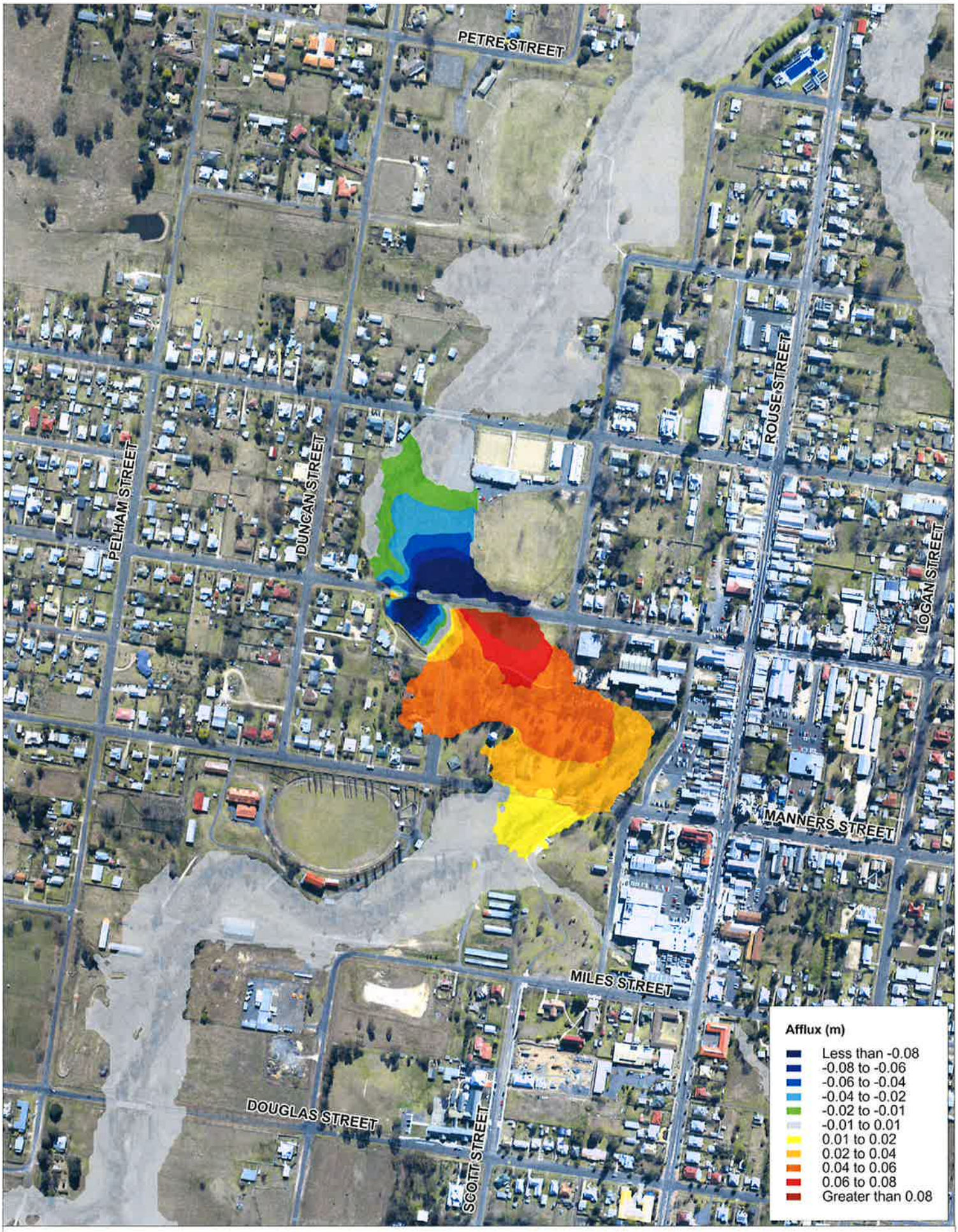

JACOBS

N

Scale: 1:4,000

Datum: MGA56
Coordinate System: MGA Zone 56

Figure 7-9

Impacts of Raising High Street Bridge, 1% AEP Event

Project: Tenterfield Floodplain Risk Management Study

7.6.2 Structural Responses: Individual Properties

It is also noted that as the AAD is dominated by four properties (two residential and two commercial), local property, disaster or flood modification measures such as changing building materials, facility disaster management plans and or local bunds or drains may provide appropriate risk reduction measures. Protecting these properties from above floor flooding in the 1% AEP flood event would reduce the damages in a 1% AEP by approximately $150,000 but only reduce the AAD by approximately $3,000. The AAD associated with these properties would not support a voluntary house purchase or raising scheme.

However, it is recommended that Council support existing property owners through any development application process where the property owner is seeking to make changes to their properties to reduce their personal flood damages. Council could provide support through provision of information on flood protection of buildings, support to development applications for modification such as house raising and if appropriate financial concessions.

The costs associated with this would be minimal and only associated with the time required for the development assessment.

8. Recommendations for Floodplain Risk Management Strategy

The existing flood risk in Tenterfield is considered low when compared to other floodplains in Australia. There are few existing properties within the 1% AEP and a relatively minor number of houses located within the PMF. As a result the flood damages for Tenterfield are relatively low and flood modification measures are considered unlikely to provide benefits that outweigh their cost. However, there is a need for Council to manage the future and continuing risk through property modification measures and disaster response measures. In particular the following are recommended for further investigation.

Priority Measures

The following measures are recommended as priority measures to be undertaken in the next 12 to 24 months.

- **Development Control:** The future flood risks for Tenterfield are largely associated with the future development of the floodplain. There are not currently significant development pressures in Tenterfield and as a result there is an opportunity to consider development controls without unduly compromising growth. It is recommended that the flood hazard criteria proposed in this FRMS is used to inform future development control and land use planning. The hazard criteria applied under Council's current LEP will support Council in identifying potential conflicts between development and flood hazard and support Council in conditioning development to manage this risk accordingly e.g. structural integrity of buildings and flood access. This information will be provided as GIS layers to Council as part of this study and as such the costs associated with implementing this control are considered minor.
- **Flood Information – 149 Planning Certificates:** The provision of flood information to the community is considered to form a key risk reduction measure for Tenterfield. Given that the majority of flood prone properties were not inundated by January 2011 and would not be inundated by the predicted 1% AEP, this is an important measure for managing future and continuing flood risk. It is recommended that information identifying the 1% AEP, January 2011 flood level is included as a comment on all planning certificates. It is also recommended that information identifying if the property has the potential to be flooded in very rare or extreme events is provided. The cost of implementing this recommendation could be largely undertaken by Tenterfield Shire Council using the GIS data provided through this FRMS. However, costs for assistance in the integration and automation of this process could range between $2,000 and $20,000 depending on Council's system, the level of detail provided and if this is undertaken in combination with other activities such as a move to web based mapping.
- **Flood Planning Levels:** A review of the current flood planning levels was undertaken as part of this FRMS with consideration given to the adoption of an FPL based on January 2011 flood levels. This option was not recommended as the measure was considered to unduly impact on existing development for the benefit of future development, of which there is minimal development pressures. Furthermore it was considered that the high and medium flood hazards that present the largest risk to life could be appropriately managed through development control under the current LEP which allows for consideration of flood hazard. Where the community sought to provide themselves with a higher level of protection information on the January 2011 flood levels could be provided through the proposed changes to the 149 planning certificates. In August 2014, the FRMC reviewed the information and recommendations provided in this study and voted to retain the FPL based on a 1% AEP plus 0.5 m freeboard.
- **Investigations into new BoM ALERT Stations:** It is recommended that improved flood warning through installation of new BoM ALERT gauges is further investigated. The costs associated with new gauges would be between $20,000 and $87,000. The cost of this is high relative to the flood damages in Tenterfield and the potential benefits in terms of reduction to AAD. However, improved flood warning provides the greatest opportunity to minimise threats to personal safety for events larger than the January 2011 flood event. As this measure would require support and funding from BoM it is recommended that this measure is discussed further with BoM as part of the FRMP.
- **Pre-cooked Flood Maps based on Design Events:** It is recommended that pre-cooked flood maps identifying properties at risk of flooding and above floor flooding for the full range of design events are prepared and distributed to emergency services personnel. These maps can be developed from the existing flood information at a relatively low cost $6,000 and will greatly assist in identifying priority areas in

the event of a flood rarer than the January 2011 flood event. These maps may also assist in a dam break scenario.

- **Flood education to improve community readiness:** The risks to personal safety may be reduced for existing and future residents for floods of all magnitudes by the enhancement of existing disaster response measures. Given the relative abundance of flood refuges in Tenterfield any steps that can be taken to pre-prepare the community and make use of the effective warning time will enable the community to take action reducing their flood damages. Flood awareness campaigns through Councils existing media including the website, newsletter, email, newspaper advertisements, public signage provides a low cost medium to distribute this information. It is recommended that Council employs an annual awareness campaign prior to the storm season that focus on reminding the community of key flood risks such as driving through floodwaters.

Secondary Considerations

The following measures are recommended as secondary measures. These measures are secondary priorities due to their cost, time required to implement and or benefit to reducing the flood risks currently applicable to Tenterfield. It is recommended that these measures are reviewed by Council with further investigations regarding their implementation taken over the next five years, subject to Council's financial constraints.

- **Future Land Use Planning:** As discussed above the future flood risks for Tenterfield are largely associated with the future development of the floodplain. At present the entire Tenterfield township is zoned as "Village" there is an opportunity as part of any future revisions to Council's planning scheme to revisit this zoning and consider alternative zonings compatible with the flood hazard. The cost of this activity would be dependent on the scale of the broader revision to the planning scheme.
- **Upgrades current Flood Siren to Include Voice Warnings**: The cost estimates for decommissioning of the current sirens and installation of a modern version is approximately $75,000. The cost of this option is significant relative to the estimated flood damages and as such it is recommended that this option is considered over a longer term planning horizon in conjunction with measures undertaken to improve flood warning for dam safety.
- **Pre-cooked Flood Maps linked to Gauge Data:** As per the pre-cooked flood maps linked to design events this data would provide an estimated flood extent based on a gauge level. These maps could be created after upgrades to the flood warning system. The mapping based on gauge data would be a moderately higher cost and as such is recommended over a long planning horizon.
- **Flood Totems:** Flood totems are a relatively low cost floodplain risk management measure and are in the order of $10,000 per Totem. The installation of flood totems is recommended for Tenterfield to preserve flood knowledge of the January 2011 event and remind the community that events larger than this event can occur. However, given that the 2011 flood event was less than 5 years ago installation of flood totems need not be undertaken as a priority action and may be installed over the next 5 year planning horizon. Council may also wish to consider funding the flood totem as a public sculpture to provide a cultural or visual asset to the park environment.
- **Support for owner driven modifications of at risk properties**: The FRMS found that while the AAD's for Tenterfield and individual properties in Tenterfield is relatively low, the damages are dominated by half a dozen properties. It is recommended that Council consider options to support owner driven and funded modification of their properties for the purposes of flood risk management. This could be achieved through, provision of information on flood protection of buildings, support to development applications for modification such as house raising and if appropriate financial concessions. Given the relatively small number of properties that fall into this category it is recommended that each application is assessed on its own merits. As protecting these properties from above floor flooding at the 1% AEP would reduce the AAD's by $3000. It is recommended that any financial assistance for these measures be capped at $3,000 per annum.
- **Improvements to road safety:** Upgrading road infrastructure to provide an immunity of a 1% AEP is likely to result in significant impacts to flooding. However, minor road raising such as pavement resurfacing undertaken in conjunction with other routine repair or maintenance works may assist in improving flood access for frequent events, with flood impacts able to be contained to parkland. It is recommended that

this option is considered as part of any future design or upgrade works for the Tenterfield Creek road crossings.

Measures Associated with Dam Safety

While the aspects of dam safety are outside the scope of work of this assessment the review of the flood warning system indicated the warning system is not functioning as per its original design intent. It is recommended that Council discuss matters relating to the operation of the Flood Warning System with the NSW Dam Safety Committee and any agreed repair or remediation actions be undertaken.

FLOODPLAIN RISK MANAGEMENT PLAN

9. Flood Risk Management Plan

9.1 Introduction

This Flood Risk Management Plan (FRMP) provides a framework for addressing flood risk in Tenterfield over the next five to ten years. The actions outlined in the FRMP address the issues identified in the FRMS and align with its recommendations. **Table 9-1** provides a summary of the recommended options that form the basis of this plan.

Table 9-1 illustrates that the majority of the recommendations focus on disaster response modification measures to manage the continuing risk for events larger than the FPL as well as the public safety of persons outside of building's during a flood event. While a number of property modification measures are proposed for managing future flood risk no flood modification measures are proposed. This is due to the fact that flood modification measures are usually undertaken to mitigate existing flood risks and as the existing flood damages in Tenterfield are low there is not a significant driver for flood modification measures.

Table 9-1 Summary of Flood Risk Management Measures

Measure	Property Modification Measures	Response Modification Measures	Flood Modification Measures
Description	Modifying existing properties to address existing, future or continuing flood risk	Modifying the response of the population at risk to enable them to better cope with a flood event.	Modifying the behaviour of the flood to remove or reduce the extent, severity or frequency of flooding.
Recommended Measures			
Priority	P1 a) Development control based on flood hazard P2 a) Flood Information on 149 Planning Certificates.	R1 a) Investigations into new BoM ALERT Stations R2 a) Pre-cooked flood maps based on design events: R3 a) Flood education to improve community readiness: R3 b) Flood totems	None
Secondary	P1 b) Future land use planning based on flood hazard P3 a) Support for owner driven modifications of at risk properties:	R1 b) Upgrades current flood Siren to Include Voice Warnings: R2 b) Pre-cooked flood maps linked to gauge data	F1 Improvements to road safety:

9.2 Implementation Schedule

The purpose of the FRMP is to provide Tenterfield Shire Council with management measures for addressing the hazards associated with flooding to minimise the financial and personal loss in the event of flooding.

The implementation schedule is the key component of the FRMP and provides a summary of all items recommended as part of the FRMS. The implementation schedule identifies the key actions, priorities responsibilities, costs and performance indicators. The implementation schedule is provided in **Table 9-2**.

The prioritisation of measures has been based on consideration of the cost of the measure and its effectiveness as a control to provide the greatest value for money for Council. In developing the priority actions consideration

was also given to the ease at which Council could action the proposed recommendations through existing Council activities.

The prioritisation has also considered feedback from the community members. For example, while the installation of flood totems is recommended it was not considered a priority activity as the existing level of community flood knowledge is relatively high given the recent 2011 flood event. However, feedback from the community indicated a positive response to this recommendation and it is therefore recommended that this is considered in the near future.

The FRMP and implementation schedule typically specifies activities covered within the first 5 years. However, as the majority of the flood risk for Tenterfield is associated with future and continuing flood risk a number of longer term planning and response measures have been proposed which may fall outside the five year horizon. These measures have been identified as valuable opportunities to reduce flood risk but are either dependant on other council activities or are considered unlikely to result in significant flood risk reductions over the short term. For example, it is unlikely that the development pressure in Tenterfield would see applications for significant development in flood prone areas such that the zoning in the current planning scheme mandates a review in the next 5 years. However, there would be value in any future updates to the planning scheme zoning considering changes based on the flood hazard categorisation provided in the FRMS. Therefore the measures included in the five to ten year horizon are provided so that they may be implemented should the appropriate circumstances arise and or funding opportunities become available.

The implementation and timing of these activities will be dependent on the availability of Council resources and funding, particularly State Government funding assistance.

Table 9-2 Implementation Schedule

Specific Actions	Priority	Responsible	Indicative Cost	Performance Indicator	Further Information
Planning Controls					
P1) Review Zoning and Development Control					
a. Incorporate flood hazard categorisation from the FRMS into current planning assessment schemes via Section 6.2 of the LEP. Outline requirements for Development Applications to address flood risk based on the flood hazard category at the site. Development should be limited in high hazard areas. Development in medium hazard areas should consider measures such as flood-proof materials, maintaining access during flooding and building above the FPL.	1	TSC	Council staff time only	Flood hazard categorisation mapped by lots and accessible to Council planning staff by December 2014. Review of planning documentation undertaken in 2014/15 financial year. Changes finalised by December 2015.	Section 7.2
b. Review the compatibility of existing landuse zoning and development controls as defined in the LEP to existing flood risks as defined by the hazard classification of this FRMS.	2	TSC	Council staff time only	Review of compatibility of existing zoning and flood hazard by 2017/2018 financial year.	Section 7.2

Specific Actions	Priority	Responsible	Indicative Cost	Performance Indicator	Further Information
c. Assuming that there are incompatibilities in the existing zonings and development controls; formulate recommended changes to the existing planning provisions to support more flood appropriate new development.	3	TSC	Council staff time only	New planning conditions developed and available for incorporation in any parallel updates or revisions to the LEP.	Section 7.2
P2) Provide Flood Information to Community on Form 149 Certificates					
a. Include information on predicted flooding at properties on 149 Planning Certificates in the *Additional Comments* field.	1	TSC	Council staff time $2,000 to $20,000 (depending on automation of system).	Information in appropriate format and accessible to Council planning staff by December 2014. . All 149 Planning Certificates issued for flood-prone lots after December 2014 show this information.	Section 7.2
b. Investigate opportunities to provide flood risk information to community through online flood risk maps and or property reports.	2	TSC	Council staff time only	Data and text for inclusion on Council's website identified by 2017.	Section 7.2
c. Provide online access to flood information and flood mapping through Council's website.	3	TSC	$15,000	Information available on Council's website by 2019	Section 7.2
P3) Support for Owner Driven Modification of at Risk Properties					
a. Identify list of building materials, products and applications that improve flood resilience. Where possible include a list of local suppliers.	1	TSC	Council staff time only	Content for website identified by 2014/2015 financial year.	Section 7.6
b. Provide information on flood protection of buildings on the Council website and provide information on using flood resilient building materials and products in relevant development applications.	1	TSC	Council staff time only	Information available on website by end of 2014/2015 financial year.	Section 7.6

Specific Actions	Priority	Responsible	Indicative Cost	Performance Indicator	Further Information
c. Investigate opportunities to support existing property owners where the property owner is seeking to make changes to their properties to reduce their personal flood damages.	2	TSC	Council staff time only	Determine financial or regulatory concessions that may be provided to property owners and draft policy by 2015/2016 financial year.	Section 7.6
d. Assuming policy is approved. Provide support to residents seeking development approval for flood mitigation works on their properties.	2	TSC	Council staff time. Any financial assistance Capped at $3,000 per annum	Implement policy and communicate to community by December 2016.	Section 7.6
Disaster Response Measures					
R1) Flood Prediction and Warning					
a. Collaborate with Council's current dam safety initiatives with respect to the existing early warning system. Scope of works to be confirmed through consultation with the NSW dam safety committee.	1	TSC	Council staff time only	Review undertaken and recommendations made by December 2014.	Outside Scope of this Study
b. Investigate opportunities to improve the flood warning system through installing new BoM alert gauges. This may include a new sub-daily ALERT rainfall gauge in the Groombridges Creek catchment and repair and incorporation of the existing streamflow gauges into the ALERT system.	2	TSC with support from BOM	Council staff time only	TSC to discuss proposed plan with BoM and apply for funding by end of 2014/15 financial year.	Section 7.5
c. Design and install additional instrumentation, hardware and software required to complete the Flood Warning System. Option to install tilt pan zoom camera on Currys Gap Road for additional flood warning information. Consider options such as flood warnings sent via SMS.	2	BoM and TSC	$20,000 to $97,000 (grants available)	Flood warning installations completed by 2015/2016 financial year.	Section 7.5

Specific Actions	Priority	Responsible	Indicative Cost	Performance Indicator	Further Information
d. Decommission the current Federation Park, Shirley Street and Douglas Street sirens and install a modern version at Shirley Street. Update siren software to provide a trigger for non-dam break flood warning.	2	TSC	$75,000	Target is December 2015, dependent on funding. It is noted that this measure also provides for dam safety which is outside the scope of this study.	Section 7.5
e. Update the Tenterfield Shire Local Flood Plan to reflect changes to the flood warning system.	2	TSC in consultation with SES	Council staff time + $10,000	Completed and within one month of new system being implemented.	Section 7.5
R2) Pre-Prepared Flood Maps for Emergency Services					
a. Improve Tenterfield Shire Flood Emergency Sub Plan by incorporating "detailed flood intelligence" prepared during the FRMS.	1	TSC in consultation with SES	SES and Council staff time only	Completed by December 2014.	Section 7.3
b. Use existing flood model results to generate maps showing properties that are likely to be inundated for various design flood events. Provide maps to SES and other emergency services.	1	TSC and SES	$6,000	Maps available by December 2015.	Section 7.3
c. Assuming installation of new flood warning system. Develop maps showing properties that are likely to be inundated for various gauge flood levels and provide maps to SES and other emergency services	2	TSC and SES	$15,000	Maps available by December 2016, assuming construction of new flood ALERT stations.	Section 7.3
R3) Improve Community Awareness					
a. Develop a community education and awareness program to integrate with other initiatives and improve preparedness for flooding.	1	TSC	Council staff time + $10,000	Documented program of community education works by October 2015 prior to 2015 wet season.	Section 7.4
b. Prepare and deliver a range of resources and materials as part of the Community Education Program (such as a Tenterfield specific FloodSafe brochure).	1	TSC and SES	Council staff time + $3,000 per annum	Materials delivered	Section 7.4

Specific Actions	Priority	Responsible	Indicative Cost	Performance Indicator	Further Information
c. Release reminders prior to the wet season through Council's newsletter, website and paper advertisements.	1	TSC	Council staff time only	Reminders released in November 2014 and procedures in place to continue in subsequent years.	Section 7.4
d. Investigate opportunities to commission a flood totem and place flood totems in public areas (e.g. parks).	1	TSC	$10,000 per totem	One totem installed by December 2016. Review whether further totems should be installed considering community feedback.	Section 7.4
R4) Additional boom gates at flood-prone road crossings					
a. Investigate the feasibility of additional boom gates.	2	TSC	Council time only	Decision reached by July 2015	Section 7.3
b. Install boom gates if supported by the outcome of (a).	2	TSC	$1,000 per crossing	Boom gates installed by December 2015.	Section 7.3
Flood Modification Measures					
F1) Road and Bridge Upgrades					
a. Consider upgrading local roads to improve flood immunity when other significant road works are being undertaken.	3	TSC	Funded through other drivers for road upgrade	Flood immunity of road considered in upgrade works.	Section 7.6
b. Develop a prioritised list and plan for road crossings to be inspected and re-opened following flooding. Incorporate in Tenterfield Shire Flood Emergency Sub Plan.	2	TSC	SES and Council staff time only	Completed by end of 2014/15 financial year.	Section 7.6.1

9.3 Importance of Consultation

As the existing flood damages for the Tenterfield township are relatively low the measures recommended focus on providing improvements through low capital cost options and use of existing Council and SES resources. This will allow for the continuation of flood safe development through the provision of flood information and improved disaster coordination and community response. It is recommended that there is regular consultation between Council, SES and other emergency response agencies to share resources and develop tools and programs in an efficient and consistent manner. It is recommended that the Tenterfield Shire Flood Emergency Plan continues to form the key documentation for disaster management activities and that additional location specific information for Tenterfield is incorporated into this document through the local flood intelligence section.

There are a number of existing resources from which Council and the SES can draw on to develop resources for the community. These resources include material presented in this document and associated GIS data, existing emergency response materials in particular the AFAC guideline for emergency planning in response to flash flood events and the SES FloodSafe guidelines (AFAC 2013).

It is important to note that of the above measures a significant proportion rely on the community taking appropriate action to be effective; for example, using a flood totem to identify areas within their community above a given flood level such as a friend, neighbour or family member's property and retreating to these areas during a flood event. It is important that this message is conveyed to the community in future flood education programs such that the community is empowered to take appropriate thereby improving the effectiveness of the measure.

The success of this FRMP will require commitment by organisations involved to dedicate appropriate time and resources to achieve the objectives and timeframes within the Plan. It is recommended that this is supported through ongoing regular communication between the relevant parties.

9.4 Funding and Timing

As part of the NSW Governments Floodplain Management Program, financial assistance is provided to Councils for the implementation of floodplain management measures. At present funds are provided on a 2:1 (State: Council) basis. The provision of state funds is dependent on state wide priorities as well as the availability of funds.

The total estimated capital costs of implementing the plan is estimated at $236,000 with maintenance costs of between $3,000 and $7,000 per annum. This maintenance cost assumes an on-going cost associated with maintaining gauges, community flood awareness campaigns and flood readiness. **Table 9-3** provides a breakdown of the estimated costs.

Given the relatively low flood damages in Tenterfield the costs of major capital works are not justified. However, it is important that the threat to life associated with the potentially high flood hazard on existing road crossings is further mitigated through improvements to flood warning and community awareness and readiness. Therefore, the proposed measures have focused on low cost activities which can largely be completed through Council's existing resources and capital funding of improvements to the flood warning system. While the direct property damages do not provide a cost benefit ratio that justifies the cost of the implementation plan it is important that Council actively seek funding to improve flood warning to reduce the risks to personal safety associated with future flood events.

Table 9-3 Timeline of Costs for Implementation Actions ($'000)

Year	1	2	3	4	5	5 – 10
P1) Review Zoning and Development Control	Nil	Nil	Nil	Nil	Nil	Nil
P2) Provide Flood Information on Form 149 Certificates						
a) Generate comments for each property	2	Nil	Nil	Nil	Nil	Nil
b) & c) Provide web maps of flooding	Nil	Nil	Nil	Nil	20	Nil
P3) Support for Owner Driver Property Modification	Nil	Nil	Nil	Nil	Nil	3*^
R1) Flood Prediction and Warning						
a) Review flood warning system for dam safety	Outside scope of this study.					
b) & c) Investigate, design and install new gauges	Nil	Nil	97	1*	1*	1*
d) Update flood sirens	Nil	75	Nil	Nil	Nil	Nil
e) Update Local Flood Plan for gauge data	Nil	Nil	Nil	10	Nil	Nil
R2) Pre-Prepared Flood Maps for Emergency Services						

a)	Incorporate detailed flood intelligence into local flood plan	Nil	Nil	Nil	Nil	Nil	Nil
b)	Pre-cooked flood maps for design events	Nil	6	Nil	Nil	Nil	Nil
c)	Pre-cooked flood maps for gauged flood levels	Nil	Nil	Nil	15	Nil	Nil
R3) Improve Community Awareness							
d)	Develop community awareness program	Nil	Nil	Nil	Nil	Nil	Nil
e)	Prepare and delivery resources to community	3*	3*	3*	3*	3*	3*
f)	Release reminders prior to wet season	Nil	Nil	Nil	Nil	Nil	Nil
g)	Install flood totem/(s)	Nil	10	Nil	Nil	Nil	Nil
R4) Additional boom gates at flood-prone road crossings							
a)	Investigate feasibility and need	Nil	Nil	Nil	Nil	Nil	Nil
b)	Install additional boom gates if required	Nil	1	Nil	Nil	Nil	Nil
F1) Road and Bridge Upgrades		Only cost effective if funded through other drivers for upgrades					
	Total maintenance only	3	3	3	4	4	7
	Total capital	2	92	97	25	20	Nil
	TOTAL	**5**	**95**	**100**	**29**	**24**	**7**

*maintenance cost estimate ^ capped at $3,000 as based on AAD investment above this level is not warranted.

9.5 Monitoring and Review of Plan Progress and Success

The FRMP provides a framework for the implementation of floodplain risk reduction measures. The FRMP is considered a live document and requires regular monitoring and review to ensure its effectiveness and ultimately the success of the plan in addressing existing, future and continuing flood risks.

An important element of this is to establish a process to track actions and rectify any sub-optimal performance from the implementation of measures. It is therefore recommended that the effectiveness of the plan is evaluated every 2 years.

The evaluation process should seek to answer the following questions

- What actions have actually been implemented?
- Where actions have been implemented was the nominated performance measure achieved?
- What strategies are outstanding that would have been implemented within this timeframe?

Where action has not been implemented, the cause for the delay should be considered along with opportunities to remove the potential blocker and/or seek alternative pathways, i.e. alternative funding sources. The plan should then be modified and updated to reflect the revised time frame and or actions to enable the success of the measures to be considered at the next review.

Where the implementation of measures has been undertaken the successful completion of these measures should be considered against the performance indicator outlined in **Table 9-2**.

The life of a FRMP is typically five to ten years. After this time, changes to industry practices, legislation, regional planning strategies, and development pressures are likely to warrant a review of the FRMS and FRMP. In addition to this a significant flood event may also provide a catalyst for review of the Flood Study which forms the basis of this FRMS and FRMP. This may occur prior to the five to ten year review period. The decision to review or update the Flood Study or FRMS and FRMP should be based on the potential implications of the change on the findings presented in this document.

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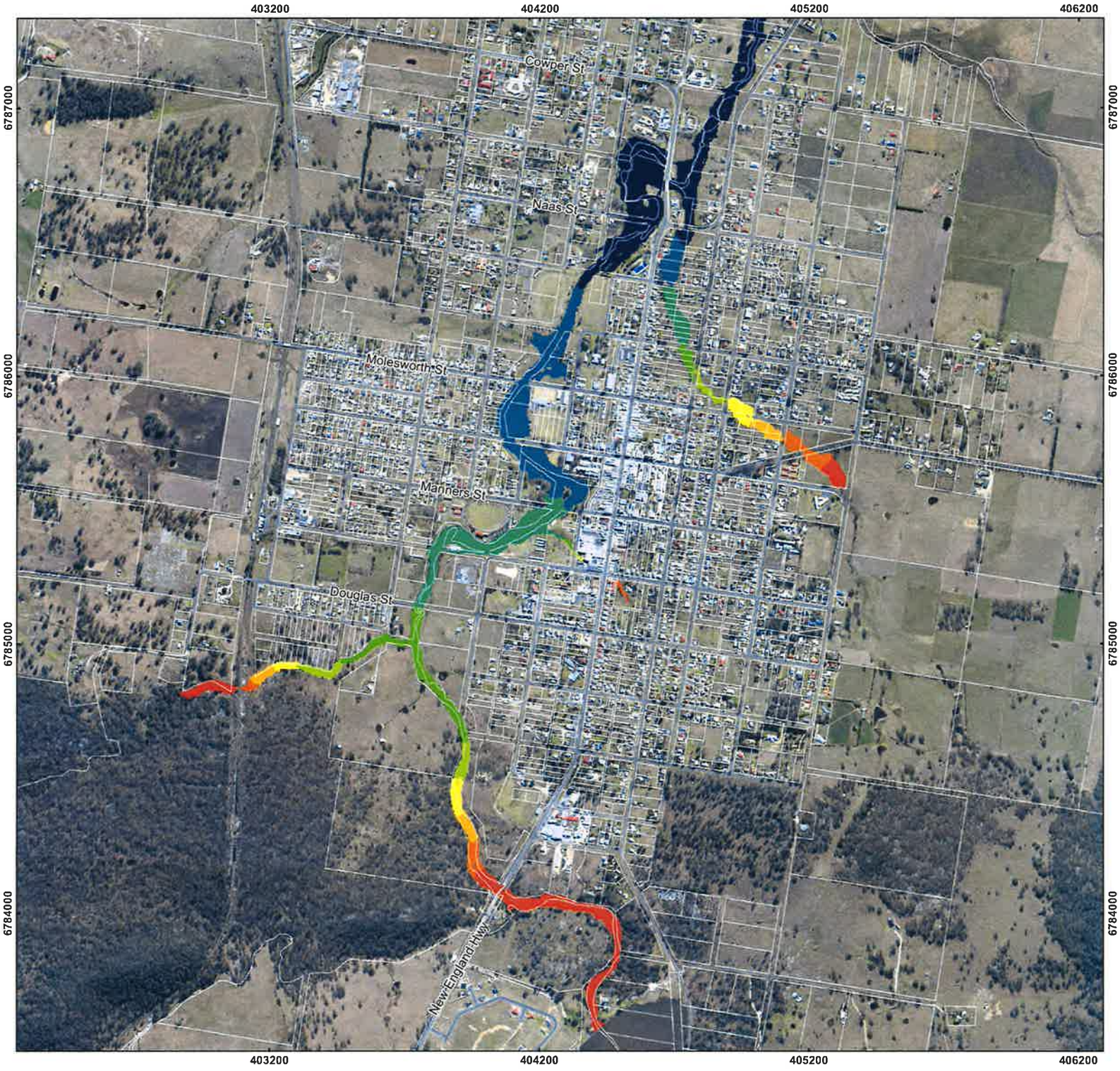
Appendix A. Flood Study Results (DHI, 2013)



Surface Elevation [mAHD]

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- 838 - 840
- 840 - 842
- 842 - 844
- 844 - 846
- 846 - 848
- 848 - 850
- 850 - 852
- >852

N

0 50 100 200 300 400 500
Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Surface Elevation Map
2001 Validation Event

Project No.: 43800373
By: MOBA
Date: 9/05/2013

DHI
Level 5
67 Astor Terrace
Spring Hill QLD 4000
Tlf: +61 7 3236 9161
Fax: +61 7 3236 9461
www.dhigroup.com

Water Depth [m]

- 0 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- >5

N

0 50 100 200 300 400 500

Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Water Depth Map
2001 Validation Event

Project No.: 43800373
By: MOBA
Date: 9/05/2013

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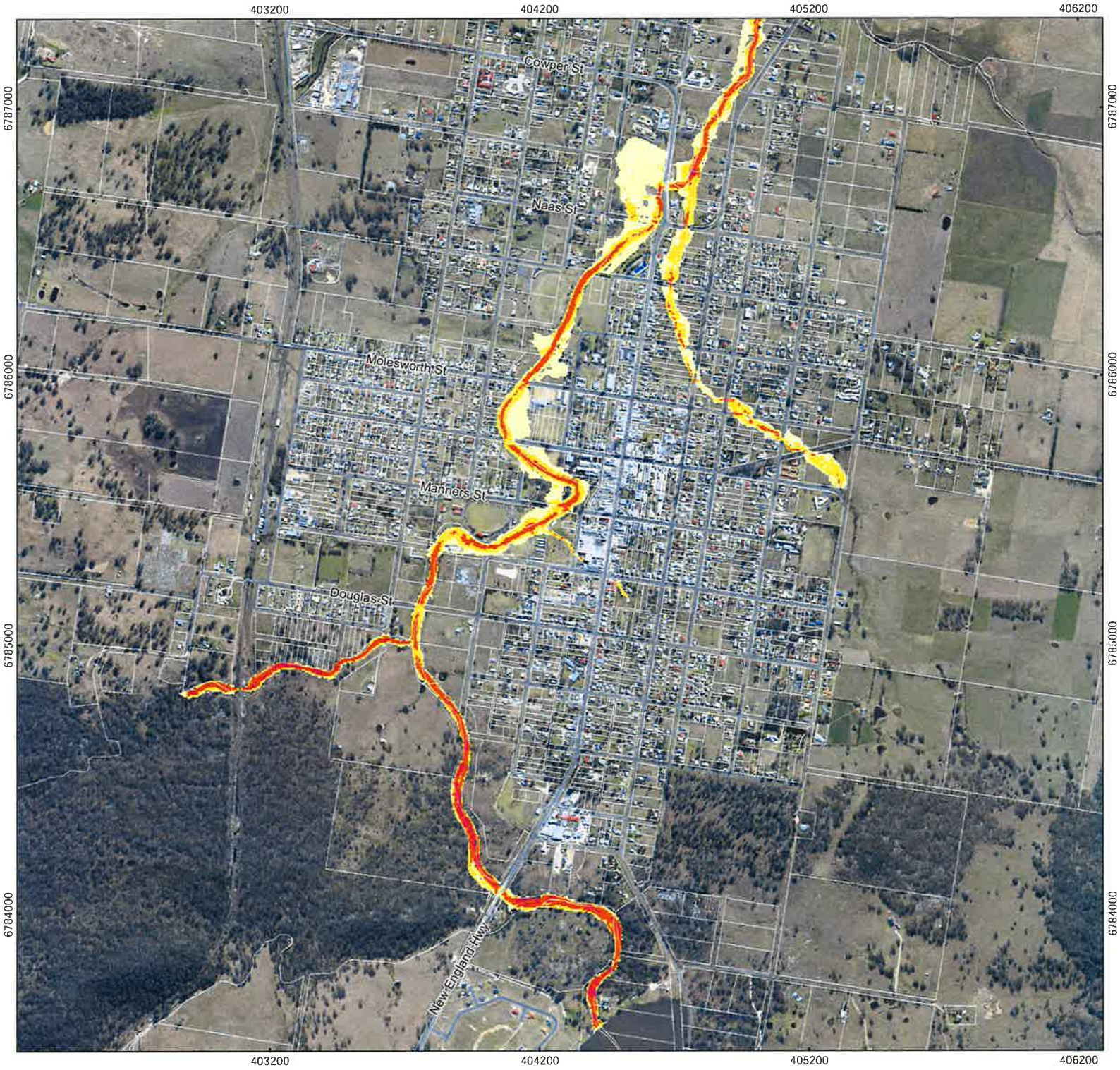

Current Speed [m/s]

- <0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- >5

N

0 50 100 200 300 400 500

Meters

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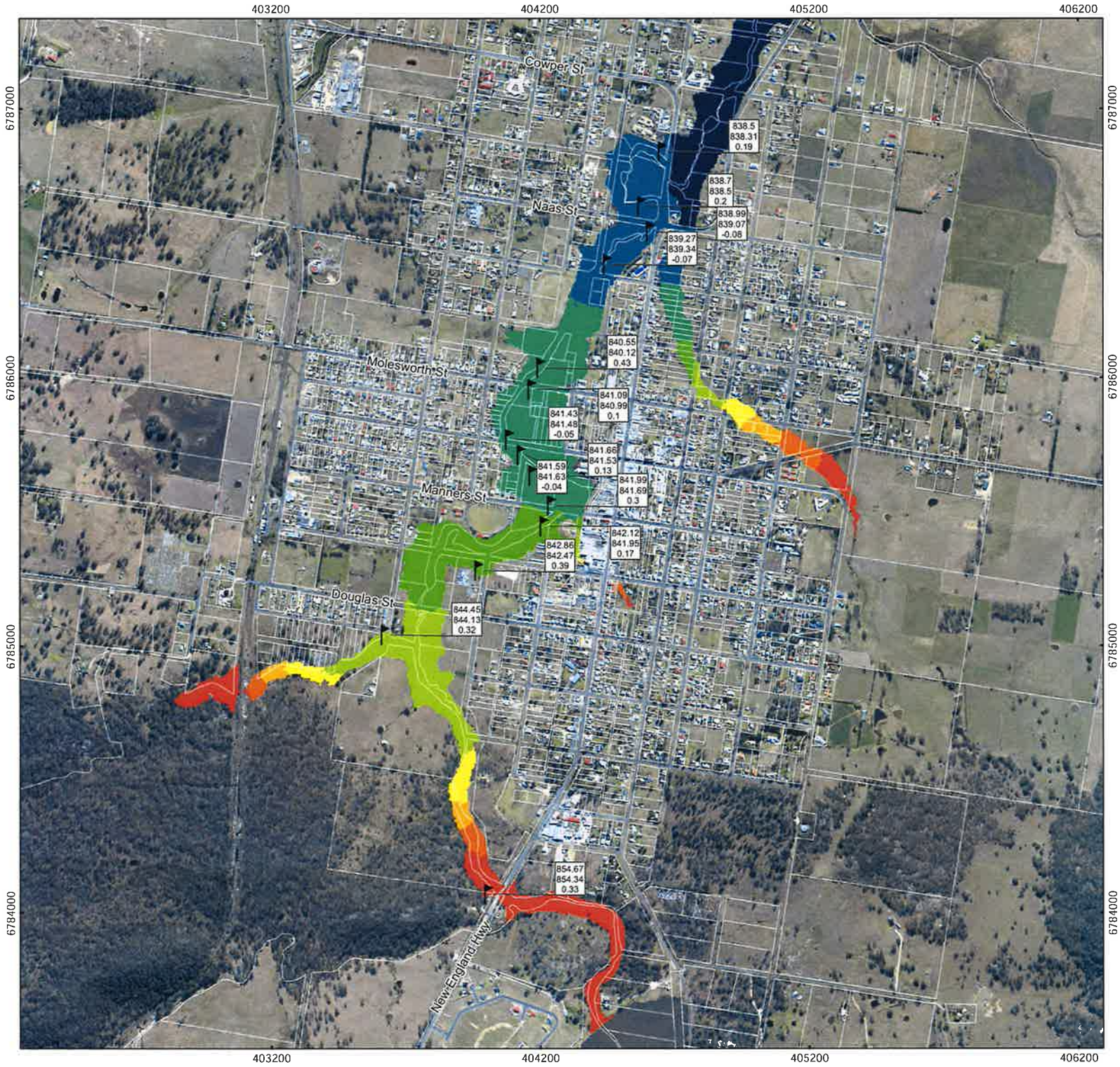

Surface Elevation [mAHD]

- <838
- 838 - 840
- 840 - 842
- 842 - 844
- 844 - 846
- 846 - 848
- 848 - 850
- 850 - 852
- >852

Spot Water Levels

Modelled
Surveyed
Difference

N

0 50 100 200 300 400 500

Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Surface Elevation Map
2011 Calibration Event

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Water Depth [m]

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- 3 - 4
- 4 - 5
- >5

N

0 50 100 200 300 400 500

Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Water Depth Map
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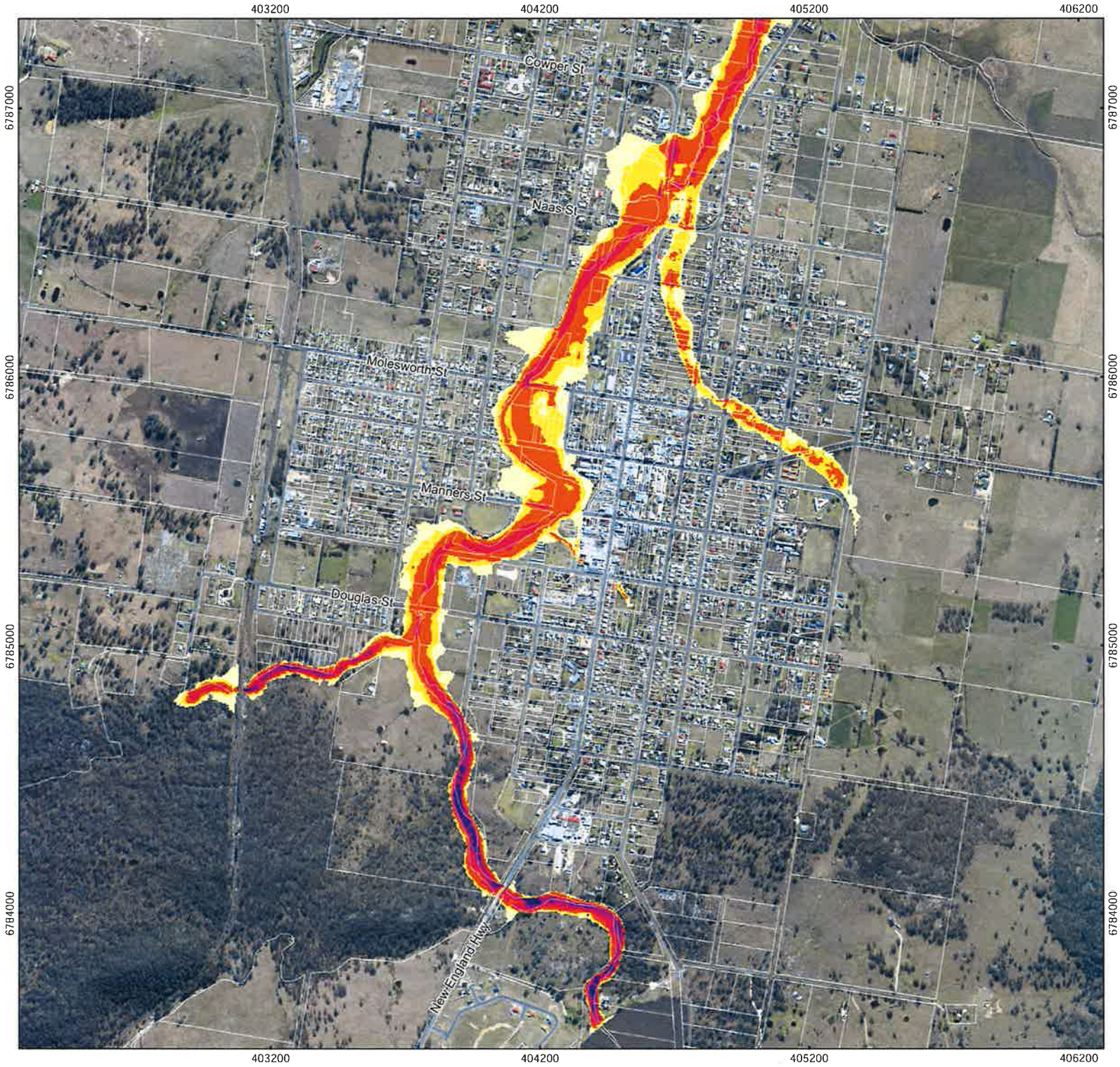

Current Speed [m/s]

- <0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- >5

N

0 50 100 200 300 400 500

Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Current Speed Map
2011 Calibration Event

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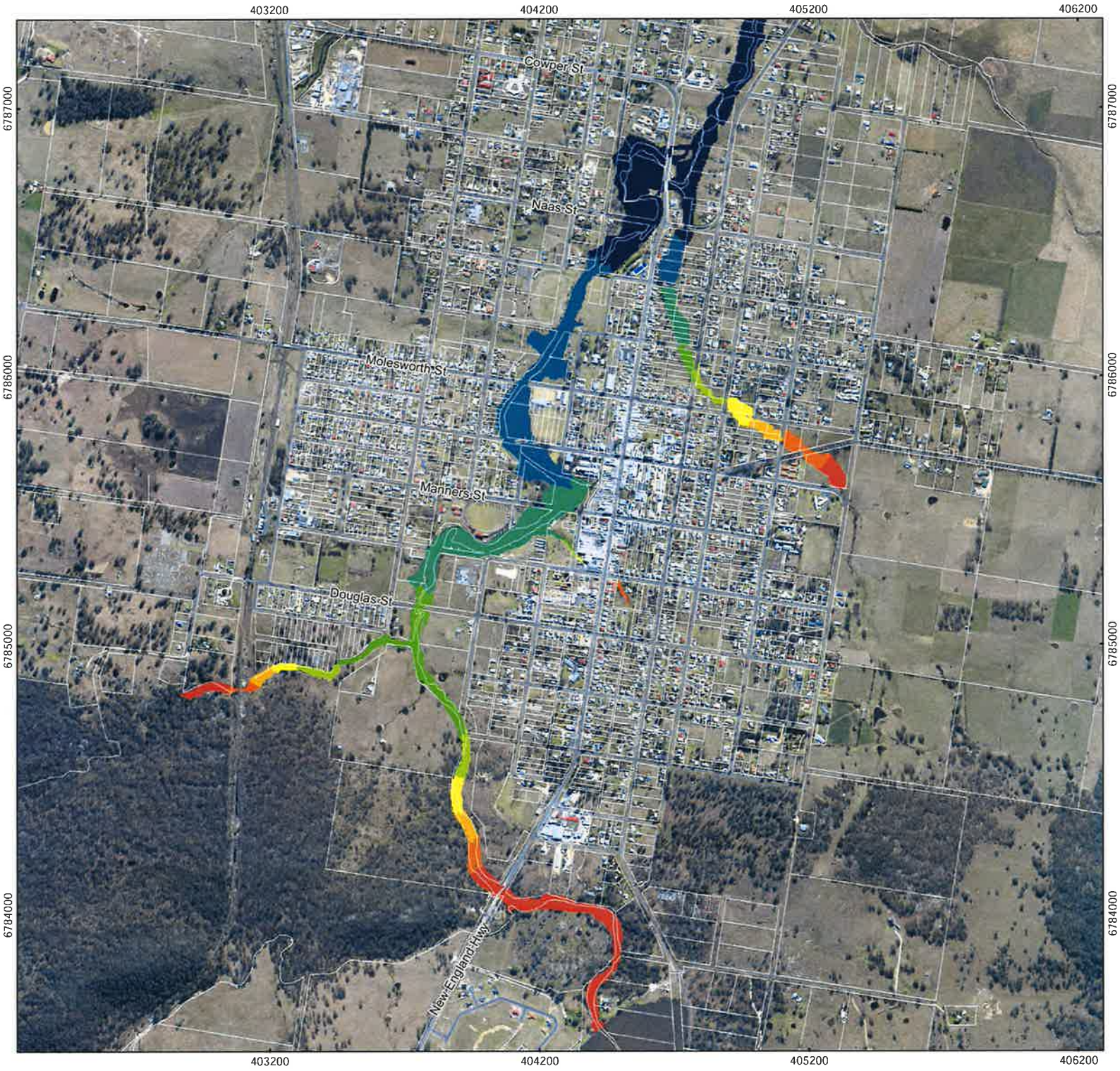

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- 846 - 848
- 848 - 850
- 850 - 852
- >852

N

0 50 100 200 300 400 500
Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Surface Elevation Map
Q10 Event

Project No.: 43800373
By: MADU
Date: 9/05/2013

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Water Depth [m]

- 0 - 0.3
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- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- >5

N

0 50 100 200 300 400 500

Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Water Depth Map
Q10 Event

Project No: 43800373
By: MADU
Date: 9/05/2013

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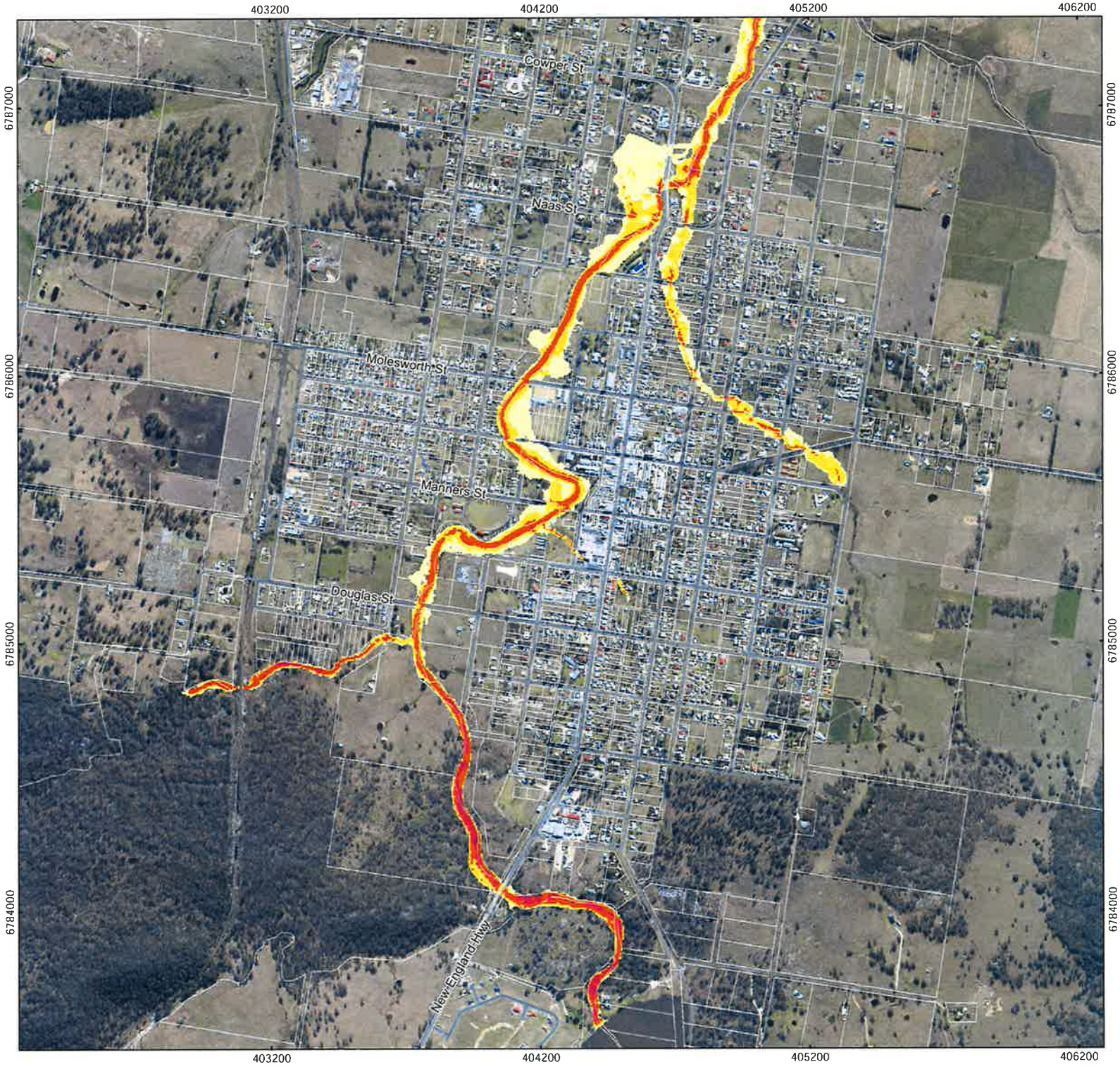

Current Speed [m/s]

- <0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- >5

N

0 50 100 200 300 400 500

Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Current Speed Map
Q10 Event

Project No.:	43800373
By:	MADU
Date:	9/05/2013

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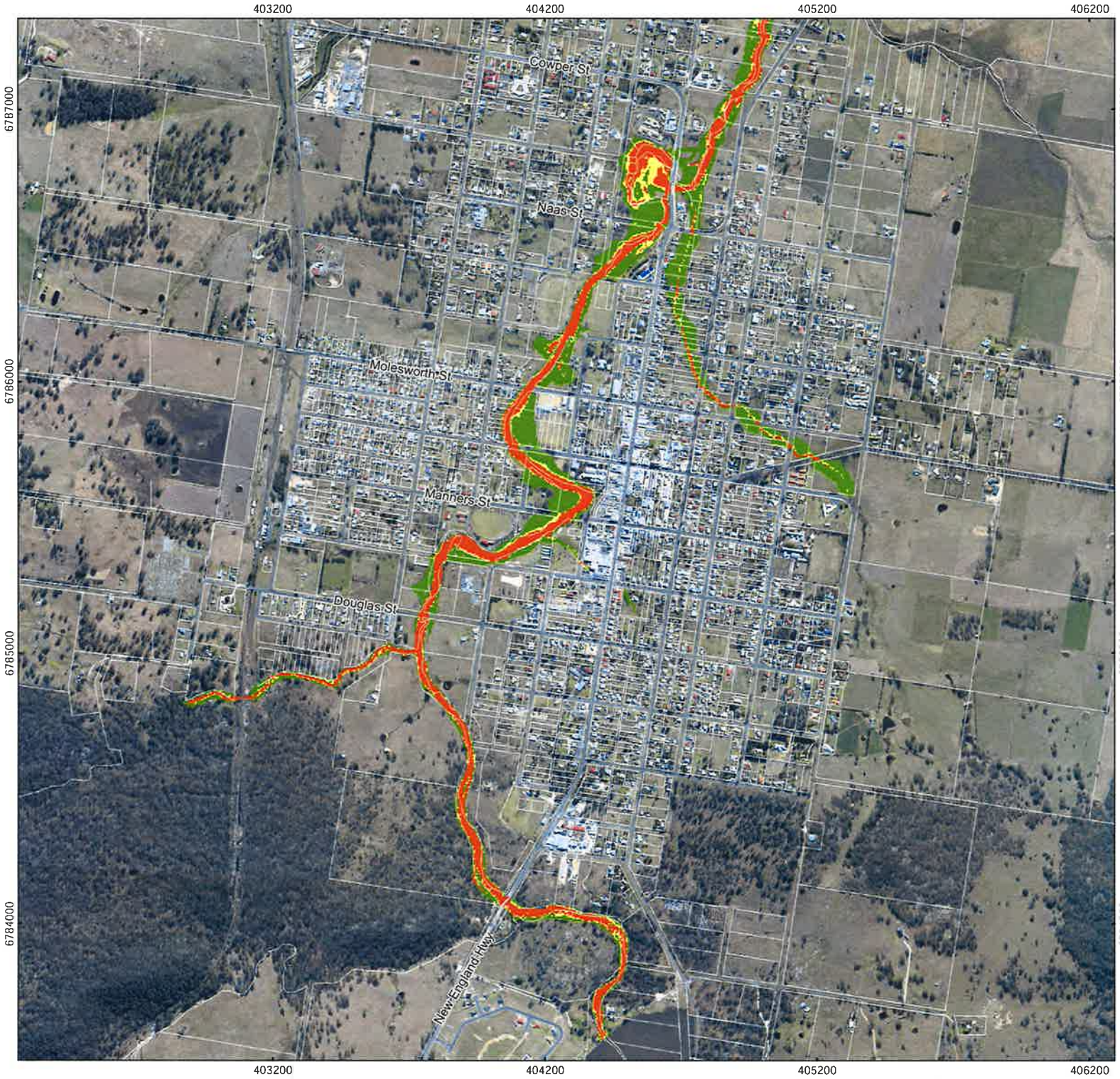

Provisional Hazard Category

- Low
- Medium
- High

N

0 50 100 200 300 400 500
Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Hazard Category Map
Q10 Event

Project No.:	43800373
By:	MADU
Date:	9/05/2013

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Hydraulic Category

- Floodways
- Flood Storage
- Flood Fringe

N

0 50 100 200 300 400 500

Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Hydraulic Category Map
Q10 Event

Project No.:	43800373
By:	MADU
Date:	9/05/2013

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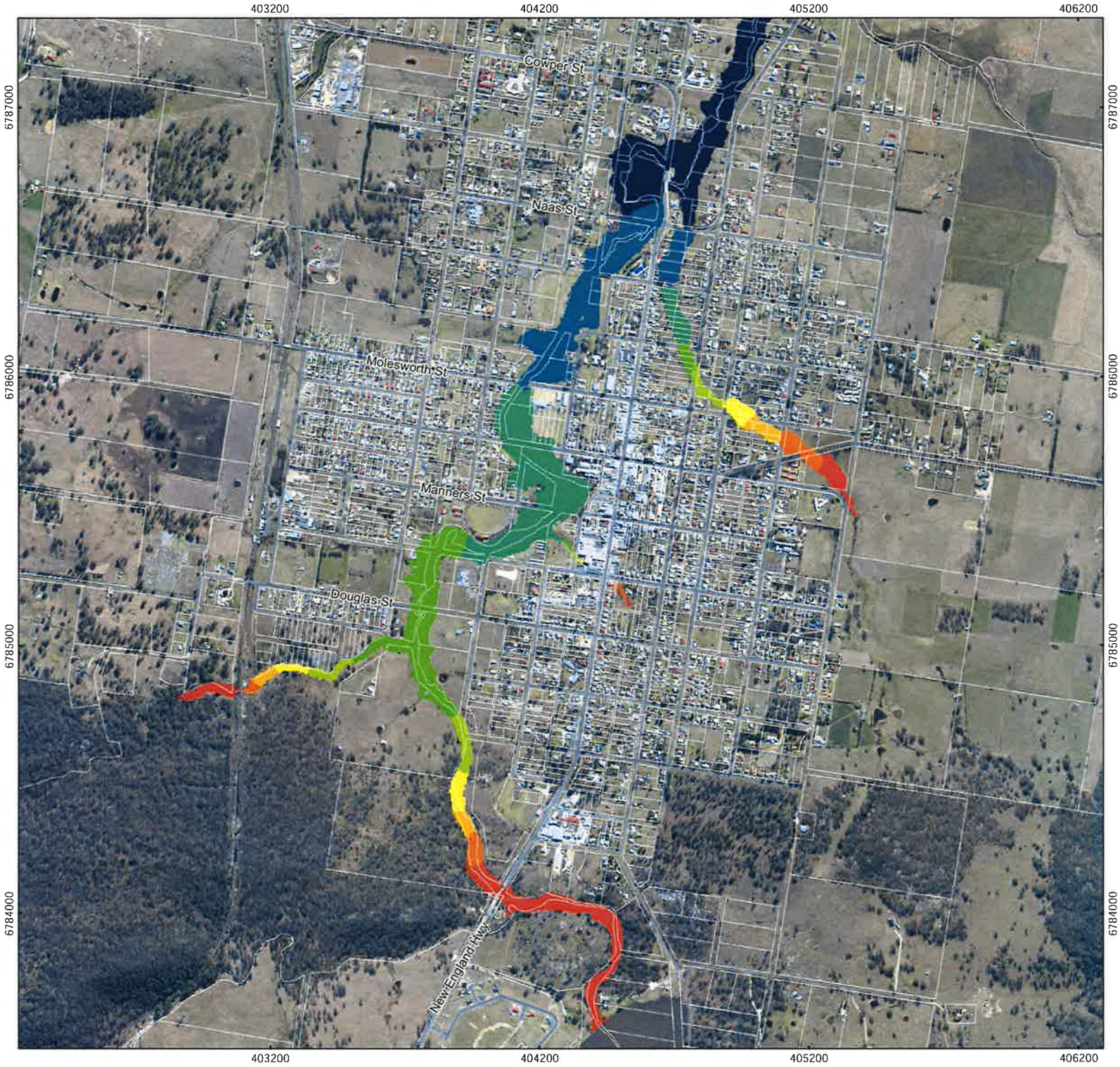

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- 838 - 840
- 840 - 842
- 842 - 844
- 844 - 846
- 846 - 848
- 848 - 850
- 850 - 852
- >852

N

0 50 100 200 300 400 500
Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Surface Elevation Map
Q100 Event

Project No.: 43800373
By: MOBA
Date: 9/05/2013

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Spring Hill QLD 4000
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Fax: +61 7 3236 9461
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Water Depth [m]

- 0 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- >5

N

0 50 100 200 300 400 500

Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Water Depth Map
Q100 Event

Project No.: 43800373
By: MOBA
Date: 9/05/2013

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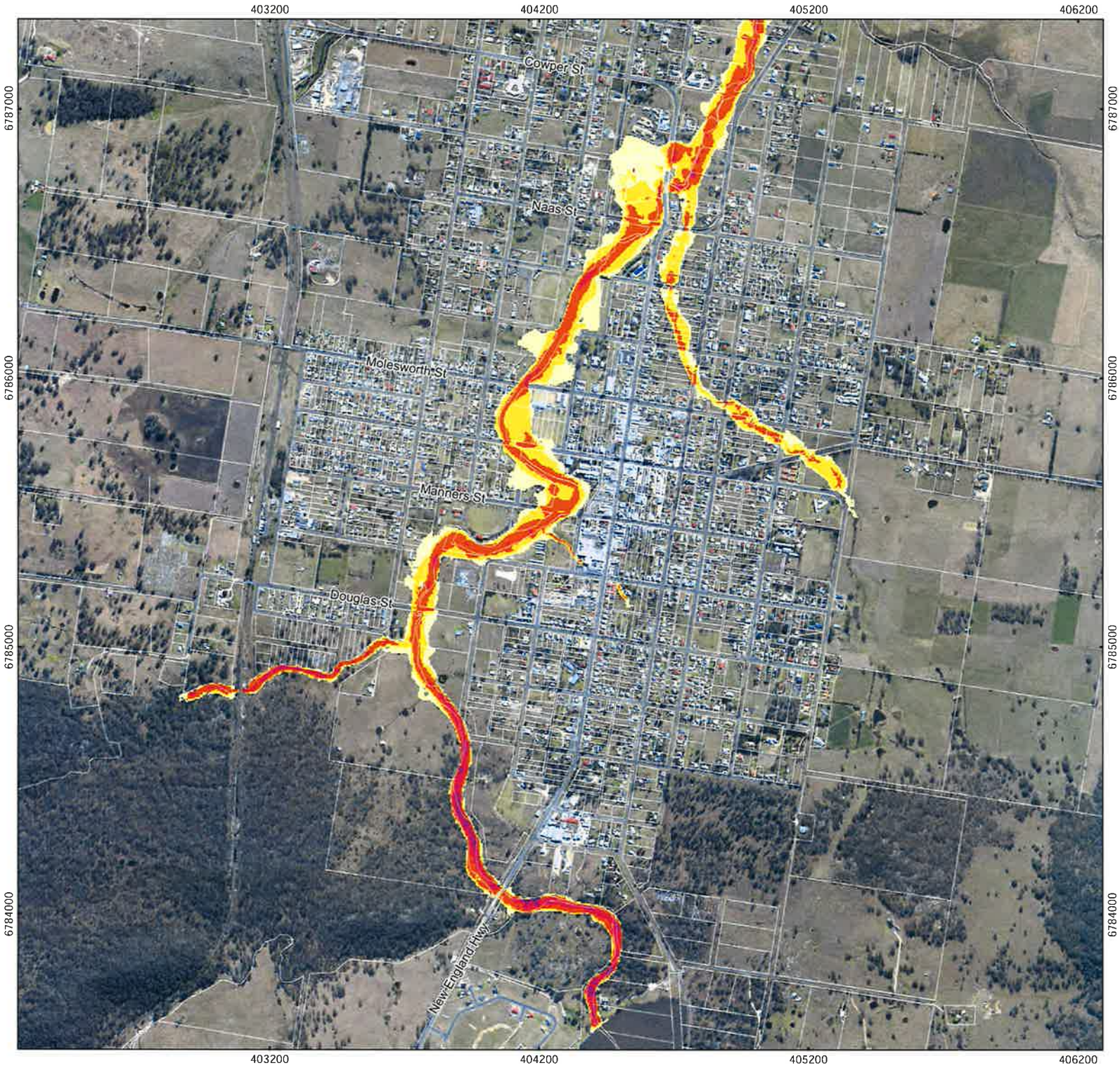

Current Speed [m/s]

- <0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- >5

N

0 50 100 200 300 400 500

Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Current Speed Map
Q100 Event

Project No.: 43800373
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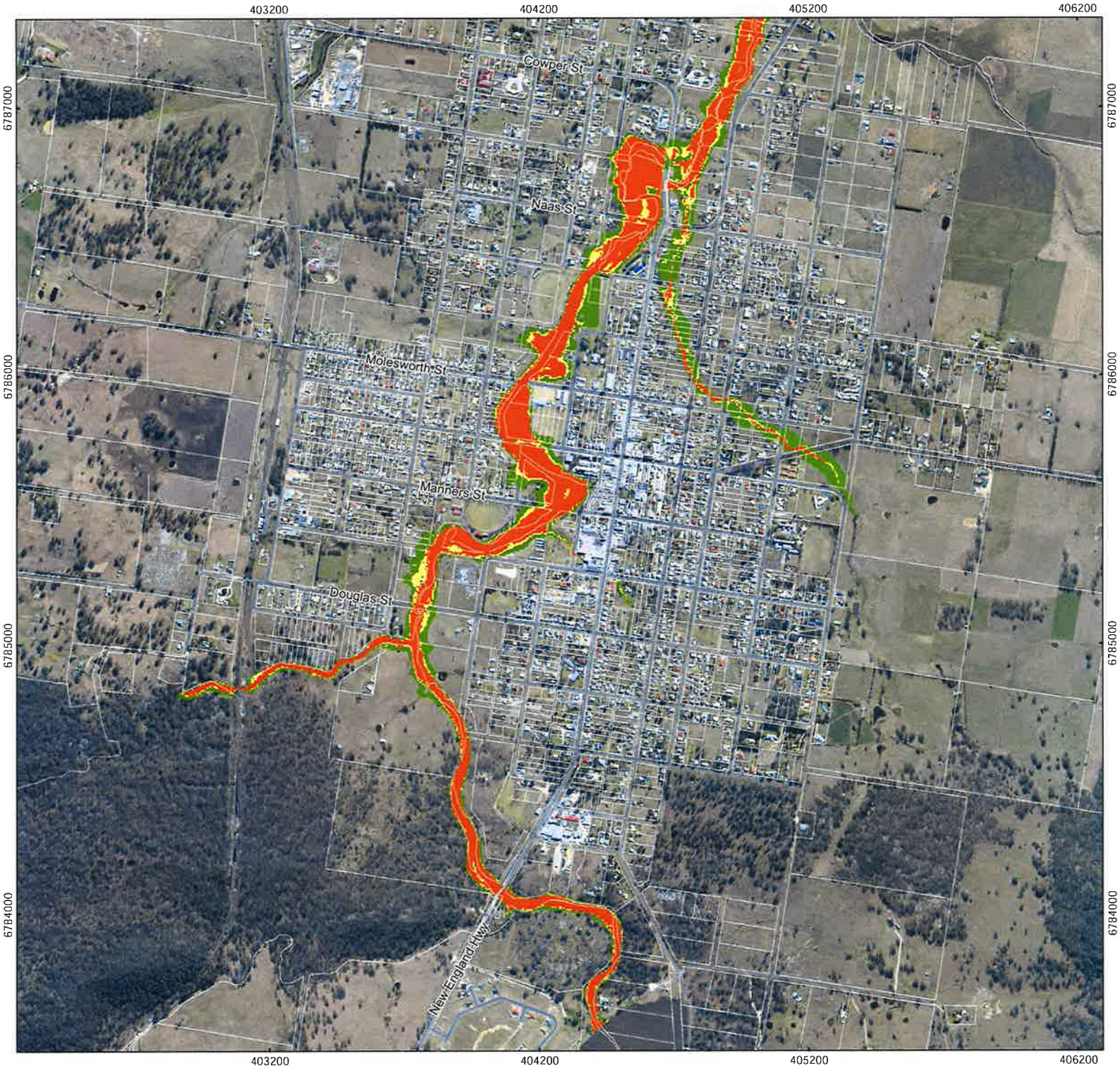

Provisional Hazard Category

- Low
- Medium
- High

N

0 50 100 200 300 400 500
Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Hazard Category Map
Q100 Event

Project No.:	43800373
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Hydraulic Category
- Floodways
- Flood Storage
- Flood Fringe

N

0 50 100 200 300 400 500
Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Hydraulic Category Map
Q100 Event

Project No.:	43800373
By:	MOBA
Date:	9/05/2013

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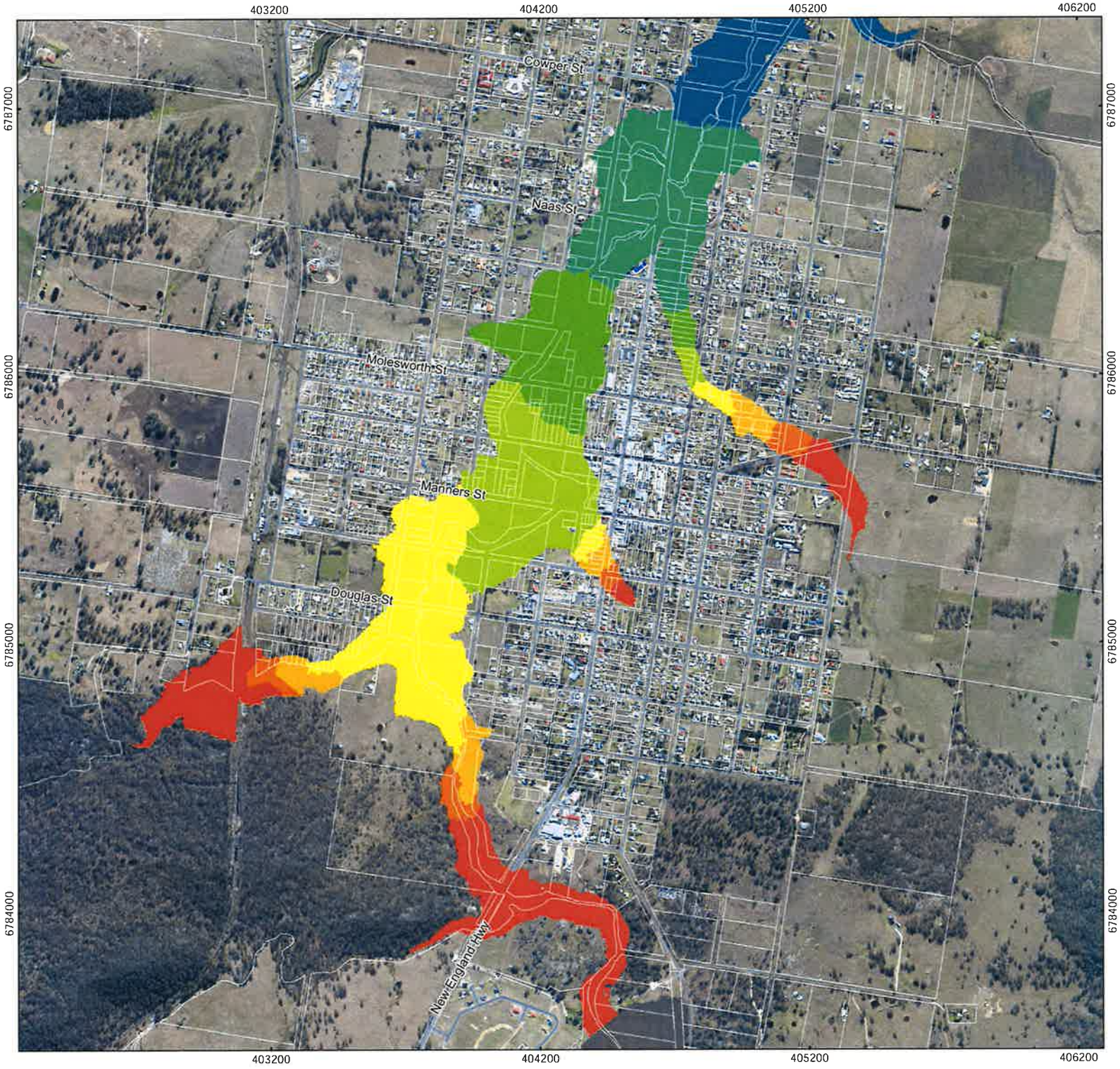

Surface Elevation [mAHD]

- <838
- 838 - 840
- 840 - 842
- 842 - 844
- 844 - 846
- 846 - 848
- 848 - 850
- 850 - 852
- >852

N

0 50 100 200 300 400 500
Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Surface Elevation Map
PMF Event

Project No: 43800373
By: MOBA
Date: 9/05/2013

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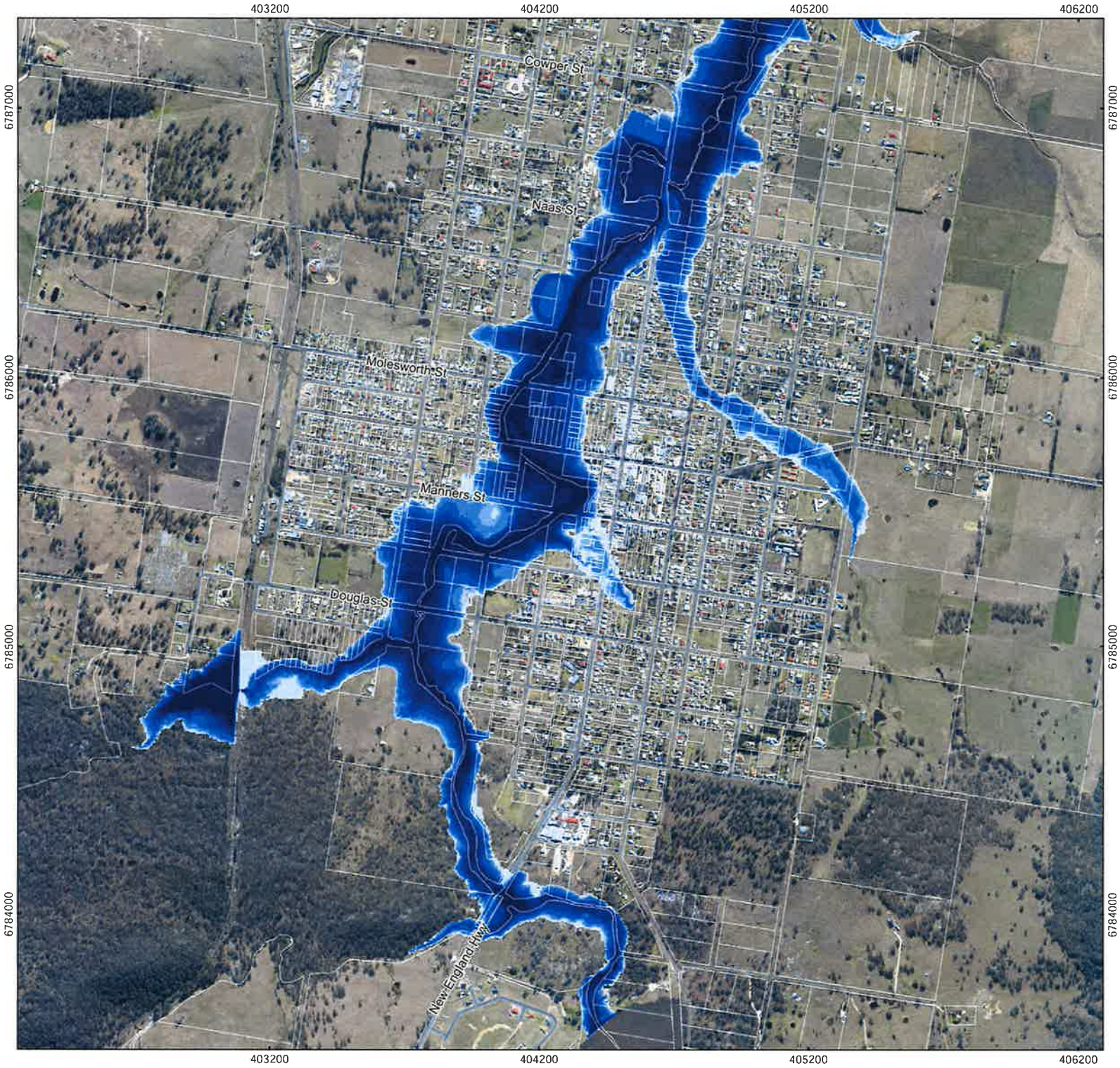

Water Depth [m]

- 0 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 -2
- 2 - 3
- 3 - 4
- 4 - 5
- >5

N

0 50 100 200 300 400 500

Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Water Depth Map
PMF Event

Project No.:	43800373
By:	MOBA
Date:	9/05/2013

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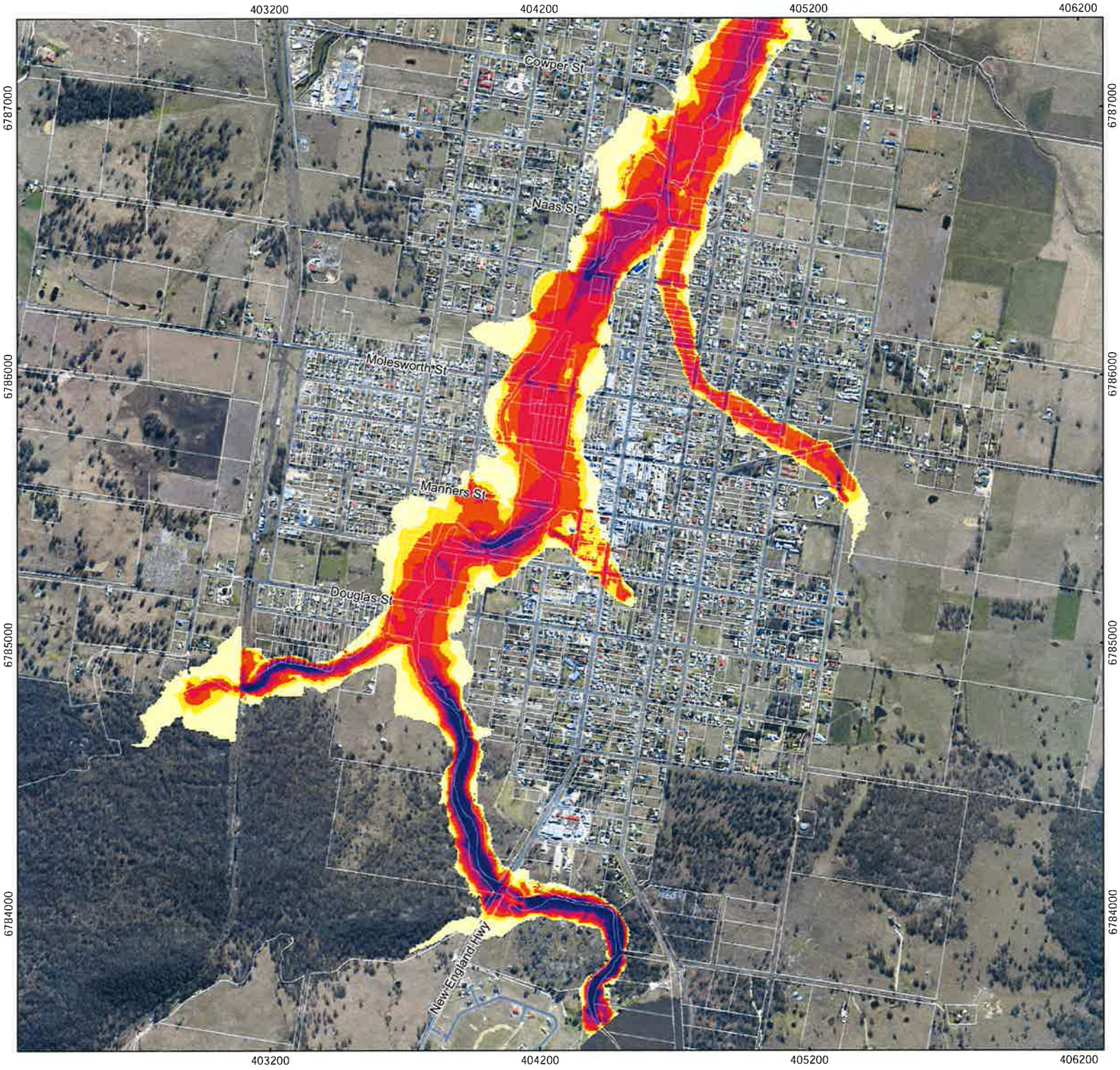

Current Speed [m/s]

- <0,5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- >5

N

0 50 100 200 300 400 500
Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Current Speed Map
PMF Event

Project No.:	43800373
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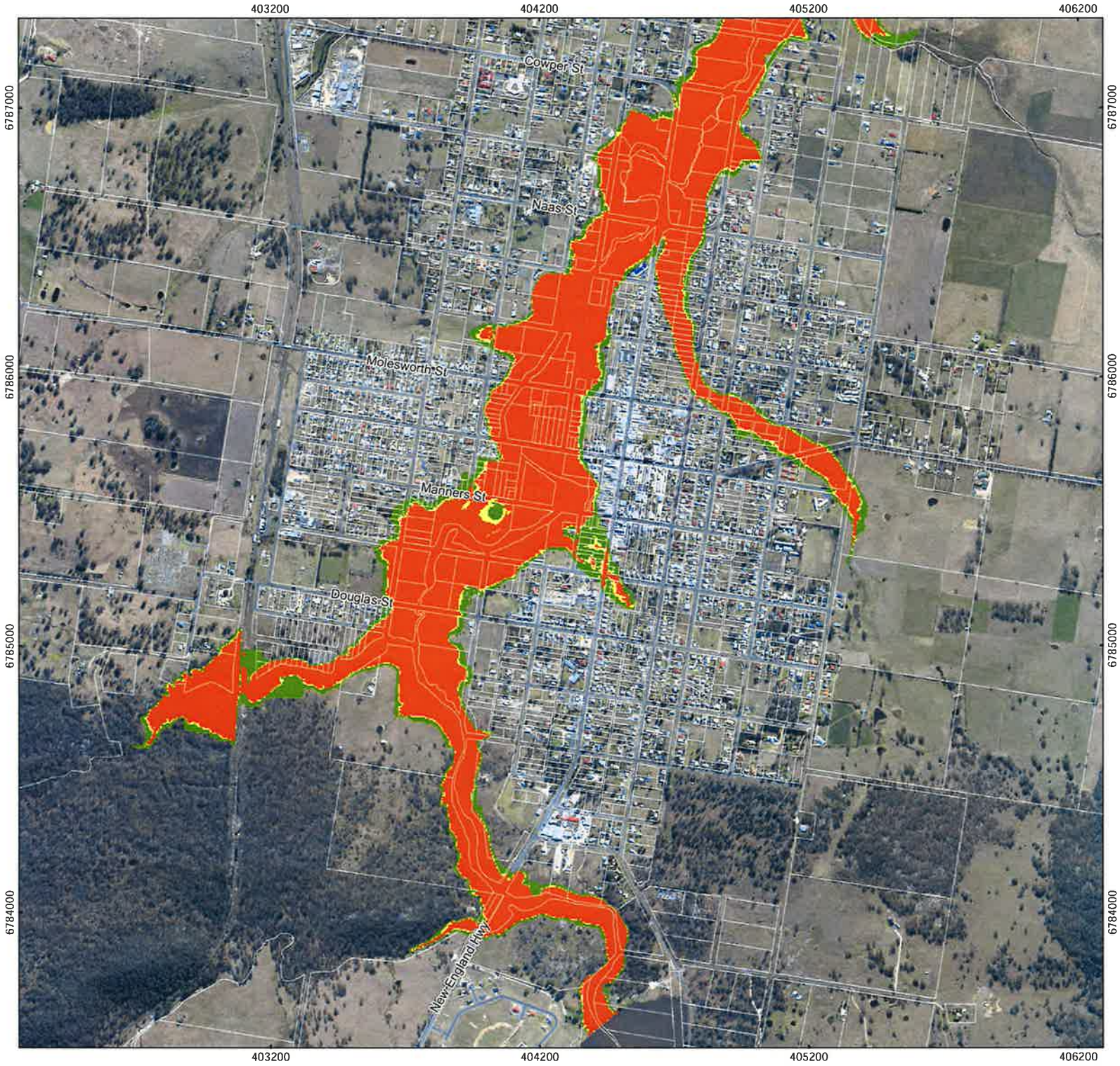

Provisional Hazard Category

- Low
- Medium
- High

N

0 50 100 200 300 400 500

Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Hazard Category Map
PMF Event

Project No.:	43800373
By:	MOBA
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Hydraulic Category

- Floodways
- Flood Storage
- Flood Fringe

N

0 50 100 200 300 400 500
Meters

Map Projection: MGA-50

Tenterfield Flood Study Update 2012

Hydraulic Category Map
PMF Event

Project No.:	43800373
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Appendix B. Model Adequacy Review

Discussion Paper

Date	49 November 2013
Project No	QE06817
Subject	Tenterfield Flood Risk Management Study: Flood Model Review – Model Adequacy

1. Introduction

This discussion paper provides a summary of the review of the Tenterfield Flood Study (TFS) undertaken by SKM as part of the Tenterfield Floodplain Risk Management Study (FRMS). The purpose of the review is to confirm that the flood modelling provides an appropriate basis for defining floodplain risks and developing risk reduction measures.

The following documentation was provided for review:

- Tenterfield Flood Study – Final Report June 2013 (DHI)
- Hydrologic and Hydraulic models provided by DHI on DVD – supplied by R.Stoeckeler
    - Design event hydraulic models (10%, 5%, 2%, 1% AEP and PMF for the 48 hour event only)
    - Flood Hazard (10%, 1% AEP and PMF)
    - Calibration model (January 2011)
    - Validation model (February 2001)
    - Sensitivity models for the 1% AEP event
    - Calibration and Validation hydrologic model
    - Design event hydrologic model for the 48 hour event only
- LIDAR data covering the total catchment area at 1m, 2m, 5m and 10m grid resolution (OEH).

The focus of this review was to confirm if the models provide an appropriate basis for accurately predicting flood risks. The commentary below outlines the findings of the review, with recommendations provided for those elements considered relevant to the FRMS.

2. Hydrology

2.1 Catchment Delineation

The overall catchment delineation upstream of the town of Tenterfield appears generally appropriate. However, there are two catchments of significant size, approximately 2.5 km^2 each, that flow into Tenterfield Creek approximately 700 m downstream of Drummond Street that are not included in the modelling.

The estimated inflow from these missing catchments for a 1 % Annual Exceedance Probability (AEP) event is 60 m^3/s. Assuming that this inflow is coincident with the Tenterfield Creek inflow then a normal depth calculation would result in a flood level of approximately 835.33 m AHD at the creek confluence. This is 4 m higher than the levels predicted by the 1 % AEP flood model at this location. However there is a hydraulic drop of approximately 5m between the downstream side of Rouse Street and the creek confluence for the 1% AEP design event.

Furthermore, the 1 % AEP design event indicates a 1.5 m head drop across Rouse Street. This indicates that the levels in town, upstream of Rouse Street are unlikely to be impacted by the missing catchments. As well, the assumption of coincident timing of flood peaks is considered conservative. Therefore, if the focus of the FRMS is on the township upstream of Rouse Street,

then the implications of the missing catchments for the FRMS are likely to be minor (in the absence of detailed testing).

It is recommended that TSC confirm the area of interest for the FRMS is upstream of Rouse Street. That is, that mapping of flood risks are not required downstream of Rouse Street.

The catchment has been delineated into 14 sub-catchments. These sub-catchments range in catchment size from 0.15 km^2 to 30 km^2. Each sub-catchment is represented in the hydrologic model (model B) as a single node. A rainfall routing model is then applied to the data assigned to the node to develop a hydrograph. The resulting hydrograph is then applied to the MIKE11 hydraulic model.

For the larger catchments of Tenterfield, Hawkins, Currys and Groombridges Creek, this single node approach can provide an overly simplistic representation of the routing and subsequently the runoff characteristics within the catchments. This can impact on the shape and peak of the predicted hydrographs. This is important, as these are the major inflows that will dominate flooding in the Tenterfield township. However, if the model is appropriately calibrated it is considered unlikely that this sub-catchment delineation would significantly change the results of the FRMS. This is discussed further in Section 3.2 below.

Should TSC identify the need to update the Flood Study, it is recommended that additional sub-catchment definition is provided for the larger catchments of Tenterfield, Hawkins, Currys and Groombridges Creek.

2.2 Catchment Parameterisation

The sub-catchment parameters of average stream length, slope, roughness and percentage impervious are used to determine the shape of the hydrographs generated by the rainfall runoff model. The parameters adopted are generally consistent with the area. The hydrologic Manning's n value of 0.07 for pervious areas is high but not inconsistent with the area. It is noted that the sub-catchment slope appears is rounded to the nearest 15 m/km. However, the values are within the range expected and this is not expected to result in significant differences in the model results.

The sub-catchment parameterisation is considered fit-for-purpose.

2.3 Calibration

The Flood Study used a joint calibration process to calibrate the hydrologic and hydraulic models. The joint calibration process requires the user to adjust the model parameters in both the hydrologic and hydraulic model in an iterative manner until the model provides a result that provides a reasonable fit to the observed flood levels. This approach is considered appropriate as there was insufficient streamflow gauging within the catchment to support independent calibration of the hydrologic model.

It is noted that the joint calibration process was undertaken using the one dimensional MIKE 11 model only. The comparison of modelled and recorded flows presented in the report demonstrates that the model provided an accurate prediction of the peak levels and is, therefore, considered appropriate.

The Flood Study report states that for the coupled 2D and 1D MIKEFLOOD model the recorded water surface level time series were used to derive estimates of event inflows (using a rating curve derived from the MIKE11 model). These inflows were then used in place of the modelled inflows for Tenterfield, Hawkins, Groombridge and Currys Creek. This was undertaken to provide a more accurate representation of the event inflows. While this approach is considered

appropriate and will provide greater accuracy for the hydraulic model, it removes the largest inflow catchments from the joint calibration process.

It is recommended that TSC seek information to confirm that outputs from the hydrologic model at Groombridge, Tenterfield, Hawkins and Currys Creek are representative of the observed flows for the January 2011 and February 2001 events.

The derivation of rainfall data to support the model calibration appears appropriate. Analysis of radar rainfall images from the event support the assessment that the flood peak occurred in the early hours of the morning of the 11th January 2011, several hours prior to the rainfall recorded at Mt McKenzie. Appendix A provides snapshots of the January 2011 Radar.

It is noted that the modelling of the January 2011 event is based on rainfall over a period of several days. In particular the model discusses rainfall totals over a 48 hour period. However, reviews of the rainfall within the model and radar images suggest that the January 2011 Tenterfield flood was caused by a 6 hour burst of very intensive rainfall that commenced at approximately 8:30pm on the 10th January, 2011.

The flood study applied a multiplication factor to the rainfall data based on ratio of rainfall totals determined at the Black Swamp daily gauge. This process is considered appropriate but has not been assessed in detail as part of this review. Assuming the 1.6 multiplication factor on the rainfall the intensity within this 6 hour period was 28.7 mm/hr placing the rainfall in the order of magnitude of a 2% AEP to 1% AEP event.

It is recommended that the January 2011 event is considered to have commenced at approximately 8:30pm on the 10th January. That is, the flood warning for the January 2011 event was approximately 6 hours, with the peak flows through town occurring at approximately 3am on the 11th January.

2.4 Design Event Hydrology

The peak design flows presented in the Flood Study were compared against the rational method and regional method from the Australian Rainfall and Runoff Update – Project 5. The purpose of this comparison is to check that the magnitude of the design flows is appropriate for the size and location of the catchments. Design flows were compared at the four major inflows of Groombridges, Currys, Hawkins and Tenterfield Creeks as well as the smaller catchment of C3.

The results are summarised in the table below, with results for all AEP's presented in Appendix B.

Catchment	1% AEP peak flow (m^3/s)						Jan 2011 (DHI) peak flow (m^3/s)
	DHI	Rational Method	Project 5 (50th percentile)	Difference Project 5 & DHI (%)	Project 5 (5h percentile)	Project 5 (95th percentile)	
Currys	40	169	74	**46%**	34	164	106
Groombridges	36	165	74	**51%**	33	163	99
Hawkins	31	86	76	**59%**	33	175	60
Tenterfield	50	252	115	**56%**	52	253	145
C3	16	37	42	**61%**	18	96	24

The results of the comparison indicate that the peak flows from the Flood Study are between 40% to 60% less than those predicted by the AR&R Project 5 50th percentile estimates and

approximately 70% less than that predicted by the rational method for the 1% AEP. It is noted that the peak flows from the Flood Study are at the lower end of the 5th percentile confidence bounds on the Project 5 peak flow estimates for each catchment. It is, therefore, considered that the peak flows estimated by the Flood Study do not provide conservative estimates of the design flows.

However, it is noted that the peak flows of the January 2011 event are within the range predicted for a 1% AEP event. There is an apparent inconsistency in the modelling in that the January 2011 event has rainfall intensities similar to that of the 2% AEP to 1% AEP 6 hour storm, yet the 6 hour design storms are not critical in the catchment.

The impact of underestimating the peak flows on the model results for the purposes of accurately defining flood risks are discussed further in Section 3.

The Flood Study reports the critical duration is 72 hours, with the longer critical duration being due to the attenuation impact of Tenterfield Dam. The Flood Study also notes that the 48 hour storm produced results very similar to the 72 hour storm and as a result the 48 hour storm was adopted for the study. Hydrologic models were only provided for the 48 hour storm and as such only this storm was reviewed as part of the study. The Flood Study reports that the critical duration of the PMF was two hours.

It is unusual for the PMF to have a critical duration significantly different from that of the design storms. It is unclear from the Flood Study report the method used to derive the PMF, in particular if both the GSDM and GSTMR method were considered.

The 48 hour storm critical duration is also considered unusually long as Tenterfield residents report very little warning in the 2001 and 2011 flood events. However, review of the peak flows through the model for the 1% AEP design flood indicates that the majority of the rise in flood levels occurs within a period of 4 hours. This observation reflects the AR&R temporal patterns for Zone 2 which have over 41% and 48% of the storm rainfall occurring in the first 2 hours for the 48 hour and 72 hour temporal patterns respectively. These high rainfall percentages within the temporal pattern are referred to as bursts.

It is recommended in AR&R to filter temporal patterns with large bursts to ensure that the total rainfall within any burst in the storm does not exceed that of the storm with a duration equivalent to that of the burst. This is called 'filtering' and is common practice. It is believed that application of filtering to the temporal patterns would remove this burst from the 72 hour and 48 hour rainfall durations and reduce the critical duration for the catchment to in the order of 6 hours.

It is recommended that TSC consider the future applications for this design hydrology and as such the need for further review the design events. In particular, that the peak design event flows are validated against regional methods and that filtering of the temporal patterns is undertaken to confirm the critical duration storm for the Tenterfield town. The implications of the design event hydrology for the Flood Study are discussed further in Section 3.2.

The losses adopted for the design hydrology are generally consistent with those adopted for the region.

3. Hydraulics

The hydraulic modelling was undertaken using two models. The first was a 1D MIKE 11 model of the upstream reaches of the catchment. This model covers a creek length of approximately 4km including Tenterfield Dam and Hawkins Dam.

Flows over Tenterfield Dam and Hawkins Dam are represented as a special weir equation which is reported as representing the spillway rating curve. For the design event modelling both Tenterfield and Hawkins Dam are modelled with an initial water level equal to the Tenterfield Dam Crest. That is, the dam is considered full at the start of the storm event. This approach is considered appropriate.

The MIKEFLOOD software couples the 1D MIKE 11 software to the 2D MIKE 21 software. This process allows the detail of structures such as bridges and culverts to be represented in 1D and the detail of the floodplain flows to be captured in 2D. This approach is considered appropriate.

This review focuses on the MIKEFLOOD model, as this model and its results provide the basis for the calculation of flood hazards for the FRMS.

3.1 Model Parameterisation

The 2D model was developed with a grid cell size of 5m (ie 2D cells of 5m x 5m). Tenterfield Creek is typically between 10m to 12m in width and, as such, the model represents the conveyance of the creek through two grid cells. This is generally considered too few cells, especially as the creek conveys the large majority of the flood. It would have been more appropriate to use 1D channels to represent the creek conveyance or to use a smaller grid size (say 3m).

It is recommended that TSC ask DHI if the choice of a 5m grid size for the 2D model was verified against the 1D MIKE11 flood model.

The adopted Manning's roughness appears appropriate when compared to aerial photography and typical values adopted for buildings and vegetation. A sensitivity assessment was also conducted to the assumed Manning's roughness indicating that a 20% increase in roughness values would result in a 150 mm increase in flood levels. Therefore, the model is not considered to be particularly sensitive to the adopted Manning's n values.

The adopted eddy viscosity (i.e. pseudo hydraulic roughness introduced in the model to artificially represent sub-grid size turbulence) is consistent with the values typically adopted for the model grid cell size and timestep and is, therefore, considered appropriate.

A constant tailwater level was adopted for the downstream model boundary. As this boundary is located over 9 km downstream of town of Tenterfield, this boundary is considered to have negligible impact on the model results through Tenterfield and is, therefore, considered appropriate.

Structures are represented in the model through the 1D MIKE 11 model and linked to the 2D domain. A number of bridge structures are represented as a culvert and weir combination. That is, the flow over the road is represented by flow over a weir within the 1D MIKE 11 model. While the 2D model presents the resultant water surface level heights at this location, the detail of flow over the road (velocities and volume) is captured in the 1D model domain. However, at (Rouses, the New England Highway Bridge, Currys Creek and Nass Street East) the road and subsequently flow over the bridge is represented in the 2D domain. Care is required when

interrogating the model results to ensure the appropriate models is selected to provide the required output.

It is noted that the Flood Study reports Rouse Street Bridge as being modelled as both a weir and a culvert. However, this is not reflected in the model. It is noted that no structures are modelled downstream of Rouse Street as such the flood levels through this area are considered to be of limited accuracy.

It is recommended that TSC confirm the area of interest for the FRMS is upstream of Rouse Street. That is that mapping of flood risks is not required downstream of Rouse Street.

3.2 Results

The model results including flows through the model coupling and structures are generally stable.

The exception to this is the peak flow through Douglas Street bridge with an instability observed in the peak flow on the falling limb of the hydrograph. This instability results in a reported peak flow of 153m^3/s for the 1% AEP with the actual peak flow through the structure at approximately 140 m^3/s. However, this instability does not appear to translate to a water surface level instability at the connections to the 2D domain and is, therefore, not considered to have significant influence on the model results.

The peak discharges for High Street and Molesworth Street Bridge West also appear to be unstable. In particular it is noted that the peak discharge through Molesworth Street Bridge West has significant sharp changes in the peak discharge. It is believed that this is cause by the way the model is schematised that results in abrupt changes in the flow regime that would not be replicated in the reality. However, neither the instability at High Street or Molesworth Street Bridge West are reflected in the water surface level results. This is illustrated in Figure 1 below.

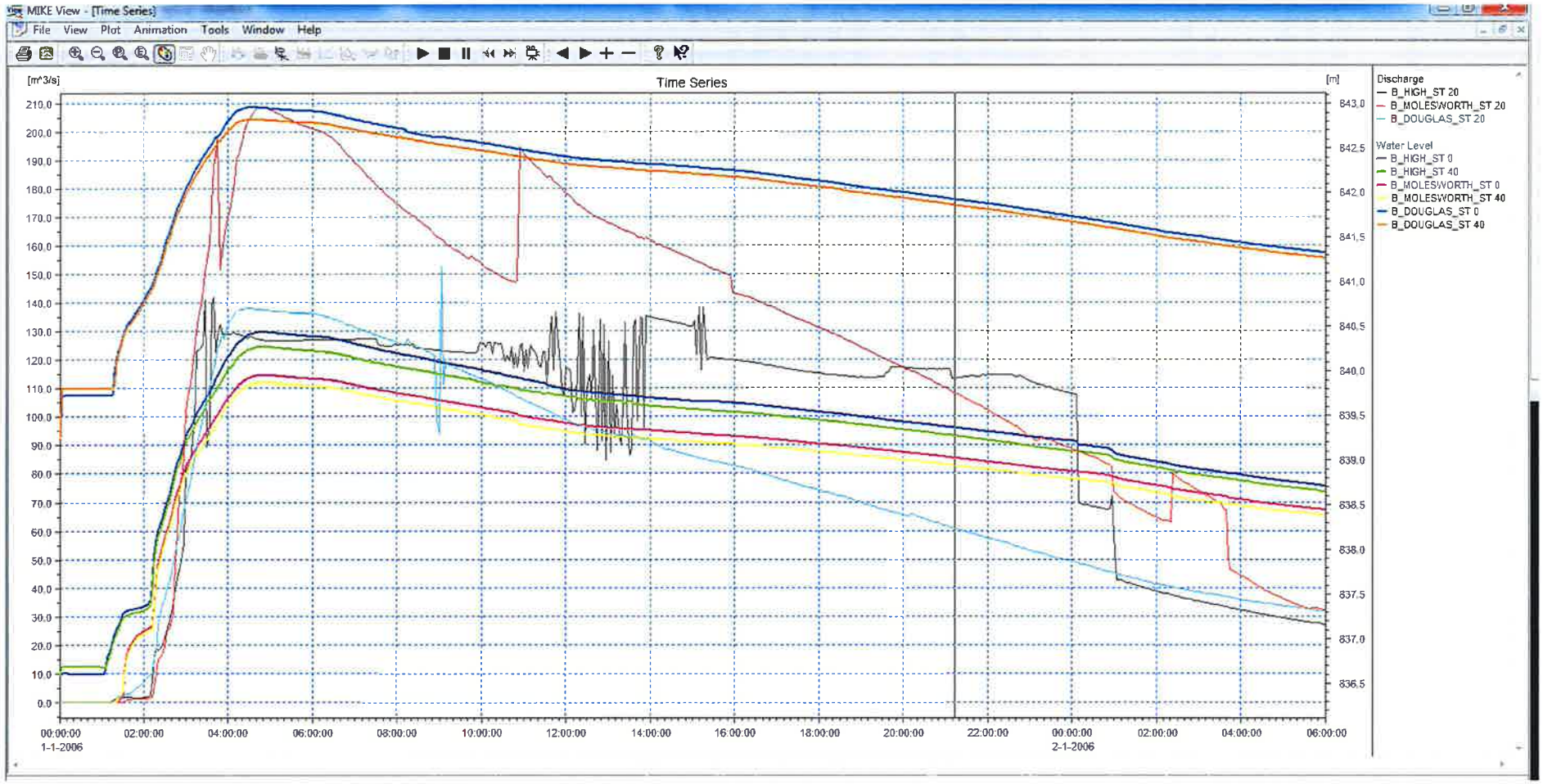


Figure 1 Flow and Water Surface

It is noted that the Flood Study reports the modelled peak discharges through downstream bridges such as Rouse Street Bridge as being less than those through the upstream bridges such as Molesworth Street Bridge West. As part of this review, a number of discharge calculations were undertaken through the MIKEFLOOD results. The results indicated that peak flows do increase downstream with peak flows of approximately 169 m^3/s upstream of Molesworth Road West and 178 m^3/s upstream of Rouse Street for the 1% AEP respectively. It is believed that the reported peak discharges at the bridges in Table C-2 of the report were sampled from the 1D domain only and may be influenced by model instabilities and or the representation of weir flow over the road in the 2D domain.

It is recommended that care is taken in interpreting and use of the peak discharges presented in Table C-2 of the flood study as these are not considered to provide accurate flows for all structures.

The model results appear to provide a reasonable calibration to the observed water surface levels in January 2011 and February 2001.

Two sensitivity assessments were undertaken as part of the Study. In particular, it is noted that sensitivity assessments undertaken as part of the Flood Study indicate that the model is sensitive to changes in flow with a 200 mm change in flood levels. This has implications for the modelling given that the hydrology is believed to underestimate the design flows. This is discussed further in Section 4.

The Flood Study recommends that the effects of blockages on structures are examined as part of any future works as the model is believed to be sensitive to the constriction associated with the bridge crossings. This recommendation appears warranted.

It is recommended that TRS consider the opportunity to examine the impact of blockages as part of the FRMS.

The Flood Study recommends that the availability of rainfall and streamflow data within the vicinity of the model is reviewed and the benefit of installing an additional rainfall gauge closer to the town is considered. This would support future calibration of the model and improve the accuracy of the model. The installation of a rainfall alert gauge may also assist in flood warning.

However, the effectiveness of such a gauge needs to be considered in the context of the short critical duration for the catchment (less than 6 hours). Based on our experiences in similar catchments in the region a telemetric rainfall gauge could be installed for approximately $10,000.

It is recommended that TRS consider the opportunity to install additional rainfall gauges in the catchment in the context of the range with other floodplain management options determined through the FRMS.

4. Conclusions and Implications for the FRMS

The model review has identified a number of issues. It is recommended that TSC consider the future applications for the flood model results to determine the need for further review or remodelling as recommended above.

The review highlighted two issues that have significant implications for the FRMS. These are

1) The design flood hydrology - appears to underestimate peak flows through the town of Tenterfield for the respective AEP.
2) Flood Warning - the 48 hour critical duration, which does not appear to reflect observations from the historical floods.

However, the above issues need to be considered in the context of the flood risks within Tenterfield. As all of the design events more frequent than a 1% AEP are largely contained within the creek, revising the hydrology for the more frequent events is unlikely to significantly change the resulting flood risks to Tenterfield. An alternative option would be to adopt the January 2011 calibrated model results as the 1% AEP. This assumption would be based on the fact that the January 2011 flows are within the expected order of magnitude of a 1% AEP event. The risk associated with this is that the January 2011 event may still underestimate the 1% AEP. Therefore, it is recommended that the change in risk between the January 2011 event and PMF or lager event is closely considered.

It is recommended that SKM, TSC and the OEH discuss the options available for the design flood hydrology to ensure that the approach provides an affordable approach for TSC whist meeting the requirements and intent of the Floodplain Development Manual.

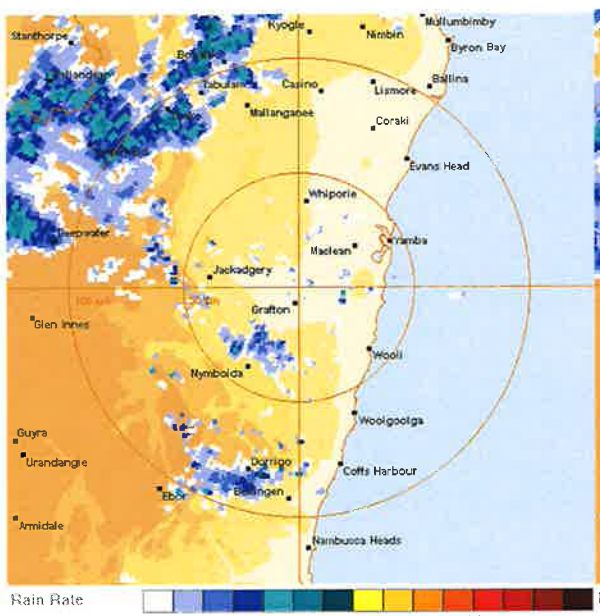
The 48 hour critical duration quoted in the flood study is not considered to provide an accurate representation of the true flood warning time for Tenterfield. This is believed to be due to the intense 2 hour burst in the 48 hour storm temporal pattern. It is SKM's expectation that an analysis of shorter duration rainfall events would yield a critical duration in the order of 6 hours (consistent with the size of the catchment and observations of the January 2011 flood).

An alternative approach that would not significantly increase the risks associated with the analysis would be to extract the flood warning time from the rising limb in the hydraulic model and use the 4 hour to 6 hour period observed in the hydraulic model. While this approach is not as accurate, it is considered to provide a result that is likely to be similar to that achieved through reassessment of the hydrologic model. Furthermore, if the January 2011 event is adopted as the 1% AEP, then the process is considered to be defensible as the modelled flow behaviour is calibrated to an observed event.

It is recommended that SKM, TSC and the OEH discuss the options available for the design flood hydrology to ensure that the approach provides an affordable approach for TSC whist meeting the requirements and intent of the Floodplain Development Manual.

Fiona Stark
Project Manager
+61 7 3026 7166 | fstark@globalskm.com

Appendix A – Radar Rainfall Images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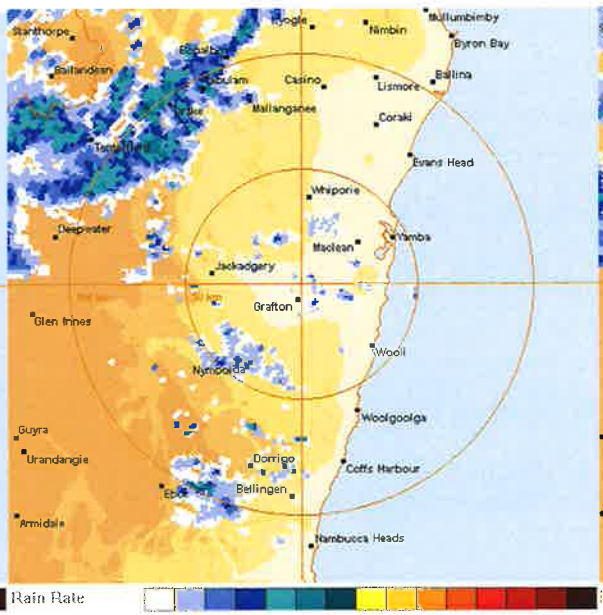
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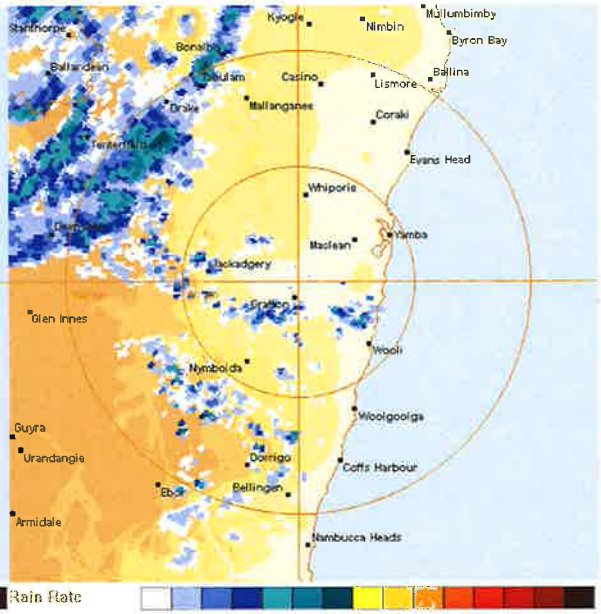
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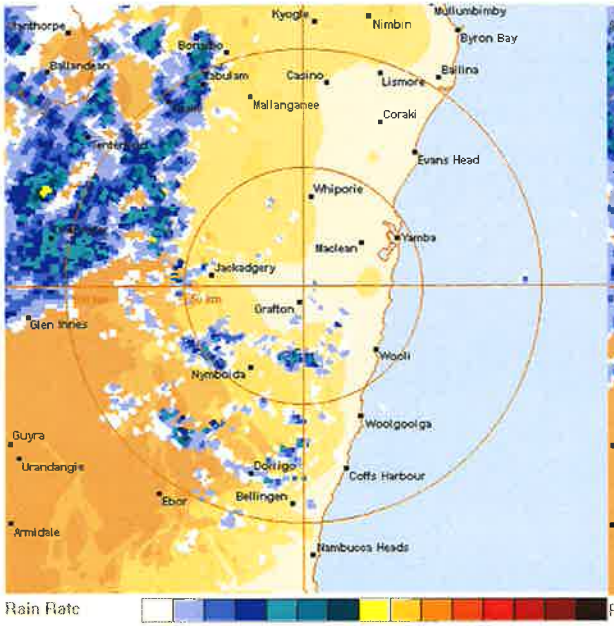
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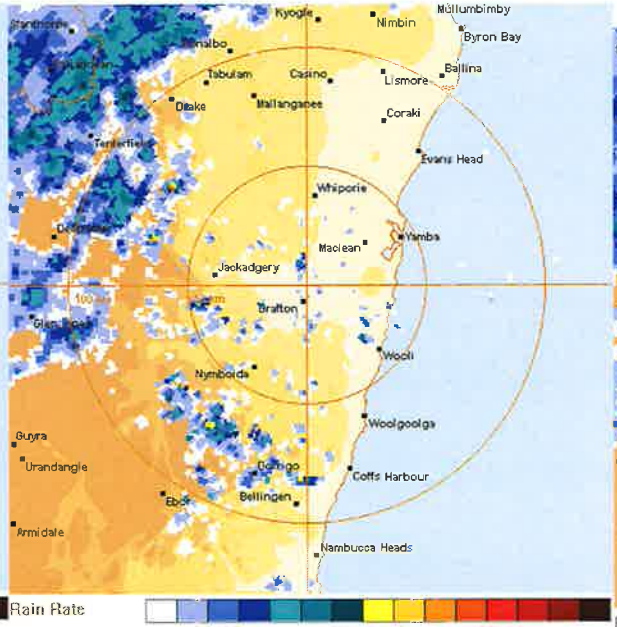
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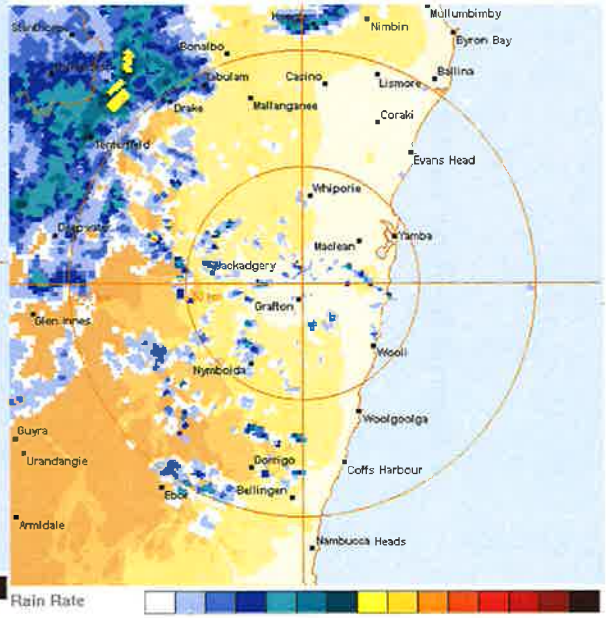
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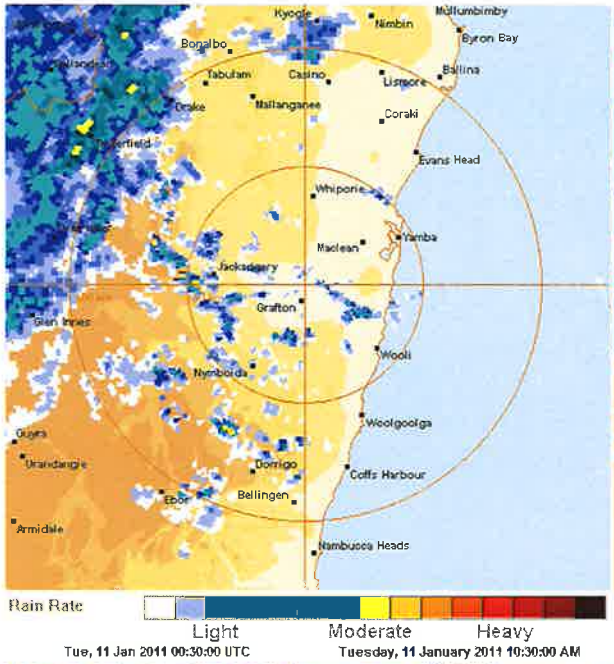
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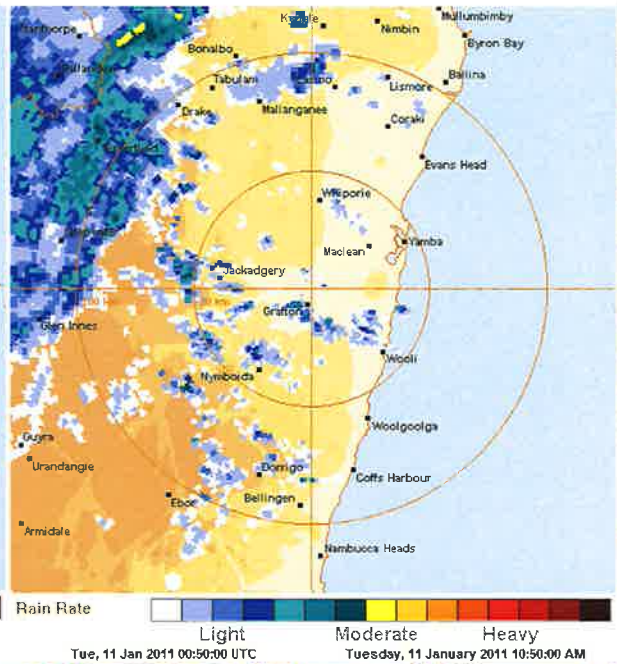
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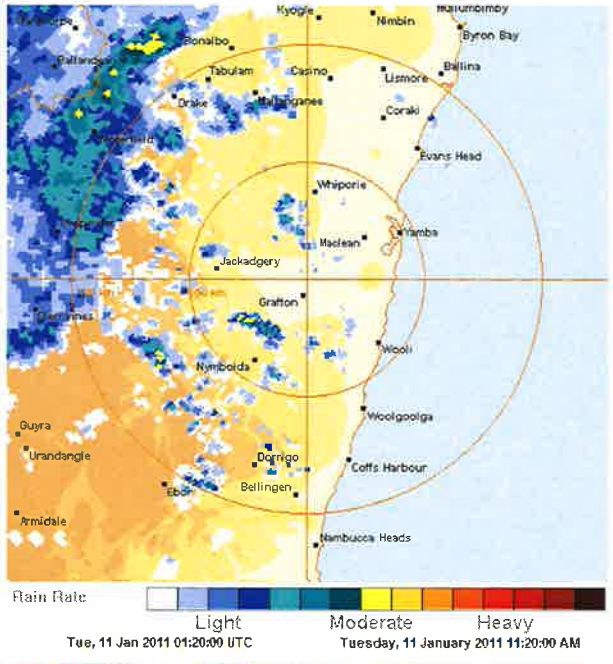
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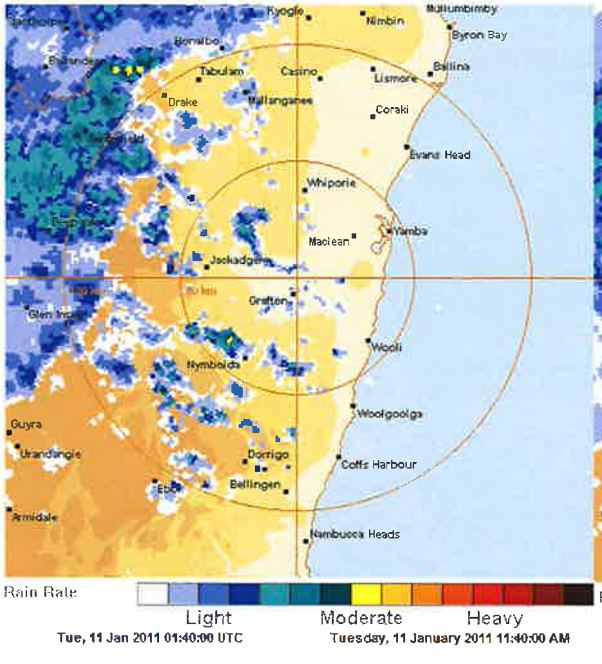
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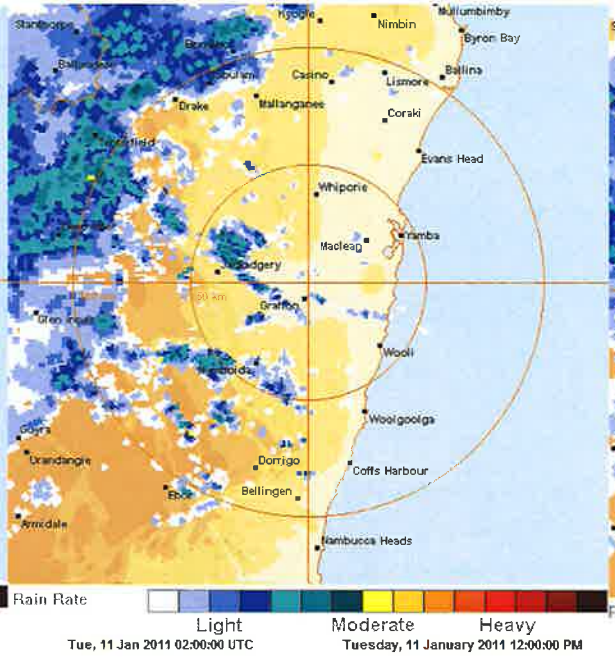
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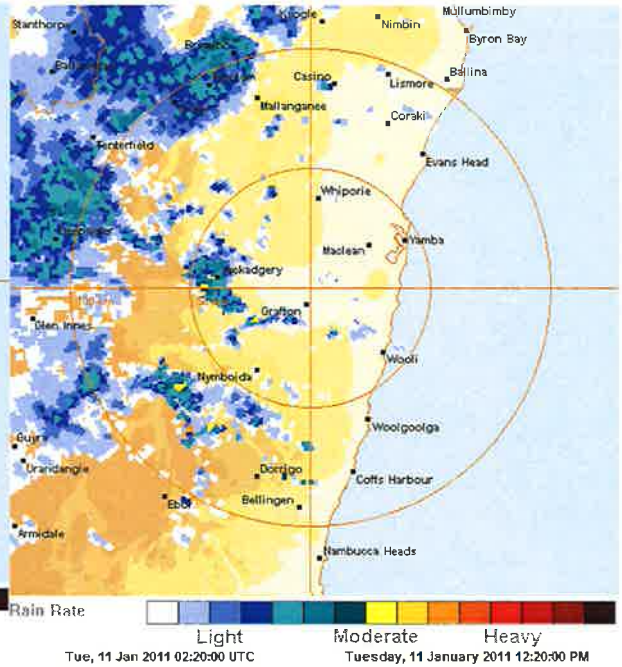
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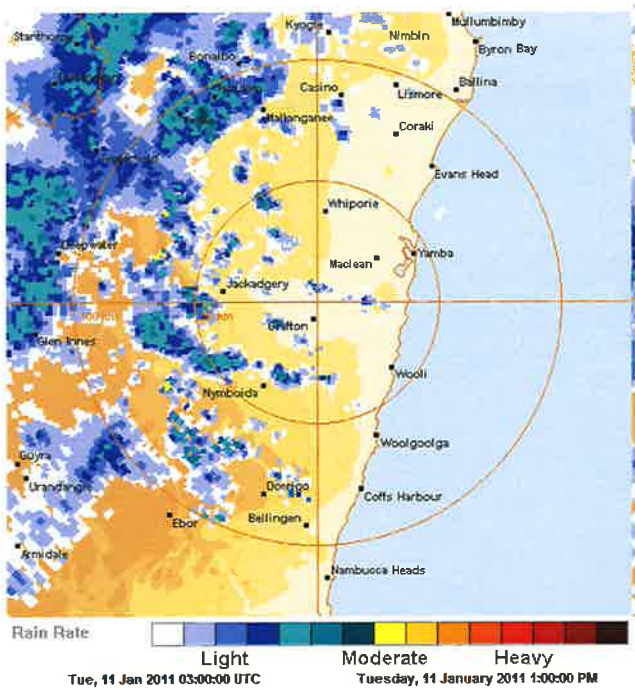
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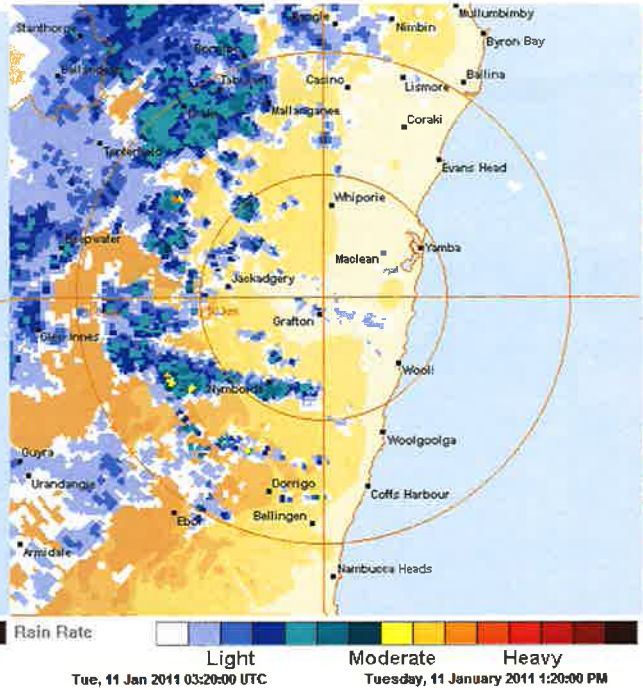
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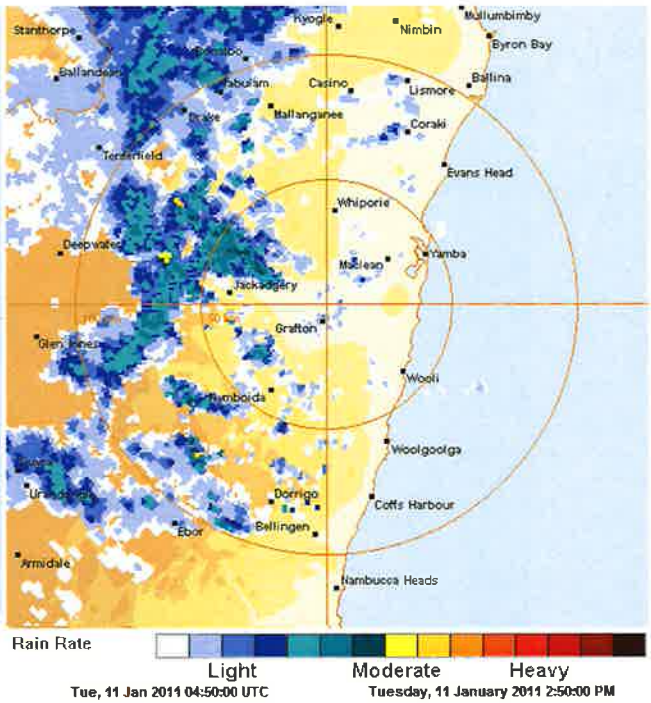
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