DEPARTMENT OF PLANNING AND INFRASTRUCTURE

STRATFORD EXTENSION PROJECT

INDEPENDENT REVIEW OF GROUNDWATER ASSESSMENT

DUNDON CONSULTING PTY LTD

30TH JUNE 2013

13-0262-R01

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1 PROJECT BACKGROUNDS

The Stratford open cut mine operated by a subsidiary of Gloucester Coal Limited (GCL) is located about 10 km south of the township of Gloucester, and has been operating since 1995, extracting coal from the upper and middle seams of the Gloucester Coal Measures. There are several open pits, including Stratford Main Pit, Bowen Road North Pit and Roseville West pit. Mining has ceased at the Stratford Main Pit which is now used for disposal of coal rejects and water storage. The Bowen Road North Pit and the Roseville West Pit started operation in 2003 and 2007 respectively, and both are still in production.

The proposed Stratford Coal Extension consists of the following:

- A continuation and extension of the mining operations for a further 11 years;
- Extension of the current Roseville West Pit to the west and south;
- Two additional open cuts – Avon North and Stratford East; and
- Extension of the Stratford and Northern Waste Emplacements.

The proposed Rocky Hill Coal Project is located approximately 3.5 to 5 km south-east of the township of Gloucester. The project is owned by Gloucester Resources Limited (GRL). GRL intends to apply for a development consent under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for an open cut mining operation and associated surface infrastructure for a 21 year mining operation.

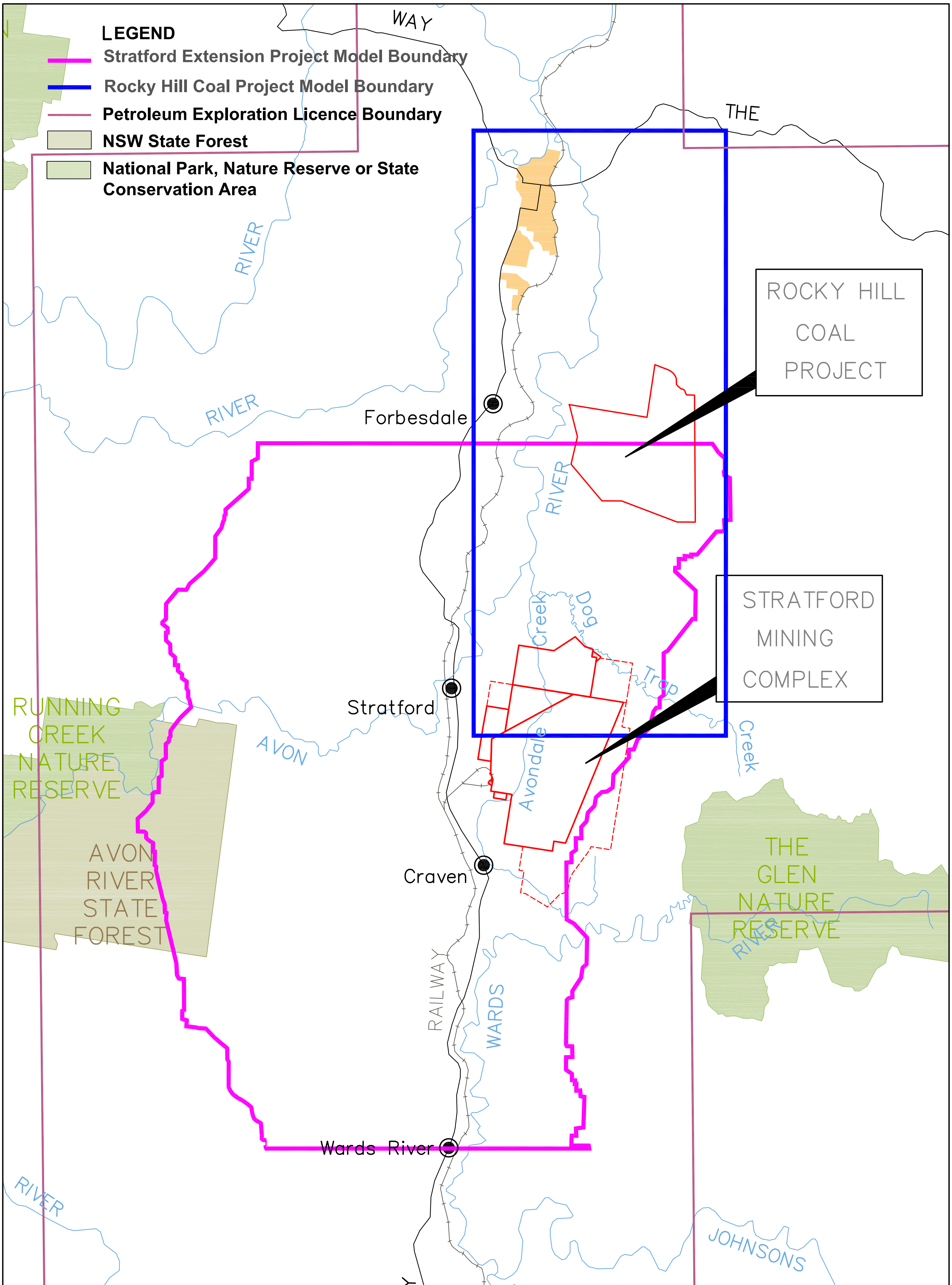
An EIS is being prepared by R W Corkery & Co Pty Ltd (RWC) in support of the application. Australasian Groundwater and Environmental Pty Ltd (AGE) has prepared a groundwater assessment report as one of the supporting specialist studies for the project.

The Rocky Hill Project consists of four principal components, viz:

- Four separate and/or contiguous open cut pits and a coal handling and preparation plant (CHPP);
- An overland conveyor for transport of product coal to a rail load-out facility;
- A rail load-out facility;
- Two power line corridors incorporating a re-located 132 kV power line and a new 11 kV power line.

The proposed production rate is 2.5 Mtpa ROM coal, with a project life of 21 years.

The locations of the two projects and the model areas applied to each, are shown on **Figure 1**.



DATE:	30 June 2013	SCALE:	1 : 125 000
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Dundon Consulting Pty Ltd

Department of Planning and Infrastructure

Model Extents for Stratford Extension Project and Rocky Hill Coal Project

Figure 1

2 SCOPE OF THIS GROUNDWATER REVIEW

Department of Planning and Infrastructure (DoPI) has requested Dundon Consulting Pty Ltd to undertake an independent review of the groundwater assessments undertaken for the Stratford Extension Project and the Rocky Hill Coal Project.

The scope of this independent review of the groundwater assessments for the two projects was detailed in the DoPI brief, as follows:

- *"Review the groundwater assessment in the EIS for the Stratford Extension project.*
- *Review the groundwater assessment in the draft EIS for the Rocky Hill coal project.*
- *Provide a comparative analysis of the two assessments, including a description of the regional groundwater system and consideration of whether the two groundwater models adequately represent this system.*
- *Provide advice on the appropriateness of the area covered by each groundwater model.*
- *Provide a description of the groundwater impacts of each project, having regard to GDEs, groundwater uses and alluvial aquifers.*
- *Provide advice on whether the cumulative assessment in each project is reasonable and adequate – including its consideration of the AGL gas project.*
- *Provide advice on whether the consideration of faults and shears is reasonable and adequate.*
- *Provide advice on any errors, absences, inaccuracies and failures to apply or adhere to groundwater and aquifer policies."*

The completion date for the review is 30 June 2013.

2.1 Documents Reviewed

The following documents have been reviewed to assist with the preparation of this report:

- *Stratford Extension Project Environmental Impact Statement, dated November 2012.*
- *Appendix A of the EIS – Groundwater Assessment – A Hydrogeological Assessment in Support of the Stratford Coal Project EIS, prepared by Heritage Computing, dated April 2012.*
- *Submission from EPA on Stratford Extension Project, comprising letter to DoPI dated 25 January 2013 and attachment 1.*
- *Letter from NOW to DoPI dated 23 May 2013, referring to EPA submission on Stratford Extension Project and proponent's response.*
- *Submission from Great Lakes Council on Stratford Extension Project, comprising letter to DoPI dated 25 January 2013 and attachments A to D.*
- *Submission by Gloucester Shire Council on Stratford Extension Project, comprising a report entitled "Stratford Extension Project – SSD 4966 – Submission by Gloucester Shire Council to an Exhibition of the Environmental Impact Statement and Development Application", dated January 2013.*
- *Stratford Extension Project – Response to Submissions, dated 2013.*
- *IESC Advice to Decision Maker on Coal Mining Project, re Stratford Extension Project, dated 20 February 2013.*

- *Rocky Hill Coal Project – Groundwater Assessment, prepared by Australasian Groundwater and Environmental Consultants Pty Ltd, dated November 2012.*

3 STRATFORD EXTENSION GROUNDWATER ASSESSEMENT

3.1 Groundwater Assessment Report

The groundwater assessment has been prepared by Heritage Computing Pty Ltd, and was finalised for public exhibition in April 2012.

The Heritage Computing report of 72 pages with figures and attachments AA to AE, comprises the following sections:

- Hydrogeological setting
- Conceptual model
- Scenario analysis
- Impacts on the groundwater resource
- Climate change and groundwater
- Management and mitigation measures
- Model limitations
- Conclusions
- Bibliography.

3.2 Overall Adequacy of the Assessment Report

I consider that the groundwater assessment overall is a sound document, that has been prepared in accordance with due consideration of the requirements of groundwater policies and relevant legislation.

The groundwater modelling has been undertaken generally in accordance with the Australian Groundwater Modelling Guidelines (MDBC, 2000; and Barnett, et al, 2012). I believe that the study has been appropriately conservative in its approach to impact assessment, and cumulative impact assessment with the other projects in the area, namely the Rocky Hill Coal Project and the AGL Coal Seam Gas Project.

A small number of omissions have been identified and listed in Section 5.3.14, and it is recommended that they be addressed in any supplementary report or report revision. Based on other information in the report, I do not consider that any of these omissions will cause me to alter my overall conclusion that the impact assessment is acceptable.

4 DRAFT ROCKY HILL GROUNDWATER ASSESSMENT

4.1 Groundwater Assessment Report

The Rocky Hill EIS is not yet publically available, but the DoPI has provided me with a draft of the groundwater assessment report, which was prepared by Australasian Groundwater and Environmental Consultants Pty Ltd. The draft report I have reviewed is dated November 2012. It comprises a 144 page report incorporating figures, with 6 appendices.

The AGE report comprises the following sections:

- Legislation, policies and guidelines
- Regional Setting
- Field investigation program
- Hydrogeological regime
- Surface water
- Mine plan
- Numerical groundwater model
- Prediction simulations
- Mitigation
- Water quality
- Water licensing
- Groundwater monitoring system
- References

4.2 Overall Adequacy of the Assessment Report

I consider that the groundwater assessment overall is a sound document, that has been prepared in accordance with due consideration of the requirements of groundwater policies and relevant legislation.

The groundwater modelling has been undertaken generally in accordance with the Australian Groundwater Modelling Guidelines (MDBC, 2000; and Barnett, et al, 2012). I believe that the study has been appropriately conservative in its approach to impact assessment, and cumulative impact assessment with the other projects in the area, namely the Stratford Extension Project and the AGL Coal Seam Gas Project.

A small number of omissions have been identified and listed in Section 5.4.14, and it is recommended that they be addressed in any supplementary report or report revision. Based on other information in the report, I do not consider that any of these omissions will cause me to alter my overall conclusion that the impact assessment is acceptable.

5 COMPARATIVE ANALYSIS OF THE TWO ASSESSMENTS

5.1 Description of the Regional Groundwater System

Setting

The two projects are both located in the Gloucester Basin, approximately 100 km north of Newcastle in NSW. The Stratford project is located 10 km south of the township of Gloucester (Heritage, 2012), while the Rocky Hill project is reported to be 3.5 to 7 km south-east of Gloucester (AGE, 2012). The township of Stroud is located about 30 km south of Gloucester, and Dungog about 35km southwest. The Duralie coal mine is located some 15 km south of Stratford mine, between the Stratford mine and Stroud.

Mining History

The Stratford open cut mine, operated by a subsidiary of Gloucester Coal Limited (GCL), is located about 10 km south of the township of Gloucester, and has been operating since 1995. There are several open pits, including Stratford Main Pit, Bowen Road North Pit and Roseville West pit. Mining is currently extracting coal from the upper and middle seams of the Gloucester Coal Measures. Mining has ceased at the Stratford Main Pit which is now used for disposal of coal rejects and water storage. The Bowen Road North Pit and the Roseville West Pit started operation in 2003 and 2007 respectively, and both are still in production.

The Duralie Coal Mine (DCM) is also operated by a subsidiary of GCL and is located about 20 km south of the Stratford mine.

AGL Coal Seam Gas (CSG) Project

AGL Upstream Gas Pty Ltd (AGL) holds a Petroleum Exploration Licence (PEL) which covers the entire Gloucester Basin. AGL is proposing to develop the Gloucester Gas Project, Stage 1 of which involves the drilling and completion of 110 CSG wells. Gas production will involve pumping of groundwater from the wells, leading to depressurisation of and recovery of gas from the coal measures.

Project approval for Stage 1 has been granted to AGL.

Climate

The area has a temperate climate and receives moderate to high rainfall. Rainfall records are available from the Gloucester PO (Site 060015), Stroud PO (Site 061071), and Craven - Longview (Site 060042). Average annual rainfalls from these three stations range from 985 mm to 1147 mm per year.

Evaporation data from the Chichester Dam station shows annual average evaporation to be 1061 mm. Bureau of Meteorology records suggest evapotranspiration for the Gloucester area is about 750 mm per annum (BOM, 2011).

The rainfall residual mass curve, which plots cumulative deviation of actual monthly rainfalls from long-term average monthly rainfalls (**Figure 2** below), shows that over the period of record, from about 1895 to 1945 was a period of below average rainfall, which was then followed by a more average rainfall pattern until the present time. In the immediate recent past, the rising trend on the curve shows that rainfall has been slightly above average over the period since June 2007, after a generally below average rainfall period which had extended from May 2004 to June 2007.

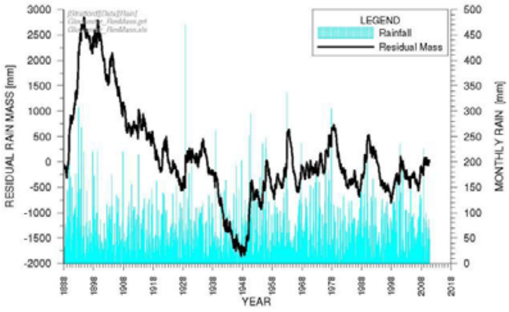


Figure A-4 Rainfall Residual Mass Curve for Gloucester Post Office (since 1888)

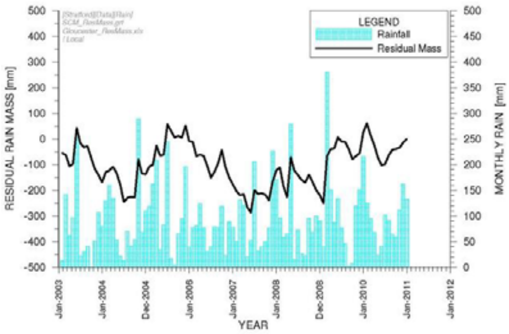


Figure A-5 Rainfall Residual Mass Curve for Stratford Coal Mine Meteorological Station

Figure 2: Rainfall Residual Mass Curve – Cumulative Deviation from Monthly Average Rainfall

Topography and Drainage

The topography of the area is controlled by the geology, which comprises Carboniferous New England Fold Belt units, overlain by the Permian coal measures, which are in turn overlain by alluvium close to the major watercourses.

Both coal projects are located within the upper catchment of the Manning River. The main river locally is the Avon River, which flows in a northerly direction within the basin. The headwaters of the Avon River are to the west of the Stratford project, and local tributaries Avondale Creek and Dog Trap Creek drain the mine area, joining the Avon just north of the project. Stratford is very close to the catchment divide, which is about 1.5 km south of the project. The land beyond the catchment divide drains w=southward in the Wards River catchment.

A tributary of the Avon River, Waukivory Creek, skirts around the southern and western sides the Rocky Hill mining lease area, and joins the Avon River just west of the project.

The outcropping basement New England Fold Belt rocks form elevated flanks to the east and west of the north-south valley area within which the two projects are located.

Geology

The two projects are located within the northern part of the Gloucester Basin, a north-south trending synclinal structure 40 km long by 13 km wide. The Gloucester Basin Coal Measures are of Permian age, and contain several coal seams, separated by interburden sediments that include conglomerate, sandstone, siltstone and mudstone. The underlying Early Permian and Carboniferous volcanic rocks occur in outcrop along the eastern and western flanks of the basin.

Subsequent periods of deformation have resulted in extensive faulting within the basin. In the eastern flank and southern section of the basin, north-south orientated thrust faulting has led to the repetitions of the coal seams one above the other, with the seams also displaying distorted bedding and cleating close to the faults, but limited brecciation. East-west orientated normal faults are also present, with accompanied displacement of the coal seams.

The Gloucester Coal Measures Group is separated into two sub-groups – Avon Subgroup (Middle Permian) and Craven Subgroup (Upper Permian). The deepest seams occur in the underlying Dewrang Group, also of Permian age. The Dewrang Group is underlain by the basement rocks of the Carboniferous Alum Mountain Volcanics.

The coal seams are relatively steeply dipping (up to 45º) on the flanks of the Basin.

The coal seams of interest to the two projects are listed in **Table 1**.

Table 1: Target Coal Seams – Stratford and Rocky Hill Projects

Group	**Sub-Group**	**Formation**	**Coal Seams**	
			Stratford Extension	**Rocky Hill**
Gloucester Coal Measures Group	Craven	Woods Road (Leloma)	Marker (M7)	
			Bindaboo	
			Deards	
		Bucketts Way	Cloverdale	Cloverdale
			Roseville	Roseville
		Wenham	Bowens Road	Bowen Road
	Avon	Waukivory Creek	Avon	Avon
Dewrang Group	-	Weismantel		Weismantel
		Duralie Road	Cheer-up	
			Clareval	

The overburden and interburden sediments are reported to be quite variable across the basin.

AGE (2012) reported that the alluvial deposits associated with Avon River and Waukivory Creek comprise an upper clay layer, above coarse-grained sands and gravels. Both Heritage (2012) and AGE (2012) reported that the alluvium is less extensive than suggested by the published geological maps. AGE reported that the alluvium appears to be more permeable closer to the Rocky Hill Project than around the Stratford Project, based on work they have undertaken recently for the Rocky Hill Project (AGE, 2012) and earlier work for the Stratford Project (AGE, 2000).

Hydrogeological Units

AGE (2012) and Heritage (2012) both recognise three distinct aquifer systems in the area, viz:

- Fractured Permian coal measures
- Weathered rock and colluvium (regolith)
- Alluvium associated with the floodplains of the Avon River and the larger creeks.

Within the Permian coal measures, the coal seams are relatively more permeable than the interburden sediments, and in a relative sense represent aquifers and aquicludes respectively.

The Alum Mountain Volcanics, of Carboniferous-Early Permian age, is the basement unit underlying and flanking the coal measures.

Existing Groundwater Use

Heritage reported that there is little reliance on groundwater bores as a water supply source, and identified 62 registered groundwater bores within approximately 5 km of any existing or proposed open cut pits on the Stratford Project. The majority (48) are on land owned by GCL, and one is on land owned by AGL.

The remaining bores are privately owned, and are licensed for stock and domestic use. Eleven (11) are in the Stratford township, and one (GW079759) is located well south of Stratford.

AGE reported 20 registered bores in the local area, of which eight (8) are located within 3 km of the Rocky Hill Mine Area boundary. The closest private bore is 1 km west of the Mine Area Boundary, and on the western side of the Avon River. The groundwater supplies are in some cases drawn from the alluvium, and in others from the Permian.

5.2 Comparison of the Two Groundwater Models

Modelling Guidelines

Both reports claim that their modelling conforms with the Australian Groundwater Modelling Guideline (MDBC, 2000).

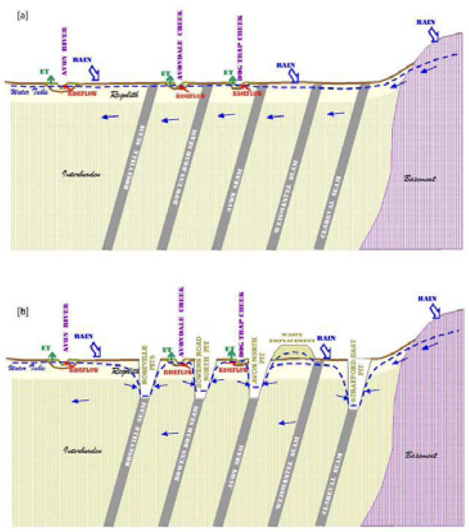
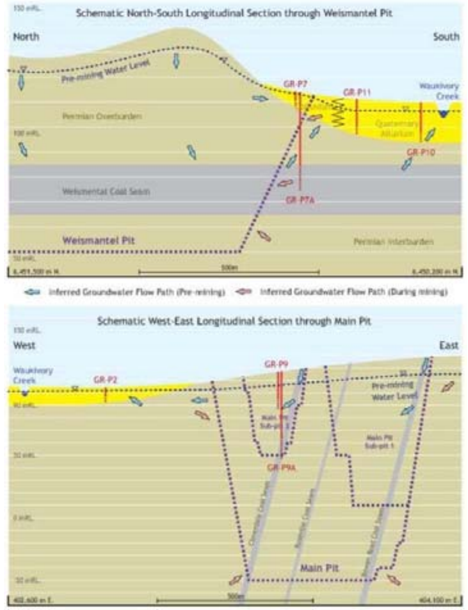
A new set of guidelines were released in 2012 (Barnett, et al, 2012). This release occurred after the Heritage report was finalised, and also after the AGE model had been set up. AGE comment in their report that in their opinion their model conforms with the new guidelines as well.

Comparison of Model Features

The main features of the groundwater modelling approach and model set up are compared in **Table 2** below.

Table 2: Groundwater Modelling Features – Comparison Between Stratford Extension and Rocky Hill Groundwater Assessments

Issue	Stratford Extension	Rocky Hill	Comment
Model Software	Heritage employed the three dimensional finite difference model code MODFLOW-SURFACT Version 4 (Hydrogeologic, 2010) for the Stratford Extension model, using the Groundwater Vistas (Version 6.11) software interface.	AGE employed MODHMS (Hydrogeologic, 2001), which includes a 3-D MODFLOW compatible simulator as well as additional modules to simulate 2-D overland surface flow and 1-D channel surface flow and solute transport.	Both models are based on the long-time industry standard MODFLOW software code developed by the USGS (McDonald-Harbaugh, 1988). In recent years, MODFLOW-SURFACT has become the standard for simulation of coal mining projects, due to its ability to accommodate saturated and unsaturated flow, and the ability to de-saturate and re-saturate model cells without the "dry cell" problems of standard MODFLOW. MODHMS is reported to have all the features of MODLOW-SURFACT, in that it can accommodate both saturated and unsaturated flow. It has the added capacity to simulate systems with strong surface water and groundwater interactions.
Conceptual Model	The Heritage conceptual model comprises the following: • Two groundwater systems are recognised (fractured rock groundwater system and alluvial groundwater system). • The conceptual model is illustrated by diagrams for pre-mining and during mining:	The AGE conceptual model can be summarised as follows: • There are three distinct groundwater systems (Permian coal measures, shallow weathered rock/colluvium and alluvium). • The conceptual model is illustrated by diagrams for pre-mining and during mining:	The conceptual models are essentially similar between the two projects. There are minor differences in the detail, but they are not material differences.

Issue	Stratford Extension	Rocky Hill	Comment
	 Figure A-25 Conceptual Groundwater Models [a] Natural conditions; [b] During mining. • Recharge occurs from rainfall and runoff infiltration, lateral groundwater flow and some leakage from streams and surface water storages. The dipping coal seams are expected to receive enhanced recharge where they subcrop or outcrop. • Groundwater levels are controlled by topography, geology and stream levels. Groundwater locally mounds beneath hills. • Groundwater discharges as baseflow to streams or evapotranspiration.	 • Recharge occurs from rainfall, lateral groundwater flows at the boundary of the Study Area, and leakage from the main rivers and tributaries. Groundwater inflow to the alluvium from the bedrock is considered to be low. During high flow events in ephemeral creeks, some recharge can occur from the creeks to the alluvium. • Groundwater levels are controlled by topography, with mounds beneath the hills and gradients to low-lying areas. • Groundwater discharges as baseflow	

Issue	Stratford Extension	Rocky Hill	Comment
	• During mining, potentiometric levels in hard rock aquifer will decline, but water table levels will tend to rise beneath waste rock emplacements.	to streams or evapotranspiration.	
Model Area	The Stratford Extension model extends between MGA Eastings 392325 and 407500 and Northings 6435000 and 6452000. This is an area of about 17 km (N-S) by 15 km (E-W), or 255 km^2, of which 170 km^2 is active in the model. Heritage selected the regional extent of their model taking into account that mining is distributed between 4 pits, and to include the cumulative impacts of CSG production. When the Rocky Hill proposal was made available in February 2012, Heritage found that the Rocky Hill project was located coincident with the northern boundary of the Stratford Extension model. The eastern and western boundaries coincide with the extent of Permian outcrop, while the northern and southern are arbitrary boundaries.	The Rocky Hill model covers an area of approximately 14.5 km (N-S) by 6 km (E-W), or 87 km^2. The boundaries of the AGE model are based on geological features on the eastern and northern sides, namely the limit of Permian sediments. The western boundary is located in the central part of the basin, where the coal seams are believed to be about 100m deep and considered likely to be very low permeability. The southern boundary coincides with the location of the existing Stratford mine, 6 km beyond the southern boundary of the Rocky Hill mine area.	The two models were set up independently of each other, and model development was well advanced before the details of both projects were clear. Each model focused on the project being assessed. As a result, the two models do not overlap significantly. The model areas are shown compared on **Figure 1**. The Rocky Hill Project is located close to the northern boundary of the Stratford Extension model. Conversely, the Stratford Project operations are located close to the southern boundary of the Rocky Hill model. Therefore neither model is able to independently simulate the two projects in their model runs due to the boundary effects of the model, and both Heritage and AGE adopted the impacts from each other's model to assess the cumulative impacts. This is considered to be acceptable, as the impacts from the two projects do not intersect, and therefore there is unlikely to be any cumulative impact of the two projects operating together.

Issue	Stratford Extension	Rocky Hill	Comment
Model Boundary Conditions	In the Stratford model, the western and eastern boundaries are no flow boundaries. The northern and southern boundaries have no specified boundary condition. Internal boundary conditions were specified as follows: • Major and minor streams are specified as 'river' cells in model Layer 1 (occasionally Layer 2), using the MODFLOW RIV package that allows water to flow in both directions between the stream and the groundwater. River conductances vary from 25 to 100 m^2/d. • Mining areas are specified as 'drain' cells using the MODFLOW DRN package, that allows flow from the groundwater to the cell but not the reverse. Drain conductances of 1000 m^2/d were used. • Rainfall recharge was set as percentages of rainfall over specified zones. Rates derived from the transient calibration modelling that were then used in the prediction model runs ranged from 0.25 % to 8 % (as detailed below). • Evapotranspiration was applied uniformly using MODFLOW's linear function with a maximum rate of 0.4	In the Rocky Hill model, the majority of the model boundaries were set as no flow boundaries in all layers. Limited cells in Layer 1 were set as constant head boundaries to represent inflow (upstream) and outflow (downstream) from the Quaternary alluvium. Internal model boundaries were set as follows: • In the steady state model, 'drain' cells were assigned to the river and creek lines, using the DRN package. In the transient model, the Avon River, Waukivory Creek and other major creeks and tributaries were simulated using the channel flow package in MODHMS, while ephemeral creeks were set as 'drain' cells. • Surface runoff from upper catchment areas were estimated based on catchment size and runoff coefficients and applied to the starting segments of the river and tributary streams. • Critical depth boundary conditions were applied to the outlets of channel flow and overland flow. • For the prediction modelling, recharge was applied across the model domain to the overland surface for the integrated transient model, rather than using the standard MODFLOW application of recharge. Recharge	It is difficult to do a complete comparison of the boundary conditions adopted in each model, due to the different modelling software used. There are no significant differences in the conceptualisation of the boundary conditions, but there are some differences in the specific parameters used, principally recharge rates. Some comparison of the recharge rates is possible, because the AGE model used rainfall percentages for the steady state simulation, using the MODFLOW recharge module. There are some differences in recharge rates between the two assessments. This is discussed further below. Note that for the transient calibration and the transient prediction runs, AGE did not use the MODFLOW recharge module, but instead used the surface water flow features of MOD-HMS. Another difference is in the use of RIVER cells by Heritage and DRAIN cells by AGE for the rivers and streams (again for the steady state calibration model only in the case of the AGE assessment). River cells allow flow from the groundwater to the streams and vice versa. Drain cells only allow flow from the groundwater to the streams. The evidence suggests that in a pre-mining

Issue	Stratford Extension		Rocky Hill		Comment
	mm/d and extinction depth of 2 m.		rates applied in the steady-state model run were Quaternary alluvium – 1% annual rainfall; weathered Permian – 0.1% of annual rainfall; hills and slope wash zone – 5% of annual rainfall. • Evapotranspiration Et was applied on the overland surface and from model Layer 1 in the integrated transient model.		condition, there is unlikely to be significant flow from the streams into the groundwater, but during mining there could well be a reversal of gradient in some areas. Therefore I consider that in general RIVER cells should be preferred for perennial streams at least. However, the use of DRAIN cells by AGE is not considered to be a critical shortcoming, as AGE only used DRAIN cells for their pre-mining simulation.
Model Layers and Geometry	**Stratford Model**		**Rocky Hill Model**		The Stratford model has 13 layers, and the Rocky Hill model 10. Apart from the inclusion of Layers 10-12 in the Stratford model to accommodate the Clareval Seam, and slight differences in the seam definition, the model layer structures are fundamentally similar. In both models, Layer 1 comprises alluvium where it is present. In other areas, Layer 1 represents regolith (colluvium / weathered bedrock). Heritage reported that where a model layer contains multiple seams and multiple interburdens, the layer has been assigned a thickness equal to the total thickness of all seams, and the interburden between the seams is assigned to the overlying aquitard layer.
	Layer	**Lithology**	**Layer**	**Lithology**	
	1	Alluvium	1	Alluvium	
	1	Regolith/weathered Permian	1	Colluvium/weathered material	
	2	Leloma Formation	2	Overburden above Cloverdale Seam	
	3	Bindaboo/ Cloverdale/ Roseville Seams	3	Cloverdale Seam to top of Roseville Seam	
	4	Wards River Conglomerate	4	Interburden	
	5	Bowens Road Seam	5	Bowen Road Seam	
	6	Dog Trap Creek Formation	6	Interburden	
	7	Avon/Triple Seams	7	Avon Seam	
	8	Waukivory Creek Formation	8	Interburden	
	9	Weismantel Seam	9	Parkers Road and Weismantel Seams	
	10	Upper Duralie Road Formation			
	11	Clareval Seam			
	12	Lower Duralie Road Formation			
	13	Alum Mountain Volcanics	10	Alum Mountain Volcanics	

Issue	Stratford Extension	Rocky Hill	Comment
Model Cell Size	The Stratford model has a uniform cell size of 50 m by 50 m.	The Rocky Hill model uses variable cell size, ranging from 50 m by 50 m within the Mine Area to 100 m by 100 m outside the Mine Area Boundary.	Cell size selection is appropriate in both models.
Model Hydraulic Parameters	Heritage reported that field testing results suggest hydraulic conductivities of 0.04 to 0.5 m/d for shallow coal, and decreasing to 10^{-4} m/d at depth; and interburden values of 0.003 to 0.1 m/d near surface, decreasing to 10^{-6} to 10^{-3} m/d at depth. The Stratford model adopted depth-variable hydraulic conductivity values for the coal seams and the interburden, with hydraulic conductivities assumed to decrease with depth in 100m increments, as follows: Coal $K = 0.4211\ e^{(-0.014 \times depth)}$ Rock $K = 0.0057\ e^{(-0.025 \times depth)}$. Calibrated hydraulic properties that were used for the prediction modelling were as follows:	AGE relied on the results of hydraulic conductivity testing performed on 13 groundwater monitoring bores constructed within the Mine Area. They also relied upon the results of testing by AGL and Stratford Coal Mine. Alluvium hydraulic conductivity values varied from 0.3 m/d to 150 m/d (plus one test result of 100-500 m/d reported by AGL). Colluvium/regolith hydraulic conductivity values were determined at two sites – with values of 0.08 m/d and 0.015 m/d. Permian hydraulic conductivity values from AGL's testing ranged from 2 x 10^{-6} m/d to 20 m/d. Coal seam conductivities were reported in the range 0.002 to 0.03 m/d. Hydraulic properties derived from the model calibration, and used for the prediction modelling, were as follows:	Both assessments made use of the results of field and/or laboratory testing to derive representative starting values for hydraulic conductivity. Both Heritage and AGE recognised that conductivity is depth-dependent within the coal seams. Both Heritage and AGE applied an algorithm to attempt to represent this feature in their respective models. Hydraulic properties other than hydraulic conductivity are difficult to determine by testing, and are generally derived from the model calibration process. Both assessments used the calibration process to derive appropriate parameter values for use in their prediction models.

Issue	**Stratford Extension**			**Rocky Hill**			**Comment**
Hydraulic Conductivity	**Lithology**	**Kh (m/d)**	**Kv (m/d)**	**Lithology**	**Kh (m/d)**	**Kv (m/d)**	Heritage used a more complex distribution of hydraulic conductivity than AGE. Overall, there is reasonable consistency between the assigned parameters, with the following exceptions: • Hydraulic conductivity of colluvium/regolith is 2-3 orders of magnitude lower in the AGE model. • Higher hydraulic conductivity values for the coal seams at very shallow depth are recognised in the Heritage model, but not in the AGE model. • Hydraulic conductivity of the coal seams at depth is about 1 order of magnitude lower in the Heritage model than in AGE's model.
Layer 1	Alluvium (channels)	10	1	Alluvium	5	0.5	
	Alluvium (floodplain)	0.2	0.002				
	Spoil	1	1	Spoil	1	1	
	Western co-disposal	0.01	0.0001				
	Colluvium/ regolith	0.2	0.002	Weathered Permian (regolith)	0.005	0.0005	
	Colluvium/ regolith (Village)	2.35	0.041				
Rock / Interburden	Rock 0-100m	6.78×10^{-3}	7.47×10^{-4}	Permian interburden	4×10^{-3}	4×10^{-4}	
	Leloma Formation	1.0×10^{-5}	7.15×10^{-4}				
	Leloma Formation (Village)	6.78×10^{-5}	1.12×10^{-3}				
Coal	***0-100m***			***0-170m***			
	Avon North, Stratford East pits	0.05	0.01	Coal seams and minor interburden	0.0264	0.00264	
	Bowens Rd North pit	0.4	0.05				
		1	0.1				
	Roseville pit	0.04	0.01				
	100-200m						
	Avon North, Stratford East pits (100-200m)	0.02	0.01				
	200-300m			***170-270m***			

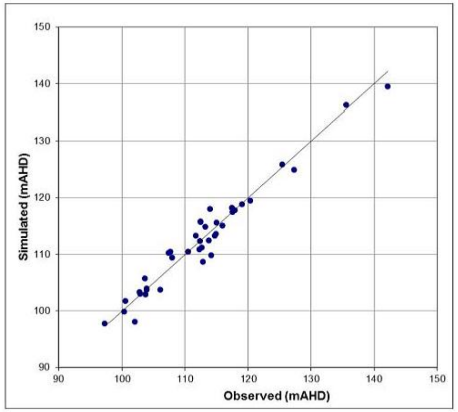
Issue	Stratford Extension			Rocky Hill			Comment
	Stratford East pit (200-300m)	1.28×10^{-4}	1.0×10^{-3}	Coal seams and minor interburden	2.64×10^{-3}	2.64×10^{-4}	
	300-400m			***270-370m***			
	Stratford East pit (300-400m)	2.47×10^{-5}	2.99×10^{-4}	Coal seams and minor interburden	2.64×10^{-4}	2.64×10^{-5}	
Storage	**Lithology**	**Sy**	**S**	**Lithology**	**Sy**	**S**	There are some differences between the models, but they are not considered material to the results. Most of the differences are related to the more complex parameterisation in the Heritage model.
Layer 1	Alluvium (channels)	0.2	-	Quaternary alluvium	0.05	0.0002	
	Alluvium (floodplain)	0.05	-				
	Western co-disposal	0.01	-	Spoil	0.1	Ss = 0.001	
	Spoil	0.1	0.005				
	Colluvium/ regolith	0.01	-	Weathered Permian	0.05	0.0002	
Coal	0-100m Avon North, Stratford East, and Roseville pits	0.01	0.0005	Coal seams and minor interburden	0.005	0.00001	
	0-100m Bowens Rd North pit	0001	0.001				
		0.01	0.001				
	100-400m All areas	0.005	0.0001				
Rock	Rock 0-100m	0.005	0.0001	Permian Interburden	0.02	0.00001	
	Leloma Formation	0.005	0.0001				

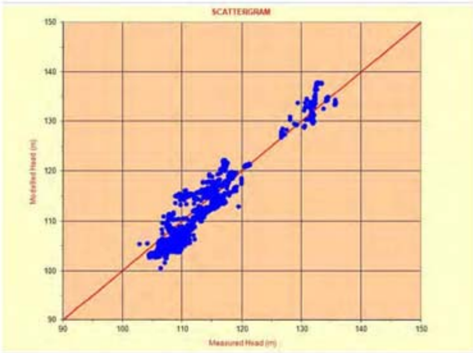
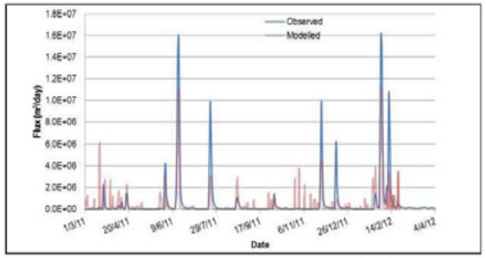
Issue	Stratford Extension			Rocky Hill			Comment
				Alum Mountain Volcanics	0.005	0.00001	

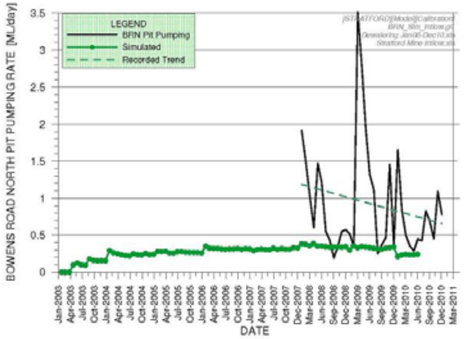
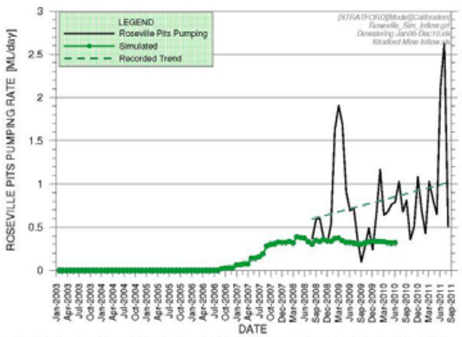
Issue	Stratford Extension		Rocky Hill		Comment
Rainfall Recharge Rate	Flood plain and channel alluvium	8%	Quaternary alluvium	1%	The AGE model used rainfall percentages for recharge in the steady-state calibration model, and used rainfall rather than recharge for the transient modelling, using the coupled surface/subsurface capability of MODHMS. There are significant differences between the Heritage recharge rates used in the transient prediction modelling and the rates used by AGE in their steady state calibration modelling. Comparison of the Heritage transient calibration water balance with AGE's steady-state calibration water balance provides some comparison of the role of recharge in the water balance, viz. • Heritage model – recharge is 45.1% of the total groundwater inflow; • AGE model – recharge is 99.4% of total groundwater inflow. The AGE model also generated much higher evapotranspiration than the Heritage model, viz: • Heritage model – Et is 35% of total groundwater outflow;
	Colluvium/ regolith	1%	Weathered Permian / regolith	0.1%	
	Western Co-Disposal Area	3%	-	-	
	Hills	0.25%	Hills or Slope Wash	5%	

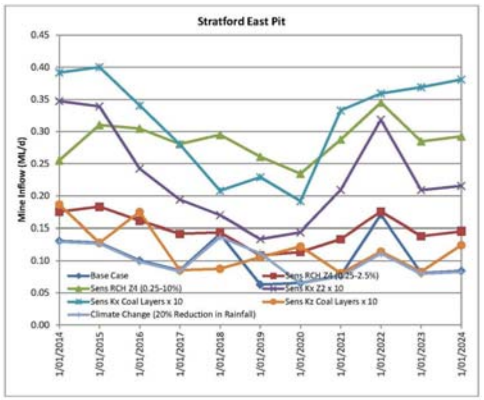
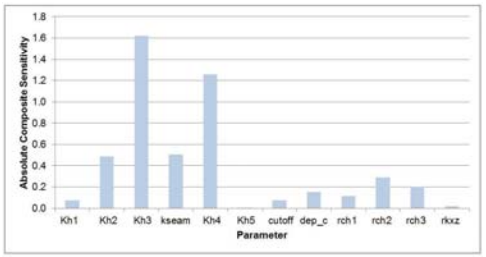
Issue	Stratford Extension		Rocky Hill		Comment
					• AGE model – Et is 97.3% of total groundwater outflow. The discrepancies in recharge and evapotranspiration perhaps should be looked at as the net difference between them – in the Heritage model, net recharge is 8% of the total groundwater inflow, whereas in the AGE model, net recharge is 2% of the total groundwater inflow. The water balance may also be influenced to some extent by the way the streams are represented in the model. AGE applied DRAIN cells to the streams, meaning that there can be no leakage from the streams into the groundwater. Heritage used RIVER cells, which allow both baseflow and leakage to occur. Stream baseflow/leakage components of the water balances in the two models were as follows: • Heritage model – leakage from streams is 54% of total groundwater inflow; baseflow to streams from groundwater is 61% of total groundwater outflow, for a net baseflow of 9%; • AGE model – leakage from streams is zero, and baseflow to the streams is 2.3% of the total groundwater outflow.

Issue	Stratford Extension	Rocky Hill	Comment
			The other reason for the differences between the two water balances is that the Heritage model was being applied in an area of many years of prior mining impact, whereas the AGE model was applied to a pre-mining situation.
Overland Flow and Stream-bed Conductance or Leakance	Stream bed conductance values were 25 to 100 m^2/d.	Overland Flow Leakance: • Alluvial zone = 0.001 /d (= 2 to 10 m^2/d conductance) • Hill zone = 0.002 /d (= 4 to 20 m^2/d conductance) Streambed leakance = 0.5 /d (= 1250 to 5000 m^2/d conductance).	The stream-bed conductance values used by Heritage are considered more likely to apply, as it will be likely that there is some bed resistance to leakage due to colmation effects. Nevertheless, the AGE values used are more conservative.
Drain Cell Conductance	1000 m^2/d	1000 m^2/d	
Scenarios Modelled	• Steady-state calibration • Transient calibration • Transient prediction simulation with only the Stratford Extension project open cut mining • Transient prediction simulation with Stratford Extension project open cut mining, plus CSG production and the proposed Rocky Hill project open cut mining. • Transient post-mining recovery model (Stratford project only) • Steady-state recovery model (Stratford project only).	• Steady-state calibration • Transient calibration • Transient prediction simulation with AGL project only • Transient prediction simulation with AGL project as well as the Rocky Hill project open cut mining • Transient post-mining recovery model	
Steady-State	Calibration was performed against 39	Calibration was performed against 39	

Issue	Stratford Extension	Rocky Hill	Comment
Calibration	bores with monitored water levels, averaged over the monitoring record to 2010. Automatic calibration using PEST software. Calibration performance is not reported.	bores with monitored water levels. Calibration performance is demonstrated by the scatter-plot of simulated vs measured heads below.  Figure 43 Observed vs Simulated Groundwater Levels – Steady State Model	
Transient Calibration	Calibration was conducted for the period January 2003 to July 2010, for 90 monthly stress periods. Initial heads were taken from the steady-state calibration. Pit inflows were also used in calibration. Open cuts were simulated by use of drain cells. Calibration was performed for 1145 targets at 39 sites. Calibration was performed manually. Calibration performance showed:	Calibration was conducted for the period March 2011 to February 2012. Daily rainfalls and monthly average evapotranspiration were used for the simulation. Calibration performance was assessed by comparing simulated vs observed hydrographs for 13 bores. The calibration is quite good for absolute levels and trends, but does not replicate the immediate recharge responses very well. In some cases, the calibration is not so good, with the model predicting a rising	Both models reported a satisfactory transient calibration performance. The Heritage model has the advantage of being calibrated against a significant period of mining stress, including calibration against monitored pit inflows. The AGE model was only able to be calibrated against the stresses imposed by climate variability, over a very short 12 month period.

Issue	Stratford Extension	Rocky Hill	Comment
	• Heads generally showed good calibration, as shown by the scatter-plot of predicted vs observed heads below.  • Predicted pit inflows were calibrated against the bottom of the envelope of plotted water volumes removed from the pit, as shown below. This excludes rainfall runoff contributions to pit water.	trend that is not seen in the observed data (eg GR-P4, GR-P5 and GR-P6). There is no comment on this discrepancy in the report. Streamflow calibration was assessed against the NOW gauging station (No 028028) on the Avon River. The model shows a good calibration (see below).  Figure 46 Observed vs Modelled Stream Flow Data for the Avon River Gauging Station (028028)	

Issue	Stratford Extension	Rocky Hill	Comment
	 Figure A-39. Bowens Road North Pit Inflow Simulated during the Calibration Period  Figure A-40. Combined Roseville Pits Inflow Simulated during the Calibration Period • SRMS = 7.8%, compared with target of 10% as per MDBC (2001). • Hydrograph calibration presented in Appendix AB is generally very good.		
Model Verification	None performed.	Model verification of the transient calibration model was assessed using hydrographs at 12 AGL monitoring bores. Some hydrographs show a very good calibration in respect of absolute values,	AGE used monitoring data from a number of AGL monitoring bores to verify their model calibration. However, the verification results were somewhat

Issue	Stratford Extension	Rocky Hill	Comment
		trends and response to specific recharge events (eg TMB01, TMB02 and TMB03), while others show poor correlation in respect of trends (eg S4MB02, S5MB02, S5MB03 and TCMB03).	mixed.
Sensitivity Analysis	Sensitivity analysis was conducted on: • Coal Kh (by increasing base values x10) • Coal Kv (increased x10) • Stratford East interburden (increased x10) • Hills recharge rate (increased x10) in turn, through observing the impact each increase has on calibration statistics.  Figure A-54. Sensitivity Analysis for Stratford East Pit Inflow	Sensitivity analysis was assessed by evaluating the effects of changes in individual model parameters on model results. AGE used relative composite sensitivity (RCS), after PEST (2008). The results (see below) indicated that the model is most sensitive to the Kh of the overburden above the Cloverdale Seam (Kh3) and the interburden between deeper coal seams (Kh4), reflected in RCS values greater than 1.  Figure 45 Relative Composite Sensitivity for Parameters in Steady-State Calibration Water balance showed a 0.0% mass balance error, with 99.4% of the inputs to the model from rainfall recharge, and 97.3% of the outputs to evapotrans-piration. Net baseflow contribution is only 68 kL/d across the model, ie only 2.3% of	The Heritage model was found to be most sensitive to uncertainty in the horizontal hydraulic conductivity of the coal seams. The AGE model however, was most sensitive to uncertainty in the horizontal hydraulic conductivity of the overburden above the Cloverdale seam (Model Layer 2) and the interburden between the lower seams (Layers 4, 6 and 8).

Issue	Stratford Extension	Rocky Hill	Comment
	The model calibration was most sensitive to increasing the coal Kh. Increasing coal Kh by a factor of 10 altered the calibration %SRMS from 7.9 to 15.4. All other parameter changes led to minimal change in calibration %SRMS.	the total discharge.	
Prediction Modelling – Mining Phase	Applied consistent with the mine plan progression detailed in the EIS, including progressive pit backfilling and use of pit voids as water storages. Pit void water levels were taken as the median water levels from 123 climate realizations from Gilbert & Associates (2012). Active miming areas were simulated using MODFLOW DRN (drain) cells. A uniform average rate of rainfall recharge was applied throughout the simulation period.	A transient model was run with 64 quarterly stress periods, covering the period from mining Year -2 to Year 14. Dewatering of the open cut pits was simulated by using MODFLOW DRN (drain) cells at the designated elevations of the seams being mined, in active mining areas. Mine progression and backfilling with waste and rejects were simulated, with annual changes according to the mine schedule, using the TMP function in MODHMS to change K and S properties each year. Backfilling was assumed to occur immediately after drain cells were switched off. An attempt to represent rainfall recharge seasonality was made through use of average quarterly rainfall rates, rather than a constant annual rainfall rate.	
Simulation of Cumulative Impacts	The prediction simulations took account of the Stage 1 of the AGL CSG project and the Rocky Hill coal project.	The prediction simulations included Stage 1 of the AGL CSG project and the existing and proposed Stratford mining	

Issue	Stratford Extension	Rocky Hill	Comment
	• The AGL project was simulated by applying stacked blanket drain cells in Model Layers 3 to 11, excluding coal shallower than 150m. Two separate scenarios were modelled – either zero or 40 m pressure heads above the roof of a target coal seam. • The Rocky Hill project was simulated by drain cells applied down to Layer 5 (Main Pit and Bowen Road Pit No 2), Layer 7 (Avon Pit) and Layer 9 (Weismantel Pit).	operations. • The AGL project was simulated by a staged well development using the fracture well (FWL) package. The assumed pumping schedule had 30 wells in Year 1, 60 in Year 2, 90 in Year 3, and 100 thereafter to Year 25, pumping initially at 1.04 ML/a, rising to 2 ML/a in Years 4-8, then falling to 0.95 ML/a in Years 9-15, and 0.48 ML/a in Years 15-25. • The Stratford Extension Project was simulated by assuming the following: o Stratford Main Pit active from 1995 to mid-2003 o Existing Roseville East pit active from mid-2006 to 2017 o Existing Bowens Road pit active from mid-2003 to 2017 o Drain cells set to 20 mAHD in these two pits o Proposed Avon North and Roseville West Extension active from 2014 to 2024 o Drain cells in new pits set at -40 mAHD o Drain cells down to model Layers 3, 5 or 7 as appropriate. o Similar mining progression to Rocky Hill project, including backfilling.	

Issue	Stratford Extension	Rocky Hill	Comment
Uncertainty Analysis Modelling	Modelling was conducted to assess uncertainty in pit inflows for possible variations in: • rainfall recharge to hills, • coal seam hydraulic conductivity (Kh and Kv) and • the overburden conductivity separating Stratford East pit from Stratford East Dam. Pit inflows were found to be very sensitive to coal and overburden horizontal conductivity and rainfall recharge, but not vertical conductivity. However, the changes tested led to reduction in calibration performance, so they are unlikely to eventuate.	Extensive parameter uncertainty modelling was undertaken, by assessing impacts on pit inflows from variations in: • rainfall rates (+/- 10%) • OLF leakage rates - alluvium (+ 100%) and hills (+ 50%) • channel leakage rates (+/- 50%) • hydraulic conductivity (Kh and Kv) of Layers 1, 3 and 4 (+/- 50%) and Layer 5 (- 50%) • Storage coefficient of Layer 1 (+/- 50%), Layer 3 (+ 100%) and Layer 4 (+ 500%) • Specific yield of Layer 1 (+/- 50%), Layer 3 (- 50%) and Layer 4 (+ 50%). The uncertainty analysis showed that the changes to hydraulic conductivity values had minimal effect on the calibration performance of the model. The uncertainty model runs led to cumulative pit inflows ranging from 8216 ML to 9207 ML, compared with the base case model prediction of 9000 ML.	
Post-Mining Recovery	Ongoing groundwater inflows to 3 final pit voids (Roseville, Avon North and Stratford East) was modelled for a 200 year post-mining period, using input from final void water balance information from	Post-mining recovery was modelled for groundwater recovery into the backfill within the Main Pit. It was modelled by a transient simulation, after converting the final areas of mining to backfill (spoil) hydraulic properties, and increasing the	

Issue	Stratford Extension	Rocky Hill	Comment
	Gilbert & Associates (2012).	recharge rate to the backfill material. It was assumed that the Main Pit would be backfilled to above the original pre-mining groundwater level by the completion of mining, and no further pit pumping would occur. The model was run until the groundwater level in the backfilled main pit reached equilibrium.	

5.3 Assessed Impacts of Stratford Extension Project

5.3.1 Pit Inflows

Pit inflows at the existing Stratford operation are inferred from monitoring records on volumes pumped from the pits. During times of rainfall, the water pumped from the pit would include both groundwater inflows, while in times of no rain, the water pumped from the pit would likely represent only groundwater inflows. Hence, the lower end of the envelope of data is considered to represent the groundwater inflows over time Pit inflows predicted during the transient calibration simulation were therefore calibrated against the lower end of the envelope of monitoring data.

The total pit inflows predicted for the Stratford Extension project range between 1.18 and 1.35 ML/d during the first 6 years, then declining to between 0.74 and 0.87 ML/d from years 7 to 11. All but about 1.5% of this pit inflow will come from the coal measures, with only 0.016 ML/d on average to come from alluvium (see **Section 5.3.10** below). Historical pit inflows to the existing Main Pit, Roseville Pit and Bowen Road Pit as predicted by the model have been around 1 ML/d. Thus the proposal is predicted to lead to an initial increased inflow of about 0.3 ML/d.

The Roseville West Pit Extension is expected to attract the highest inflow, with an average rate of about 0.5 ML/d.

5.3.2 Drawdowns

Predicted drawdowns in the water table at the end of mining due to the Stratford Extension Project only are shown on the left in **Figure 3** below, and indicate that the extent of drawdowns exceeding 1m is quite localised, and do not include either Stratford Village or the only other private licensed bore (GW079759, located to the south).

The cumulative impact of the Stratford Extension, together with the AGL CSG project and the Rocky Hill Coal Project, at the end of the Stratford project in 2024, are shown on the right in **Figure 3** below. The region with water table drawdowns exceeding 1m is much more extensive. However, again the impact on existing users in Stratford Village and the southern registered bore is less than 1 m drawdown.

In both cases illustrated below, the 1 m drawdown effect does not extend as far as the nearest mapped 'biophysical strategic agricultural land' along the Avon River, which is more than 2000m away from the proposed mining areas in the proposal.

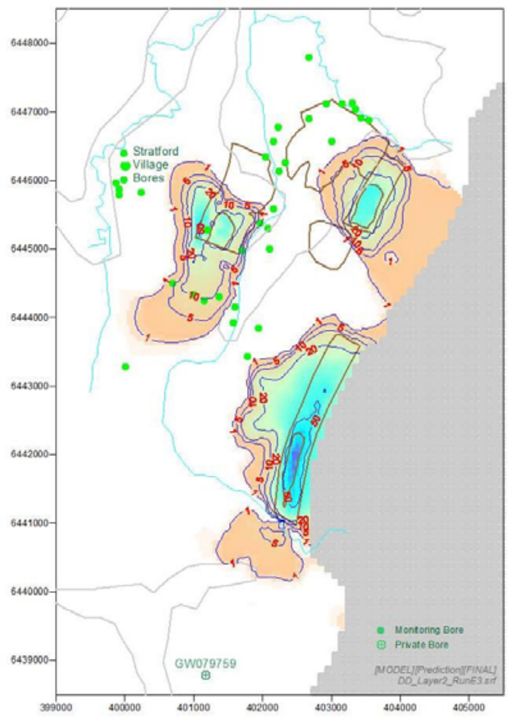


Figure A-57. Predicted Watertable Drawdown Contours at the end of the Project [m]

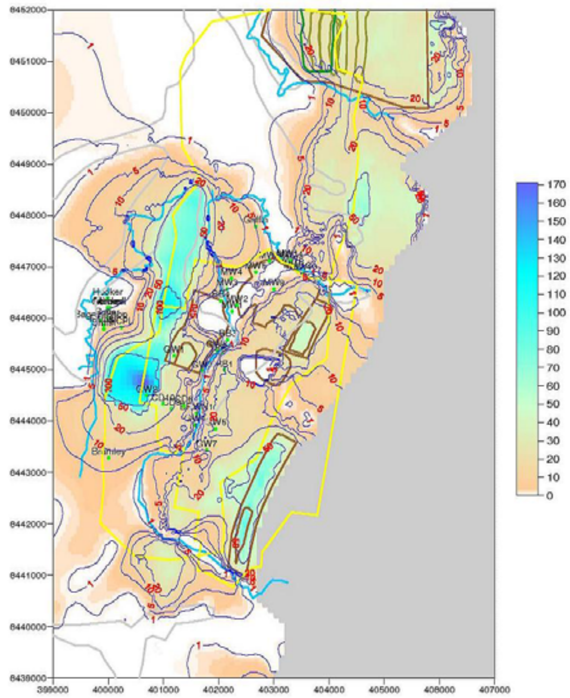


Figure A-58. Predicted Watertable Drawdown Contours Resulting from the Cumulative Effects of All Three Projects at 2024 [m]

Figure 3: Predicted Water Table Drawdowns at the End of the Project – Stratford Extension Only and Cumulative Drawdowns.

5.3.3 Changes in Groundwater Flow and Quality

There would be a temporary change in groundwater flow pattern during mining, as groundwater will flow towards the active pits in response to lowering of groundwater levels/pressures. Post-mining, the groundwater flow pattern regionally is predicted to return to close to the pre-mining pattern, but there will be local groundwater sinks at the 3 proposed final voids, as discussed below in **Section 5.3.7**.

During mining, the quality of groundwater inflow will be a mix of the source water qualities, primarily coal measures water quality. After mining, the geochemistry of the waste rock will be a major determinant of groundwater quality in the backfilled pits. The EIS reports that the waste rock is not expected to be potentially acid-forming (PAF), except at the Stratford East pit. Segregation and selective handling of PAF waste is proposed, and the EIS reports that this management strategy is expected to limit the potential of long-term groundwater quality problems from re-saturation of waste rock backfill in the pits.

Final void salinities are predicted to increase slowly over time, to eventual salinities of about 12,000 µS/cm in the Roseville West void, 9,000 µS/cm in the Avon North void, and 6,000 µS/cm in the Stratford East void. As the voids are groundwater sinks, the higher salinities in the voids are not expected to affect groundwater salinity in surrounding areas.

The overall conclusion is that there will be no appreciable change in groundwater salinity as a consequence of mining.

5.3.4 Changes in Surface Water Quality

The predicted slight reduction in baseflow of about 0.1 ML/d to Dog Trap Creek is expected to result in a smaller contribution of saline water from the coal measures, and hence a slight reduction in the salinity of streamflow in the creek.

5.3.5 Changes in Hydraulic Properties

Heritage (2012) state that the hydraulic properties would be changed over the mine footprint, due to the replacement of in situ rock with more permeable waste rock in the in-pit emplacements. Hence hydraulic gradients within the backfill material would be flatter, and rainfall recharge would be higher.

5.3.6 Baseflow Changes

The main local drainage systems in the vicinity of the Stratford Extension Project are Dog Trap Creek, Avondale Creek and Avon River.

The Stratford Extension modelling suggests that there will be no discernible baseflow impact on the Avon River.

Dog Tap Creek would continue as a gaining stream, with continuing baseflows, but baseflows are predicted to decline by an average of 0.07 ML/d (25 ML/a), with a peak impact of 0.08 ML/d (29 ML/a). Baseflows in Avondale Creek are predicted to vary both up and down through the project, ranging from a gain of about 0.05 ML/d to a reduction of about 0.17 ML/d (ie gain of 18 ML/a to a reduction of 62 ML/a). Average net reduction in baseflow is 0.02 ML/d (7.3 ML/a).

The predicted changes in baseflow are reported to have a negligible effect on natural streamflows.

5.3.7 Post-Mining Recovery

Post-mining recovery has been determined by:

- Firstly, a transient model run for a 200 year period to predict ongoing groundwater inflows and groundwater levels within the backfill in each of the three final pit voids in the mined out pits; and
- Secondly, a steady state run, to predict long-term equilibrium water levels and inflows.

From the transient simulation, it is predicted that substantial water level recovery will occur in all three voids within the first 40 years post-mining, but water level recovery continues to occur slowly thereafter. Water levels are predicted to be still rising slowly after 200 years, but all three voids will remain as permanent groundwater sinks. Accompanying this is a progressive decline in inflow rates in the Roseville void, and steady inflow rates to the other 2 voids, with rates of 0.04 ML/d, 0.29 ML/d and 0.34 ML/d respectively predicted for 200 years after cessation of mining.

Steady state post-mining modelling predicted long-term equilibrium inflow rates of 0.77 ML/d, 0.03 ML/d and 0.11 ML/d to the Roseville, Avon and Stratford voids respectively. It is noted that these results appear to be quite different to those derived from the transient model, as shown in **Table 3** below:

Table 3: Comparison of Final Void Inflow Rates Predicted by the Transient and Steady-State Recovery Model Simulations

Model	Roseville Void		Avon North Void		Stratford East Void	
	Water Level (mAHD)	Inflow (ML/d)	Water Level (mAHD)	Inflow (ML/d)	Water Level (mAHD)	Inflow (ML/d)
Transient Recovery Model – 200 Years	111.6	0.04	99.6	0.29	91.4	0.34
Steady-State Recovery Model	111.6	0.77	125	0.33	145	0.11

This has been discussed with Heritage (pers comm), who explained that different final void sizes were assumed for the transient and steady-state recovery models. The steady-state recovery run was done when the groundwater assessment report was essentially finished, as a means of checking the void water levels predicted by the surface water assessment (Gilbert & Associates, 2012). By that stage, the final pit voids had been significantly enlarged from the sizes initially planned.

However, Heritage also explained that even using the same void sizes, there is not good agreement between the predicted void water levels calculated by the separate groundwater and surface water models. The reason for this difference is not explained.

5.3.8 Groundwater Dependent Ecosystems (GDEs)

It was reported in the Stratford EIS that, due to the predominantly brackish-saline baseflows, there are no known groundwater dependent ecosystems, or surface water bodies (lakes, wetlands, etc) fed by groundwater, within the region of predicted impact of the project.

5.3.9 Groundwater Users

It is predicted that at no stage will drawdown impact from the project exceed 1 m at any of the 12 licensed bores in Stratford and the one other licensed bore located in the vicinity of the project (GW079759).

5.3.10 Alluvial Aquifers

The open cuts are proposed to be not within 40m of Avondale Creek or Dog Trap Creek, and no direct pumping of alluvial groundwater will occur.

Mining is proposed to pass through an area mapped on the geological maps as alluvium, but drilling has shown that the alluvial sediments are more restricted than mapped, and are confined to the alignment of the drainages. No deep alluvium with favourable subsoil properties was identified during search for rehabilitation material, and there is also only one groundwater licence in the Avon Water Source. It has been concluded that the alluvium present over much of the mapped area is not a significant alluvial water source, and the only significant alluvial groundwater would be that occurring along Dog Trap Creek and Avon River.

Water loss from alluvial and regolith groundwater has been assessed for losses through enhanced leakage to the underlying fractured rock, interruption of rainfall recharge to the alluvium/regolith removed during mining, and removal of the groundwater stored within the alluvium/regolith removed during mining. These losses have been determined to be on average through the mine life:

- Enhanced leakage to underlying fractured rock – 0.09 ML/d (33 ML/a)
- Reduction in rainfall recharge – 0.036 ML/d (13 ML/a)
- Groundwater storage in alluvium/regolith material mined out – 0.085 ML/d (3 ML/a).

The first would continue for some time after mining ceases, but the others are temporary, and apply only for the period of active mining. Long-term losses from the alluvium post-mining have not been assessed.

5.3.11 Cumulative Impact Assessments

The AGL Gloucester Gas Project was included in the prediction simulations for the Stratford Extension Project. The Rocky Hill Coal Project was also included. As the sequencing of the gas wells and the Rocky Hill open cuts was not known, a conservative approach was taken, by assuming that all wells and pits are active for the 11 years of mining in the Stratford proposal.

The Rocky Hill open cuts were simulated by drain cells down to model Layer 5 in the Main Pit and Bowen Road 2 Pit, Layer 7 in the Avon Pit, and Layer 9 in the Weismantel Pit. The CSG project was simulated as stacked blanket drains from model Layer3 to Layer 11 (ie continuous drain cells applied in each coal seam model layer below 150m depth).

Initial cumulative assessment was conducted with the CSG project, but without Rocky Hill. The model predicted water production from the gas wells to be in the range 4.4 ML/d to 6.6 ML/d. Average groundwater inflow rates to the Stratford pits would reduce by 0.4 to 0.5 ML/d if the gas wells were all operated in parallel during the entire 11 years of the Stratford project. If gas extraction were precluded from the Stratford lease areas then the AGL CSG project would reduce Stratford pit inflows by a little more than 0.1 ML/d.

5.3.12 Consideration of Faults and Shears

Although Heritage (2012) report that in some drillholes, higher groundwater inflows were associated with intersection of faults, no comment is made about how this might affect the conceptual model or the control of groundwater flow. The range of hydraulic conductivity values determined from testing, spanning several orders of magnitude, have all been considered equally in determining representative hydraulic conductivity values in each hydrogeological unit. This is consistent with the common approach to modelling of fractured rock aquifers by considering them to be equivalent to a homogeneous material at the scale of interest in mine dewatering projects.

I consider that this is not necessarily an error or omission, as it is very common in the Permian coal measures in NSW for faults to act as barriers to flow, rather than conduits for enhanced flow. The reports of higher inflows associated with fault intersections can be associated with localised enhancement of permeability, especially at shallow depths. At depth, it is very uncommon for faults to be significant flow pathways for groundwater flow.

The model has been successfully calibrated on the basis that fault flow paths are not factors in groundwater flow, and I have seen nothing in the monitoring data to suggest that faults are significant conduits for flow on a regional basis.

Shear zones on the other hand could act as conduits. However, no reference is made to shear zones in the discussion on geology or structural geology. It is unclear to me whether this is an omission or evidence that no significant shear zones are present in the project area.

5.3.13 Consideration of Climate Change

The Heritage study approached climate change impacts by assuming a 20% reduction in rainfall infiltration in a transient simulation covering the calibration and prediction phases of the project.

The calibration performance decreased only slightly, indicating that the model is not overly sensitive to this climate change assumption, and can therefore be used for prediction modelling without re-calibration.

Prediction modelling showed that inflows to the Stratford East pit would reduce by 2% for a 20% reduction in rainfall recharge.

5.3.14 Errors, Omissions and Inaccuracies

In my opinion, there are no major errors, omissions or inaccuracies in the Stratford Extension groundwater assessment. There are a small number of minor issues that should be addressed in any report revision of supplementary report, namely:

- Compliance with the Aquifer Interference Policy has not been addressed, however NOW has stated in its submission that the impacts are within Level 1 of the minimal impact considerations for drawdown at any water supply work as defined in the Aquifer Interference Policy (AIP)..
- Consideration of shear zones should be addressed. A statement justifying the approach with respect to faults and shear zones in the model would be helpful.
- There was some discrepancy in the assessment of post-mining recovery of groundwater levels and long-term groundwater inflows to the final mine voids. The post-mining recovery should be clarified for the correct final void sizes.
- It would be helpful to investigate reasons for different predictions between the groundwater and surface water recovery modelling.

Based on other information in the report, I do not expect that responses to the above additional issues will lead to a changed conclusion.

5.3.15 Adherence to Groundwater Policies

The groundwater assessment report addresses the project's compliance with the relevant groundwater legislation, namely the *Water Act 1912* and *Water Management Act 2000.*

The report acknowledges that the project will likely cause the interception of groundwater from two water sources – fractured rock and alluvium. Groundwater extraction from the fractured rock aquifer is not currently covered by any Water Sharing Plan, but the report states that Stratford Coal Complex holds current Water Act Part 5 licences (combined total of 1021 ML/a) which is well in excess of the predicted maximum for all existing and proposed mining areas combined (600 ML/a).

The relevant alluvial water source is the Avon River Water Source, and the *Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Sources 2009* is the relevant WSP. The combined maximum alluvial groundwater takes from each of the open cuts is 54 ML/a. The report states that GCL currently holds a total of 140 ML/a of allocations for unregulated river water in the Avon River Water Source.

Hence it appears that adequate licences are already held by the applicant to cover both affected water sources.

The Heritage report does not address the Aquifer Interference Policy, which was not introduced until after completion of the Stratford Project groundwater assessment report.

5.4 Assessed Impacts of Rocky Hill Project

5.4.1 Pit Inflows

Total groundwater inflows to all mine pits are predicted to range up to 1.25 ML/a. The peak inflow rate is predicted to occur in Year 4, as indicated in **Figure 4** below. From Year 6, inflows stabilize around 0.6 ML/a.

AGE indicate that the seepage rates in **Figure 4** do not allow for evaporation losses or removal of water in the coal and waste rock extracted from the pits. Accordingly, the actual accumulation of groundwater in the pits could be up to 25% less than the rates predicted by the modelling.

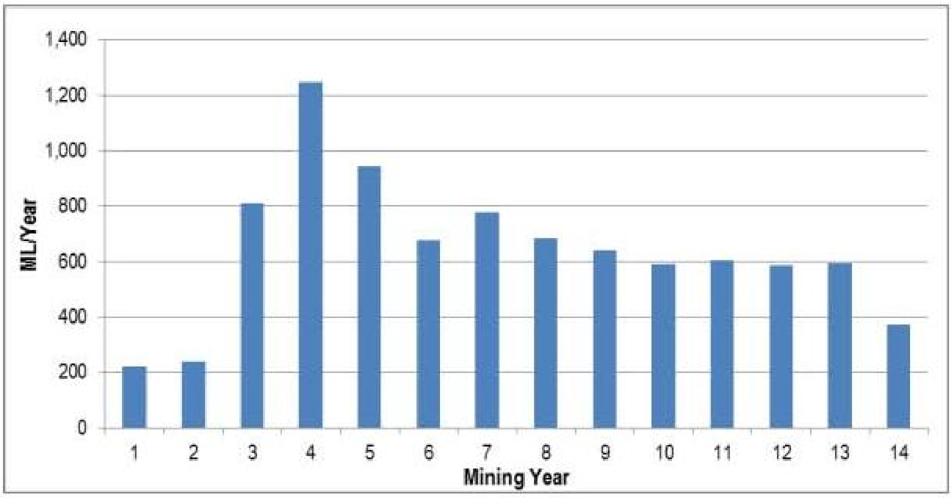


Figure 57 Simulated Annual Seepage

Figure 4: Predicted Combined Groundwater Inflows to All Open Cuts

5.4.2 Drawdowns

Predicted drawdowns in the water table at the end of mining due to the Rocky Hill Coal Project only are shown on the right in **Figure 5** below, and indicate that the extent of drawdowns exceeding 1m is localised virtually to within the pit area, extending a maximum of 500m from the northern extent of the main pit. There is predicted to be a small encroachment into the Waukivory Creek alluvium at the southern end of the mine areas.

More extensive depressurisation is predicted for the coal measures, for example in Layer 5, the Bowen Road Coal Seam, the 1 m drawdown contour extends up to 0.3 km east of the Main Pit, up to 2 km to the north, and 1.5 km south-west of the Mine Area Boundary.

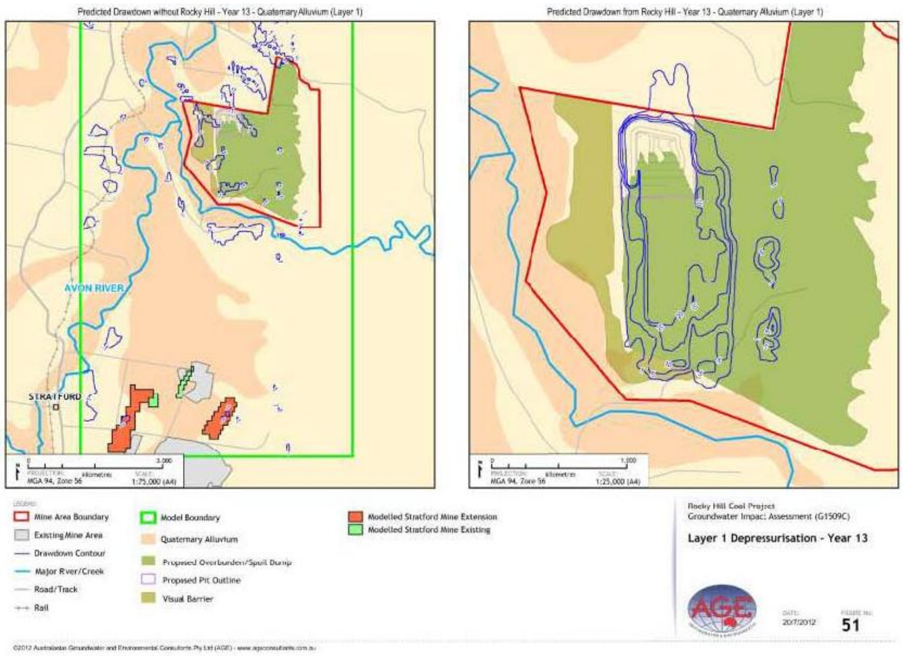


Figure 5: Predicted Drawdowns in Water Table (Model Layer 1) at End of Mining (Year 13) – AGL Only and Rocky Hill Only

5.4.3 Changes in Groundwater Flow and Quality

Baseline monitoring indicated that groundwater quality in the Permian is saline, with EC ranging between 2470 µS/cm and 7480 µS/cm. As the Permian discharges into the alluvium, the alluvium too has a high salinity, with EC ranging from 1003 µS/cm and 6450 µS/cm in alluvium monitoring bores GR-P1, GR-P2 and GR-P3. Alluvium bores GR-P10 and GR-P11 which are closer to Waukivory Creek reported salinities ranging from 589 µS/cm to 1642 µS/cm EC.

The mining and emplacement of overburden and coarse rejects back into the pit is predicted to have the following effects:

- A slight improvement in water quality of pit inflows.
- Rainfall recharge will be higher to the backfill than pre-mining recharge to the site.
- Solute will likely be liberated from the backfilled overburden and coarse reject material. EC of the components of solute leachate is likely to range between <300 µS/cm from overburden/interburden material, and <4900 µS/cm from the coarse reject material, but the overall EC is likely to be closer to the overburden/interburden leachate salinity.
- Increased rainfall recharge will lead to lower salinity of the water in the backfill.
- Ultimately post-mining, groundwater salinity flowing from the Permian to the alluvium is expected to be slightly less saline than at present.

Water management controls have been suggested to limit impacts from other sources of potential contaminants associated with the waste disposal, mine workshop, fuel storage, etc.

5.4.4 Changes in Surface Water Quality

No mention is made of any potential impacts on surface water quality,

5.4.5 Changes in Hydraulic Properties

These impacts are not specifically addressed in the AGE report. However, AGE do refer to higher hydraulic conductivity and higher rainfall recharge rates to the backfilled spoil relative to pre-mining in-situ rock conductivity and recharge rates.

5.4.6 Baseflow Changes

Baseflow changes due to the Rocky Hill Project are not addressed in the groundwater assessment report.

5.4.7 Post-Mining Recovery

The post-mining recovery transient modelling involved converting the final areas of mining to overburden properties and applying additional recharge to the overburden. It is presumed that reference to 'overburden' means 'backfill' or 'mine spoil', not pre-mining in situ overburden.

The modelling showed that groundwater levels in the backfilled Main Pit recover to equilibrium within less than 15 years after completion of mining, with most occurring in the first 5 years. The post-mining equilibrium level of 117 mAHD is 4-5 m higher than pre-mining, but not high enough to reach ground surface. The water levels within the backfill are predicted to have a flatter gradient than pre-mining, due to the higher permeability of the backfill compared with in-situ rock.

Recovery in the other pits (Weismantel and Avon Pits) is predicted to be even faster, as mining and backfilling of these pits is planned to be completed earlier than in the Main Pit.

5.4.8 Groundwater Dependent Ecosystems (GDEs)

A stygofauna survey recovered 432 invertebrates from the groundwater monitoring bores, with only 4 individuals recovered from the coal seam groundwater. In view of the very low presence of stygofauna in the coal groundwater, and the predicted minimal impact on groundwater levels in the alluvium aquifers, it was stated that the project would be highly unlikely to have an impact on stygofauna.

Riparian vegetation along Waukivory Creek includes some phreatophytic species, dependent on groundwater. However, the modelling predicted no significant drawdowns in the alluvium, so it was concluded that there would be no impact from the project on the riparian vegetation.

5.4.9 Groundwater Users

AGE report that there are 8 registered bores within 3 km of the project, the nearest private bore being 1 km to the west, on the western side of the Avon River. This bore (GW054940) is an abandoned shallow well excavated into the Quaternary alluvium of the Avon River. The model predicts no drawdown in this well from the Rocky Hill project.

Bores GW200330 and GW0800487 are located within the Layer 5 (ie Bowen Road coal seam) predicted zone of influence. The first is reported to be abandoned, and the second is usable, but not currently in use. However, AGE concludes that these bores, drilled in 1905 into Permian sediments, are not deep enough to penetrate the Bowen Road coal seam, and are probably completed in the overburden above the Cloverdale seam, which is Layer 2 in the model. The model predicts zero drawdown in Layer 2 at these bore locations.

Hence, AGE indicate that no existing private user will be affected by the project.

5.4.10 Alluvial Aquifers

AGE ran two model scenarios to assess the impact of Rocky Hill on the alluvial groundwater system:

- Cumulative impacts from Stratford and AGL;
- Cumulative impacts from Stratford, AGL and the Rocky Hill Project.

By subtracting impacts in the first run from impacts in the second, the impact due to Rocky Hill alone was calculated.

The net reduction in upward groundwater flow from the Permian to the Waukivory Creek and Avon River alluvium due to the Rocky Hill project ranged from around 0.05 ML/d in Years 1-2 to a peak of around 0.3 ML/d (ie 110 ML/a) in Year 6 then declining to 0.1 ML/d by the end of mining at Year 14.

The predicted drawdowns in Layer 1 (see **Figure 5** above) do show some drawdown in the alluvium, in three areas:

- Southern parts of Avon, Bowens Road 2 and Wiesmantel Pits which intersect the alluvium of Waukivory Creek.
- Southwestern part of Main Pit where the access ramp encroaches on the alluvium.

Direct inflows from the groundwater to the Pits is predicted to be in the order of 0.01 ML/d to 0.12 ML/d (ie 4 to 44 ML/a).

AGE note that the reduction in Permian flow to the alluvium would result in a lower groundwater salinity in the alluvium for the period of impact.

5.4.11 Cumulative Impact Assessments

Cumulative drawdown impacts have not been presented for the water table. Rather, AGE have presented the predicted water table drawdown due to the AGL project, without the Rocky Hill project, as depicted below on **Figure 5** above in **Section 5.4.2**. The report text infers that both AGL and Stratford projects are included in the left pane of **Figure 5**, however, there are no drawdown contours around the Stratford Mine near the southern boundary of the AGE model, and the Heritage report did predict water table drawdowns in that area at Year 2024, which presumably would equate to Year 10 or Year 11 of the Rocky Hill project. Hence, it is concluded that **Figure 5** does not include any impact from Stratford.

Cumulative drawdowns in the coal measures are more significant, as illustrated by the predicted drawdowns in Model Layer 5 at Years 7 and Year 13 on **Figure 6** below.

There are several zones of predicted water table drawdown exceeding 1 m that superimpose with the mining impacts, but also occur broadly outside the zone of Rocky Hill impact.

The AGL project has a much more severe and more widespread effect on depressurisation of the underlying coal measures, with greater than 100 m depressurisation at each wellhead and greater than 10 m depressurisation over the wellfield area which overlaps with the Rocky Hill Project. The depressurisation effects of the AGL project are predicted by the AGE model to not have a significant impact on the water table, hence the limited impacts displayed in **Figure 6**.

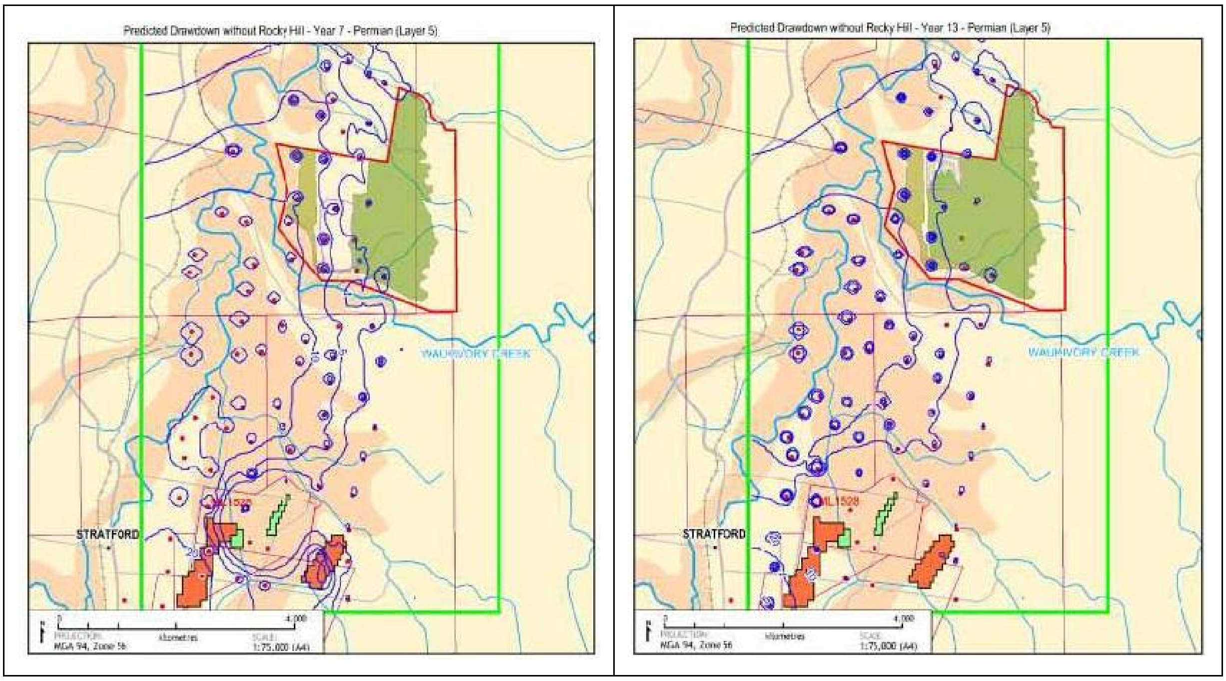


Figure 6: Predicted Cumulative Drawdowns AGL Project and Stratford Extension Project (Excluding Rocky Hill Project) – Model Layer 5 – Year 7 and Year 13

It is not clear how AGE included the Stratford mining operation in their model. Being on the model boundary, it is likely that model edge effects would influence the predicted drawdowns. It appears that AGE reviewed the predicted impacts described by Heritage in the Stratford groundwater assessment report, and included the predicted drawdowns from the Heritage report at the appropriate years. Note that by Year 13 of the Rocky Hill project, the Stratford Extension project is expected to be completed, so there is no impact shown around the Stratford project for Year 13 above.

AGE concluded that there is no cumulative impact between the two coal mining projects. I concur with this conclusion.

5.4.12 Consideration of Faults and Shears

AGE recognises that there are structures and faults within the Gloucester Basin, but has not included any structures or faults within the numerical model. AGE relies upon the principle of simplicity or parsimony, as discussed in the MDBC groundwater modelling guidelines (MDBC, 2000). This principle is described in the guideline thus:

> *"… the conceptual model should be developed using the principle of simplicity (or parsimony), such that the model is as simple as possible, while retaining sufficient complexity to adequately represent the physical elements of the system, and to reproduce system behaviour."*

AGE argued that there is *"… limited information to suggest with any confidence the location, orientation, magnitude or hydraulic characteristics of any fault or structure."* AGE further argues that while it is a common perception that fault zones are conduits for increased groundwater flow, this is not necessarily the case, and faults commonly exhibit low hydraulic conductivity in synclinal region such as the Gloucester Basin.

I generally concur with the view that often faults are barriers to flow rather than conduits for enhanced flow. However, my reason for this view is that even though the faults may have an enhanced permeability, the faults commonly cause a dislocation of the primary flow paths in the coal measures which are primarily the coal seams and some bedding plane features, thus reducing the regional continuity of groundwater flow.

AGE relied on the sensitivity modelling to account for any uncertainty relating to geological complexity due to faulting. I concur with this approach.

5.4.13 Consideration of Climate Change

Climate change has not been specifically addressed by the AGE report.

5.4.14 Errors, Omissions and Inaccuracies

In my opinion, there are no major errors, omissions or inaccuracies in the Rocky Hill groundwater assessment. There are a small number of minor issues that should be addressed in any report revision of supplementary report, namely:

- There is a need to calculate maximum take from the alluvial water source.
- Impact on baseflows has not been assessed.
- No mention is made of possible impacts on surface water quality.
- The effects of climate change have not been considered in the assessment.

Based on other information in the report, I do not expect that responses to the above additional issues will lead to fatal flaw.

5.4.15 Adherence to Groundwater Policies

AGE report that GRL holds a total of 267 unit shares or 267 ML/a under the *Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources* (the WSP), which is greater than the predicted impact on the alluvium associated with Waukivory Creek and Avon River (average 55 ML/a). It should be noted that the requirement for licensing under the WSP relates to the maximum impact, rather than average. The maximum take from the alluvial water source has not been identified in the report.

Nor has the report identified baseflow impacts on surface flow (if any) on Waukivory Creek or Avon River attributable to the project.

It is recommended that the appropriate licensing requirements be determined in accordance with the WSP principles and rules.

Further, no reference has been made to the Aquifer Interference Policy. This should be included in any supplementary or revised assessment report.

6 SUBMISSIONS

6.1 EPA

EPA raised the following issues relating to surface water and/or groundwater:

- Because of concerns about saline water releases from the project, EPA proposed a condition that in times of wet weather, the Stratford Mining Complex must be a zero discharge mine site.
- EPA proposed a condition to ensure that there is no discharge of mine water (such as from the pit voids) after the end of the mine life.
- EPA referred a request to NOW to consider whether mining close to Trap Dog Creek and/or Avondale Creek might cause unacceptable drawdown or pollution of those creeks.
- Additional surface water monitoring locations are proposed by EPA upstream and downstream of operations in Trap Dog Creek and Avondale Creek.
- EPA requested that waste rock must be assessed to determine if it is potentially acid forming (PAF); and that PAF material not be disposed of above groundwater level without EPA approval.

The NOW submission in response to the requests above by EPA is discussed in **Section 6.2** below. In short, NOW considers the EIS has satisfactorily assessed the potential impacts on Trap Dog Creek and Avondale Creek.

NOW also considers the risks to water quality from the final pit voids is minimal.

The matters raised by EPA have been in my opinion been addressed satisfactorily by the applicant in the Response to Submissions document (SCM, 2013).

6.2 NOW

NOW's brief submission dated 23 May 2013 was prepared in response to the EPA submission discussed in **Section 6.1** above.

Firstly, NOW considers that the groundwater model used for the assessment is fit for purpose, and the losses from the alluvium and connected surface water have been assessed conservatively. NOW also confirms that the impacts are within Level 1 of the minimal impact considerations for drawdown at any water supply work as defined in the Aquifer Interference Policy (AIP). NOW considers that the drawdown impacts have been adequately addressed.

Secondly, with respect to risk of post-mining pollution from final pit voids, NOW considers the risk to water quality is minimal.

Notwithstanding these conclusions, NOW recommended that the water management program include:

- establishment of monitoring bores in areas where alluvium has been excavated, including mine spoil, and alluvial areas beyond the mine footprint to determine longer term groundwater gradients;
- reassessment of water quality impacts if the monitoring shows a groundwater gradient from the mine footprint towards the alluvial areas; and
- mitigation works such as a low permeability barrier, if a rise in discharge of lower salinity groundwater to the alluvium is predicted.

I concur with the NOW recommendations.

6.3 Great Lakes Council

Attachment ‘D’ to the Great Lakes Council submission deals with water matters.

In summary, the Council’s water-related issues are:

- Cumulative impacts of the mine on groundwater, together with the AGL CSG Project and the Rocky Hill Coal Project.
- Potable water supplies, GDEs, and future increased importance of groundwater resources for agriculture and stream baseflow under climate change scenarios.
- Lack of discussion about mitigation following potential drawdown of groundwater.
- The creation of four permanent final pit voids (including the Rocky Hill project).

The proponent has responded satisfactorily in my opinion to the Great Lakes Council submission in the Response to Submissions document (SCM, 2013).

The groundwater model used for the Stratford Extension groundwater assessment (Heritage, 2012) did not initially include the Rocky Hill project. However, as the impacts from the Stratford Extension Project have been shown to be quite localised, much smaller in magnitude generally than the potential impacts of the AGL CSG project as reported, and do not overlap with the impacts predicted by the Rocky Hill groundwater assessment, it is considered acceptable that the model does not include both mining projects.

I am also satisfied that the impact assessment carried out for the Stratford Extension Project is sound, is conservative, and has been undertaken in accordance with the Australian Groundwater Modelling Guidelines (MDBC, 2000; and Barnett et al, 2012).

6.4 Gloucester Shire Council

The Gloucester Shire Council submission runs to 123 pages, and is very wide-ranging. The issues that relates to groundwater are found in the following sections:

- Section 4 (The Mine Plan), sub-section b (Embankments and voids)
- Section 5 (Mine Impact Issues), sub-section c (Water), part ii (Groundwater)
- Section 8 (Cumulative Impact), sub-section a (Ground and surface water)
- Section 9 (Proposed Conditions of Consent)

The proponent has in my opinion satisfactorily responded to the Gloucester Shire Council in its Response to Submissions document (SCM, 2013). The response dealing with groundwater issues is contained in that document in Section 15.5.

I generally concur with the proponent’s responses, and with the NOW conclusion that the drawdown impacts have been adequately addressed.

As indicated above, I am satisfied that the modelling has been generally undertaken in accordance with the Australian Groundwater modelling Guidelines (MDBC, 2000; and Barnett et al, 2012), and that the impact assessment is sound and conservative. I also consider that the cumulative impacts have been addressed satisfactorily.

6.5 IESC Advice

The advice from the Committee has been noted. Specific comments on those matters relating to groundwater follow.

The Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) asked the IESC Committee to provide advice on two questions, viz

> *1. What are the likely impacts of the proposed mine on surface and ground water resources, in particular, changes to surface and groundwater dynamics and water resources which may support terrestrial and aquatic habitat?*
>
> *2. Does the Committee find the water balance and conclusions relating to water management provided by the proponent and attached to the brief to be reasonable?*

The Committee's response consisted of 9 paragraphs.

Paragraph 1 relates to frog species, and is outside my area of expertise.

Notwithstanding that the Committee was not asked to provide advice on cumulative impacts, in **Paragraph 2** the Committee states that it considers that *"… there is insufficient information provided to adequately assess cumulative impacts of surrounding coal mining and coal seam gas proposals"*. In any case, I do not agree with this, for the reasons that have been covered in **Sections 5.3.11** and **5.4.11** above.

I think that the Committee has not acknowledged the difficulty faced by a proponent in accurately representing other projects in their assessment of cumulative impacts, particularly in relation to scheduling, as each separate proponent is very protective of its own project plans until they are finalised and ready for public release. This applies particularly to the Stratford Extension Project, as the impact assessment was undertaken at a time when there was limited information available on the specific details of the Rocky Hill proposal. The EIS for that project is still not yet on public exhibition. Likewise, there was very limited information available on the scheduling of proposed development of the AGL Project Therefore the Stratford groundwater impact assessment took a very conservative approach to cumulative impact assessment, by assuming that both the Rocky Hill Coal Project and the AGL CSG Project are fully active throughout the period of proposed mining from the Stratford Extension Project. Accordingly, the predicted impacts are likely to be overestimated.

I have not reviewed in detail the prediction of impacts from the AGL CSG project, as it did not form part of my brief for this project, other than to satisfy myself that the impacts predicted from that project are much larger and more extensive than those predicted to occur from either the Stratford Extension Project or the Rocky Hill Coal Project. I am satisfied that the impacts on groundwater levels from each of the two coal projects are unlikely to overlap with each other.

The recommendation made by the Committee in **Paragraph 3** is expected to be included within the conditions of approval for the project, if approved.

Paragraph 4 of the IESC advice concerns the water balance. This was included in the surface water studies, and as such did not form part of the scope of my review.

In **Paragraph 5** the Committee questions the veracity of the groundwater modelling, saying that in one case a 1.5 km drawdown is predicted. I have been unable to find reference to this magnitude of pressure reduction. Figure A-58 (Heritage, 2012) shows maximum cumulative water table drawdowns up to approximately150m, but not as great as 1500m. The drawdowns due to Stratford Extension Project alone are much smaller, with drawdowns of more than 10m extending only a few hundred metres from the open cuts. Subject to the comments above, I am confident that the modelling has been carried out appropriately, and I am confident in the results.

The Committee at **Paragraph 5** also declares a low level of confidence in the combined results of the groundwater modelling and the water balance conceptualisation, *"… given the significant variation in groundwater inflows required to calibrate the water balance model".* I find this statement puzzling.

Groundwater inflow rates are impossible to monitor directly, as groundwater inflow is usually a disseminated occurrence, and the water accumulating in the pits comprises both surface runoff and groundwater inflow, as well as drainage from waste rock deposited back in the pit. The quantity that can be monitored is the volume of water pumped out from the pit, as the separate components of inflow, or the changing storage level, cannot be individually measured.

At any time, the volume of water in the pit is a reflection of contributions from each of the above sources, as well as fluctuating volumes of stored water, as water is pumped out intermittently, not continuously at the same rate as it accumulates. Hence, actual groundwater inflow rates can only be determined indirectly over time, by comparing the volumes pumped out between times when there is no rainfall with periods when there is rain, and the component derived from rainfall runoff can be estimated based on assumed runoff rates. At times when there is no rain, the accumulation of water in the pit is assumed to be derived predominantly from groundwater inflow. When there is rain, the water accumulation is from both sources.

Because of the uncertainties, it is usual to verify the adopted groundwater inflow rates by use of water balance modelling. For its part, the groundwater model was calibrated against the low end of the envelope of monitored rates of water removal from the pit. Considering the uncertainties, I am satisfied that there is acceptable agreement between the surface water modelling and the groundwater modelling.

Overall, the model calibration in my opinion is very good. It will be possible, over time, to periodically re-calibrate the model to improve its confidence level even further, as the mining proceeds and impacts are monitored. Periodic re-calibration of the model is likely to be a condition of approval for the project, if approved.

I endorse the recommendation concerning regional monitoring by the Committee in its **Paragraph 6**. A coordinated monitoring program covering the basin should be encouraged between the operators of all three projects.

Paragraph 7 concerns surface water, and is outside my area of expertise.

In **Paragraph 8**, the Committee states that backfilling of voids and minimisation of pit lakes is best practice environmental management. I do not agree with this. I believe that final voids can be an important component in ongoing water management, particularly in relation to the containment of saline groundwater in areas where there is a potential risk of long term salinity problems.

Paragraph 9 is outside my area of expertise.

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