Central Region Water Resilience Project - Sustaining Production in a Changing Climate

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Abstract

BHP Mitsubishi Alliance's (BMA) Central Region metallurgical coal mines (comprised of Caval Ridge, Peak Downs, Saraji and Saraji South Mines) in Queensland, Australia, store mine affected water (MAW) in water storage dams and dormant mine pits onsite. When available local storage is exceeded, MAW is pumped via the Central Region pipeline and stored at Saraji South Mine.

One of the most significant risks to production at these mines is a dry climate resulting in water supply shortfall. Applying iterative analysis between Mine Water Balance modelling and infrastructure design, a range of alternatives were analysed to identify a preferred solution that addresses inter-annual climatic variability. Climate change impacts were also considered as part of the assessment.

This paper describes the methodology applied to determine a preferred solution.

Keywords: Goldsim, Pipeline, Reuse, Metallurgical coal

Context – Existing Situation and Observed Environmental Changes

BMA's Central Region mines comprises Caval Ridge Mine (CVM), Peak Downs Mine (PDM), Saraji Mine (SRM) and Saraji South Mine (SSM). Stored mine affected water (MAW) enables coal mining and processing activities. MAW is the predominant source of water for these mines, generally supplying over 80% of all water demand through recycling, thereby minimising demand on other sources. The storage of MAW allows for management of water supply over the highly variable climate in the Bowen Basin. Where required, MAW is supplemented with water supplied from Bingegang Weir on the Mackenzie River (via BMA's Bingegang Pipeline) for PDM, SRM and SSM, and Burdekin Dam (via the Burdekin (Sunwater) and Western Corridor (BMA) Pipelines) for CVM.

At the commencement of the Study (December 2019), the Central Region mines held approximately 47,000 ML of inventory, with the majority held at SSM. The SSM mine plan proposed the return to production for a number of dormant pits used as MAW storages. With a reduction in MAW inventory, and with dormant pits returned to mining, alternative supply and storage was required to ensure the mines are climatically resilient and production is sustained both in wet and dry years.

Preliminary investigations were completed to determine whether water could be sourced from other offsite sources. Additional high security allocations cannot be secured from the Nogoa-Mackenzie river system (which supplies SRM, PDM & SSM via the Bingegang Pipeline, and BMA's Blackwater Mine (BWM)) as the system is fully allocated. During the 2017-19 drought, high security allocations came within months of being reduced to 50% of their annual totals due to the low storage levels in the upstream Fairbairn Dam. The ongoing reliability of this water source represents a significant risk during droughts with this risk identified as having potential to be increased as a result of climate change. Extensive infrastructure upgrades of the Bingegang Pipeline (over 120km of pipelines and multiple pump stations) would also be required to convey water from this source to the PDM point of demand.

BHP's Water Stewardship position is to support the United Nations Sustainable Development goal of a 'water secure' world by 2030. Decisions that minimise sourcing water supply from other offsite sources (dams, other surface water supplies and the environment) aligns with BHP's Water Stewardship position.

The study focussed on how existing MAW could be reused and production sustained whilst minimising water sourced from offsite sources in the face of a drying climate.

Approach: Study Method Overview

The study was staged as follows:

- Stage 1: Alternative Validation
- Stage 2: Trade Off Multi-Criteria Assessment
- Stage 3: Preferred Alternative Optimisation and Engineering

Throughout each stage, iterative analysis was applied between Mine Water Balance modelling (informing the water resilience benefits from specific alternatives and capacities) and engineering infrastructure design supported by cost estimates, to permit comparison between alternatives. A range of capacities were evaluated to identify the preferred solution that sustained production and reduced the risk presented by inter-annual climatic variability and predicted climate change.

The alternatives were assessed in Stage 1 and 2 against a range of qualitative (environmental, social, closure, community) and quantitative (capital and operational cost, production benefits), with an overriding screening criteria of climatic resilience. Once a preferred alternative was identified at the end of Stage 2, capacity optimisation and engineering was undertaken. All alternatives were compared against Business as Usual (BAU) – i.e. no change.

Water Balance Modelling & Climate Resilience Analysis – Method

A combined Central Region Water Balance Model (CRWBM) was developed in the Identification Phase Study (IPS (2019)). The CRWBM was developed from the four individual mine Water Balance Models (WBMs) which track the movement of both water quantity and quality (particularly Electrical Conductivity) through the model. Embedded within these models are stochastically generated datasets that represent the climatic range for the mines. The outputs from the WBM provide probability based results, with a focus on the 5th/95th percentile results.

At the commencement of the Selection Phase Study (SPS), the WBM was updated to included changes to starting water levels, starting water quality for Electrical Conductivity, catchment disturbance (current and future), production data, the water transfer network, Coal Handling Processing Plant (CHPP) and dust suppression demands, offsite water release utilisation estimates and Trigger Action Response Plan (TARP) levels at each site.

Reflecting actual practice on the ground, the TARP for each site is embedded in the CRWBM to guide the analysis. The TARP prioritises the use of MAW over other sources (i.e. offsite surface water sources), enacts transfer between sites, storage of MAW and when available and required, environmental release.

The key statistics assessed were Total Stored Water Inventory, Site Water Stored Inventory, Total Annual External Water Source Use, Total Annual Release, Total CHPP Shortfall, Total Dust Suppression Shortfall, and Site Pit Interruption Days (to account for wet weather impacts). A range of other results were produced however these key statistics were the focus.

The study concentrated on the dry weather impacts, as wet weather impacts affect pit accessibility and access to mining areas, however there are many variables in the wet weather impacts.

The options analysis using the CRWBM compared results against minimal to no investment as the base case, with an assessment period of 20 years.

Consideration of Climate Change

The initial phase studies (2017-2019) identified that Climate Change needed to be considered as the study progressed. When the study commenced in 2019, BHP were in the process of developing a climate change

Table 1 Climate Change Data – 2030

Climatic Percentile	Annual Rainfall (Change from Current) %	Annual Evaporation (Change from Current) %
P5	- 7.7	5.4
P50	- 7.3	5.0
P95	-7.9	3.5

guideline. Draft advice from this guideline was developed through a screening process of all the different climate change models available. The guideline contained data centred around 2030, 2050 and 2070, each covering a 20 year period. The 2030 data covers the period of 2020 to 2040, which is the assessment period for the CRWBM. Table 1 shows a summary of the potential magnitude changes for the 2030 climate data, for the "Hot" climate change scenario which was considered the worst case.

The 2030 Climate Change Data suggests a predicted reduction in rainfall of slightly less than 8 % and an increase in evaporation in the range of 3.5 to 5.4 %. However, the climate change models and the available input data did not provide guidance on a key climatic factor, being the potential changes to the interannual trends.

Without information on how the interannual trends may change, directly using the available climate data to assess the potential impacts of climate change was considered to have limited value. For example, climate change may lead to longer drier periods or longer drier and longer wetter periods. BHP are continuously reviewing and updating approaches to access climate change when new datasets become available.

Due to the potential variability, understanding how the operations manage extended wet or dry periods is key to assessing the resilience of the water management system. The operational response to extended wet and dry periods has been observed to counter any impacts of climate variability (i.e. demands are reduced during dry periods, returned to normal during wet).

Sensitivity assessments were completed during IPS and SPS and identified that an increase in evaporation of 4 % could translate to a reduction of up to 10 % in stored water inventory which has the potential to increase water use from external sources and the risk of shortfall.

Alternatives Considered

During the precursor IPS, 56 alternatives were considered. At a high level, these included:

- Desalination for reuse
- Agriculture, with and without treatment in the immediate and neighbouring areas
- Commercial reuse to 3rd party industries
- Maximising reuse of MAW

From an initial analysis and multi-criteria assessment of the 56 alternatives, it was determined that Maximising Reuse of MAW and Desalination for reuse were preferred. Three alternatives emerged as warranting further assessment to mitigate the dry climate risks both at these and other BMA mines, with sub-alternatives. The alternatives considered were:

- Alternative 1 – Bi-Directional Pipeline (SSM to SRM): three different discharge locations;
- Alternative 2 – SSM Water Treatment Plant (WTP): two different capacities with reuse at other Central Region mining operations; and
- Alternative 3 – Pipeline to Daunia Mine (DNM) (a BMA operation approximately 50km away) with no treatment: via two alternative pipeline routes

Assessment of the benefits from each of these alternatives to the Central Region mines was completed using the CRWBM with concept engineering as inputs to the options assessment.

Options Assessment & Decision Making Process

A Multi-Criteria Assessment (MCA) process was adopted to support the decision making process. The non-cost criteria included

Regulatory and Approvals, Community and Reputation, Flexibility and Scalability, Post Implementation Risk (including closure liability), Health and Safety Risk, Operational Impact / Simplicity, and Environment and Sustainability. A final (fatal flaw) screening criteria of Meets Study Objectives (improves climatic resilience and reduces water sourced from offsite sources and the environment) was included.

Criteria weightings were agreed prior to the assessment using the Analytical Hierarchical Process. Comparative assessment of each alternative was completed for the given non-cost criteria and tested against the fatal flaw criteria to identify the top two sub-options. Once the preferred two sub-options were identified, the capital costs and operational costs for the seven sub-options were reviewed to confirm the best performing alternative.

The results of the non-cost MCA are presented in the below figure.

		Alternative 1 - Bi-Directional Pipeline (SSM to SRM)			Alternative 2 - SSM WTP		Alternative 3 - Pipeline to DNM	
Criteria	**Weight**	**Alt 1A (Jacaranda)**	**Alt 1B (S13)**	**Alt 1C (Dudley's)**	**Alt 2A**	**Alt 2B**	**Alt 3A**	**Alt 3B**
Regulatory and Approvals	Important	0	1	0	-2	-2	-2	-2
Community and Reputation	Important	-1	0	-1	-2	-2	-1	-1
Flexibilty and Scalibilty	Important	2	0	1	-1	-1	1	1
Post Implementation Risk	Important	1	1	0	-1	-1	0	0
Health and Safety Risk	Mandatory	0	0	0	-1	-1	-2	-1
Operational Impact/Simplicity	Important	1	0	-1	-2	-2	0	0
Environment & Sustainability	Important	0	0	0	-1	-1	-1	-2
Meets study objectives	Critical	1	1	1	-3	-3	-2	-2
Overall Weighted Score		0.43	0.36	0.14	-1.43	-1.43	-0.93	-0.86
Is there a Fatal Flaw?		No	No	No	Fatal Flaw	Fatal Flaw	No	No
Relative Risk		Lowest Risk	Neutral Risk	Neutral Risk	Highest Risk	Highest Risk	High Risk	High Risk

Figure 1 *MCA Combined Alternative Scores (Non-Cost)*

Alternative 2 (WTP at SSM) was found to be fatally flawed as it did not lead to long-term resilience improvements for the Central Region mines and would result in a 'stranded' asset at SSM. Brine by-products would also require ongoing management and result in a potential closure liability.

Alternative 3 (Pipeline to DNM) was less preferred as the benefits from the connecting pipeline would be limited, with supply to DNM being constrained during dry periods as water would be retained for the benefit of the Central Region mines.

Alternative 1 (Bi-Directional Pipeline) was confirmed as the preferred alternative, revalidating the outcomes of IPS. This alternative comprised a new bi-directional pipeline from SRM (Jacaranda Pit) to SSM (Roper Pit) with a capacity of 9.7 GL/a, complementing existing infrastructure that enabled bi-directional transfers from CVM to SRM via PDM.

Solution Refinement

From interrogation of the preferred alternative results, further analysis was undertaken to assess whether a lower transfer rate would achieve similar water resilience improvements. A lower transfer rate of 6.4 GL/a (same capacity north as per the existing south pumping pipeline) was assessed, with comparison to the previously proposed 9.7 GL/a.

The model results confirmed the following two key outcomes:

- Water Movements: For a 35% increase in pipeline capacity, the increase in transfer volume is less than 10% over the life of the asset operation (20 years). This was due to the limited period where mine water requires transfer south, as opposed to the total installed capacity, and
- Predicted total raw water usage and the CHPP shortfall: for a 35% increase in pipeline capacity, the reduction in raw water usage and shortfall is less than 3%.

Based on the limited climate resilience benefits of the additional capacity and higher capital cost, it was concluded that the higher (9.7 GL/a) pipeline capacity would not deliver value for the investment. Therefore, the lower capacity of 6.4 GL/a was adopted.

The lower capacity pipeline also afforded the following benefits:

- Reuse of over 80% of the existing pipeline constructed in 2015
- 60% of pipelines within SSM could also be reused
- Where upgrades / replacement was required, these pipelines could be reused by SSM operations to support pit dewatering

The total stored inventory over the design horizon (20 years) with a capacity of 6.4 GL/a is presented in Figure 2 below.

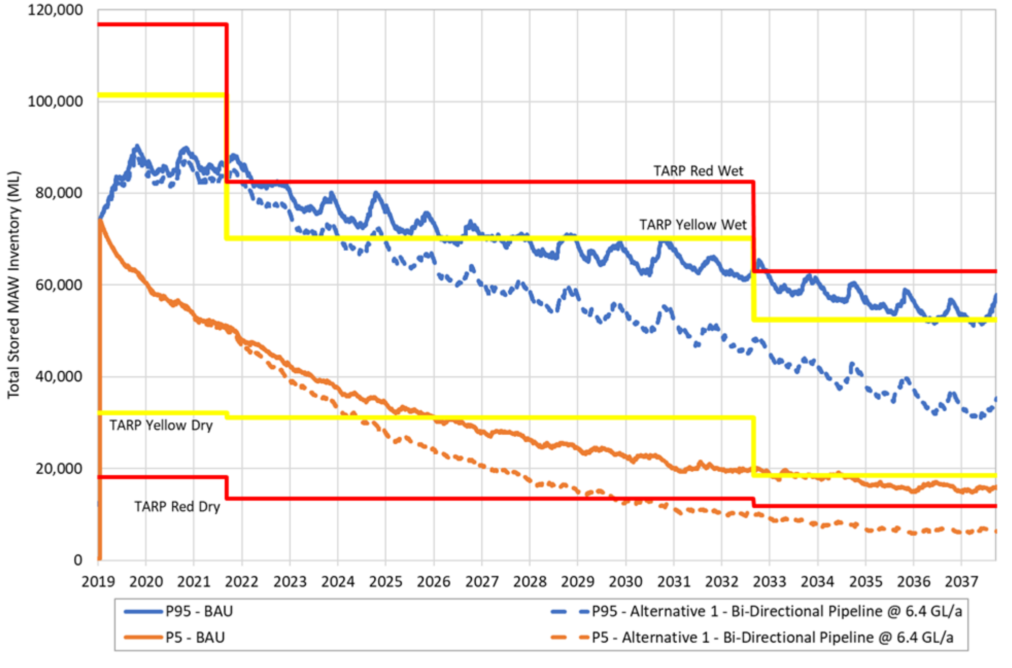

Figure 2 *Predicted Stored Mine Affected Water – 2019 to 2039: BAU v Alternative 1*

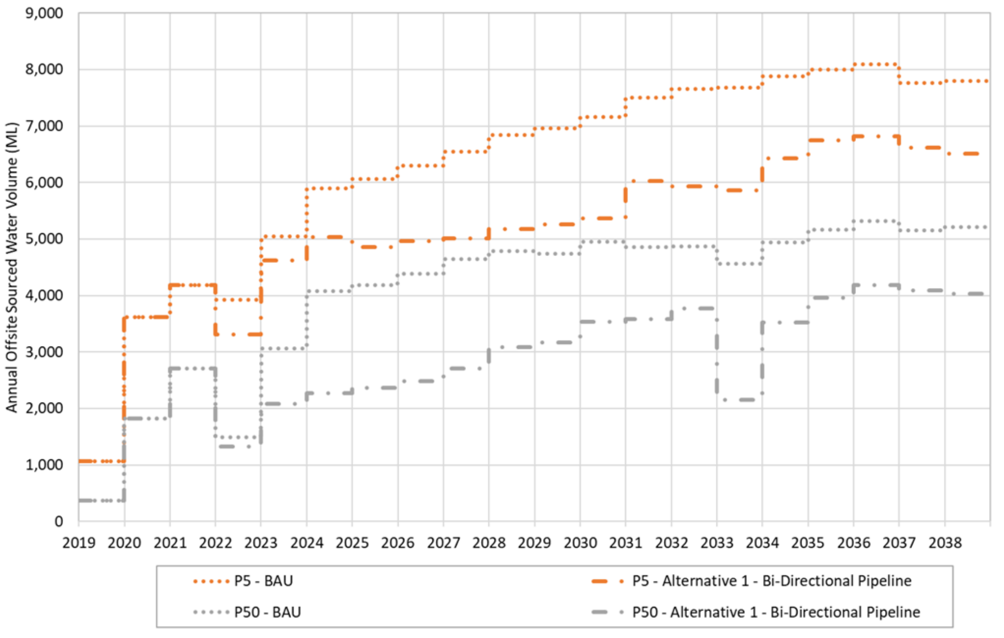

***Figure 3** Predicted Raw Water Use – 2019 to 2039: comparison of Alternative 1 to BAU*

Importantly, the analysis demonstrated that with this capacity, the operations can sustain production from the 5th to 95th percentile climatic range, meeting production demands and minimising water sourced from offsite sources. The predicted mine water volumes reduce overtime, as reuse is prioritised and available onsite storages also reduce.

The mines mostly remain within the Trigger Action Response Plan (TARP) Red Wet / Red Dry limits for the Central Region Mines. There are minor exceedances of the TARP Red Dry threshold from 2030 onwards in a 5th percentile dry climatic scenario, however production is still maintained.

Without optimisation, as stored MAW volumes decrease due to reuse, offsite sourced water demand would typically increase. The analysis shows that both MAW use can be optimised whilst reducing water sourced from the environment. This is shown in Figure 3 below.

Predicted raw water use across the Central Region mines over the design horizon is presented in the below figure. When compared to the base case (BAU), there is a significant reduction in offsite sourced water, with predicted reductions of up to 2,600 ML/year representing >50% reduction under median climatic conditions and up to 1,600 ML/year in dry climatic conditions (>20% reduction).

Study Outcomes and Conclusions

As shown above, the implementation of the bi-directional pipeline, with a capacity of 6.4 GL/a, maximises the beneficial reuse of MAW and reduces the quantum of water sourced from the environment for all years, aligning with BHP's Water Stewardship initiative.

Production at the four Central Region mines – CVM, PDM, SRM and SSM – would be sustained across a variable climate. Although a detailed analysis of climate change was not possible, the predicted impacts of climate (being a drier climate) can be managed.

As an investment to sustain production, the optimised capacity reduced the overall capital cost, making capital available for other projects in the BMA portfolio. The pipeline design also retained optionality and flexibility in the event there is a change in design intent, the predictions are not correct or more extreme events occur in future warranting a larger pipeline.

The risk of water supply shortfall resulting in production impacts due to a drying climate will be reduced once the project is implemented.

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