Memorandum

TO: Stephen O'Donoghue – Department of Planning and Environment
FROM: Erin Askew - WMAwater
DATE: 19 November 2018
SUBJECT: Vickery Coal Extension Project – Peer Review of Flood Modelling
PROJECT NUMBER: 118088

1. OVERVIEW

The Vickery Coal Project is located 25km north of Gunnedah, NSW. The open cut coal mining operation has an existing footprint and associated aspects approval but has not commenced development. Whitehaven Coal Limited is seeking approval for an extension to the approved mining footprint and associated aspects via the Vickery Coal Extension Project (referred to as the Extension Project). In addition, the Extension Project includes construction and operation of a rail spur. The Project is located within the Namoi River Floodplain, although the majority of the mine works are located beyond the floodplain, the proposed rail spur crosses the floodplain. The Environmental Impact Statement (EIS) has considered the impacts of the Extension Project on flood behaviour via the *Vickery Extension Project – Flood Assessment, August 2018 WRM Water and Environment* (the Flood Assessment*).* The EIS was placed on Public Exhibition in October 2018.

The Project's location within the Namoi River floodplain has meant that flooding has been identified as an issue of concern. In order to inform its assessment, the Department of Planning and Environment has engaged WMAwater as an independent expert to undertake a Peer Review of the Flood Assessment. The following sections outline this review. The review aims to consider the appropriateness of the methodology applied and the outcomes of the assessment undertaken.

Following review of the Flood Assessment and that review being supplemented with discussions with the proponent's flood assessment specialist (WRM), it has been determined that the assessment generally appears to be undertaken in accordance with industry best practice, however some aspects of the assessment are not documented in the Flood Assessment report. Documentation of these aspects would assist in providing clarity to the reader.

It is acknowledged that the purpose of the assessment is to determine impacts of the proposal on flood behaviour however some of the clarifications identified would add to reader understanding and assist in building confidence in the assessment that has been undertaken.

2. DATA AND REFERENCES AVAILABLE

The primary source of data relied upon for this review is the *Vickery Extension Project Environmental Impact Statement – Appendix C Flood Assessment, August 2018.* The Flood Assessment outlines the methodology adopted and results of the hydrologic and hydraulic modelling undertaken to address the Secretary's Environmental Assessment Requirements (SEARs) as they relate to flooding. No other Sections of the EIS have been reviewed. The review has been informed by documentation in the Flood Assessment report describing the methods applied, modelling files have not been sighted to confirm application of the methods.

Whitehaven Coal Limited engaged Royal HaskoningDHV to undertake a review of the Flood Assessment. The review (dated 13th August 2018) was provided to WMAwater as a supplementary document. The summary and conclusions of the review are similar to those of this peer review.

In addition, a field visit was undertaken on the 22nd and 23rd of October 2018. The field visit included meetings with the proponent's flood assessment specialist consultant and local community representatives. These discussions have helped to inform the peer review included in the following sections.

The SEARs as they relate to flooding are outlined in Section 2.1 of the Flood Assessment, this review has considered how the Flood Assessment has address these items.

The Project is located within the Namoi River floodplain, changes to Part 8 of the *Water Act 1912* in 1999 allowed for more strategic control of rural flood control works through the preparation of Floodplain Management Plans (FMP). The FMPs aim to outline management measures for the floodplain that are hydraulically, environmentally and economically sustainable as well as being accepted by the community. The FMP for the Carroll to Boggabri reach of the Namoi River was gazetted in 2006. At its basic level the FMP sets out a series of controls for works on the floodplain which may be relevant to the Extension Project.

In addition, the FMP identifies, at a strategic level, floodways which are essential to the orderly passage of the Reference Flood and a set of criteria which determine if a proposed work is complying. Works within these areas or that are deemed to be non-complying are required to demonstrate that they do not impact on flood behaviour through a detailed investigation. The investigation must consider the hydraulic, environmental, social and economic impacts of the works. The FMP also outlines criteria for which works would be considered unacceptable and include cumulative and individual flow diversion targets, increases in flood levels on adjacent landholders and adjacent dwellings and the maximum threshold for increases in velocity.

Section 50 of the *Water Management Act 2000* supersedes the relevant sections of the Water Act and a new Draft FMP for the Upper Namoi Valley was prepared in 2016. The general principles and overall criteria of the Draft FMP are consistent with the 2006 FMP, with the exception that the Draft FMP identifies a number of management zones and applies varying works approval assessment criteria across each zone. The management zones cover areas in addition to the floodways identified in the 2006 FMP. This allows for more refined criteria to be applied more appropriately to each zone. The Extension Project interacts with Zones AD (defined floodways, major discharge areas), AID (ill defined floodways, major discharge areas), BL (areas important for conveyance and pondage of floodwaters during a flood), C (flood fringe areas) and D (special protection zone, environmental and/or cultural significance). For example, the assessment criteria that applies to Zone BL is summarised below:

- Maintain adequate flood connectivity to ecological and/or cultural assets, and facilitate fish passage.
- No disturbance of the ground surface (or erosion) at a heritage site.
- Peak flood flow redistribution onto adjacent landholdings limited to 5%.
- Flood levels increased by no more than 20cm.
- No change in flood levels at high value infrastructure.
- Flood velocity increases limited to 50% of pre development values.

There are no specific standards that apply to flood modelling that can be referred to as part of this review. Instead a series of guidelines including Australian Rainfall and Runoff 1987 (ARR 1987), Australian Rainfall and Runoff 2016 (ARR2016), Australian Institute of Disaster Resilience Handbook 7 – Managing the Floodplain: A Guideline to Best Practice in Flood Risk Management in Australia and industry experience provide guidance on what is accepted as best practice.

3. SPECIFIC COMMENTS

3.1. Section 2 Assessment requirements and regulatory framework

Section 2.1, Table 2.1 required the assessment of the 1 in 10 year event. This, as noted, has not been included in the assessment.

Table 2.1 also requires that the impacts on other properties, assets and infrastructure are identified. This aspect would benefit from more explicit discussion in the form of tables etc.

3.2. Section 3 Drainage characteristics

Section 3.1 Paragraph 4 and 7 refer to the 10% and 2% AEP floods, neither of these events have been included in mapping. It can be difficult for the reader to understand the relative scale between events and the readers' understanding would be improved by including mapping of these events or for the discussion to be related to a historical event for which mapping does exist.

The Flood Assessment discusses a number of times, the independent mechanisms that result in flooding in the local creeks (Stratford, Driggle Draggle, Bollol and Merrygowen) and the Namoi River. It is acknowledged that this may be the typical case and a coincident flood event is unlikely to result in greater impacts than presented in the Flood Assessment, however the community has observed coincident events, including the interaction of Coxs and Rangira Creeks with Namoi River flooding. The Flood Assessment would benefit from further discussion of this aspect and possibly the assessment of impacts during a coincident event to demonstrate the impacts of the proposed works under a different assumption.

It is noted that an inflow boundary for CoxsCk_US is identified on Figure 5.1, the Flood Assessment does not discuss how this boundary was derived. Clarification should be provided.

In addition, a gap in flood mapping is shown on Figures 5.5 – 5.7 downstream of the Namoi Tributaries model, the reasoning for this gap in flood information may not be clear to the reader and could result in reduced confidence in the assessment. This should be clarified, alternatively, the downstream boundary for the Namoi Tributaries models could be relocated to the Namoi River channel. It is acknowledged that this area is downstream of all proposed works and inclusion of this data is unlikely to affect the assessment of the Extension Project impacts.

3.3. Section 4 Estimation of flood discharges

The methodology described in Section 4.1 including the determination of design discharges by flood frequency analysis (FFA) at the Gunnedah gauge and the use of a 3 times the 1% AEP extreme event are appropriate. The gauge location, upstream of the Project and with no significant tributaries and entering between the gauge and the Project (noting that there are some minor contributing catchments such as Rangira, Stratford, Driggle Draggle and Bollol Creeks in the vicinity), in addition to the available record length (approaching 50 years) make the use of FFA appropriate for determining design flood discharges for the Flood Assessment.

The use of XP-RAFTS to determine design discharges into the smaller creek systems is also appropriate. TUFLOW is a widely used 2D hydraulic model and its use in the Flood Assessment is appropriate.

The Flood Assessment draws on a range of information from the Carroll to Boggabri Flood Study undertaken in 2003. This flood study established a MIKE-11 hydraulic model to determine flood behaviour across the study area.

Section 4.1 and 4.2 discusses an overview of the methodology. These sections refer to the calibration of the models with some aspects discussed here and the results of the calibration discussed later in Section 5.3.

The Flood Assessment would benefit from linking these sections together or providing further clarification in the earlier sections. As the Flood Assessment stands, it gives the impression that the TUFLOW model was calibrated to results from the existing MIKE-11 model. It is acknowledged that this is not the case following a review of Section 5.3, however calibration to previous model results would not typically be the most appropriate method, rather calibration to known flood information, as has been done, would be appropriate.

Section 4.2 discusses inflow discharges extracted from the existing MIKE-11 model and the variable proportions of discharge across the floodplain flow paths. Clarification on how these flow splits were determined and their appropriateness for use for design events is required.

The use of FFA to determine design discharges at Gunnedah is the most appropriate method for this location. The discussion in Section 4.2.2 requires further details in order to determine that the method has been applied in accordance with best practice. Additional details include what assumptions were made for events between 1955 and 1968, is there any benefit to including the period from 2015 – 2018, are there other events prior to 1955 that may influence the results, how was the fit achieved, was software such as FLIKE used, what is the likely variability around the discharge estimates for the 1955 event, given that the current rating curve is applied? A table showing the peak flood heights and assumed discharge would also benefit the reader. Labels identifying key historical events on Figure 4.3 would also be beneficial. The Flood Assessment states that the results are consistent with previous assessments but does not provide details, other than to say the predicted magnitude of previous events was similar. Additional details would assist the reader and give credibility to the study.

The method to determine the extreme flood event is reasonable and appropriate for this catchment. The discussion provided in Section 4.2.3 is somewhat misleading, as the limitation on use of FFA to determine the PMF is not unique to the Namoi River catchment. There would not be a stream gauge anywhere in Australia that would have a record length suitable for determining the PMF. The text tends to indicate limitations with the data for this catchment and creates uncertainty, when the method used is completely appropriate.

The catchment delineation on Figure 4.4 appears reasonable from the information available on the figure. It is noted that catchments UG01 – UG03 do not appear to be used in the hydraulic modelling. This could be clarified in the text.

Regional Flood Frequency Estimation (RFFE) is a tool developed as part of the research undertaken to support ARR2016. The tool utilises an understanding of design discharge estimates at 853 gauged catchments to inform estimates of design discharges at ungauged locations. The use of RFFE is a reasonable approach for validating the order of magnitude of design discharge estimates for the Namoi River Tributary catchments from XP-RAFTS. Given the uncertainty and limitations around the design estimates in RFFE, it is not appropriate to calibrate a runoff routing model to these estimates. It is assumed that the parameters in XP-RAFTS have not been adjusted to provide a closer calibration match to RFFE.

The Flood Assessment uses the data and methodologies described in ARR1987. It is acknowledged when the assessment was commenced that the new data and methodologies described in ARR2016 were not yet released, however they have now been officially available for almost 2 years and represent best practice data and approaches. The Flood Assessment identifies that the design discharges would likely be lower if ARR 2016 methodologies were adopted. Given the aim of the flood assessment is a relative comparison, this is a reasonable approach.

Section 4.3.3 notes that the storage exponent ‘X’ of 0.25 has been adopted, a suggested starting value is typically 0.75. Justification for the use of 0.25 should be provided.

In reference to Table 4.2, clarification is required as to why the PERN ‘n’ value adopted for BC01 and BC02 differs from the remainder of the sub-catchments.

The methods described in Section 4.3.4 Paragraph 2 are appropriate for determining the Probable Maximum Precipitation however further details of the calculations are required in order to confirm the application of the methods. Resulting values do appear to be reasonable and of the scale that would be expected.

In reference to Table 4.3, it is assumed that a range of durations have been assessed to determine the peak discharge and that appropriate durations have been selected for the smaller tributaries included in the Namoi River model. The critical durations for each design discharge and the method used to determine should be documented.

3.4. Section 5 Hydraulic modelling

Section 5.2 discusses the various aspects of the TUFLOW model development including topographic data. The 2000 ALS data has been used in the Flood Assessment in combination with a range of more recent topographic data.

The 2000 ALS data used in the 2003 Carrol to Boggabri Flood Study, has been shown to contain a 'tilt' across each aerial scan sweep. Given these issues it would be useful to see the areas where the various other more recent topographic datasets are applied and an indication of how well each dataset ties in to the surrounding data sets.

The Flood Assessment states that the 2000 ALS is the same data used in the 2003 Carrol to Boggabri Flood Study, while this statement is fundamentally valid, the issues with the 2000 ALS would be of more consequence with the use of that data within a 2D model than if utilised on a sampled cross section basis as applied in the 2003 Flood Study.

In addition, it is acknowledged that the topographic data has been validated against 188 natural surface survey points, additional validation checks are often undertaken to ensure that the selected grid resolution is able to appropriately represent the river and creek channel conveyance. The Flood Assessment does not refer to any additional checks. Typically, a simple cross section comparison may be provided to confirm the channel representation. More sophisticated methods such as conveyance comparisons or validation by alternative hydraulic models can also be used.

Section 5.2.2 notes that when the survey was captured approximately 22m^3/s was flowing down the river. The bathymetry below this level would not have been captured. The method applied to account for this is noted as, subtracting this volume from the main channel discharge. This volume is relatively minor in comparison to that which would flow during a relatively frequent 20% AEP flood (where approximately 500m^3/s would flow down the main channel). This method is considered to be simplistic and could lead to inaccuracies in the model calculated depths through these sections, particularly for smaller more frequent events. The method is however unlikely to significantly impact predictions for larger less frequent events (such as the 1% AEP flood) or significantly alter the outcomes of the impact assessment undertaken. It is worth noting that there are alternative adjustment techniques available to approximate the channel below the water line which would not have the same potential inaccuracies for frequent events.

Figures 5.1 and 5.2 show the TUFLOW model configurations. The configurations shown appear to be reasonable. In regard to inflow boundaries, it is assumed that inflows CC10 and DMG13 include all catchment discharge (CC01 – CC09 and DMG12 – DMG13) to that point and that the discharge is not representative of the local catchments for which the labels apply. The same query exists for VC02 and VC09 for catchments VC04, VC06, VC01 and VC03 (Figure 5.1) and BC03 and DD04 for catchments BC01, BC02, DD01 – DD03 and DD07 (Figure 5.2). This clarification should be provided in the text or on the figure. As noted earlier the source of inflow CoxsCk_US is not documented. Additional details would also benefit the reader in clarifying which systems have been included in the modelling. A later comment in Section 5.3 Paragraph 4 gives the reader the impression that some of these other smaller systems (noted by landholders) are not accounted for and included in the modelling. Collygra and Deadmans Creeks are included in the Namoi River model and could also be identified in Table 5.2.

Figure 5.1 would also benefit from adding labels to the included culverts so that they can be cross checked with Table 5.3.

It is noted in Section 5.2.3, that Manning's 'n' surface roughness values were adjusted to achieve a calibration fit, some additional clarification is required to indicate how much the values were adjusted. Additionally, is it reasonable to assume the low vegetation cover value adopted for crops is representative of the conditions in

both 1955 and 1998. Should a higher Manning's 'n' value for cropping be applied to design events, would the impacts of the Extension Project be substantially different. A sensitivity assessment where Manning's 'n' values are adjusted would typically be undertaken to demonstrate the sensitivity of the modelling outcomes to these assumptions.

A map showing the spatial distribution of these values has not been provided and therefore the appropriateness of application cannot be reviewed.

Section 5.2.4 discusses the development of the design event hydrographs based on the 1984 event extracted from the existing MIKE-11 model, this appears to be a reasonable approach. The text should discuss if any validation of the event hydrograph was undertaken prior to adopting from the MIKE-11 model.

The application of the normal depth outflow boundaries is an appropriate methodology.

Section 5.2.5 describes the inclusion of additional hydraulic features such as culverts and banks. The described method appears appropriate but some further clarification on which structures were modelled in 1D and which in 2D, in addition to how the levees and banks were included in the modelling should be provided.

A reason for the difference in modelled results versus recorded data is reported as differences in vegetation type at the time of the event. It is noted that the adopted value for cropping was considered to be low and an increase to this value is unlikely to lower modelled flood levels closer to those recorded.

A map showing the PMF extent for the Namoi Tributaries is not provided in the Flood Assessment.

3.5. Section 6 Flood impact assessment

Section 6.2.2 aims to describe the various components of the proposed rail spur, culverts, bridges, embankments in relation to the Draft FMP zones. It is difficult for the reader to determine the locations and sizing of the assumed structures. A map showing what assumptions have been made in the TUFLOW model in terms of structure sizing and placement, additionally including the FMP Zones, would greatly assist in clarifying this for the reader. In addition, the method to represent these structures within the TUFLOW model has not been described and can therefore not be reviewed for appropriateness. It is however understood from discussions with the proponent's flood assessment specialist consultant that layered flow constrictions have been applied, which would be an appropriate method for representing these structures within TUFLOW. The method used should be documented in the Flood Assessment, including any assumptions that have been made.

The impacts of realignment of Blue Vale Road are discussed in Section 6.2.3. The discussion notes that the proposed road has not been included in the proposed case modelling. It is not clear what the intent of the statement "is proposed to have the same flood immunity as the existing road" is. A comparison of the existing and proposed road locations should be provided, and an assessment of the potential impacts made. Suitable assumptions can be made and documented to allow an understanding of the potential impacts to be determined.

Section 6.2.4 references Figure 2.2, this figure does not exist within the Flood Assessment. This section also discusses the impacts of the Extension Project Borefield and Pipeline, it is not clear if the statement of impacts is based on modelling or opinion. This should be clarified.

The impacts of the Extension Project within the Namoi Tributary catchments of Stratford and South Creeks are described in Section 6.3. The discussion does not provide a comparison to all the components of the Draft FMP criteria that would apply to Zone C, including drainage times, flow redistribution and percentage changes to velocity. Further analysis and discussion should be provided.

Section 6.4 goes on to compare the impacts of the Extension Project Rail Spur against only some of the Draft FMP criteria. The Draft FMP velocity criteria is related to a percentage change in velocity and not an absolute change, the Flood Assessment does not show the velocity changes in terms of percentage. In addition, the

Draft FMP assessment criteria for flow redistribution is based on an overall and individual adjacent landholder criteria. Section 6.4.3 describes flow redistribution on an overall floodplain basis and does not quantify the change to individual properties. This information would be key to adjacent landholders and should be provided.

It is noted that the Flood Assessment indicates that the 5% AEP design event is representative of a large flood under the Draft FMP, it appears that for this section of the Namoi River catchment, that the 1984 event remains as the large design flood. It is acknowledged that they are of a similar magnitude however this should be clarified within the Flood Assessment.

Section 6.4.1 states that the impacts are generally confined to Whitehaven owned land, this statement should be explicitly clarified, with the exceptions identified.

The colour scheme used on Figures 6.2 – 6.10 is difficult for the reader to follow, particularly through the flood level reduction categories where a number of colours are very similar.

Section 6.4.4 states that the Extension Project does not impact on drainage times. Changes to drainage time is a criteria to be assessed under the Draft FMP. Hydrographs at various locations across the floodplain should be provided to support the statement made.

Section 6.4.5 discusses the cumulative impacts of the development and existing infrastructure. Cumulative assessment typically considers future development in addition to the proposed and existing development. The assessment described in this section does not appear appropriate. The assessment should ensure that currently approved but possibly not yet constructed floodplain works and developments are included in the assessment.

Section 6.5 sets out a discussion and reasoning behind not assessing the impacts of the Extension Project under a future climate scenario. While the points raised are somewhat reasonable, the SEARS (Table 2.1) sets out this requirement. Additionally, the uncertain nature of climate change and longevity of the Project make understanding the sensitivity of the impacts of the Extension Project in these uncertain future climate conditions essential.

3.6. Section 7 Summary of findings

Section 7 Paragraph 3, Sub Paragraph 3, dot point 2 is missing “value” in high infrastructure.

4. CONCLUSIONS

The *Vickery Extension Project – Flood Assessment, August 2018, WRM Water and Environment* and supporting data and materials as outlined in Section 2, have been peer reviewed considering the appropriateness of the methodology applied and the outcomes of the assessment undertaken. The peer review has determined that the assessment is generally undertaken in accordance with industry best practice but would be improved with additional detail reported on a range of aspects. Essential aspects include:

- Coincident flooding,
- Flood Frequency Analysis,
- PMP calculations,
- Calibration to RFFE,
- Rail spur hydraulic structure assumptions,
- Discussion of impacts against all FMP criteria,
- Cumulative assessment,
- Climate change assessment.

Further details regarding a range of other aspects would assist in improving reader understanding and improve confidence in the outcomes of the assessment. These aspects are discussed in the previous sections.