VICKERY EXTENSION PROJECT
ENVIRONMENTAL IMPACT STATEMENT

ATTACHMENT 4
PEER REVIEW LETTERS

WHITEHAVEN COAL

KALF AND ASSOCIATES Pty Ltd
Hydrogeological, Numerical Modelling Specialists

KA Peer Review of HydroSimulations Groundwater Modelling Assessment of the Vickery Extension Project

Dr F. Kalf
B.Sc. M.App.Sc PhD
8 August 2018

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Background and Summary

This report is the Kalf and Associates Pty Ltd (KA) peer review commissioned by Whitehaven Coal Pty Ltd (Whitehaven) for the HydroSimulations (HS) hydrogeological and groundwater modelling assessment. This KA review of the final draft of the HS report follows on from contributions by KA for a modification request submitted during the initial calibration modelling stage, and a draft peer review in 2016.

For the modelling review herein the available Modelling Guideline documents (NWC 2012, MDBC 2001) content have been taken into consideration in this assessment. A modelling appraisal checklist is provided herein as an attached Appendix that also has provision for a 'fit-for-purpose' item 9.2.

Open cut and underground mining were conducted at the former Vickery Coal Mine from 1996 to 1998. Similar mining was conducted at the former Canyon Coal Mine that ceased operations in 2009 although rehabilitated after closure. Observation bore water levels and quality monitoring is conducted at these mines.

Whitehaven also operates the Rocglen and Tarrawonga coal mines situated 5km east and 10km north of the Extension project.

The proposed open-cut mining Extension lies within the 'Approved Mine' zone and would access the underlying Permian hard rock sedimentary Maules Creek Formation that contains a number of coal seam strata. This formation is in turn overlain by weathered overburden with adjacent off-site alluvial sediments to the south-west associated with the Namoi River, Driggle Draggle Creek situated north of the site area and Stratford Creek, a poorly defined drainage gully south of the Project area.

Previous investigations have indicated two groundwater systems in the region. They included high hydraulic conductivity and low salinity (500 mg/L) unconsolidated alluvial sediments of the Namoi River floodplain and fractured hard rock of the Maules Creek Formation with low hydraulic conductivity and good to brackish groundwater (500 to 5,700 mg/L TDS).

The Namoi River alluvium also occurs within a deeper groundwater paleochannel situated south west some 4 to 5kms distant from the River channel comprised of sandy coarse gravels grading into sands at depth.

The Project also intends to use the existing Blue Vale void as a water storage.
(HS 2018 – Section 5.7)

Numerical groundwater modelling has included two calibration simulations (initial, pre-mining) and a transient calibration (2006-2011); a verification run (over the period 2012 to 2017); transient prediction model simulations under incremental and cumulative conditions (from 2018 to 2044) and a transient recovery period to near equilibrium conditions in association with an final open cut void.

Modelling predictions indicate negligible influence on the Namoi alluvial sediments with the watertable drawdown restricted to the hard rock "island" of the Maules Creek Formation at the end of mining. Consequently there would be negligible influence on Namoi River runoff or baseflow.

The modelling results indicate that no private bore drawdown is predicted to exceed the

'minimal harm' required by the Aquifer Interference Policy (AIP) of less than 2m drawdown with influence likely to be in the range 0.2m to 0.5m.

The modelling results indicate no significant drawdown and therefore insignificant influence on identified ecosystems due to the Extension and cumulative influence. There would be no significant change in the groundwater or surface water quality.

Project groundwater inflow to the Extension would be sourced entirely from the Permian Maules Creek Formation and overall would vary up to 1.42 ML/day. The increase in flow from the alluvium to the hard rock is not significant (maximum 0.0745 ML/day post mining).

At completion of mining and rehabilitated waste emplacement zone the HS report predicts that any rainfall seepage from this zone to the alluvial embayment would average at 0.03 ML/d and up to 0.02 ML/d post mining with seepage having a salinity of about 3000 mg/L, that is less than the salinity of shallow groundwater seepage at that location.

There would also be a final void within the post-mining landform with inflow in the range 0.3 and 0.5 ML/day ultimately balanced by evaporative loss. The void will act as a sink in perpetuity with no escape of contained void water. The void would therefore also attract groundwater and seepage from the surrounding spoil emplacement materials.

The Extension Project would have no drawdown influence on the Tarrawonga mine groundwater system at any time during operation or post recovery, or from the Tarrawonga mine on the Extension Project.

Peer Review Assessment

Previous Studies and Reviews

The proposed mining area has had numerous assessments conducted (Section 2.1 HS 2018). They include geotechnical, hydrogeological and hydrogeochemical studies conducted in 1982, 1984 and in addition to an EIS for the original Vickery Coal Mine site (1986). Heritage Computing (2012 now HS) prepared the Groundwater Assessment for the 'Approved Mine' area. References for these studies are provided in the HS report.

Hydrogeological and Modelling Description

The hydrogeological description of the region and modelling work described in the HS (2018) report is detailed and comprehensive. The report covers a wide range of topics that are included within the main headings of: Introduction; Hydrogeological Setting; Conceptual Model; Groundwater Modelling; Model Results; Impacts on the Groundwater Resource; Climate Change and Model Uncertainty; Management and Mitigation Measures; Conclusions; Model Limitations; References.

Model Conceptualisation and Simulation Methods

Model pre-mine and end-of-mine conceptualisation for the Vickery Extension Project by HS is considered suitable as well as the model layering configuration. A total of 14 layers were used which is adequate for the five main coal seams and separation interburden units simulated including the basal Boggabri volcanics represented in layer 14 and alluvium, regolith and overburden represented in Layers 1 and 2.

HS have used the USGS MODFLOW-USG (USG) code as opposed to the availability of the well-known MODFLOW-SURFACT (MS) code previously used by HS for the Vickery

'Approved Mine' model analysis (HS 2012). The rectilinear variable cell mesh structure used with MS was converted using the same mesh for use with the USG code for the Extension Project model analysis.

The boundaries chosen for the model area are also suitable. They included no-flow along the eastern Mooki Thrust and the northern edge of the model underlain by low hydraulic conductivity strata. Remaining model edges were set up using general head boundaries with heads set equal to the regional groundwater levels at these locations. These are at a sufficient distance not to interfere or influence drawdowns within or surrounding the Extension zone.

Depiction of the various ephemeral and perennial stream channels have been modelled using the USG 'River' package with the ability to set stage such that the creeks act either as gaining or losing streams or as ephemeral drainage channels without leakage. This is considered suitable for the modelled area.

The model uses variable gross recharge as a percentage of rainfall and evapotranspiration as input and output respectively, which is suitable, rather than application of variable net recharge. Evapotranspiration rates and hence volume appear low but this is mainly due to watertables situated at a depth greater than the 3m ET extinction depth applied within the region. It may also be due in part to the use of BOM[1] average ET rates or lower used by HS that consequently do not allow much higher ET rates for watertables near or at surface in the USG code. The lower applied rainfall in the calibration however would have probably compensated for any possible disparity.

Steady-state simulation was used to set up initial conditions and was combined with transient runs in the HS model. Hydraulic parameters were based on measured values and those used in previous modelling studies of the mining site.

HS have elected to use Richard's equation, a means of simulating variably saturation, in MODFLOW-USG together with 'Upstream Weighting'. It should be noted that the use of such variably saturation relationship in this case has no direct relationship with regard to geological media properties but allows acceptable numerical convergence. The report states that simulations could not be run without the use of this Richard's equation. The methodology adopted is considered suitable.

Model Calibration and Prediction

The calibration simulations included: Initial 'Steady State' Calibration (pre-mining and Upper Namoi alluvial pumping); Transient Calibration from 2006 to 2011; Verification from 2012 to 2017; Transient Prediction both incremental (Extension alone) and cumulative (plus Rocglen and Canyon mine) and Transient Recovery. For the 'Steady state' simulation the model was run over a very long transient period (10,000 years) using constant inputs. This was specifically chosen to buffer the numerical solution which otherwise would have led to numerical instability due to high hydraulic conductivity contrasts in the region. This is an acceptable approach in numerical modelling practice for these types of highly variable hydraulic conductivity conditions rather than the storage being set to zero by the model code under the steady state simulation option.

Manual (trial and error) calibration and verification was used without the PEST code as the model would have required considerable run times using this code given the model's current 1.34 million cell mesh count. However, it would have been possible to reduce this cell mesh count considerably given that it had already had been established that there would be no

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[1] BOM: Bureau of Meteorology.

drawdown influence by the Extension or the 'Approved Mine' at the Tarrawonga mine and vice-versa. Hence analysis could have been applied at Tarrawonga as a separate sub-model with the main model northern area truncated and by also applying a variable cell mesh rather than a regular mesh in the USG code. For example it would have been possible and acceptable not to apply high resolution cell mesh in the model that lie outside the influence of depressurisation or watertable drawdown influence.

The inclusion of the Blue Vale water storage would mitigate mining effects according to HS (2018 –Section 5.7.1) and would only have a minor effect on baseflow in Draggle-Draggle Creek. Solute migration from the storage void to the Namoi River has been calculated to be about 0.015 ML/day with total dissolved solids 0f 38 kg/day distributed within the ten geological modelled units down to the Upper Group Seams. The concentration of solute would decrease during its migration due to rainfall dilution and it is estimated that the increase in salinity in the river would be 0.007%. These calculations appear plausible and is less than the 1% regulation requirement.

A total of 152 monitoring sites and 2,867 transient calibration targets were adopted to calibrate the model. Calibrated hydraulic conductivity and storage parameters used in the model are provided in the HS (2018) Table 13. All values of hydraulic conductivity and storage appear plausible.

Calibration fit statistic for the steady state case was 6.3 % SRMS (scaled root mean square HS 2018 Table 11) which is within the 10% recommended The transient case statistic had a 5% SRMS (Table 14) and verification a SRMS of 7.1 % (Table 16) which are both within the range recommended of 5 to 10% in the modelling guidelines document (MDBC 2001).

The total water balance presented in Tables 12 ('Steady State') Table 15 (Transient State) and 16 (Verification) are considered reasonable and plausible (HS 2018) notwithstanding comments earlier about ET rates.

Comparison made between measured and modelled hydrographs are considered to be fair to good and acceptable given the mixed mining activity in the region and uncertainty about precise past mining operations and some VWP known inaccuracies.

Verification provided a reasonable check on the calibration and the state of uncertainty.

Open-cut mining prediction was simulated using the standard 'drain' methodology with subsequent spoil infilling and changes in hydraulic parameters and rainfall recharge. Water balance for the prediction phase as shown in Table 18 (HS 2018) and is acceptable.

Sensitivity
Sensitivity analysis was conducted on vertical and horizontal hydraulic conductivity (K_z and K_x), and specific yield (for transient calibration) as these were found to have the most sensitive influence.

Groundwater Monitoring and Mitigation
There is currently a groundwater monitoring network in place at the Vickery Mine and Rocglen Mine area (Section 8.4, HS 2018). KA agrees with the proposed groundwater monitoring program presented in Table 26 (HS 2018). Also that this data should be adequate to validate the modelling prediction in the future with the addition of two additional bores to monitor waste rock 'emplacement' groundwater mounding and water quality of any leachate.

No mitigation measures are anticipated.

Conclusions

This peer review has assessed the adequacy of the hydrogeological data and the numerical model for predicting the drawdown influences of the proposed Extension. The hydrogeological description, conceptualisation, model design, simulations and reporting have been conducted in a professional manner and described in detail.

All predicted drawdown lies within the mine boundaries. No significant water table drawdown occurs within the alluvial sediments.

Predictions of drawdown due to the proposed Extension together with the existing approved mine plan and cumulative effects will have minimal influence on the environment. No private bores would be detrimentally affected by the Extension mining proposal.

Monitoring bore data should be reviewed and compared with modelling results every 5 years.

References

Heritage Computing Pty Ltd (HS 2012) *Vickery Coal Project Groundwater Assessment.* Report *HC2012/15 prepared for Whitehaven Coal Pty Ltd.*

HydroSimulations (HS) 2018. *Vickery Extension Project - Groundwater Assessment. Report prepared for Whitehaven Coal Pty Ltd. Project No HC2018/05c. May.*

National Water Commission (NWC) 2012 *Australian Groundwater Modelling Guidelines. Report prepared by Barnett, B., et. al. Waterlines Report Series No 82, June.*

Murray Darling Basin Commission (MDBC) 2001. *Groundwater Flow Modelling Guideline. Report prepared by Middlemis, H., Merrick, N., and Ross, J., Jan.*

APPENDIX

MODEL APPRAISAL

	ISSUES	Not applicable or Unknown					COMMENTS
1.0	**THE REPORT**						
1.1	Is there a clear statement of project objectives in the modelling report?		Missing	Deficient	Adequate	Very good	
1.2	Is the level of model complexity clear or acknowledged?		Missing	No	Yes		
1.3	Is a water or mass balance reported?		Missing	Deficient	Adequate	Very good	
1.4	Has the modelling study satisfied project objectives?		Missing	Deficient	Adequate	Very good	
1.5	Are the model results of any practical use?			No	Maybe	Yes	
2.0	**DATA ANALYSIS**						
2.1	Has hydrogeology data been collected and analysed?		Missing	Deficient	Adequate	Very good	
2.2	Are groundwater contours or flow directions presented?		Missing	Deficient	Adequate	Very good	
2.3	Has all relevant potential recharge data been collected and analysed?		Missing	Deficient	Adequate	Very good	
2.4	Has all relevant potential discharge data been collected and analysed?		Missing	Deficient	Adequate	Very good	
2.5	Have the recharge and discharge datasets been analysed for their groundwater response?		Missing	Deficient	Adequate	Very good	
2.6	Are groundwater hydrographs used for calibration?			No	Maybe	Yes	
2.7	Have consistent data and standard elevation units been used?			No	Yes		
3.0	**CONCEPTUALISATION**						
3.1	Is the conceptual model consistent with project objectives and the required model complexity?		Unknown	No	Maybe	Yes	
3.2	Is there a clear description of the conceptual model?		Missing	Deficient	Adequate	Very good	
3.3	Is there a graphical representation of the modeller's conceptualisation?		Missing	Deficient	Adequate	Very good	
3.4	Is the conceptual model unnecessarily simple or unnecessarily complex?			Yes	No		
4.0	**MODEL DESIGN**						
4.1	Is the spatial extent of the model appropriate?			No	Maybe	Yes	
4.2	Are the applied boundary conditions plausible and unrestrictive?		Missing	Deficient	Adequate	Very good	
4.3	Is the software appropriate for the objectives of the study?			No	Maybe	Yes	
5.0	**CALIBRATION**						
5.1	Is there sufficient evidence provided for model calibration?		Missing	Deficient	Adequate	Very good	
5.2	Is the model sufficiently calibrated against spatial observations?		Missing	Deficient	Adequate	Very good	

5.3	Is the model sufficiently calibrated against temporal observations?		Missing	Deficient	Adequate	Very good	
5.4	Are calibrated parameter distributions and ranges plausible?		Missing	No	Maybe	Yes	
5.5	Does the calibration statistic satisfy agreed performance criteria?		Missing	Deficient	Adequate	Very good	
5.6	Are there good reasons for not meeting agreed performance criteria?		Missing	Deficient	Adequate	Very good	Performance criteria have been met
6.0	**VERIFICATION**						
6.1	Is there sufficient evidence provided for model verification?		Missing	Deficient	Adequate	Very good	
6.2	Does the reserved dataset include stresses consistent with the prediction scenarios?		Unknown	No	Maybe	Yes	
6.3	Are there good reasons for an unsatisfactory verification?		Missing	Deficient	Adequate	Very good	
7.0	**PREDICTION**						
7.1	Have multiple scenarios been run for climate variability?		Missing	Deficient	Adequate	Very good	Climate change variability low and high rainfall
7.2	Have multiple scenarios been run for operational management alternatives?		No	Deficient	Adequate	Very good	
7.3	Is the time period for prediction comparable with the duration of the calibration period?		Missing	Greater than	Similar to	Less than	Calibration 2006 to 2011 Verification 2012 to 2017 Prediction 2018 to 2044.
7.4	Are the model predictions plausible?			No	Maybe	Yes	
8.0	**SENSITIVITY ANALYSIS**						
8.1	Is the sensitivity analysis sufficiently intensive for key parameters/		Missing	Deficient	Adequate	Very good	
8.2	Are sensitivity results used to qualify the reliability of model calibration?		Missing	Deficient	Adequate	Very good	
8.3	Are sensitivity results used to qualify the accuracy of model prediction?		Missing	Deficient	Adequate	Very good	
9.0	**UNCERTAINTY ANALYSIS**						
9.1	If required by the project brief, is uncertainty quantified in any way?		Missing	No	Adequate	Yes	
9.2	**Is the model 'fit-for-purpose'?**			No		Yes	

T.A. (Tom) McMahon FTSE
Professor Emeritus

THE UNIVERSITY OF
MELBOURNE

Whitehaven Coal Limited,
c/- Resource Strategies Pty Ltd,
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Attention: Brian Cole

Dear Mr Cole

I have completed my assessment of the Vickery Extension Project Surface Water Assessment Report and my comments are set out below. My review consisted of reading and commenting on draft reports by Advisian, the latest being Vickery Extension Project Surface Water Assessment Rev. 1.15, July 2018. Based on my reading and studying the Report, I recommended a number of changes, and I can confirm that all these have been appropriately addressed by the consultant. The Report consists of an Executive Summary and 12 Sections (the last is a set of References) plus an Annexure.

Following a brief introduction to the Project (Section 1), in Section 2 the Secretary's Environmental Assessment Requirements are discussed. As far as I can ascertain, all these requirements have been dealt with.

Relevant legislation, policy and guidelines are described in Section 3 which also includes comments of relevance to the Project based on the Water Management Act 2000, the Protection of the Environment Operations Act 1997, the Environment Protection and the Biodiversity Conservation Act 1999 (Commonwealth) and the Dam Safety Act, 2015. Regarding policy and plans, the relevance of the following documents is noted in Section 3: the National Water Quality Management Strategy, the NSW Water Quality and River Flow Objectives, the State Water Management Outcomes Plan, the Water Sharing Plans - Surface Water, the Namoi Catchment Action Plan 2010-2020, the NSW State Rivers and Estuaries Policy, the NSW Farms Dams Policy, and the Floodplain Management Plan. Two technical and policy documents - the ANZECC Guidelines for Fresh and Marine Water Quality 2000 and the Namoi Catchment Water Study - are also considered.

In Section 4 the existing surface water environment is described which is supplemented by maps, photos, figures and tables. Rainfall and evaporation are summarised in tabular and chart form. In Section 4.2 the climate change scenarios of rainfall and evapotranspiration, based on the 2015 CSIRO update that are applicable to the site, are outlined.

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Section 4 also includes a description for the Project area of topography, vegetation, land use, soils, fluvial geomorphology, riparian vegetation, aquatic ecology and geochemistry, the latter with respect to the overburden, interburden and coal rejects, and water quality. Based on an analysis of water quality data from the Rocglen, Canyon and Tarrawonga Coal mines, it is concluded that the "… risk of contaminants in water released from Project sediment basins impacting downstream waters is considered to be very low". I concur with this observation.

Section 5 addresses surface hydrology under three headings – 5.1 Regional Hydrology, 5.2 Local Hydrology and 5.3 Flow Modelling. Section 5.1 is a factual description of the three major reservoirs on the Namoi River, and the general details of catchment size, average flows and stream gauging measuring stations in the Namoi catchment relevant to the Project. Section 5.2, which deals with local hydrology, contains a description of the three main creeks (Driggle Draggle, Stratford and South) and the three drainage lines that convey runoff into and within the Project area.

Section 5.3 consists of three sub-sections. Section 5.3.1 is a description of the Australian Water Balance Model (AWBM) and its application by the consultant. As there are no streamflow gauges located on any of the streams within of the Project area, runoff in the local streams was estimated using AWBM, which is a conceptual rainfall-runoff model, and outputs runoff based on inputs of rainfall and evaporation. AWBM is widely used across Australia for rainfall-runoff modelling and, appropriately, is the basis of the runoff estimation in this Report. Section 5.3.2 describes in detail the calibration and validation of AWBM parameters based on Maules Creek catchment which is the closest catchment to the Project area with concurrent rainfall and evaporation data. I am confident that the surface hydrology analysis is appropriate and, within the limits of the available data, follows standard practice. Finally, in Section 5.3.3 estimates of natural runoff, based on the calibrated AWBM, that drain into the Project area are summarised.

Water quality monitoring sites and data are summarised in Section 6 along with the ANZECC Water Quality Criteria. Details are provided in Annexure A. Although I do not regard myself as an expert in water quality assessment, I have, however, considerable experience in reviewing other mining reports and water quality aspects of ecological modelling. Based on Section 6, I concur with the three summary points listed in Section 6.3. I note that trigger values for receiving waters will be prepared as part of the Water Management Plan for the Project.

Section 7 describes the operational water management system during the life of the Project which is a prerequisite to understanding the performance of the water management system discussed in the Section 8. Details provided in Section 7 include: *Objectives and Design Criteria* where runoff is classified into four distinct categories (undisturbed area runoff, rehabilitated area runoff, disturbed area runoff and mine water); *Overview of Conceptual Project Water Management System* (which includes a description of sediment dams, coal contact water dams, mine water dams, existing storage dam, diversion dams, Blue Vale void, Namoi River pump station and groundwater borefield, supporting structures, and mine infrastructure areas services); *Progressive Development of the Mine and Water Management System* (for Project year 3, Project year 7, Project year 13, Project year 21 and final landform supplemented by five figures showing mine layout and water management system components); *System Inflows*; *Collection and Storage* (which is designed to provide sufficient capacity to store, treat and discharge runoff under normal and extreme conditions); *Water Requirements* (include identification of the major demands being haul roads and preparation plant,

air quality management, ROM pad and stockpile dust suppression, and the mine infrastructure area and facilities, and a summary of the external water sources); *Waste Rock Emplacement Drainage Management*; *Management of Overburden, Inter-burden and Coal Rejects; Sediment Dam Design and Operation* (noting that the sizing of the sediment dams will be based on the NSW Landcom construction guidelines); *Coal Contact Water Dam Design and Operation; Additional* (water) *Supply*; *Water Conveyance Structures*; *Flooding*; and *Wastewater Treatment and Effluent Disposal*. Based on my previous experiences this list appears to include the key components and operational criteria to model at a daily time-step the management of water throughout the life of the Project.

Section 8 includes a very detailed outline of the analysis and performance of the proposed water management system. A schematic flow chart of the Mine water management system is Figure 8.1. It identifies the storages, relevant components and flow paths required to model the Mine water system. I have reviewed the schematic and based on the information provided confirm that the water balance model appears to represent the key components of the Project's water management system. A separate water balance (monthly time-step) extending over 1000 years is developed to assess the long-term water level and salinity in the final void following mine closure (discussed in Section 8.10).

The Report details, also in Section 8, model input data. Climate input data consist of two types – historic data and climate change data. The water balance utilises 124 years of daily rainfall (from 1899) and equivalent length of pan evaporation data. To provide sequences for assessing the variability of the water management system performance, 98 sequences each 26 years in length are adopted beginning in successive years from July 1893.

To examine the impact of climate change, projected changes in rainfall and evaporation (based on the 2015 CSIRO update) (as set out in Sections 4.2 and 8.2.1.2) are superimposed on the historical data. This is a suitable approach to examine the effect of climate change on hydrology.

Another major sub-section in Section 8 is Runoff Modelling in which there is a description about how the daily runoff inflows to the storages in the water management system are estimated. To select appropriate parameters to represent the runoff characteristics, the consultant reviewed a wide range of data available in consultancy reports and adopted suitable values.

The 98 sequences of climate and runoff data covering the range of potential future climate conditions are input to the water balance model to assess the adequacy of the proposed water management system. This approach by the consultant to assessing the performance of the water management system under a range of climate conditions is appropriate. As no independent data are available to check model adequacy, the approach taken was to review how the model accounted for gains, losses and water use. In addition, the consultant applied a Monte Carlo sensitivity analysis that provides guidance on the uncertainty in several key water management variables (Table 8.16) due to the uncertainty in the runoff.

Furthermore, in Section 8 the mine void water balance following mine closure is addressed. Four climate scenarios incorporating realistic estimates of rainfall and evaporation were considered as input to a monthly water balance model. The results of the modelled void water level and salinity are estimated for the next 1000 years based on a synthetic, yet realistic, climate sequence. I believe the conclusions in the Report regarding the final void water levels and salinity levels are appropriate.

Based on the details provided in Sections 7 and 8, I am confident that the surface hydrology analyses and subsequent water management modelling are appropriate and satisfactory and, within the limits of available data, are scientifically defensible.

Section 9 deals with the impact of potential changes in catchment area on the hydrology of Driggle Draggle and South Creeks and on the Namoi River flows. From the hydrology information presented in the Report, I concur with the consultant that there should be little impact on the flows of either creek or in the Namoi River.

Mitigation and management measures, which are described in Section 10, are based three principles: source control, separation of water of different quality, and recycling of site water. I observe that these principles are taken into account in the proposed management of coal contact water, waste rock emplacement, sediment dams, site discharges, air quality control, security of water supply and final void.

The final reporting section (Section 11) deals with monitoring and licensing. With regard to hydrologic monitoring, I note that the water management analysis and modelling described in the Report were impeded by the lack of runoff estimates for the site. I concur with the consultant's recommendations regarding the need for sufficient monitoring of all components of the mine water balance to permit an assessment of the performance across the water management system under operating conditions. There is especially a lack of measured data characterising runoff for the range of conditions experienced at mine sites.

In summary, I conclude that, overall, the study detailed in the Vickery Extension Project Surface Water Assessment Report was completed in a professional and detailed manner, and the conclusions in the Report are appropriately supplemented by suitable modelling studies carried out by the consultant.

Yours sincerely

T.A. McMahon
5 August 2018

Vickery Mine Extension – Flood Assessment Review

Client: Whitehaven Coal (c/o Resource Strategies)

Reference: PA1842 Vickery Mine Extension – Flood Assessment Review

Revision: 02/Final

Date: 13 August 2018

Royal HaskoningDHV

Document title:	Vickery Mine Extension – Flood Assessment Review
Document short title:	
Reference:	PA1842 Vickery Mine Extension – Flood Assessment Review
Revision:	02/Final
Date:	13 August 2018
Project name:	PA1842 Vickery Mine Extension – Flood Assessment Review
Project number:	PA1842
Author(s):	Rohan Hudson

Drafted by:	Rohan Hudson
Checked by:	Ben Patterson
Date / initials:	28/5/2018 B.G.P
Approved by:	Rohan Hudson
Date / initials:	13/8/2018 R.M.H

Classification
Final

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1   Introduction

Whitehaven Coal Limited (Whitehaven) has commissioned Royal HaskoningDHV (RHDHV) to undertake an independent review of the Vickery Mine Extension – Flood Assessment Report (WRM, 2018).

The proposed Vickery Mine Extension is located on and adjacent to the Namoi River floodplain between Gunnedah and Boggabri as presented in Figure 1-1. The proposed rail spur has the potential to cause an impact on flood levels on the Namoi River floodplain and Deadmans Gully Creek, while other mine associated infrastructure needs to consider flood flows from Driggle Draggle Creek, Stratford Creek and South Creek.

Further details of the proposed Mine Expansion are provided in the Flood Assessment Report (WRM, 2018) and should be referred to as necessary.

The aim of this report is to provide an independent desktop review of the WRM Report 0800-02-G8, dated 16 February 2018 and titled: Vickery Mine Extension – Flood Assessment Report and the final version of the same report dated 10 August 2018 (WRM Report 0800-02-G10). The Flood Assessment Report (WRM, 2018) presents the methodology and results of the hydrological and hydraulic modelling undertaken to address the flooding related requirements in the Secretary's Environmental Assessment Requirements (SEARs) and in particular determine flooding characteristics in the various watercourses located in the vicinity of the Project under existing conditions (pre-mine) and proposed conditions with the mine in place.

The main aim of this report is to review the technical adequacy of the flood assessment. The focus of this includes a review of the:

- Adopted hydrology (i.e. estimates of design (i.e. 10yr, 100yr ARI and PMF) river/catchment discharge)

- Parameterisation of the hydraulic (flood) model, including a review of adopted:
  - model setup
  - elevation data
  - roughness assumption
  - structure parameterisation
  - achieved model calibration and verification
  - parameterisation of the proposed developed condition scenario

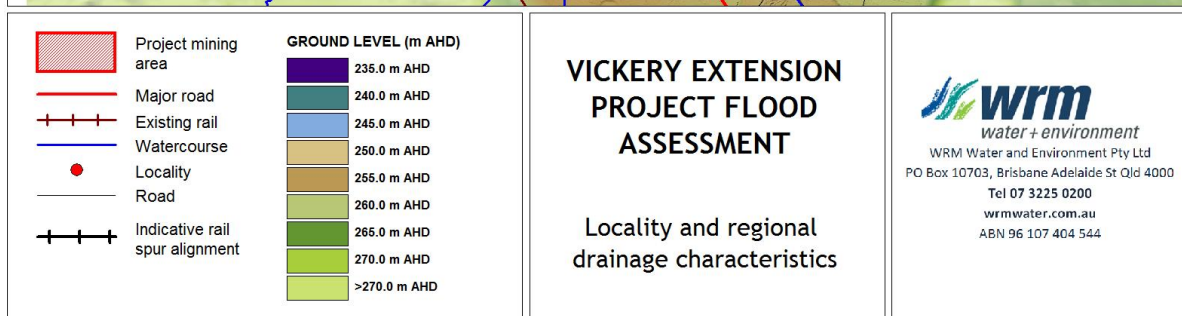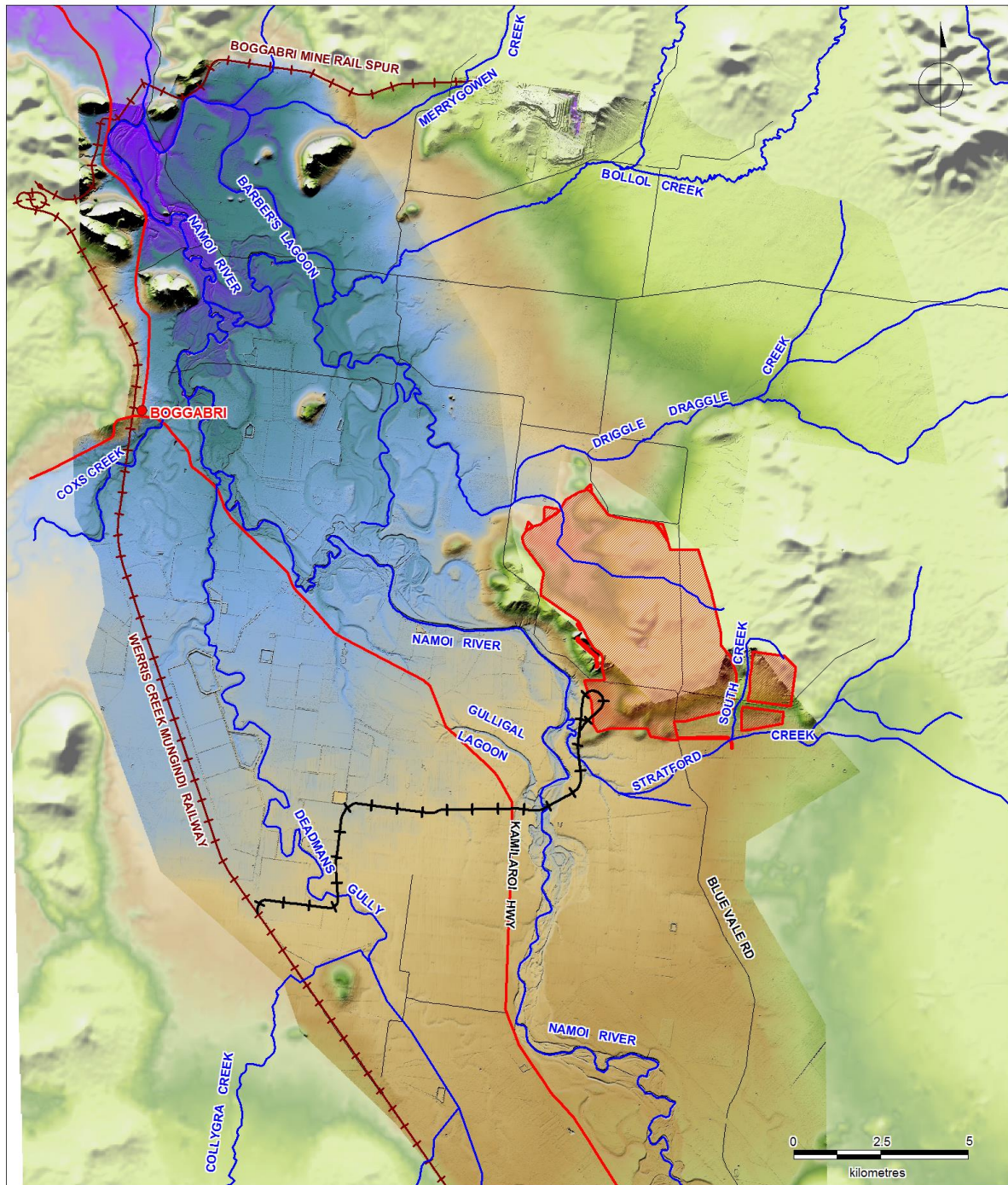- Validity of the conclusions regarding the impact of the mine extension project.

Figure 1-1: Locality and regional drainage characteristics (Fig 1.3 (WRM, 2018))

2   Review of Regulatory Framework

2.1   Secretary's Environmental Assessment Requirements

The SEARs for the Project were issued on 19 February 2016 and updated on 19 July 2018 (State Significant Development (SSD) 7480). The WRM Flood Assessment Report (2018) was prepared to address the flooding related SEARs, as well as the various agencies' requirements and recommendations which supported the SEARs.

While this review report is focused on assessing the technical nature of WRM (2018) it appears that Table 2.1 and Table 2.2 (WRM, 2018) show that the requirements of the SEARs have been addressed either by the Flood Assessment Report or other documents included in the EIS (which were not reviewed in this assessment).

2.2   NSW Government's Flood Prone Land Policy and Floodplain Management Plans (FMPs)

The Floodplain Development Manual (NSW Government, 2005) (the Manual) has been prepared to support the NSW Government's Flood Prone Land Policy. The primary objective of the policy is to develop sustainable strategies for managing human occupation and use of the floodplain using risk management principles. The Manual provides a framework for implementing the policy to achieve the policy's primary objective. It also outlines processes for ensuring these needs are addressed through the development of Floodplain Management Plans (FMPs).

Part of the Project area, including the Project rail spur, is located within the gazetted Namoi River floodplain defined by the Carroll to Boggabri FMP (NSW DNR, 2006). The FMP identifies a set of rules that determine whether works on the Namoi River floodplain comply with the intent of the FMP.

OEH and Department of Primary Industries – Water (DPI Water) (now DI-Water) have developed a draft of a new Floodplain Management Plan for the Upper Namoi Valley Floodplain (draft FMP) in pursuance of Section 50 of the *Water Management Act 2000* to replace the now superseded part of the *Water Act 1912*. The draft FMP contains rules to coordinate the approval of new flood works or amendments to existing flood works in a similar manner to the existing FMP. However, rules have now been defined for a number of management zones that represent different hydraulic and ecological regions across the floodplain. The management zones have been defined in accordance with clause 41A of the *Water Management (General) Regulation 2011* (the Regulation). Descriptions of the management zones are given in Table 2-1. The locations of the zones are shown in Figure 2-1.

Figure 2-1 shows that parts of the Project mining area are located within the Zone C (flood fringe) management zone. The Blue Vale Road realignment (part of the Approved Mine) crosses the AID (ill-defined floodway) and BL (floodplain) management zones (Stratford Creek) and the Project rail spur crosses the AD (defined floodway), AID, BL and C management zones. The objectives given in the draft FMP for each management zone that have been adopted for the assessment of the Project infrastructure are as follows:

- flood levels should not increase by more than 20 cm on adjacent privately-owned landholdings;
- increases in flood level and velocity should not impact on high value infrastructure (houses);
- peak flood flow should not be redistributed more than 5% across the floodplain;

- velocity should not increase by more than 50%;

- flood connectivity to ecological and/or cultural assets and facilitate fish passage should be maintained;

- drainage time on adjacent land holdings within 24 hours of existing drainage times should be maintained;

- the cumulative impact that the proposed flood work and other existing works on the landholding may have on adjacent landholdings should be considered; and

- should not impact on heritage sites.

Table 2-1 – Upper Namoi River Management Zones, Draft FMP

Management Zone	Description
AD (defined floodways)	Includes defined floodways with major drainage lines and other areas where a significant discharge of floodwater occurs during all flood events. These areas are generally characterised by relatively high flood flow velocity and depth
AID (ill-defined floodways)	Includes ill-defined floodways that are major discharge areas without clear channels or banks
(BU/BL (floodplain)	Includes areas of the Upper/Lower Liverpool Plains Floodplain that are important for the conveyance of floodwater during large flood events and for the temporary pondage of floodwaters during the passage of a flood. Its outer boundary is defined by a slope of less than or equal to 0.5%
C (flood fringe)	Contains flood fringe and flood protected developed areas
CU (Urban)	Contains urban areas
D	Is a special protection zone for areas of ecological and/or cultural significance

2.3   Guidelines on Flood Modelling and Estimation

While a number of guidelines exist regarding flood modelling and estimation including: Australian Rainfall and Runoff 1987; Australian Rainfall and Runoff 2016; Australian Emergency Management Handbook Series and the NSW Floodplain Management Manual, there is no specific standards (Australian or International) that apply to flood modelling. Instead ongoing education is required to ensure that "best-practice" techniques are adopted in a given study. "Best practice" techniques improve with time and are generally disseminated through presentations at conferences such as those organised by the Floodplain Management Association (FMA) or Engineers Australia. Software providers such as BMT (TUFLOW) or XP software (RAFTS) also provide training.
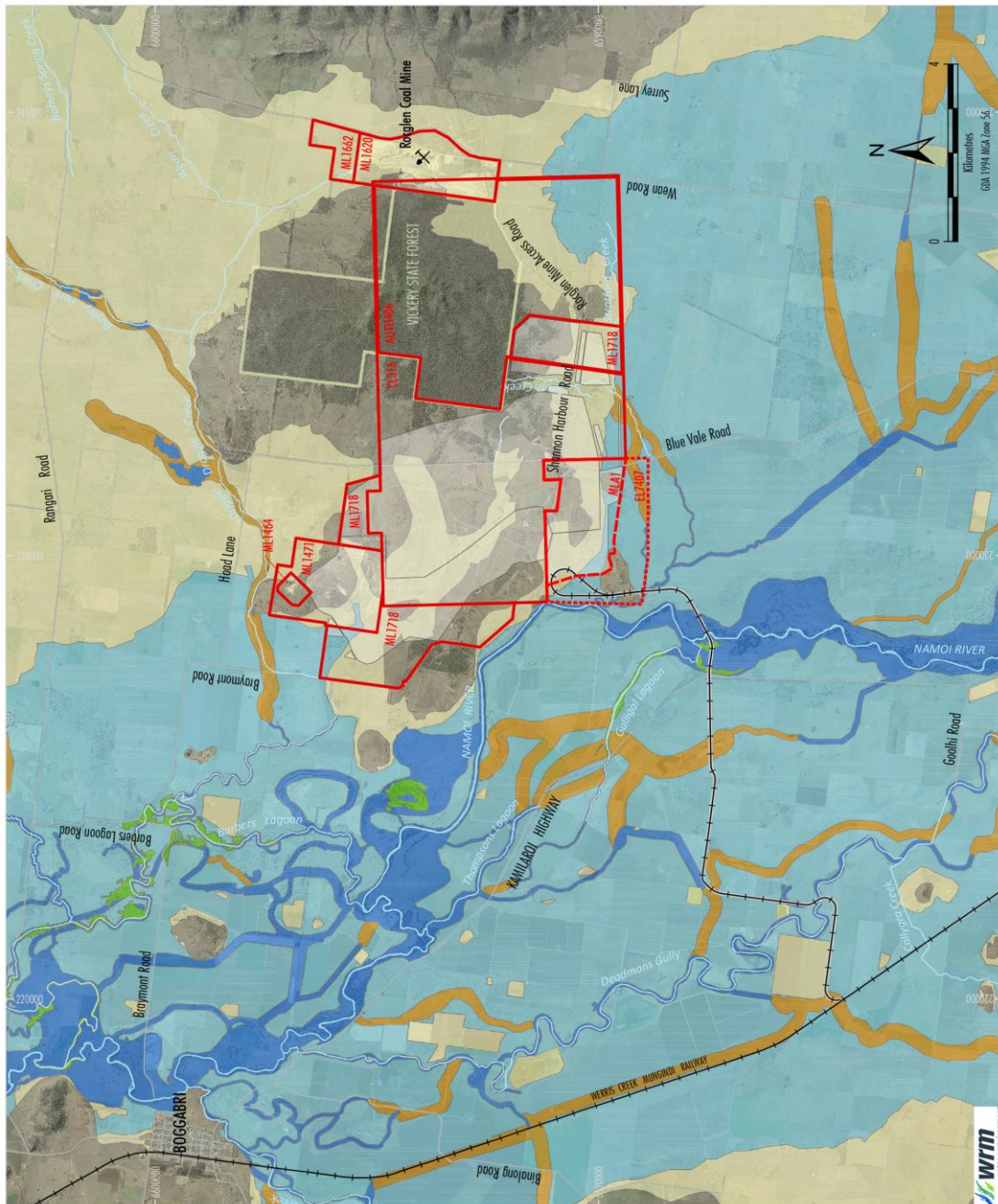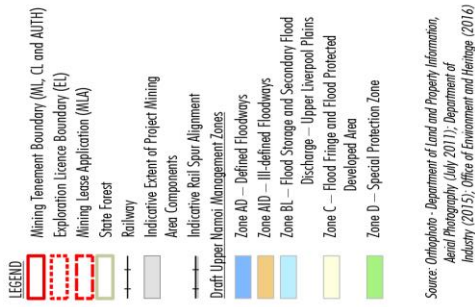
Figure 2-1: Draft FMP Management Zones Near Proposed Mine Extension (Fig 2.1 (WRM, 2018))

3 Review of Flood Discharge Estimates

3.1 Design Event Terminology (AEP & ARI Explanation) and Considerations

Design flood events are hypothetical floods used for floodplain risk management. They are based on having a probability of occurrence specified either as:

- Annual Exceedance Probability (AEP) expressed as a percentage; or
- Average Recurrence Interval (ARI) expressed in years.

The relationship between AEP and ARI is presented in **Table 3-1** with further descriptions of typical design event terminology provided in **Figure 3-1**.

Table 3-1: Design Event Terminology (AEP & ARI Explanation)

Annual Exceedance Probability AEP (%)	Average Recurrence Interval (ARI, 1 in X years)	Comment
Probable Maximum Flood (PMF)		A hypothetical flood or combination of floods which represent an extreme scenario. The PMF is usually generated by applying an estimate of the probable maximum precipitation (PMP) to a hydrologic model.
0.2%	**500 yr**	A hypothetical flood or combination of floods likely to occur on average once every 500 years or with a 0.2% probability of occurring in any given year
0.5%	**200 yr**	As for the 0.2% AEP flood but with a 0.5% probability or 200 year return period.
1%	**100 yr**	As for the 0.2% AEP flood but with a 1% probability or 100 year return period.
2%	**50 yr**	As for the 0.2% AEP flood but with a 2% probability or 50 year return period.
5%	**20 yr**	As for the 0.2% AEP flood but with a 5% probability or 20 year return period.
20%	**5 yr**	As for the 0.2% AEP flood but with a 20% probability or approximately a 5 year return period.

Although the probability of a flood of a given magnitude occurring remains the same from year to year (unless the flood regime is altered or new data leads to a revision of statistical estimates), the chance of such a flood occurring at least once in any continuous period increases as the length of time increases. **Table 3-2** shows the probability of experiencing various-sized floods at least once or twice in a lifetime. Over an 80 year timeframe/lifetime there is a 55% change of experiencing a 1 in 100 ARI (1% AEP) flood event.

The adoption of assessing floodplain change using the 1% AEP is usually based on this being an acceptable level of risk to the community that balances the regularity of damages occurring, against the additional cost to infrastructure of designing it to a higher level of protection.

Table 3-2: Probability of experiencing a given-sized flood one or more times in 80 years

Source: Managing the floodplain: a guide to best practice in flood risk management in Australia (AEMI (2013))

Annual exceedance probability (%)	Approximate Average recurrence interval (years)	Probability of experiencing a given-sized flood in an 80-year period	
		At least once (%)	At least twice (%)
20	5	100	100
10	10	99.9	99.8
5	20	98.4	91.4
2	50	80.1	47.7
1	100	55.3	19.1
0.5	200	33.0	6.11
0.2	500	14.8	1.14
0.1	1,000	7.69	0.30
0.01	10,000	0.80	0.003

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
Rare	0.11	10	10	9.49
	0.05	5	20	20
	0.02	2	50	50
Very Rare	0.01	1	100	100
	0.005	0.5	200	200
	0.002	0.2	500	500
	0.001	0.1	1000	1000
Extreme	0.0005	0.05	2000	2000
	0.0002	0.02	5000	5000
			PMP/ PMPDF	

Figure 3-1: Australian Rainfall and Runoff (2016) Preferred Terminology

3.2   Design Discharge Estimation Techniques

Estimates of design discharge for a given AEP can either be based on:

Flood Frequency Analysis (FFA): If a sufficient duration (normally > 50 years) of river discharge data is available extremal analysis can be used to estimate design discharges. The use of FFA is preferable as it removes uncertainty between the amount of rainfall and resulting river discharge that is inherent in hydrological modelling. However, FFA depends on the availability of a sufficient length of good quality discharge data. Issues with rating curves (used to determine river discharge based on the measurement of water levels) can reduce the accuracy of design discharge based on FFA.

Hydrological modelling (using design rainfall data): if no or insufficient river discharge data is available (i.e. the catchment or site is not "gauged"), then hydrological modelling is the most accurate method of determining design discharge. A hydrological (or catchment) model uses a parameterisation of the catchment to calculate the rate of river discharge from a given rainfall event. Typical hydrological models used in Australia include: XP-RAFTS, RORB, WBNM and ILSAX.

Regional Flood Frequency Estimation (RFFE): A RFFE for ungauged catchments is now available at (https://rffe.arr-software.org/). The technique is based on data from 853 gauged catchments and may be suitable for non-urban catchments with an area between 0.5 sq km and 1,000 sq km. It is available for use as a first pass estimate of catchment discharge but is less accurate than hydrologic modelling or FFA.

Direct Rainfall Hydraulic Modelling (using design rainfall data): Direct rainfall (or rain-on-grid) modelling applies rainfall data direct to the surface of a 2D flood model (i.e. TUFLOW). Advantages of this method are that no sub-catchment delineation is required (a source of potential error in hydrologic models) and flow is then routed using the hydraulic model (which accounts for storage) which again reduces potential inaccuracies that occur in hydrologic models. Provided that a reasonable digital elevation model (i.e. LiDAR data) and appropriate roughness values are used (depth varying manning's is usually required) this method tends to produce more accurate results in ungauged catchments than a traditional hydrologic catchment model. The down side to this method is that 2D model run times are much slower than a 0D catchment model.

3.3   Namoi River

3.3.1   Catchment Overview

A description of the catchment is provided in WRM (2018) and is repeated below for background.

Figure 1-1 shows the drainage system within the area of interest between Gunnedah and Boggabri and the location of the Project mining area and Project rail spur.

The main drainage feature in the area of interest is the Namoi River, which drains in a northerly direction to the west of the Project mining area. The Namoi River catchment is bounded by the Great Dividing Range in the east, the Liverpool Ranges and Warrumbungle Ranges in the south, and the Nandewar Ranges and Mt. Kaputar to the north. Major tributaries of the Namoi River include Cox's Creek and the Mooki, Peel, Cockburn, Manilla, and Macdonald rivers, all of which join the Namoi upstream of Boggabri. The catchment area of the Namoi River to Boggabri is approximately 22,600 square kilometres (km^2).

The Namoi River adjacent to the proposed mine is characterised by a 50 metre (m) to 70 m wide main channel meandering along a lower terrace floodplain. The lower terrace contains several remnant river channels and is about 500 m to 1,200 m wide. The lower terrace floodplain cuts through the greater Namoi River floodplain that varies in width from 6 km to 11 km.

The Namoi River floodwater remains within the banks of the lower terrace floodplain in the vicinity of the Approved Mine for events up to about the 10% AEP flood. For larger events, floodwater overflows at several locations onto both the eastern and western floodplains.

Floodwater overflowing from the Namoi River onto the western floodplain drains in a westerly direction to Deadmans Gully. Deadmans Gully converges with Collygra Creek, which eventually drains to the Namoi River south of Boggabri.

Floodwater overflowing onto the eastern floodplain to the south of the Approved Mine drains in an unconfined manner until it drains into Stratford Creek. Stratford Creek drains into the Namoi River immediately to the south of the Project.

For events between the 5% and 2% AEP events, floodwater that overflows onto the eastern and western floodplains drains independently of the main river channel, with flood levels that are generally lower than the adjacent Namoi River flood levels. For larger events, the floodwaters converge and flow as one water body across the entire floodplain.

3.3.2   Review of Design Discharge Estimates and Method

WRM (2018) reports that Namoi River design discharges for the 20%, 5% and 1% AEP events were estimated by undertaking an annual series FFA of the recorded flows at the Gunnedah stream gauge (gauge no. 419001). An extreme event equal to three times the 1% AEP flood event was then used in the assessment as a representation of the PMF.

The Gunnedah stream gauge is located approximately 26 km upstream of the Approved Mine. Peak discharges at Gunnedah are considered representative of discharges at the Project site as the major tributaries to the Namoi River (the Manilla River, Macdonald River, Peel River and the Mooki River) join the Namoi River upstream of the Gunnedah stream gauge, with no other major tributaries joining the Namoi River between Gunnedah and the Project site. The location of the gauge is considered appropriate for the derivation of design estimates of discharge for the proposed Mine Expansion Project.

The use of FFA for events up to the 1% AEP (100yr ARI) flood event is considered appropriate for the Namoi as nearly 50 years of data (from 1968 to 2015) was used in the analysis. An estimate of discharge from the 1955 event (derived by converting the observed peak flood marks near the gauge to a flow using the current rating curve) was included in the series of annual maximum discharge as presented in **Figure 3-2**. It should be noted that inclusion of this event nearly doubles the estimate of 1% AEP discharge (refer Section 3.3.3).

Figure 3-2 shows the FFA for the Namoi River at the Gunnedah stream gauge as a LPIII distribution fitted to the annual series. The 95% and 5% confidence limits of the estimate are also shown. **Table 3-3** shows the WRM (2018) estimated peak discharges for the 20%, 5% and 1% AEP design flood events including the peak discharges for three historical events from the LPIII distribution. The results suggest that the 1955 flood had an AEP of about 1% and the 1998 event had an AEP of about 7%.

It should be noted that the "Flood Series" in **Figure 3-2** refers to 1968 to 2015 recorded stream data at the Namoi River Gunnedah gauge station. "Historical Data" refers to the derived peak discharge for the 1955 flood event. It is reported that the Gunnedah and Carroll Floodplain Management Study adopted by Gunnedah Shire Council (SMEC, 1999) concluded that the 1955 flood event had an AEP of between 1.4% and 1.0% and the Carroll to Boggabri Flood Study (SMEC, 2003) concluded that that the 1955 flood event had an AEP of 1% at the Gunnedah stream

gauge. WRM reports that FFA results are consistent with previous studies and are suitable for this study, however, no results of the previous study were provided for comparison.
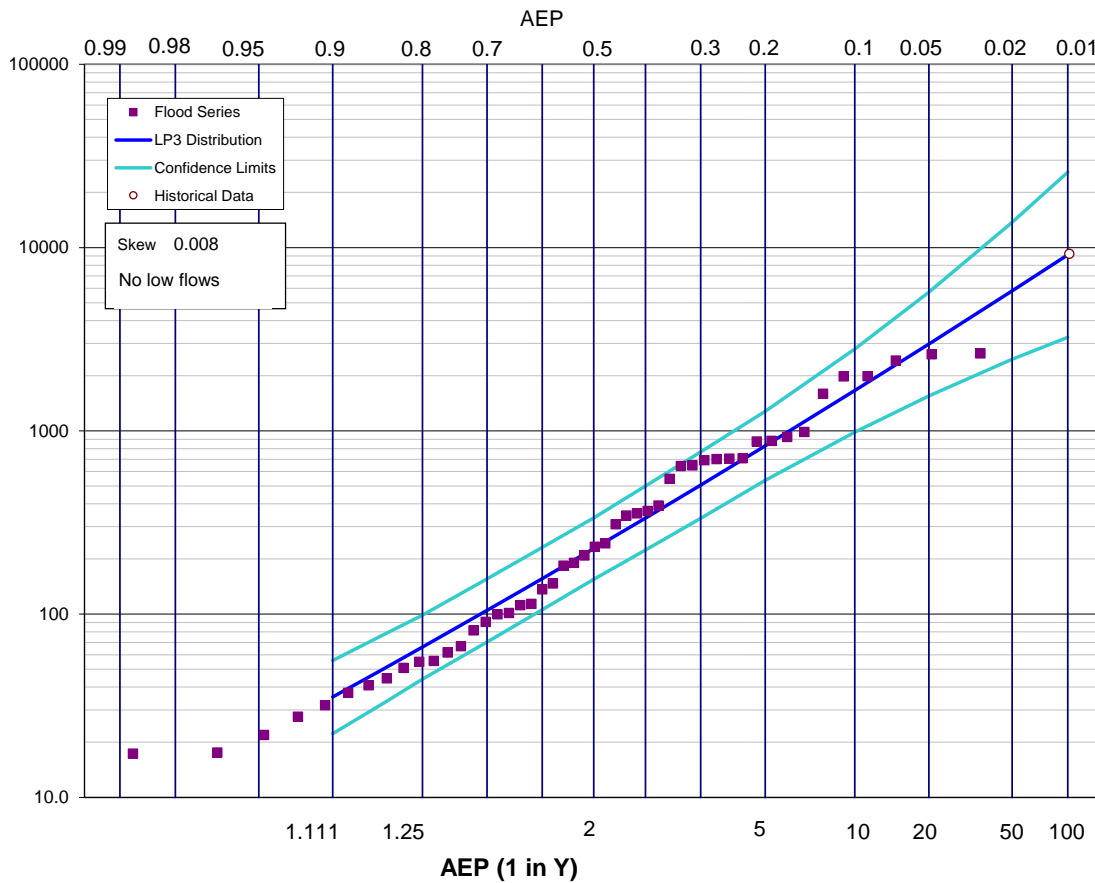
Figure 3-2: **FFA for the Namoi River at Gunnedah (gauge no. 419001)** *Fig 4.3 (WRM 2018)*

Table 3-3 – Historical and peak design discharges, Namoi River at Gunnedah (gauge no. 419001)
(Copy of Table 4-1 WRM (2018))

Event	Peak discharge (m³/s)
20% AEP	828
1998 (approx. 7% AEP)	2,617
5% AEP	2,975
1% AEP	9,141
1955 (approx. 1% AEP)	9,260
Extreme (3 x 1% AEP)	27,423

3.3.3 Check of 1% AEP Namoi Design Discharge

A desktop check of the design discharge for the Namoi was undertaken using the BoM water data website (http://www.bom.gov.au/waterdata/). An automated FFA for the Namoi River (Gunnedah) gauge is presented in Figure 3-2 and indicated a 1% AEP discharge of only 3100 m^3/s. However, it is important to note that this only considers data from 1968 to 2018 so does not include the large 1955 event. Inclusion of the 1955 event significantly increases the estimates of rare flood discharges and results in the estimation of the 1% AEP as being 9141 m^3/s.

It should be noted that it appears that the Office of Water (NSW DPI) holds daily total flow data for gauge 419001 going back to December 1891 (http://realtimedata.water.nsw.gov.au/water.stm?ppbm=SURFACE_WATER&rs3&rskm_org).

The observed discharge for 26/2/1955 was 707060 ML/day (or average daily flow of 8183 m^3/s). However, as this is an average daily flow, the peak would have been higher indicating the calculated value of 9260 m^3/s for the event is likely to be appropriate. However, as the highest rating in the gauging table is 2187 m^3/s, minor errors in rating extrapolation should be considered.

The inclusion of a longer period of data in the Annual Maximum Series used in the FFA would provide increased certainty of the 1% AEP design discharge and allow for an estimate of the 0.5% AEP (i.e. 200yr ARI) and potentially the 0.2% AEP (i.e. 500yr ARI) to be made. Alternatively the use of design hydrological modelling techniques could be used to create a data set to compare the FFA derived data set to, though it should be acknowledged that provided the Annual Maximum Series are of suitable quality (including confidence in the rating table (especially at high flows)), the FFA should provide a better quality estimate of design discharge.

A check of the design flows at the Boggabri gauge (i.e. the gauge downstream of Gunnedah) using the BoM water data website is presented in **Figure 3-4** and indicated a 1% AEP discharge of 4150 m^3/s. This seems low compared to design WRM (2018) discharge estimates from the Gunnedah gauge, especially as it includes the data from 1955 to 2018 and includes the peak flow from the February 1955 event (though the discharge from this event was only 4247 m^3/s). The significantly lower discharge observed at Boggabri for the 1955 events either indicates an error with the rating curve or significant floodplain storage occurring between the two gauges. Given the very wide floodplain and low channel gradient, significant floodplain storage is considered likely.

In addition to the influence of floodplain storage (which could be quantified by extending the hydraulic model to include both gauges) and the potential for rating errors, the censoring of low flow data in undertaking the FFA would result in an increased estimate of the 1% AEP discharge at the Boggabri guage.

3.3.4 Conclusions regarding Review of Namoi Design Discharge

A review of the method and magnitude of the Namoi River design discharges provided in the WRM (2018) indicate that they are appropriate for the Vickery Mine Expansion Flood Assessment. While inclusion of additional discharge data going back to 1891, or development of hydrological estimates using design rainfall and ARR2016 techniques would increase confidence in the FFA estimate, because the main purpose of the study is to determine relative impact (and not absolute design planning levels) the adopted design discharges are considered appropriate.
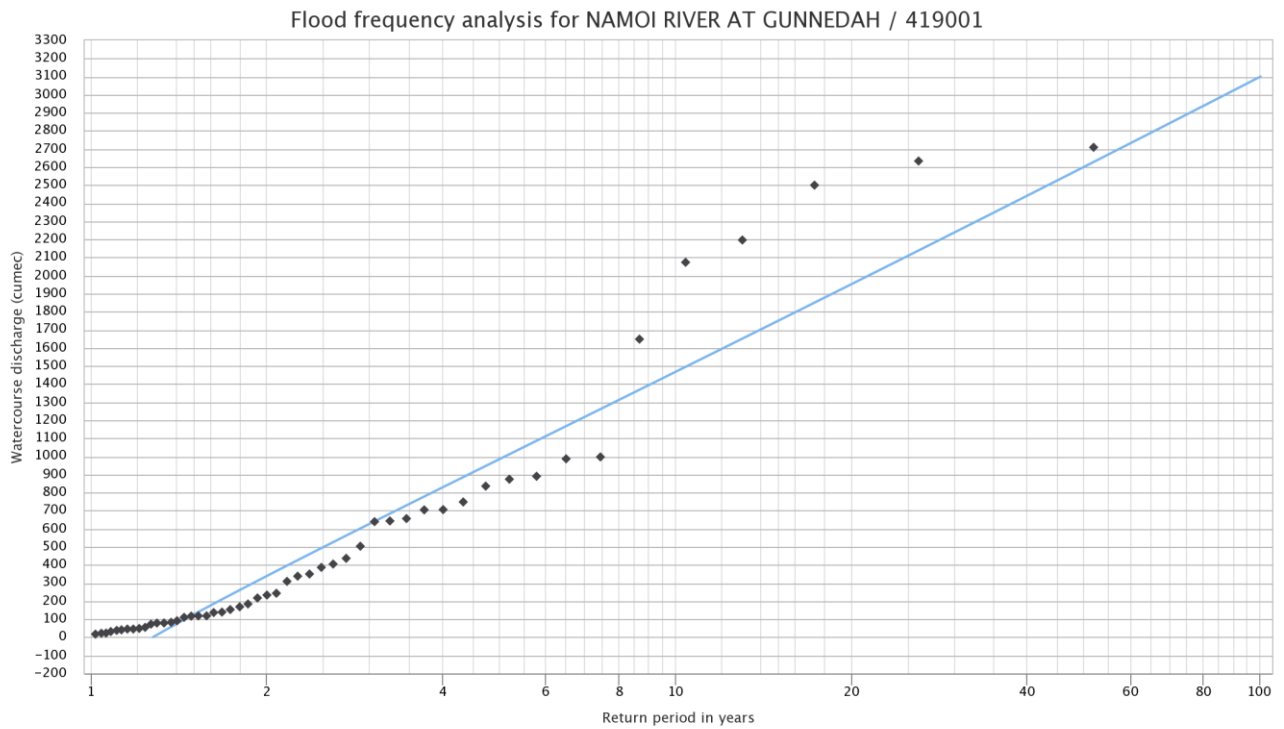
Figure 3-3: *BoM Automated* FFA for the Namoi River at Gunnedah (gauge no. 419001)
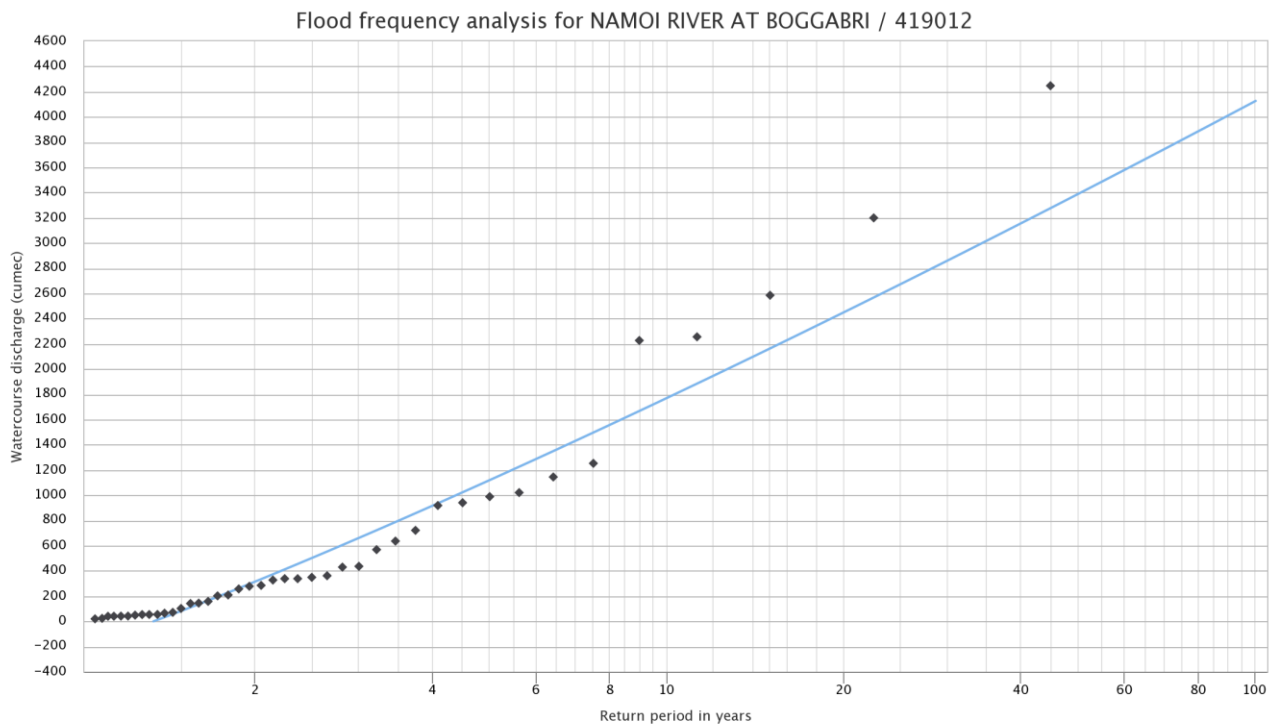
Figure 3-4: *BoM Automated* FFA for the Namoi River at Boggabri (gauge no. 419012)

3.4 Local Catchments

3.4.1 Overview

A description of the catchment is provided in WRM (2018) and is repeated below for background.

Several minor tributaries, including Stratford Creek, drain into the Namoi River from the east, to the immediate south of the Approved Mine and Driggle Draggle and Bollol creeks to the north of the Approved Mine. The catchment areas of Stratford, Driggle Draggle and Bollol Creeks to the Namoi River are 105 km², 248 km² and 158 km² respectively.

The catchments of Stratford, Driggle Draggle, Bollol and Merrygowen Creeks generally drain independently of the Namoi River across broad and ill-defined flow paths, generally at shallow depths. Driggle Draggle Creek receives overflows from Bollol Creek during large flood events. They are all potentially affected by backwater flows from the Namoi River at their downstream ends.

A minor tributary of Stratford Creek, referred to as South Creek, drains from the Vickery State Forest in a southerly direction between the open cut and the secondary infrastructure area in a generally unconfined manner. The catchment area of South Creek to Stratford Creek confluence is 7 km².

A tributary of Driggle Draggle Creek crosses the Project mining area. It drains around the northern side of the Project footprint.

3.4.2 Review of Design Discharge Estimates and Method

WRM (2018) calculated design flood discharges in the Namoi River tributaries, including Collygra Creek, Deadmans Gully, Stratford Creek, South Creek, Driggle Draggle and Bollol Creek using the XP-RAFTS hydrological software (XP Software, 2013). They were then validated against design discharges estimated using the Draft Australian Rainfall and Runoff (ARR) Regional Flood Frequency Estimation model (RFFE) (Ball J et al, 2016).

Catchment modelling using XP-RAFTS is an appropriate technique to determine discharges for the tributaries. A review of the important elements of the catchment modelling is provided in Table 3-4. Overall the assumptions and methodology are appropriate and the design discharges as presented in Table 4.7 of WRM (2018) are appropriate for the study. The adoption of ARR87 techniques should provide a conservative (i.e. higher estimate of design discharge) than if the newer ARR2016 data sets were adopted.

Table 3-4 – Review of XP-RAFTS Catchment Modelling

Review Element	Comment
Catchment Discretisation	Catchment discretisation of the sub-catchment used in the model is presented in Figure 3-5 (below) and summarised in Table 4.2 of (WRM, 2018). It appears to be appropriate.
Catchment Parametrisation	Area: Assumed to be from GIS and hence likely accurate (range 2.2 to 43.5 km²) Slope: Assumed to be from GIS and hence likely accurate (range 0.2 to 2.2%) Roughness: Ranges between 0.06 and 0.08 which appears reasonable Routing: *Channel routing was modelled using the Muskingum method with a storage exponent 'X' of 0.25. The sub-catchment and routing link parameters were adjusted to obtain the best match between modelled discharges and those estimated using the*

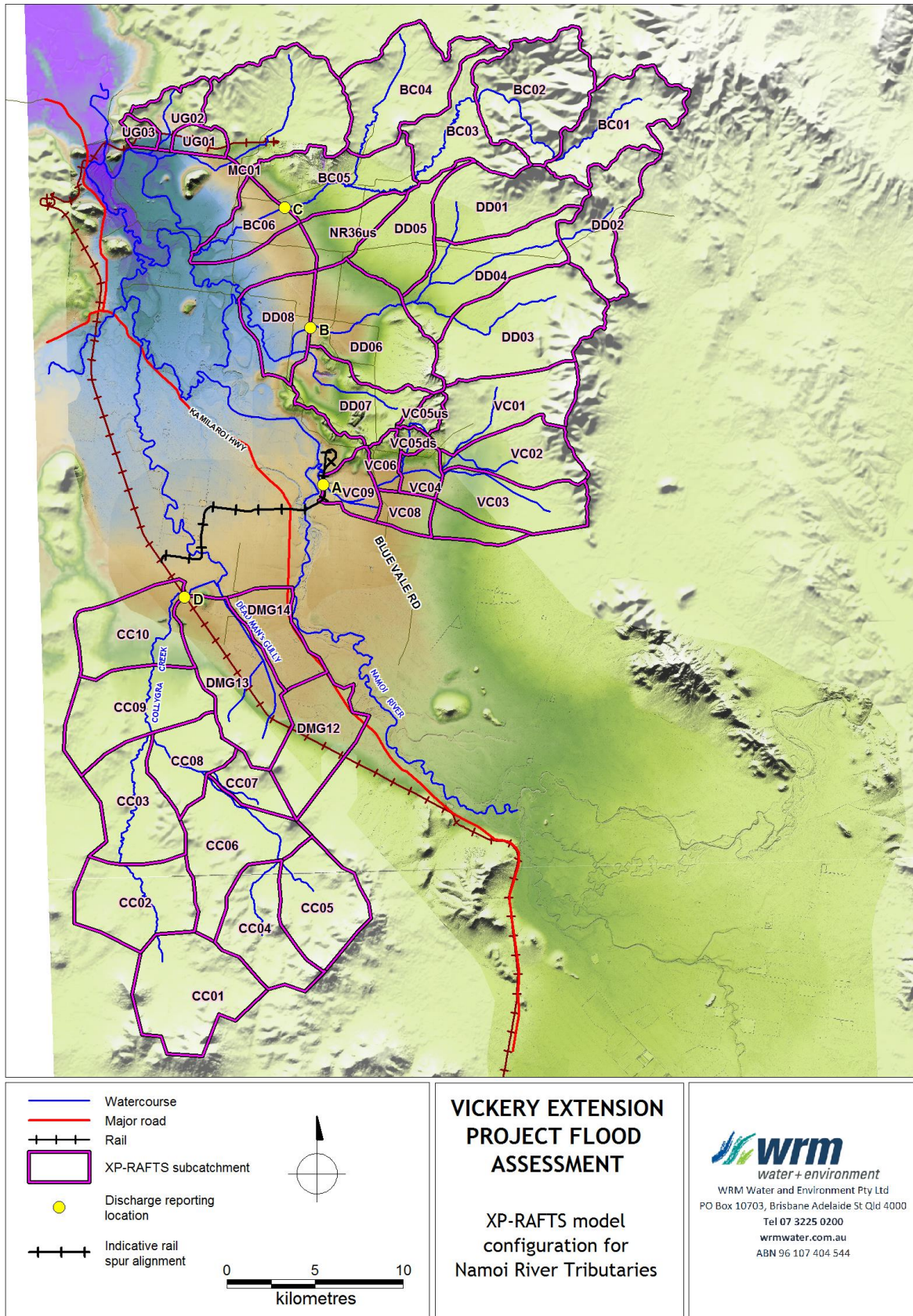| Review Element	Comment
	RFFE. E-water suggests a starting value of 0.75 for natural catchments. If this was reduced to better match the RFFE values it may reduce the accuracy of the XP-RAFTS which, if appropriately set up, should be more accurate than the RFFE.
Initial and Continuing Losses	For this study, an initial loss of 25 mm and continuing loss rate of 2.5 mm/hour were adopted for all design events up to 1% AEP. The adopted initial loss and continuing loss for the PMF event is 0 mm. These values appear to be appropriate.
IFD Data	The 20%, 5% and 1% AEP rainfall intensities were obtained from Intensity-Frequency-Duration (IFD) data determined from ARR Volume 2 (IEAust, 1987). It is of note that the 2016 IFD rainfalls are some 10% to 20% lower than the 1987 IFD rainfalls. The differences in rainfall intensities are not expected to affect the magnitude of the impacts of the Project. It is agreed that, for the purpose of an impact assessment, the 1987 IFD rainfalls remain appropriate, however, given that more data was used to generate the 2016 IFD data they are likely to be the better data set.
Temporal Pattern	The assessment used the single ARR87 temporal patterns which tend to produce a higher discharge than that obtained using the process outlined in ARR2016. The use of ARR87 is appropriate for this assessment.
Critical Duration	No information of the resulting critical duration was specified in the WRM (2018) report. It is assumed that a range of storm durations were assessed and the critical duration was determined and adopted for the design hydrology.
RFFE Comparison	Table 4.3-4.6 (WRM (2018)) show a comparison between XP-RAFTS design peak discharges and those estimated using the RFFE at the following four locations (shown in Figure 3-5). The results indicate that the XP-RAFTS predicted peak design discharges are generally in good agreement with the RFFE estimates (to within 14%). Given that the XP-RAFTS model has been based on the physical characteristics of the catchment, the predicted flood discharges from the XP-RAFTS model have been adopted for the study. Given the accuracy of the XP-RAFTS which, if appropriately set up, should be more accurate than the RFFE, this is appropriate. However, as previously discussed, WRM adjusted parameters in XP-RAFTS to more closely match the RFFE estimates which may have reduced the accuracy of the hydrological prediction. A comparison to the RFFE prior to adjustment would be useful. However, as the main objective of the study is a comparison between current and proposed changes, the accuracy of the magnitude of design discharge is considered appropriate. The use of a direct rainfall hydraulic model could reduce uncertainty surrounding the estimation of routing parameters.
Extreme Event / PMF	The adoption of an extreme event for the Namoi River is considered reasonable for the large catchment and is common practise. The use of GSDM GTSM methods for PMP estimation is considered appropriate for the smaller catchments. However, as the resulting PMP values or calculation sheets area not presented in the WRM (2018) report they could not be assessed. However, a comparison of PMF discharges to the 1%AEP value is in-line with expectations.

Figure 3-5: XP-RAFTS model configuration for Namoi River Tributaries (Fig 4.4 WRM)

4 Review of Flood Model Predictions

Hydraulic (flood) models are a representation of the channel and floodplain and are used to calculate flood depths and velocity for a given river discharge. One-dimensional (1D, i.e. HEC-RAS, MIKE11, Estry) models use cross-sections to represent the channel and floodplain, while two-dimension (2D, i.e. TUFLOW, MIKE21) models use a small "cell" or volume with a given elevation and allow water to flow in any direction reducing the requirement for an assumptions on flow conditions to be made. 2D models are far more computationally intensive than 1D, however, given modern increases in computing power this is now less of an issue.

Two separate hydraulic (flood) models were developed for the study: the Namoi River model, and the Namoi Tributaries model. This is appropriate as preliminary hydraulic modelling results indicated that the peak flood levels across the Driggle Draggle Creek floodplain in the vicinity of the Project are not influenced by the Namoi River tailwater levels at the Project area. These models are reviewed below.

Software selection: The use of TUFLOW as the hydraulic model for the study is considered appropriate. TUFLOW (BMT WBM) estimates flood levels and velocities on a fixed grid pattern by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow. It also incorporates a one-dimensional or quasi two-dimensional modelling system (ESTRY). The one-dimensional (ESTRY) and two-dimensional (TUFLOW) schemes are solved independently, but are dynamically linked at the boundary to ensure continuity (mass) is conserved.

4.1 Review of Namoi River Model

4.1.1 Model Overview

Full details of the Namoi River model are presented in WRM (2018). The model extends approximately 19 km upstream and 23 km downstream of the Project and covers an area of some 452 km^2 and includes Stratford Creek and Collygra Creek. The model features and extents are provided in Figure 4-1.

A summary of key model features includes:

- 15m grid TUFLOW Model

- Hydrology for the Namoi River from FFA (as reviewed in Section 3.3)

- Hydrology for Stratford Creek and Collygra Creek from XP-RAFTs (as reviewed in Section 3.4)

- Uses a range of elevation data sources (see below)

- 1D structure representation of road and rail culverts

- Calibrated to the 1998 flood and validated to the 1955 flood events
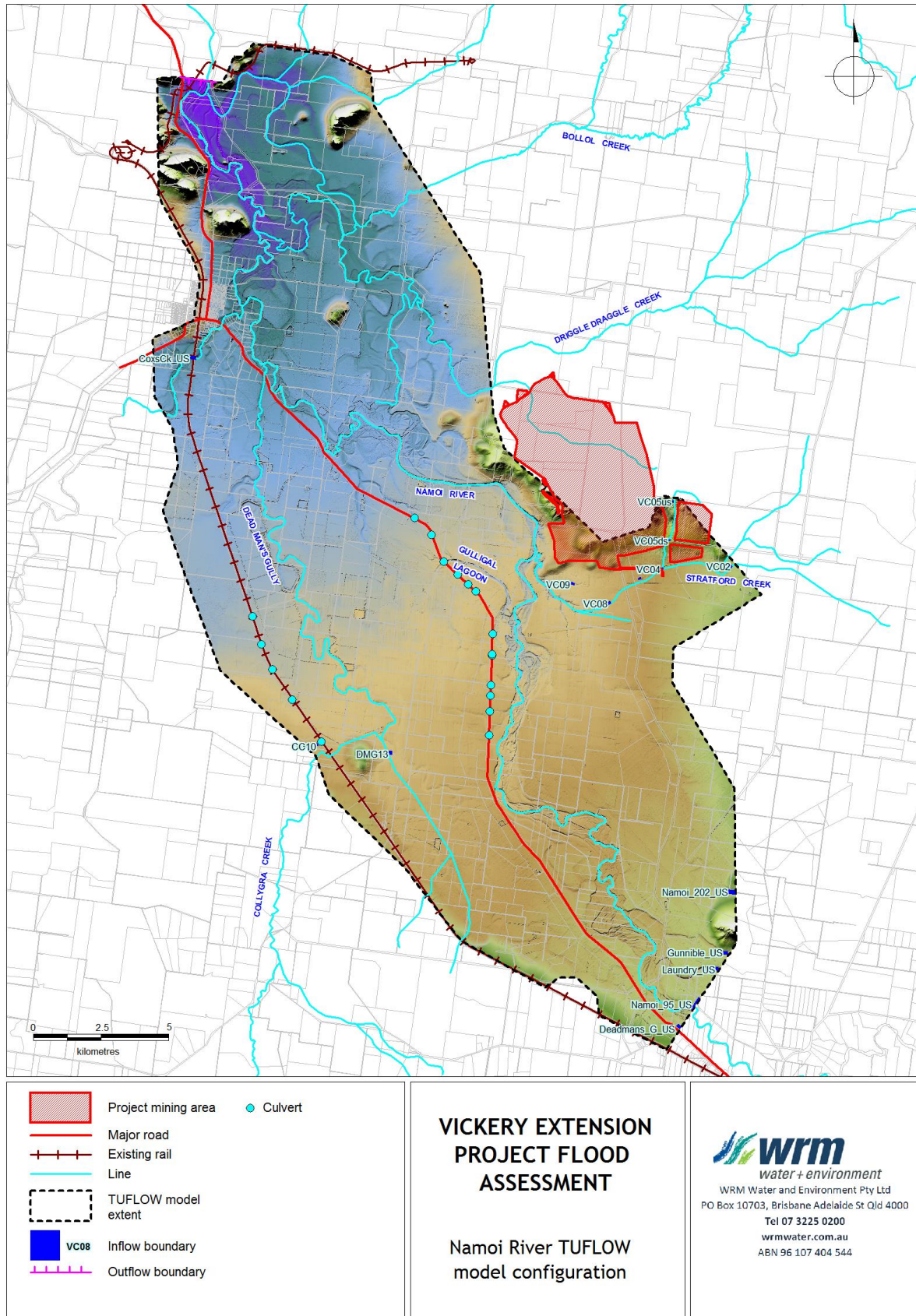
Figure 4-1: Namoi River TUFLOW model configuration (existing conditions)
Source: WRM (2018) Figure 5.1

4.1.2 Detailed Namoi River Model Review

A review of the important elements of the Namoi River TUFLOW modelling is provided in Table 3-4.

Overall the assumptions and methodology appear appropriate and the assessment of the existing conditions appears to be appropriate. The lack of a final design (i.e. detailed design of the rail spur and road re-alignment will not be made until development approval is granted) means that the final level of impact cannot be determined in the review of WRM (2018). However, provided the final design is modelled appropriately and produces a similar or lower level of impact as predicted in the proposed scenario modelling presented in WRM (2018) the level of impact is likely to be considered acceptable.

Table 4-1 – Review of Namoi River TUFLOW Model

Review Element	Comment
Model Extents	The model extents are considered appropriate however, extending the model slightly (i.e 1-2km d/s of Rangari Rd) downstream would allow a check of observed discharge at the Boggabri Gauge to be made. Extending the model further upstream to the Gunnedah Gauge would also be beneficial for calibration and validation and to allow a check of the gauge rating to be made.
Model Resolution	A 15m grid resolution was adopted and is considered appropriate for the study area.
Inflow Boundary	Design inflows for the Namoi and local catchment were reviewed in Chapter 3 and appear appropriate. Hydrograph shape/volume is based on the 1984 event as provided in the SMEC (2003) Mike 11 model. Calibration and validation event inflows are based on SMEC (2013) and are assumed to be correct.
Downstream Boundary	A single normal depth outflow boundary was adopted for the Namoi River model. The outflow boundary of this model is located approximately 23 km downstream of the Approved Mine and as such would not impact on peak flood levels at the Project area. This is considered appropriate.
Elevation Data	Topographic data for the hydraulic model was obtained from a number of sources as detailed in Section 5.2.2 of WRM (2018). The underlying topographic data for the Namoi River model area between Gunnedah and Boggabri was provided by the NSW Department of Environment and Climate Change as Airborne Laser Survey (ALS), acquired during 2000. This is the same base data that was used in the Carroll to Boggabri Flood Study (SMEC, 2003). A range of other ALS and data sources were used. The resulting DEM as presented in Figure 4-1 appears appropriate for the study.
Surface Roughness	Adopted hydraulic roughness (Manning's 'n') values used in the hydraulic model is discussed in Section 5.2.3 of WRM (2018). The range of values presented in Table 5.1 of WBM (2018) appear appropriate. While a figure of the actual spatial distribution of roughness was not given – provided it is similar to that used in other WRM studies (previously reviewed by Royal HaskoningDHV) it is likely to be appropriate.
Structures	Adopted hydraulic structures used in the hydraulic model are discussed in Section 5.2.4 of WRM (2018). Table 5.3 of WRM (2018) provides details of the existing major hydraulic structures within the Namoi River hydraulic model extent. The locations of the structures are shown in Figure 4-1. Details of these structures were obtained from Australian Rail Track Corporation and Gunnedah Shire Council. The existing hydraulic

Review Element	Comment
	structures were modelled within the one-dimensional scheme (ESTRY) directly linked to the two-dimensional model as well as two-dimensional openings.
	The earthen levees, drainage banks and dams located across the floodplain have been included in the model topography by explicitly defining the embankment alignment and crest levels from the available aerial survey data.
	This is approach is considered appropriate.
Model Calibration	The Namoi River hydraulic model was calibrated to the available data for the 1998 flood event. Inflow data is based on the MIKE11 model reported in SMEC (2003) refer Figure 4.1 of WRM (2018). The model results were compared to: observed peak flood levels at four location (refer Figure 5.3 of WRM (2018), the previous MIKE 11 results and the observed flood extent (refer Appendix B in WRM (2018)).
	The TUFLOW model was able to reproduce observed flood levels to within between 0.11 and 0.28 m of observed flood levels which was a significant improvement on the accuracy of the MIKE 11 model. The flood extent was also well predicted by the TUFLOW model.
	Provided the MIKE11 inflows are accurate, this is considered an excellent degree of calibration, though it should be noted that the event is only approximately a 7% AEP (i.e. 14 yr ARI) magnitude.
Model Verification	The Namoi River hydraulic model was validated to the available data for the 1955 flood event. Inflow data is based on the MIKE11 model reported in SMEC (2003) refer Figure 4.2 of WRM (2018). The model results were compared to: observed peak flood levels at six location (refer Figure 5.4 of WRM (2018) and the previous MIKE 11 results.
	The TUFLOW model was able to reproduce observed flood levels to within between - 0.12 and 1.05 m of observed flood levels which is similar to the accuracy of the MIKE 11 model.
	Provided the MIKE11 inflows are accurate, this is considered a good degree of validation (considering potential inaccuracies in observed flood marks) to an event that is approximately a 1% AEP (i.e. 100 yr ARI) magnitude. The bias to over-predict flood levels within the model introduces a degree of conservatism to the flood level predictions.
	The modelling shows the Project mining area (with the exception of the Project rail spur) is outside the extent of the 1955 flood from the Namoi River.
Proposed Conditions Model Updates	Section 6.1 of WRM (2018) provides some detail of the updates to the model required to represent the proposed conditions which included "*incorporating changes in topography due to the Project mining landforms and Project rail spur.* Figure 6.1 of WRM (2018) shows the locations of the proposed levees and rail spur.
	No detail of any rail spur structures are provided in WRM (2018), however, it is understood that the final detailed design of the rail spur will occur after approval of the project (refer Section 6.2.2 and 6.4.1 of WRM (2018)) and it can be assumed that the design will be such that there is negligible impact on flood levels near the spur which will be checked by incorporating the final design in the TUFLOW model when it is available. Provided the TUFLOW model adequately includes a schematisation of the final rail spur (including fill, bridges and culverts) it is considered a suitable tool for quantifying the potential impact.

4.2 Review of Namoi Tributaries River Model

4.2.1 Model Overview

Full details of the Namoi Tributaries River model are presented in WRM (2018). The model features and extents are provided in Figure 4-2.

A summary of key model features includes:

- 10m grid TUFLOW Model
- Hydrology for the Local Catchment using a XP-RAFTS model (as reviewed in Section 3.4)
- Uses a range of elevation data sources (see below)
- 1D structure representation of road and rail culverts
- Model not calibration due to lack of available data available. However, roughness's were based on the calibration outcomes of the Namoi River model so should be applicable.

4.2.2 Detailed Namoi River Tributaries Model Review

A review of the important elements of the Namoi Tributaries River TUFLOW modelling is provided in Table 4-2. Overall the assumptions and methodology appear appropriate the assessment of the existing conditions appears to be appropriate.

Table 4-2 – Review of Namoi Tributaries River TUFLOW Model

Review Element	Comment
Model Extents	The model covers an area of approximately 53.7 km^2 across the Driggle Draggle Creek and Bollol Creek floodplain. The model extents are considered appropriate,
Model Resolution	A 10m grid resolution was adopted and is considered appropriate for the study area.
Inflow Boundary	Design inflows for the local catchment were reviewed in Chapter 3.4 and appear appropriate.
Downstream Boundary	Four normal depth outflow boundary was adopted for the Namoi Tributary River model. While these are appropriate consider the Mine Project location, extending the model downstream to the Namoi Channel would provide a full description of tributary flood behaviour.
Elevation Data	As per Table 4-1. The resulting DEM as presented in Figure 4.2 appears appropriate for the study.
Surface Roughness	As per Table 4-1. Considered appropriate.
Structures	No structures are located in this model domain.
Model Calibration	The model was not calibrated or validated due to a lack of available flood marks in the area. Due to lack of Mine Works in the area this is appropriate.
Proposed Conditions Model Updates	There are no current proposed mine extension works on the 1% AEP tributaries floodplain.
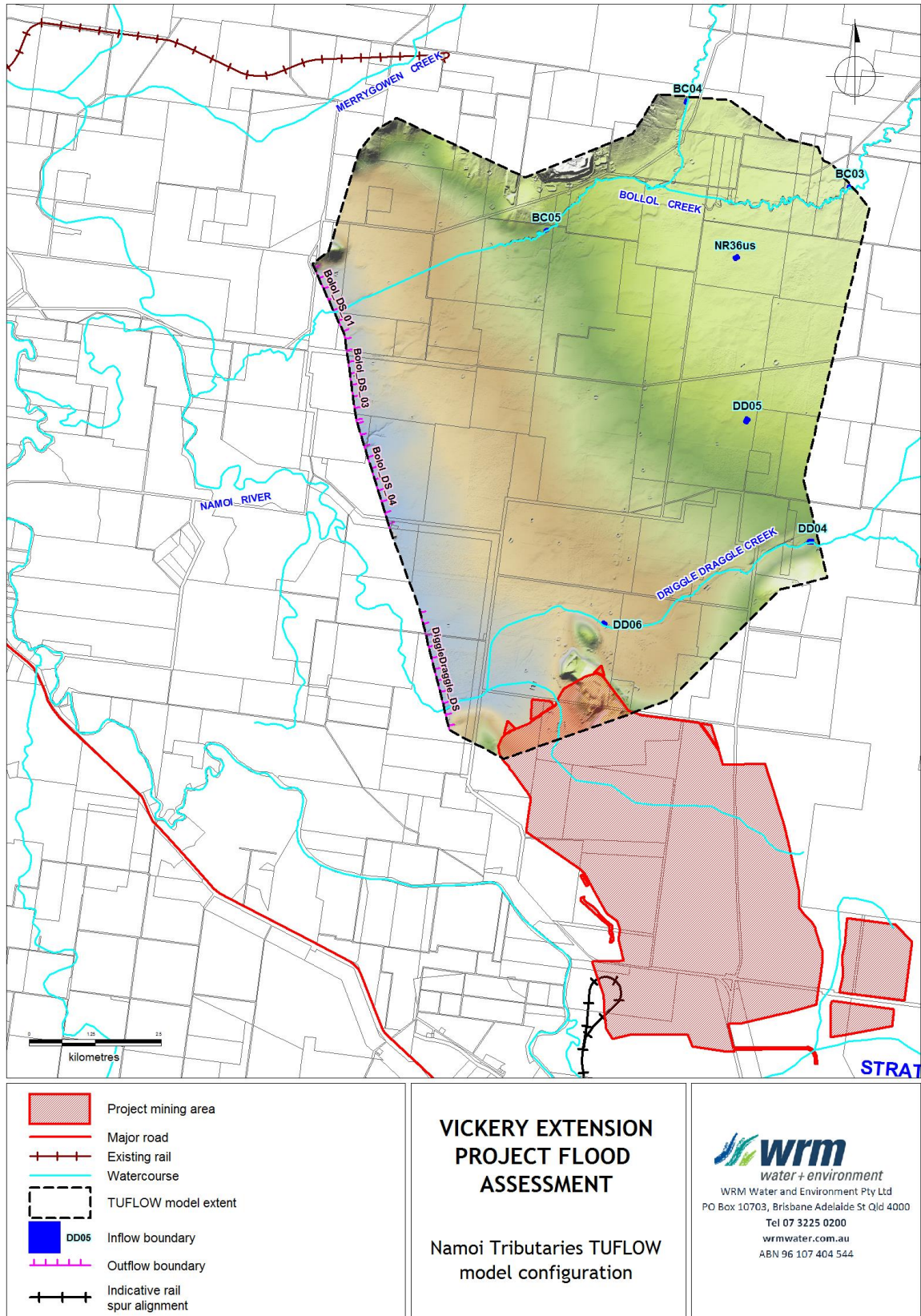
Figure 4-2: Namoi River Tributaries TUFLOW model configuration (existing conditions)
Source: WRM (2018) Figure 5.2

4.3   Review of Existing Condition Model Results

Figure 5.5, Figure 5.6 and Figure 5.7 of WRM (2018) show the predicted peak flood depths and extents along the Namoi River, Driggle Draggle Creek, Stratford Creek and South Creek floodplains for the 20%, 5% and 1% AEP design events respectively. While Figure 5.8 of the report shows the peak flood depths and extent adjacent to the Project for the extreme event (PMF in the Namoi River Tributaries and three times 1% AEP in the Namoi River). This defines the extent of flood prone land adjacent to the Mine Project. Likewise Figure 5.9, Figure 5.10 and Figure 5.11 of WRM (2018) show the predicted peak flood velocities along the Namoi River, Stratford Creek, South Creek and Driggle Draggle Creek floodplains for the 20%, 5% and 1% AEP design events respectively.

It should be noted that it appears that PMF results for the Namoi Tributaries Model have not been included in Figure 5.8 of WRM (2018).

The presentation of results is considered appropriate to evaluate the project and are in-line with expectations of flood behaviour for a large floodplain such as the Namoi. The inclusion of contours of peak flood level would assist interpretation of results but are not essential to the aims of the assessment.

The existing conditions modelling shows that flood protection levees are not required for the Namoi River flooding.

The existing conditions hydraulic model results show that the secondary infrastructure area is affected by shallow depths of flooding from Stratford Creek and the south-western corner of the secondary infrastructure area and the south-eastern corner of the open cut are affected by shallow depths of flooding from South Creek. It is proposed to construct levees in these areas to prevent water from inundating these areas during the operational phase and following mine closure.

4.4   Review of Proposed Condition Model Results and Impact Assessment

Figure 6.2, Figure 6.3 and Figure 6.4 of WRM (2018) show the predicted flood level impacts while Figure 6.5, Figure 6.6 and Figure 6.7 show the predicted changes in peak flood velocities along South and Stratford Creeks due to the proposed levees for the 20%, 5% and 1% AEP events respectively.

The predicted impact of the proposed levees on peak flood levels and velocities along South and Stratford Creeks is small (less than 0.05 m) and are generally localised near the levees (within land owned by Whitehaven). There are no predicted increases in peak flood levels or velocities at existing privately-owned land and dwellings due to the proposed levees and therefore the proposed levees would satisfy the criteria of the draft FMP.

The impacts from the levee are in-line with expectations due to the minor loss in floodplain storage.

The mapped impacts associated with the rail spur provided in (WRM 2018) suggest that very low impact structures (i.e. raised trestle (or similar) and long span (or slender pier) bridges) has been used in the proposed condition model. The report states that:

"Further work to optimise the locations of openings and bunds will be undertaken during detailed design to confirm the design objectives would be met."

This means that because the current impact is not of the final design, the end impact of the rail spur cannot currently be determined. However, provided the final proposed condition model has a similarly negligible impact as that reported in WRM (2018), the level of impact is likely to be deemed as acceptable, as the maximum 1% AEP afflux of 0.3m (WRM (2018) Figure 6.10) is localised to a very small area located on Whitehaven owned land, while the maximum impact on non-Whitehaven land is < 0.1m.

4.4.1 Impact on flow distribution

Given the flat nature of the Namoi River floodplain, the draft FMP has recognised that it is important to maintain the existing distribution of flood flows across the floodplain for both relevant small and large design events. For the purposes of this assessment, the Namoi River floodplain was delineated into the following flow paths:

- Namoi River (NR);
- Namoi River Branch (NRB);
- Gulligal Lagoon (GL);
- Deadmans Gully (DMG); and
- Primeag (conveying flow to the west of Deadmans Gully) (PA).

The impact of the Project rail spur on the flow distribution at each cross section for the 5% AEP event is summarised in Table 6.1 of WRM (2018). The results show that the distribution of flow across the floodplain is not significantly altered by the Project rail spur (i.e. a max change of only 1.4% was predicted for CoxsCk US) and according to the modelling would not result in a consequential effect to neighbouring properties or the environment.

The change in flow distribution should be rechecked following confirmation of the final design of the rail spur and any associated mine works.

5   Summary and Conclusions

A summary of the independent review of the Vickery Mine Extension – Flood Assessment Report (WRM, 2018) includes:

Namoi Design Flood Discharge Estimates

A review of the method and magnitude of the Namoi River design discharges provided in the WRM (2018) indicate that they are appropriate for the Vickery Mine Expansion Flood Assessment. While inclusion of additional discharge data going back to 1891, or development of hydrological model estimates using design rainfall and ARR2016 techniques would increase confidence in the FFA estimate, because the main purpose of the study is to determine relative impact (and not absolute design planning levels) the adopted design discharges are considered appropriate.

Local Catchment Design Discharge Estimates

WRM (2018) calculated design flood discharges in the Namoi River tributaries, including Collygra Creek, Deadmans Gully, Stratford Creek, South Creek, Driggle Draggle and Bollol Creek using the XP-RAFTS hydrological software. They were then validated against design discharges estimated using the Draft Australian Rainfall and Runoff (ARR) Regional Flood Frequency Estimation model (RFFE).

Catchment modelling using XP-RAFTS is an appropriate technique to determine discharges for the tributaries. A review of the important elements of the catchment modelling is provided in Table 3-4. Overall the assumptions and methodology are appropriate and the design discharges as presented in Table 4.7 of WRM (2018) are appropriate for the study. The adoption of ARR87 techniques should provide a conservative (i.e. higher estimate of design discharge) than if the newer ARR2016 data sets were adopted.

Namoi River Model Review

A review of the important elements of the Namoi River TUFLOW modelling is provided in Table 3-4. Overall the assumptions and methodology appear appropriate the assessment of the existing conditions appears to be appropriate.

Namoi River Tributaries Model Review

A review of the important elements of the Namoi Tributaries River TUFLOW modelling is provided in Table 4-2. Overall the assumptions and methodology appear appropriate the assessment of the existing conditions appears to be appropriate.

Review of Impact Assessment

The predicted impact of the proposed levees on peak flood levels and velocities along South and Stratford Creeks is small (less than 0.05 m) and are generally localised near the levees (within land owned by Whitehaven). There are no significant predicted increases in peak flood levels or velocities at existing privately-owned land and dwellings due to the proposed levees and therefore the proposed levees would satisfy the criteria of the draft FMP. The impacts from the levee are in-line with expectations due to the minor loss in floodplain storage.

The mapped impacts associated with the rail spur provided in (WRM 2018) suggest that very low impact structures (i.e. raised trestle (or similar) and long span (or slender pier) bridges) has been used in the proposed condition model. The lack of a final design (i.e. detailed design of the rail spur and road re-alignment will not be made until development approval is granted) means that the final level of impact cannot be determined in the review of WRM (2018). Whitehaven (as per email 11/8/2018) have confirmed (as is committed in the EIS) that they will design and construct the rail spur to achieve the level of impact described in the WRM (2018) Flood Assessment. Provided this commitment is met, and the end impact is as presented in WRM (2018), the level of impact is likely to be considered acceptable.

6   Peer Review Requirements

I Rohan Hudson (the principal reviewer) declare that I have no conflict of interest in undertaking this review. As a Principal Water Resources Engineer with 18 years of experience have sufficient expertise to provide a critical review of the WRM (2018) report and study. While no regulation or standards regarding hydraulic model assessment exist (refer Section 2.3) the assessment considers that in general the WRM (2018) assessment was undertaken using best-practice techniques.

Details of professional indemnity insurance held by the peer reviewer as an employee of Royal HaskoningDHV are below.

Royal
HaskoningDHV

MARSH

Lee Bamford
Senior Account Executive
Marsh Pty Ltd
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15 December 2017

CERTIFICATE OF CURRENCY
PROFESSIONAL INDEMNITY INSURANCE

INSURED ORGANISATION
Haskoning Australia Pty Ltd

PROFESSIONAL SERVICES
The provision of design and advice in relation to design, drafting, technical calculation, technical
specification, project management, construction management, feasibility studies, programming and time
flow management, quantity surveying, surveying, technical advice, inspection, training in respect of the
above.

PERIOD OF INSURANCE
From 31 December 2017 at 4:00pm local standard time to 31 December 2018 at 4:00pm local standard time

INSURERS

NAME	POLICY NUMBER	PARTICIPATION %
AAI Limited trading as Vero Insurance	LSS019868048	100%

LIMIT OF LIABILITY
Not less than $1,000,000 any one claim and in the aggregate

NOTIFICATION OF LOSS TO
AAI Limited ABN 48 005 297 807 trading as Vero Insurance
Level 33, 530 Collins Street, Melbourne, VIC, 3000

In accordance with the ongoing commitment by Marsh to quality management philosophies, this certificate
has been verified for accuracy of content by:

Yours faithfully,

Lee Bamford
Senior Account Executive

SOLUTIONS...DEFINED, DESIGNED, AND DELIVERED.

**MARSH & McLENNAN
COMPANIES**

7 References

1. ARR2016 - Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2016, *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia

2. ARR87, IEAust, 1987, *Australian Rainfall and Runoff, A Guide to Flood Estimation* Pilgrim, DH, (ed), Institution of Engineers, Australia, Barton, ACT, 1998

3. SMEC, 2003, *Carroll To Boggabri Flood Study and Compendium of Data,* Land and Water Conservation, March 2003.

4. WRM, 2018a, *Vickery Mine Extension – Flood Assessment Report*, Report No 0800-02-G8, dated 16 February 2018

5. WRM, 2018b, *Vickery Mine Extension – Flood Assessment Report*, Report No 0800-02-G10, dated 10 August 2018

Whitehaven Coal Limited
C/- Resource Strategies Pty Ltd
PO Box 1842
Milton QLD 4064

Attention: Brian Cole

Dear Brian

Independent Peer Review of Vickery Extension Project Environmental Impact Statement Draft Noise and Blasting Assessment (Version A) Wilkinson Murray Pty Limited

1   Introduction

SLR Consulting Australia Pty Ltd (SLR) was engaged by Whitehaven Coal Limited (WCL) (the Proponent) to undertake an independent peer review of the specific environmental matter of noise and blasting impacts with respect to the Vickery Extension Project (the Project) Environmental Impact Statement (EIS). Wilkinson Murray Pty Limited (WMPL) was engaged as the Principal (Acoustical) Consultant by WCML to prepare the Noise and Blasting Assessment in relation to the Project in accordance with the Secretary's Environmental Assessment Requirements (SEARs) issued by the New South Wales (NSW) Department of Planning and Environment (the Department) dated 12 March 2018.

The review has been prepared and guided by the requirements of the Departments Guideline 9 Peer Review (Draft Environmental Impact Assessment Guidance Series) dated June 2017, and in particular Section 2.3 *What are the criteria?*, and this letter presents the findings of SLR's peer review.

2   Requirements (Guideline 9 Section 2.3.1 Suitability of reviewers)

The Project SEARs do not specify that an independent peer review should be undertaken for any specific environmental matter. However, following the introduction of the NSW Noise Policy for Industry (NPfI) by the NSW Environment Protection Authority (EPA) in October 2017, the Proponent considered it prudent to arrange a peer review of noise and blasting impact assessment for the Project by an independent company and a suitably qualified 'senior practitioner'. SLR and company Director Glenn Thomas have significant experience in the specialist field of large scale mining and resource infrastructure environmental acoustics.

Prior to being engaged in December 2017 by WCL to undertake the peer review, SLR and its Director considered potential matters that may present a conflict of interest. SLR declared that it provides environmental services (excluding acoustics) to WCL in relation to its mining operations, and does not provide any environmental services (including acoustics) with respect to the Project.

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Appendix A
Independent Peer Review of Vickery Extension Project Environmental Impact Statement
Draft Noise and Blasting Assessment (Version A) Wilkinson Murray Pty Limited

Job No: 610.17804
610.17804-L01-v1.0
Date: 9 August 2018

Following this disclosure SLR and its Director acknowledged and agreed it would take all reasonable steps during the peer review process to avoid and or manage any conflicts of interest should they arise, and make further declarations should it be necessary to do so. In June 2018, SLR was engaged by WCL to undertake routine environmental noise monitoring for the month of June at five of the WCL's mining operations. In order to manager any potential conflict of interest as a result of the engagement, SLR Peer Reviewer (Glenn Thomas) will not be involved in the environmental noise monitoring including any planning, field measurements, noise analysis or reporting.

3   Procedure (Guideline 9 Section 2.3.2 Review Practice)

SLR attended an initial Project briefing on Monday 29 January 2018 at WMPL's North Sydney Office. In attendance were the following representatives:

- The Proponent (WCL): Brian Cole;

- Principal (Acoustical) Consultant (WCML): Roman Haverkamp and John Wassermann;

- Principal (Planning) Consultant (Resource Strategies Pty Ltd): Mitch Kelly; and

- Peer Reviewer (SLR): Glenn Thomas.

In view of the application of the NPfI and the associated updates and changes by comparison with the previous NSW Industrial Noise Policy (INP), it was agreed that WMPL would provide SLR with copies of its proposed noise modelling methodology and calculation procedures focusing on the key assessment variables namely:

- Determination of fixed plant and mobile equipment sound power levels (SWLs);

- Selection of mine operating scenarios and mobile equipment layouts;

- Investigation of the feasible and reasonable noise mitigation measures;

- Establishment of standard and noise-enhancing meteorological parameters;

- Assessment and application of modifying factor corrections; and

- Application of the NPfI intrusive mine noise level and the 10th percentile (P10) mine noise level.

SLR initially reviewed the proposed noise modelling methodology and calculation procedures, and a teleconference was convened on Wednesday 28 February 2018 to discuss the key outcomes of the initial review with the representatives, that included:

- Checking the proposed locomotive SWL and update as required;

- Confirming the Coal Preparation Plant proposed SWL of the 115 dBA was achievable subject to enclosure as required;

- Confirming the proposed truck activity ratings, with the haul cycle comprising approximately equal periods of stationary, up gradient loaded, and down gradient unloaded activity;

- Endorsing the standard and noise-enhancing meteorological parameters (as per NPfI Fact Sheet D) including conservatively adopting moderate to strong night-time temperature inversion conditions for the purposes of predicting the NPfI intrusive mine noise levels;

- Appling the 'C-A' screening test with respect to potential low frequency noise (LFN) annoyance, and if required further assess for LFN in accordance NPfI Fact Sheet C; and

- Presenting the NPfI intrusive (and maximum) mine noise levels in the noise (and blasting) assessment consistent with NPfI Section 3.3.2 *Noise prediction*;

Appendix A
Independent Peer Review of Vickery Extension Project Environmental Impact Statement
Draft Noise and Blasting Assessment (Version A) Wilkinson Murray Pty Limited

Job No: 610.17804
610.17804-L01-v1.0
Date: 9 August 2018

SLR was provided with a draft report dated 28 March 2018, and provided comments on the draft report for WMPL's consideration on Monday 9 April 2018, and the key comments included:

- Clarifying the use of the Interim Construction Noise Guideline (ICNG) with respect to the construction of the rail spur;

- Clarifying the application of NPfI Table 4.1 *Significance of Residual Noise Impacts*;

- Seeking further explanation of the LFN assessment approach and resulting outcomes;

- Noting the assessment noise impact on vacant land was subject to the preparation of the relevant noise contour diagrams;

- Checking the maximum mine noise level prediction methodology and update as required; and

- Checking the intrusive construction noise level prediction methodology and update as required.

SLR was subsequently provided with a second draft Noise and Blasting Assessment report (Version A) dated 24 April 2018. SLR is satisfied that all of the key comments were addressed either in the second draft report, or in follow-up discussion with WMPL. However, there remained a residual concern that the predicted maximum noise levels may understate the potential impact of the Project at night. SLR was provided with a Final (draft) Noise and Blasting Assessment report (Version A) dated 1 July 2018, and is satisfied with the (adjusted) maximum noise levels as presented in Table 5-12 of the report.

4 Conclusion

Based on the peer review procedure described in **Section 3** of this letter, SLR confirms that the Noise and Blasting Assessment for the Project has been prepared in accordance with the appropriate requirements of the SEARs, including the Noise Policy for Industry (NPfI), and the Interim Construction Noise Guideline (ICNG).

Furthermore, road and rail noise impacts have been assessed in accordance with the NSW Road Noise Policy (RNP) and Rail Infrastructure Noise Guideline (RING) respectively.

Noise and vibration impacts from blasting have also been assessed in accordance with the SEARs which refers to the EPA's Assessing Vibration: a Technical Guideline, which in turn defers to requirements of the Australia and New Zealand Environment Council's (ANZEC) Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration.

Notwithstanding, a number of points of clarification were identified during the peer review period, and this was mainly due to the introduction of the NPfI, and applying the new policy to a large scale mining operation. SLR is satisfied that the all of the key comments have now been addressed.

In summary, this peer review confirms that the Noise and Blasting Assessment for the Project conforms to the relevant guidelines. The report is comprehensive, considers other stakeholders and has been undertaken in a professional manner. The conclusions reached in the report are supported by appropriate assessment methodologies, calculations and assumptions where necessary to do so.

Please contact the undersigned should you require any additional information.

Yours sincerely

GLENN THOMAS
Director

TODOROSKI AIR SCIENCES

26 July 2018

Brian Cole
Executive General Manager - Projects Delivery
Whitehaven Coal Limited
PO Box 600
231 Conadilly St, Gunnedah NSW 2380 Australia

RE: Vickery Extension Project Air Quality and Greenhouse Gas Assessment – Peer Review

Dear Brian,

Todoroski Air Sciences have conducted a peer review of the Vickery Extension Project Air Quality Assessment report (**Ramboll, 2018**) (the Report).

The peer review is limited to the information presented in the Report and did not have access to any modelling files used in the assessment or to other additional data. The review focused on the following key aspects of the Report,

+ The estimated dust emissions and assumptions used to derive these;

+ The metrological data and the period chosen for the assessment; and,

+ The predicted dust levels at receptors.

The modelling predictions in the Report indicate that there would be no privately-owned receptor impacted in regard to air quality.

It is noted that the project incorporates a gradual increase in the rate of activity, and greater levels of activity towards the end of the mine life. In general, this provides time for the operator to optimise their dust management and mining practices before reaching peak production levels, and may help to minimise dust.

Overall, the peer review considers that:

+ The quantity of dust estimated to be emitted is consistent with a typical coal mine operation of this scale. There is a notably large proportion of haul road emissions, but this appears to arise due to the nature of the mine plans. Overall the total quantity of dust per unit of coal mined is consistent with such open cut operations. The total emissions predicted to arise do not appear to underestimate the total that may be expected to occur.

- The modelling year is chosen primarily to allow a reasonable cumulative assessment to be made, and appears to be relatively consistent with the prevailing trends in the weather in this area. The data used in the modelling appears to display the expected diurnal and seasonal trends that would occur.

- The controls proposed appear to be sufficient and consistent with general best practice, especially in light of the relatively low predicted dust contributions.

- The scale of the impacts predicted appears to be consistent with the reviewer's expectations given the estimated dust emission levels and the distance of sources to receptors. The Report indicates low levels of dust contribution due to the project.

- Whilst the reviewer may have made different modelling choices and applied different assumptions for some key aspects of the assessment, these are unlikely to change any of the overall conclusions in the Report. In other situations (other mines in other localities) these assumptions may have a bearing on the outcome, but in this case are not significant and are considered simply as differences in modelling preferences.

The peer review additionally provided some comments on minor issues in the Report such as typos, clarity of graphs and potential clarification/ explanation of some parts, etc. via comments inserted into the assessment report that was reviewed. The feedback on these minor items is not detailed in this review letter as it would not alter any findings.

The peer review thus found that overall the Report presents a generally satisfactory assessment of the potential dust impacts that may arise in this case due to the Project.

Please feel free to contact me directly if you would like to discuss or clarify any aspect of this review.

Yours faithfully,
Todoroski Air Sciences

Aleks Todoroski

References

Ramboll (2018)
    "Vickery Extension Project Air Quality and Greenhouse Gas Assessment", prepared by Ramboll, June 2018

5 July 2018

Brian Cole
Executive General Manager, Project Delivery
Whitehaven Coal Limited
121 Merton Street
BOGGABRI NSW 2382

Dear Brian,

RE: VICKERY EXTENSION PROJECT PEER REVIEW OF BIODIVERSITY ASSESSMENT REPORT AND BIODIVERSITY OFFSET STRATEGY

Whitehaven Coal has asked me to review the Biodiversity Assessment Report and Biodiversity Offset Strategy (BARBOS) developed for the Vickery Extension Project by Resource Strategies Pty Ltd. This letter briefly outlines my role in the Vickery Extension Project (VEP) and the BARBOS, and the findings of my review.

I am an Accredited BioBanking Assessor (No. 0011) and have previously authored and reviewed BARBOS applying the NSW *Framework for Biodiversity Assessment* (FBA) guidelines. Given this I consider I have a detailed understanding of the requirements of the FBA and what the NSW Office of Environment and Heritage requires within a BARBOS. Furthermore I have a good knowledge of the ecology across the Liverpool Plains.

In reviewing the Vickery Extension Project BARBOS, I aimed to ensure that it met the FBA and EPBC Act guidelines, accurately reflected the findings of the baseline flora and fauna reports and, as far as is possible prior to finalisation, provided a feasible and realistic biodiversity offset strategy for the project.

My review comments have been incorporated to my satisfaction and I consider that the Vickery Extension Project BARBOS meets the requirements of the FBA and EPBC Act guidelines.

Yours Sincerely,
HUNTER ECO

Dr Colin Driscoll
Environmental Biologist

Disclosure: I was involved in aspects of the reporting for the Vickery Extension Project providing flora and vegetation assessments for Offsets 7 and 8. This has not affected my capacity for providing an objective review of this BARBOS which is a technical presentation of facts in a prescribed format.

BAEconomics

Specialists in minerals, energy and agricultural economics

35 Endeavour Street, Red Hill, ACT Australia 2603

Brian Cole
Executive General Manager, Project Delivery
Whitehaven Coal

Dear Brian

Re: **Peer Review of the Vickery Extension Project Economic Assessment**

I have now completed my review of the report entitled 'Vickery Extension Project Economic Assessment: Report prepared for Whitehaven Coal Limited' prepared by AnalytEcon dated July 2018 following discussions with the authors. My initial assessment of this report was based on a version that I received on 3 June 2016. Following the receipt of my comments on that version of the report, the authors updated the report and I received further amended versions on 24 April 2017 and 4 May 2017. I received the latest version of the updated report on 25 July 2018.

The report consists of a detailed cost benefit analysis of the Vickery Extension Project and the 'Approved Mine' together with a regional impact assessment and an agricultural impact assessment. The report sets out in detail the methodology that has been applied in making these assessments, states the assumptions made and includes a sensitivity analysis on key model parameters.

I supplied the authors of the report detailed comments on its content and suggestions for improvement based on the draft supplied to me on 3 June 2016. I made further minor comments on the version of the report supplied to me on 24 April 2017.
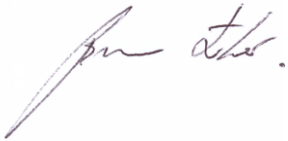
All of these comments have been addressed to my satisfaction by the authors in the final version of the report supplied to me on 25 July 2018. In addition to updating assumptions in the most recent version of the report AnalytEcon has taken into consideration the most recent technical guidance from the NSW Department of Planning and Environment on valuation of externalities.

In my reviews I have noted that some assumptions used by AnalytEcon to estimate the potential economic effects of the Vickery Extension Project could be considered to be conservative. In other words, such assumptions will tend to have somewhat under-stated the benefits to New South Wales of approval of the Extension Project.

In my opinion the current version of the report has been competently completed and provides a fair assessment of the net value of the Vickery Extension Project to New South Wales. There remains some uncertainty regarding the split of net benefits between the local region and the remainder of New South Wales. However, given data availability I believe that AnalyEcon has made a reasonable judgement about the definition of the relevant project region. This is not an issue with the methodology but rather the data that are available to adequately disaggregate separate regions within the State as set out by the 2015 assessment Guidelines. Regardless of this issue I believe that AnalytEcon has demonstrated that the Vickery Extension Project will make a large net contribution to the economy of New South Wales should it be approved and I am in no doubt that the estimated total net benefit to New South Wales is a reasonable reflection of likely total net benefits. In my assessment AnaytEcon's estimates of the net regional benefits are also reasonable.

As part of the review process I made detailed comments regarding some of the key assumptions underlying the assessment and the methodology that has been employed. In my opinion the assumptions adopted in the final assessment, including those adopted for the sensitivity analysis, encompass a range that might reasonably be expected to represent the prospects for the coal industry in the long term, the time period over which decisions need to be assessed for investment in very long-term assets.

Yours sincerely,

Brian S Fisher PhD DScAgr AO PSM FASSA
Managing Director

1 August, 2018