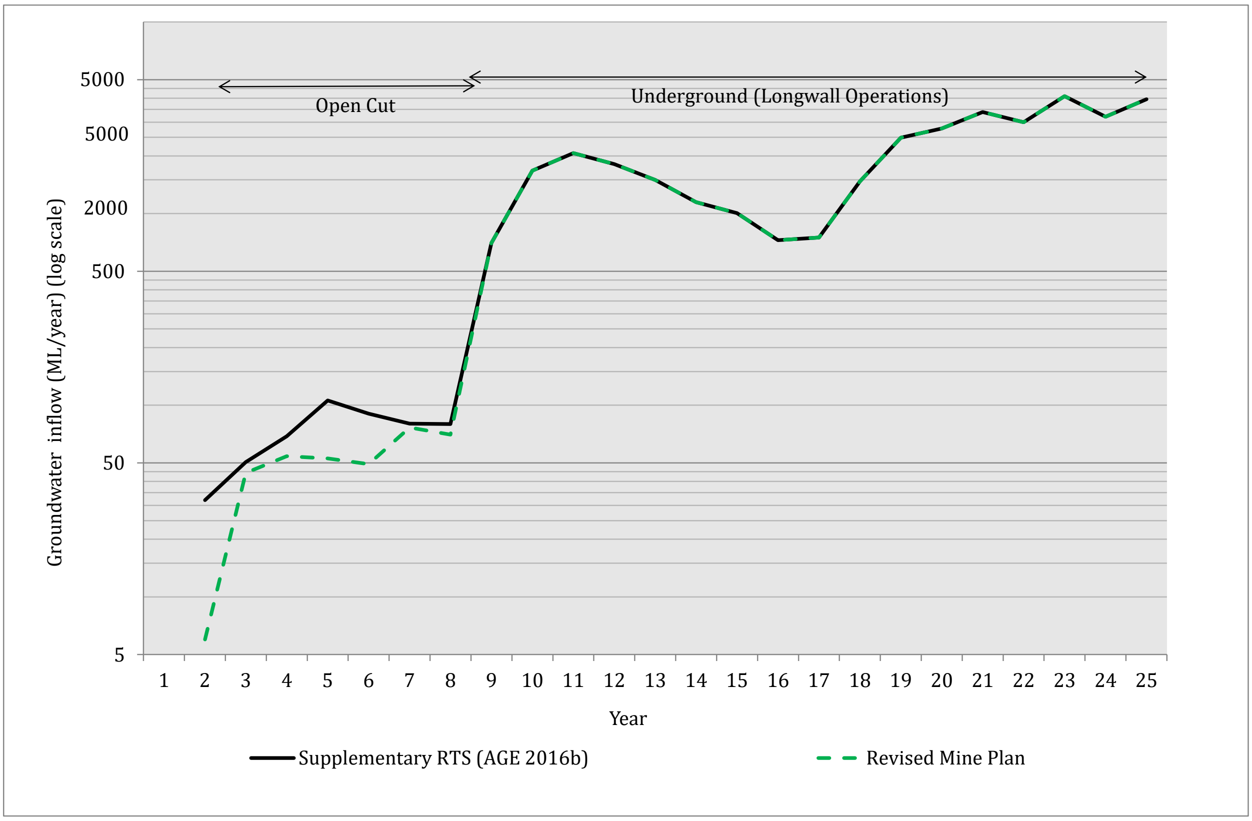


Figure 3-1 Predicted seepage to open cut and underground mining areas

3.1.2 Indirect interception of groundwater

The Project will directly abstract groundwater from the Permian coal measures that are intercepted due to mining, and also from a borefield within the Quaternary alluvium, if make up water is required to supplement water demands for mining operations. In addition to this, the reduced groundwater pressures within the Permian coal measures will also indirectly influence the flow of groundwater from the Permian bedrock into the alluvial aquifers. Whilst the proposed mining operations will not directly excavate any alluvial sediments, an indirect impact will occur when the groundwater pressure within the Permian bedrock reduces, which reduces the flow of water from the bedrock into the overlying alluvial aquifers. The changes in the groundwater flow were extracted from the updated numerical model to determine how the reduced footprint of open cut mining will influence the indirect interception of groundwater. The change of the flow of groundwater from the Permian bedrock to the alluvium is provided within the table included within Appendix A.

The table provided within Appendix A shows the net flow of groundwater from the Permian bedrock to the alluvium is negative during the open cut mining period. This occurs because the drawdown within the alluvium induced around the borefield increases the hydraulic gradient between the Permian bedrock and the alluvium, increasing the flow of Permian groundwater into the alluvium. The net flow into the alluvium from the Permian increases by about 100 ML up to year eight of the Project due to the reduced open cut mining footprint. This occurs because there is slightly less depressurisation within the Permian bedrock when the footprint of open cut mining is reduced allowing steeper hydraulic gradients to promote greater flow of Permian groundwater into the alluvium.

In the model, the pumping from the borefield within the alluvial aquifer induces a flow of water from the surface water systems due to the lower head in the underlying aquifer. The induced flow from the surface water system is also tabulated in Appendix A. The results shown within the table indicate a similar impact to that reported within the Supplementary RTS, although with a slight reduction (compared to the EIS) due to the reduced footprint of open cut mining and associated incidental drawdown of water from the alluvial aquifer.

3.1.3 Water licensing

Reducing the footprint of open cut mining will slightly reduce the peak volume of water license units required to account for the Project impacts on the Bylong River Water Source (Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources). The volume of water licence units required to account for water taken from the Sydney Basin - North Coast Water Source (North Coast Water Source) within the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources (North Coast WSP) will be unchanged from previously estimates presented within the Supplementary RTS. The total number of water licence units required to account for the Project impacts each year are shown graphically for each water source in Figure 3-2 and Figure 3-3.

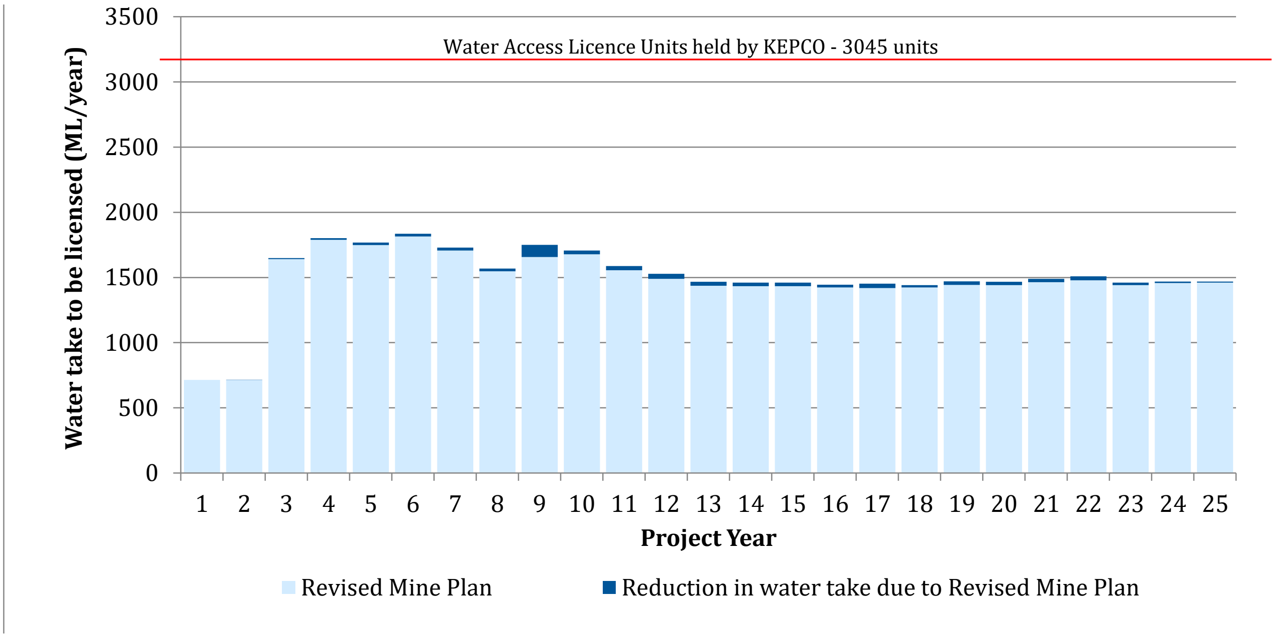


Figure 3-2 Water licensing requirement (mining interception + borefield + agriculture) from Bylong River Water Source

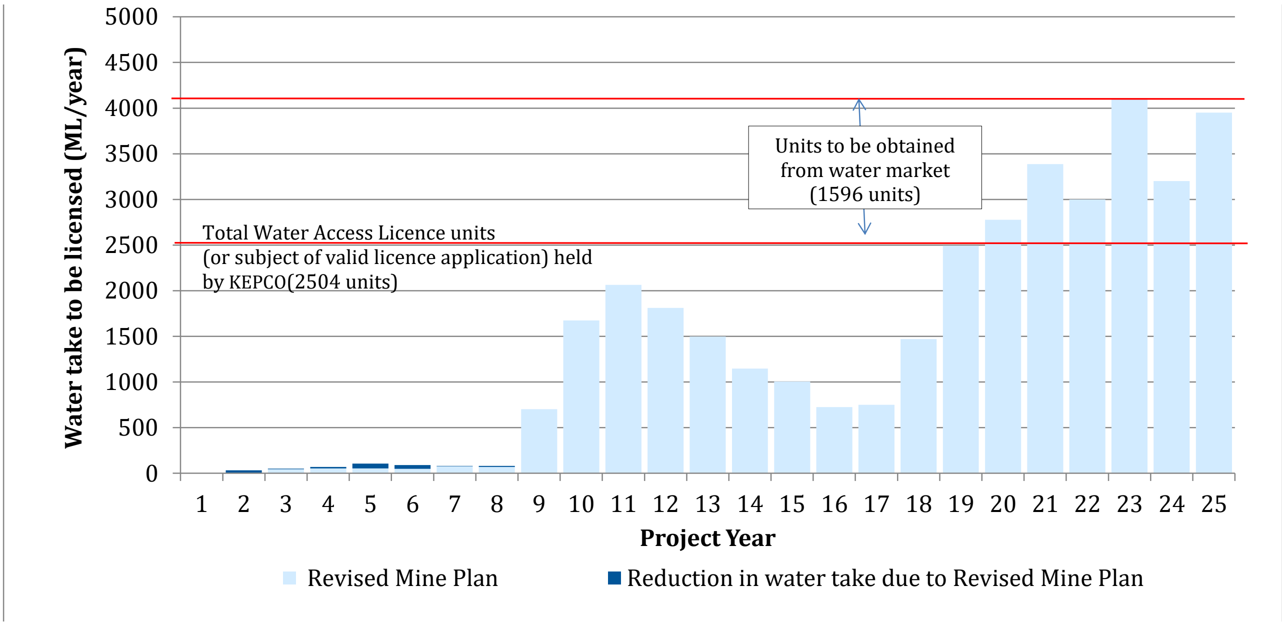


Figure 3-3 Water licensing requirement from North Coast Water Source

A more detailed tabulated breakdown of the model predictions and the calculated water take requiring licensing from each water source for the reduced footprint of open cut mining is also included within Appendix A. KEPCO hold 3,045 units of groundwater within the Bylong River Water Source which remains sufficient to account for the surface water and groundwater, predicted to be taken by the Project both directly and indirectly from the alluvial groundwater systems within the vicinity of the Project. Therefore, the impacts and the mitigation measures proposed for the alluvium remain essentially unchanged for the Revised Mine Plan with a reduced footprint of open cut mining.

Modelling undertaken during the Supplementary RTS, indicated a peak water take of 4,099 ML/year (in PY 23) to occur from the North Coast Water Source during the proposed longwall mining. This peak predicted water take remains unchanged by the Revised Mine Plan. This is because the underground mining remains unchanged.

KEPCO has previously applied for a water licence for 2,093 units under the *Water Act 1912* for the Project to extract groundwater from the Permian strata. Department of Industry Crown Lands and Water Division (DoI-Water) has advised this licence application is valid and will be transferred as a licence under the North Coast Porous and Fractured Rock Water Sharing Plan which commenced on 1 July 2016. KEPCO has acquired 411 units of water access licences from the North Coast Water Source as a result of land acquisitions which have occurred. The additional water licences (1,596 units) to account for the water predicted to be taken from the North Coast WSP will be obtained by KEPCO from the open market. The NSW Water Register[1] indicates there are 182 Water Access Licences for groundwater within the North Coast Water Source with a total share component of 64,673.5 units (including potable and domestic water). Given the amount of licences within this water source and the volume of units required for the Project (i.e. 1,596 units), it is expected the additional entitlement will be obtainable prior to underground mining to account for predicted water takes. KEPCO is actively pursuing the additional units of water allocation and has commissioned a water broker to facilitate this. As there is no change to the peak impacts to the Project, the mitigation measures proposed for the North Coast Water Source remain unchanged for the Revised Mine Plan.

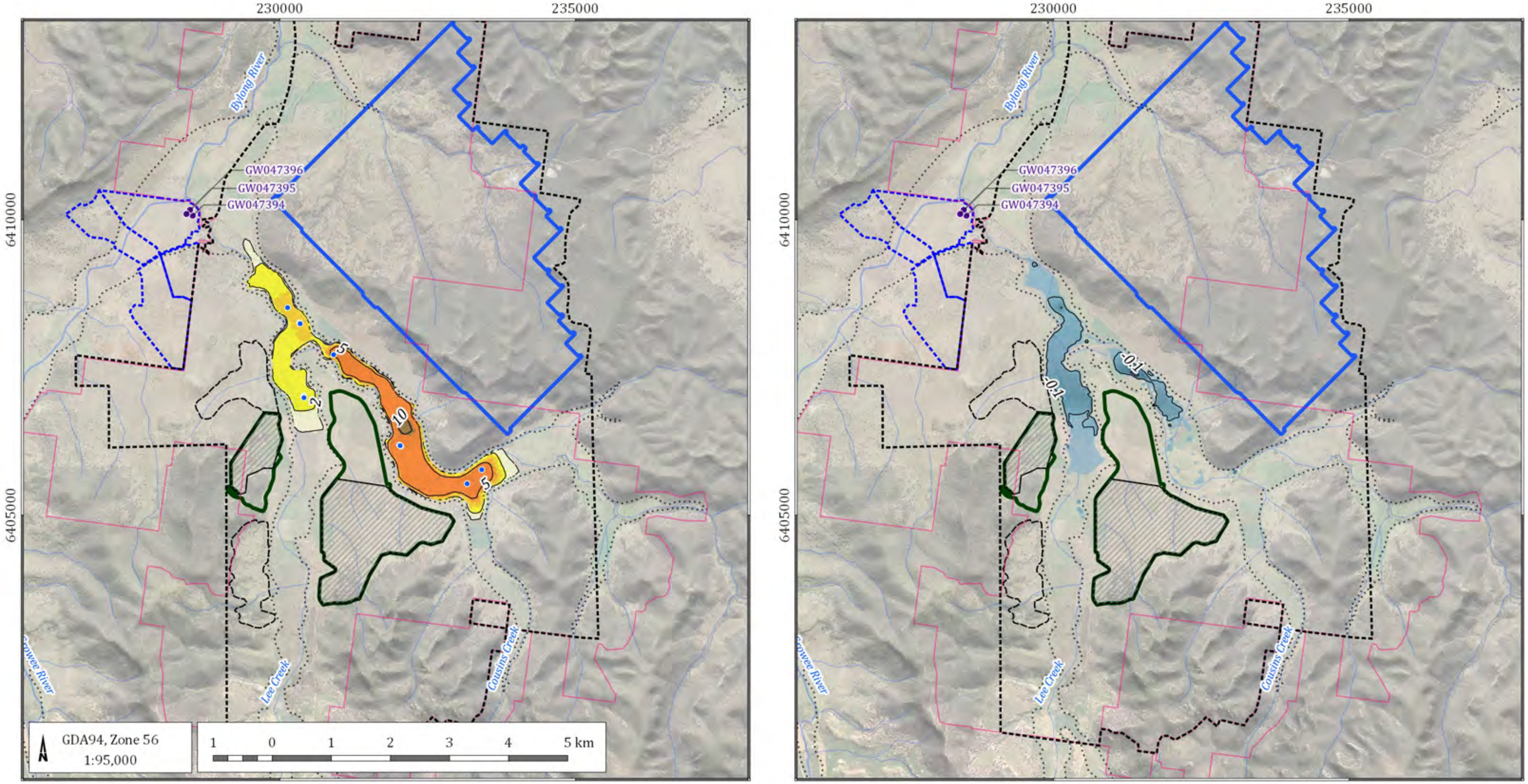
3.1.4 Drawdown

The numerical modelling conducted for the approvals process indicates the proposed borefield and to a lesser extent, the mining activities, will result in drawdown occurring within the Bylong River and Lee Creek alluvial aquifers. The Supplementary RTS included figures that illustrated the extent of the maximum drawdown occurring during the mine life within the alluvium (refer AGE 2016b Figure 6-17.)

The drawdown predicted by the updated model representing the Revised Mine Plan was extracted from the model and compared to the previously predicted drawdown. Figure 3-4 shows the previously predicted drawdown (AGE 2016b) and the reduction in the predicted maximum drawdown due to the reduced open cut mining footprint. The figure indicates there is typically between 0.1 m and 0.2 m less drawdown occurring within the alluvial aquifer due to the Revised Mine Plan. This relatively limited reduction in drawdown is expected, as the drawdown within the alluvium is dominated by the abstraction of water from the borefield pumping bores which have remained the same as the Supplementary RTS within the numerical model. The peak in the borefield demand occurs in year 9 of the project life, which coincides with a period of extended drought represented in the groundwater model, resulting in a conservative indication of the maximum drawdown within the alluvium. The modelling from the Supplementary RTS and for the Revised Mine Plan indicates in these circumstances, there will be no adverse impacts on neighbouring private landholder's bores within the alluvium. Therefore the conclusions of AGE (2017) regarding impacts on the alluvial and private bores remains unchanged for the Revised Mine Plan.

[1] http://www.water.nsw.gov.au/water-licensing/registers accessed on 18 June 2018

Maximum drawdown (AGE 2016b) | **Reduction in maximum drawdown**



LEGEND

- Original Open Cut mining area
- Overburden Emplacement Area
- Underground Extraction Area
- Quaternary alluvium
- Drainage
- KEPCO owned land
- Project Boundary
- Eagle Hill property
- RTS 2 proposed bores
- Private bores on Eagle Hill property

Drawdown (m)

- 1-2
- 2-3
- 3-4
- 4-5
- 5-10
- 10-15
- Drawdown contour (m)

Reduced drawdown (m)

- -0.2- -0.1
- -0.1- 0.0
- Reduced drawdown contour (m)

Bylong Coal Project (G1606T)

Predicted maximum drawdown within alluvium (AGE 2016b) and reduction in maximum drawdown due to Revised Mine Plan

DATE
28/06/2018

FIGURE No:
3-4

G:/Projects/G1606.Bylong Coal Project/3_GIS/Workspaces_QGIS/G1606T_new_mine_plan_20180508/03.04_G1606T_Predicted maxium drawdown within alluvium.qgs

3.2 Post mining impacts

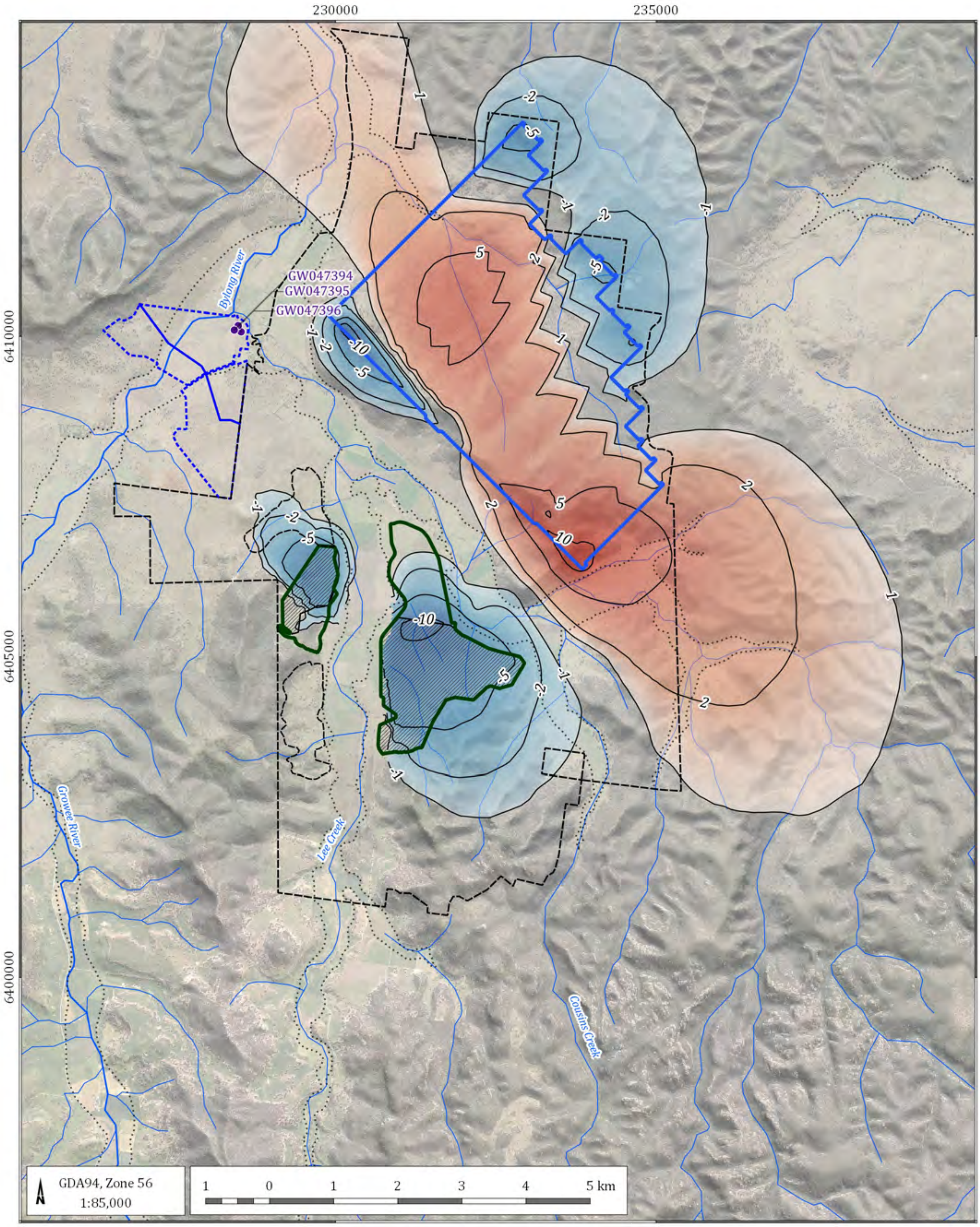
The sections below describe the influence of the Revised Mine Plan on the post mining impacts predicted by the numerical modelling. The most recently calibrated numerical model developed for the Supplementary RTS was used to assess the post mining impacts. The model was updated with the Revised Mine Plan and then used to simulate the recovery in the groundwater regime post mining. The Supplementary RTS did not assess post mining recovery and therefore it was also necessary to run a second scenario with the mine plan and landform presented in the EIS/RTS. The water budgets and water levels were then extracted from two scenarios, one with revised mine plan and one with the EIS mine plan within Supplementary RTS and compared to determine the changes in impacts attributable to the Revised Mine Plan with reduced mine footprint and updated final landform.

3.2.1 Water levels

The post mining impacts on groundwater levels were last described within the EIS (AGE 2015). The numerical modelling indicated that post mining groundwater levels would rise above pre-mining levels within the backfilled pit by up to about 10 m. This was due to the higher than background recharge rate applied to the spoil piles within the backfilled mining areas.

Figure 3-5 shows the change in groundwater levels in the Coggan coal seam layer 500 years post mining using the recalibrated Supplementary RTS model and the larger EIS/RTS mine plan. Similar to the EIS, it shows that there will be no significant residual drawdown post mining, and as the system recovers the groundwater levels will rise above pre-mining levels within the backfilled open cut mining areas. The rising water levels are indicated by a negative value on the contour lines shown within Figure 3-5.

The groundwater levels for the EIS mine plan were compared with the Revised Mine Plan with reduced mining footprint to determine the incremental changes. Figure 3-6 shows the change in groundwater levels predicted within the Coggan coal seam due to the Revised Mine Plan with reduced footprint of open cut mining. It shows the groundwater levels mound about 2 m higher in the Eastern open cut due to the Revised Mine Plan. Whilst there are some differences in the post mining water levels, the conclusion from the EIS is that there will be no significant residual drawdown post mining remains valid for the Revised Mine Plan.



LEGEND

- Project Boundary
- Eagle Hill property
- Open Cut mining area (Reduced footprint)
- Open Cut mining area
- Overburden Emplacement Area
- Underground Extraction Area
- Quaternary alluvium
- Drainage
- Private alluvium bores

Change in head

-10	1
-5	2
-2	5
-1	10

Bylong Coal Project (G1606T)

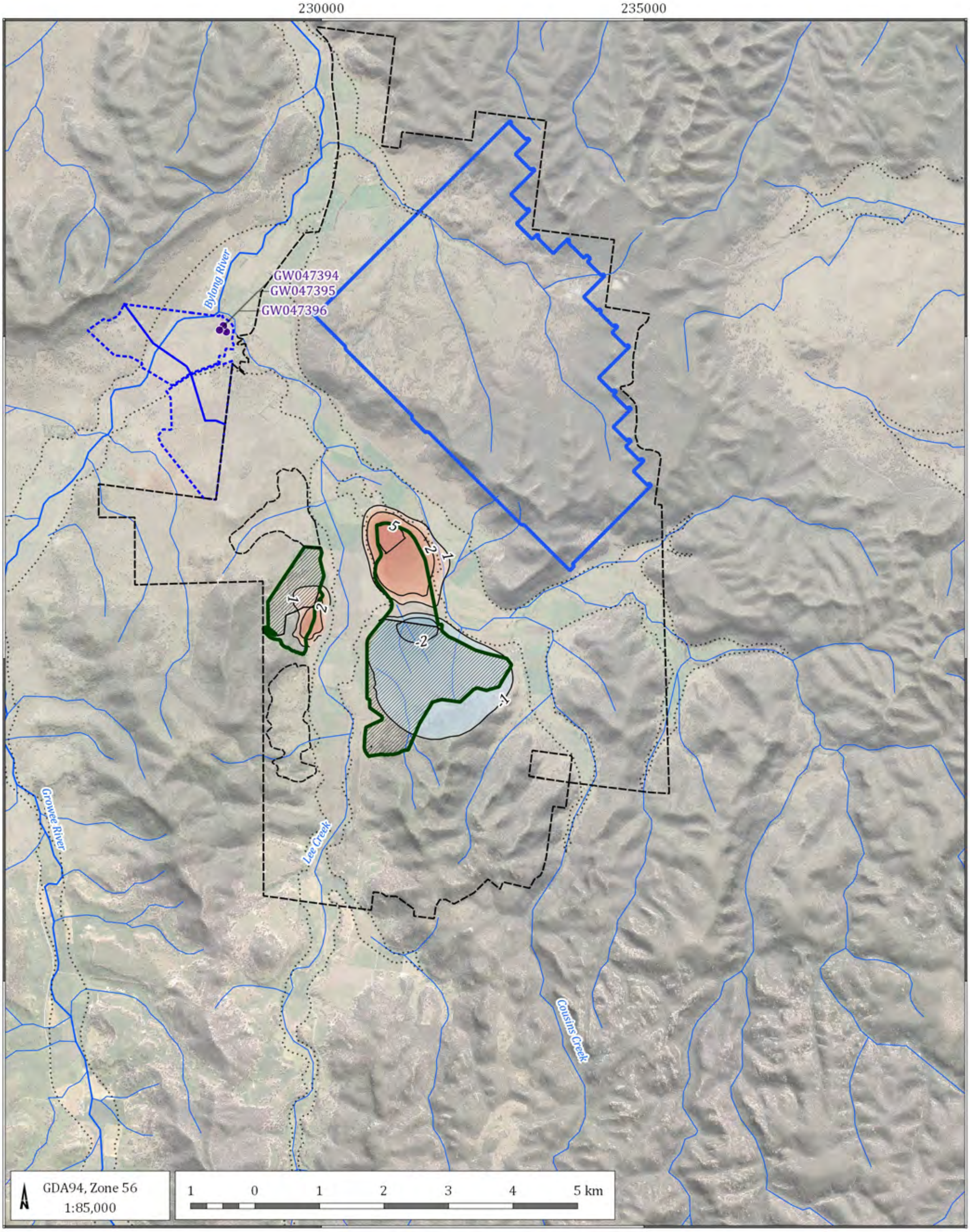
Change in heads layer 8 (Coggan Seam) 500 years post mining for Supplementary RTS model

AGE

DATE 12/07/2018

FIGURE No: **3-5**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1606.Bylong Coal Project/3_GIS/Workspaces_QGIS/G1606T_new_mine_plan_20180508/03.05_G1606T_Change in heads layer 8 (Coggan seam) 500 years post mining for supplementary RTS model.qgs



LEGEND

- Project Boundary
- Eagle Hill property
- Open Cut mining area (Reduced footprint)
- Open Cut mining area
- Overburden Emplacement Area
- Underground Extraction Area
- Quaternary alluvium
- Drainage
- Private alluvium bores

Change in head

-2	1
-1	2
	5

Bylong Coal Project (G1606T)

Incremental change in heads layer 8 (Coggan seam) 500 years post mining due to reduced mine footprint and landform

AGE

DATE 12/07/2018

FIGURE No: **3-6**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1606.Bylong Coal Project/3_GIS/Workspaces_QGIS/G1606T_new_mine_plan_20180508/03.05_G1606T_Change in heads layer 8 (Coggan seam) 500 years post mining for supplementary RTS model.qgs

3.2.2 Water take

The EIS (AGE 2015) indicated that the groundwater system would slowly recover over a period of approximately 100 years post mining to a point where there would be no net water take from the alluvial aquifer. The Supplementary RTS model with the Revised Mine Plan indicates the groundwater system re-equilibrates with no long-term reduction in flow of groundwater to the alluvium after 100 years. The impacts for the Revised Mine Plan with reduced open cut mining footprint therefore remain consistent with previous predictions, and the post mining management measures remain valid.

3.2.3 Water salinity

The EIS used a salt balance to assess the potential for seepage through the rejects within the backfilled open cut mining areas to influence the salinity of groundwater within the adjacent alluvial aquifer (refer AGE 2015, Section 10.11.3). The method used the flow rates within the alluvial aquifer from the numerical model, along with assumed salinity for each source of water to calculate the salt load to the alluvium.

The sources of water entering the alluvium were rainfall recharge, seepage from the creeks, flow from up valley through the alluvium and groundwater entering the alluvium from the underlying Permian bedrock which was assumed to contain the most concentrated source of salt. The salinity of the Permian groundwater flow to the alluvium was increased to represent potential seepage from the backfilled open cut mining areas to estimate the salt load to the alluvium and the potential for the beneficial use of the alluvial groundwater to be impacted by rejects disposal within the mining area over the life of the Project.

The Supplementary RTS model was used to represent post mining flows to the alluvium. The post mining groundwater flows were then used to estimate the salt load to the alluvial groundwater system occurring for the Revised Mine Plan. It should be mentioned that the salinity of each of the water sources to the alluvium was also updated based on salinity measurements from the pumping and monitoring bores installed within the alluvial aquifer as part of the Supplementary RTS. Table 3-1 presents the updated water flows to the alluvium, the assumed salinity of each source and the calculated salt load to the alluvial aquifer for the existing and Revised Mine Plan with reduced open cut mining footprint.

There is some difference in the salt loads and salinity in Table 3-1 compared to the EIS due to changes in the groundwater flows from the recalibrated model and the assumed salinity for the up-valley groundwater. These updated salinity values were derived from recent groundwater drilling and pumping investigations in the Bylong River alluvium during the Supplementary RTS.

Table 3-1 Updated water and salt budget – Bylong River and Lee Creek alluvium adjacent to open cut mining areas

Component	Total inputs to alluvium (ML/year) (a)		Estimated salinity			
					Salt load (t/yr) d = ([a x c]/1000)	
	Existing mine plan	Reduced mine footprint	EC (µS/cm) (b)	TDS (mg/L) c = (b x 0.67)	Existing mine plan	Reduced mine footprint
Rainfall recharge	753	753	1,000	670	505	505
Seepage from river	291	291	200	134	39	39
Up-valley inflow	539	538	700	469	253	252
Permian inflow	173	172	2,000	1,340	232	230
TOTAL	**1,756**	**1754**			**1,028 = (585 mg/L)**	**1,026 = (585 mg/L)**

Table 3-1 shows that reducing the footprint of open cut mining very slightly reduces the flow of Permian groundwater to the alluvium by 1 ML/year (173 ML/year reduced to 172 ML/year). This reduces the calculated salt load by a negligible 2 t/year when compared with the EIS mine plan. This small change in salt load does not significantly change the salinity of the alluvial groundwater which is calculated to be equivalent to a Total Dissolved Solids (TDS) of 585 mg/L for both mine plans. Therefore, the impacts on the alluvium can be concluded to be the essentially the same for both the Revised Mine Plan with reduced footprint of the open cut mining and the EIS mine plan. The salt budget indicates the salinity would rise to 684 mg/L if the Permian groundwater increased in salinity from 2,000 to 3,500 µS/cm (component b in Table 3-1), due to the rejects emplacement within the backfilled open cut. The increase in salinity of 99 /mg/L is considered unlikely to impact on the beneficial use of the alluvial groundwater. These results indicate the conclusion from the EIS remains the same that the Permian makes up a small portion of the recharge to the alluvium, and therefore the beneficial use of the alluvial groundwater would be not change post mining due to backfilling of rejects within the open cut.

The Revised Mine Plan and consequent reduction in the land disturbance footprint results in a negligible change to salinity when compared to the EIS mine plan. Therefore, the conclusions regarding salinity reached during the EIS remain unchanged and no changes to management or mitigations measures proposed are required for the reduced footprint of open cut mining.

4 Bylong River flow

KEPCO also requested AGE provide more information about the impact predicted by the numerical model on flow in Bylong River, in response to stakeholder concern that flows in the Bylong River would cease due to mining.

It is important to note that the Project is proposed within an ephemeral creek system which experiences intermittent flows only following significant rainfall events. Observations during KEPCOs baseline monitoring period has indicated the ephemeral creek system frequently has long periods of no surface water flow and reduces to comprise a chain of ponds that are windows to the water table for long periods between rainfall events. Rainfall runoff modelling conducted by the projects surface water consultants (WRM) has indicated only five flow events would occur in an average rainfall year with flows between 263 and 697 ML/day. The number of flow events would reduce to an average of 2.3 events over the Millennium drought.

During the approvals process, the baseflow to the Bylong River from the neighbouring alluvial aquifer has been estimated using two model scenarios, one with mining and one without mining. The difference between the baseflow in each of these models is then used to calculate the change attributable to the Project.

The rate of baseflow calculated by the Supplementary RTS model (AGE 2016b) was analysed to calculate the change in baseflow occurring on private property located beyond the buffer zone of properties purchased by KEPCO.

Figure 4-1 shows the baseflow and the change due to mining on the private property beyond the KEPCO owned buffer zone.

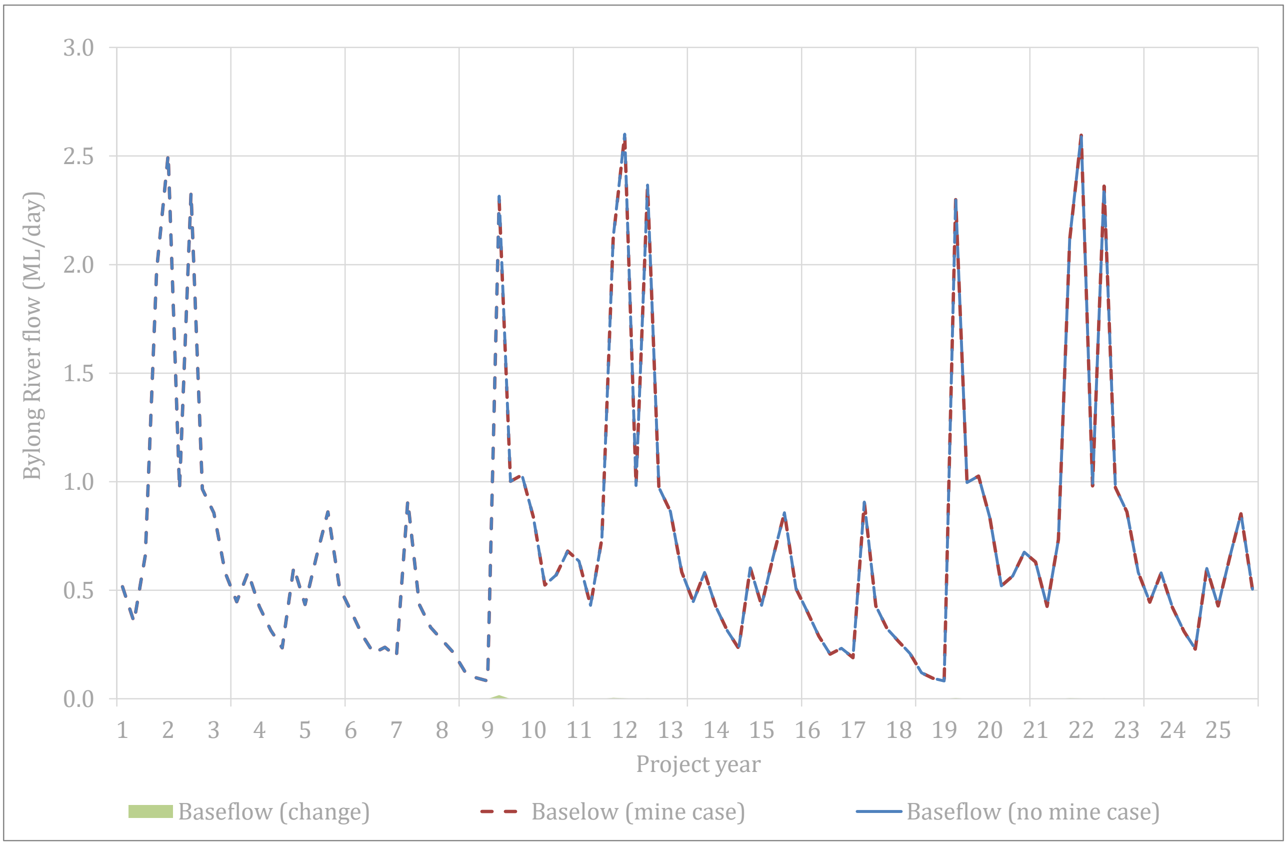


Figure 4-1 Simulated baseflow on private land

The graph shows the predicted baseflow for the models with and without mining are almost identical, except for a small difference in year 9. This indicates the reduction in baseflow reported during the EIS and RTS occurs within the vicinity of the proposed mining and within the KEPCO owned buffer zone.

When considering the impacts predicted on baseflow, it is important to understand the underlying assumptions within the groundwater model. The model assumes rainfall recharge occurs in climatic cycles similar to the Millennium Drought. This approach was adopted in the RTS and Supplementary RTS to incorporate the variability in climatic conditions that submissions had noted could influence water availability within the Bylong River water source. The periods of low baseflow occur during the drought cycle with the high peaks occurring when the drought breaks. In the model, the peak in baseflow reduction coincides with the peak in borefield demand; a conservative coincidence that exacerbates the drawdown and the loss of baseflow predicted by the model. It is during this year that a negligible 1.6 ML of baseflow is taken from the system on land not owned by KEPCO as shown in Figure 4-1 above.

As noted above the rainfall runoff events for an average year were estimated to generate flows within the Bylong River of between 263 and 697 ML/day. Therefore the 1.6 ML/year (or 0.004 ML/day) loss of baseflow predicted as a result of the Project on land outside the KEPCO owned buffer zone will not detectably affect the duration of surface water flows in the Bylong River catchment.

The results of the uncertainty analysis prepared by AGE (2016a) for the supplementary EIS were used to determine the upper limit to the baseflow reduction on private land. Figure 4-2 below shows the change in baseflow on private land for the:

- basecase scenario (also green line in Figure 4-1 above);
- 99th percentile due to the cumulative impact of the proposed mining and the borefield pumping;
- 99th percentile due to the proposed mining only; and
- 99th percentile due to the proposed borefield pumping only.

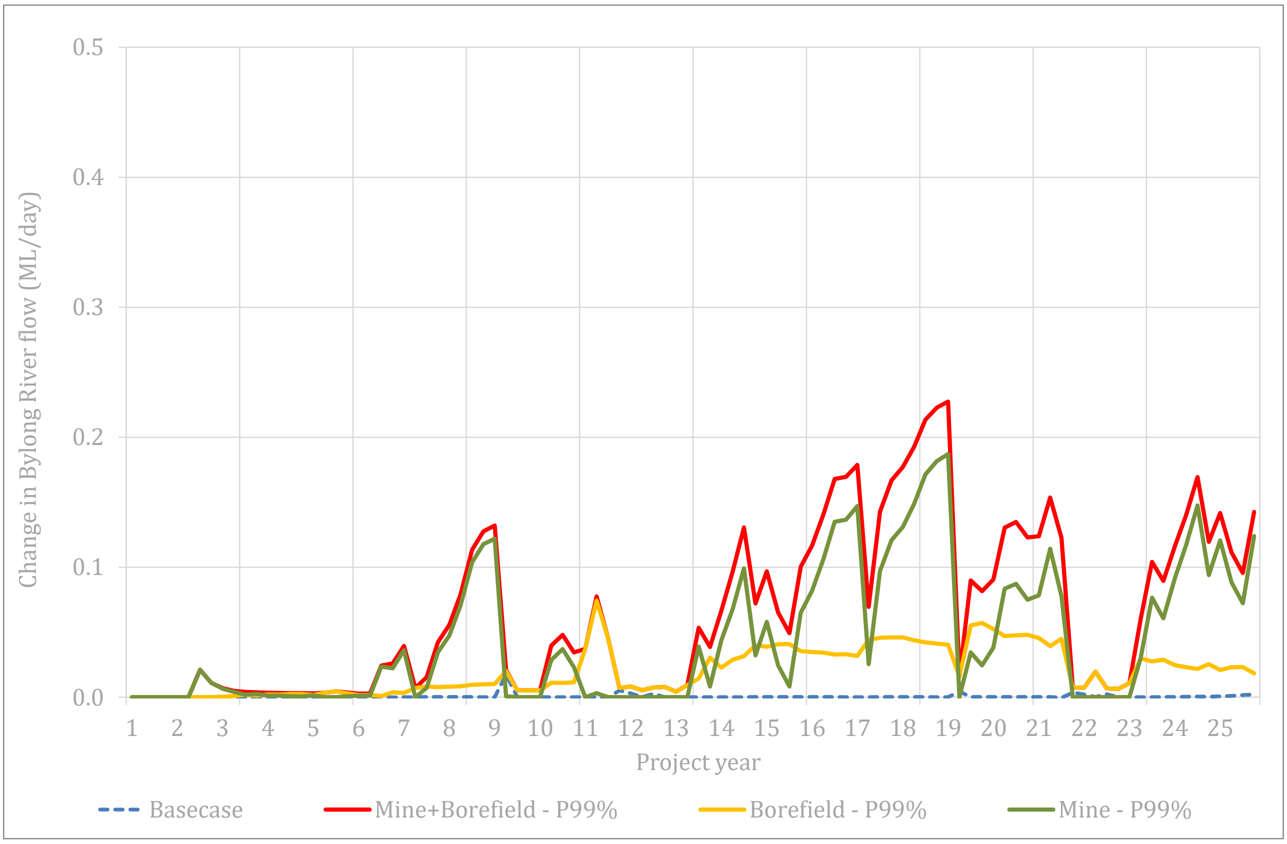


Figure 4-2 Change in baseflow on private land (99th percentile)

The results show that the mine activities create the majority for the baseflow reduction, accounting for up to 0.18 ML/day at the 99th percentile. As noted previously this flow reduction is negligible compared to total flow in the Bylong river flow of 263 to 697 ML/day. Borefield pumping accounts for just 0.07 ML/day at the 99th percentile, which is logical considering the private land is relatively remote from the proposed borefield.

When considering predictions of the numerical model, it is important to note natural behaviour of the Bylong River. Firstly the majority of the abstraction from the Bylong River water source is via wells because it is known that the surface water flows are unreliable. Therefore flow within the surface water system is not the primary water source for agriculture in the area, which is why the majority (98.9%) of the water access licences are for groundwater in the Bylong River water source.

Secondly, whilst there may not be reliable flow at the surface, which is a common situation for many Australian streams, there remains significant continuous flow underground through the alluvial aquifer as it is the only route for water to flow out of the Bylong valley. KEPCOs baseline monitoring has shown that during dry periods, groundwater levels within the alluvium fall below the bed of the streams in many areas as these systems are not deeply incised below much of the flood plain. During extended periods of below average rainfall, the streams form a chain of ponds along the drainage alignment which are windows to the water table, but with no continuous baseflow. Whilst the numerical model predicts a continuous baseflow, it is limited in its ability to represent the small ponds and undulations that occur within the flood plain in response to climatic conditions. The model therefore represents the average baseflow change along the entire alignment of the Bylong River rather than the flow to each of the pond systems.

KEPCO will account for all groundwater and surface water removed by the Project with water licences held for the relevant water source in accordance with NSW government policy described in the Aquifer Interference Policy (DPI-Water, 2012). This means there will be no net increase in the volume of water abstracted from the Bylong River water source beyond that already approved by abstraction by KEPCO and other owners of water access licences. The only difference is that the impacts of the Project's abstraction of groundwater will be monitored, whereas there is currently no requirement for the owners of water access licences to monitor their individual and cumulative impact on the water source.

5 Bioregional Assessment modelling

In May 2018, the Commonwealth Government released the results of numerical groundwater modelling of undertaken for the Hunter Region (Herron et al, 2018) as part of their Bioregional Assessment Program. The Bioregional Assessments (BA) aims to identify potential groundwater related issues from which the Commonwealth government's Independent Expert Scientific Committee (IESC) will refer to for assessed requirements for local-scale environmental impact assessments. Page 29 of the Key Findings report relevantly states:

> *This assessment predicts the likelihood of exceeding levels of potential hydrological change at a regional scale. It also provides important context to identify potential issues that may need to be addressed in local-scale environmental impact assessments of new coal resource developments. It should help project proponents to meet legislative requirements to identify the environmental values that may be affected by coal resource development, and to adopt strategies to avoid, mitigate or manage potential impacts. These assessments do not investigate the social, economic or human health impacts of coal resource development, nor do they consider risks of fugitive gases and impacts unrelated to water.*
>
> *Bioregional assessments are not a substitute for careful assessment of proposed coal mine or CSG extraction projects under Australian or state environmental law. Such assessments may use finer-scale groundwater and surface water models and consider impacts on matters other than water resources. However, the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (a federal government statutory authority established in 2012 under the EPBC Act) can use these assessment results to formulate their advice. Local data can be used to constrain results of the regional-scale modelling to better inform the management response.*

The IESC has provided advice over the Project on two occasions:

1. Gateway Certificate Application in correspondence dated 14 March 2014 providing responses to the requesting agencies queries; and
2. Submission on the EIS in correspondence dated 16 November 2015.

KEPCO's EIS and associated approvals documents have addressed the issues raised within the above correspondence. This has included detailed groundwater and surface water modelling to address the potential impacts of the Project to the surrounding hydrological regime.

Whilst time has not permitted an exhaustive review of the BA modelling, from an initial review it is clear there are significant differences between the broader scale BA approach and the EIS/RTS/Supplementary RTS numerical modelling. It is important to note these when considering the predictions of the BA. The differences relate to the:

- greater cell size in the BA model;
- no water level calibration points around the Bylong Project in the BA model;
- no representation of rivers and creeks adjacent to the Bylong Project in the BA model;
- agricultural and mining water abstraction exceeding licence entitlements in the BA model;
- representation of unsaturated flow in the BA model; and
- extreme representation of fracturing from longwall mining in the BA model.

The BA model adopted a minimum cell size of 500 m in plan view. This cell size is too coarse to allow key features of the Bylong Project that are less than 500m in extent to be accurately represented by the model. Keys features less than 500 m include the longwall mining panels and the bed rock buffer zone between the underground and open cut mining areas and the Bylong River that retards the connection to the alluvial aquifer. In contrast the modelling conducted for the Bylong Project approvals has a minimum cell size of 75m and down to 10m around the river/borefield which allows all key features to be represented.

The BA model uses water level observations from 64 groundwater monitoring sites to constrain model parameters. This is a very limited number considering the regional scale of the model. In addition, there are no water level observations in the vicinity to the Project which means the BA model is not calibrated for local conditions in the area of the Bylong project.

The BA model only represents the lower reaches of the Bylong River below the confluence with the Growee River. It does not represent the reaches of the Bylong River and Lee Creek adjacent the Bylong Project where impacts have been forecast by the approvals models. In addition the BA model assumes there is a permanent depth of 3 m of water in the Growee River and Bylong River. Photographs provided during the approvals process show this is not the case (AGE 2013, Figure 5.6).

The BA model assumes all water supply bores within the Bylong River and Growee River alluvium are able to abstract their full entitlement each year. In reality, KEPCO proposes to utilise a proportion of its alluvial entitlements to account for the predicted indirect impacts of mining. This means the BA modelling allows for abstraction from mining and licensed water bores that exceeds the allowable entitlements. This is not the case in the modelling for the approvals process that remains within the sustainable limits set by the capped entitlements system.

The BA model represents groundwater flow through the unsaturated zone (vadose zone). This approach uses the van Genuchten equations and requires parameters that determine permeability in the unsaturated zone. These values are derived for soils but are not commonly available for rock profiles introducing uncertainty to the model predictions. The modelling for the Project approvals process was changed to the 'pseudo soil' during the Supplementary RTS phase, so that it did not represent flow through the unsaturated zone and therefore did not require the uncertain parameters associated with the van Genuchten equations (refer to Section 6.1 of the Supplementary RTS).

Finally, the BA model represents the development of extreme fracture networks above longwall mining areas that extend 500m in height and 250m below the proposed mining areas for the Project. The hydraulic conductivity in the subsided zones is changed in the BA model by 9 to 20 orders of magnitude. This means that at the extremes the hydraulic conductivity can change by 100,000,000,000,000,000,000 times the base value at 20 orders of magnitude. This will result in hydraulic conductivity values well beyond that of known earth materials.

6 Summary and conclusions

The Supplementary RTS groundwater model for the Bylong Coal Project was updated to represent a reduced open cut mining footprint to confirm the impacts as requested by DPE. The numerical modelling indicated that the Revised Mine Plan slightly reduces the direct groundwater inflow to the open cut mining areas and the indirect water take/drawdown on the alluvial aquifers. Whilst there is some reduction in the drawdown and water take, the nature of the impacts on the alluvial aquifer remain essentially unchanged as it is the proposed borefield, which induces the majority of the impact on the alluvium. This is because the borefield extracts water directly from the alluvial aquifer via a network of bores, rather than an indirect impact from open cut mining that must propagate through the buffer zone of bedrock remaining between the mining area and the alluvium. The peak in the borefield demand occurs in year 9 of the project life, which coincides with a period of extended drought represented in the groundwater model, providing a conservative indication of the maximum drawdown within the alluvium.

The peak water take from the Permian/Triassic strata occurs due to underground mining and this remains unchanged. Therefore, the nature of the impacts presented in previous work for the approvals process remain essentially unchanged, and the measures proposed to account for, monitor and manage groundwater impacts remain appropriate.

KEPCO also requested AGE provide more information about the impact predicted by the numerical model on flow in Bylong River, in response to stakeholder concerns regarding the impacts to flows in Bylong River due to mining. The proposed mining for the EIS mine plan and the Revised Mine Plan will both reduce the baseflows in the Bylong River in the immediate vicinity of the Project components (on KEPCO owned land). This is because the river is highly connected to the alluvial aquifer. The modelling indicates that even during a period of extended drought and pumping from the borefield, the baseflow losses to land not owned by KEPCO will be negligible and will not result in impacts to the intermittent surface water flows currently experienced following rainfall. The Project will account for all groundwater and surface water removed with water licences in accordance with the NSW government Aquifer Interference Policy. This means there will be no net increase in the volume of water abstracted from the Bylong River water source should the Project be approved. KEPCO have prepared a Water Management Plan which identifies how the impacts will be monitored and managed including trigger action response plans for impacts on groundwater and surface water.

In summary the Revised Mine Plan reduces the impact on the groundwater and surface water systems (via baseflow) during mining and post-mining. Therefore, impacts presented in the Supplementary RTS should be considered worst case.

7 References

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Department of Primary Industries (2012) "*NSW Aquifer Interference Policy: NSW Government policy for the licensing and assessment of aquifer interference activities*", September 2012, ISBN 978 1 74256 338 1

Appendix A Tabulation of water licencing requirements

A.1 Model water budgets and water licensing for the Revised Project mine plan

Year	Numerical model water budget item (ML/year)					Water licensing (ML/year)					
						Hunter Unregulated WSP			North Coast WSP		
	(a) Permian to alluvium flow change	(b) borefield pumping	(c) agricultural pumping (capped)	(d) stream flow change	(e) mine inflow	(f) Surface water take (=d)	(g) Ground water take (=a+b+c-d)	Total water take (=f+g)	Ground water take (=e)	Surface water take (=0)	Total water take (=e+0)
1	0	0	714	0	0	0	714	714	0	0	0
2	0	0	714	0	6	0	714	714	6	0	6
3	-73	1,000	714	372	44	372	1,269	1,641	44	0	44
4	-76	1,150	714	529	54	529	1,259	1,788	54	0	54
5	-65	1,100	714	641	53	641	1,108	1,749	53	0	53
6	-88	1,189	714	502	49	502	1,313	1,815	49	0	49
7	-78	1,071	714	565	76	565	1,142	1,707	76	0	76
8	-68	901	714	474	70	474	1,073	1,547	70	0	70
9	-17	960	714	920	702	920	737	1,657	702	0	702
10	3	960	714	662	1,675	662	1,015	1,677	1,675	0	1,675
11	41	800	714	729	2,065	729	826	1,555	2,065	0	2,065
12	55	720	714	630	1,812	630	859	1,489	1,812	0	1,812
13	13	710	714	383	1,498	383	1,054	1,437	1,498	0	1,498
14	9	710	714	421	1,148	421	1,012	1,433	1,148	0	1,148
15	10	710	714	489	1,006	489	945	1,434	1,006	0	1,006
16	0	710	714	417	725	417	1,007	1,424	725	0	725

Year	Numerical model water budget item (ML/year)					Water licensing (ML/year)					
						Hunter Unregulated WSP			North Coast WSP		
	(a) Permian to alluvium flow change	(b) borefield pumping	(c) agricultural pumping (capped)	(d) stream flow change	(e) mine inflow	(f) Surface water take (=d)	(g) Ground water take (=a+b+c-d)	Total water take (=f+g)	Ground water take (=e)	Surface water take (=0)	Total water take (=e+0)
17	-6	710	714	491	751	491	927	1,418	751	0	751
18	0	710	714	432	1,471	432	992	1,424	1,471	0	1,471
19	19	710	714	691	2,492	691	752	1,443	2,492	0	2,492
20	18	710	714	496	2,776	496	946	1,442	2,776	0	2,776
21	40	710	714	588	3,387	588	876	1,464	3,387	0	3,387
22	54	710	714	559	2,999	559	919	1,478	2,999	0	2,999
23	17	710	714	372	4,099	372	1,069	1,441	4,099	0	4,099
24	33	710	714	417	3,202	417	1,040	1,457	3,202	0	3,202
25	36	710	714	487	3,952	487	973	1,460	3,952	0	3,952