MALABAR

MAXWELL UNDERGROUND MINE

APPENDIX B

Groundwater Review

Our Ref: **HA2025/10**

Date: **16 May 2025**

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From: **Dr Noel Merrick**

Re: **Maxwell Joint Tailings and Rejects Management Project (Modification 3 to SSD 9526) – Groundwater Review**

Introduction

This technical note responds to the email request from Malabar Resources Limited [**Malabar**] on 6 February 2025 for provision of advice to WRM Water & Environment Pty Ltd [**WRM**] on groundwater inflows to be taken into consideration in WRM's water balance modelling of the Maxwell Underground Mine [**Maxwell**] final voids.

A Modification to Development consent SSD 9526 [**Modification 3**] is being sought to allow transfer of tailings from Mt Arthur Coal Mine [**MAC**] to the Maxwell East Void, and to permit receipt of tailings at the Maxwell North Void.

Key aspects of Modification 3 would include:

- Construction and use of an aboveground tailings transfer pipeline (from MAC) within the Maxwell Development Consent Boundary across land previously disturbed by the Drayton Open Cut Mine to the Maxwell East Void.
- Construction and use of an aboveground return water pipeline adjacent to the Maxwell East Void tailings transfer pipeline (to return water to MAC).
- Construction and use of an aboveground tailings and coarse rejects transfer pipeline from the Maxwell Coal Handling and Preparation Plant to the Maxwell North Void.
- Receipt of approximately 5.7 million tonnes (Mt) of tailings (up to a maximum of 6.6 Mt) from MAC and storage within the Maxwell East Void.
- Deposition of tailings and coarse rejects in the Maxwell North Void.

In providing this advice, four videoconference meetings were held between WRM, Malabar, BHP, Resource Strategies and HydroAlgorithmics.

Analytical Modelling

The scope of work was limited to the provision of general advice to WRM by HydroAlgorithmics based on existing knowledge of groundwater conditions in the vicinity of the voids and on previous groundwater modelling estimation of future groundwater conditions, and to establish likely hydraulic gradients from the groundwater system to the voids as pit lakes develop after operations cease at Maxwell.

Conversion of hydraulic gradients to groundwater inflows is achieved by an analytical modelling algorithm. The simplest such algorithm is Darcy's Law which assumes a linear relationship between groundwater discharge and hydraulic gradient. In this study, an improved algorithm has been applied which recognises a quadratic shape for the water table adjacent to a pit lake as it forms in a void, as illustrated conceptually in **Figure 1**.

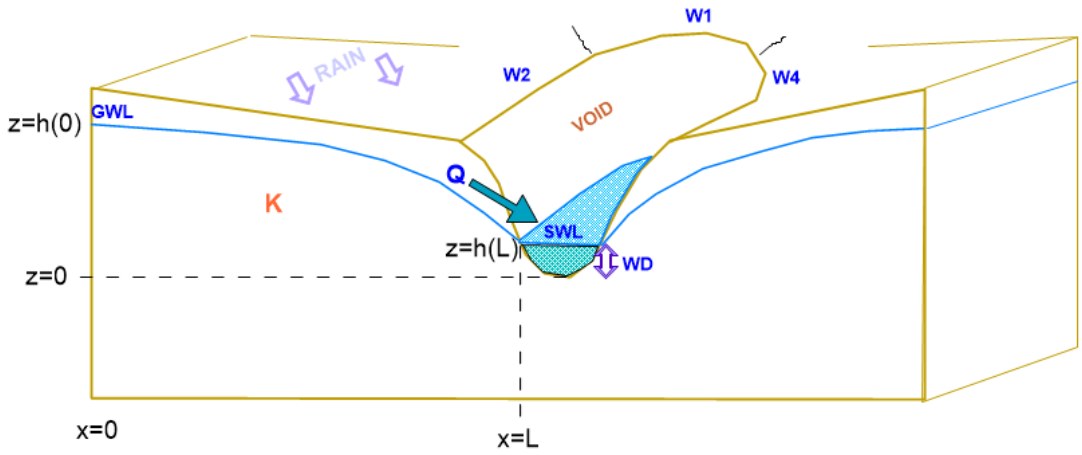

Figure 1. Conceptual model for groundwater discharge to a void

The steady-state groundwater flow equation for this situation simplifies to:

$$h(x) = h(L) + \frac{(L^2 - x^2)\,Q}{2\,L\,K\,A}$$

which can be rearranged to give a formula for discharge (Q):

$$Q = [h(x) - h(L)]\,\frac{2\,L\,K\,A}{(L^2 - x^2)}$$

Setting x=0:

$$Q = 2\,[h(0) - h(L)]\,\frac{2\,L\,K\,A}{(L^2)} = 2\,\frac{(GWL - SWL)}{L}\,K\,A$$

$$Q = 2\,grad\,K\,(WD)\,\sum W_i$$

Where:

- *grad* is the hydraulic gradient;
- *K* is hydraulic conductivity;
- *WD* is water depth;
- *Wi* is the void perimeter divided into 4 segments (i = 1 to 4) for north, west, south and east;
- *Q* is discharge; and

- A is the contact area of spoil with lake water, through which groundwater discharge occurs.

The resulting discharge is exactly double the rate given by Darcy's Law, as this approach allows for the increased hydraulic gradient at the point of discharge to the void.

In practice, the hydraulic gradient is allowed to differ in each of the four directions:

$$Q = 2\,K\,(WD)\,\sum W_i\,grad_i$$

Water depth (WD) will vary with time as the lake rises and as tailings are deposited. The hydraulic gradient also will reduce with time as the lake rises, leading to a time-varying discharge:

$$Q(t) = 2\,K\,(WD(t))\,\sum W_i\,grad_i(t)$$

Groundwater Level Information

Information on the spatial variation of hydraulic gradients, under the influence of final voids, can be gleaned from the post-closure numerical groundwater modelling for Maxwell, conducted by HydroSimulations (2019). The predicted water table contours 100 years after mining has ceased are illustrated in **Figure 2**.

Figure 2. Future predicted water table elevations (mAHD) [after HydroSimulations, 2019]

Since the post-closure modelling was done, new monitoring bores were installed around the North Void, and data has become available from bores monitoring the groundwater levels associated with the Liddell Ash Dam. These bores are relied upon for more accurate hydraulic gradients to the north and east of the voids.

Figure 3 shows the historical range in shallow groundwater levels at regolith bores GW01S and DS1 to the north and east of North Void, both holes being about 15 metres (m) depth. Bore F1164 is much deeper (190 metres below ground level) within the Greta Coal Measures. Immediately prior to the commencement of Drayton mining, the groundwater level at bore F1164 was 187-190 metres Australian Height Datum (mAHD), which would be indicative of future levels when groundwater equilibrium is attained. As there is a natural vertical gradient in the downwards direction, the equilibrium water table at that location is expected to be similar to that at GW01S. In September 2024, the groundwater level at bore F1164 was 145 mAHD, and rising, as it was controlled by the water level in the void at that time.

Figure 3. Measured groundwater elevations (mAHD) near North Void and East Void

Bore GW02S (14 m depth) near East Void has current groundwater levels (190-193 mAHD) consistent with those at the ash dams (187-189 mAHD), as shown in **Figure 4**.

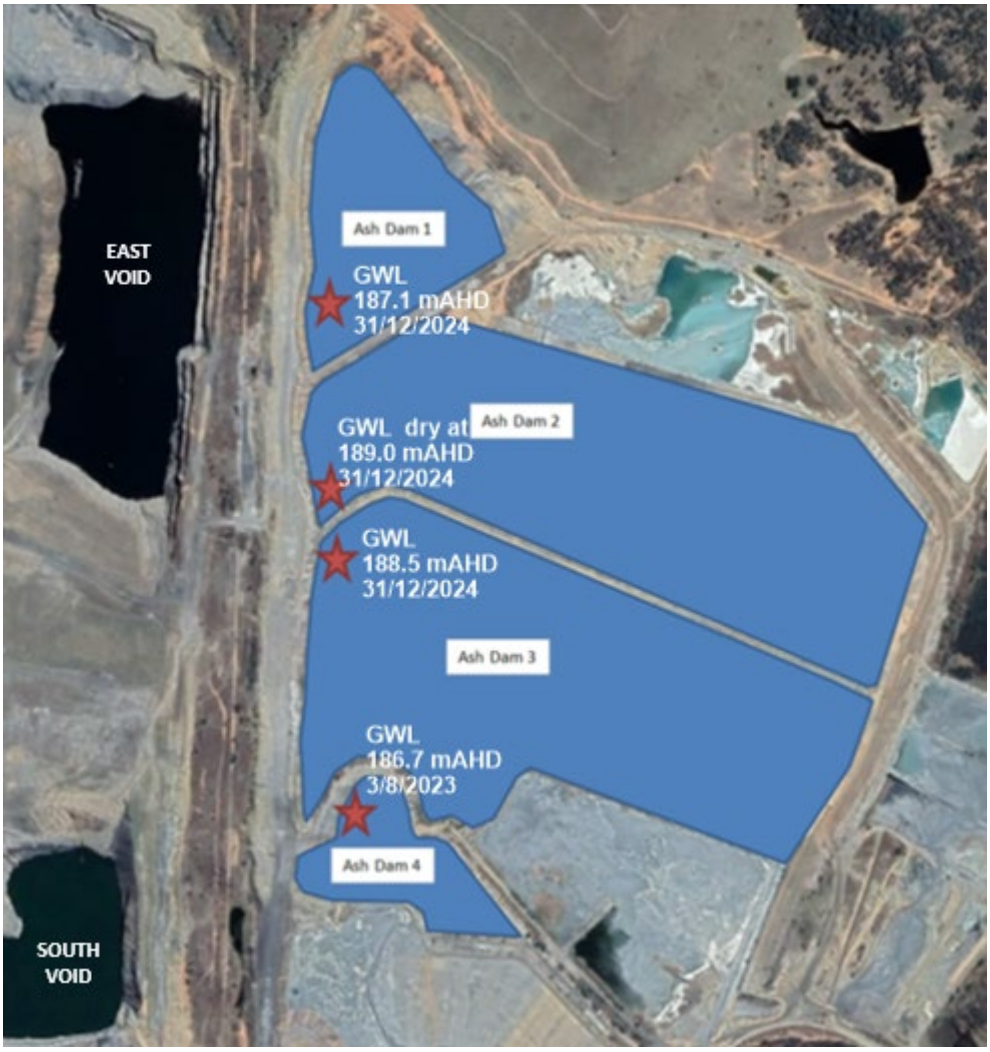

Figure 4. Measured groundwater elevations (mAHD) beneath the Liddell Ash Dams

Inflow Calculations

For each of the three voids, WRM provided the time-varying void lake water levels [*SWL(t)*] and the contact areas [*A(t)*] between spoil and lake water, which take into account the deposition of tailings in East Void initially and North Void subsequently. No tailings are planned to be deposited in South Void.

The adopted reference groundwater levels (GWL_i) and their distances (L_i) from the voids are tabulated in **Appendix A** (**Table A1** and **Table A2**, respectively) for each direction, assuming peripheral segment lengths (W_i) listed in **Table A3** to allow partitioning of inflows from each direction.

The adopted hydraulic conductivity (K) values are 0.7 metres per day (m/day) for spoil and 0.002 m/day for weathered overburden in the coal measures along the eastern edge of Coal Lease (CL) 229 and Mining Lease (ML) 1531. HydroSimulations (2019) cited two measurements of 0.7 m/day and 1.6 m/day spoil hydraulic conductivity by Mackie Environmental Research (2009) and Australasian Groundwater and Environmental Consultants Pty Ltd (2013). The lower K value (i.e. 0.7 m/day) has been adopted as it is more consistent with the groundwater inflows determined by WRM (2019) in order to achieve a calibrated water

balance in a previous surface water assessment. In the HydroSimulations (2019) groundwater model, Layer 2 was designed to capture the approved fill level of MAC Tailings and proposed fill level for East Void (HydroSimulations, 2019), as well as undisturbed weathered rock adjacent to mined areas. The overburden hydraulic conductivity (i.e. 0.002 m/day) is the calibrated value for weathered rock in Layer 2.

The calculated directional inflows to each void, comprised of spoil seepage and inflows from weathered rock, are tabulated in **Table 1** for North Void, **Table 2** for East Void, and **Table 3** for South Void from 2025 to 2092.

Table 1. Groundwater inflows to North Void [kL/day]

YEAR	SWL (mAHD)	Q(kL/day)	QNW	QW	QS	QE	QNE
2025	145.3	**2139**	758	481	898	1.6	7.6
2026	146.8	**2090**	748	468	873	1.6	7.5
2035	162.7	**1059**	450	212	397	0.7	4.5
2042	183.3	**20**	53	-11	-21	0.0	0.5
2043	183	**22**	48	-9	-17	0.0	0.5
2047	178.4	**69**	56	4	8	0.0	0.6
2052	175	**96**	60	13	24	0.0	0.6
2057	173.9	**104**	61	15	28	0.0	0.6
2062	173	**109**	62	17	31	0.1	0.6
2067	172.3	**113**	62	18	33	0.1	0.6
2072	171.7	**117**	62	19	35	0.1	0.6
2077	171.2	**119**	62	20	37	0.1	0.6
2082	170.9	**121**	62	20	38	0.1	0.6
2087	170.6	**122**	63	21	39	0.1	0.6
2092	170.4	**123**	63	21	39	0.1	0.6

Notes: kL/day = kilolitres per day

Table 2. Groundwater inflows to East Void [kL/day]

YEAR	SWL(mAHD)	Q(kL/day)	QN	QW	QS	QE
2025	141.4	**386**	103	164	113	5.0
2026	150.5	**278**	75	120	80	3.8
2035	170.4	**4.6**	1.4	2.2	1.0	0.1
2042	172.0	**2.2**	0.7	1.1	0.4	0.1
2043	174.5	**2.9**	1.0	1.5	0.3	0.1
2047	175.4	**2.9**	1.0	1.5	0.3	0.1
2052	175.0	**2.9**	1.0	1.5	0.2	0.1
2057	174.0	**2.9**	0.9	1.5	0.4	0.1
2062	173.0	**2.6**	0.8	1.3	0.4	0.1
2067	172.3	**2.2**	0.7	1.1	0.4	0.1
2072	171.7	**1.9**	0.6	0.9	0.4	0.1
2077	171.2	**1.4**	0.4	0.7	0.3	0.0
2082	170.9	**1.0**	0.3	0.5	0.2	0.0
2087	170.6	**0.7**	0.2	0.3	0.1	0.0
2092	170.4	**0.5**	0.1	0.2	0.1	0.0

Notes: kL/day = kilolitres per day

Table 3. Groundwater inflows to South Void [kL/day]

YEAR	SWL(mAHD)	Q(kL/day)	QN	QW	QS	QE
2025	141.6	**2484**	1195	333	953	3.1
2026	143.5	**2461**	1180	331	947	3.1
2035	162.7	**1535**	680	221	631	2.4
2042	174.0	**475**	122	91	261	1.5
2043	175.0	**359**	62	77	220	1.4
2047	175.0	**359**	62	77	220	1.4
2052	175.0	**359**	61	77	220	1.4
2057	173.9	**487**	128	93	265	1.5
2062	173.0	**589**	181	105	301	1.6
2067	172.3	**667**	221	115	329	1.7
2072	171.7	**733**	256	123	353	1.7
2077	171.2	**788**	284	130	372	1.8
2082	170.9	**820**	301	134	383	1.8
2087	170.6	**852**	317	138	394	1.8
2092	170.4	**873**	328	141	402	1.9

Notes: kL/day = kilolitres per day

Each void is predicted to act as a net sink for groundwater. No void is expected to behave as a net flow-through system. When directional flows are considered, the only predicted occurrence of an outflow from a pit lake is for the North Void in the westerly and southerly directions (marked red in **Table 1**) for a short period of time in 2042 and 2043. These escapes of water are not of concern because they are of low volume and would be retained internally in spoil.

The temporal variation of groundwater inflow to each void is presented at **Figure 5**. This shows that South Void is expected to receive most groundwater, partly due to its not receiving any tailings, thereby maximising the contact area between spoil and lake water. North Void also is expected to receive relatively high groundwater inflows until tailings begin to be deposited from 2040. As all discharges are positive, or zero, no net escape of water is anticipated from any void at any time in the future.

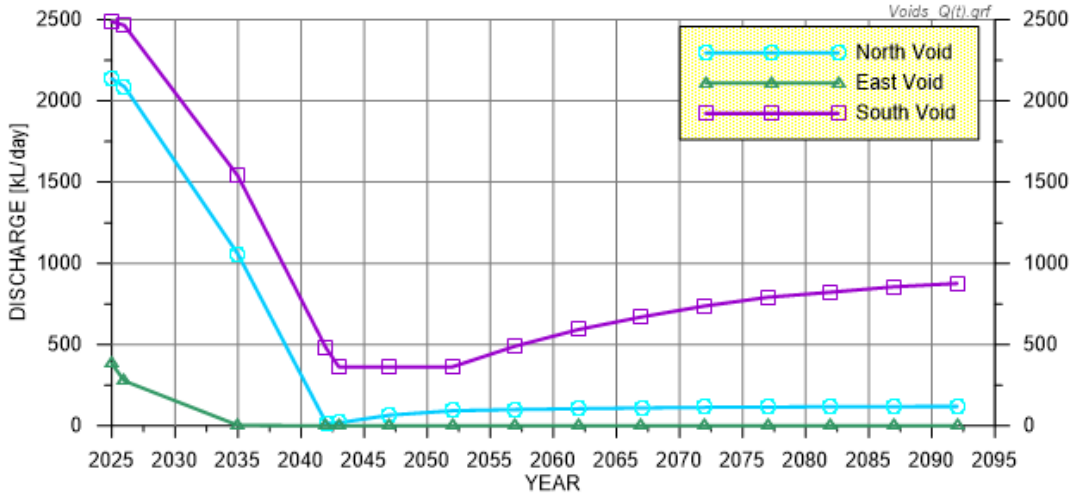

Figure 5. Predicted groundwater inflow variations with time

The stage-discharge curves in **Figure 6** are required by WRM as an input to their water balance modelling (i.e. to improve overall accuracy of inflow calculations). Refining the stage-discharge curves for WRM's water balance model went through multiple iterations until the curves stabilised and the separate surface water and groundwater models converged.

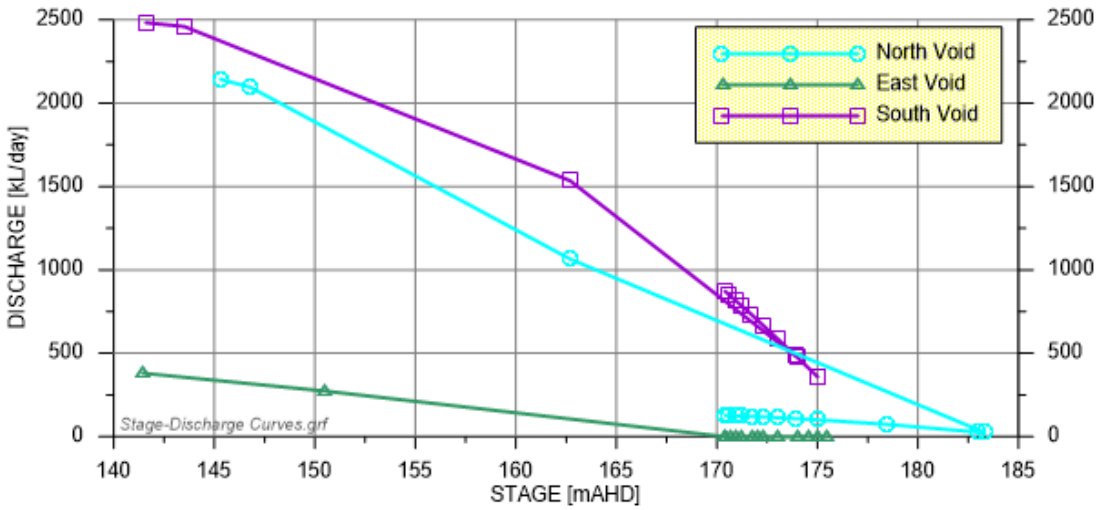

Figure 6. Predicted stage-discharge curves

Licensing of Water Takes

The Q(kL/day) column in **Tables 1-3** lists the best estimates of groundwater takes for each void, presented in **Table 4** as annual volumes.

Table 4. Groundwater takes [ML/year]

YEAR	NORTH VOID	EAST VOID	SOUTH VOID
2025	780	140	910
2092	45	0.2	320

Notes: ML/year = megalitres per year

Most of these takes would be sourced from rainfall recharge passing through spoil. HydroAlgorithmics' understanding of the *NSW Aquifer Interference Policy* (NSW Department of Primary Industries, 2012) is that short-circuit rainfall-derived groundwater resulting from waste emplacement is exempt from licensing.

However, there are some directional flows originating in the coal measures overburden east of the Maxwell mining tenements (i.e. CL 229 and ML 1531). These flow components are recorded in the QE columns in **Tables 1-3** and in the QNE column in **Table 1**. They are presented in **Table 5** as annual volumes.

Table 5. Licensable groundwater takes [ML/year]

YEAR	NORTH VOID	NORTH VOID	EAST VOID	SOUTH VOID	TOTAL
	QE	QNE	QE	QE	
2025	0.6	2.8	1.8	1.1	6.3
2092	0.04	0.2	0.0	0.7	0.9

Notes: ML/year = megalitres per year

Table 5 indicates that post-mining shares of 1 to 6 megalitres per year equivalents should be secured from the *North Coast Fractured and Porous Rock Groundwater Sources*. The numerical modelling by HydroSimulations (2019) predicted groundwater takes from this source averaging 3 ML/year during mining with a maximum of 11 ML/year, in the Maxwell Infrastructure area. At that time, no post-mining groundwater takes were expected.

References

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2013. Groundwater Impact Assessment, Mt Arthur Coal Open Cut Modification. Report for Mt Arthur Coal. Project No. G1602. January 2013.

HydroSimulations (HS), 2019. Maxwell Project: Groundwater Assessment in Support of an EIS. Report HS2018/44 for Malabar Coal Limited, July 2019.

Mackie Environmental Research (MER), 2009. Hydrogeological Characterisation of coal measures and overview of impacts of coal mining on groundwater systems in the Upper Hunter Valley of NSW, PhD thesis, Faculty of Science, University of Technology, Sydney.

NSW Department of Primary Industries (DPI) - Office of Water, 2012. NSW Aquifer Interference Policy. 31pp.

WRM Water & Environment Pty Ltd (WRM), 2019. Surface Water Assessment: Maxwell Project Report 1383-02-J5 for Malabar Coal Limited, July 2019.

APPENDIX A

Table A1. Reference groundwater levels (GWLi) [mAHD]

DIRECTION	NORTH VOID	EAST VOID	SOUTH VOID
North	198	176	176
West	180	180	180
South	180	176	180
East	180	187	186

Table A2. Distance (Li) of reference groundwater level (GWL) to void [m]

DIRECTION	NORTH VOID	EAST VOID	SOUTH VOID
North	450	1600	500
West	700	2000	500
South	1000	1300	700
East	1400	250	350

Table A3. Segment length (Wi) along void periphery [m]

DIRECTION	NORTH VOID	EAST VOID	SOUTH VOID
North	200 (NW), 700 (NE)	400	1000
West	300	800	250
South	800	400	1000
East	500	900	500
TOTAL	2500	2500	2750