JBP scientists and engineers

Mooball Village Flood Risk Assessment

Draft Report

29 November 2021

Tweed Shire Council

PO Box 816,

Murwillumbah NSW 2484

TWEED SHIRE COUNCIL

JBP Project Manager

Daniel Rodger
Jeremy Benn Pacific
Suite T46, 477 Boundary Street
Spring Hill QLD 4000
Australia

Revision History

Revision Ref / Date Issued	Amendments	Issued to
C0003 (DRAFT) / October 2021		LM
C0004 (DRAFT) / November 2021	Updated culvert levels	LM

Contract

This report describes work commissioned by Leon McLean, on behalf of Tweed Shire Council, by a letter dated 29 July 2021. Sam Andrews and Nilantha Karunarathna of JBP carried out this work.

Prepared by .... Sam Andrews BEng
Hydrologist – Hydraulic Engineer

Reviewed by .... Nilantha Karunarathna
Principal Engineer

Approved by .... Daniel Rodger BSc MEng CEng CMarEng MIEAust
Director

Disclaimer

Jeremy Benn Pacific ("JBP") has prepared this report for the sole use of Tweed Shire Council (the “Client”) and its appointed agents in accordance with the Agreement under which our services were performed.

JBP has no liability regarding the use of this report except to the Client. No other warranty, expressed or implied, is made as to the professional advice included in this report or any other services provided by JBP. This report cannot be relied upon by any other party without the prior and express written agreement of JBP.

The conclusions and recommendations contained in this report are based upon information provided by others and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information obtained by JBP has not been independently verified by JBP, unless otherwise stated in the report.

The methodology adopted and the sources of information used by JBP in providing its services are outlined in this report. The work described in this report was undertaken between July and November 2021 and is based on the conditions encountered and the information available during this period of time. The scope of this report and the services are accordingly factually limited by these circumstances.

Any assessments of works or costs identified in this report are based upon the information available at the time, and where appropriate are subject to further investigations or information which may become available.

JBP disclaim any undertaking or obligation to advise any person of any change in any matter affecting the report, which may come or be brought to JBP's attention after the date of the report.

Certain statements made in the report that are not historical facts may constitute estimates, projections or other forward-looking statements, and even though they are based on reasonable assumptions as of the date of the report, such forward-looking statements by their nature involve risks and uncertainties that could cause actual results to differ materially from the results predicted. JBP specifically does not guarantee or warrant any estimate or projections contained in this report.

Unless otherwise stated in this report, the assessments made assume that the sites and facilities will continue to be used for their current purpose without significant changes.

Where field investigations are carried out, these have been restricted to a level of detail required to meet the stated objectives of the services. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant delay in issuing this report.

Acknowledgements

JBP acknowledges the use of the hydrologic and hydraulic models developed within the 2019/20 Tweed Flash Flood Forecasting System, and the structure dimension data supplied for this new investigation by Council.

Copyright

Executive Summary

This report was undertaken by JBPacific on behalf of Tweed Shire Council (TSC) to provide an improved assessment of flood risk in Mooball Village to enable application of appropriate flood planning levels for this area.

Mooball Village is located adjacent to the Burringbar Creek, upstream of the Pacific Motorway. The North Coast Railway runs across Mooball Village and acts as an informal levee which partly protects the village from flooding originating from Burringbar Creek. Previously, this area was represented within the hydraulic model in 2-dimensions (2D) only, with the embankment crest level included within the model topography and flow through culverts represented as a break in the digital elevation model through the embankment. The results of the flood model showed that following heavy rainfall in the upper Burringbar catchment, flood levels in Mooball Village can be lower than the main Burringbar Creek due to the protection offered from the railway embankment, although floodwater is still able to inundate the village due to backflow through the embankment.

This new hydraulic assessment was performed to refine flood modelling around the Mooball township and to investigate the potential changes in flood inundation if the embankment was breached. Enhancements to the 2D flood model included improved definition of the railway embankment, addition of new 1D structures to represent culverts, refinement of the hydrologic model within the small upstream watershed south-west of Mooball Village and the addition of ten new inflows within the Tuflow hydraulic model to reflect the new sub-catchments.

The updated model was simulated for the design-event, a 1% Annual Exceedance Probability (AEP) scenario. The following flood levels were recorded within Mooball Village, at approximately the rear of the Victory Hotel, at 5909 Tweed Valley Way, and for any impacted properties.

1. For reference, the original Council flood planning level was 12m AHD, and the updated Tweed Flash Flood Forecasting System peak flood level were approximately 12.2m AHD.
2. In this revised investigation the updated 1% AEP flood level is 12.56m AHD
3. In this revised investigation, additional scenarios include the following:
    a. Removal of the entire railway embankment during the 1% AEP. This results in the peak flood level at the central Mooball reporting point to be 12.64m AHD. The flood extent increases west of the Pottsville Road intersection, and the largest increases to flood levels occur to the east of the intersection, increasing by up to 0.3m.
    b. Inclusion of a 30m breach within the railway embankment during the 1% AEP. The peak levels at the central Mooball reporting point were 12.57m AHD. The flood extent increases west of the Pottsville Road intersection around the location of the breach. However, unlike the removal of the embankment, the peak flood levels do not increase to the east of the intersection.
    c. Inclusion of a flood gate on the railway embankment during the 1% AEP. This initially allows local runoff to flow from Mooball through the culverts towards the Burringbar Creek. However, the long duration flooding of the creek holds the gates closed for a long period, resulting in the peak flood level within central Mooball to be 12.56m AHD (i.e. it matches the regional flood level). The flood extent does not increase nor does the peak flood level increase around Mooball Village or through the main channel of Burringbar Creek north of the village.

Table of contents

Executive Summary iii
1 Introduction 1
2 Background to breach scenario modelling 3
3 Design Scenarios 4
3.1 Model setup 4
3.2 Updated results of the baseline model 5
3.3 Removal of Railway Embankment 8
3.4 Rail Embankment Breach with coincident 1% AEP flooding 11
3.5 Railway culvert flood gate 14
4 Summary and limitations 16
4.1 Limitations 16

List of Figures

Figure 1-1: Mooball Village location 2
Figure 3-1: Top: Railway culvert, bottom: Road culvert 5
Figure 3-2: Flood Planning extent and peak water level contours (Supplied by TSC) 6
Figure 3-3: Flood levels from the 2019/20 Tweed Flash Flood Forecasting System 6
Figure 3-4: Peak depth and flood height contours -1% AEP existing 7
Figure 3-5: Peak velocity magnitude and direction -1% AEP existing 7
Figure 3-6: Removed Rail Embankment 8
Figure 3-7: Peak depth and flood height contours -1% AEP removed rail embankment ... 9
Figure 3-8: Peak velocity magnitude and direction -1% AEP Removed embankment 9
Figure 3-9: Difference in peak elevation -removed embankment vs. existing 10
Figure 3-10: Rail Embankment Breach Location 11
Figure 3-11: Pre and Post embankment section at breach location 12
Figure 3-12: Peak depth and flood height contours -1% AEP breached rail embankment 12
Figure 3-13: Peak velocity magnitude and direction -1% AEP breached embankment 13
Figure 3-14: Difference in peak elevation -breached embankment vs. existing 13
Figure 3-15: Peak depth and flood height contours -1% AEP flood gates at rail culvert ... 14
Figure 3-16: Peak velocity magnitude and direction -1% AEP flood gates at rail culvert .. 15
Figure 3-17: Difference in peak elevation flood gates at rail embankment vs. existing 15

List of Tables

Table 3-1: Culvert properties. 4

Abbreviations

AEP .... Annual Exceedance Probability

ARI .... Average Recurrence Interval

ARR .... Australian Rainfall and Runoff

AWRA-L .... Australian Water Resource Assessment – Landscape the BoM's daily soil moisture data

BoM................................ Bureau of Meteorology

DEM .... Digital Elevation Model

DPIE................................ Department of Planning, Industry and the Environment

LGA................................ Local Government Area

FRMS .... Floodplain Risk Management Study

FRMP .... Floodplain Risk Management Plan

LiDAR.............................. Light Detection And Ranging remote sensing of ground level information

OEH .... Office of the Environment and Heritage, now DPIE

SES .... State Emergency Services

TSC................................ Tweed Shire Council

URBS .... Unified River Basin Simulator hydrological modelling software

1 Introduction

Mooball village is a small township located in the Burringbar Creek catchment of the Tweed Local Government Area (LGA). It is located in an area of high annual rainfall, with the potential for flash flooding. In 2019/20, JBPacific (JBP) developed the Tweed Flash Flood Forecasting System ('the System') for the Upper Coastal Creeks catchments of Burringbar Creek and Crabbes Creek. This project included the development of a regional-scale 1D-2D flood model using the Tuflow software package, covering the upper coastal creeks including Mooball village. The model included detailed topography and major infrastructure, which was assessed under a range of rainfall scenarios aligned with Australian Rainfall and Runoff (ARR) guidelines. Figure 1-1 shows the hydraulic model extent and the location of Mooball village.

The North Coast Railway runs across Mooball Village and acts as an informal levee which partly protects the village from flooding originating from Burringbar Creek. The area was represented within the hydraulic model in 2D only, with the embankment crest level included within the model topography and culverts represented as a single cell-width flowpath through the embankment. The results of the flood model showed that following heavy rainfall in the upper Burringbar catchment flood levels in Mooball Village can be lower than the main Burringbar Creek due to the protection offered from the railway embankment, although floodwater is still able to inundate the village due to backflow through the embankment.

This new hydraulic assessment was performed to refine flood modelling around the Mooball township and to investigate the potential changes in flood inundation if the embankment was breached. The following changes were made within the existing Tuflow 1D-2D flood model:

- Improved definition of the railway embankment within the model topography
- Addition of a 1D structure to represent the culvert under the railway embankment
- Addition of a 1D structure to represent the culvert under the Tweed Valley Way
- Refinement of the hydrologic model within the small upstream watershed south-west of Mooball Village
- Addition of ten new inflows within the Tuflow hydraulic model to reflect the new sub-catchments.

The updated model was then used to simulate the following scenarios:

1. A revised 1% Annual Exceedance Probability (AEP) flood extent (based on a re-run of the worst-case modelling from the existing study)
2. 1% AEP flood event with the entire railway embankment removed
3. 1% AEP flood event with a 30m breach within the railway embankment
4. 1% AEP flood event with a flood gate on the railway embankment culvert.

Figure 1-1: Mooball Village location

2 Background to breach scenario modelling

Raised flood defence structures, embankments and levees rarely offer complete protection against flooding as there is residual risk that the floodwaters may exceed the defence standard or overload them causing a failure. This process is known as breaching and can be assessed through numerical hydraulic modelling. Whilst embankment breaches are rare, their consequences can be significant and need to be considered within land use planning, emergency response and community engagement to understand the residual risk for any flood-prone community.

There are several guidance documents that can be used to support the hydraulic modelling of an embankment breach. Much of this guidance has been developed within the UK and USA, where information was gained from their large number of defences or physical modelling tests. The following guidance was reviewed for this assessment:

- Guidance on how to apply a breach within the Tuflow hydraulic modelling software can be found within the Tuflow manual[1].
- UK Environment Agency (2017): Breach of Defences Guidance provides information on the geometry of typical embankment breaches[2].
- UK Wales (2020): Flood Risk Management: Modelling Blockage and Breach Scenarios provides guidance on how to apply blockage at structures and breaches in defences[3].
- UK Environment Agency (2020): Reservoir Flood Mapping Specification provides information on hydrograph shape for 1D modelling[4].
- (USA) Froehlicj., D (1995): Embankment Breach Parameters Revisited provides a range of datasets on measured embankment failures[5].

The following breach modelling approach was applied:

1. Define trigger location: This was specified at the Pottsville Road intersection, which is the location of anecdotal reports from a 2017 flood event of water coming within "an inch of the crest". The same location was identified from the June 2016 model calibration event.
2. Define trigger time: The Tuflow manual outlines several trigger approaches to initiate the breach; either at a specified time, when the water level reaches a specified height, or when the water level difference between two triggers exceeds a specified amount. Other guidance from the UK Environment Agency (2017) states "If we consider breach is to be modelled for a defence then a start time should be that point where there is at least some loading on the defence to ensure we are not overly precautionary. In a river or 'non wave' tidal situation this can be considered to be a water level at ¾ of the defence height". Following this guidance, the breach time occurs when water levels reach 13.5mAHD.
3. Define final geometry of the breach: A breach geometry needs to consider the scour depth/elevation, the length of breach and time to erode. The following has been applied:
   - The scoured elevation is based on the natural ground level downstream of the embankment (13.2m AHD) - based on guidance within Environment Agency (2017).
   - The width of the breach is 30m. This was selected to allow several adjacent cells of the model to be breached, which has a grid resolution of 8m, and is supported by guidance from Natural Resources Wales (2020) which gives the typical embankment breach of 40m for an earth bank and 20m for a hard defence. As the embankment shows features of each type, the mid-range value of 30m was considered appropriate.
   - The time to erode was set to 30 minutes, to ensure maximum time of water flow through the breach.

1 BMT (2018) TUFLOW USER Manual – Build 2018-03-AC
2 Environment Agency (2017) "Breach of Defences Guidance", Modelling and Forecasting Technical Guidance Note
3 Natural Resources Wales (2020) "Flood Risk Management: Modelling Blockage and Breach Scenarios", Document reference number GN43
4 Environment Agency (2020) "Reservoir flood mapping specification", Horizon House, Deanery Road, Bristol BS1 5AH
5 Froehlicj, D. (1995) Embankment dam breach parameters revisited., Accessed on 21 October 2021 from: https://www.researchgate.net/publication/239964974_Embankment_dam_breach_parameters_revisited

3 Design Scenarios

3.1 Model setup

The flood model developed for the 2019/20 Tweed Flash Flood Forecasting System was enhanced and used for this investigation. The following changes were made within the existing Tuflow 1D-2D flood model:

- Improved definition of the railway embankment within the model topography: The approach to modelling large culverts through the embankment was improved for this high-detail investigation. The full railway embankment was restored, removing the artificial break added into the elevation model to allow flow through a culvert.
- Addition of a 1D structure to represent the culvert under the railway embankment: This was added immediately downstream of the Mooball Village. Dimensions were supplied by Council and are shown in Table 3-1 and an image of the structure in Figure 3-1.
- Addition of a 1D structure to represent the culvert under the Tweed Valley Way: This was added adjacent to the new 1D embankment culvert. Dimensions were not available from Council's asset database and were estimated by Council staff during a field inspection. The dimensions applied are shown in Table 3-1, and an image of the structure in Figure 3-1.
- Refinement of the hydrologic model within the small upstream watershed south-west of Mooball Village. This was split into ten additional sub-catchments.
- New direct-rainfall inputs have been added to the small upstream catchment flowing from the hills towards Mooball.

The updated model was used to simulate the following scenarios:

- A revised 1% AEP flood extent. This was based on a re-run of the worst-case modelling from the existing study, which was the 1% 6hr event using temporal pattern 8. This inflow scenario closely represents the adopted design flood level for Mooball Village.
- 1% AEP flood event with the entire railway embankment removed
- 1% AEP flood event with a 30m breach within the railway embankment
- 1% AEP flood event with a flood gate on the railway embankment culvert.

Table 3-1: Culvert properties.

	Mooball Railway Culvert	Tweed Valley Way Culvert
Invert	8.17 mAHD	8 mAHD*
Obvert	11.22 mAHD	10 mAHD*
Culvert Layout	3.1m x 3.8m (H x W)	2m* x 1.5m* (H x W)
Length	7m*	10m*
* Estimated by Council staff		

Figure 3-1: Top: Railway culvert, bottom: Road culvert

3.2 Updated results of the baseline model

The upgraded model was re-run for a 1% AEP flood event and compared to previous results. The inclusion of the new culvert structure under Tweed Valley Way and new flow discharges from the refined hydrology model did result in a change in flood conditions. This increased the flood depth at four properties east of Pottsville Road. The following figures show previous and updated flood conditions, which indicate the following:

- Figure 3-2 shows previous Council flood estimates (prior to the Tweed Flash Flood Forecasting System model). Peak water levels are approximately 12m AHD at Mooball Village, and appear to be caused by backflow under the embankment.
- Figure 3-3 shows the model results from the 2019/20 Tweed Flash Flood Forecasting System model. Peak water levels do not extend over the entire township. Flood waters are limited to the eastern side of Mooball Village, however have an increased flood level of approximately 12.2m AHD. The reduced extent is considered to be due to changes in the DEM.
- Figure 3-4 and Figure 3-5 show the new velocity, depth and water level maps, with peak levels now approximately 12.56m AHD at Mooball village. These peak levels are the result of both backflow from the main channel, however now also include flows running down from the hills through the village.

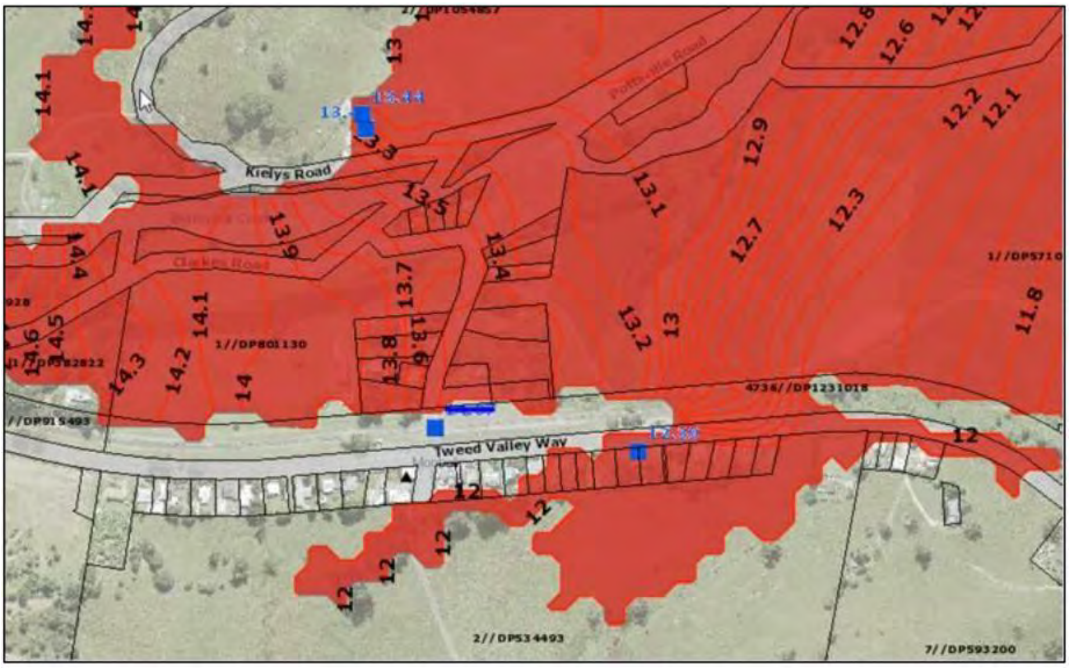

Figure 3-2: Flood Planning extent and peak water level contours (Supplied by TSC)

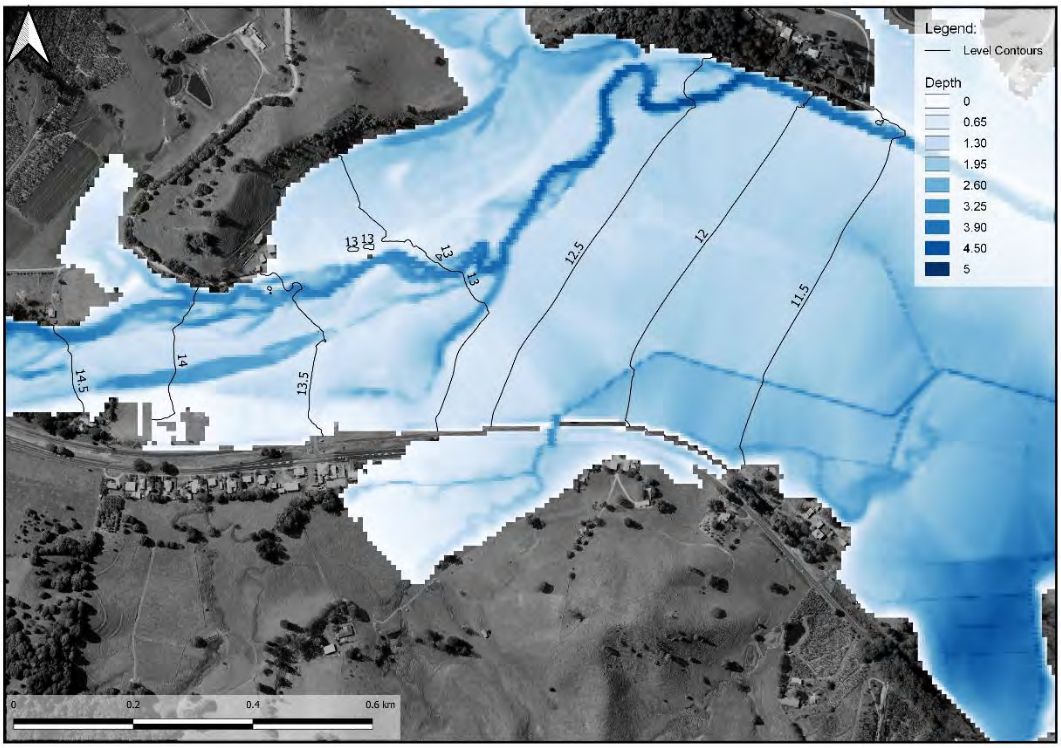

Figure 3-3: Flood levels from the 2019/20 Tweed Flash Flood Forecasting System

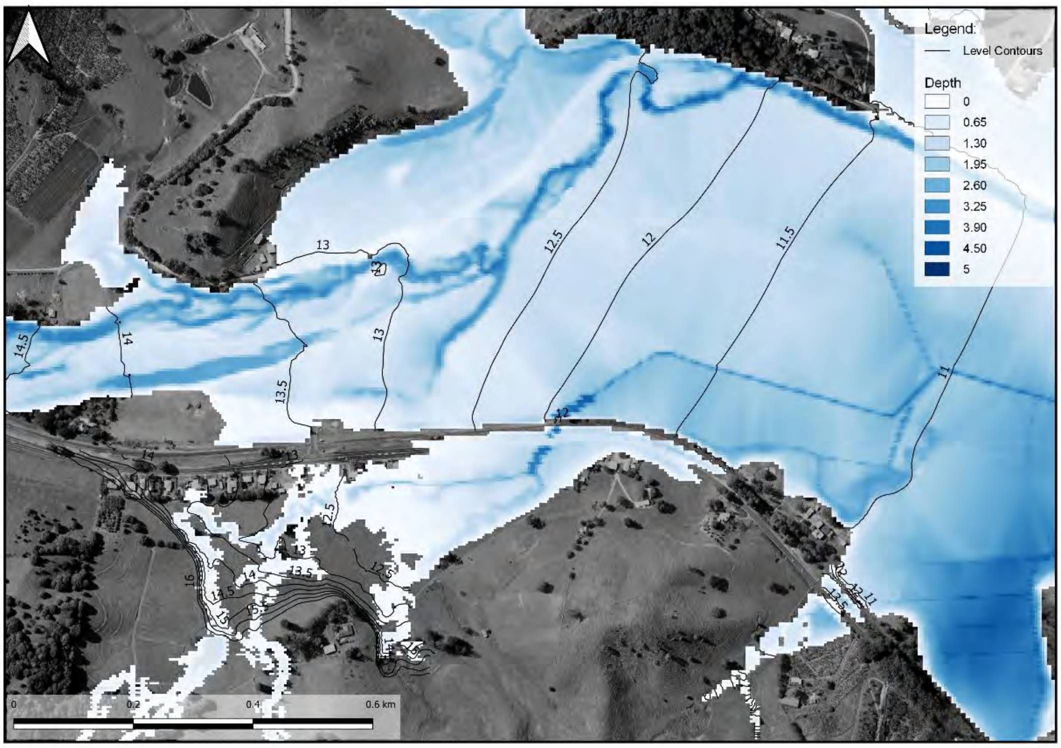

Figure 3-4: Peak depth and flood height contours -1% AEP existing

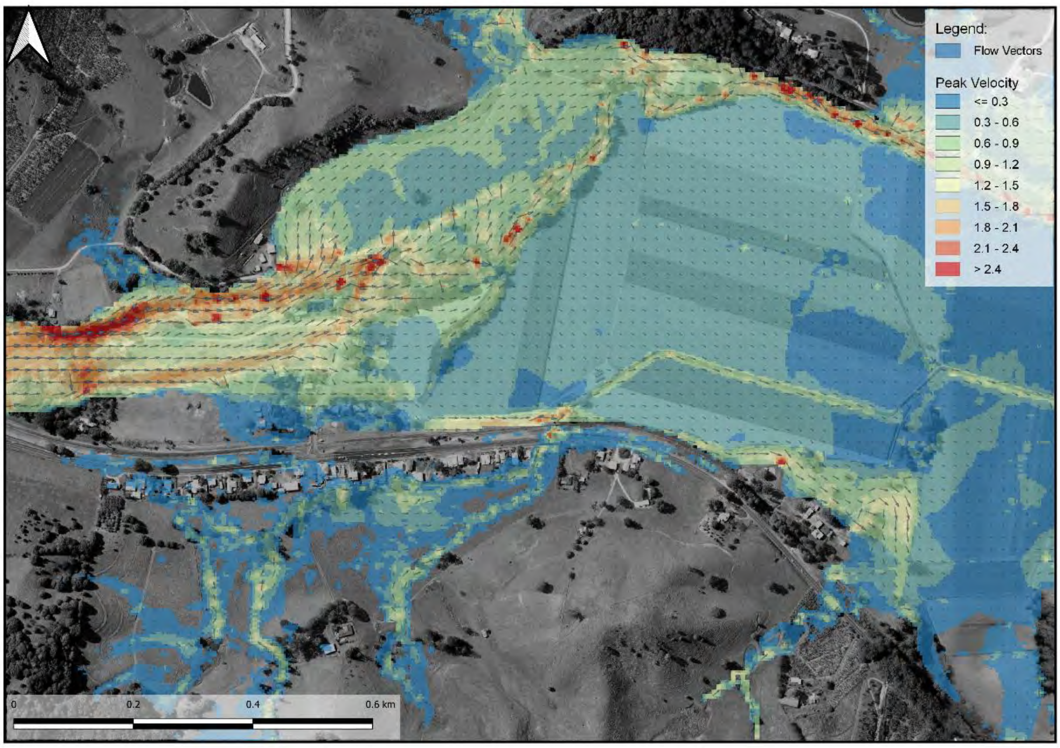

Figure 3-5: Peak velocity magnitude and direction -1% AEP existing

3.3 Removal of Railway Embankment

The railway embankment running alongside Mooball Village acts as an informal levee for the village, offering protection from Burringbar Creek flooding. Once the embankment is removed, storage which was previously retained by the embankment crosses the Tweed Valley Way and begins filling the lower-level flood compartment to the south of the embankment as shown in Figure 3-9. When the railway embankment was removed from the modelling scenario, the maximum flood extent increases due to the lowered elevations allowing additional flow paths across the Tweed Valley Way. The peak water levels within Mooball increase to approximately 12.64m AHD. The flood extent increases west of the Pottsville Road intersection, and the largest increases to flood levels occur to the east of the intersection, increasing by up to 0.3m.

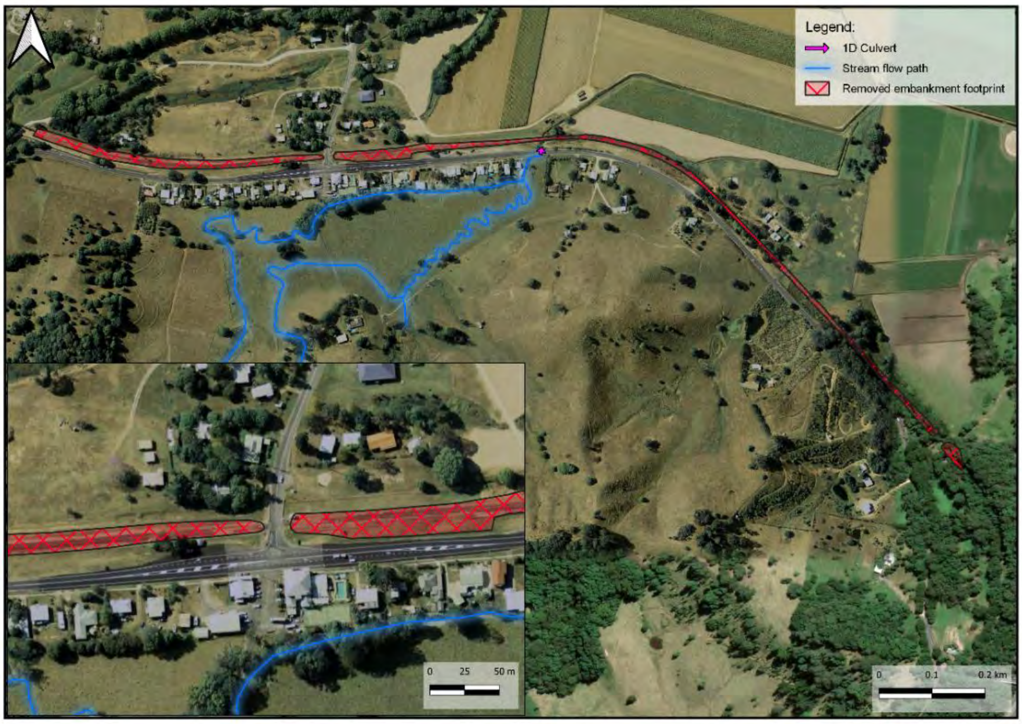

Figure 3-6: Removed Rail Embankment

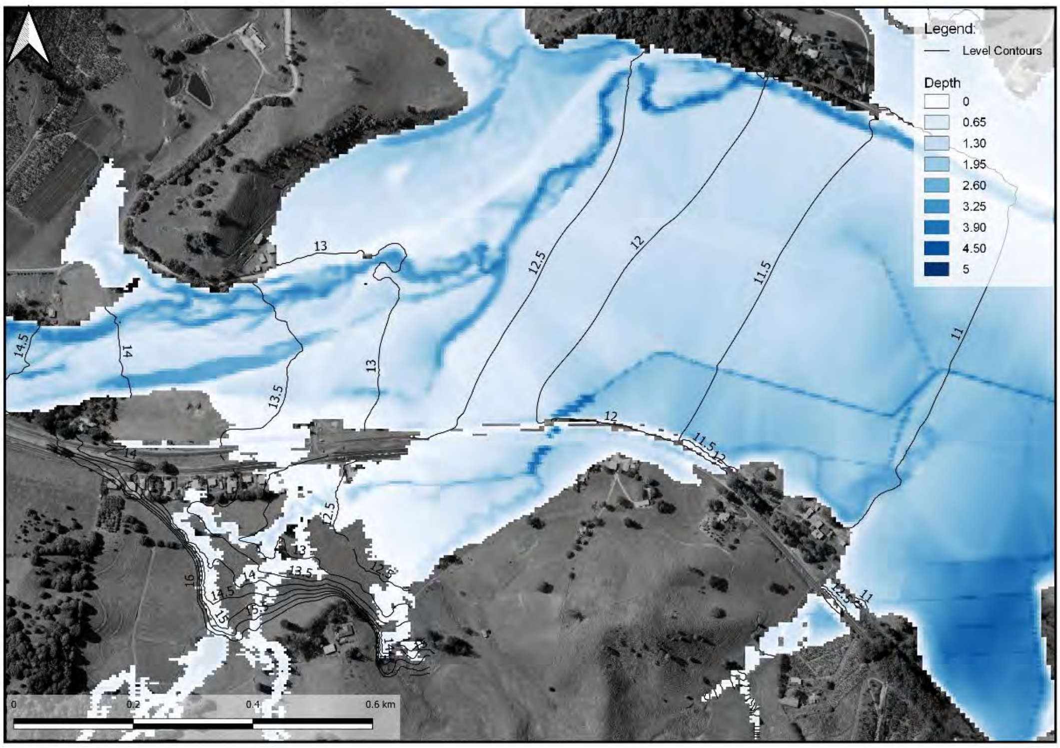

Figure 3-7: Peak depth and flood height contours -1% AEP removed rail embankment

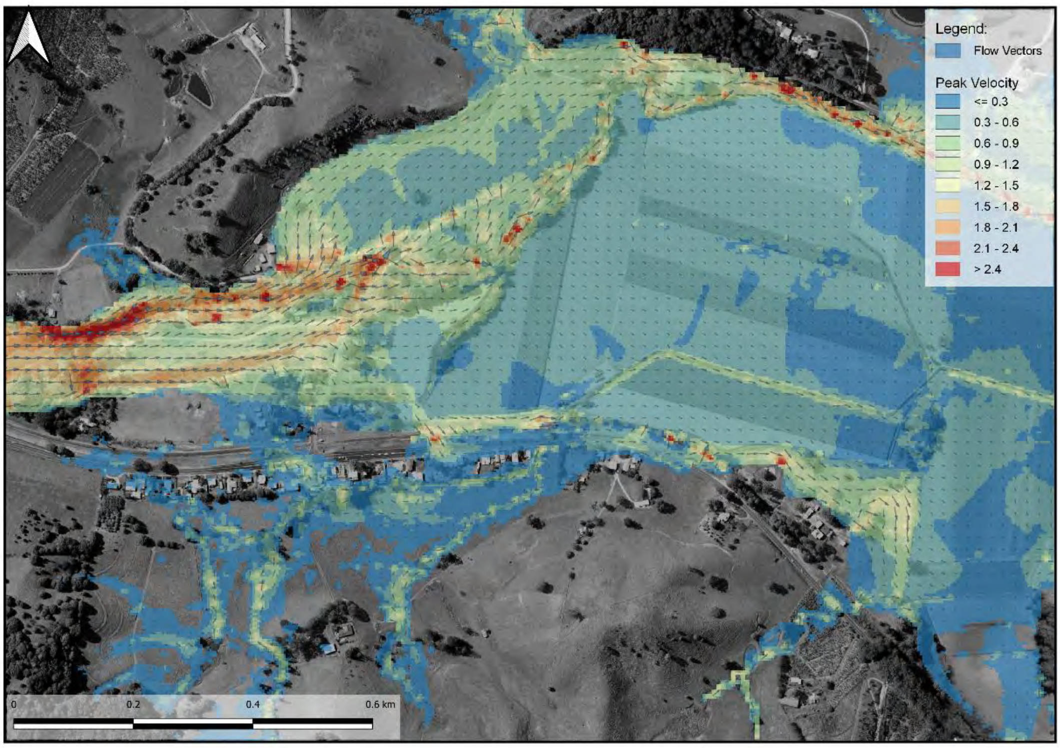

Figure 3-8: Peak velocity magnitude and direction -1% AEP Removed embankment

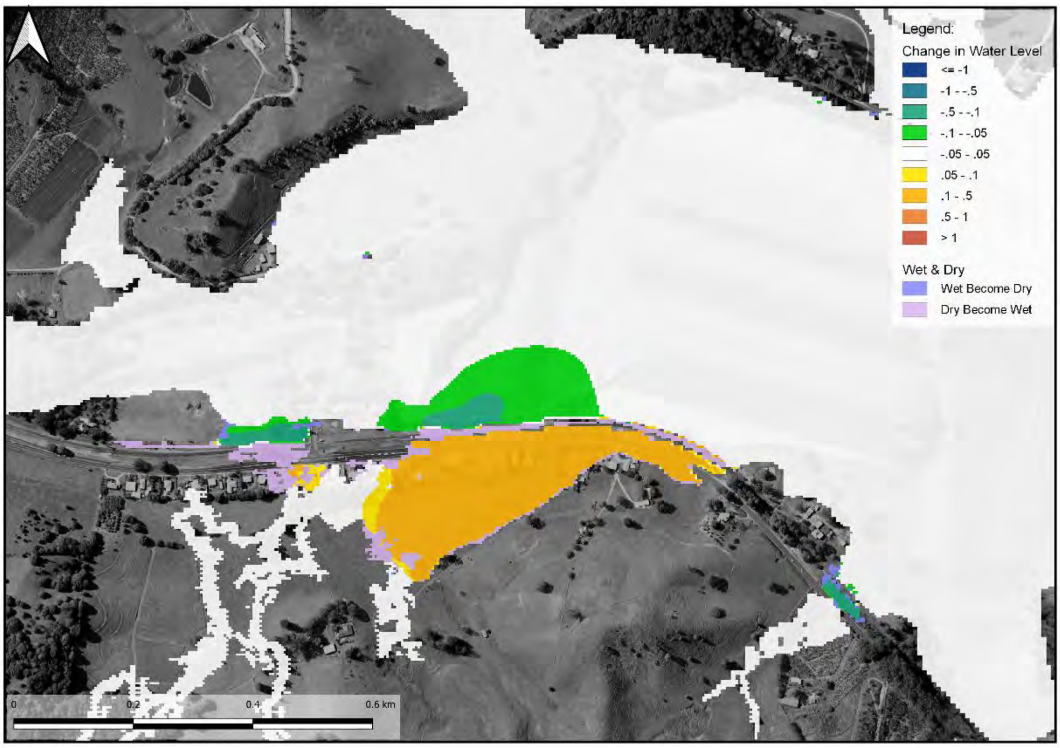

Figure 3-9: Difference in peak elevation -removed embankment vs. existing

3.4 Rail Embankment Breach with coincident 1% AEP flooding

The rail embankment is not designed to perform as a levee and consists of porous fill material in ballast & sub-ballast sections of the embankment. The 1% AEP peak flood lapping at the west of Pottsville Road has a lower elevation to the rail crest height, but is a cause of concern since the rail embankment is acting as an informal levee.

Ballast enables rapid draining due to its loose packing during construction and its ability to settle under vibrations caused by railway use. Under lateral flood loading, it is possible that ballast material could erode and cause an overtopping breach. There is also a possibility of the rail embankment breaching due to piping failure, however this has not been a focus of this study.

Following the approach provided in Section 2, a breach has been incorporated into the model at the Pottsville Road intersection. The breach occurs when water levels reach 13.5mAHD, and evolves into a 30m wide scoured condition, with invert level at 13.2m AHD which corresponds to the toe level of the embankment.

Figure 3-10 shows the modelled breach location, and Figure 3-11 shows the pre- and post-embankment section view at the breach location.

Due to the relatively low water levels causing the embankment breach, the main outcome from this scenario is the increased flood extents due to an additional flow path being formed across the Tweed Valley Way. Changes in peak water level either side of the embankment breach were minimal, and within the bounds of +/-50mm, as shown in Figure 3-14. The final peak flood level was approximately 12.57m AHD.

Figure 3-10: Rail Embankment Breach Location

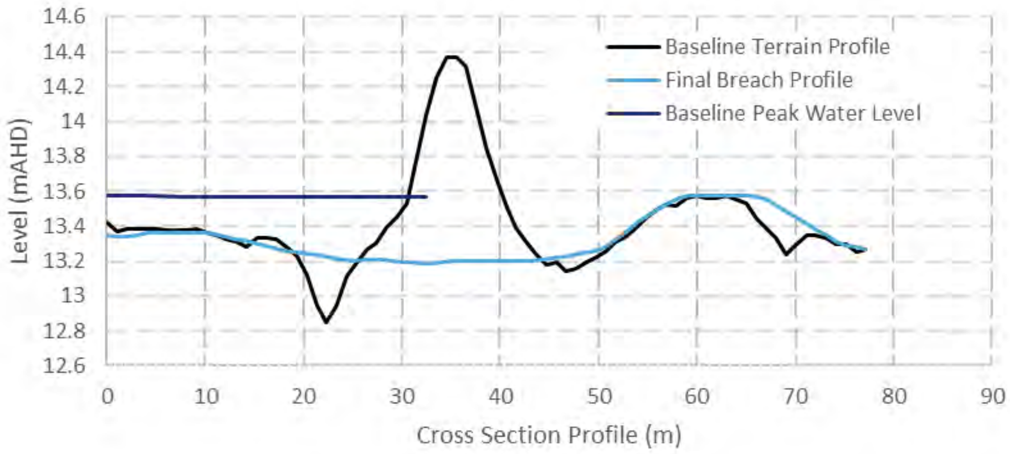

Figure 3-11: Pre and Post embankment section at breach location

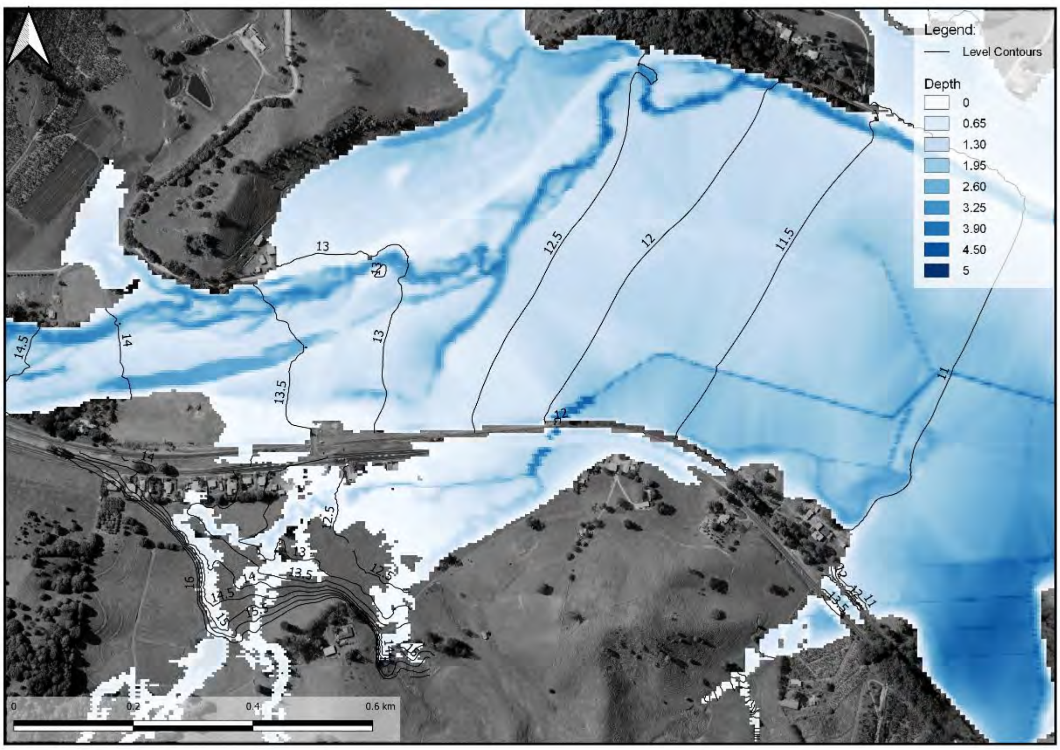

Figure 3-12: Peak depth and flood height contours -1% AEP breached rail embankment

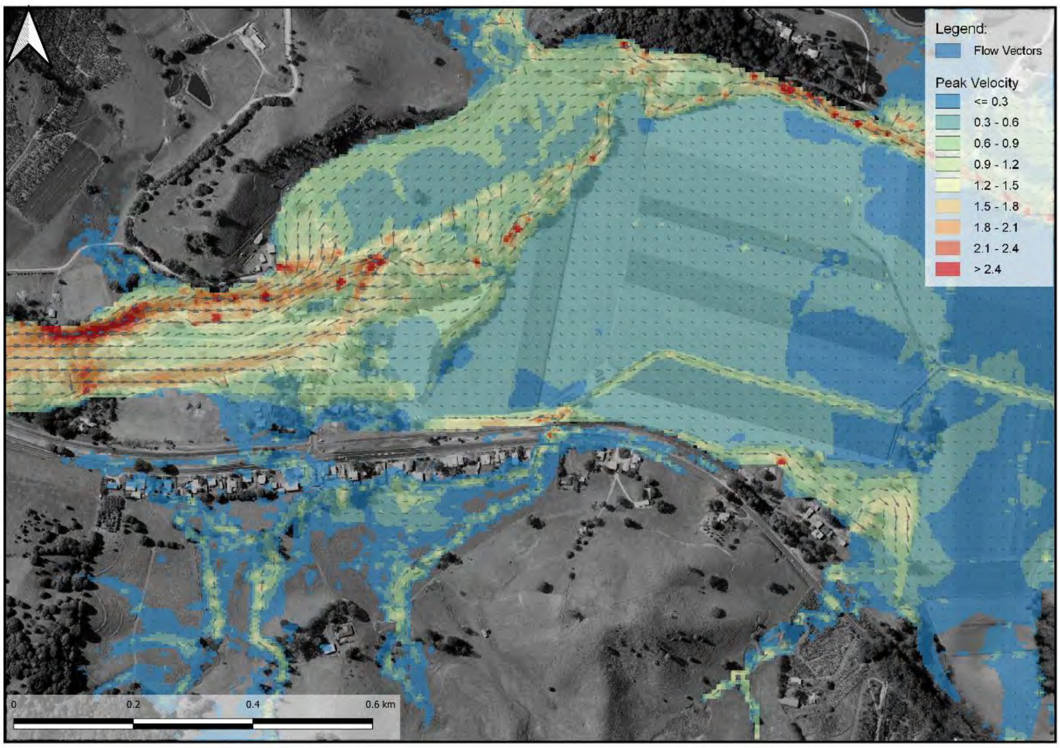

Figure 3-13: Peak velocity magnitude and direction -1% AEP breached embankment

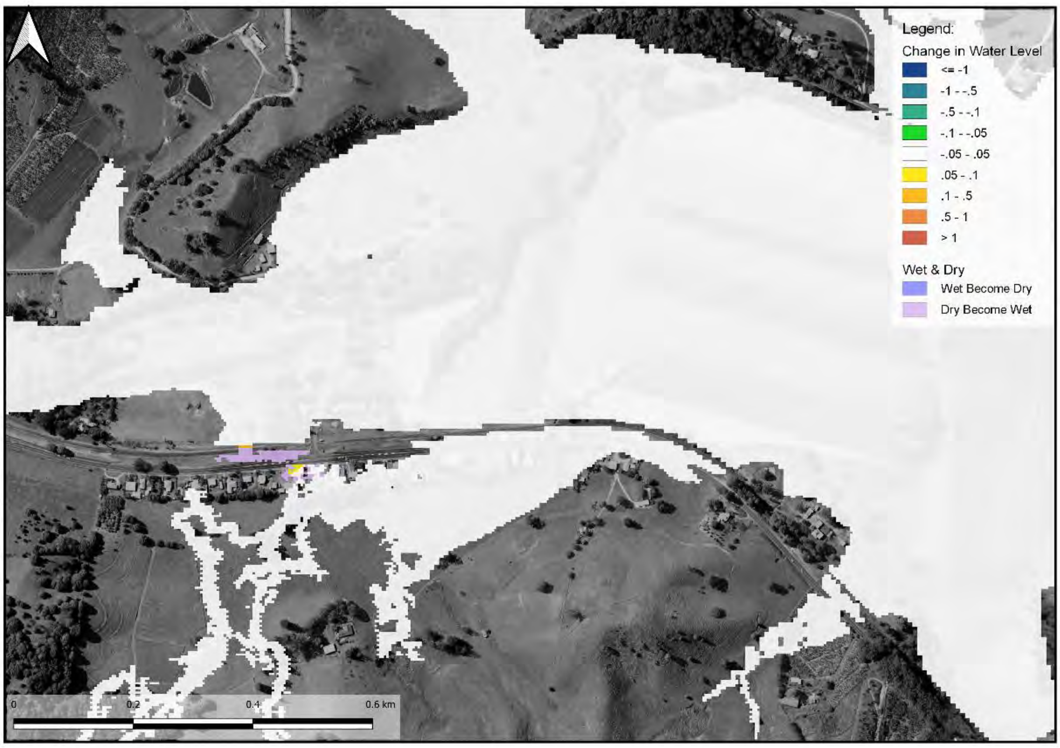

Figure 3-14: Difference in peak elevation -breached embankment vs. existing

3.5 Railway culvert flood gate

The 1% scenario without breach conditions was re-simulated with a new flood gate added to the railway culvert. The 1D culvert through the railway line embankment was configured to operate as a unidirectional flow which restricts backflow from the regional flooding caused by Burringbar Creek.

At the start of the simulation, the flood gate allows local flows to flow from Mooball Village towards Burringbar Creek. As water levels rise in the main creek, they hold the flood gates closed. Due to the relatively long storm duration required to produce peak flood levels in the regional model, the gates are held closed for several hours. During this timeframe, the local runoff is prohibited from flowing through the culverts, until local water levels exceed the regional water levels. During this time, the local runoff causes localised flooding, with a peak flood level of 12.56m AHD at Mooball. Whilst these flood levels match the non-gate baseline scenario, the addition of floodgates is not expected to increase water levels and they are expected to have a positive influence on Mooball flood levels under different storm conditions.

The inclusion of a flood gate did not influence flood extents or peak flood levels, as shown in Figure 3-17.

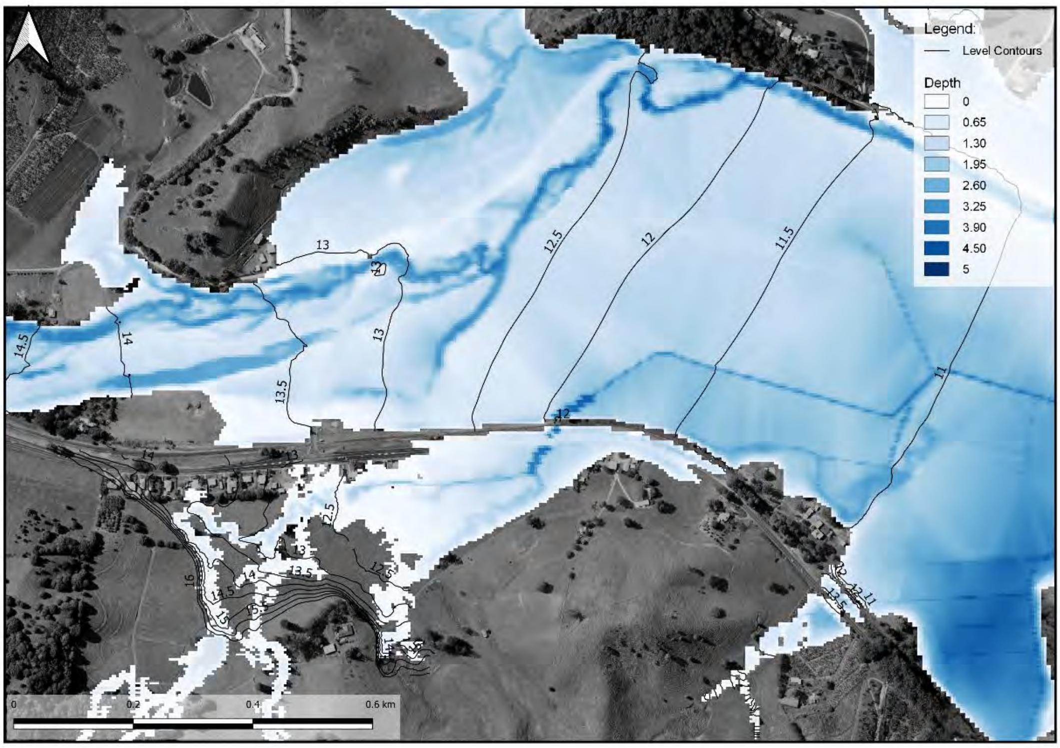

Figure 3-15: Peak depth and flood height contours -1% AEP flood gates at rail culvert

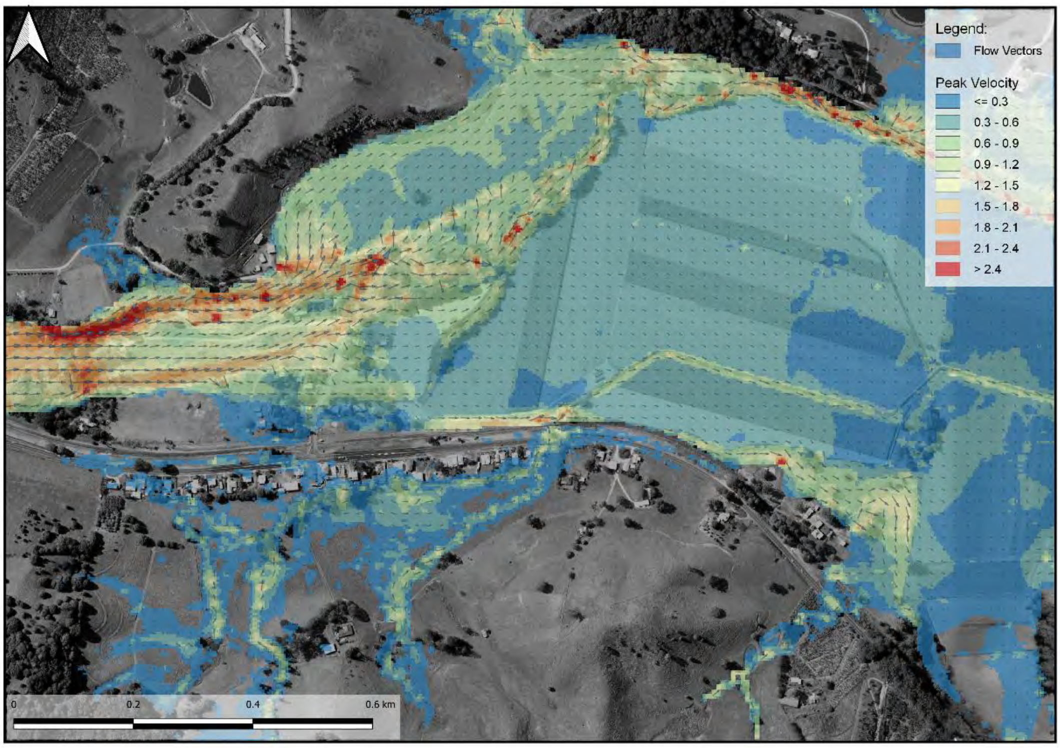

Figure 3-16: Peak velocity magnitude and direction -1% AEP flood gates at rail culvert

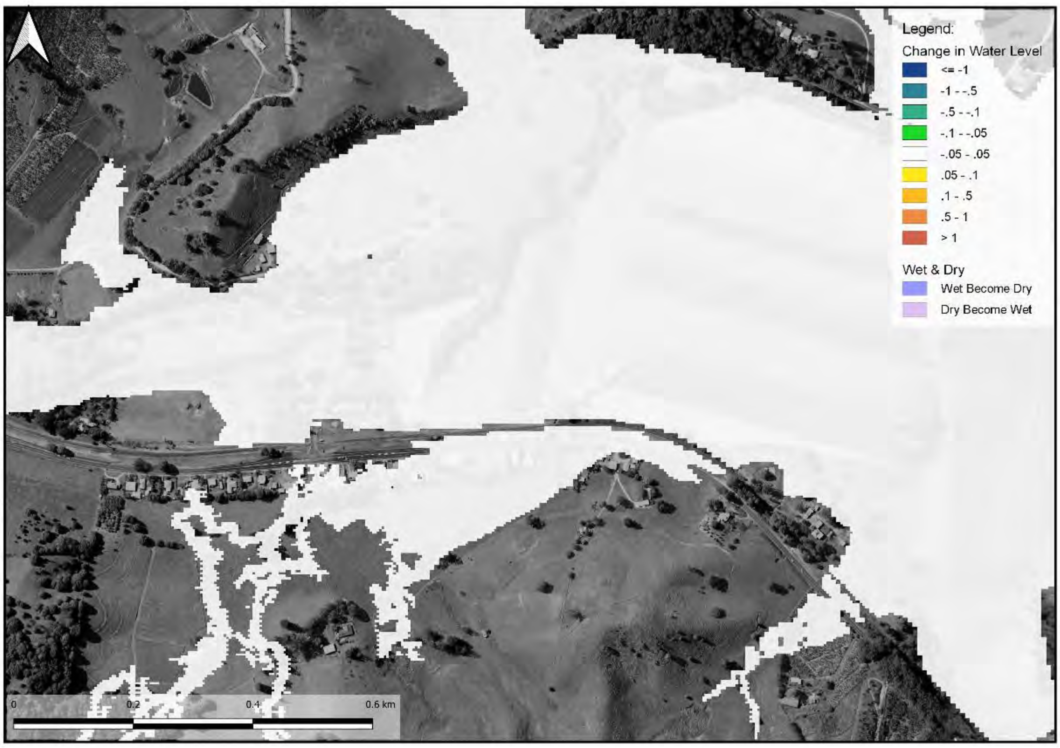

Figure 3-17: Difference in peak elevation flood gates at rail embankment vs. existing

4 Summary and limitations

This report was undertaken by JBPacific on behalf of Tweed Shire Council (TSC) to provide an improved assessment of flood risk in Mooball Village to enable application of appropriate flood planning levels for this area. This included: (1) to provide an improved, more accurate, assessment of flood risk in the Mooball Village, and (2) to test the impact/feasibility of a flood mitigation measure to reduce flooding in the village using a floodgate.

Enhancements were made to the 2D hydraulic model developed for a regional-scale assessment. This included improved definition of the railway embankment, addition of new 1D structures to represent culverts, refinement of the hydrologic model within the small upstream watershed south-west of Mooball Village and the inclusion of direct-rainfall modelling for the small upstream catchment behind Mooball Village.

The updated model was simulated for the design-event, a 1% Annual Exceedance Probability (AEP) scenario, which resulted in an updated 1% AEP flood level of 12.56m AHD. This flood level is higher than against Councils existing flood planning level of 12m AHD, and the updated Tweed Flash Flood Forecasting System level of approximately 12.2m AHD. The increase is due to

- The inclusion of the small upstream drainage channel above Mooball Village which now flow into the backwater-affected culverts
- An improved representation of the Tweed Valley Way culvert which facilitates backflow through the railway embankment.

New scenario testing was undertaken for several scenarios where the railway embankment was removed or breached, and new flood gates added to culverts. By changing the railway embankment, the following changes in peak flood levels were observed, when compared to the updated 1% AEP flood level of 12.56m AHD. These have been compared near to the Victory Hotel, 5909 Tweed Valley Way.

1. Removal of the entire railway embankment during the 1% AEP. This results in the peak flood level at the central Mooball reporting point to be 12.64m AHD. The flood extent increases west of the Pottsville Road intersection, and the largest increases to flood levels occur to the east of the intersection, increasing by up to 0.3m.
2. Inclusion of a 30m breach within the railway embankment during the 1% AEP. The peak levels at the central Mooball reporting point were 12.57m AHD. The flood extent increases west of the Pottsville Road intersection around the location of the breach. However, unlike the removal of the embankment, the peak flood levels do not increase to the east of the intersection.
3. Inclusion of a flood gate on the railway embankment during the 1% AEP. This initially allows local runoff to flow from Mooball through the culverts towards the Burringbar Creek. However, the long duration flooding of the creek holds the gates closed for a long period, resulting in the peak flood level within central Mooball to be 12.56m AHD (i.e. it matches the regional flood level). The flood extent does not increase nor does the peak flood level increase around Mooball Village or through the main channel of Burringbar Creek north of the village

4.1 Limitations

Whilst an improved investigation, the study retains some limitations. By using the adopted regional model for a site-specific investigation a relatively course grid sizing remains. This is suitable for regional flood studies however may limit the results for urban drainage studies. For any future studies it is recommended that the regional model continues to be updated in urban flood areas to provided better accuracy and certainty in decision making.

JBPacific conducted several sensitivity tests in terms of location and size of breach extent which showed minimal difference to the reported modelling outcome. However, further sensitivity testing associated with the timing and duration of embankment failure may improve confidence in results as other scenarios are tested. Additionally, further rainfall scenario testing should be performed to determine and model the critical flood scenario at Mooball Village, particularly due to the new drainage catchment created to the south-west of the town. The adopted 1% AEP flood scenario used in this study was determined using the regional model and is based on flooding from Burringbar Creek.

Overall, the updated flood modelling results are considered suitable to be used to define Councils' new flood planning and development extent. The removal of the railway embankment results in the largest flood extent and levels south of the rail embankment, and could be considered the worst-case scenario.

Offices in
Australia
Cambodia
Ireland
Romania
Singapore
UK
USA

Registered Office
477 Boundary Street,
Spring Hill QLD 4000
Australia

t: +61 (0)7 3085 7470
e:info@jbpacific.com.au