Appendix 2

Water Balance Assessment by Environ Pty Ltd

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28th January 2015

By Email

Mr Alex Irwin
RW Corkery Pty Limited
62 Hill Street
ORANGE NSW 2800

Re: LOM Project Modification, Evaluation of Site Water Balance

Dear Mr Irwin

Introduction

Werris Creek Coal Pty Ltd (WCC) is proposing a modification to the LOM which includes a review of the site water management. The following site water balance model (WBM) revision forms part of the review and informs the Environmental Assessment (EA) for the modification proposal.

RW Corkery & Co. Pty Ltd, at the request of WCC, prepared a Project Overview which was submitted to the Department of Planning and Environment. On the basis of this document the Department of Planning and Environment have requested that water balance modelling be completed to understand the Site's water storage requirements, and to evaluate what storage options are available in the event that the site storages are exceeded.

Model Calibration

ENVIRON has previously undertaken a number of rounds of amendments to the original site WBM, developed by GSSE in December 2010 for a previous Werris Creek Mine EA[1]. The revised site WBM prepared by ENVIRON was primarily used in order to provide back-up to a calibrated groundwater model, also undertaken by ENVIRON[2] for use in the Annual Review requirement of the Project Approval[3]. A basic summary of the WBM representing flow to the open cut void is shown in **Figure 1**.

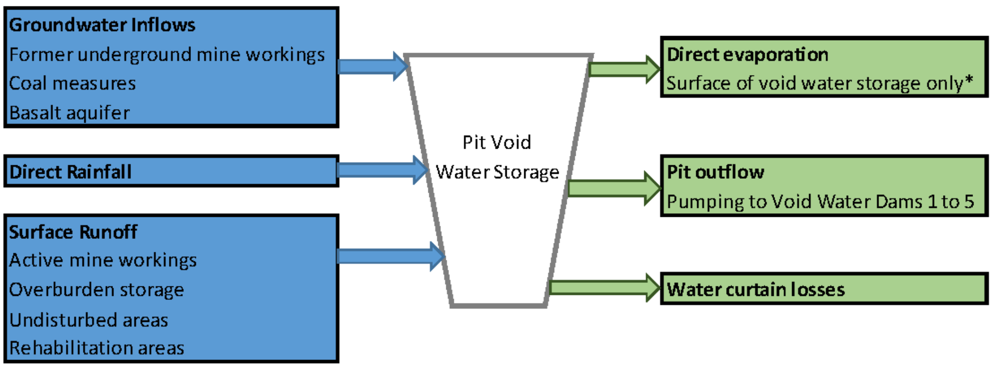


Figure 1 Site Conceptual Water Balance

[1] GSSE, Surface Water Assessment, Life of Mine Project, December 2010.
[2] ENVIRON, Evaluation of Impacts to Groundwater from the Werris Creek Coal Mine Operations, May 2014.
[3] PA 10_0059 issued, the Minister for Planning and infrastructure's delegation, on 25 October 2011.

Based on this schematic, groundwater inflows to the open cut were estimated by Equation 1.

Open cut out flow = Surface water inflows + Groundwater inflows - change in open cut void water storage - water curtain losses [1]

Groundwater inflows and overburden seepage have been determined using a calibrated groundwater model described in more detail in ENVIRON's Annual Review reporting[2]. Overburden seepage was determined using the calibrated groundwater model, and is directly related to rainfall and infiltration assumptions.

Surface water runoff was determined in ENVIRON's most recent iteration of the WBM from rainfall rates, the catchment area and assumptions on infiltration and evaporation. To estimate the contribution from surface water runoff to the open cut void, daily rainfall data was input to the WBM either directly to the void surface area or as a percentage of runoff from areas discharging into the void. The void surface area was calculated from the relationship between the geometry of the void space using survey data gathered by WCC.

Three areas were identified to provide runoff input to the void:

- the active open cut area [50% runoff];
- bare/compacted soil area to the north of the active open cut area [60% runoff]; and
- undisturbed land to the north of the active open cut area ("Old Colliery" Hill) [20% runoff].

Runoff coefficients were initially taken from the GSSE surface water assessment[1]. With the exception of the void surface itself, the effects of evaporation on surface water are incorporated in the runoff coefficients.

Evaporative losses from the void water surface are calculated on the basis of daily average evaporation (in mm derived from Bureau of Meteorology monthly averages at Quirindi Post Office) from the surface area of the void. The surface area of the void changes as a result of the geometry of the void area and the volume of water predicted to be within it.

Open cut void water storage has been surveyed by the site surveyor since August 2012. Open cut outflows are measured through a flow meter that is routinely monitored. Water from the open cut void is pumped to five Void Water Dams located within the mine site boundary. These are named Void Water Dam (VWD) 1, 2, 3, 4 and 5. The monitoring data for open cut outflows, including information on estimated water curtain losses, were provided to ENVIRON by WCC.

Data measured at the Mine between September 2012 and April 2014 was used for the calibration work. In September 2012, the volume of water contained within the void was calculated to be 410 ML. In April 2014, the volume of water contained within the void was calculated to be 20 ML. The total change in storage was therefore calculated to be 390 ML.

Water pumped out of the open cut and recirculated through the mine workings as a water curtain has not been included in the out of pit pumping total but has been included as a simple loss from the void. It has been assumed that 95% of this water returns to the void in-pit storage, and 5% is lost through the pumping and reticulation process. This approach was considered reasonable as the purpose of the curtain is to maintain saturation at the working face and therefore there is direct connectivity through the workings (post blast) to the open cut void.

Figure 2 presents the volume of water in the void calculated from the initial WBM run between September 2012 and April 2014 against site measurements. It has been estimated by WCC that the reporting error for measurements may be as high as ± 10 ML per month. High and low bounds to the mine water measurements have been applied for comparison. Likewise, there is error associated with the modelling work of ± 10 ML per month which has also been applied to the model results.

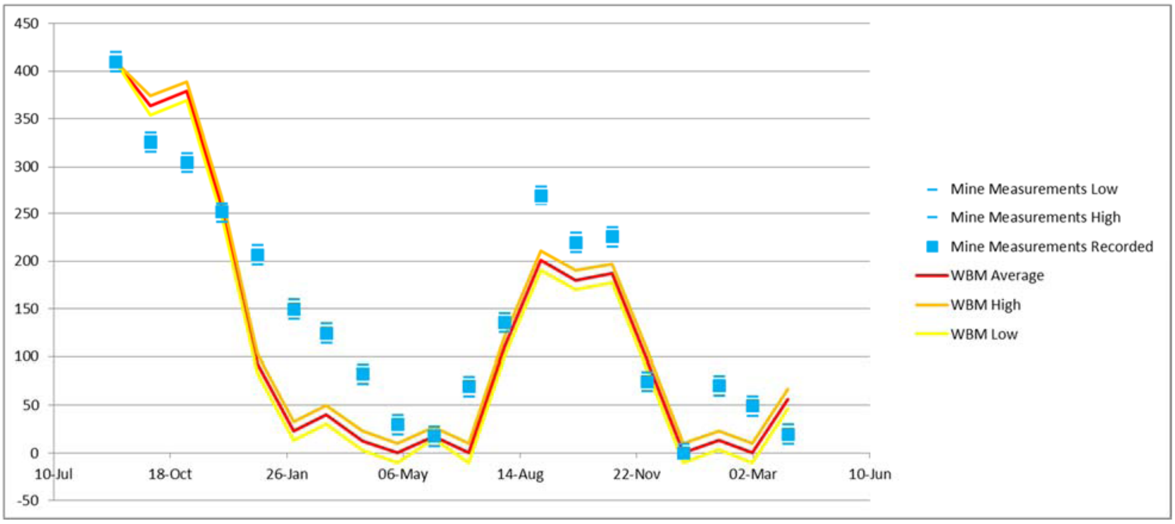


Figure 2 Site Water Balance, initial calibration

The results presented **Figure 2** suggest that the initial WBM shows a tendency to over- or under-predict the volume of water in the void. Although the monitoring data for outflows and groundwater inflows provided relatively detailed model parameters, it was considered that the runoff coefficients applied from the previous GSSE work may be overgeneralized. As a result, a simplified runoff model incorporating a single surface store/base flow store based on a modified version of the Boughton Australian Water Balance Model (AWBM)[4] was incorporated into ENVIRON's WBM. As a result of this addition, the closeness of fit between monitoring results and the WBM was improved as in **Figure 3**.

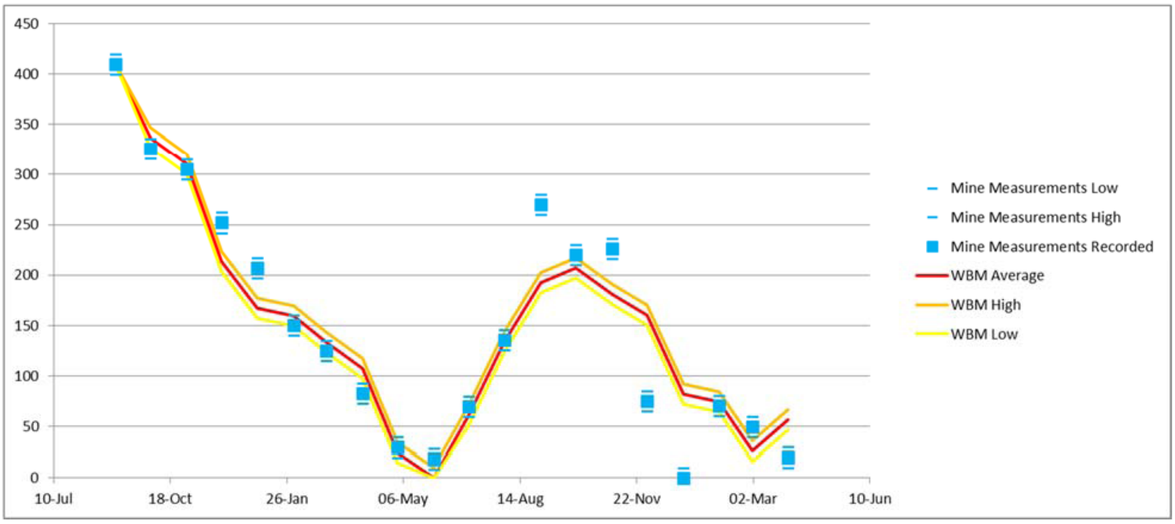


Figure 3 Site Water Balance, refined calibration

The revised WBM incorporating the more AWBM surface store/base flow store runoff model was used for all additional investigations.

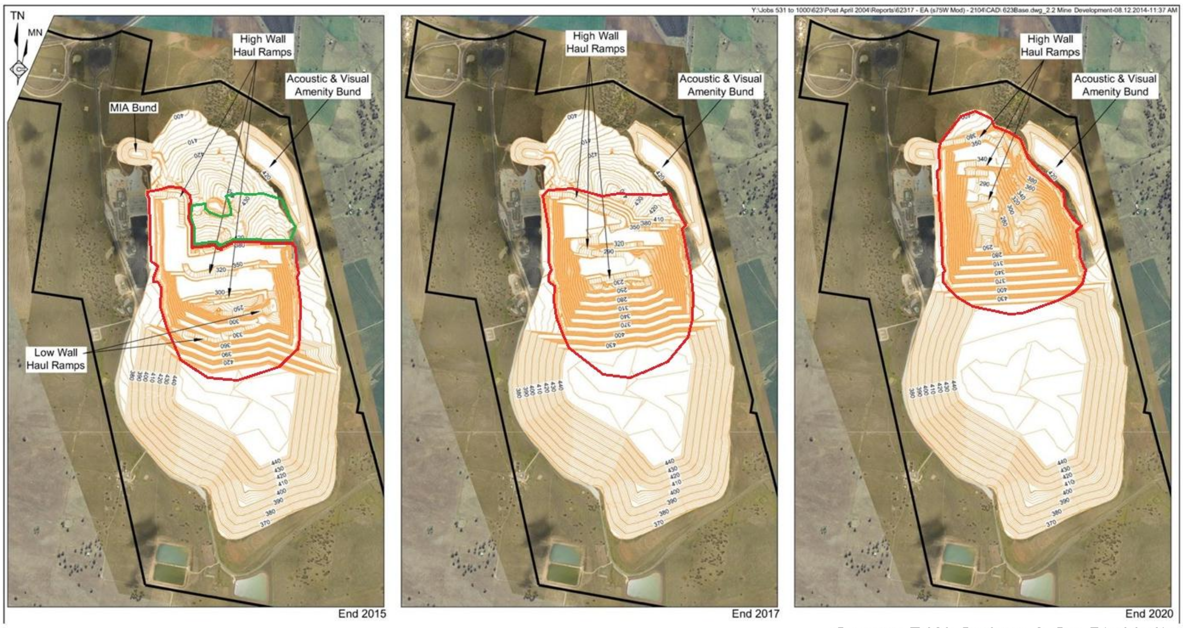
[4] Boughton, W. (2004). The Australian Water Balance Model. Environmental Modelling & Software 19 (10), 943-956.

Future Scenarios

Future development of the mine has been set out by R.W. Corkery & Co. Pty Limited (RWC) in the Environmental Assessment report (EA) for the modification proposal. Three future scenarios have been assigned for the WBM to be used in a predictive model:

- Development of the void and rehabilitation area in 2015;
- Development of the void and rehabilitation area in 2017 including the removal of VWD2 and VWD5; and
- Development of the void and rehabilitation area by 2020 including the removal of VWD2 and VWD5.

The area contributing surface runoff to the open cut void changes in each of these scenarios as per **Figure 4**. The red line shows the area contributing runoff from active mine workings or rehabilitation areas, the green line (2015 scenario only) shows undisturbed areas contributing runoff to the open cut void.



Source: R.W. Corkery & Co. Pty Limited

Figure 4 Future Mine Scenarios

The model was run using a 113 year data set of daily rainfall for Werris Creek Post Office (Station Number 055062 between 1900 and 2013) to simulate a range of weather scenarios and assess dry and wet weather conditions for the remaining life of mine including input from the current groundwater model.

In terms of water management, the key objectives for the WBM were to enable analysis of the circumstances under which the open cut void would contain water, when pumping out from the void to VWDs could not occur due them being full.

The previous ENVIRON WBMs were used to verify the groundwater modelling assumptions and were compared with actual monitoring data for the volume of water in the open cut and pumped out. To be used in a predictive mode, a number of alterations were needed as follows:

- Incorporation of the VWDs: this included an allowance for direct rainfall and pumping from the open cut void plus evaporation. Evaporation was incorporated into the model by determining the relationship between the volume of water in the VWDs and the surface water based on geometry data for the VWDs provided by WCC;
- Consumptive water uses as a loss to the model for use in dust suppression and miscellaneous water usage in the admin/workshop based on the last two years' data provided by WCC; and
- Annual groundwater inflows modelled by ENVIRON for the 2015 (54 ML), 2017 (47 ML) and 2020 (22 ML) scenarios.

The mine is constrained by a condition that specifies zero allowable discharge from the VWDs. For this reason, the predictive WBMs were set so that water would preferentially be allowed to fill the open cut void rather than overflow from the VWDs. As per the EA prepared by RWC, 63 ML was reported as available within the open cut in addition to storages in the VWDs although this is not a static figure and likely to change over the life of the Mine. For example, as the active mining area reaches the lowest point of the open cut void, this available capacity would be significantly reduced. The approach to managing water was therefore set with the objective of trying to maintain the open cut as dry as possible.

Analyses on the WBM were undertaken based on median, low runoff and high runoff scenarios. Statisitical analysis of runoff rates between 1913 and 2013 allowed the determination of years where the annual rate of runoff was equivalent to the median (1999), the 90th percentile high runoff 'wet' scenario (1919) and the 15th percentile low runoff 'dry' scenario (1938). These specific years are used to illustrate how the WBM is used for water management decisions and the results are presented in **Table 1**.

Table 1: Void Water Balance

		Year 2015			Year 2017			Year 2022		
		Median	**15th %ile**	**90th %ile**	**Median**	**15th %ile**	**90th %ile**	**Median**	**15th %ile**	**90th %ile**
Inputs	Rainfall/runoff	737	570	1,043	835	643	1,192	792	605	1,130
	Groundwater Inflow	54	54	54	47	47	47	22	22	22
	Input (return) from Underground	67	67	67	-	-	-	-	-	-
	Total	**858**	**691**	**1,164**	**882**	**690**	**1,239**	**814**	**627**	**1,152**
Outputs	Evaporation	408	381	329	428	408	374	409	328	358
	Water use	365	365	365	365	365	365	365	365	365
	Total	**773**	**746**	**694**	**793**	**773**	**739**	**774**	**693**	**723**
Balance		**85**	**-55**	**470**	**89**	**-83**	**500**	**40**	**-66**	**429**

Conclusions

ENVIRON has previously undertaken a number of rounds of amendments to the original Mine WBM, developed by GSSE in December 2010 for the Werris Creek Coal Mine LOM Project. The revised WBM prepared by ENVIRON was primarily used in order to provide back-up to a calibrated groundwater model, also undertaken by ENVIRON for use in the Annual Review requirement of Project Approval 10_0059.

Although the monitoring data for outflows and groundwater inflows used in these models provided relatively detailed input parameters, it was considered that the runoff coefficients applied from the previous GSSE work may be overgeneralized. As a result, a simplified runoff model incorporating a single surface store/base flow store based on a modified version of the Boughton AWBM was incorporated into ENVIRON's WBM. As a result of this addition, the closeness of fit between monitoring results and the WBM was improved.

ENVIRON's revised WBM was used to assess future development of the Mine as per the modification proposal. Three future scenarios have been assigned for the WBM to be used in a predictive model:

- Development of the void and rehabilitation area in 2015;
- Development of the void and rehabilitation area in 2017 including the removal of VWD2 and VWD5; and
- Development of the void and rehabilitation area by 2020 including the removal of VWD2 and VWD5.

Analyses were undertaken using average, 'wet' and 'dry' runoff years. For the 2015 scenario, in order to ensure that there are zero overflows, for the 'dry' scenario, by pumping out of the open cut void as per existing mine water management procedures, the water balance shows a deficit of 55 ML in one year. There would be a net reduction in storage in the VWDs over the course of the year. Given the VWDs are currently operating near operational capacity and have a combined volume of 714ML (maximum spillway capacity 755 ML), this is almost certainly manageable and there would not be a requirement to import water for dust suppression purposes.

For the median runoff scenario, in order to ensure that there are zero overflows, the net annual balance leads to 85 ML which must be managed. That is, in an average rainfall year, without additional management of water, this would lead to water accumulating in the VWDs or in the open cut void. For the 'wet' scenario, this annual balance is 470 ML. Without an alternative strategy for managing this water, this may result in the accumulation of water within the VWDs (if not full) or the open cut void during a median or 'wet' rainfall year. For the 2017 and 2022 model runs, a similar pattern occurs with a net water deficit during 'dry' years and excess volumes of water of up to 500 ML per year during 'wet' years.