

ADDITIONAL CROSSING OF THE CLARENCE RIVER AT GRAFTON – EIS

Peer Review of Flooding and Hydrology Assessment



Looking north-easterly (downstream) from the lower deck of the existing bridge over the Clarence River at Grafton. The new bridge is planned to be located close to the existing bridge, about 70m away, in the direction of the photograph. The piers of the new structure will be aligned with the piers of the existing bridge to minimize navigational and hydraulic interference. Nevertheless the new bridge is predicted to increase flood levels upstream by some 6-8cm in a moderate flood. Accordingly it is proposed to raise the levels of the existing levees upstream by 20cm on both sides of the River to avoid increased flooding of the urban areas of Grafton and South Grafton.

5 December 2014

NSW Department of Planning & Environment

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Final Report

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1 INTRODUCTION

This peer review was commissioned in early August 2014.

1.1 Terms of Reference

The DP&E's terms of reference for the review are reproduced in **Attachment B**. These required an independent peer review of the flooding and hydrological aspects of the Project presented in the Environmental Impact Statement (EIS) and the Submissions Report (SP).

The DP&E requested a 'Preliminary Review' within two weeks of commencement which gave initial consideration to the assessment of hydrology and flooding issues in the EIS and provided comment on the technical adequacy and completeness of these assessment and identified whether additional information was required to address gaps in the hydrological and flooding assessment. This preliminary review was provided to the DP&E on 24 August 2014.

The second and more substantive phase of the review then commenced. This required the reviewer to:

- (a) consolidate the findings of the Preliminary Review including feedback from the DP&E and RMS;
- (b) review the appropriateness and effectiveness of management and mitigation measures recommended for the Project, taking into account relevant guidelines, industry best practice and research or monitoring evidence (preferably published);
- (c) review agency comments on the hydrological impact assessment;
- (d) review the RMS reports submitted following exhibition (in this case the Submissions Report);
- (e) prepare a report on the findings of the Review, including:
 - adequacy and completeness of the hydrological and flooding impacts assessment;
 - compliance of the Project with applicable legislation and guidelines;
 - adequacy and appropriateness of the management and mitigation measures recommended for the Project; and
 - recommended actions and conditions of approval that could be applied to avoid, minimise, mitigate, and/or manage the residual flooding impacts (should the Department recommend approval of the Project).

1.2 Documents Reviewed and Activities Undertaken

The documents that were reviewed are listed in **Attachment A**.

The focus of the terms of reference was on the following key documents:

- (a) the EIS including the *Technical Paper: Flooding and Hydrology Assessment*¹ within which the bulk of the hydrological and flooding assessments are reported; and
- (b) the Submissions Report which included submissions received and RMS's response to these submissions.²

During the review, two site visits were undertaken. This included visits to the existing and proposed bridge locations and a limited inspection of the Grafton levee system.

The reviewer also attended an information session that RMS held for landholders with flooding concerns. This was held on 16 September 2014 and the reviewer attended as an observer.

The reviewer also held meetings and discussions with the following:

- (a) State Emergency Service Regional Office, Grafton;
- (b) Water Floodplain & Coast (North East) Regional Operations Group, Office of Environment & Heritage (OEH);
- (c) Clarence Valley Council; and
- (d) BMT WBM, Brisbane.

1.3 Principal Issues for this Review

Having regard to the terms of reference, the reviewer's assessment of key flooding and hydrological issues associated with the Project, and the various submissions that have been received, a number of key issues have been identified. These are listed below under **Sections 1.3.1** and **1.3.2**.

The reviewer's consideration of each of these issues is provided in **Sections 2** and **3** below.

The issues have been divided into those associated with the quantification and assessment of the Impact, and those relating to the proposed mitigation measures, as listed below:

1.3.1 Quantification and Assessment of Flood Impact (**Section 2**)

- overall adequacy of the information provided and the methodology applied (**Section 2.1**);
- consistency with the Director General's Requirements, relevant legislation, published material and industry best practice (**Section 2.2**);
- veracity of the flood modelling (**Section 2.3**);
- assessment of changed flood behaviour caused by the new bridge over a range of flood events (**Section 2.4**);
- potential for increased flood levels downstream of the new bridge (**Section 2.5**); and
- impacts on emergency management during floods (**Section 2.6**).

¹ Refer Document A10 listed in **Attachment A**.

² The 'response to submissions' prepared by Clarence Valley Council and submitted after the Submissions Report was issued, was also reviewed. (Refer Document A19 listed in **Attachment A**).

1.3.2 Proposed Mitigation Measures to Address Flood Impact (**Section 3**)

- clarity over scope of mitigation measures and their maintenance (**Section 3.1**);
- staging of mitigation work (**Section 3.2**);
- sedimentation and erosion mitigation (**Section 3.3**);
- lost opportunity to implement broader flood mitigation scheme (**Section 3.4**);
- constructability of proposed levee raising (**Section 3.5**);
- mitigation for areas not protected by raised levees (**Section 3.6**);
- drainage measures behind levees including Pound Street pumps and basin (**Section 3.7**).

In the event that the DP&E recommends approval of the Project, draft conditions of approval have been prepared and are presented in **Attachment C** for DP&E's consideration.

2 QUANTIFICATION AND ASSESSMENT OF FLOOD IMPACTS

2.1 Overall Adequacy of Information and Assessment Approach

The flooding and hydrology aspects of the Project have been investigated using the Lower Clarence River Flood Model that was originally developed and calibrated as part of Clarence Valley Council's flood studies and floodplain risk management studies that have been undertaken over the last decade.

More recently Council has commissioned very detailed flood model assessments of the overtopping of Grafton's and South Grafton's levees that will occur during moderate flooding of the Clarence River.³ The EIS Project team has benefitted by having direct access to this model. A number of improvements to the model structure and to the topographic data used in the model have also been made since the modelling undertaken for RMS' assessment of the route options.

It is the reviewer's opinion that overall, the base data and the approach to computer modelling which have been adopted in the EIS, are of a good standard and appropriate to the requirements of the Project. These tools are the best available for assessment of flood impacts in Grafton and South Grafton and the adjacent floodplains of the Clarence River.

Whilst there are no major deficiencies with the modelling approach or the underlying model data for the purposes of the EIS, the absence of a feasibility study for the proposed levee raising and the absence of a dwelling survey has hindered proper assessment of some of the proposed mitigation measures within the EIS.

If the DP&E recommend approval of the Project, the review has identified some improvements to the modelling approach and the underlying data that need to be undertaken prior to detailed design and construction.

³ Refer documents A6 and A9 listed in **Attachment A**

2.2 Consistency with Assessment Requirements including DGEARs

The Director General's Environmental Assessment Requirements (DGEARs) were issued for the Project on 3 October 2013 and contain six specific matters related to flooding and hydrology. These comprised:

- changes in flood regime;
- consistency with relevant floodplain risk management plans (FRMPs);
- impacts to existing and future receivers and infrastructure;
- identification of potential impacts to bed and banks stability and velocity distributions;
- assessment of any proposed mitigation measures; and
- assessment of climate change impacts.

With the exception of the second item relating to consistency with any FRMPs (refer paragraphs 3.4(a) and 3.4(b) below) all of these requirements have been addressed in the EIS documentation, and consistency with the DGEARs has been demonstrated in the EIS.

However there is no discussion about the quantum of flood level rise that might be considered acceptable for the Project, as is the usual practice when assessing major road projects that cross floodplains. The unstated approach for the current project appears to be one of 'minimisation' of impacts.⁴ Nevertheless if the Project proceeds to detailed design and construction, there will need to be quantitative standards developed to guide the design process, particularly as it appears the two principal flood mitigation measures that have been proposed, i.e.:

- Option '2' levee raising); and
- house raising of dwellings located outside the levees,

are only preliminary concepts at this stage.

2.3 Veracity of Flood Modelling

WMAwater were engaged by RMS to conduct an independent assessment of the flood modelling undertaken for the Project.⁵ This included some community engagement and consultation.

WMAwater's overall conclusion was that the flood model was suitable for assessing the flood impacts of the Project. Whilst they identified minor issues in the model, these did not impact on its ability to be used during the EIS. A list of recommended improvements was identified for future stages of the Project.

The key outcomes of this work including recommendations for the future use of the model were as follows:⁶

- the flood model will benefit from refinement including an update of its eddy viscosity approach;

⁴ One general requirement of the DGEARs was to include measures to "avoid, minimise and if necessary, offset the predicted impacts ..."

⁵ WMAwater's report appears as Appendix A in the Submissions Report (refer document A17).

⁶ Various matters identified by WMAwater and subsequently addressed by BMT WBM prior to finalisation of the EIS, have not been listed here.

- during detailed design, further survey needs to be undertaken of the riverbed to inform the bridge design. This new survey is to be compared with that currently used in the flood model and the model updated if required;
- prior to any design of flood mitigation works, verification of the assessed afflux of the bridge using HEC-RAS should be undertaken using the procedure outlined by WMAwater;
- the modelling procedure which uses a form loss as well as a constriction to the flow width of the model cells at the bridge crossing, should be revised to obtain the most accurate representation of the bridge afflux in the model;
- WMAwater recommended that if houses are to be raised as part of any property modification measures, these should be raised to the 100 year ARI flood level plus 0.5m freeboard. (The reviewer suggests that this level should also allow for climate change, consistent with the approach to climate change presented in the EIS and Submissions Report);⁷
- detailed floor level survey of the affected properties needs to be undertaken during detailed design;
- during detailed design, consideration should be given to updating the flood hydrology. This could include updating the flood frequency analysis and application of the latest hydrologic practice following release of the new Australian Rainfall and Run-off publication;
- the incorrect reporting of the current 'extreme' event as a probable maximum flood (PMF) event should be rectified in future stages of the Project.⁸

2.4 Assessment of Changed Flood Behaviour

Because of the extensive levees that have been constructed within Grafton and South Grafton, small changes in the river level can produce significantly higher changes in water levels behind the levees. The maximum height to which the level rises behind the levees is a function not only of the river level but also the duration of levee overtopping. Consequently the shape as well as the peak level of the flood hydrograph in the river influences the depth and extent of ponding behind the levees. The flood model used in the EIS accounts for these hydrodynamic influences.⁹

The changed flood behaviour resulting from construction of the new bridge, has been determined by estimating the local rise in flood level immediately at the bridge¹⁰ and then using the flood model to assess the extent to which this change propagates upstream and downstream from the new structure. The reviewer agrees with WMAwater's assessment that this is an appropriate methodology from which to determine the changed flood behaviour, both inside and outside the levees, and both upstream and downstream from the new bridge.

The resultant increases in river levels immediately upstream of the new bridge are estimated to range from 6cm to 8cm.¹¹ If unmitigated, maximum flood level rises of 8cm and 67cm

⁷ Refer ID CC1 in Table 4-1 'Summary of revised environmental management measures' of the Submissions Report

⁸ In the opinion of the reviewer, this is unlikely to have any material impact on the adequacy of the flood assessment reported in the EIS and it is a matter that can be rectified in future stages of the project.

⁹ However, the reviewer notes that variations in hydrograph shape have not been considered in the EIS modelling but has been suggested as a potential future improvement to the modelling approach.

¹⁰ This local rise in flood level has been calculated using the procedures set out in the 1978 publication listed in document A1, which have been derived from physical measurements of different pier and pile configurations.

¹¹ At the location of the existing bridge – refer Table 4-2 of document A13.

would occur behind the Grafton and South Grafton levees, respectively, during a 50 year design flood event. The modelling analyses show that the largest impacts occur during the 50 year event noting that during a 20 year flood or smaller event, there is no significant overtopping of either the Grafton or South Grafton levees. Further during events bigger than the 50 year flood, such as the 100 year flood, significant overtopping is otherwise occurring and consequently the impact of the bridge on flood levels behind the levees is somewhat reduced.

The EIS proposes to mitigate flood level rises behind the levees by increasing the height of the existing levees (as per 'Option 2'). Since levees were first constructed over 50 years ago, levee raising has been a very contentious issue in Grafton and South Grafton (and elsewhere within the Clarence River floodplains). Increasing the height of a levee reduces the storage of floodwaters on the floodplain behind the levee, leaving additional floodwaters within the River channel which can exacerbate inundation on the opposite side of the River as well as in downstream areas. Consequently the raising of the Grafton and South Grafton levees to compensate for the increased river level caused by the new bridge, can be problematic if the levees are raised too high.

Given the past history, any levee modifications will likely be contentious.

2.5 Potential for Increased Flood Levels Downstream

The reviewer understands that concerns have been raised that the new bridge will aggravate flood behaviour downstream and raise levels.

Theoretically, if the bridge was constructed and the upstream levees were not raised, additional overtopping of areas behind the levees would occur, and consequently, the flood levels downstream of the bridge would reduce by a small amount. Further, if the proposed levee raising occurred to a height greater than the bridge afflux, more floodwaters would be confined to the river channel and downstream flood levels would rise by small amount.

Given that the rises in river levels caused by the bridge are quite small (i.e. maximum 6cm–8cm), the reviewer estimates the consequential impact downstream to be much smaller, irrespective of whether the levees were raised or not. As mentioned in the previous paragraph, there would be a potential concern for downstream landholders if the upstream levees were raised to a height much more than the bridge afflux. Nevertheless the modelling undertaken to date, which the reviewer understands assumed the levees were raised 20cm, has identified no significant increases downstream.¹²

Because of these concerns, and if the Project is approved, the levee raising proposal will need to ensure a neutral outcome for the whole floodplain both upstream and downstream of the new bridge.

¹² Refer Figures 5-10, 5-11, 5-12 and 5-13 of document A13 which all show the change to be between -3cm and +3cm, for the 20 year, 50 year, 100 year and PMF design floods. The reviewer considers this reported range to be too coarse to address all concerns of downstream owners. Nevertheless the reviewer anticipates the actual impacts to be much smaller than that suggested by the range that has been adopted for reporting the model results. Further, note that the 20cm levee raising that has been used for these model runs would be more than double the bridge afflux.

2.6 Impacts on Emergency Management

Council's 2007 *Grafton & Lower Clarence Floodplain Risk Management Plan* (refer document A4) identified very significant emergency management issues associated with the evacuation of Grafton during an extreme flood. Concerns were raised that if, for whatever reason, the population failed to fully evacuate, there could be a serious loss of life within Grafton once major overtopping of the levees occurred. A contributing factor was the lack of capacity for the population to evacuate Grafton via the existing bridge, particularly if a breakdown occurred or vehicle movements were otherwise restricted. As identified in the EIS, the new bridge should increase the egress capacity and consequently reduce the time taken to evacuate Grafton.

When flood evacuation is a concern, it is a normal procedure to carry out an evacuation capability assessment (ECA) in order to assess the evacuation risks. Based on his discussions with the SES, the reviewer understands that an ECA has not yet been completed for Grafton although work on the preparation of an ECA was initiated a few years ago but not completed. Therefore the current risks to the population of Grafton during a major flood emergency have still not been properly quantified and the potential emergency management benefits of the new bridge aren't properly understood. In the opinion of the reviewer these benefits could potentially be very significant.

Because the risk to life issue is so important for Grafton, the reviewer considers that the detailed design phase of the Project (if approved) should seek to maximise the emergency management benefits of the new crossing in a major flood. This will likely necessitate the active involvement of the SES in this phase of the Project including their provision of an upgraded Flood Plan for Grafton that includes the new bridge.

3 PROPOSED MITIGATION MEASURES

3.1 Scope of Mitigation Measures to Address the Bridge Afflux

To offset the increased flooding that will result from the rise in river levels upstream of the new bridge, the Project includes 'Mitigation Option 2' which comprises:

- 3.7km of raised levee on the northern side of the river; and
- 7km of raised levee on the southern side of the river.

There are only limited details of the proposed levee raising. In terms of the documentation in Appendix E of the EIS, this recommends either Option 2 or 4 as being suitable and the components of these options are only addressed in a cursory fashion.

The EIS documentation is not entirely clear about the height of the raising, referring in some places to the levees being raised by "0.2m" in other places to "up to 0.2m". Unless there is concurrence between RMS and Council on an alternative mitigation proposal then, as discussed in Section 2.5, it is the reviewer's opinion that the raising height should be selected to achieve a neutral outcome for all areas upstream and downstream of the bridge. Noting that the river level rise will be some 6cm-8cm adjacent to the existing bridge and then diminishes upstream, raising the proposed levee lengths, i.e. 3.7km (north bank) and 7km (south bank), on both sides of the river by 0.2m may not be appropriate as this height is

more than double the rise in level caused by the new bridge. Consequently this will require further consideration during detailed design.

The reviewer understands the mitigated flood level impacts reported in the EIS for Option 2 have been determined assuming a levee raising of 0.2m. If reduced raising is proposed, these impacts will need to be reassessed.¹³

The crest level of the existing levees is not uniform and includes considerable variability in height.¹⁴ Consequently the proposed level raising will need to consider whether it will 'smooth out' any irregularities which may be a practical response to the current situation and may assist in long-term maintenance of the levees (supposedly by the Council). Nevertheless this might have some localised flood impacts to areas immediately behind the levee.

The practicality of constructing the levee raising is discussed further in **Section 3.5** below.

3.2 Staging of Mitigation Work

The EIS and Submissions Report make it clear that the levee raising work will need to have been completed before construction work within the river begins. This is because the new piers result in an afflux and therefore, once they are constructed, the risk of additional flooding upstream arises.

Special consideration will be required during construction relating to equipment and structures placed within the river due to the flood risks. This equipment and structures have the potential to alter flood behaviour and/or be washed away and become flood debris downstream.

3.3 Sedimentation and Erosion Mitigation Measures

In the reviewer's opinion, the potential changes in river velocities near the new bridge and the proposed scour protection measures, have been adequately addressed in the EIS and the Submissions Report, consistent with the DGEARs.

3.4 Opportunity to Implement Broader Flood Mitigation Schemes

Grafton and South Grafton are exposed to significant flood risks in terms of property damage and personal safety. Floodplain risk management is a key responsibility of the Council under the NSW Floodplain Development Manual. The Manual also places responsibilities on state agencies such as RMS when undertaking projects in the floodplain.

Concerns have been raised during submissions that the proposed flood mitigation for the Project should be coordinated with the Council, and where appropriate, an alternative scheme that might better meet the broader flood mitigation objectives for local communities should be undertaken. For example it has been suggested that:

¹³ The impacts, particularly downstream, need to be reported in finer detail than has occurred in the EIS. (Refer comments in Footnote 12).

¹⁴ The reviewer understands local variations of ± 0.2 to ± 0.3 m are frequent with larger increases in some places. Refer Figures 2-1 and 2-3 of document A9.

- there is an obligation to provide flood immunity for a 100 year flood event;¹⁵
- the design of any levee augmentation work should be undertaken in consultation with the Council to ensure that the work is aligned with future flood mitigation proposals where these are being considered by Council;¹⁶
- the design of any levee augmentation work should not preclude or negatively impact the viability of Council's future flood risk mitigation actions;¹⁶
- detailed investigation of a potential flood bypass near Junction Hill is warranted before selecting a preferred flood mitigation option for the Project;¹⁷ and
- the Project should provide the opportunity to address inconsistencies and inequalities within the South Grafton levee system.¹⁸

Within the Submissions Report RMS have generally responded to these concerns by stating that they have no formal flood mitigation responsibilities apart from addressing the direct impact of the Project.

In responding to these issues, the reviewer suggests DP&E consider the following when providing their response to the Project and the position which RMS has taken:

- (a) the DGEARs require consistency with relevant floodplain risk management plans (FRMPs). The only such FRMP was prepared for Council in 2007 (refer document A4).¹⁹ This FRMP makes various recommendations for Grafton and South Grafton which may be relevant to the current project. These include:
 - (i) undertaking a property survey;
 - (ii) evaluation of voluntary house purchase and voluntary house raising schemes;
 - (iii) regular maintenance of the existing levee system, including minor adjustments for damage or settlement to ensure consistency with original design plans;
 - (iv) completion of outstanding maintenance issues identified in the 2004 levee audit. In particular the FRMP noted that more detailed investigations will be required if significant levee augmentation schemes are subsequently proposed, including geotechnical assessments, preliminary designs, floor level survey, economic assessments, environmental review and identification of community views;
 - (v) preparation of a flood evacuation capability assessment to determine the requirements and capability of the SES to safely evacuate residents from Grafton having consideration to the affected population, warning times, flood behaviour, available evacuation routes, and the potential for catastrophic levee failure; and
 - (vi) improved community awareness of the risk of flooding and particularly the need to evacuate the town prior to levees overtopping.
- (b) In order to ensure consistency with the FRMP, and in response to items (i) through (vi) listed above:
 - (i) a property survey (including floor levels, number of storeys and building construction type) should be undertaken for all dwellings and other significant buildings, where the rise in flood level or changed flood behaviour is of concern. (It appears RMS has already proposed to undertake this);²⁰

¹⁵ Item 2.5.15 of the Submissions Report.

¹⁶ Item 2.5.13 of the Submissions Report.

¹⁷ Item 2.5.12 of the Submissions Report.

¹⁸ Items 2.5.9, 2.5.10 and 2.5.11 of the Submissions Report.

¹⁹ The reviewer understands this plan is currently being modified in respect to its recommendations for Brushgrove but these changes will not alter its findings for Grafton or South Grafton.

²⁰ Refer ID FH4 in Table 4-1 'Summary of revised environmental management measures' of the Submissions Report.

- (ii) the proposed house raising of affected dwellings outside the levee needs to be closely coordinated with Council. If severely flood affected dwellings are identified, these may need to be acquired.²¹ Further as noted in **Section 2.3** of this review, the dwellings will need to be raised to a minimum of the 100 year flood level plus 0.5m freeboard, allowing for climate change;
 - (iii) the levee raising will need to be undertaken in a manner which minimises maintenance and addresses the present inconsistencies in levee crest levels. Further, RMS should have regard to the original levee crest levels when raising levees. This will need to be coordinated with Council;
 - (iv) it will be necessary to ensure the structural integrity of the raised levees including for provision of appropriate stability during overtopping in major events. See further comments under **Section 3.5** below;
 - (v) the SES should be requested to prepare a flood evacuation capability assessment (ECA) and to provide input into the design of the Project to ensure that all residents of Grafton can be safely evacuated in any flood event. In the reviewer's opinion, it would be inappropriate to leave the SES' assessment, including any consideration of upgrading the SES' Flood Plan, until after the design and construction of the Project is completed;
 - (vi) a component of the community consultation conducted for the Project should comprise improved community awareness of the risk of flooding and the need to evacuate the town prior to its levees overtopping.
- (c) Having regard to consideration of other broader and more major flood mitigation schemes (e.g. the bypass of floodwaters around the northern side of Grafton) it is the reviewer's opinion that the RMS project should not preclude or negatively impact the viability of such schemes. Nevertheless such schemes need to have been adopted by Council following a proper process of documentation and evaluation. Apart from the measures contained within the 2007 Floodplain Risk Management Plan referred to above, the reviewer is unaware of other proposals that have been adopted by Council (or have been seriously evaluated and reached a stage where 'adoption' was imminent). In the reviewer's opinion it would be unreasonable to require the RMS to undertake investigations of these potential schemes for Council in order to comply with this requirement.

3.5 Constructability of Proposed Levee Raising

There are a number of practical construction issues associated with RMS' proposal to raise 3.7km of existing levees in Grafton and 7km of existing levees in South Grafton. These issues are listed below with the potential implications for the Project included in brackets:

- varied land ownership including numerous small holdings. (Consequently consultation with a large number of owners may be required. Acquisition of additional land or widening of existing easements may be required in order to facilitate the construction and maintenance of the proposed works);
- lack of easements. (To facilitate construction and maintenance of the raised levees, there may be a need for RMS to acquire easements and alter the terms of some existing easements where these do not permit the proposed raising/maintenance);
- variable construction types including earthen embankments, roadways, concrete walls, walls of buildings, etc. (Where the levee forms part of existing structures,

²¹ If required, such acquisitions will likely be few noting Council's FRMP identified that "no major voluntary purchase schemes appear to be warranted within the Clarence Valley" (Section 6.1.5 of document A4).

additional consideration will need to be given to the environmental impact of the proposed works on these existing structures);

- inadequate side slopes on earthen levees. (In these circumstances, additional land acquisition/easements to provide for a widened base may be required);
- unknown and potentially inadequate geotechnical stability of the levees. (This may necessitate demolition and reconstruction of the levee);
- unknown foundation conditions of earthen, concrete and masonry structures. (This may necessitate demolition and reconstruction of the levee);
- inconsistent levee heights as noted in paragraph 3.4(b)(iii) above. (This will likely require re-establishment of a uniform levee crest level); and
- unknown or inadequate stability of levee during overtopping. (This will likely require levee strengthening and/or armouring of the crest and downstream slopes of the levee).

Item 2.5.16 of the Submissions Report notes that *"a team of geotechnical engineers visually inspected the levee and examined levee information provided by Clarence Valley Council on the state and extent of the existing levee system. As a result of these investigations, Roads and Maritime acknowledges the logistical constraints associated with the raising of the levee and will design the levee upgrade taking these constraints into consideration"*. Despite this statement, there is insufficient information in the EIS and Submissions Report to provide confidence that the above issues can be addressed.

The reviewer suggests that RMS be requested to provide further information to confirm the practicality of raising the Grafton and South Grafton levees, given the matters listed above.

3.6 Mitigation for Areas not Protected by Levees

The EIS and submissions report lacks any detailed consideration of the impacts of the levee on agricultural activities in areas of the floodplain that are not protected by levees. However the changes in flood level on rural lands are very small and are unlikely to have any significant impact on agricultural activities. Nevertheless the reviewer considers it appropriate that prior to detailed design, standards be developed for agricultural land to ensure that unacceptable impacts do not occur.

With the implementation of 'Option 2', the EIS reports that there will be some 45 properties affected by residual impacts. These are generally located outside the area protected by the levee with a large number on Carrs Island and Carrs Peninsular. Whilst it is not stated in the EIS, the reviewer presumes these properties have been identified because they contain a dwelling or significant building. The flood level increases are in the range from 3cm to 10cm for all modelled events.

Given the limited opportunities to flood proof these buildings, the most practical means to offset the increased flood level will be through house raising, acquisition or payment of compensation. The absence of flood level surveys and other property information (refer paragraph 3.4(b)(i) above) makes it difficult to estimate the extent of activities that will be needed to mitigate the increased flood level to these properties.

As many dwellings on Carrs Island/Peninsular have already been raised in past decades (as a consequence of previous levee raisings), their current structural configuration may facilitate further raising.

Further, in cases where dwellings are incapable of being raised, or for whatever reason it is inappropriate to raise dwellings (e.g. stairs for elderly residents), there will need to be an undertaking from RMS to negotiate an outcome with the affected residents which might potentially include monetary compensation.

Prior to commencement of detailed design, it will be important that standards be developed to guide this mitigation work. These standards will need to specify the minimum flood level increase for which RMS will undertake mitigation measures.

3.7 Drainage Measures behind Levees

Drainage measures are proposed within the levee area of Grafton and South Grafton, on both the southern and northern approaches to the new bridge, respectively. The reviewer understands that the 20 year ARI flood immunity standard is to be adopted for these road approaches. Given the importance of the new bridge to improving the evacuation of Grafton during a major flood, it is important that this flood immunity standard is not progressively eroded due to the impacts of climate change. Accordingly during detailed design, the flood immunity standard of the relevant drainage measures will need to be confirmed at the 20 year flood level allowing for climate change.

At the Pound Street viaduct, it is proposed to provide pumps, a detention basin and improved gravity drainage to ensure the specified flood immunity standard is achieved. The reviewer notes that whilst these works will be constructed by the Project, ongoing operation and maintenance will likely be by Council. The Submissions Report notes the need for close liaison with Council during the design of these works to ensure that they can be satisfactorily operated and maintained by Council over the long term. In addition the reviewer notes the commitment by the Project to provide a backup generator(s) for continued operation of the pumps during electrical power outages.

During detailed design it will also be necessary to prepare a drainage strategy for the areas adjacent to the southern and northern approaches to ensure that the roadworks do not cause third party impacts.

4 SUMMARY AND CONCLUSIONS

- (a) The computerised flood modelling utilised in the EIS has been based on the latest Council model which includes detailed simulation of the overtopping of the Grafton and South Grafton levees. The underlying data and the modelling approach adopted in the EIS are of a good standard and are appropriate for the requirements of the EIS. Improvements to the model and its underlying data have been identified for future stages of the Project should the Department recommend approval.
- (b) One of the Director General's Environmental Assessment Requirements (DGEARs) required consistency with the Council's floodplain risk management plan (FRMP). This FRMP was developed by Council in 2007 and identified a number of matters relating to levees, house raising and emergency management that could potentially impact the Project. The issue of consistency with these details within the FRMP does not appear to have been explicitly addressed in the EIS.

- (c) The new bridge will raise flood levels immediately upstream by 6cm-8cm, and this increased level will progressively diminish in an upstream direction. RMS proposes to mitigate this impact on the Grafton and South Grafton communities inside the levees, by raising the levees. The modelling undertaken to date has assumed raising of the levees by 20cm over distances of 3.7km (north side) and 7km (south side). This assumed increase in levee heights is more than double the afflux to be caused by the new bridge and the reviewer recommends that during detailed design, the proposed height of the levee raising be refined to ensure a neutral impact on those protected by the levees and those located on the floodplain downstream of the new bridge.
- (d) As the increased river levels will result largely from the piers and piles used to support the new bridge, the proposed mitigation measures will need to be implemented before the pier/pile construction which will likely occur early in the construction sequence. Further there will need to be a thorough construction flood risk assessment undertaken once the construction activities are known, to ensure upstream and downstream areas of the floodplain are not impacted by a flood during the construction.
- (e) There are a number of practical construction issues associated with the proposed levee raising. These are related to the various construction types, uneven levee crests, reliance on existing buildings, unknown structural and geotechnical stability and different landownership requirements. These will likely be problematic and potentially expensive for RMS to resolve. There are insufficient details within the EIS and Submissions Report of how these matters are to be resolved. The reviewer recommends that the necessary engineering and property investigations be undertaken as soon as possible to ensure that if the project is recommended for approval, there can be confidence that the proposed levee raising can be undertaken and that any secondary environmental impacts of these works are acceptable or can be successfully mitigated.
- (f) The EIS identifies about 50 properties that will be affected outside the levees. These properties supposedly have houses or significant buildings that are impacted and mitigation measures (principally house raising) are proposed. Again this mitigation option has not been investigated in any detail and lacks the necessary property survey to identify on a property-by-property basis, the measures that are to be implemented. The reviewer recommends that this survey together with an assessment of the viability of house raising (or acquisition or other measures) be undertaken as soon as possible. Any house raising/acquisition proposals will also need to be consistent with Council's FRMP.
- (g) There is potential for the Project to significantly reduce the evacuation risks for the population of Grafton during a major flood. There has not been a thorough evacuation capability assessment (ECA) carried out by the SES for the existing situation or for the improvements that could result if the project was implemented. Whilst there is little doubt that the new bridge will provide an improvement, given the serious risk to life issues which currently exist, it is the reviewer's opinion that the new bridge and its approaches need to be designed so that any opportunities to maximise the flood evacuation benefits to Grafton are not overlooked through lack of planning. Accordingly the SES should be requested to investigate the flood evacuation and traffic management arrangements for the new bridge so that they can provide input into the design of the bridge (if approved). This should include preparations of 'before' and 'after' ECAs.
- (h) Suitable standards relating to the allowable flood rise on individual properties should be developed. These would trigger the need for any proposed mitigation measures and would also guide negotiations with property owners.

- (i) During the detailed design phase, a comprehensive drainage study should to be undertaken all the works inside the levees to ensure there are no unacceptable impacts on third parties or existing infrastructure.
- (j) Flood immunity standards for house raising (i.e. minimum 100 year flood level plus 0.5m freeboard) and the new road approaches (i.e. minimum 20 year ARI flood level) should be determined after allowing for climate change.
- (k) Draft conditions relating to hydrology and flooding issues have been included in **Attachment C** for consideration by the Department.

ATTACHMENT A

DOCUMENTS REVIEWED

Documents Reviewed

These documents were provided by DP&E, RMS or BMT WBM during the course of the review, or were already in the reviewer's possession. The documents are listed in chronological order.

- A1. *Hydraulics of Bridge Waterways*. Prepared by the Hydraulic Branch, Bridge Division. Office of Engineering and Operations. Bureau of Public Roads. US Department of Transportation. Second Edition 1970 including March 1978 revision.
- A2. *RTA's Water Policy*. (Undated).
- A3. *RTA Code of Practice for Water Management. Road Development and Management*. April 1999.
- A4. *Grafton and Lower Clarence Floodplain Risk Management Plan*. Volume 1 – Main Report. Prepared for Clarence Valley Council by Bewsher Consulting Pty Ltd. June 2007.
- A5. *RTA Supplement to Austroads Guide to Road Design. Part 5 (2008): Drainage Design*. RTA/Pub: 11.096. 3 March 2011.
- A6. *Lower Clarence Flood Model Update 2013*. Prepared for Clarence Valley Council by BMT WBM. September 2013.
- A7. Director General's Requirements. Issued 3 October 2013.
- A8. *Grafton, South Grafton and Maclean. Emergency Management Report*. Prepared for Clarence Valley Council by BMT WBM. February 2014.
- A9. *Grafton and Maclean Levee. Overtopping Study – Phase 2: Technical Report*. Prepared for Clarence Valley Council by BMT WBM. February 2014.
- A10. *Appendix E – Technical Paper: Flooding and hydrology assessment*. (Confidential Draft. Dated June 2014 inside front cover). Prepared for RMS by BMT WBM. July 2014.
- A11. *Preliminary Drawings. Additional Crossing Clarence River. Volume 2 – New Grafton Bridge And Pound Street Viaduct Replacement – 80% Concept Design*. Prepared by ARUP. Issue 0. 4 July 2014.
- A12. *Environmental Impact Statement. Additional Crossing of the Clarence River at Grafton*. (Draft for Adequacy Review). Prepared for RMS by Arup Pty Ltd. July 2014.
- A13. *Appendix E – Technical Paper: Flooding and hydrology assessment*. (Final version). Prepared for RMS by BMT WBM. August 2014.
- A14. *Environmental Impact Statement. Additional Crossing of the Clarence River at Grafton*. (Final version). Prepared for RMS by Arup Pty Ltd. August 2014.
- A15. *Additional Crossing of the Clarence River at Grafton – Responses to independent hydrological review by Bewsher*. This was an email response provided by RMS to

DP&E on 1 October 2014 in response to some preliminary review comments made by the reviewer in his letter to DP&E of 24 August 2014.

- A16. Copies of submissions provided to the reviewer by DP&E on 26 September 2014. These comprised 16 submissions made by the general public during the EIS exhibition period and one submission (No. 17) that was received after the close of the exhibition period on 19 September 2014. These included redacted submissions from those who requested confidentiality or were submitted to the DP&E by a third party.
- A17. *Submissions Report. Additional Crossing of the Clarence River at Grafton.* Prepared for NSW Roads and Maritime Services by Arup Pty Ltd. October 2014.
- A18. Additional information provided by BMT WBM following a meeting with the reviewer held on 30 October 2014. This information comprised:
- a. maps showing sensitivity of impacts to an intermediate event between a Q20 and Q50 flood;
 - b. map showing sensitivity of impacts to a starting water level in South Grafton Common; and
 - c. extract from spreadsheet which calculates the K_p value used as the form (energy) loss parameter in TUFLOW to assess the afflux of the new bridge.
- A19. *Response to submissions for Additional Crossing of the Clarence River at Grafton (SSI 6103).* Letter from Clarence Valley Council to DP&E. 21 November 2014.

ATTACHMENT B

**TERMS OF REFERENCE
FOR THIS PEER REVIEW**

Request for Services

Date	11 July 2014
Requestor	Michael Young
Contact Phone Number	02 9228 6437
Contact Email	michael.young@planning.nsw.gov.au
Project Name	Additional Crossing of the Clarence River Project at Grafton SSI-6103 – Independent Hydrological Review
Contractor Company	Bewsher Consulting Pty Ltd
Specified Personnel	Drew Bewsher
Service Start Date	Immediately or as agreed with the contractor
Service End Date	28 November 2014 or as agreed with the contractor

Background

The applicant, Roads and Maritime Services, has submitted an application for the Additional Crossing of the Clarence River at Grafton project as State Significant Infrastructure under Part 5.1 of the *Environmental Planning and Assessment Act 1979*.

The main components of the Additional Crossing of the Clarence River at Grafton project comprises the building of a new bridge about 70 metres downstream of the existing bridge (which would be retained) and upgrading parts of the road network in Grafton and South Grafton to connect the new bridge to the existing road network. The project would also include ancillary works, structures and facilities required for the purposes of the project. The proposed bridge would be about 450 metres long and 16 metres wide, and would be on a constant 4500 – metre radius over the Clarence River. The bridge deck would have one northbound lane and one southbound lane for vehicles and a shared path (for pedestrians and cyclists) about 3.1 metres wide on the western side that would connect to the Pacific Highway at Iolanth Street in South Grafton and to Pound Street in Grafton. The existing bridge would be retained with one northbound lane and one southbound lane.

The department issued environmental assessment requirements for the project on 3 October 2013. The environmental assessment requirements identify hydrological impact assessment as one of the key environmental issues associated with the proposal. The department seeks independent advice as to the technical adequacy of the applicant's assessment of hydrological impacts; the appropriateness and effectiveness of management and mitigation measures the applicant has recommended for the project; and recommended conditions should the department recommend approval of the project.

The RMS is currently finalising preparation of the Environmental Impact Statement (EIS), and has indicated it expects to lodge the draft EIS with the Department in late July 2014.

Tasks

The department requires an independent peer review of the hydrological impact assessment of the Additional Crossing of the Clarence River at Grafton proposal. The independent review shall:

1. Preliminary Review

- (a) Review the hydrology and flooding assessment and comment on the technical adequacy and completeness of the assessment. The Preliminary Review shall take into account relevant hydrology and flooding guidelines, requirements and legislation.

The review shall include, but is not limited to:

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- i. the hydrology and flooding assessment methodology (hydrologic and hydraulic);
 - ii. flood management objectives and criteria;
 - iii. flood models used and flooding events modelled; and
 - iv. construction and operational impacts on flood behaviour in Grafton and South Grafton (including climate change); and adequacy of the information presented and whether it is sufficient to enable an assessment of hydrological and flooding impacts of the proposal to be made;
- (b) Consider whether additional information is required to address gaps in the hydrological and flooding assessment. The consultant shall take into account relevant statutory and non-statutory guidelines and requirements for the assessment of hydrological and flooding impacts; and
- (c) Prepare a report on the findings of the Preliminary Review.

2. **EIS Review**

- (a) Consolidate the findings of the Preliminary Review, following department comments on the report required under task 1(c);
- (b) Review the appropriateness and effectiveness of management and mitigation measures recommended for the project, taking into account relevant guidelines, industry best practice and research or monitoring evidence (preferably published);
- (c) Review agency comments on the hydrological impact assessment;
- (d) Review the RMS reports submitted following exhibition:
- i. when the response to submissions report is submitted — review the RMS response to hydrological and flooding impacts raised in submissions received on the proposal; *and*
 - ii. if a preferred infrastructure report is submitted — undertake a review of the hydrological and flooding impacts of the amendments to the proposal; and
- (e) Prepare a report on the findings of the EIS Review, including:
- i. adequacy and completeness of the hydrological and flooding impacts assessment;
 - ii. compliance of the project with applicable legislation and guidelines;
 - iii. adequacy and appropriateness of the management and mitigation measures recommended for the project; and
 - iv. recommended actions and conditions of approval that could be applied to avoid, minimise, mitigate, and/or manage the residual flooding impacts (should the department recommend approval of the project).

3. **Meetings**

- (a) Meet with the Department, the RMS and/ or its consultants/ contractors, and relevant public agencies, as required. It is anticipated that three meetings will be required:
- i. during completion of task 1(c)—to discuss the consultant's Preliminary Review and recommendations, including identification of additional hydrology and flooding information, and recommendations for additional hydrology and flooding impact assessment (where so recommended);
 - ii. following completion of task 2(c)—to discuss the consultant's review and response to agency comments on the EIS; and
 - iii. during completion of task 2(e)—to present the consultant's review and recommendations of the hydrological assessment of the proposal.

4. **Findings and Conclusions**

- (a) Prepare a report on the findings of the independent review, including:
- i. adequacy and completeness of the hydrological assessment;
 - ii. adequacy and appropriateness of flood management and mitigation measures recommended for the project; and
 - iii. recommend actions and conditions of approval that could be applied to avoid, minimise, mitigate and manage the hydrology and flooding impacts (should approval be recommended).

Reporting

The consultant's proposal for the scope of work is to include provision for the following:

1. **One Preliminary Review report (task 1(c)).** The Preliminary Review report will be provided for review by the department (within two weeks of the lodgement of the Environmental Impact Statement (EIS)).
2. **One final draft EIS Review report (task 2(e)).** The final draft EIS Review report shall incorporate consideration of one consolidated set of comments provided on the draft EIS Review report. The final draft EIS Review report will be reviewed by the department (within two weeks of the lodgement of the Response to Submissions Report and/or Preferred Infrastructure Report).

3. **One final EIS Review report (task 4(a)).** The final EIS Review report shall incorporate consideration of the department's comments. The final EIS Review report will be included in the Secretary's environmental assessment report, and published when the department makes its recommendation for the project.

ATTACHMENT C

DRAFT CONDITIONS

Hydrology and Flooding

- C1. Permanent scour protection measures shall be implemented prior to and during construction on the banks of the Clarence River in the vicinity of the bridge works, and around bridge piers to protect the riverbank and riverbed from erosion and instability during construction and operation.
- C2. The Proponent shall consult with and provide feasible and reasonable assistance to Council and NSW State Emergency Service, to prepare any new or necessary update(s) to the relevant evacuation, traffic management and flood plans and documents in relation to flooding events, to reflect changes to flooding levels, flows and characteristics, as a result of the SSI.
- C3. The Proponent shall seek advice from the NSW State Emergency Service on measures that can be reasonably incorporated into the design of the SSI to maximise the evacuation capability of Grafton and South Grafton during a major flood emergency. This is to include but not be limited to consideration of signage relating to flood evacuation, alternative access on/off the bridge approaches for use only during flood emergencies, contra-flow traffic arrangements to maximise egress capacity during a flood emergency, arrangements to allow some continued use of the bridge for flood egress once local flooding of the approaches exceeds the flood immunity standards of the SSI.
- C4. The Proponent shall seek advice from the NSW State Emergency Service and the Council on the content of community consultation material to improve the community's awareness of the risk of flooding and particularly the need to evacuate Grafton prior to the levees overtopping. Any community consultation materials or activities produced by the SSI that deal with flood risks or flood evacuation issues, are to include this content.

Flood Management

- C5. The Proponent shall provide for the bridge approach roads and associated drainage systems to a 20 year ARI flood immunity standard, including for climate change.
- C6. The Proponent shall undertake further flood modelling based on the detailed design of the SSI. The flood modelling shall:
 - (a) incorporate the recommendations of WMAwater outlined in Appendix A *EIS flooding and hydrology technical paper peer review* in the document listed in condition A2(c);
 - (b) include a detailed floor level survey of potentially affected properties;
 - (c) update the flood frequency analysis and application of the latest hydrological practice of the new *Australian Rainfall and Runoff* publication;
 - (d) assess the same design flood events as those in the EIS, including the probable maximum flood (PMF);
 - (e) assess and report all flood height changes to a resolution no coarser than 1cm; and
 - (f) allow for climate change conditions.

- C7. The flood modelling carried out under condition C6 shall inform a review of the proposed flood mitigation measures for the SSI. The review shall be prepared by a suitably qualified expert, in consultation with OEH and Council, and submitted for the approval of the Secretary, prior to work commencing on the Grafton and South Grafton levees, or as otherwise agreed by the Secretary. The provision of flood mitigation measures shall:
- (a) be based on documented flood management objectives for houses and urban area uses and grazing land and other rural uses, developed in consultation with OEH and Council. The flood management objectives shall cover flood level (height), duration, velocity and direction, and flood evacuation; and
 - (b) ensure that the SSI including changes to the height of levees, has a neutral impact on the areas protected by the levees and properties located downstream of the new bridge.

These measures shall be incorporated into the Hydrological Mitigation Report required under condition C11 (where applicable).

- C8. The proposed flood mitigation measures shall be implemented prior to construction commencing in the Clarence River, including pier/pile construction and the installation of temporary in-river rock platforms, unless otherwise agreed by the Secretary.
- C9. The Proponent shall undertake engineering and property investigations of the levees prior to detailed design to inform the structural capability of changes to the levees. Any work to augment the structure of the levees shall be carried out in consultation with Council and affected landowners.
- C10. Where the flood management objectives referred to in condition C7 cannot be complied with, the Proponent shall:
- (a) achieve compliance through modified design of the SSI; or
 - (b) achieve an acceptable level of mitigation of impacts through alternative at property design measures (e.g. raised access tracks, flood refuge, house raising) in consultation with affected landowners; or
 - (c) reach agreement with affected landowners on impacts to property.

Hydrological Mitigation Report

- C11. Prior to the commencement of construction within the floodplain that has potential to alter flood behaviour, the Proponent shall submit for the approval of the Secretary a **Hydrological Mitigation Report**. The Report shall provide details of all feasible and reasonable flood mitigation measures for properties where flood impacts are predicted to increase as a result of the SSI. The Report shall be prepared by a suitably qualified expert and be based on detailed surveys (e.g. floor levels) and flood modelling of the detailed design. The Report shall:
- (a) identify properties in those areas likely to have an increased/exacerbated flooding impact and detail the predicted impact. The types of impacts to be considered include all those examined in the EIS including but not limited to changes in flood levels and velocities, alteration to drainage, reduction in flood evacuation access or capability, impacts on infrastructure, impacts on stock and agriculture, and impacts to the environment;
 - (b) identify mitigation measures to be implemented to address these impacts:

- (c) identify measures to be implemented to minimise scour and dissipate energy at locations where flood velocities are predicted to increase as a result of the SSI and cause localised soil erosion and/or pasture damage;
- (d) demonstrate consistency with the flood management objectives that are to be developed for the SSI in consultation with Council and SES as described in condition C7;
- (e) confirm the measures are consistent with Council's *Grafton & Lower Clarence Floodplain Risk Management Plan Volume 1 – Main Report (June 2007)*;
- (f) be developed in consultation with directly-affected landowners; and Council and NSW State Emergency Service in relation to public assets and community flood evacuation issues;
- (g) identify operational and maintenance responsibilities for items (a) to (c) inclusive;
- (h) where levee raising is proposed, 'smooth out' any local irregularities in the existing levee crest height where considered appropriate by the Council and where this may assist in long-term maintenance of the levees;
- (i) where house raising is proposed, ensure habitable floor levels are raised to a minimum height of the 100 year ARI flood plus 0.5m freeboard, including for climate change, unless justified by site-specific assessment; and
- (j) refer to the assessment described in condition C6.

Construction shall not commence on any components of the SSI that have potential to alter flood conditions until such time as works identified in the hydrological mitigation report have been completed, unless otherwise agreed by the Secretary.

- C12. Based on the mitigation measures identified in condition C11, the Proponent shall prepare and implement a final schedule of feasible and reasonable flood mitigation measures proposed at each directly-affected property in consultation with the landowner, and consistent with the flood management objectives described in condition C7. The schedule shall be provided to the relevant landowner(s) prior to the implementation/construction of the mitigation works, unless otherwise agreed by the Secretary. A copy of each schedule of flood mitigation measures shall be provided to the Department and Council prior to the implementation/construction of the mitigation measures on the property.
- C13. The Proponent shall employ a suitably qualified and experienced independent hydrological expert, whose appointment has been endorsed by the Secretary, to deal with all hydrological matters and assist landowners in negotiating feasible and reasonable mitigation measures.

Drainage

- C14. During detailed design, the Proponent shall undertake a detailed drainage study of the SSI adjacent to the northern and southern approach roads within the levees to ensure there are no adverse impacts to property or existing infrastructure. The study shall be carried out with Council and include the design of the Pound Street drainage basin and pumping station, and Council's existing drainage and flood relief systems.
- C15. Any drainage works that are intended to be operated by Council are to be designed to minimise on-going maintenance. Facilities such as back-up generators are to be provided to ensure continued operation during electrical power outages.

C16. A **Construction Flood Management Plan** to detail how construction impacts on hydrology and flooding from works on the flood levee and within the Clarence River and its floodplain will be minimised and managed. The Plan shall be prepared by a suitably qualified and experienced hydrologist and developed in consultation with the OEH, SES and Council, and shall include, but not necessarily be limited to:

- (i) assessment of the probabilities and consequences in terms of flood damages and personnel safety over the likely construction period including for possible extensions to this period;
- (ii) details of works and activities, including structures within the Clarence River, which may be impacted by a flood during construction and associated risks;
- (iii) details of measures to ensure work sites and plant and equipment are secure during flooding events and do not become flood debris or impact on property and the environment;
- (iv) management measures and procedures that would be implemented prior to a flooding event, including timeframes for securing work sites and moving plant and equipment,
- (v) consideration of the flood management objectives described in condition C7;
- (vi) monitoring of the work sites during flood events;
- (vii) mechanisms for the monitoring, review and amendment of this plan; and
- (viii) certification by the hydrologist that the resultant flood risks during construction are acceptable and have been sufficiently mitigated to ensure any significant adverse flood impacts to people or property, on and off site, are unlikely to occur.