HYDROLOGIC MITIGATION REPORT

Nambucca Heads to Urunga upgrade

FEBRUARY 2013

NAMBUCCA HEADS TO URUNGA – PACIFIC HIGHWAY HYDROLOGIC MITIGATION REPORT

FINAL REPORT

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MARCH 2013

Project Nambucca Heads To Urunga – Pacific Highway Hydrologic Mitigation Report	**Project Number** 111036
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Date 12 March 2013	**Verified by** M K Babister

Revision	Description	Date
4	FINAL REPORT	FEB 2013
3	FINAL DRAFT REPORT	FEB 2013
2	DRAFT REPORT	JAN 2013
1	DRAFT REPORT	DEC 2012

NAMBUCCA HEADS TO URUNGA – PACIFIC HIGHWAY HYDROLOGIC MITIGATION REPORT

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1. INTRODUCTION

1.1. Project Overview

The Australian and NSW governments have been jointly upgrading the Pacific Highway since 1996. Currently, $4.84 billion has been committed to continue the highway upgrade. This will complete a four lane divided road:

- From Hexham to Port Macquarie.
- From Ballina to the Queensland border.
- From Raleigh to Woolgoolga in the rapidly developing Coffs Harbour region.

In addition, significant progress will be made on the Port Macquarie to Raleigh section by completing the Kempsey Bypass, making a substantial start on the Frederickton to Eungai upgrade and preparing the remaining two lane sections for construction.

The proposed upgrade of the Pacific Highway between Warrell Creek and Urunga is part of the Pacific Highway upgrade program being implemented by Roads and Maritime Services (RMS)[1]. The project is 42 kilometres in length, commencing at the northern end of the existing dual carriageway highway at Allgomera (referred to as the Allgomera deviation), connecting with the existing Waterfall Way interchange, north of Urunga.

The funding has been provided in the current $3.6 billion five year program to progress planning and pre-construction activities. This includes additional geotechnical field investigations, which are currently underway.

A brief outline of the history of the project is as follows:

- June 2003: RTA commenced planning a dual carriageway upgrade of the Pacific Highway from Macksville to Urunga.
- November 2004 to February 2005: Route options were placed on public display.
- November 2005: The NSW Minister for Roads announced the preferred route for the Macksville to Urunga section.
- September 2007: Preferred Route Submissions Report (including a review of the preferred route and four options suggested by the community) released.
- June 2008: The proposal was displayed for public comment. Warrell Creek to Urunga upgrade concept design (including the Warrell Creek and Macksville to Urunga upgrade).
- January–March 2010: Environmental Assessment (EA) Report publicly exhibited from 28 January to 29 March 2010 for comment.
- November 2010: Submissions and Preferred Project Reports released.
- July 2011: Project approved by the NSW Minister for Planning and Infrastructure.

[1] Roads and Maritime Services was created on 1 November 2011. It includes parts of the former Roads and Traffic Authority (RTA) that managed delivery of road network infrastructure.

In October 2010 WMAwater reviewed the hydrology, flooding and river crossing aspects of the proposed Pacific Highway upgrade, Nambucca River Crossing, and consulted with Council and residents who have raised issues regarding the impact of the bypass on flooding. The purpose of this review was to assess the technical suitability of the work carried out by SKM, for quantifying the impacts of the proposed Macksville Bypass on Nambucca River flood levels.

In 2011 WMAwater assessed a community proposed alternate route across the Nambucca River floodplain.

1.2. Background

In 2012 the impacts of the major waterway crossings were assessed using a detailed two dimensional hydraulic model, the results of which are contained in the Warrell Creek to Urunga Pacific Highway Upgrade Modelling Report (2012, Reference 4) and replicated herein where necessary. This report deals only with the Nambucca to Urunga section.

The model study areas were determined in consultation with Roads and Maritime Services, Nambucca Shire Council, Bellingen Shire Council, and Office of Environment and Heritage to ensure that it met the needs of both the NSW flood program and the Warrell Creek to Urunga Pacific Highway upgrade modelling study.

The Bellinger and Kalang Rivers study area is defined as:

- Upstream to Bellingen Bridge (Lavenders Bridge) on the Bellinger River,
- To 2.5km past the Brierfield Bridge on the Kalang River, and
- Downstream to the Pacific Ocean.

The Deep Creek study area is defined as:

- Upstream limit on Deep Creek - 1km upstream of Sullivans Road;
- Upstream to stream bed level of 10 mAHD for all other tributaries, including Buchanans, Cow, Boggy, Cedar and other Unnamed Creeks,
- Upstream limit includes the Valla Urban Release Area
- Downstream limit – Pacific Ocean.

The results of the hydraulic modelling for each system, under existing conditions (ie. prior to the upgrade construction) is contained in the following reports:

- *Bellinger and Kalang Rivers Hydraulic Modelling Report (2012, Reference 2)*
- *Deep Creek Flood Study* (2012, Reference 3)

1.3. Purpose of this Report

The purpose of this report is to satisfy B13 of the conditions of approval for the Nambucca Heads to Urunga section of the Warrell Creek to Urunga Pacific Highway upgrade which requires RMS prior to commencing construction to submit a hydrological mitigation report which "details all feasible and reasonable flood mitigation measures for all properties where flood impacts are predicted to increase as a result of the project".

Table 1 details the specific items required to be addressed within condition B13 and where they are addressed within the report.

The impacts of the Warrell Creek to Urunga Pacific Highway upgrade determined in Reference 4 were used for this report. Impacts during construction are not addressed as the exact construction techniques are still being refined as part of the design phase. Floor level survey of properties near the embankments was undertaken by the RMS, and used to inform this study.

Table 1: Condition B 13 Condition components

B13 Condition	Addressed in section
Prior to commencement of construction within areas affected from increased afflux from Nambucca River and Kalang River crossings, the Proponent shall submit a hydrological mitigation report for the approval of the Director General detailing all feasible and reasonable flood mitigation measures for all properties where flood impacts are predicted to increase as a result of the project.	This report. Nambucca River is not part of Stage 1 ie NH2U project. Although not listed under this condition B 13 RMS has acted in good faith and addressed Deep Creek in this hydrological mitigation report.
The report shall be based of detailed floor level survey and associated assessment of flood affected properties.	Section 3.2
a) Identify all properties likely to have an increased flooding impact and detail the predicted increased flooding impact;	Section 2 and 4.1.4
b) Identify mitigation measures to be implemented where increased flooding is predicted to adversely affect access, property or infrastructure.	3.4
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 project and cause localised soil erosion and/or pasture damage;	4.3
d) Be developed in consultation with OEH, the relevant council, NSW State Emergency Service and directly-affected property owners; and	3.1
e) Identify operational and maintenance responsibilities for items (a) to (e)	4.3

inclusive.	
The Proponent shall not commence construction of the project on or within areas likely to alter flood conditions until such times as works identified in the hydrological mitigation report have been completed, unless otherwise agreed by the DG.	Covered in this report for Nambucca to Urunga, and section 3.4

2. NAMBUCCA TO URUNGA PACIFIC HIGHWAY UPGRADE MODELLING

2.1. Overview

As part of the *Bellinger and Kalang Rivers- Hydraulic Modelling Report 2012* (Reference 2), and *Deep Creek Flood Study* 2012 (Reference 3), two dimensional hydraulic (TUFLOW, Reference 1) models were developed of the major waterway crossings. These models were calibrated to represent observed historical flood behaviour. Modelling of a range of design flood events under existing conditions was undertaken as part of the study. The models developed in the early study were adopted for the modelling of the Warrell Creek to Urunga Pacific Highway Upgrade with exception of the Upper Warrell Creek Crossing. This report addresses only the impacts of the Nambucca to Urunga Section of the upgrade.

In order to assess the impacts of the current concept the road embankment levels were incorporated into the 2D hydraulic model grid. The base models (described in Reference 2, and 3) were modified to represent the culvert and bridge sizing as per the project approval used for the current concept model.

If the current concept impacts exceeded the approved impacts refinements were made to the design. The waterway openings which meet the approved impacts are referred to herein as the “New Concept”.

Impacts were calculated for the 1% AEP event which is used to determine the road level and opening sizes. The resultant impacts of the concept designs compared to the existing conditions are shown in Figure 4 to Figure 7.

In addition a small frequent event (10% AEP) and the 0.05% AEP event which is required for bridge design were modelled (these results are not reproduced herein, Refer to Reference 8).

The following maximum impacts were determined for each crossing:

2.2. Kalang River Crossing

- Maximum 0.07m afflux at any residence located in the floodplain upstream of the crossing in the 1% AEP flood event.
- Maximum 0.09m afflux immediately upstream of the crossing (therefore within the corridor) in the 1% AEP flood event.

Table 2:Change in 1% AEP flood levels for the Kalang River crossing

Location	EA Report	WMAwater	Change
Upstream of the Project	60 mm	90 mm	+ 30 mm

At affected residence (1053 Martells Road, Urunga)	50 mm	70 mm	+ 20 mm

2.3. Deep Creek Crossing

- No predictable increase within the limits of accuracy of the model at any residence located in the floodplain upstream of the crossing in the 1% AEP flood event.

- Maximum 0.06m afflux immediately upstream of the crossing in the 1% AEP flood event.

Table 3:Maximum predicted change in 1% AEP flood level upstream of the Deep Creek crossing

	EA Report	**WMAwater**	**Change**
Approved concept design	10 mm	130 mm	+ 120 mm
Refined concept design	10 mm	60 mm	+ 50 mm

Note: The levels in the EA Report and WMAwater review are based on significantly different 1% AEP flood levels.

3. MITIGATION MEASURES

3.1. Process Outline and Consultation

Potential mitigation measures for reducing the afflux caused by the project were discussed with RMS included the widening of the Kalang River crossing opening, however this would require a major increase in bridging in order to significantly reduce the impact. It was therefore considered more cost effective to determine property specific mitigation measures. For Deep Creek changes were made to the design to decrease the afflux (aligning the piers with the existing bridge and increasing the deck level to above the 1% AEP level).

RMS staff and WMAwater contacted property owners immediately upstream of the proposed Pacific Highway upgrade crossings of Kalang River and Deep Creek, where the bypass was having a moderate or major impact. Therefore where:

- Where the maximum impact on agricultural land was >0.05m,
- Where there was an impact exceeding 0.04m at a dwelling or major farm shed which may house expensive farm equipment that can't be moved in the event of a flood.

At each property owner meeting the hydraulic modelling of the Bypass was explained and results in the form of animations and maps of flood behaviour for a range of design and historical events and impacts for the 1% AEP Event were shown to the resident. The effect of the Bypass on inundation times was also discussed.

Where the following criteria were exceeded for a 1% AEP Event further discussions were held with the landholder about mitigation measures:

- Where the maximum impact on agricultural land was >0.07m,
- Where there was an impact exceeding 0.05m at a dwelling or major farm shed which may house expensive farm equipment that can't be moved in the event of a flood.

All proposed mitigation measures and impacts of the bypass were discussed with effected landholders. The Nambucca and Bellingen Shire Councils, the NSW State Emergency Service, NSW OEH were also consulted in the development of this report.

The Nambucca Shire Council were consulted in September and October 2012 and provided with the flood modelling results for the Kalang and Deep Creek catchments. On 4 September 2012 Nambucca Shire Council were forwarded a copy of the final draft Environmental Assessment for the Kalang and Deep Creek crossings. The council strategic planner reviewed the EA and presented his review to Council on 25 October 2012.

The Bellingen Shire Council were consulted in July 2012 and provided the updated modelling information for the Kalang catchment as well as the status of RMS' consultation with affected land owners. Council officers were contacted via telephone on 4 July 2012 and the increased afflux upstream of Deep Creek and the Kalang River crossings along with the preparation of the hydrological mitigation report were discussed. RMS was advised that Council was satisfied with the level of consultation undertaken and indicated that it did not have any additional specific consultation requirements. It was requested that RMS provide a copy of the final hydrological mitigation report to Council. In August 2012 Bellingen Shire Council were forwarded a copy of the final draft Environmental Assessment which was subsequently accepted without modification.

The NSW State Emergency Service was consulted in July 2012 however they did not provide any comment.

NSW OEH representatives were also consulted regarding the revised modelling in July 2012, February 2013. Agencies were forwarded a copy of the Environmental Assessment (Reference 7).

The flood mitigation agency consultation is also discussed in Reference 6.

3.2. Site Inspection, Meetings with Landholders, and Floor Level Survey

Meetings were held with the following landholders (meeting dates):

Kalang River

- Jonathon & Catherine Brown & Shayler, (28 Aug 12, 11 Dec 2012)
- Mr & Mrs Maida & Ellis Bugg, (8 Aug 12)
- Jennifer McBroom, (7 Aug 12, 11 Dec 12)
- Mr & Mrs Margaret & Don McCombie, (19 Jun 12)
- Bernd Rupprecht, 21 Jun (and Caretakers Gayle & Thomas Sharkey),4 Jul 12
- Mr & Mrs Robert & Catherine Scott, (7 Aug 12, 13 Dec 12)

Deep Creek

- Mr & Mrs John & Pamela McCormack, (7 Aug 12, 6 Dec 12)
- Mr & Mrs Wiley, (24 Aug 12)
- Mr and Mrs David and Karen Hirst, (1 Nov 12)
- Jason Shepard and Rebecca Holgate, (28 Aug 12)
- Mr and Mrs Maydwells (1 Feb 13)

A meeting and site inspection was undertaken by RMS staff and WMAwater. Where the floor level was close to the 1% AEP level a floor level survey was undertaken.

3.3. Determination of Properties Requiring Mitigation Works

3.3.1. Kalang River

The only property which exceeded the above criteria is the McCombie Property on the Kalang

River South bank upstream of the proposed crossing. The property includes agricultural land and a house. Impacts on parts of the agricultural land reach 0.09m and impacts at the dwelling reach 0.07m in a 1% AEP. Based on floor level survey and site inspection it was determined that the impact of the highway upgrade would affect the McCombie property that would need to be addressed and this is addressed below.

The 504 South Arm Road (Rupprecht) property on the north bank of the Kalang River opposite was also approached as the flood extent was close to a small shed. The floor level of the shed was surveyed and the contents of the shed confirmed to be either stored above flood level or easily moveable items in the event of a flood and no work required.

3.3.2. Deep Creek

Impacts upstream of Deep Creek crossing were moderate, with no houses effected by operational afflux (all were above the 1% AEP level) and required no mitigation measures.

3.4. Potential Property Mitigation Measures

Discussions were held with the property owners regarding:

- What the property is used for
- House construction type
- Evacuation strategies and flood plans for both humans and animals
- Low points in the property
- What machinery is stored in the sheds

A range of property specific measures such as shelving in the shed, raising the floor of the shed by 100mm, raising the evacuation route used by the cattle in times of flood were discussed with the property owner. The property owner has a DA in with Council to demolish the current dwelling and rebuild the house above the 1% AEP flood level. The property owner has declined all offers of mitigation measures discussed above. The property owner was also compensated prior to the current flood modelling for flooding impacts caused by the highway upgrade.

The McCombie's were concerned with drainage of their property during a flood but also under normal conditions/ during small freshes. RMS have committed to dealing with local drainage of the property during construction and post construction as part of the detailed design phase. The McCombies agreed with this strategy.

4. OPERATIONAL FLOOD IMPACTS AND DESIGN MITIGATION

4.1. Impacts Associated with Changes in Flood Behaviour

4.1.1. Inundation times

The highway upgrade will have minor impacts on flood levels at some local roads, eg South Arm Road. However the highway upgrade will have negligible effect on the length of time local roads are cut during flood events. Therefore evacuation times are unlikely to be effected. For example South Arm road (Kalang River) which is cut for approximately 24hrs during a 1% AEP event would be cut for an additional 20 minutes for such an event. Inundation times upstream of the Deep Creek crossing in a 1% AEP event will change by less than 10 minutes. The increased inundation times will be less than stated above in smaller (more frequent) events.

The highway upgrade will also have a negligible effect on the total length of time properties are inundated. However there will be minor changes in the length of time a property is inundated above a certain level. For example properties just upstream of the Kalang River Bridge would be inundated above 4mAHD (ground level is approximately 2mAHD) in a 1% AEP event for an additional 1hr 10mins. No mitigation is therefore required.

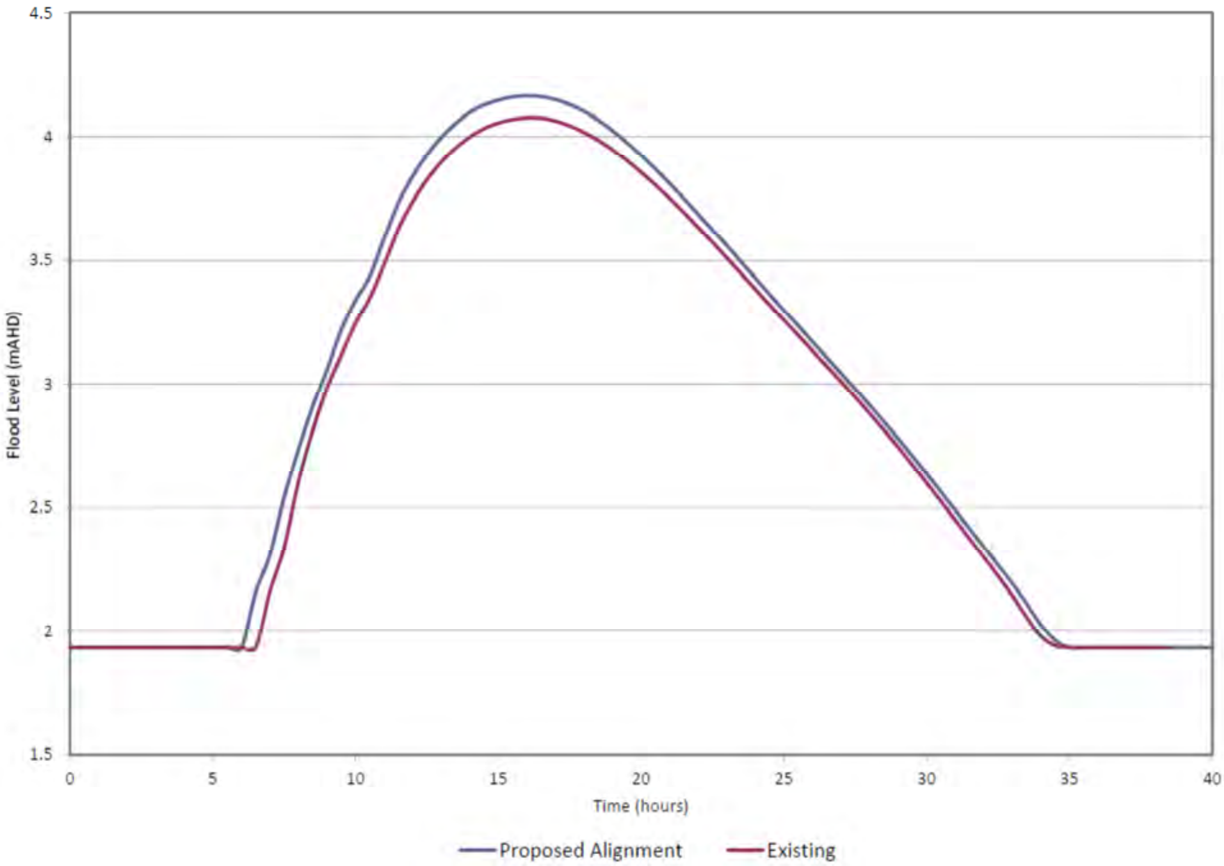

Diagram 1: Kalang River Inundation Times for Existing and Proposed Highway Upgrade scenarios

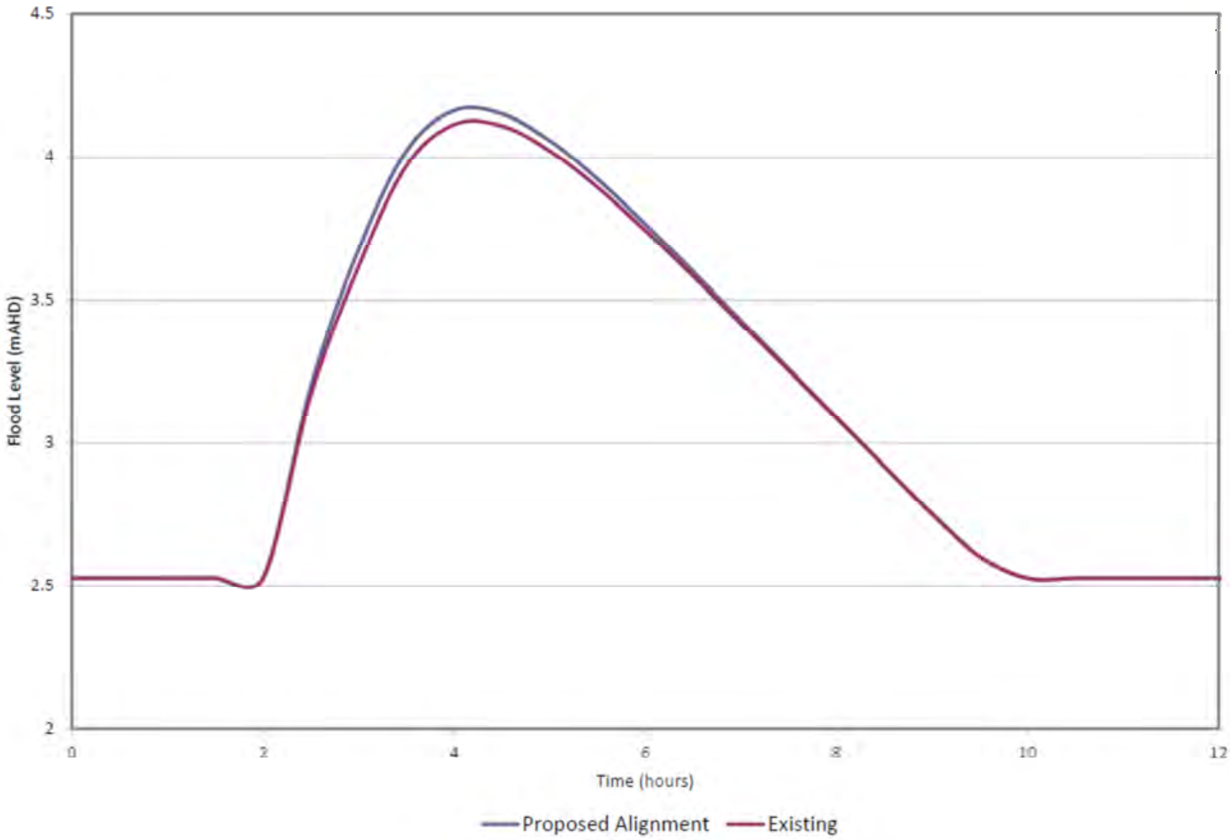

Diagram 2: Deep Creek Inundation Times for Existing and Proposed Highway Upgrade scenarios

4.1.2. Evacuation and Flood Warning Time

The Pacific Highway Upgrade will not cause any significant changes to local evacuation routes or flood warning times. While the upgrade will result in minor changes to flood levels, this is at the peak of the event. No significant changes occur to the rising limb of the hydrograph. No mitigation is therefore required. The Pacific Highway Upgrade will in fact improve evacuation across the region.

4.1.3. Low Flow Drainage Paths

Low flow drainage paths exist on the floodplain which drain agricultural land. A number of small natural drainage paths also exist. Where the highway upgrade crosses these paths minor culverts or table drains may be required to ensure the properties drain in a similar manner to present. These will be addressed in the detailed design phase including the small drainage path on the McCombie property on the Kalang River near the existing dam.

4.1.4. Stock Refuge

As the Pacific Highway upgrade is not crossing any large floodplains that are used for significant amounts of cattle farming or pasture, the road will have minimal impact on stock refuge in a flood event. On the Kalang River, land upstream of the waterway crossing contains easily accessible high ground. No mitigation is therefore required.

4.2. Flood Benefits Associated with the Project

The project will provide significant benefit to the local, regional and interstate community allowing flood free highway access, during floods up to and including a 1% AEP event, between Warrell Creek and Urunga. This in combination with the other planned highway upgrade projects to the north and South, including the Urunga to Bonville sections previously completed to the north, will ultimately provide a safer and more flood resilient stretch of highway.

4.3. Scour Protection and Siltation of the Floodplain

Peak flood velocities for the 1% AEP event are provided in Figure 5 and Figure 7. Scour protection should be provided in areas where the velocities exceed 2m/s which will result in erosion of soil. Velocities are typically increased within culverts but will reduce within a short distance of the structure and usually within the road corridor using dissipation measures.

Some form of scour protection is required at the following culvert locations:

- Chainage 77865
- Chainage 63505
- Chainage 62425
- Chainage 61665
- Chainage 61185

All major bridge structures (Kalang River, Deep Creek etc) will also be subject at times to high velocities 2.2- 2.7m/s (in a 1% AEP event) in the channel. A detailed assessment of scour has not been undertaken at this stage and is part of detailed design, instead this report has flagged potential areas where scour is likely to be required. Scour protection is typically designed in the detailed design phase where the final opening dimensions are known, in consultation with regulatory agencies.

Siltation may occur on the upstream side of the road embankment where velocities are reduced. Any scour works contained within the road corridor will be the reasonability of RMS to maintain.

A detailed Maintenance Plan will be prepared as the design is developed which will demonstrate how the selected design and materials will achieve the serviceability and durability outcomes required for each asset. This will include a detailed maintenance schedule with responsibilities.

4.4. Blockage

Floods in North Wollongong in August 1998 and Newcastle in June 2007 have highlighted the significance of blockage in elevating flood levels at hydraulic structures (bridges, culverts).

Some Councils have implemented a “blockage” policy that must be adopted for all design flood analysis. In other local government areas this issue has been addressed on a case by case basis. Whilst there is no “industry standard” approach for blockage, this issue is being reviewed as part of the review of Australian Rainfall and Runoff Research Project 11 (Reference 5). Structures with a width of less than 6m can be prone to blockage. These may require a management program to ensure they are free of debris.

5. CONCLUSIONS

The purpose of this report is to address B13 of the conditions of approval for the Warrell Creek to Urunga Pacific Highway upgrade. Prior to commencing construction RMS is required to submit a hydrological mitigation report which "details all feasible and reasonable flood mitigation measures for all properties where flood impacts are predicted to increase as a result of the project". This report addresses these issues.

Mitigation works are required for only one property on the Kalang River as a result of increased flooding from the Pacific Highway Upgrade. However, following discussions with the landholder and a site assessment it was agreed that the only mitigation works required were adequate drainage of the property which will be undertaken in the detailed design phase. No mitigation works are required for 504 South Arm Road in the Kalang River catchment.

No mitigation works are required on Deep Creek.

6. REFERENCES

1. WBM BMT

   Tuflow User Manual – GIS Based 2D/1D Hydrodynamic Modelling
   2010

2. WMAwater

   Bellinger and Kalang Rivers Hydraulic Modelling Report
   2012

3. WMAwater

   Deep Creek Flood Study
   2012

4. WMAwater

   Warrell Creek to Urunga Pacific Highway Upgrade Modelling
   2012

5. Engineers Australia

   Australian Rainfall and Runoff- Revision Project 11- Blockage of Hydraulic Structures – Stage 2 report

   Draft 2012

6. RMS

   Pacific Highway Upgrade: Warrell Creek to Urunga- Decision Report – Kalang River and Deep Creek Crossings

   August 2012

7. RMS

   Environmental Assessment: Kalang River and Deep Creek Crossings - Pacific Highway Upgrade, Warrell Creek to Urunga

   August 2012

Figures

Appendix A

APPENDIX A: GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	The Council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill development:** refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.

	redevelopment: refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.
disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level

	(see flood planning area).
flood mitigation standard	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammetic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the “flood liable land” concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPL’s are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the “standard flood event” in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.

flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves: • the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or

- water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or

- major overland flow paths through developed areas outside of defined drainage reserves; and/or

- the potential to affect a number of buildings along the major flow path.

mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.
minor, moderate and major flooding	Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **minor flooding:** causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded. **moderate flooding:** low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **major flooding:** appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
modification measures	Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.
peak discharge	The maximum discharge occurring during a flood event.
Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event

	should be addressed in a floodplain risk management study.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
probability	A statistical measure of the expected chance of flooding (see AEP).
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to “water level”. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.