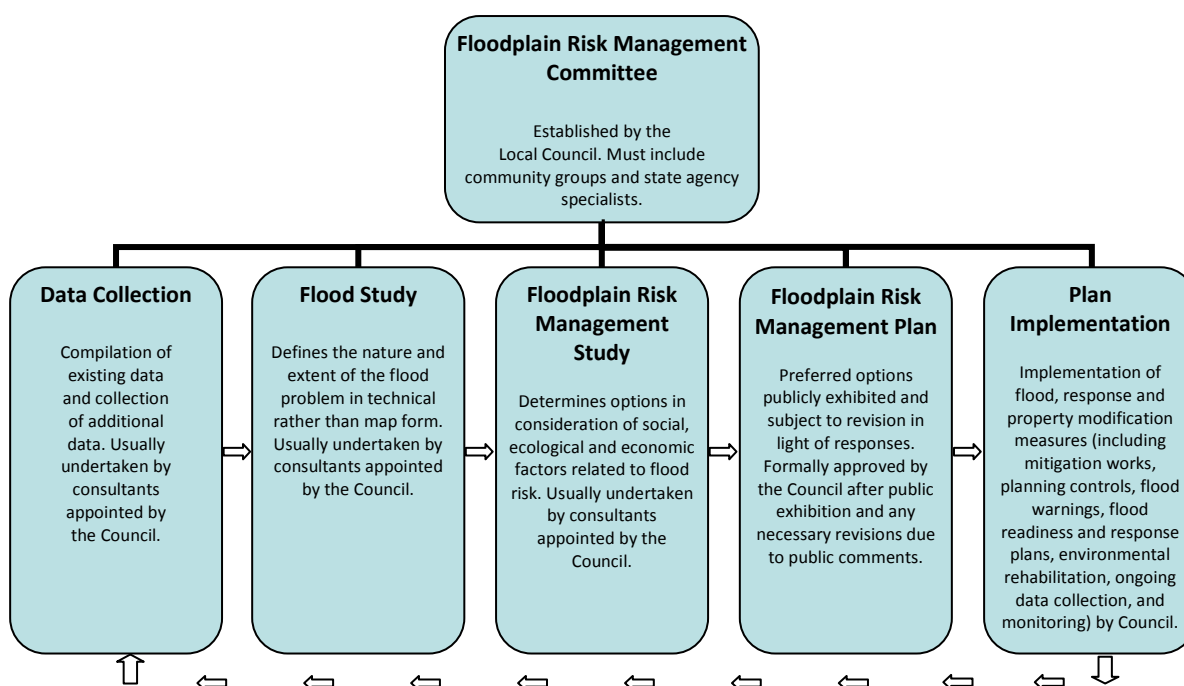


The NSW State Government's Flood Prone Land Policy (Policy) provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

The Policy provides for technical and financial support by the NSW Government through five sequential stages.

1. **Data Collection** (as part of asset management and preparation for the following stages of the process)
2. **Flood Study** (determining the nature and extent of the flood problem)
3. **Floodplain Risk Management Study** (evaluation of management options for the floodplain, with respect to both existing and proposed development)
4. **Floodplain Risk Management Plan** (involving formal adoption by Council of a plan of management for the floodplain)
5. **Implementation of the Plan** (implementation of property, response and flood modification measures to manage existing and future risk so that the continuing risk to the community is acceptable and sustainable)

Figure 1.1: The Floodplain Risk Management Process



The Bega Valley Shire Council (Council) is responsible for local planning and land management within the Bega and Brogo Rivers catchment and associated floodplains, including the management of river flood events. The Council had allocated funds and proposed to prepare a comprehensive Flood Risk Management Study and Plan for the study area, in accordance with the NSW Government's "Floodplain Development Manual: the management of flood liable land", April 2005 (The Manual). The Flood Study constitutes the first stage of the floodplain risk management process for the Bega and Brogo Rivers, with a focus on two localities requiring a detailed assessment: floodplain between Bega and Mogareeka Inlet and Candelo village, in which flooding may have impact upon residents, properties and infrastructure.

SMEC was commissioned by Bega Valley Shire Council to prepare this Flood Study on behalf of Bega Valley Shire Council. The following report documents the work undertaken and presents outcomes that define flood behaviour for existing catchment conditions.

2 ACKNOWLEDGEMENT

This study was undertaken by SMEC Australia Pty Ltd, with funding provided from the NSW Government's Flood Risk Management Program (part of Natural Disaster Resilience Program) through the NSW Office of Environment and Heritage (OEH) and Bega Valley Shire Council.

Numerous organisations and individuals have contributed both time and valuable information to the Bega and Brogo Rivers Flood Study. The study team acknowledges the contributions made by these groups and individuals, in particular:

- Mr Wayne Sartori, Mr Gary Louie, Mr Graeme Williams, Mr Derek van Bracht and Mr Shaun Bell (members of the Bega Valley Shire Council project team)
- Members of the Bega Valley Shire Council Floodplain Management Technical Sub-committee
- The landowners and residents of Bega Valley Shire Council who contributed by providing flooding information during public consultation and discussed their experiences with the study team during the field visits
- NSW OEH representatives who provided a guidance in technical area of compliance with Floodplain Management Guidelines
- Members of the NSW Office of Water and Bureau of Meteorology who assisted in obtaining the rainfall and hydrometric data
- Members of the NSW State Water who assisted in obtaining the relevant dam information for Brogo Dam
- Members of the Eraring Energy who assisted in obtaining the relevant dam information for Cochrane Dam
- Members of the Manly Hydraulics Laboratory who assisted in supplying ocean and gauge data
- Members of Roads and Maritime Services (RMS) - Bega who assisted in supplying the relevant bridge drawings
- Mr Michael Collins (surveyor, Caddey Searl & Jarman Pty Ltd)
- XP-SWMM Solutions, software technical support team.

Bega Valley Shire Council has prepared this document with financial assistance from the NSW and Commonwealth Governments through the Natural Disaster Resilience Program. This document does not necessarily represent the opinions of the NSW or Commonwealth Governments.

3 INTRODUCTION

As a part of the Bega Valley Shire Council Floodplain Risk Management Plan development, SMEC was engaged by the Council in March 2012 to undertake a flood study of the Bega and Brogo Rivers floodplain for two locations: Bega to Mogareeka Inlet and Candelo Village. The purpose of the flood study was to identify the flooding issues that affect the project locations and establish hydrologic and hydraulic models required to determine flood behavior under existing conditions. Findings from the flood study will be used in the subsequent Floodplain Risk Management Study to address the existing, future and continuing flood risks.

The Bega Valley Shire is located approximately 400 km south of Sydney and 600 km north east of Melbourne along the Princes Highway and approximately 230 km south-east of Canberra along the Snowy Mountains Highway on the NSW South Coast. The Bega Valley Shire LGA extends from Bermagui in the north to the Victorian border in the south. Bega is the major business centre of the region. The other major towns in the Shire are Eden, Merimbula, Pambula and Bermagui. Other smaller towns and villages in the Shire, include Tathra, Pambula Beach, Tura Beach, Cobargo, Candelo, Wolumla, Bemboka, Wyndham, Kalaru and Towamba.

The Bega Valley Shire is the largest local government area in coastal NSW, with an area of 6,280 km² and has the longest coastline of any local government area in the state. The Shire's coastal fringe extends from Wallaga Lake (Bermagui) in the north to Cape Howe on the Victorian border in the south. Inland, higher peaks of the Great Dividing Range give way to rolling hills and numerous rivers and streams.

The area is home to Aboriginal people of the Yuin and Monaro nations, the Traditional Owners of the lands and waters of the Shire.

Figure 3.1: Bega Valley Shire Council Local Government Area



The LGA is sparsely populated, largely because 75% of the area belongs to various National Parks and State Forests. The Shire has a population in excess of 31 000 (based on 2006 census), while Bega alone is home to over 4500 people.

Bega Valley is particularly known for its dairy industry, though tourism is of growing importance. The summer holiday seasonal population far exceeds the usual population in the Bega Valley Shire as the coastal areas are popular holiday destinations. Tourism is concentrated in the coastal towns of Bermagui, Tathra, Merimbula-Pambula and Eden which increase three-fold during holiday season.

4 OBJECTIVES

The primary objective of this Flood Study was to define the flood behaviour under historical and existing conditions within the study area to provide basis for future quantification of the likely flood damages and risks under current floodplain conditions. The study was expected to produce information on flood levels, velocities, hydraulic categories, provisional hydraulic hazard categories for a range of design flood events, under existing catchment and floodplain conditions. The design events of interest were the Probable Maximum Flood (PMF) event and the 0.2%, 1%, 2%, 5% and 10% AEP events. To achieve this objective the project activities included collection, compilation and review of relevant data (including previous reports, survey, aerial photography, and flood data).

The focus of the study was investigation of mainstream river flooding and associated overland flow flooding in conjunction with elevated ocean level boundary conditions, allowing for effects of bridge structures, expected blockage and waterway sedimentation. The hydrologic and hydraulic modelling was required to satisfy the study objectives with the models and produced results forming the basis for a subsequent Floodplain Risk Management Study where detailed assessment of flood mitigation options and floodplain risk management measures would be undertaken. Therefore, the models established in the flood study were prepared with the aim to be suitable for use to assess a range of management options in the Floodplain Risk Management Study and Plan.

Other specific objectives and issues expected to be included in the investigation were:

- The impact of an elevated ocean level boundary condition at the river estuary at Mogareeka, both due to sea level rise associated with climate change and storm surge impacts;
- The impact of the Princes Highway Bridge and Tarraganda Lane Bridges at Bega and the bridge over the Bega River at Mogareeka as an obstruction to flow;
- The impact of debris collecting on those bridges during flooding;
- The effect of the proposed Bega bypass by the RTA and other potential overland flow impacts;
- The effects of full water storages;
- The effects of existing and future development within the Bega township, the Jellat Jellat Flats and also the villages of Candelo, Kalaru, Tathra and the locality of Mogareeka.
- The effects of sedimentation and debris build-up in the Bega River downstream of the Bega township including the confluence of the Bega and Brogo Rivers;
- Options for installation sites of remote early flood warning indicators on both the Bega and Brogo Rivers;
- Review and update the existing 1979 Water Resources Commission of New South Wales Flood Inundation Map of the Bega and Brogo Rivers at Bega to incorporate the recent 2010 & 2011 events and the Probable Maximum Flood and also produce associated flood hazard maps to current floodplain management standards;
- Inundation and flood hazard mapping for the villages of Candelo, Kalaru, sections of Tathra and the localities of Mogareeka and the Jellat Jellat flats;
- Emergency management issues that would assist the community in being prepared for flood events in consultation with the local NSW SES. This should include flood intelligence, information forecasting, flood warning, media releases etc.

5 STUDY AREA

5.1 Catchment Description

The river systems associated with the Bega and Brogo River catchments converge at the township of Bega. They start in farmland areas on uphill slopes below an escarpment of the Great Dividing Range to the north and west of Bega, then flow through the township before flowing into the Tasman Sea at the Bega River mouth. The mouth is situated at Mogareeka some 2.5 km north of the village of Tathra and approximately 24 km downstream of Bega. The smaller villages of Candelo and Bemboka are upstream of Bega. The Bega River shares a confluence with the Bemboka River some 15 km upstream of Bega.

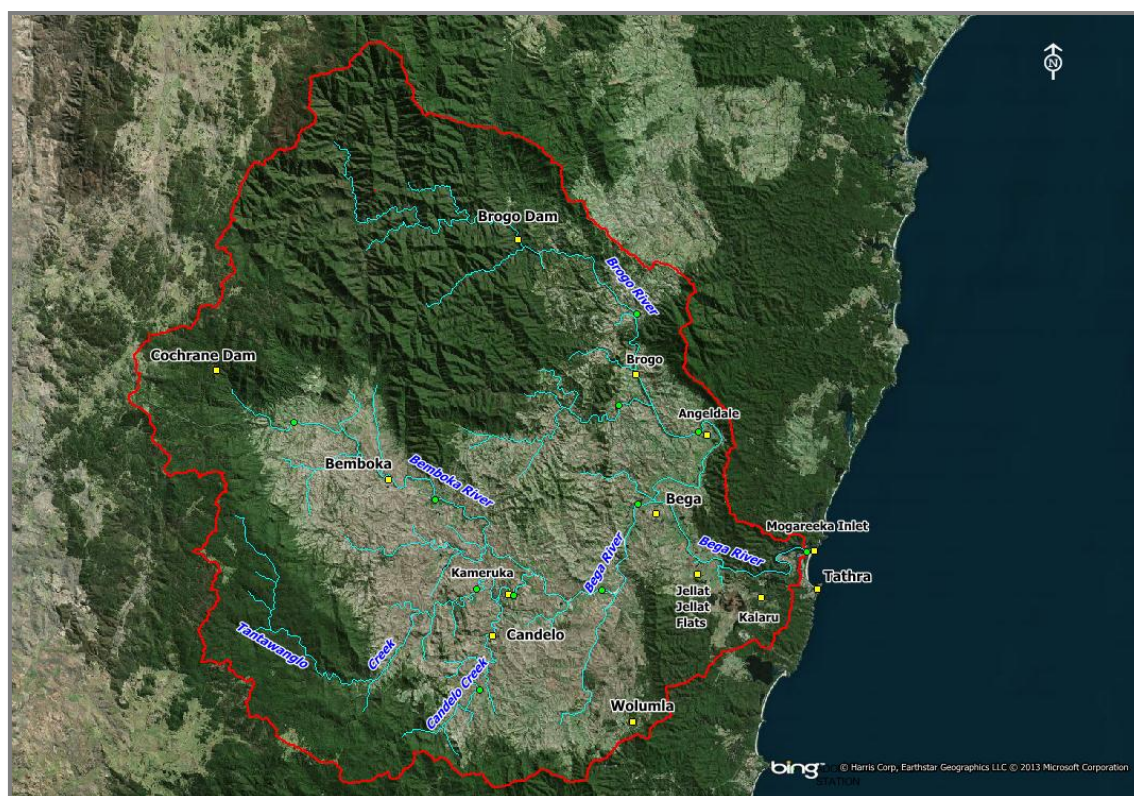
The combined catchment area of the two river systems is approximately 1940 km² at Mogareeka. The Bega River is the larger of the two rivers contributing a catchment area of some 1030 km² at the confluence while the Brogo River contributes about 780km². The remaining catchment area contributes about 125km² between the Bega/Brogo Rivers confluence and the ocean outlet. The overall catchment is dominated by rural landscapes consisting of farmland and forested areas.

The Bega River borders the township of Bega on its western, northern and eastern sides. The inundation patterns for past floods indicate that Bega township is mainly flooded by overbank flow from the Bega River. Floodwaters back up from the confluence of the two rivers and spread over low-lying areas. Backwater effects can also influence flood levels at Bega from downstream river reaches and associated bridges.

The Brogo River significantly increases the flood levels in the Bega River during flooding. There is high likelihood and occurrence for both rivers to be in major flood simultaneously and to peak within a short space of time. A similar timing of peaks is to be expected as both rivers have similarly sized and adjacent catchments. The downstream section of the Bega River (from Jellat Jellat) is under a tidal influence, which in significant flood events creates backwater effect that progress further upstream towards Bega.

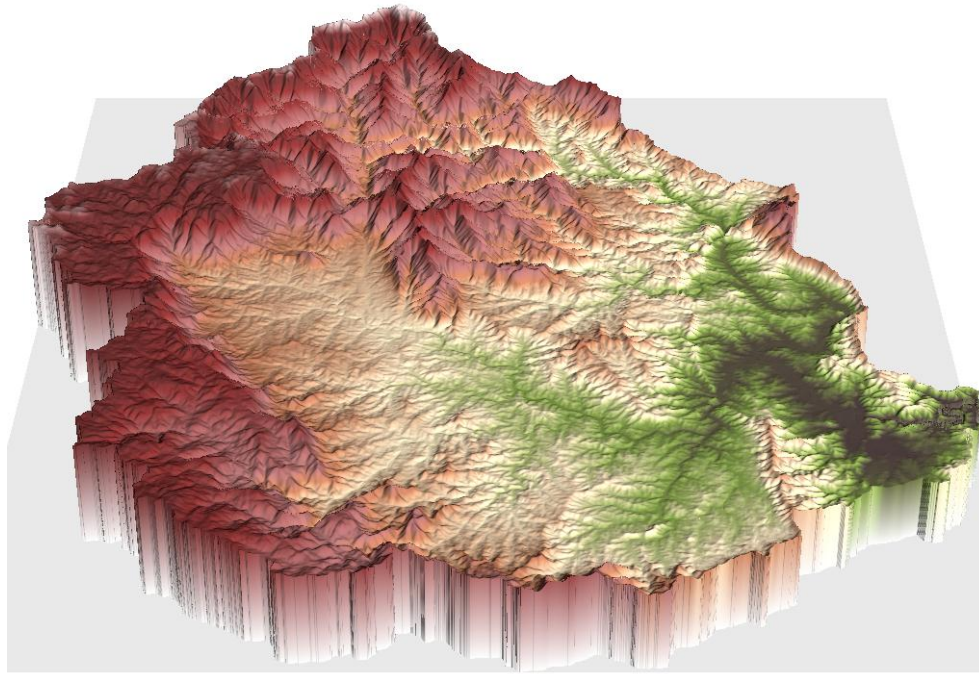
A large water supply dam is located on the Brogo River 15km upstream of Brogo and has an impact on the hydrology of this part of the catchment. Cochrane Dam (originally known as Georges Creek Dam) is located at Brown Mountain about 16km upstream of Bemboka along the Bemboka River and services as a water supply storage for the town of Bemboka and as a hydroelectric scheme for power generation.

Figure 5.1: Catchment Diagram



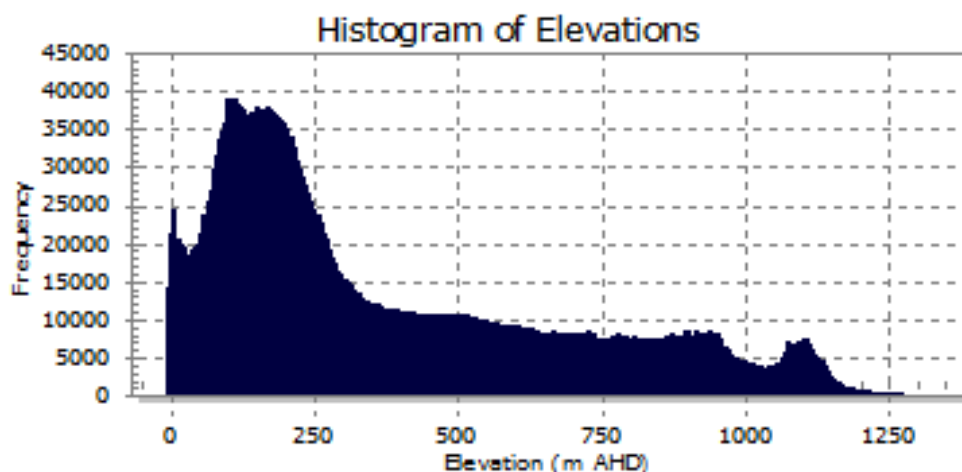
Elevations within the catchment range from about 1320 mAHD in the most upper reaches to ocean levels at Mogareeka. Elevations at Bega and Candelo are about 15 mAHD and 100 mAHD respectively. The slopes along the rivers are relatively steep in the upper reaches, followed by a fairly constant and mild slope of approximately 0.05% downstream of Bega to the outlet at Mogareeka.

Figure 5.2: Perspective View of Catchment



The variation in elevation is noted in a perspective view of the catchment in Figure 5.2 above and shown graphically in a histogram in Figure 5.3 below. This graph uses the digital terrain model throughout the catchment and analyses the number of points at a given elevation. The digital terrain model uses SRTM data at a spacing of about 1 second or approximately 30m. The Figure shows the variation in elevation from within the catchment, with most of the points between about 0 mAHD and 350 mAHD. Above 1100 mAHD the number of elevation points decline reaching an elevation maximum of about 1320 mAHD at the top of the catchment. 10% of the topographic data points have an elevation greater than 900 mAHD, 50% of the points are above 260 mAHD, and 90% of the points are above 75 mAHD.

Figure 5.3: Histogram of Elevations within Catchment



5.2 Flood Modelling Area

The Bega township has a history of both mainstream and overland flooding and Council is targeting to review the extent of flooding documented so far in light of two recent events experienced during 2010 and 2011, as inundation during these events occurred in some unexpected areas. Some properties on the Bega township fringe also experience local overland flow during flooding due to backwater effects. Access to the downstream villages of Kalaru and Tathra were disrupted during the events. Some areas of these villages also experience a backwater effect when the Bega River is in flood. A number of bridges were lost in the rural areas due to debris build up, abutment damage and approach damage causing isolation of residents in some localities for a number of days.

The village of Candelo has also had a past reported history of flooding in some areas adjacent to Candelo Creek which runs through the middle of the village. Candelo Creek eventually drains into the Bega River.

The specific areas for which Council requested detailed and reliable information on flooding are shown on Figures 5.4-5.7 (extracted from Council's Project Brief).

Figure 5.4: Bega Township



Figure 5.5: Jellat Jellat

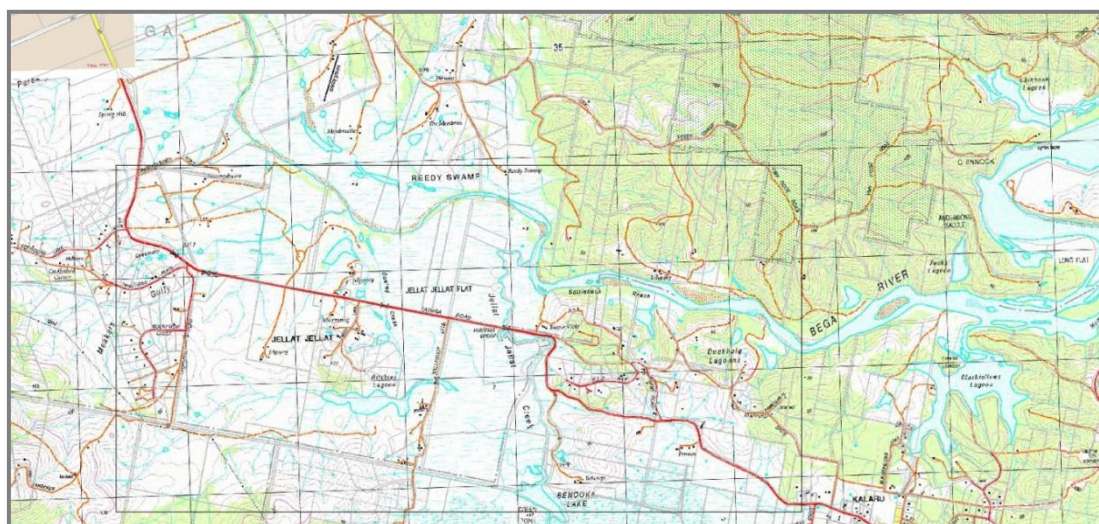
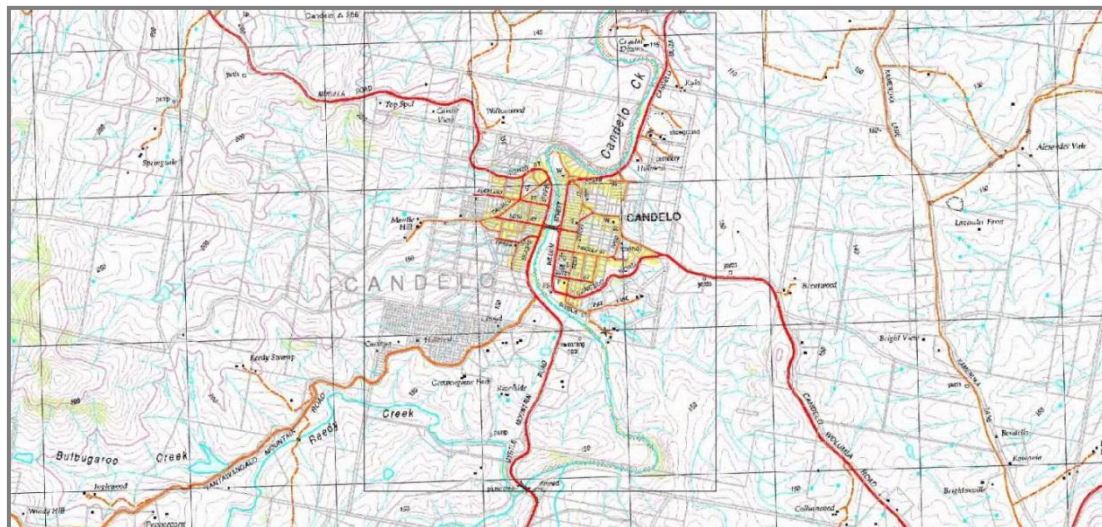


Figure 5.6: Kalaru, Mogareeka and Tathra



Figure 5.7: Candelo Village



For the purpose of hydraulic modelling in this study, these areas were grouped into two distinctive localities:

- Bega to Mogareeka including Jellat Jellat, Kalaru, Mogareeka and Tathra
- Candelo village

The overall study area includes a number of structures that have an impact on behaviour of flooding and, as such, require to be allowed for in modelling. These hydraulic structures include:

- The Bega River bridges including the Princes Highway Bridge, Tarraganda Lane Bridges (the river and the anabranch bridge) and Tathra to Bermagui bridge over the Bega River at Mogareeka
- Jellat Jellat Weir (also known as Russells Creek Weir)
- The Candelo Town Bridge
- Brogo River dam and Cochrane dam

The information on these structures is obtained from design drawings, additional survey and communication with relevant asset owners. The relevant information and geometry of these structures is discussed in the following sections of this report.