Floodplain Risk Management Plan

Bega & Brogo Rivers FRMSP

59916044

Prepared for
Bega Valley Shire Council

26 March 2018

Cardno
Shaping the Future

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Executive Summary

Overview and Purpose

This Floodplain Risk Management Plan (FRMP) for the Bega and Brogo Rivers region has been prepared by Cardno for Bega Valley Shire Council in accordance with the New South Wales (NSW) Flood Prone Land Policy and the principles of the Floodplain Development Manual (NSW Government, 2005).

Flooding in the study area can pose a hazard to some residents and properties near creeks and overland flow paths. The Bega and Brogo Rivers FRMP has been developed to provide mitigation options to direct and co-ordinate the future management of flood prone land within the Bega and Brogo Rivers catchment. It also aims to educate the community about flood risks so that they can make more informed decisions regarding their individual exposure and responses.

The preparation of this FRMP follows on from previous documents which have been prepared to assist in addressing flood risk for the Bega and Brogo Rivers floodplain; namely the Bega and Brogo Rivers Flood Study (SMEC, 2014) and the Bega and Brogo Rivers Floodplain Risk Management Study (FRMS) (Cardno, 2018).

Study Area, Existing Flood Behaviour and Economic Damages

The study area is located in the Bega Valley Shire LGA on the South Coast of NSW, approximately 80 km from the Victorian border. The total catchment area of the two river systems is 1,810 km^2 at the confluence at Bega, of which the Bega River contributes 1,030 km^2, and the Brogo River 780 km^2.

In the upper catchment is the township of Candelo. Candelo Creek runs through the middle of the Candelo Township, with a single crossing in the middle of town. While access over this bridge is lost in flood events above the 5% AEP, both sides of the community have flood free evacuation roads out of Candelo.

The township of Bega is the largest settlement within the catchment area. The township is primarily residential, with a central commercial district. Small areas at the edge of the town are light industrial. Outside the township is open pasture for cattle grazing. Due to historical flooding experiences, much of the developed areas of Bega are outside of the mainstream 1% AEP flood extent, although some low-lying regions at the edges of the township are inundated by this event. The lower areas of the town are typically used for open space and recreational purposes.

Flooding of the Bega Township is largely driven by overbank flows from the Bega River. Flooding from the Bega River is compounded by flows from the Brogo River, as the systems are adjacent to each other and of a similar size, so peak flows arrive at Bega at similar times.

Downstream of Bega, approximately half way to the River's outfall into the Tasman Sea, are two inter-related geographic features, Bottleneck Reach and Jellat Jellat.

Bottleneck Reach runs for approximately 7 km and fully contains all events up to and including the PMF. Bottleneck Reach also results in backwater effects extending upstream towards Bega. In the PMF event, this backwater effect extends as far as the Princes Highway.

Because of this constriction a large storage area forms upstream of Bottleneck Reach. This region, Jellat Jellat, is a permanent water body. In flood events, the restriction at Bottleneck Reach causes the area to operate as a significant flood storage area. In the 1% AEP, the region stores approximately 9.7 million cubic metres of water. In the PMF, this storage volume increases to approximately 21.9 million cubic metres. In comparison to the total flow volumes, this represents storage of 2% of the total flood volume in the 1% AEP and 1% of the flood volume in the PMF.

The outlet of the Bega River is located at Mogareeka. The tidal influence extends approximately 15 km upstream to Jellat Jellat, although in large flood events, the influence of ocean levels extends as far upstream as Bega.

In the Floodplain Risk Management Study, an assessment was undertaken to identify the number of properties affected by different frequency storm events, as well as an estimate of the appropriate economic damages for that event. The table over page summarises these results.

Table i Flood affected properties and damages under existing conditions

Flood Event	Properties with Over-floor flooding	Properties with Over-ground flooding	Flood Damage
10% AEP	13	24	$1,435,177
5% AEP	40	59	$6,333,165
2% AEP	66	98	$10,764,761
1% AEP	96	137	$16,419,641
0.5% AEP	112	145	$18,261,042
0.2% AEP	116	148	$19,231,182
PMF	351	284	$55,349,244
Average Annual Damage			**$875,879**

Management Options and Implementation Program

Under the merits-based approach advocated in the NSW State Government's Floodplain Development Manual (NSW Government, 2005), and in consultation with the community, Council and stakeholders, a number of potential options for the management of flooding and/or the associated risks to life and property were identified in the FRMS.

These included:

> Flood modification measures (e.g. levees, road raising and upgrades);

> Property modification measures (e.g. house raising, voluntary purchase, land swap); and

> Emergency management measures (e.g. flood warning systems, education and awareness).

An extensive list of potential options was assessed against a range of criteria (technical, economic, environmental and social). Hydraulic modelling of some of the flood modification options was undertaken to provide a comprehensive analysis of those options that would involve significant capital expenditure.

Of the 24 options that proceeded to assessment in the multi-criteria matrix, the top three were:

> P 2 Building and development controls

> EM 2 Flood Warning System

> EM 3 Public Awareness and Education.

Of the structural options assessed, excluding the road raising options for emergency access only, the top three options identified by the multi-criteria analysis were:

> L.2.3: 1% AEP Levee – Auckland Street

> L.1.3: 1% AEP Levee – Bega and Auckland Streets

> L.4.3: 1% AEP Levee – Bega Street.

> Given these levee options are mutually exclusive, the other levee options for Auckland Street (L.2.1 and L.2.2), Bega and Auckland Streets (L.1.1 and L.1.2), and Bega Street (L.4.1 and L.4.2) would not be adopted in the FRMP.

> It is recommended that the top 12 highest-ranking options, representing those options that provide the greatest benefit to the community on a value for money basis, be adopted as actions in the FRMP.

The implementation plan provides a prioritisation of options that have been based on the Multi-Criteria Assessment (MCA) scores from the FRMS.

This FRMP represents the considered opinion of the local community on how to best manage its flood risk and its flood prone land. It provides a long-term guide for the future development of the community, and will be subject to periodic revision. It should be noted that some options require additional investigations, design, system development and/or funding before they can proceed to the implementation phase.

This plan should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change include new flood events and experiences, legislative change, alterations in the availability of funding and reviews of Council planning policies. In any event, a review every five to ten years or so is warranted to ensure the ongoing relevance of the Plan.

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** Figures are attached as A3 plots at conclusion of report.*

Glossary

Annual Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded each year; it would occur quite often and would be relatively small. A 1% AEP flood has a low probability of occurrence or being exceeded each year; it would be fairly rare but it would be relatively large.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Creek Rehabilitation	Rehabilitating the natural 'biophysical' (i.e. geomorphic and ecological) functions of the creek.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events. E.g., some roads may be designed to be overtopped in the 1 in 1 year or 100% AEP flood event.
Development	The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flash flooding	Flooding which is sudden and often unexpected because it is caused by sudden local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within 6 hours of the rain that causes it.
Flood	Relatively high stream flow, which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood fringe	The remaining area of flood-prone land after floodway and flood storage areas have been defined.
Flood hazard	Potential risk to life and limb caused by flooding.
Flood-prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land. Floodplain Risk Management Plans encompass all flood-prone land, rather than being restricted to land subject to designated flood events.
Floodplain	Area of land that is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Floodplain management measures	The full range of techniques available to floodplain managers.
Floodplain management options	The measures that might be feasible for the management of a particular area.

Flood planning area	The area of land below the flood planning level and thus subject to flood related development controls.
Flood planning levels	Flood levels selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. The concept of FPLs supersedes the “Standard flood event” of the first edition of the Manual. As FPLs do not necessarily extend to the limits of flood prone land (as defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
Flood storages	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.
Geographical Information Systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High flood island	The flood island includes enough land higher than the limit of flooding (i.e. above the PMF) to cope with the number of people in the area. During a flood event the area is surrounded by floodwater and property may be inundated. However, there is an opportunity for people to retreat to higher ground above the PMF within the island and therefore the direct risk to life is limited. The area will require resupply by boat or air if not evacuated before the road is cut. If it will not be possible to provide adequate support during the period of isolation, evacuation will have to take place before isolation occurs.
High hazard	Flood conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.

Low flood island	The flood island is lower than the limit of flooding (i.e. below the PMF) or does not have enough land above the limit of flooding to cope with the number of people in the area. During a flood event the area is isolated by floodwater and property will be inundated. If floodwater continues to rise after it is isolated, the island will eventually be completely covered. People left stranded on the island may drown and property will be inundated.
Low hazard	Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.
Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures that are to apply and the means and timing by which the plan will be implemented.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
Net Present Worth (NPW)	The value in the present of a sum of money, in contrast to some future value it will have when it has been invested at compound interest.
Overland flow	The term overland flow is used interchangeably in this report with “flooding”.
Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	The flood calculated to be the maximum that is likely to occur.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation, see Annual Exceedance Probability.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
Stormwater flooding	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.

Topography	A surface that defines the ground level of a chosen area.

* Terminology in this Glossary have been derived or adapted from the NSW Government Floodplain Development Manual (2005) where available.

Abbreviations

AAD	Average Annual Damage
AEP	Annual Exceedance Probability
AHIMS	Aboriginal Heritage Information Management System
ARI	Average Recurrence Intervals
ASS	Acid Sulfate Soils
BC Act	NSW *Biodiversity Conservation Act 2016*
BoM	Bureau of Meteorology
DCP	Development Control Plan
EECs	Endangered Ecological Communities
EMP	Estuary Management Plan
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
FPA	Flood Planning Area
FPL	Flood Planning Levels
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
GIS	Geographic Information System
ha	Hectare
HHWSS	High High Water Solstice Springs
IFD	Intensity Frequency Duration
IPCC	Intergovernmental Panel on Climate Change
km	Kilometres
km^2	Square kilometres
LEP	Local Environment Plan
LGA	Local Government Area
LiDAR	Light Detecting and Ranging
m	Metre
m^2	Square metre
m^3	Cubic Metre
mAHD	Metres to Australian Height Datum
MCA	Multi-criteria Assessment
ML	Mega Litres
mm	Millimetre
m/s	Metres per second
NPV	Net Present Value
NP&W Act	NSW *National Parks and Wildlife Act 1974*
NPW	Net Present Worth
NSW	New South Wales

OEH	Office of Environment & Heritage
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
POEO Act	NSW *Protection of the Environment Operations Act 1997*
RCP	Representative Concentration Pathway
SEPP	State Environmental Planning Policy
SES	State Emergency Service

1 Introduction

Cardno were commissioned by Bega Valley Shire Council to undertake the Floodplain Risk Management Study and Plan for the Bega and Brogo Rivers region.

The Floodplain Risk Management Study (FRMS) was undertaken to define the existing flooding behaviour and associated hazards of the study area, and to investigate possible mitigation options to reduce flood damage and risk.

This report, the Floodplain Risk Management Plan (FRMP) details a proposed implementation strategy for the flood risk management options identified in the Floodplain Risk Management Study (FRMS).

Both documents have been prepared in accordance with the New South Wales (NSW) Flood Prone Land Policy and the principles of the Floodplain Development Manual (NSW Government, 2005), and both have been undertaken alongside community consultation to ensure that community concerns are addressed appropriately

This project has been completed with financial and technical assistance from the NSW Office of Environment and Heritage (OEH).

1.1 Report Context

The NSW Floodplain Risk Management Process progresses through six steps in an iterative process through the following six stages:

1. Formation of a Floodplain Management Committee.
2. Data Collection.
3. Flood Study.
4. **Floodplain Risk Management Study.**
5. **Floodplain Risk Management Plan.**
6. Implementation of the Floodplain Risk Management Plan.

This report addresses aspects of Step 5 (FRMP).

The preparation of this FRMP follows on from previous documents which have been prepared to assist in addressing flood risk for the Bega and Brogo Rivers floodplain; namely the Bega and Brogo Rivers Flood Study (SMEC, 2014) and the Bega and Brogo Rivers Floodplain Risk Management Study (FRMS) (Cardno, 2018).

1.2 Report Objectives

The objectives of Floodplain Risk Management Plan are to:

> Reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the flood hazard and risk;

> Reduce private and public losses due to flooding;

> Protect and where possible enhance the river and floodplain environment;

> Be consistent with the objectives of relevant State policies;

> Ensure that the draft floodplain risk management plan is fully integrated with Council's existing corporate, business and strategic plans, existing and proposed planning proposals, meets Council's obligations under the *Local Government Act 1993* and has the support of the local community;

> Ensure actions arising out of the draft plan are sustainable in social, environmental, ecological and economic terms;

> Ensure that the draft floodplain risk management plan is fully integrated with the local emergency management plan; and

> Establish a program for implementation.

2 Existing Flood Behaviour

The following provides an overview of the catchment and the existing flooding behaviour within the Bega region. A more detailed assessment can be found in the FRMS (Cardno, 2018).

2.1 Study Area

The study area is located within the Bega Valley Shire local government area (LGA) on the South Coast of NSW, approximately 80 km from the Victorian border (**Figure 1-1**). The total catchment area of the two river systems is 1,810 km^2 at the confluence at Bega, of which the Bega River contributes 1,030 km^2, and the Brogo River 780 km^2.

The two rivers meet at the Bega Township and eventually discharge into the Tasman Sea at Mogareeka, 24 km downstream from Bega. The region between the Bega Township and Mogareeka contributes another 125 km^2 of catchment area. The total catchment area for the Bega River at its outlet is approximately 1,935 km^2.

In the upper catchment is the township of Candelo Candelo Creek runs through the middle of the Candelo Township, with a single crossing in the middle of town. While access over this bridge is lost due to overtopping in flood events above the 5% Annual Exceedance Probability (AEP) event, both sides of the community have flood free evacuation roads out of Candelo.

The township of Bega is the largest settlement in the catchment. The Bega Township is bordered by the Bega River on its western, northern and eastern sides. The confluence with the Brogo River is immediately north of the township. The township is primarily residential, with a central commercial district. Small areas at the edge of the town are light industrial. Outside the township is open pasture for cattle grazing.

Due to historical flooding, much of the developed areas of Bega areas outside the mainstream 1% AEP flood extent, although some low-lying areas at the edges of the township are affected by this event. The lower lying areas of the town are typically utilised for open space and recreational purposes.

Flooding of the Bega Township is largely driven by overbank flows from the Bega River. Flooding from the Bega River is compounded by flows from the Brogo River, as the systems are adjacent to each other and of a similar size, so peak flows arrive at Bega at similar times.

Downstream of Bega, approximately half way to the river's outfall into the Tasman Sea, are two inter-related geographic features, Bottleneck Reach and Jellat Jellat.

Bottleneck Reach is a significant constriction, throttles the flow from over 1,000 m wide upstream in the 1% AEP and Probable Maximum Flood (PMF) events down to 300m through the constriction. In the 1% AEP flood, flows reduce to 3,900 m^3/s through Bottleneck Reach, down from 10,400 m^3/s in the Bega River upstream of this feature; a reduction of over 60%.

Bottleneck Reach runs for approximately 7 km and fully contains all events up to and including the PMF. Bottleneck Reach also results in backwater effects extending upstream towards Bega. In the PMF event, this backwater effect extends as far as the Princes Highway.

Because of this constriction, a large storage area forms upstream of Bottleneck Reach. This region, Jellat Jellat, is a permanent water body bounded to the north by the Bega River, and large ranges on the east and west and a smaller range to the south. In flood events, the restriction at Bottleneck Reach causes the area to operate as a significant flood storage area. In the 1% AEP, the region stores approximately 9.7 million cubic metres of water. In the PMF, this storage volume increases to approximately 21.9 million cubic metres. In comparison to the total flow volumes, this represents storage of 2% of the total flood volume in the 1% AEP and 1% in the PMF.

The outlet of the Bega River is located at Mogareeka. The tidal influences extend upstream approximately 15 km to Jellat Jellat, although in large flood events the influence of ocean levels extends as far upstream as Bega.

2.2 Flood Behaviour

Peak flood depths modelled in the study area are shown in **Figure 2.1** and **Figure 2.2** for the 10% AEP event and the 1% AEP event respectively. A full presentation and discussion on the existing flood behaviour is in the *Bega and Brogo Rivers Floodplain Risk Management Study* (Cardno, 2018).

2.3 Damage Analysis

A flood damage assessment for the existing catchment conditions was completed and is detailed in the FRMS (Cardno, 2018; refer **Table 2-1**). Based on the analysis described in the FRMS, the average annual damages (AAD) for the study area under existing conditions is $875,879.

Table 2-1 Bega & Brogo Rivers Existing Damage Analysis Results

	Over floor flooding	Maximum Over floor Depth (m)	Over ground flooding	Total Damages ($Dec 2016)
PMF				
Residential	212	10.79	212	$ 32,706,217
Commercial	71	7.48	71	$ 22,528,752
Industrial	68	10.54	1	$ 114,275
Total	**351**		**284**	**$ 55,349,244**
0.2% AEP				
Residential	70	4.18	95	$ 7,898,960
Commercial	45	4.44	52	$ 11,219,371
Industrial	1	0.27	1	$ 112,851
Total	**116**		**148**	**$ 19,231,182**
0.5% AEP				
Residential	66	4.05	93	$ 7,426,756
Commercial	45	4.29	51	$ 10,762,252
Industrial	1	0.14	1	$ 72,035
Total	**112**		**145**	**$ 18,261,042**
1% AEP				
Residential	55	3.81	86	$ 6,480,135
Commercial	41	4.08	50	$ 9,904,483
Industrial	0	0.04	1	$ 35,023
Total	**96**		**137**	**$ 16,419,641**
2% AEP				
Residential	38	3.19	59	$ 4,145,498
Commercial	28	3.48	39	$ 6,619,263
Industrial	0	0.00	0	$ -
Total	**66**		**98**	**$ 10,764,761**
5% AEP				
Residential	22	2.53	39	$ 2,426,445
Commercial	18	2.81	20	$ 3,906,720
Industrial	0	-	0	$ -
Total	**40**		**59**	**$ 6,333,165**
10% AEP				

	Over floor flooding	Maximum Over floor Depth (m)	Over ground flooding	Total Damages ($Dec 2016)	
Residential	6	1.17	15	$	617,225
Commercial	7	1.45	9	$	817,952
Industrial	0	-	0	$	-
Total	**13**		**24**	**$**	**1,435,177**
Average Annual Damages				**$**	**875,879**

2.4 Consultation

The community has played an important role in assisting Council in the preparation of the Floodplain Risk Management Study and Plan.

Early in the project, a newsletter describing the study and a survey designed to understand the community impacted by the study, their experiences with flooding, their key concerns relating to flooding of the local area and any suggestions for ways to manage flood risk was sent to 1,568 property owners within the study area. The survey was also made available on Council's website.

Community input was sought to inform the development and assessment of flood risk management options through a series of workshops. The first workshop was undertaken to introduce the study to the community, and to hold a preliminary discussion on potential mitigation strategies. In general, the community had a good understanding of flood risk from the Bega and Brogo Rivers. Residents and business owners seemed prepared for some of these events and therefore the impacts of the flooding were often mitigated to some effect. There was a high level of interest in flood warning systems.

The second series of workshops was held following the development of the potential flood risk management options, during the public exhibition period.

2.4.1 Public Exhibition

The Draft Bega and Brogo Rivers Flood Risk Management Study and Plan was placed on public exhibition from 11 October 2017 to 5 November 2017. A variety of methods including workshops were employed to inform the community of the exhibition process and to invite them to view the plan and indicate the extent of their support for the plan.

Twenty (21) residents attended the community workshop during the public exhibition, Council received several phone calls and office visits throughout the exhibition period, a small number of one-on-one meetings were held with interested individuals onsite to discuss the project; and ten (10) formal submissions were received.

A summary of feedback received from the community and responses to them are provided in the Bega and Brogo Rivers Floodplain Risk Management Study.

3 Potential Floodplain Management Options

Flood risk can be categorised as existing, future or residual risk:

> **Existing Flood Risk** – existing buildings and developments on flood prone land. Such buildings and developments by virtue of their presence and location are exposed to an 'existing' risk of flooding.

> **Future Flood Risk** – buildings and developments that may be built on flood prone land. Such buildings and developments would be exposed to a flood risk when they are built.

> **Residual Flood Risk** – buildings and development that would be at risk if a flood were to exceed management measures already in place. Unless a floodplain management measure is designed to withstand the PMF, it will be exceeded by a sufficiently large event at some time in the future.

The alternate approaches to managing risk are outlined in **Table 3-1**.

Table 3-1 Flood Risk Management Alternatives (SCARM, 2000)

Alternative	Examples
Preventing / Avoiding risk	Appropriate development within the flood extent.
Reducing likelihood of risk	Structural measures to reduce flooding risk such as drainage augmentation, levees, and detention.
Reducing consequences of risk	Development controls to ensure structures are built to withstand flooding.
Transferring risk	Via insurance – may be applicable in some areas depending on insurer.
Financing risk	Natural disaster funding.
Accepting risk	Accepting the risk of flooding because of having the structure where it is.

Measures available for the management of flood risk can be categorised according to the way in which the risk is managed. A range of possible options were considered as part of the FRMS, where they are discussed in detail. The findings of the FRMS are briefly summarised in the following sections.

3.1 Flood Modification Measures

Flood modification measures are structural options aimed at preventing, avoiding or reducing the likelihood of flood risks.

A total of 46 preliminary flood modification options were identified for the Bega and Brogo Rivers floodplain. These options are outlined in Error! Reference source not found. and shown in **Figure 3-1** for the Bega study area options and **Figure 3-2** for the Candelo study area options.

Those options marked with an asterisk (*) were modelled to assess their impact on flood behaviour and to calculate the extent to which they reduced the AAD.

Table 3-2 Potential Flood Modification Options

Option ID	Option	Option Outline
Levees These options are focused on the potential construction of levee banks or flood walls to create barriers to flood waters		
L1.1-L1.3*	Bega and Auckland Street Levee	All the options have a significant constraint with regard to the flood levels and the amount of road raising required to achieve the flood protection required. Even protecting to the 10% AEP requires levee heights of up to 5.5m. This poses construction constraints, pedestrian access constraints, has negative visual impacts, and would require upgrades to all associated property accesses.
L2.1-L2.3*	Auckland Street Levee	
L3.1-L3.3*	Millowine Avenue Levee	
L4.1-4.3*	Bega Street Levee	

Option ID	Option	Option Outline
		For completeness, and discussion with the community, all levees have been assessed for all three crest levels, to provide protection in the 10% AEP, 5% AEP and 1% AEP events.
Road Raising These options propose improved access during flood events by raising road levels and, where possible, create detention basins (using the raised road as a levee) upstream of flooding issues		
R.1	Raising of Carp Street, Bega	As with the levee options, a significant number of these options require substantial road raisings to achieve flood free status in even small events, and significant raises for 1% AEP protection (up to 10 m in some locations). Large road raises in developed areas are not feasible due to maintaining connections with properties (as discussed above with reference to levees). For this reason, many of the road raising options were not recommended for inclusion in the FRMP. Road raising in Candelo (R.12), Ravenswood Road (R.5), and Kirkland Avenue (R.11) were the only options recommended for inclusion in the FRMP as emergency management options.
R.2*	Raising of East Street, Bega	
R.3	Raising of Tathra Road, Bega, location A	
R.4*	Raising of Tathra Road, Jellat Jellat, location C	
R.5*	Raising of Ravenswood Street, Bega	
R.6*	Raising of Tathra-Bermagui Road, Tathra	
R.7*	Raising of Tathra Road, Jellat Jellat, location D	
R.8*	Raising of Tathra Road, Jellat Jellat, location E	
R.9*	Raising of Tathra Road, near Bega	
R.10	Raising of Bega Road, Bega	
R.11*	Raising of Kirkland Road, Bega	
R.12*	Raising of Power Street, Sharpe Street and William Street in Candelo	
Vegetation Management These options primarily focus on increasing capacity and efficiency of creeks through the removal of debris and invasive species		
V.1	Vegetation management along the Bega River adjacent to the township to improve flood conveyance capacity	Option aims to improve flow conveyance and reduce breakouts from River in large events. Modelling showed this option was ineffective for modifying flood behaviour, and it was not recommended for inclusion in the FRMP.
Road Upgrades These options look to improve existing access routes to ensure they are safe for a high level of traffic in a flood event		
U.1	Upgrade of Boundary Road, near Bega, to provide access to hospital in PMF event.	Flood safe alternative access to hospital. This option was recommended for inclusion in the FRMP.
U.2	Installation of flood flaps on culverts under Sharpe Street, Candelo.	Prevention of backwater flows from Candelo Creek into properties on Sharpe Street. This option was recommended for inclusion in the FRMP.

The economic evaluation of each modelled option was performed by considering the reduction in the amount of flood damages incurred for the design flood events and then comparing this value with the cost of implementing the option. The results indicated that, overall, the structural options have low B/C ratios, with the implementation costs exceeding the benefits delivered (Cardno, 2018).

A structural modification measure will require additional investigations and design development to further assess feasibility, develop a more detailed cost estimate, and to develop the level of detail necessary for construction, taking due consideration of all physical, environmental and social constraints. During this process, the concept option may be altered marginally or significantly to suit such constraints. This detailed design will also be required to be (re-)modelled to demonstrate the mitigation benefits of the final design are appropriate and meet the flood mitigation objectives.

3.2 Property Modification Measures

Property modification measures are focused on preventing, avoiding or reducing consequences of flood risks. Rather than modify the flood behaviour, these measures aim to modify existing properties (e.g. by house raising) and/or impose controls on property and infrastructure development (NSW Government, 2005). Property modification measures, such as effective land use planning and development controls, are essential for ensuring that future flood damages are appropriately contained, while at the same time allowing ongoing development and use of the floodplain.

Three potential property modification options were considered in the FRMS (Cardno, 2018; refer **Table 3-3**). All three options were recommended for inclusion in the FRMP.

Table 3-3 Potential Property Modification Measures

Option ID	Option	Option Outline
PM1	Voluntary Purchase	Voluntary purchase of properties that are within high risk zones, and for which structural and property modification options are not suitable or practical. However, there are a range of activities that need to be undertaken to enable the voluntary purchase of any individual property. As discussed in Section 11.2.1 of the FRMS (Cardno, 2018), the implementation of this option would involve the development of a Voluntary Purchase policy that outlines the circumstances under which Council would potentially acquire significantly flood affected properties. The Council would then prepare a voluntary purchase scheme. It is an OEH requirement that a Voluntary Purchase Scheme be prepared, and only after a Scheme is in place may a local Council apply for the necessary funding to undertake the acquisition(s).
PM2	Building and Development Controls	This option provides for a review of the LEP 2013 and DCP 2013 by Council, taking into account the advice and recommendations made in Section 8.2 of the FRMS (Cardno, 2018). Following review, should amendments to the LEP and/or DCP be required, these would be achieved via a Planning Proposal prepared under s3.33 of the *Environmental Planning and Assessment Act 1979*, in accordance with *A Guide to Preparing Planning Proposals* (DP&E, 2016). The Secretary (or their delegate) can then issue a Gateway determination that specifies if the proposal can proceed, and under what circumstances. For example, it may specify additional studies or consultation required, and a schedule for implementation. Further information on this option is provided in Section 11.2.2 of the FRMS (Cardno, 2018).
PM3	Flood Proofing	Flood proofing involves undertaking structural changes and other procedures in order to reduce the damage caused to the property by flooding. Flood proofing of buildings can be undertaken through a combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding. These include modifications or adjustments to building design, site location or placement of contents. Measures range from elevating or relocating, to the intentional flooding of parts of the building during a flood in order to equalise pressure on walls and prevent them from collapsing. In addition to flood proofing measures that are implemented to protect a building, temporary / emergency flood proofing measures may be undertaken prior to or during a flood to protect the contents of the building. Further information on this option is provided in Section 11.2.3 of the FRMS (Cardno, 2018).

3.3 Emergency Response Modification Measures

Emergency response modification measures aim to reduce the consequences of flood risks by:

> Increasing the effective warning time, such as via the use of flood warning systems;

> Planning the evacuation of an area so that it proceeds smoothly during a flood event;

> Preparing for a flood event (e.g. stockpiling sand and sandbags for future deployment); and

> Enabling recovery following a flood event.

These types of measures are typically incorporated into the local flood plan, and education of the community on the contents of the plan is very important. As noted within the Floodplain Development Manual (NSW Government, 2005) these measures effectively modify the response of the community at risk to better cope with a flood event.

Of all the floodplain risk management options available for consideration, it is only emergency management modifications (which includes community planning) that addresses the residual flood risk after all the flood and property modification options have been implemented. Emergency management and education measures are an effective ongoing flood risk management tool (NSW Government, 2005).

A number of emergency response modification options are suitable for consideration within the floodplain. These are summarised below in **Table 3-4**.

Table 3-4 Potential Emergency Response Modification Measures

Option ID	Option	Option Outline
EM1	Information transfer to State Emergency Service (SES)	The findings of the Flood Study and the FRMS&P provide an extremely useful data source for the SES. Transfer of the flood intelligence from this study, such as road overtopping depths and timings, the locations of flood-affected properties, and the flood behaviour of high-risk regions, would be communicated to the NSW SES to assist in their flood response strategies.
EM2	Flood warning system	Investigation and development of a flood warning / alert system tied to upstream gauges to provide advance warning to the community of impending flood events. Further information on this option is provided in Section 11.3.2 of the FRMS (Cardno, 2018).
EM3	Public awareness and education	Improvement of flood awareness in the community to reduce the overall flood risk. A draft outline of an awareness campaign is provided in Appendix B

3.4 Data Collection

A data collection strategy is proposed in addition to the potential options discussed. This would involve the collection of relevant data such as survey of flood marks and records of property flooding, following a flood event. This data could then be analysed to develop further information about flooding behaviour in the catchment to aid in planning and emergency management.

3.5 Multi-criteria Assessment of Options

To assist Council in identifying the flood management options that provide the most benefits for the community, all options need to be compared against each other based on factors including but not limited to the reduction in flood risk and economic flood damages.

As documented in the FRMS (Cardno, 2018), a multi-criteria assessment (MCA) approach was used for the comparative assessment of all options identified using a similar approach to that recommended in the Floodplain Development Manual (2005). This approach uses a subjective scoring system to assess the merits of each option. The principal value of such a system is that it allows comparisons to be made between alternatives using a common index. In addition, the MCA makes the assessment of alternatives “transparent” (i.e. all important factors are included in the analysis).

However, this approach does not provide an absolute “right” answer as to what should be included in the plan and what should be omitted. Rather, it provides a method by which Council, community and stakeholders can re-examine options and, if necessary, debate and revise the relative scoring assigned.

Each option is given a score according to how well the option meets specific considerations. In order to keep the scoring system simple a framework has been developed for each criterion.

A total of 24 potential flood management options were subject to the MCA (Cardno, 2018). Each of the options was then ranked against each other based on the total scores, allowing identification of the preferred options, namely those that provide the greatest benefit to the community. The MCA matrix is attached in **Appendix A**.

The options assessment outcomes from the FRMS (Cardno, 2018) are summarised in **Table 3-5**.

Table 3-5 Options MCA Rankings

ID	Description	Rank
P2	Building and development controls	1
EM2	Flood warning system	2
EM3	Public awareness and education	3
EM1	Information transfer to the SES	4
P3	Flood proofing guidelines	5
DC1	Data collection following a flood event	6
P1	Voluntary purchase	7
U.2	Flood flaps on Sharpe Street culverts	8
U.1	Upgrade of Boundary Road	9
L.2.3	1% AEP Levee - Auckland Street	10
L.1.3	1% AEP Levee - Bega and Auckland Streets	11
L.4.3	1% AEP Levee - Bega Street	12
R.11	Raising of Tathra Road and Kirkland Avenue	17
R.12	Candelo Road Raising	19
R.5	Raising of Ravenswood Road	20
L.3.3	1% AEP Levee – Millowine Avenue	21

Of the structural options assessed, excluding the road raising options for emergency access only (options U.1 and U.2), the top three options identified by the multi-criteria analysis were:

> L.2.3: 1% AEP Levee – Auckland Street

> L.1.3: 1% AEP Levee – Bega and Auckland Streets

> L.4.3: 1% AEP Levee – Bega Street.

Given these levee options are mutually exclusive, the other levee options for Auckland Street (L.2.1 and L.2.2), Bega and Auckland Streets (L.1.1 and L.1.2), and Bega Street (L.4.1 and L.4.2) would not be adopted in the FRMP.

The rankings are proposed as the basis for selecting management options for inclusion in the FRMP, and for prioritising their implementation.

The FRMS (Cardno, 2018) recommended that the top 12 highest-ranking options, representing those options that provide the greatest benefit to the community on a value for money basis, be adopted as actions in this FRMP. The ranking of the options is proposed to be used as the basis for prioritising the components of the FRMP. The options selected for inclusion should be based on both their likely benefits and the likely funding available from Council and the State Government.

4 Implementation Program

The development and adoption of this plan is the first step towards implementation. It outlines the beneficial measures to achieve reduced flood risk within the Bega and Brogo Rivers region and the priorities for implementation. The proposed implementation program essentially forms the action list for this Plan.

The benefit of following this sequence is that gradual improvement of the floodplain and reduction in flood risk occurs as the funds become available for implementation of any identified options.

Further steps in the floodplain management process from this point forwards are:

1. Floodplain Risk Management Focus Group to consider and adopt recommendations of this Plan
2. Council to consider the Floodplain Risk Management Focus Group's recommendations
3. Council to adopt the Plan and submit an application for funding assistance to OEH and other agencies as appropriate
4. As funds become available from OEH, other state government agencies and / or Council's own resources, implement the measures in accordance with the established priorities.

For less expensive measures, Council may be able to source funding readily and these measures can progress through implementation relatively quickly. For more expensive measures Council will need to submit an application for funding assistance to OEH and other agencies as appropriate.

It should be noted that some measures such as planning related matters can be implemented by Council fairly readily, whereas, a structural modification will need to progress to further feasibility assessment and a detailed design stage before it can be built. This is to develop the detail of the measure for construction taking due consideration of all physical, environmental and social constraints. During this process, the concept option may be altered marginally or significantly to suit such constraints. This detailed design will also be required to be modelled to demonstrate the mitigation benefits of the final design are appropriate and meet the flood mitigation objectives.

This FRMP should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change could include new flood events and experiences, legislative change, alterations in the availability of funding and reviews of Council planning policies. In any event, a review every five years is warranted to ensure the ongoing relevance of the Plan.

4.1 Key Stakeholders

As a part of the implementation of the FRMP and the detailed feasibility investigation and/or design phase of some of the options, liaison should be undertaken with key stakeholders. These stakeholders should include, but are not limited to:

> Private residents – in particular, those affected by proposed works;

> Community groups;

> Roads and Maritime Services (RMS) – with regard to any impacts on any RMS roads in the study area;

> NSW SES – particularly with regards to the emergency management options. Generally, the SES should also be kept informed of changes to the flood behaviour resulting from any of the implemented options; and,

> OEH – as it is likely that funding would be sourced from OEH for a number of the options, they should be consulted as a part of the design process.

4.2 Implementation Plan

The list of recommended management options (**Table 3-5**) has been developed into an implementation plan.

Table 4-1 lists the following information relevant to the implementation of the management actions:

> An estimate of capital costs for each structural action;

> The agency or organisation likely to be responsible for the action and/or funding; and

> The priority for implementation (high, medium, or low) as an outcome of the FRMS.

The measures identified in **Table 4-1** represent a capital outlay of approximately $21.2M. However, high and medium priority actions have a total cost of approximately $5.8M.

Experience with these types of Plans has identified that the works are undertaken when and as funding becomes available, as well as when various opportunities might arise specifically for an option. In general:

> Non-structural measures can generally be implemented in the short term (1 to 3 years), as they are relatively low in capital expenditure and generally revolve around policy and information; and

> Priority structural measures can generally be implemented in the medium term (3 to 20 years), and will be implemented as funding and opportunities arise.

Table 4-1 Floodplain Risk Management Measures Recommended for Inclusion in the Bega & Brogo Rivers Risk Management Plan

ID	Description	Estimated Capital Cost	Estimated Recurring Cost	Funding Sources / Responsibility	Priority for Implementation
PM2	Building and development controls	$15,000	$500	Council	High
EM2	Flood warning system	$250,000	$2,500	Council / OEH / SES	High
EM3	Public awareness and education	$25,000	$1,000	Council / SES	High
EM1	Information transfer to the SES	$3,000	$0	Council / SES	High
PM3	Flood proofing guidelines	$15,000	$1,000	Council	High
DC1	Data collection following a flood event	$5,000	$3,000	Council / SES	High
PM1	Voluntary purchase	$4,500,000	$0	Council / OEH	Medium
U.2	Flood flaps on Sharpe Street culverts	$50,000	$10,000	Council / OEH	Medium
U.1	Upgrade of Boundary Road	$945,000	$9,450	Council	Medium
L.2.3	1% AEP Levee - Auckland Street	$3,791,200	$25,000	Council / OEH	Low
L.1.3	1% AEP Levee - Bega and Auckland Streets	$4,246,700	$40,000	Council / OEH	Low
L.4.3	1% AEP Levee - Bega Street	$7,313,300	$50,000	Council / OEH	Low
Total Cost of Implementing the Plan (All options)		$21,159,200	$142,450		
Total Cost of Implementing the Plan (High and Medium options)		$5,808,000	$27,450		
Total Cost of Implementing the Plan (High options)		$313,000	$8,000		
Total Cost of Implementing the Plan (Structural options)		$16,346,200	$134,450		
Total Cost of Implementing the Plan (Non-structural options)		$4,813,000	$8,000		
Total Cost of Implementing the Plan (Non-structural options, excl. VP)		$313,000	$8,000		

5 Recommendations and Conclusion

This report presents the findings of the FRMP for the Bega and Brogo Rivers study area. The investigations and consultations undertaken as part of the FRMS (Cardno, 2018) identified a number of flood risk issues for the floodplain. Based on these issues, a series of floodplain management measures were developed, and have been recommended in this FRMP.

The shortlist of 12 floodplain management measures recommended for inclusion as actions in the FRMP are generally based on opportunities for short to medium term work and comprise levees, road raising, and flood warning systems (refer **Section 4**). The majority of the measures are independent and therefore can be undertaken as isolated projects. These measures will likely require further detailed assessment and detailed investigation prior to any implementation.

The implementation strategy may not necessarily approach the options from “highest ranking to lowest ranking” but will also need to incorporate various other considerations such as existing works programs, availability of funding and other opportunities to combine floodplain works with other activities.

While the rankings of the shortlisted options are useful, it should be recognised that the FRMP needs to retain sufficient flexibility such that Council (or other responsible agencies) may implement any of the measures at any time, regardless of their ranking. Such an instance may arise, for example, where funding becomes available through a specific grant or funding program, which would allow for the implementation of a lower ranked option before a higher ranked option. Alternatively, opportunities to implement specific options ancillary to another project may arise from time to time, such as when a road is proposed for upgrade the road raising may be undertaken concurrently.

As noted in Section 4 of this report, for less expensive measures, Council may be able to source funding readily and these measures can progress through implementation relatively quickly. For more expensive measures, Council will need to submit an application for funding assistance to OEH and other agencies as appropriate. Some measures can be implemented by Council fairly readily, such as those related to planning or development controls. In contrast, a flood modification option will need to progress to further feasibility assessment and a detailed design stage before it can be built.

Additional investigations and design development are required for flood modification or property modification options to further assess feasibility, develop a more detailed cost estimate, and to develop the level of detail necessary for construction, taking due consideration of all physical, environmental and social constraints.

The recommended flood modification options as described in this FRMP may be modified marginally or significantly because of this process, and the detailed design will need to be (re-)modelled to demonstrate the mitigation benefits of the final design are appropriate and meet the flood mitigation objectives. The final step in progressing a flood modification option to implementation is to conduct an environmental impact assessment in accordance with the requirements of the EP&A Act (refer **Section 7.3**). Other approvals, permits or licences may be required prior to implementation. This process may also be applicable to other types of management options, such as the design, development and implementation of flood warning systems.

For property modification measures, such as P1, which recommends voluntary property acquisitions, the development of a policy and accompanying scheme for must be undertaken to allow Council to apply for the necessary funding and to enable them to discuss the proposed acquisitions strategy with the community. These activities must take place before any acquisitions, if approved by Council and the relevant landowner could occur.

Hence, it is recommended that the Plan be regarded as a “living document” requiring review and modification over time. The catalysts for change may include new flood events and experiences, legislative change, changes in the availability of funding, reviews of Council’s strategic plans prepared under the Integrated Planning and Reporting System, or amendments to their planning policies.

6 Qualifications

The Bega and Brogo Rivers Floodplain Risk Management Study and Plan have been prepared by Cardno for Bega Valley Shire Council and as such should not be used by a third party without proper reference.

The investigation and modelling procedures adopted for this study follow industry standards and considerable care has been applied to the preparation of the results. However, model set-up and calibration depends on the quality of data available. The flow regime and the flow control structures are complicated and can only be represented by schematised model layouts.

Hence there will be a level of uncertainty in the results and this should be borne in mind in their application.

The report relies on the accuracy of the survey data and pit and pipe date provided.

Study results should not be used for purposes other than those for which they were prepared.

7 References

Cardno (2018) *Bega and Brogo Rivers Floodplain Risk Management Study*

NSW Government (2005) *NSW Floodplain Development Manual: the management of flood liable land*, April 2005, Sydney, NSW Government

SMEC (2014) *Bega and Brogo Rivers Flood Study at Bega*. Prepared by SMEC.

Bega & Brogo Rivers FRMSP

FIGURES

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Date
25/01/2017

Size
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Scale
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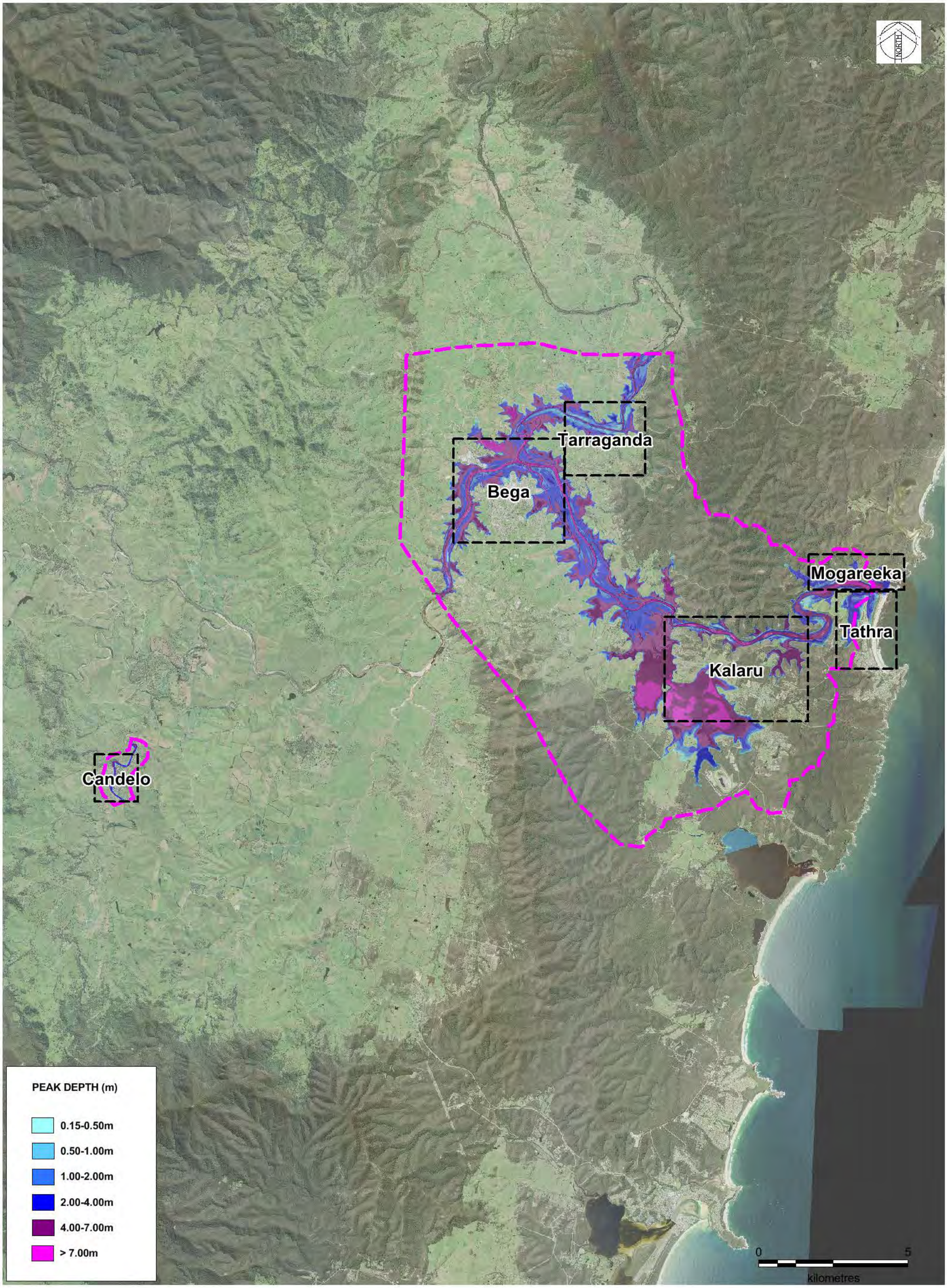
BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
STUDY AREAS
FIGURE 1-1



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Date
3/5/2017

Size
A3

Scale
1:50,000

BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
10 % PEAK FLOOD DEPTH

FIGURE 2.1

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Date
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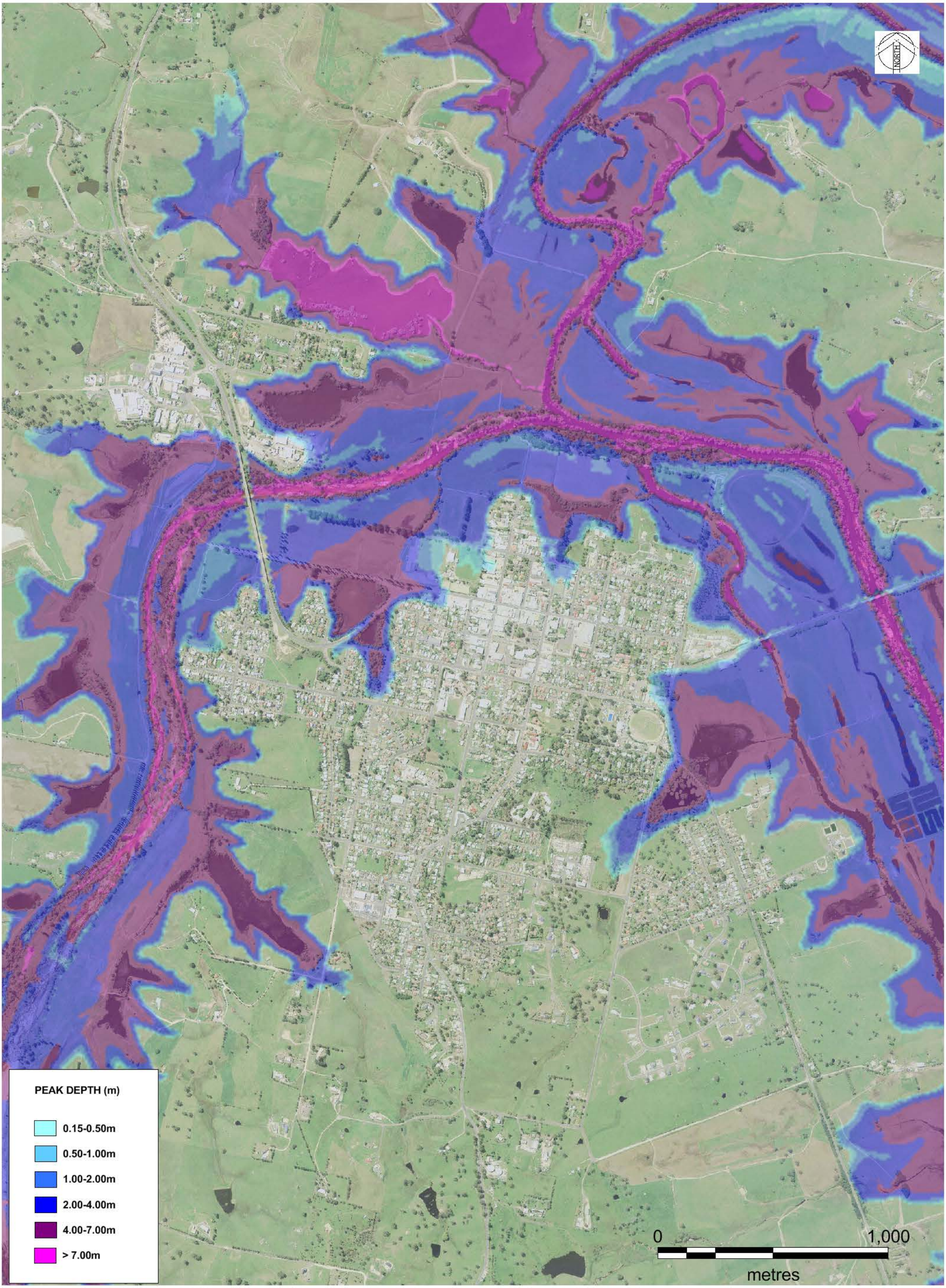
Size
A3

BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
CANDELO INSET
10% AEP PEAK FLOOD DEPTH
FIGURE 2.1A



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Date
17/5/2017

Size
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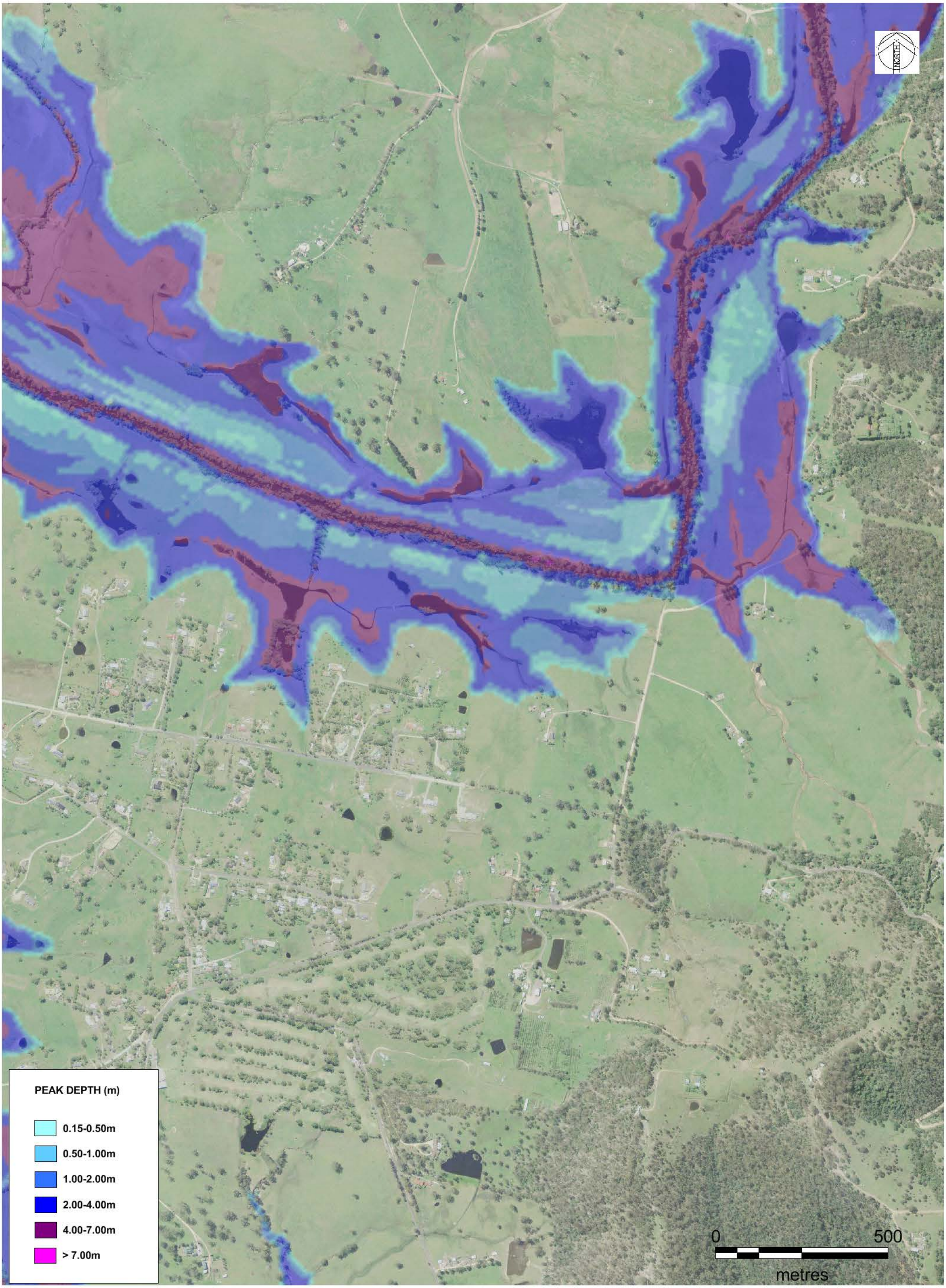
BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
BEGA INSET
10% AEP PEAK FLOOD DEPTH
FIGURE 2.1B



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Date
17/5/2017

Size
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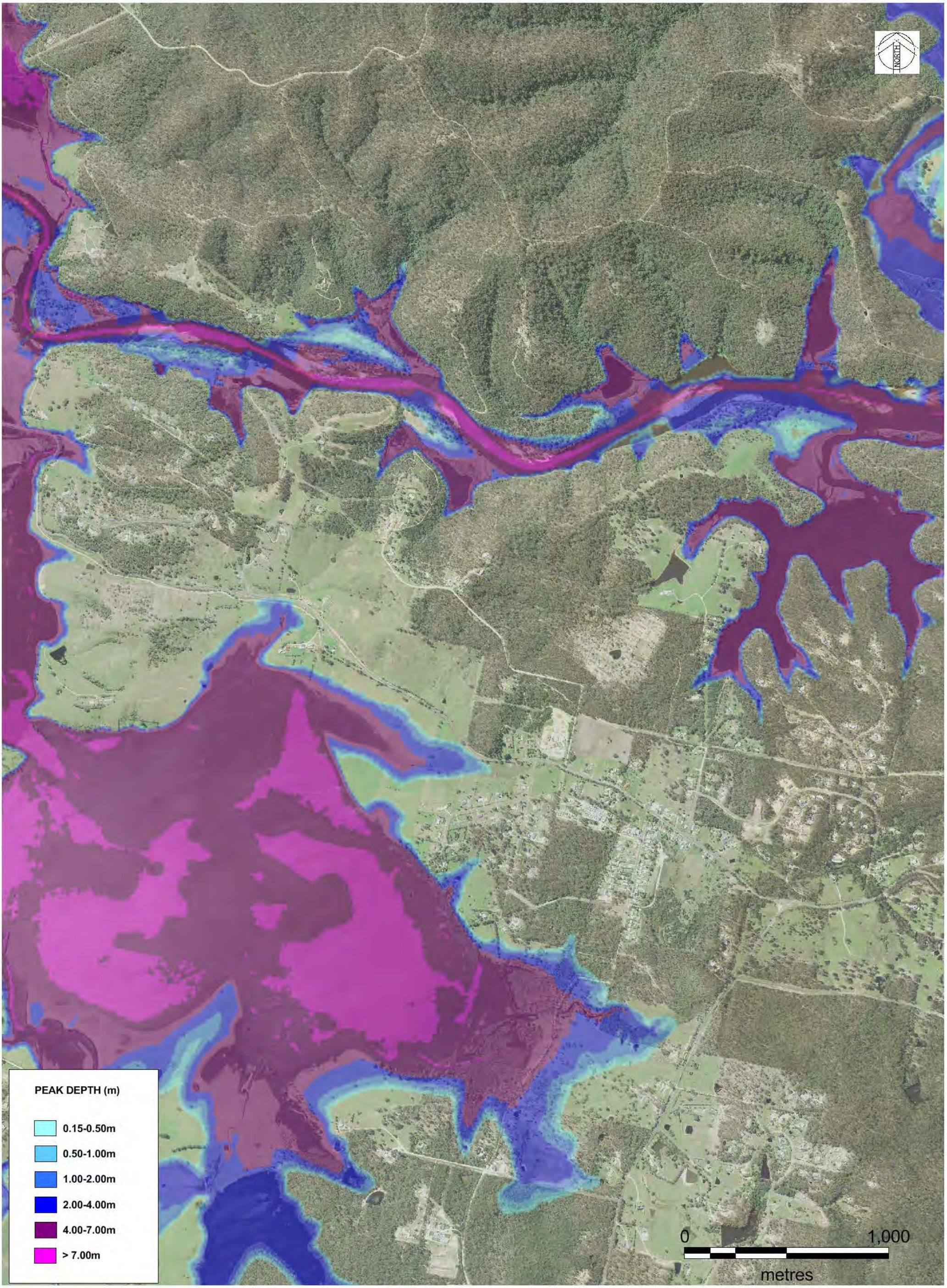
BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
TARRAGANDA INSET
10% AEP PEAK FLOOD DEPTH
FIGURE 2.1C



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Size
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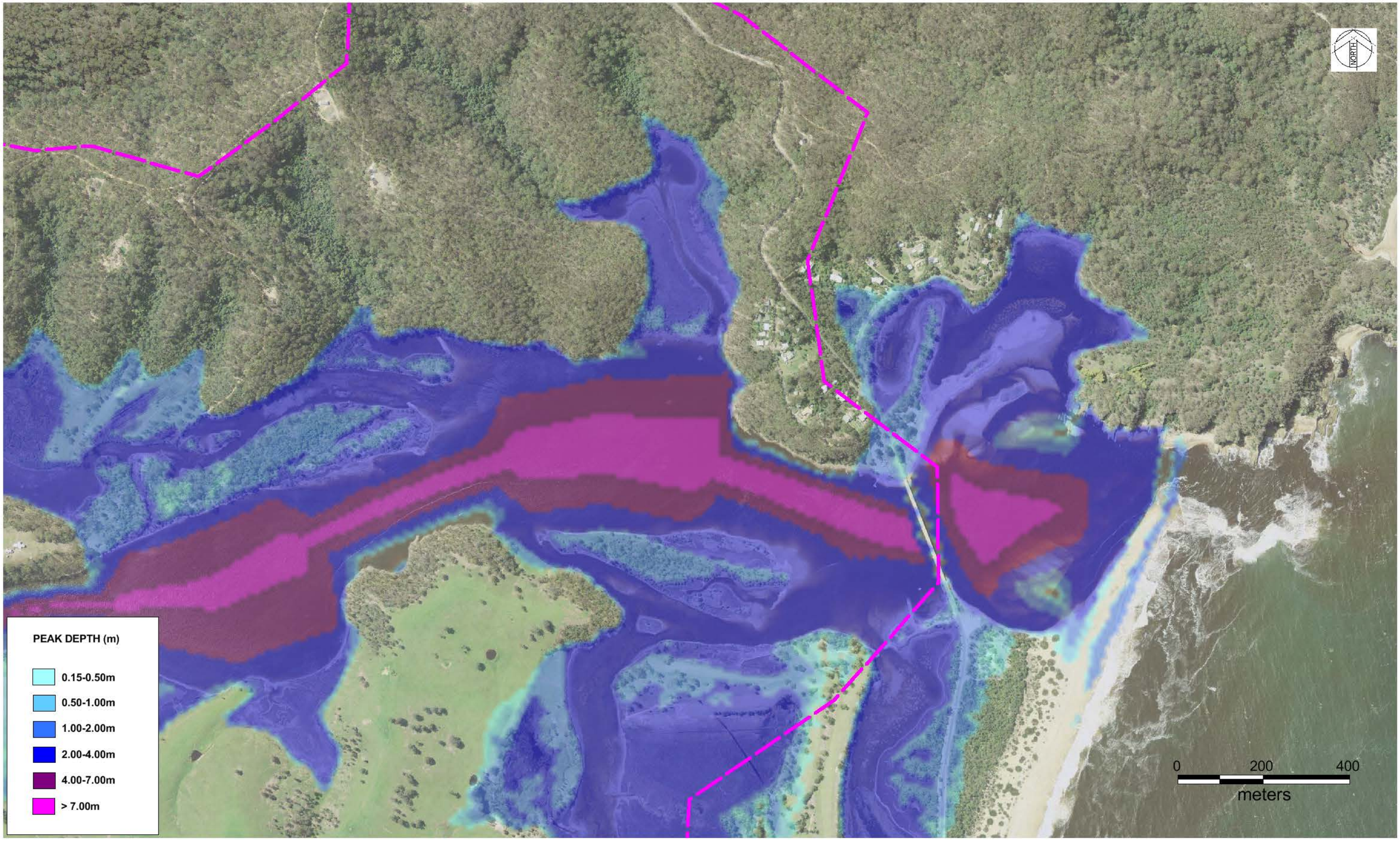
BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
KALARU INSET
10% AEP PEAK FLOOD DEPTH
FIGURE 2.1D



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Date
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Size
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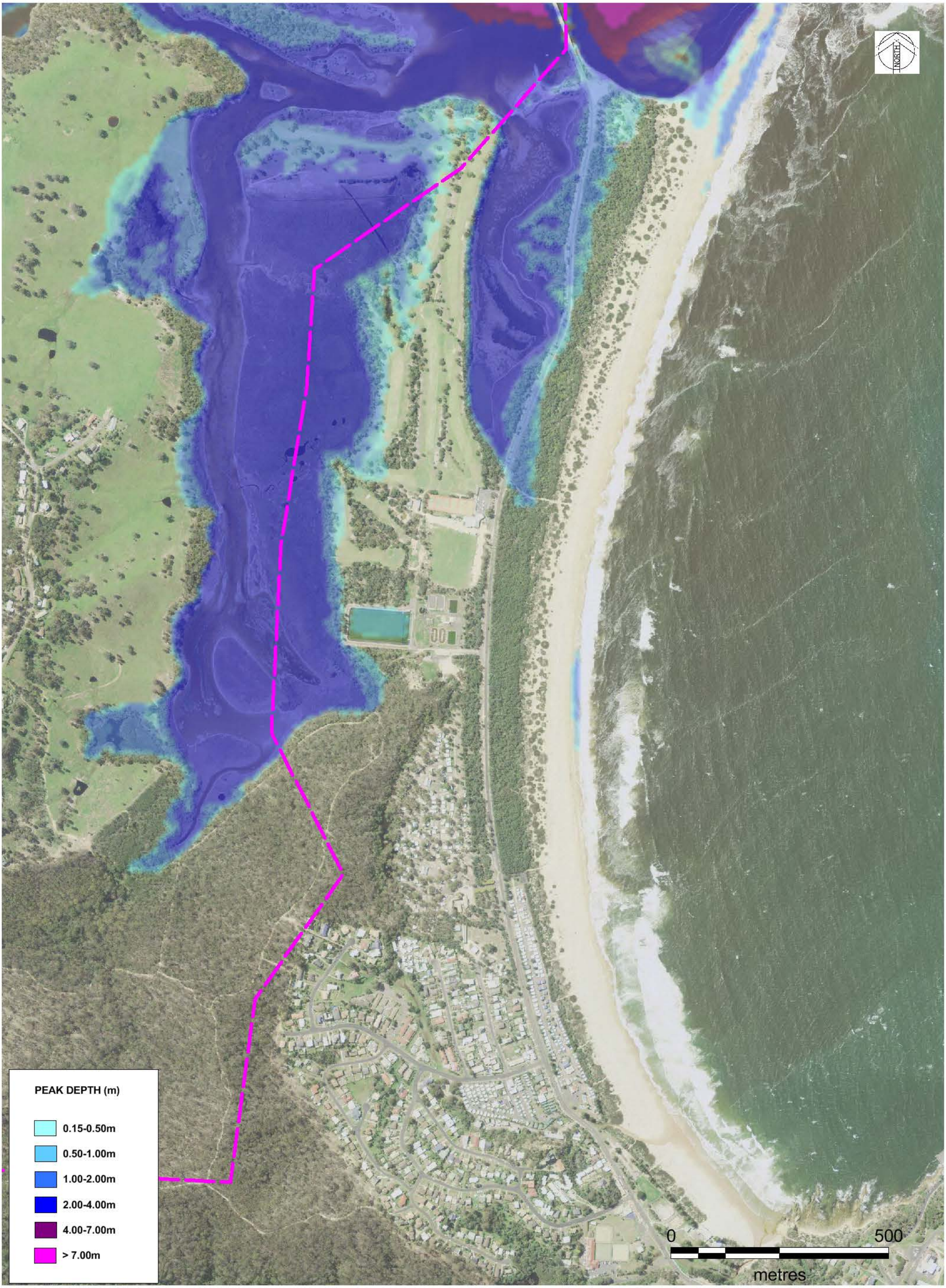
BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
MOGAREEKA INSET
10% AEP PEAK FLOOD DEPTH
FIGURE 2.1E



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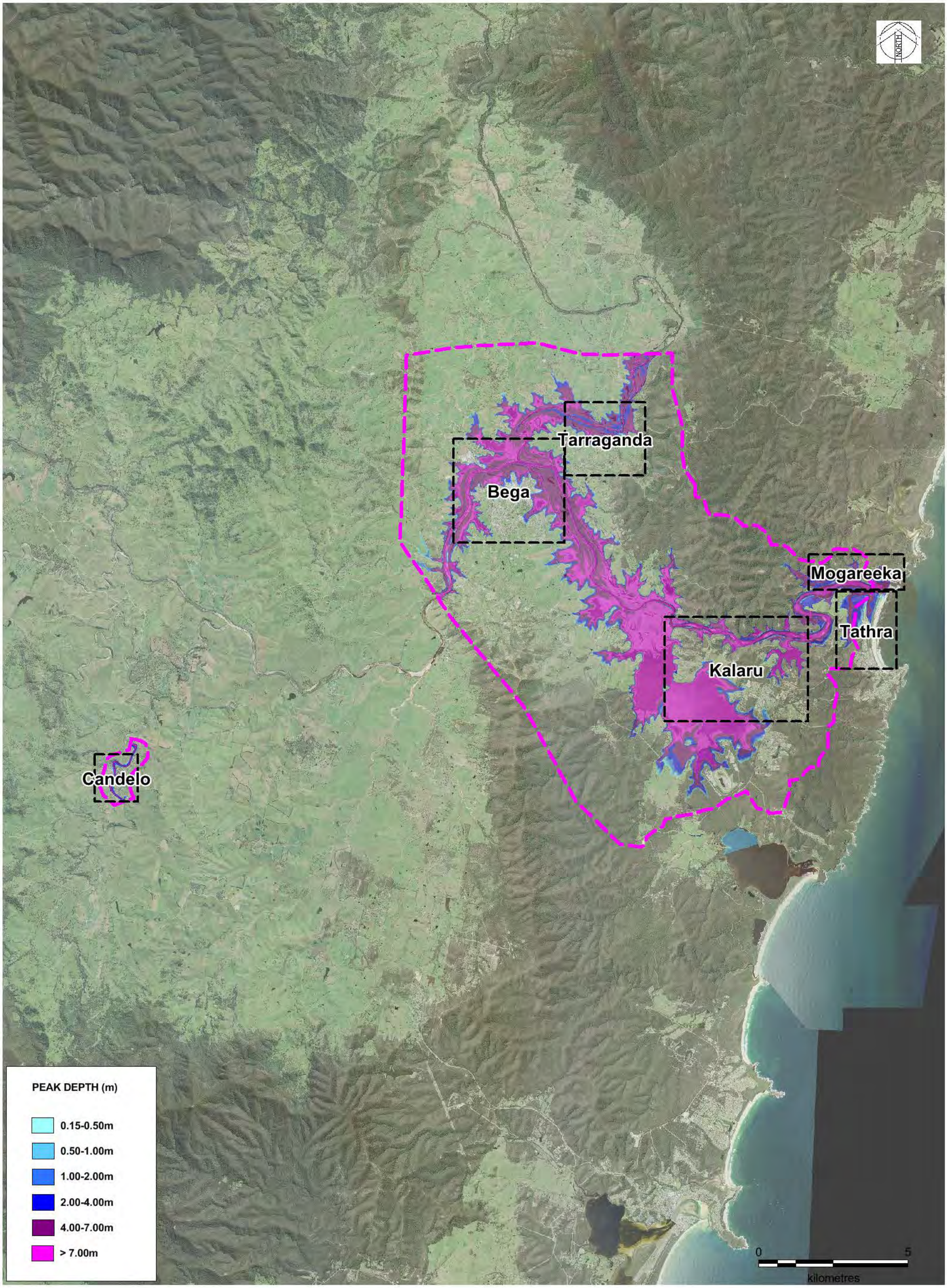
Date
17/5/2017

Size
A3

BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
TATHRA INSET
10% AEP PEAK FLOOD DEPTH
FIGURE 2.1F



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Shaping the Future

Date
3/5/2017

Size
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Scale
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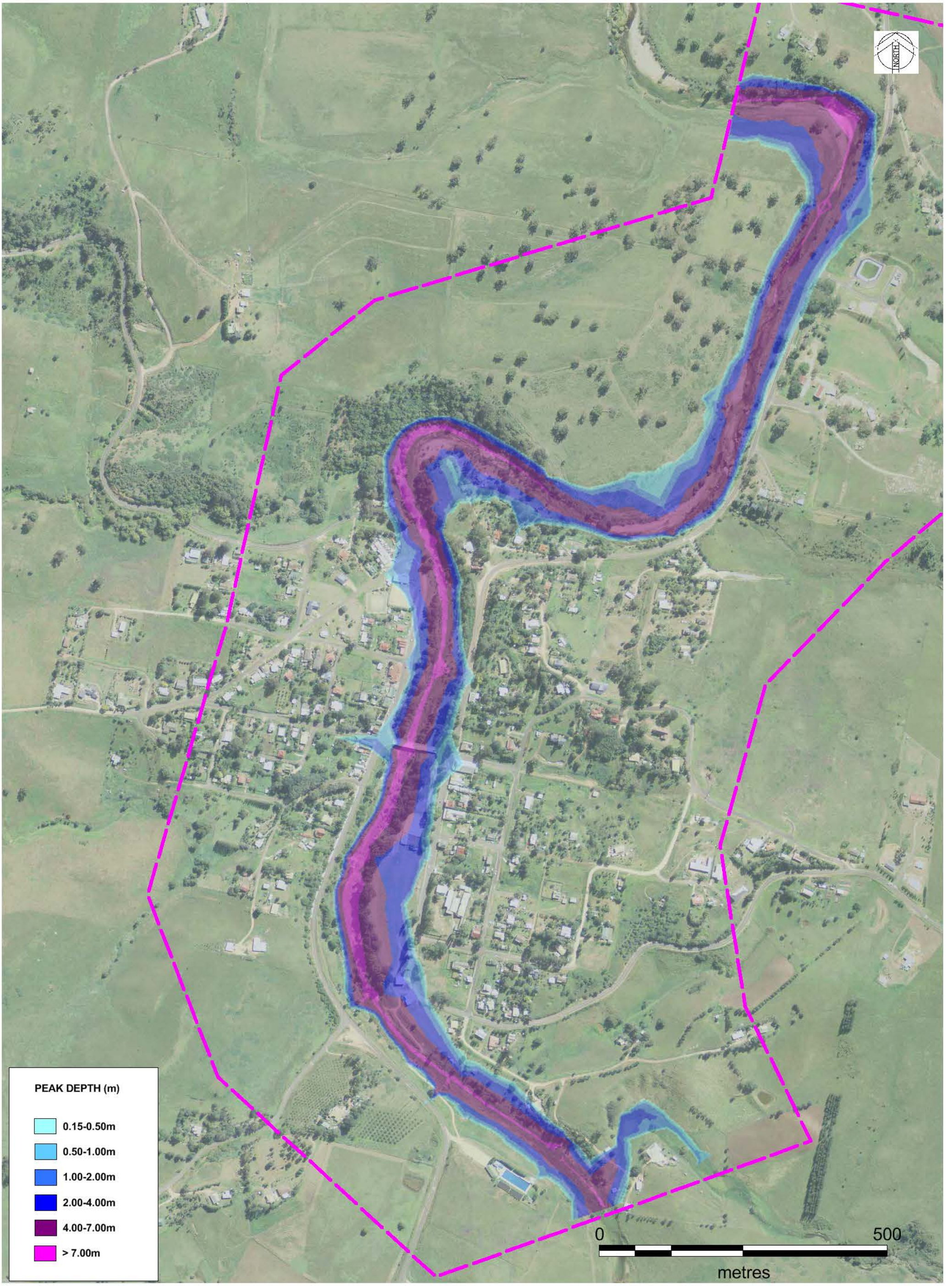
BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
1 % PEAK FLOOD DEPTH

FIGURE 2.2



Cardno
Shaping the Future

Date
6/6/2017

Size
A3

BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
CANDELO INSET
1% AEP PEAK FLOOD DEPTH
FIGURE 2.2A

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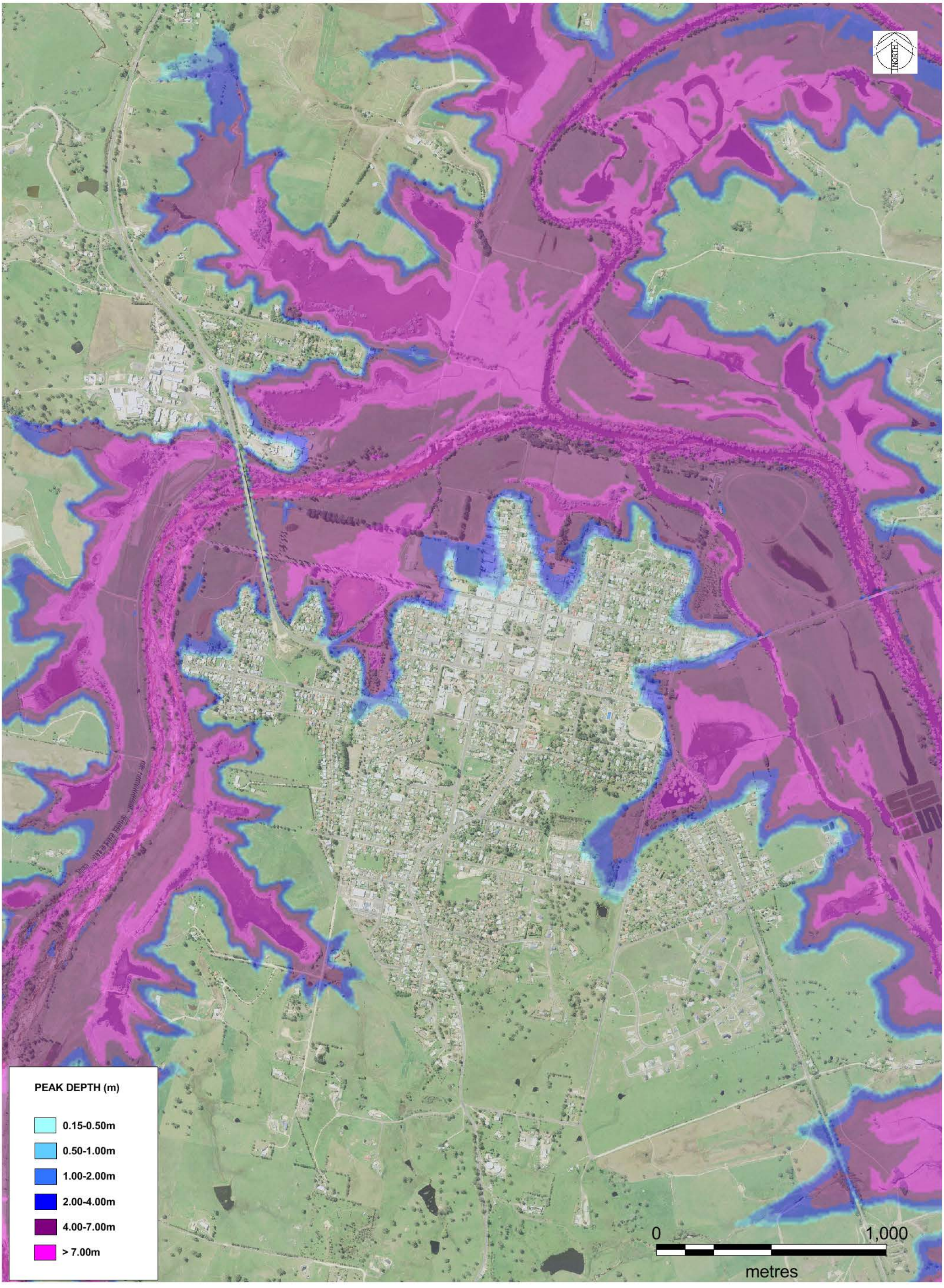

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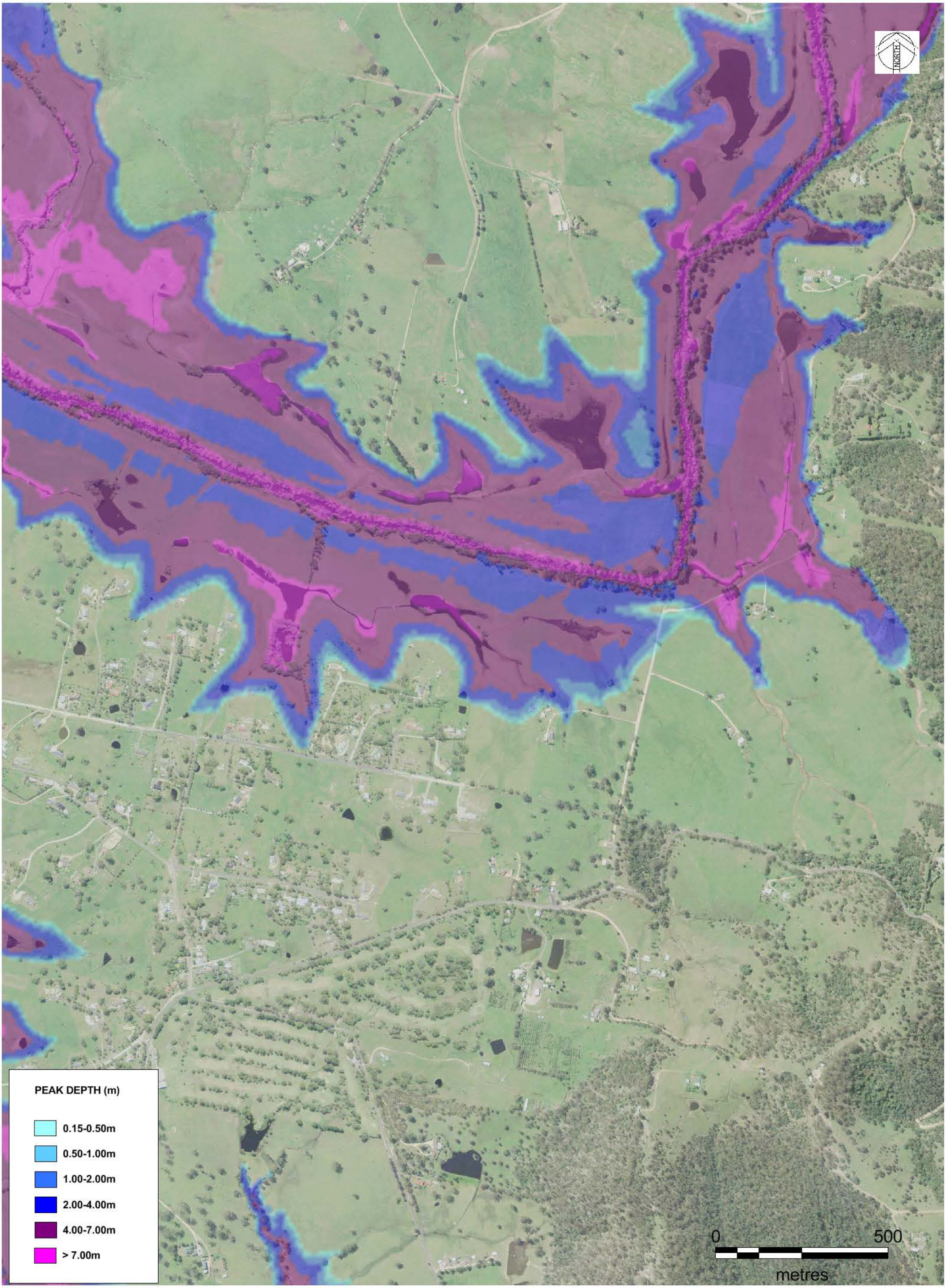
Cardno
Shaping the Future

Date
17/5/2017

Size
A3

BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
BEGA INSET
1% AEP PEAK FLOOD DEPTH
FIGURE 2.2B



DATE PLOTTED: 25/01/2017 BY: Luke Evans
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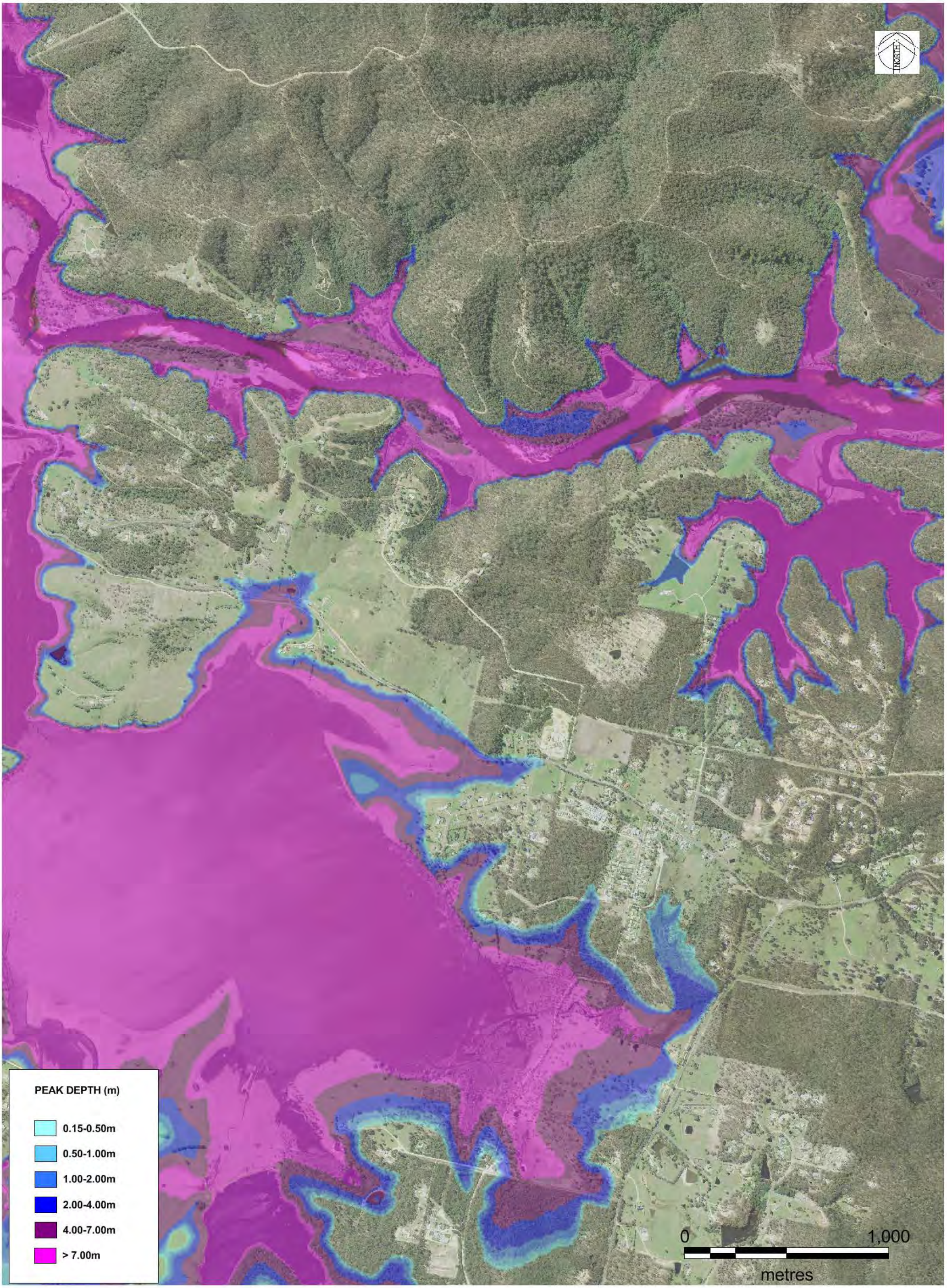
Date
17/5/2017

Size
A3

BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
TARRAGANDA INSET
1% AEP PEAK FLOOD DEPTH

FIGURE 2.2C



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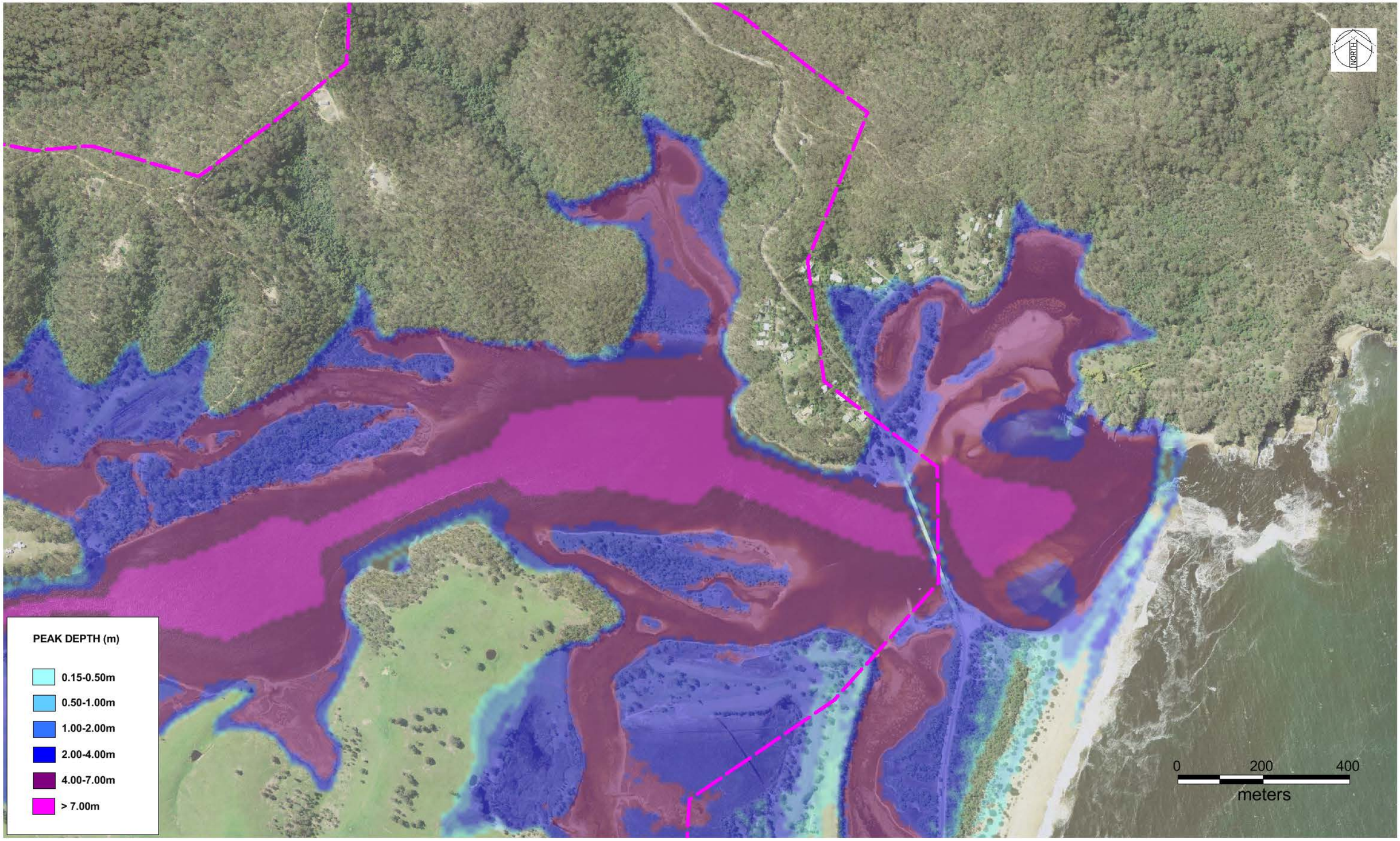
Date
17/5/2017

Size
A3

BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
KALARU INSET
1% AEP PEAK FLOOD DEPTH
FIGURE 2.2D



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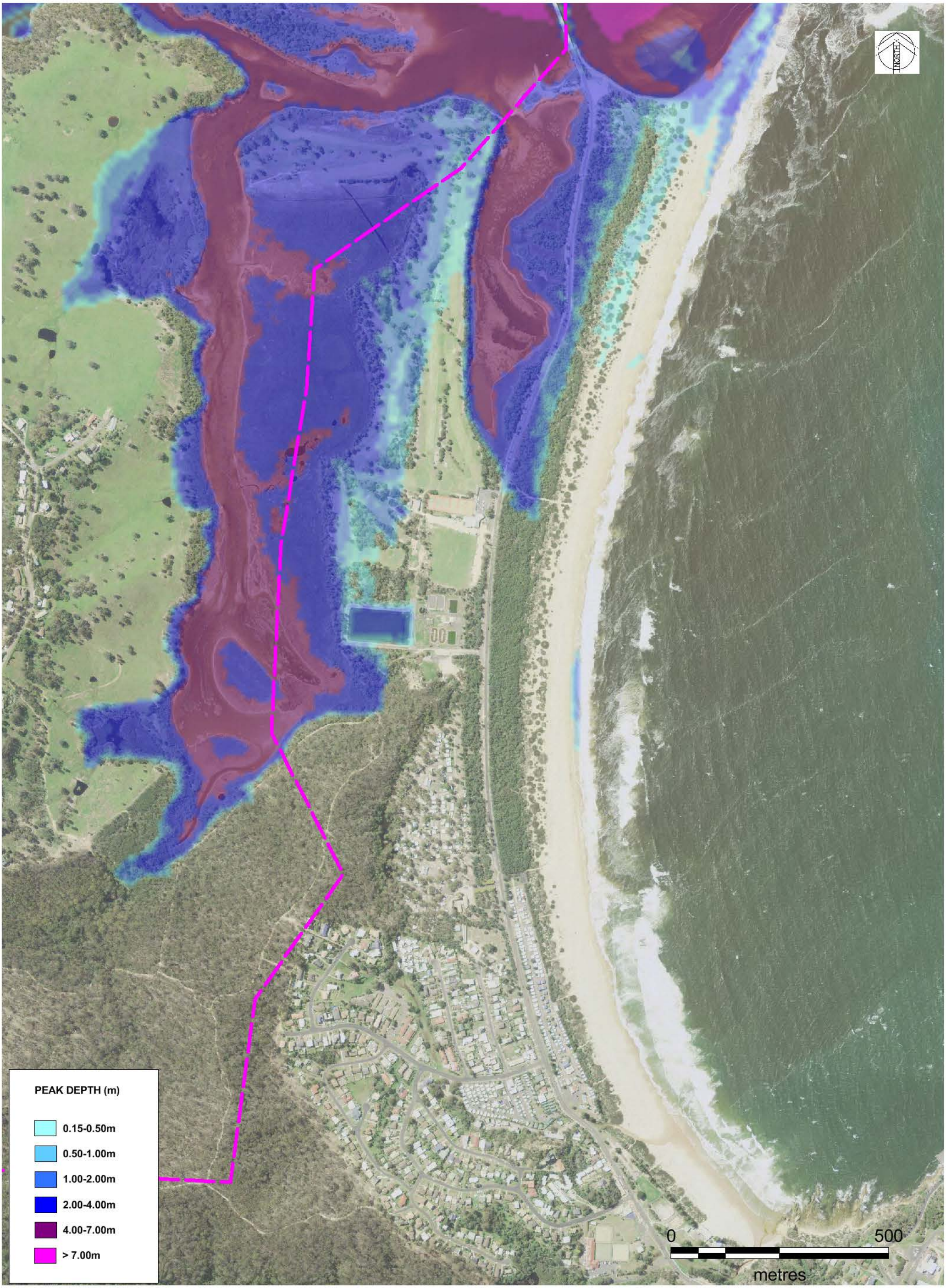
Date
3/5/2017

Size
A3

BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P

MOGAREEKA INSET
1% AEP PEAK FLOOD DEPTH
FIGURE 2.2E



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Size
A3

BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
TATHRA INSET
1% AEP PEAK FLOOD DEPTH
FIGURE 2.2F

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Date
25/01/2017

Size
A3

Scale
1:50,000

BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
BEGA MITIGATION OPTIONS
FIGURE 3-1

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Date
25/01/2017

Size
A3

Scale
1:2,000

BEGA VALLEY SHIRE COUNCIL
BEGA AND BROGO FRMS&P
CANDELO MITIGATION OPTIONS
FIGURE 3-2

Bega & Brogo Rivers FRMSP

APPENDIX A

MULTI-CRITERIA ASSESSMENT

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Bega and Brogo Rivers FRMSP - Multi Criteria Assessment - Ranked

ID	Description	Estimate of Capital Cost	Estimate of Recurrent Cost	Net Present Value (7%, 50 years)	Reduction in AAD	NPV of Reduction in AAD	Benefit - Cost Ratio	Score on Benefit Cost Ratio	Reduction in Risk to Property	EconomicScore	Reduction in Risk to Life	Reduction in Social Disruption	Community Criteria	Council Support	Social Score	Surface water Quality	Groundwater	Flora/fauna Impat	Acid Sulfate Soils	Heritage	Environmental Score	TOTAL SCORE	RANK on TOTAL SCORE
P2	Building and Development Controls	$15,000	$500	$21,900	NC	N/A	N/A	2	2	2.0	1	1	0	1	0.8	0	0	0	0	0	0.0	4.8	1
EM2	Flood warning system	$250,000	$2,500	$284,502	NC	N/A	N/A	1	2	1.3	2	2	2	2	2.0	0	0	0	0	0	0.0	4.7	2
EM3	Public Awareness and Education	$25,000	$1,000	$38,801	NC	N/A	N/A	2	0	1.3	1	1	2	2	1.5	0	0	0	0	0	0.0	4.2	3
EM1	Infomation transfer to the SES	$3,000	$0	$3,000	NC	N/A	N/A	2	0	1.3	1	0	2	2	1.3	0	0	0	0	0	0.0	3.9	4
P3	Flood Proofing Guidelines	$15,000	$1,000	$28,801	NC	N/A	N/A	2	1	1.7	0	0	1	1	0.5	0	0	0	0	0	0.0	3.8	5
DC1	Data collection following a flood event	$5,000	$3,000	$46,402	NC	N/A	N/A	2	0	1.3	0	0	2	2	1.0	0	0	0	0	0	0.0	3.7	6
P1	Voluntary Purchase	$4,500,000	$0	$4,500,000	$1,356,000	$18,713,812	4.2	2	1	1.7	1	1	-2	0	0.0	1	0	0	0	0	0.2	3.5	7
U.2	Flood Flaps on Sharpe St Culverts	$50,000	$10,000	$188,007	NC	N/A	N/A	2	0	1.3	0	1	0	1	0.5	0	0	0	0	0	0.0	3.2	8
U.1	Upgrade of Boundary Road	$945,000	$9,450	$1,075,417	NC	N/A	N/A	0	1	0.3	1	1	2	1	1.3	1	0	0	0	0	0.2	2.1	9
L.2.3	1% AEP Levee - Auckland Street	$3,791,200	$25,000	$4,136,219	$176,053	$2,429,663	0.6	-1	1	-0.3	2	1	-2	1	0.5	0	0	0	0	-1	-0.2	-0.4	10
L.1.3	1% AEP Levee - Bega and Auckland Streets	$4,246,700	$40,000	$4,798,730	$205,863	$2,841,063	0.6	-1	1	-0.4	2	1	-2	1	0.5	0	0	-1	0	-1	-0.2	-0.4	11
L.4.3	1% AEP Levee - Bega Street	$7,313,300	$50,000	$8,003,337	$208,636	$2,879,333	0.4	-1	1	-0.4	2	1	-2	1	0.5	0	0	0	0	-1	-0.2	-0.5	12
L.2.2	5% AEP Levee - Auckland Street	$2,780,300	$15,000	$2,987,311	$96,212	$1,327,797	0.4	-1	1	-0.3	1	1	-2	1	0.3	0	0	0	0	-1	-0.2	-0.6	13
L.1.2	5% AEP Levee - Bega and Auckland Streets	$4,178,300	$30,000	$4,592,322	$103,940	$1,434,450	0.3	-1	1	-0.4	1	1	-2	1	0.3	0	0	-1	0	-1	-0.2	-0.7	14
L.4.2	5% AEP Levee - Bega Street	$6,094,400	$40,000	$6,646,430	$106,201	$1,465,653	0.2	-1	1	-0.4	1	1	-2	1	0.3	0	0	0	0	-1	-0.2	-0.8	15
L.2.1	10% AEP Levee - Auckland Street	$1,207,300	$10,000	$1,345,307	$35,755	$493,446	0.4	-1	0	-0.7	0	0	-1	1	0.0	0	0	0	0	-1	-0.2	-1.5	16
R.11	Riasing of Tathra Road and Kirkland Avenue	$750,000	$7,500	$853,506	NC	N/A	N/A	-2	0	-1.3	1	1	1	1	1.0	0	0	0	0	0	0.0	-1.7	17
L.3.3	1% AEP Levee - Millowine Ave	$2,344,900	$15,000	$2,551,911	$2,262	$31,217	0.0	-2	1	-1.0	2	1	-2	1	0.5	0	0	-2	0	-1	-0.2	-1.7	18
R.12	Candelo Road Raising	$2,325,000	$25,000	$2,670,019	$28,774	$397,103	0.1	-2	1	-1.0	1	1	-2	1	0.3	0	0	0	0	0	0.0	-1.8	19
R.5	Riasing of Ravenswood Road	$1,000,000	$10,000	$1,138,007	NC	N/A	N/A	-2	0	-1.3	0	1	1	1	0.8	0	0	0	0	0	0.0	-1.9	20
L.3.2	5% AEP Levee - Millowine Ave	$1,407,000	$10,000	$1,545,007	$927	$12,793	0.0	-2	1	-1.0	1	1	-2	1	0.3	0	0	-2	0	-1	-0.2	-2.0	21
L.1.1	10% AEP Levee - Bega and Auckland Streets	$4,423,500	$20,000	$4,699,515	$27,380	$377,864	0.1	-2	0	-1.3	0	0	-1	1	0.0	0	0	-1	0	-1	-0.2	-2.9	22
L.3.1	10% AEP Levee - Millowine Ave	$599,000	$5,000	$668,004	$953	$13,152	0.0	-2	0	-1.3	0	0	-1	1	0.0	0	0	-2	0	-1	-0.2	-2.9	22
L.4.1	10% AEP Levee - Bega Street	$5,470,100	$30,000	$5,884,122	$29,641	$409,068	0.1	-2	0	-1.3	0	0	-1	1	0.0	0	0	0	0	-1	-0.2	-2.9	22

NC - Not Costed

Bega & Brogo Rivers FRMSP

APPENDIX B

COMMUNITY EDUCATION & AWARENESS STRATEGY

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B Community Education and Awareness

Community awareness of flood behaviour and flood risks is essential to minimise risk to life during flood events. An aware and educated population will be able to respond to flood events quickly and appropriately, reducing risks to themselves, their property and to others.

B.1 Current Community Awareness of Flood Behaviour and Risk

Community consultation (refer Section 4 of the Floodplain Risk Management Study) has been undertaken throughout this study through:

> A questionnaire that was distributed to residents at the commencement of the study that collected information on respondents' history, awareness and expectations of flooding; and,

> Community workshops held at key stages of the study.

The questionnaire results showed:

> A significant number of respondents (65%) were concerned with risk to property due to flooding, 39% were concerned with inconvenience related to flooding, and 27% were concerned with risk to life due to flooding;

> More than half (55%) of respondents were concerned with floods affecting specific roads in the area, 45% of respondents were concerned with flooding at their property, and 23% were concerned with flooding in public areas;

> Many respondents (60%) had heard of Flood Planning Levels (FPLs) and felt that they were necessary for the protection of property and life, while only some (31%) of respondents understood what a freeboard is and why it is included in the FPLs;

> The most popular option chosen by respondents to minimise flood-related risk was the placing of restrictions on development on flood-prone land with 50% of respondents choosing this option. 35% of respondents considered stopping all new developments on land with any potential to flood as needed to minimise flood-related risk;

> The implementation of planning and flood-related development controls was the most popular management option chosen by residents for the Bega River and Brogo River area with 51% of respondents choosing this option as most preferred. On the other hand, the voluntary purchase of highly affected properties by Council was by far the most unpopular management option with only 12% of respondents choosing it as their most-preferred option.

It is an advantage that the community understands that flooding will occur along the rivers and creeks within the study area. The community also appreciates the need for planning controls to ensure that development undertaken within the floodplain is appropriate.

The key aim of education and awareness actions is to build on this understanding in order to develop within the community an awareness of the severity of possible future flooding, so that community flooding expectations are more closely aligned with the actual flood risks and impacts of future flood events.

B.2 Building Community Awareness

Discussed below are strategies that may be implemented to raise community knowledge and awareness of flooding within the study area.

B.2.1 Short Term

B.2.1.1 Targeted Correspondence with High Risk Properties

The investigations undertaken as part of this study have shown that a number of properties within the study area are at such a significant flood risk, that voluntary purchase was identified as a means of responding to this risk. These properties begin to experience high hazard flows and loss of access in the 5% AEP, and have peak flood depths of over 4m in the PMF. It is recommended that these properties be contacted following the adoption of this study in order to inform them of the outcomes, and what these outcomes mean for residents. It is suggested that part of the correspondence include:

> A summary of peak flood levels for properties for the design events, along with the level observed in the 2010 event for comparison,

> A summary of flood timings for their region, noting that there will be very little warning of imminent flooding,

> Direction to the NSW SES FloodSafe resources; and,

> Contact details for sources of additional information.

The purpose of this initial correspondence would be begin a discussion with these high risk residents, to assist them in understanding the flooding risks in their location and to guide them in developing a personal flood plan.

B.2.1.2 Develop a Post-Flood Data Collection and Mail-out Strategy

The collection of post-flood data was recommended as part of the Floodplain Risk Management Study. In addition to this, it is recommended that the data collected be expanded to create information that will help the community to better understand the flood event and general catchment flood behaviour. This may include the collection / determination of data such as:

> The approximate recurrence internal of the rainfall intensity and peak river / creek flows;

> The approximate recurrence interval of any major overground flooding;

> A comparison of the storm event with previous historical events and design events. Comparison could be made against rainfall, flows or depths;

> Timings of peak flows or levels; and,

> The timing and duration of road overtopping / closures.

Following the development of the post-flood collection strategy, a post-flood information mail-out should be developed to pass this information on to the community. The purpose of presenting this data to the community is to allow them to relate their recent flood experience to other historical events and to design events.

Being able to compare their recent flood experience with predicted flows and levels from a 1% AEP or PMF event, would give them a greater understanding of what such an event would look like, and what would be required for them to be safe in such an event.

B.2.2 Medium Term

B.2.2.1 Flood Height Indicators within the Study Area

In order to further increase the flood information conveyed from these markers, it is recommended that the flood height of both historical and design flood events be marked in visual, accessible locations. The purpose of these markings would be to demonstrate to the community both the relatively size of historic events, as well as the flood depths that can be expected in large flood events.

Markings could be applied to telegraph poles or the entrance to the community centres to demonstrate height, and kerbs to demonstrate flood extents.

The height markings would serve as a visual aid to assist the community in understand the significant flood heights that occur along the Bega River during large flood events.

B.2.2.2 Develop a Flood Information Package for New Residents

The documents prepared for the Flood Safe initiative will provide new residents an introduction to flood behaviour and risks within the study area. It is recommended that an information package be distributed to new residents that contains a short letter from Council discussing the current flood management program, the flood safe documents, links to further information, and contact details of Council staff should they have any further queries or concerns.

B.2.2.3 Develop FloodSafe Brochure and FloodSafe Toolkit

The NSW SES has developed Local FloodSafe Guides, which give specific information for areas at risk of floods. These guides are produced in collaboration with Council and regional and local NSW SES units. The NSW SES recommends that these guides are reviewed every 5 years.

The NSW SES has also prepared templates allowing Local Guides to be prepared for individual regions. Different guides may be prepared for general township flooding, flash flooding and rural flooding. Development of the forms can be organised through contacting the NSW SES.

The NSW SES FloodSafe website (www.floodsafe.com.au) also allows for the creation of personal plans and business plans. Variations of plans are also available for riverine and flash flooding regions. It is recommended that a reference to this tool be made in the FloodSafe Guide to make residents and owners aware of this tool, and that residents and business NSW SES are encouraged to prepare a personal or business plan.

B.2.2.4 Hold a FloodSafe Launch Event

Following the development of the FloodSafe documents, a public launch may be held to inform the community of the availability of this material and to provide an opportunity for the community to discuss flooding issues with Council and NSW SES.

B.3 Triggers for Education & Awareness Actions

B.3.1 *Actions resulting from a large flood event*

Immediately following a large flood event is a good time to encourage residents to take an interest in flood behaviour in the catchment. At this time many residents actively seek flood information on the event and general flood behaviour. This should also be seen as an opportunity to encourage residents to develop personal flood response plans with the flood event still clear in their minds.

It is recommended that the following actions be undertaken following a large flood event in the catchment:

> Undertake the post-flood data collection;

> If mitigation strategies have been adopted, asses their effectiveness in the flood event;

> Prepare the post flood mail-out for the event; and,

> Undertake the post flood mail-out to inform residents about the recent flood.

B.3.2 Actions resulting from a Period of 5 years without a large flood event

After a period of time without a large flood event, there is a risk that community flood awareness will begin to fall.

As such, it is recommended that if a period of five years elapses without a large flood event, a community mail-out be undertaken to inform / remind residents of flood risks within the catchment.

This mail-out may include a short letter from Council detailing the reasons for the mail-out and discussing historical flood events, the FloodSafe brochures, any previous post-flood mail-out forms, and links to other information sources.

The aim of this exercise is to ensure that residents remain aware of both flood risks within the catchment and appropriate risk management actions to take in flood events.

About Cardno

Cardno is an ASX200 professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage and deliver sustainable projects and community programs. Cardno is an international company listed on the Australian Securities Exchange [ASX:CDD].

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