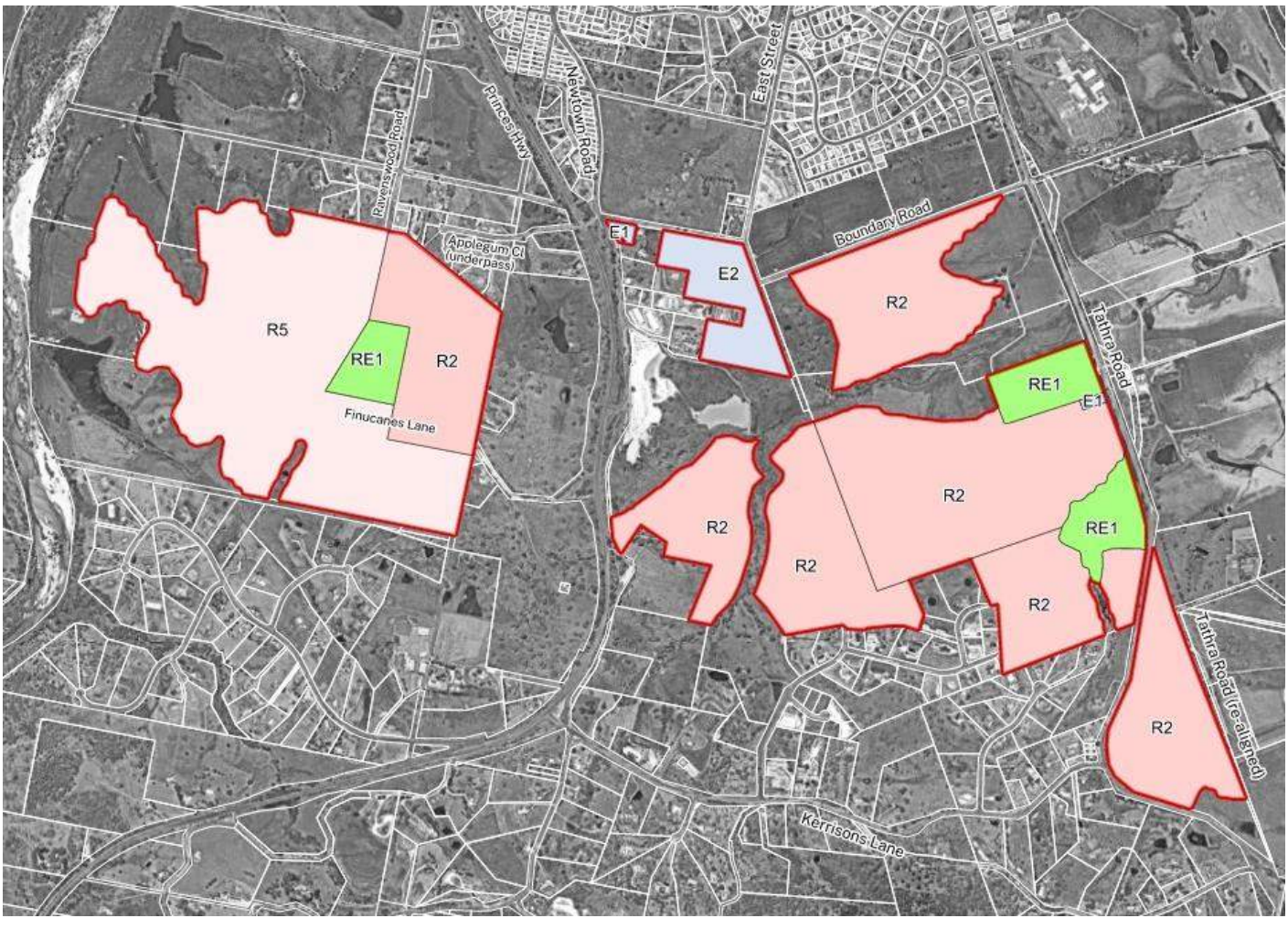
Flooding Assessment

Bega Urban Land Release Planning Proposal

ADW Johnson and Bega Valley Shire Council

14 April 2025

→ **The Power of Commitment**



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Acknowledgement of Country

GHD acknowledges Aboriginal and Torres Strait Islander peoples as the Traditional Custodians of the land, water and sky throughout Australia on which we do business. We recognise their strength, diversity, resilience and deep connections to Country. We pay our respects to Elders of the past, present and future, as they hold the memories, knowledges and spirit of Australia. GHD is committed to learning from Aboriginal and Torres Strait Islander peoples in the work we do.

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Definitions/Terminology

Term	Definition
AEP	Annual Exceedance Probability - The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood level (height) has an AEP of 5%, there is a 5% chance (that is, a one-in-20 chance) of such a level or higher occurring in any one year
AHD	Australian Height Datum
ARR 2019	Australian Rainfall and Runoff 2019
Bio-retention	A common stormwater quality treatment method including infiltration of stormwater through a filter media and treatment through a combination of physical, chemical and biological processes
BoM	Bureau of Meteorology
DCP	Development control plan
DFE	Defined Flood Event or design flood
EY	Exceedances per year
IFD	Intensity-Frequency-Duration curves
LEP	Local environmental plan
LiDAR	Light Detection and Ranging Terrain Data
m	Measure of length/height/distance (metres)
mm	Millimetres
mAHD	Metres above Australian Height Datum
m/s	Measure of velocity (metres per second)
MUSIC	The Model for Urban Stormwater Improvement Conceptualisation is the most widely used tool to quantify impacts and mitigation with relation to urban stormwater pollutants. The tool can be utilised to conceptualise stormwater treatment trains and estimate resulting treatment performance
NSW	New South Wales
The Precinct	The Kellyville and Bella Vista Precinct with respect to the Transit Orientated Development (TOD) Program
TOD	Transit Orientated Development rezoning areas
PMF	Probable maximum flood
PMP	Probable maximum precipitation
RFFE	Regional flood frequency estimate
RORB	Runoff routing model
TOD rezoning areas/Blocks	Individual areas within the Transit Orientated Development precincts
Rouse Hill Development Area (RHDA)	the Area within which Sydney Water is the designated authority responsible for the management of trunk drainage land, and within which regional detention basins are provided
Stormwater detention	Detaining runoff temporarily with the objective of reducing the peak rate of runoff released and therefore reducing downstream flooding impacts associated with increasing urbanisation
Stormwater quality objectives	Objectives are commonly defined for catchments with relation to stormwater quality. They may include typical urban pollutants (e.g. nutrients, suspended solids) and be expressed in the form of a required reduction to be achieved, or the achieving of a baseline load
Trunk Drainage Lands (TDL)	Drainage infrastructure intended to collect smaller local drainage systems and appropriately convey to a discharge point. Sydney Water (SW) is designated as the Acquisition Authority for land that is identified for Rouse Hill Trunk Drainage Land (TDL) purposes within the RHDA, Stages 1 to 4
TUFLOW	Two-Dimensional Unsteady Flow model, named TUFLOW
XP_RAFTS	Runoff Analysis and Flow Training Simulator

1. Background

1.1 Introduction

This report presents the Flooding Technical Study for three precincts identified in the Bega Structure Plan, supporting the development of a Planning Proposal for the Bega Urban Release Area (or three precinct-based planning proposals).

Flood risk and stormwater management is required for the Bega Urban Release Area to support development.

Flood risk can be related to:

– regional waterway flooding (such as associated with the Bega River in this case) on account of larger catchment runoff.
– local flooding in tributaries draining to regional waterways on account of local stormwater runoff.
– overland flow flooding within undeveloped and developed (rezoned) areas on account of local stormwater runoff.

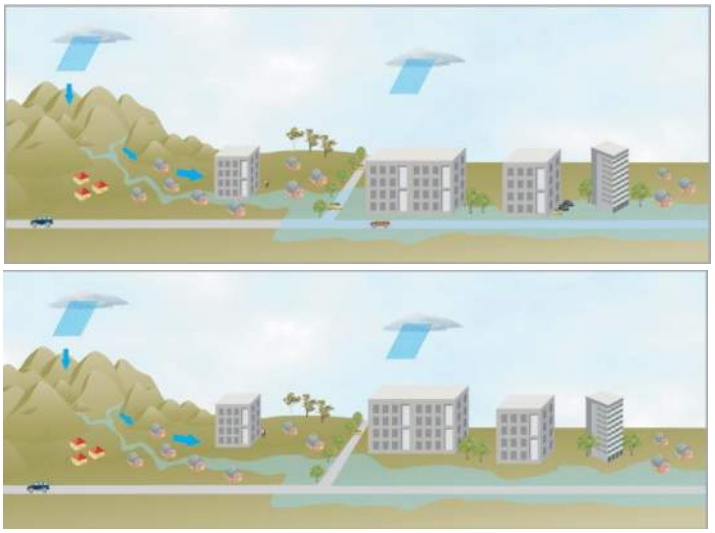


Figure 1.1 Impact from regional flooding is a critical consideration for precinct planning (illustrative only)

Therefore, several aspects of flood risk and stormwater management need to be considered.

For regional waterway flooding, management would typically involve addressing flood risk in land use planning. For local and overland flow flooding, urban densification can result in a change in runoff generation due to increasing impervious areas. This requires management of impacts to rates of discharge during storm events. Water Sensitive Urban Design strategies such as riparian corridors and/or detention facilities can be provided at a lot scale or at a larger precinct/regional scale to manage flood risk.

Flood risk and stormwater quantity

For **regional waterway flooding,** management would typically involve addressing flood risk in land use planning.

For **local and overland flow flooding**: Management would involve appropriate collection, conveyance and management infrastructure, for stormwater conveyance within and from the precinct

1.2 The Bega Urban Release Area

In 2021 the Bega Valley Shire population was approximately 35,761 and is forecast to grow to 38,138 by 2036. Based on the current average household size at 2.22 persons per household, this will require an additional 1,070 homes in the next 14 years.

Bega Valley Shire is currently experiencing a severe housing shortage, both for purchase and rental stock. Recent acceleration in the demand for housing within the Shire because of COVID-19 regional migration and retention means that facilitating development of future urban release areas in Bega is now a priority to ensure that there is a pipeline of housing supply in the area.

The estimated dwelling yield from this planning proposal is 2,113 dwellings and this is targeted at the short, medium and long-term supply of housing for the Bega Valley Shire for the next 40 years.

The Bega Structure Plan has been developed to provide a strategic framework around the development of the area to the south of the Bega CBD. The structure plan articulates how housing can be developed by considering future development land, planning requirements, infrastructure servicing, transport, property ownership and the views of the community. This analysis identified three precincts (Figure 1.2) within the area suitable for residential, commercial, retail and open space requirements.

Development of the Structure Plan was supported by the following technical studies: Economic Impact Assessment, Recreation Needs Assessment, Biodiversity HEV Mapping Validation, Preliminary Aboriginal Heritage Desktop Assessment and Preliminary Contaminated Land Assessment.

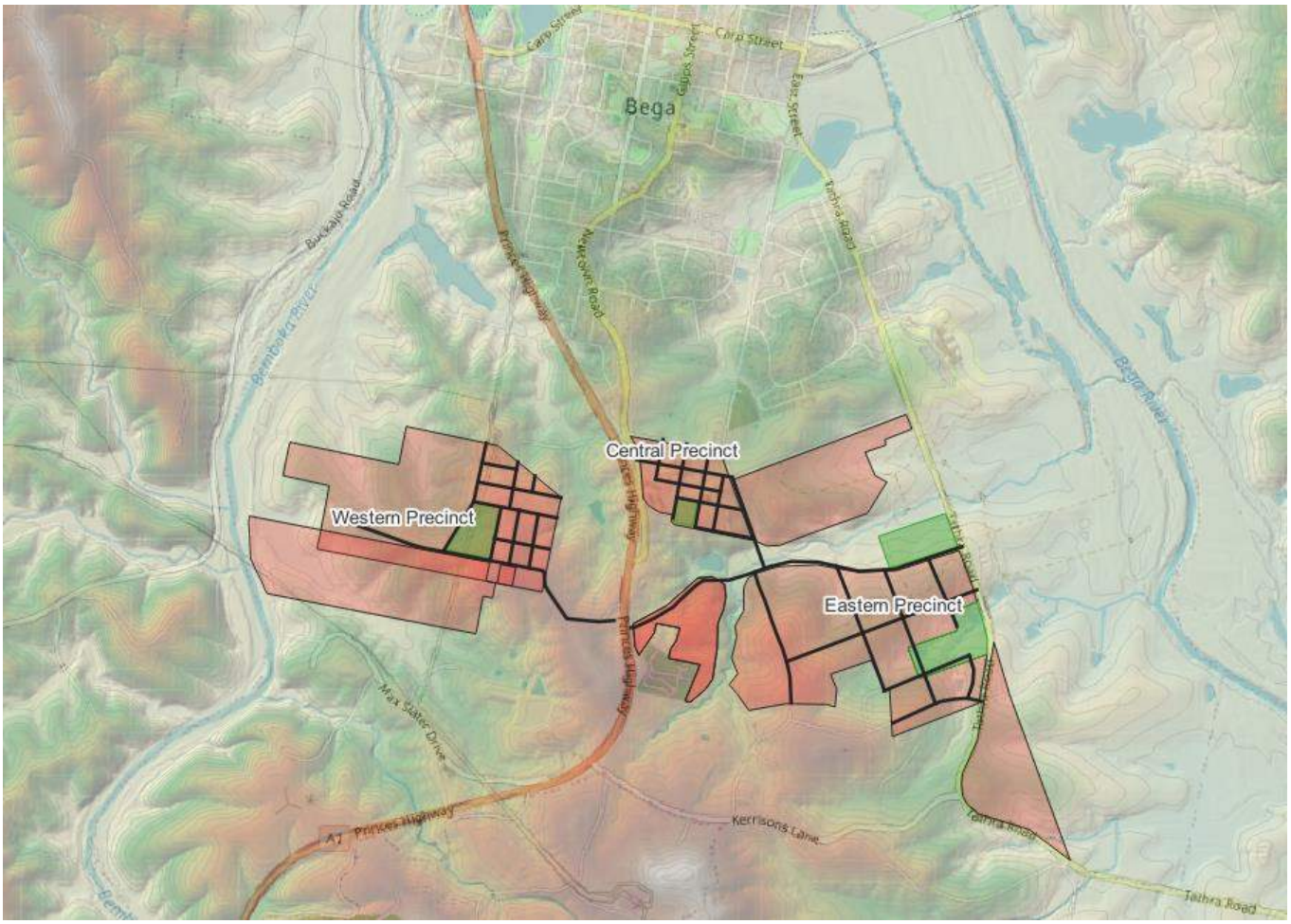


Figure 1.2 Bega Urban Release Precinct Location

1.3 Key Past Studies

1.3.1 Bega and Brogo Rivers Flood Study at Bega (SMEC 2014)

The Bega and Brogo Rivers Flood Study, is a regional flood study, that developed hydrologic and hydraulic models for regional waterway flooding from upstream of Bega to the outlet at Mogareeka, and Candelo Creek at Candelo. The study provided information on flood depths and extents, water levels, flows and velocities for a range of

design flood events, including 10%, 5%, 2%, 1%, 0.2% AEP and Probable Maximum Flood (PMF) events. Further objectives were to identify hydraulic and preliminary hazard categories for the six design flood events, and to provide preliminary flood planning levels based on the 1% AEP event plus freeboard including consideration of catchment and ocean flooding using three cases in an envelope approach.

The hydrologic modelling employed the XP-RAFTS software package while the hydraulic model used the XP-SWMM2D software modelling package. The XP-SWMM2D model, internally coupled with the TUFLOW numerical engine for 2D computations, simulated a complex link between the channel and floodplain for accurate representation of the distribution of flows and resulting flood levels and velocities, including the incorporation of bridges and the dynamic impacts of tailwater conditions. The XP-SWMM2D hydraulic modelling utilised Council' 2008 LIDAR survey in conjunction with cross-sections developed by ground/bathymetric survey in 2012.

The XP-SWMM2D hydraulic model provided a close calibration using the February 1971 and March 2011 events. The XP-SWMM2D generally overestimated flood levels for the March 1983 event, indicating that for smaller sized floods, conservative estimates may be produced by the model.

The study provided a basis for preparation of the Floodplain Risk Management Study and Plan, which is the next stage for Council to progress toward in the floodplain management process.

1.3.2 Floodplain Risk Management Study and Plan Bega & Brogo Rivers 2009 (Cardno, 2018)

The Floodplain Risk Management Plan (FRMP) for the Bega and Brogo Rivers region was prepared 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). The FRMP followed 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).

The FRMS included a review was undertaken of the hydrological and hydraulic models developed for the Flood Study (SMEC 2014) to determine if they are appropriate for use in the FRMS. The review found that the models were generally suitable for use in the FRMS. However, the review noted concerns in the use of a 25 m grid cell size, the lack of calibration of the entrance failure and an assumption that Council would open the entrance in design events. As a result, the FRMS was updated to use a nested grid for the township of Bega in order to allow a more detailed assessment of this region. With regard to the entrance condition, sensitivity assessments were that showed negligible changes (less than 0.05 m) in flood levels. The assessment also found that increasing the height of the entrance berm by a full metre only resulted a flood impact of <0.1 m across areas with development or infrastructure. Consequently, it was concluded that the flood levels at Bega were relatively insensitive to entrance conditions.

1.4 Limitations/Assumptions/Clarifications

This report has been prepared by GHD for ADW Johnson and Bega Valley Shire Council and may only be used and relied on by ADW Johnson and Bega Valley Shire Council for the purpose agreed between GHD and ADW Johnson and Bega Valley Shire Council as set out in this report.

GHD otherwise disclaims responsibility to any person other than ADW Johnson and Bega Valley Shire Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report. The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared. The opinions, conclusions and any

recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

The basis of this report includes the following key assumptions:

– All flood data was obtained from Council and the models developed by Cardno for the Floodplain Risk Management Study and Plan Bega & Brogo Rivers 2009 (Cardno, 2018) and therefore considered to be acceptable for this current assessment. No flood simulations were undertaken for the present assessment.
– It is noted that this report is compiled on the basis that the form, development and layouts within individual rezoning areas are unknown.
– The NSW Flood Prone Land Policy (DPE 2023) applies to urban and rural floodplains in New South Wales and to both flooding from regional waterways and local overland flooding. Since the local overland flooding is a function of the local topography and design within the rezoning areas, which was unknown at the time of the report, this report only applies to the flooding from the Bega River and tributaries identified as Strahler Order 3 and greater.
– We draw your attention to Section 2.2.3 and matters around the issue of Australian Rainfall and Runoff 2019 Version 4.2 issued on 27/08/2024.

2. Legislative, policy and guideline context

2.1 Legislative requirements

2.1.1 Water Management Act 2000 and Water Act 1912

The *Water Management Act 2000* (WMA) and the *Water Act 1912* are the key legislation for the management of water within NSW. These Acts regulate the extraction of water, the use of water, the construction of works such as dams and weirs, and the carrying out of activities in or near water sources in NSW. The provisions of the WMA are being progressively implemented to replace the *Water Act 1912*. Since 1 July 2004, the new licensing and approvals system has been in effect in those areas of NSW covered by commenced water sharing plans, which are made under the WMA.

A controlled activity approval under the WMA is required for certain types of developments and activities that are carried out in or near waterfront land. The design and construction of the project would need to consider the NSW Office of Water's guidelines for controlled activities on waterfront land. The floodplain management provisions under the *Water Act 1912* have transitioned to the WMA, including the provisions of floodplain management plans and 'flood works' i.e. works that affect, or are likely to affect, flooding and/or floodplain functions.

2.2 Policies, planning controls and guidelines

2.2.1 NSW Flood Risk Management Manual and NSW Flood Prone Land Policy

The *NSW Flood Risk Management Manual* (DPE, 2023) provides for the development and implementation of sustainable strategies for managing human occupation and use of the floodplain. It contains the NSW flood prone land policy, the primary objective of which is to reduce the impacts of flooding and flood liability on communities and individual owners and occupiers of flood prone property in NSW.

It provides guidelines in relation to the management of flood liable lands, including any development that has the potential to influence flooding, particularly in relation to increasing the flood risk to people and infrastructure. Project activities that have the potential to increase flood risk through, for example, increasing stormwater runoff would be subject to consideration under the NSW Flood Risk Management Manual. The manual 'promotes the use of a merit approach which balances social, economic, environmental and flood risk parameters to determine whether particular development or use of the floodplain is appropriate and sustainable'. The NSW Flood Risk Management Manual is supported by several compendium guidelines, which include amongst others:

- AG01-flood-risk-management-administration-arrangements.
- EM01-flood-risk-management-emergency-management-planning-support.
- FB01-flood-risk-management-understanding and managing flood risk.
- FB02-flood-risk-management-flood-function.
- FB03-flood-risk-management-flood-hazard.
- FG01-flood-risk-management-framework-delivery.
- LU01-flood-risk-management-impact-risk-assessment.
- MM01-flood-risk-management-measures.

2.2.2 Planning Circular PS 24-001

The Planning Circular PS 24-001 supplements Planning Circular PS 21-006 *Considering flooding in land use planning: guidance and statutory requirements* and provides additional information to planning authorities in relation to addressing flood risk in land use planning and development assessment under the Environmental Planning and Assessment Act 1979. The circular outlines existing flood-related planning policies and provides

further information and advice on their application in planning. The circular also provides updates on flood-related policy initiatives underway, including action taken in response to the 2022 NSW Flood Inquiry. Consistent with the findings of the NSW Flood Inquiry 2022, the department recommends applying a risk-based approach when addressing flooding in planning decisions.

2.2.3 Australian Rainfall and Runoff

Australian Rainfall and Runoff (Ball J, Babister et al, 2019) (ARR 2019) is the primary technical publication for stormwater and hydrological estimates and design considerations. The technical analysis and development of the hydrologic and hydraulic models, including the management of flooding, has been considered under this guideline. The approaches presented in ARR 2019 are relevant tor policy decisions and projects involving:

– Infrastructure such as roads, rail, bridges, dams and stormwater systems.
– Flood management plans for urban and rural communities.
– Flood warnings and flood emergency management.
– Estimation of extreme flood levels.

The studies in Section 1.3 were prepared under Australian Rainfall and Runoff 1987. Then there have been several updates to Australian Rainfall and Runoff, to the present version 2019 Version 4.2 (ARR 2019v4.2). Version 4.1 saw a substantial change to the methodologies used in rainfall-runoff modelling with, amongst others, the introduction of 10 temporal patterns of rainfall and updated design rainfall estimates. Version 4.2 included, again amongst others, the concept that because our climate is changing, unadjusted historical observations are no longer a suitable basis for design flood estimation: they must be adjusted to reflect the impacts of rising global temperatures. Guidance is provided based on a systematic review and meta-analysis of peer-reviewed science.

These matters were ‘flagged’ with Council for the current assessment. Council advised to base the Bega Urban Land Release Planning Proposal on the flood modelling undertake for the studies in Section 1.3. further discussion on global temperature rise and climate change is provided in Section 5.1.3.

2.2.4 Bega Valley Shire Council

2.2.4.1 Local Environmental Plan, 2013

LEP 2013 provides Clause 5.21 (flood planning) and Clause 5.22 (special flood planning) with the following flood planning objectives:

– minimise the flood risk to life and property associated with the use of land
– allow development on land that is compatible with the land’s flood hazard, considering projected changes as a result of climate change
– avoid significant adverse impacts on flood behaviour and the environment
– enable the safe occupation and efficient evacuation of people in the event of a flood.

Clause 5.21(2) provides that the flood planning requirements apply in the ‘flood planning area’. Considerations for the consent authority include that the development:

– is compatible with the flood function and behaviour on the land
– will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties
– will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood
– incorporates appropriate measures to manage risk to life in the event of a flood
– will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses.

Clause 5.22 has the following objectives:

– to enable the safe occupation and evacuation of people subject to flooding,

– to ensure development on land is compatible with the land's flood behaviour in the event of a flood,
– to avoid adverse or cumulative impacts on flood behaviour,
– to protect the operational capacity of emergency response facilities and critical infrastructure during flood events,
– avoid adverse effects of hazardous development on the environment during flood events.

This Clause applies to:

– for sensitive and hazardous development—land between the flood planning area and the probable maximum flood, and
– for development that is not sensitive and hazardous development—land the consent authority considers to be land that, in the event of a flood, may—
    - (cause a particular risk to life, and
    - require the evacuation of people or other safety considerations.

The LEP lists several sensitive and hazardous development purposes.

2.2.4.2 Development Control Plan, 2013

Development control plans support LEPs and provide guidance on stormwater and flooding controls which Council use to assess proposed development. These controls are based on sound management principals. DCP 2013 provides Section 5.8 – Planning for Hazards, Flood Planning, Coastal Hazards and Climate Change. The Flood Planning section applies to:

– to the flood and/or sea level rise affected portion of flood control lots. Lots that meet any of the following criteria are considered flood control lots:
    - within or partially within a Flood Planning Area (FPA) or Probable Maximum Flood (PMF) extent where a Flood Study exists
    - *(not applicable) within or partially within the Flood Planning Area (FPA) for the Bermagui River floodplain*
    - within 100m of the coastline
    - below 3m AHD along the coastline and estuarine foreshores
– For land within catchments that has not had contemporary flood studies or flood risk management plans and studies prepared, development in the following areas may require additional flood information to support any development proposal:
    - within 40m of a creek
    - within 10m of a major drainage system

The DCP provides controls for mainstream flooding and local overland flow flooding, lists Flood Planning Constraints Categories, which are applied to type of development proposed. For each Flood Planning Constraints Categories and type of development proposed, flood controls are documented with regards to minimum flood level, minimum ground level, building components, structural soundness, flood affectation, emergency response, management/design and parking/driveway access. The controls are too numerous to replicate here, and the reader is referred to the DCP 2013 for the recommended flooding controls.

In terms of stormwater the DCP 2013 provides general requirements for soil and stormwater management. Amongst others the DCP recommends that development incorporate the principles of Water Sensitive Urban Design. These include minimisation of impervious surfaces and provision for the collection, reuse and management of stormwater to reduce reliance on potable water and ensure that pre-development water quality is maintained or enhanced in post-development runoff. Subdivisions are to be designed so that stormwater flows for rainfall events of a 1% AEP and greater can pass without causing damage to property and infrastructure. Stormwater flows for events larger than the 20% AEP for residential development and 10% AEP for commercial and industrial development are not required to be contained within piped drainage systems however the overflow path must be planned, clearly evident on the site and contained within suitable easements, public reserves and road reserves.

2.2.5 Local Flood Plans (SES)

Local flood plans are prepared by the NSW State Emergency Service (SES) as part of broader local disaster plans. Local flood plans outline the preparations, responses and recovery actions that are to be undertaken prior to, during and following a major flood event. The local flood plan for the area within the vicinity of the project is the *Bega Valley Local Flood Plan (SES, 2021).*

The plans provide context to flooding in the region, including the extent and timing of major floods, areas of high risk of flooding which may require evacuation by emergency services, key evacuation routes, and the location of emergency shelters within the area covered by the Plan.

3. Baseline Conditions

3.1 Catchments, Drainage and Flooding

The Bega and Brogo River catchments confluence at Bega, before discharging to Mogareeka Inlet and the ocean. Both catchments rise in farmland areas on uphill slopes below an escarpment of the Great Dividing Range to the north and west of Bega (SMEC, 2014). The Bega River shares a confluence with the Bemboka River some 15 km upstream of Bega. The combined catchment area is approximately 1940 km^2 at Mogareeka with the Bega River being the larger if the two catchments. The overall catchment is dominated by rural landscapes consisting of farmland and forested areas.

The Bega River drains around 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. Regional floodwaters back up from the confluence of the two rivers and spread over low-lying areas. Backwater effects can also influence regional flood levels at Bega from downstream river reaches and associated bridges (SMEC, 2104).

The Brogo River significantly increases the regional 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.

Bega has a long history of regional flooding and has experienced significant flood damages over the years (SMEC, 2014). Previous documented flood events include floods in 1851, 1870, 1873, 1893, 1898, 1919, 1934, 1963 among others. While relatively recent events in Council's records and local newspaper articles note events in February 1971, March 1983, February 2010, March 2011, and March 2012. These events have historically caused significant damages to infrastructure and disruption to the community. The largest flood in recent history was the February 1971 event and as such was used in the calibration of the hydrologic and hydraulic models in addition to the March 2011 event. The March 1983 and February 2010 events were used in the validation of models.

An analysis of water levels was undertaken by the Water Resources Commission (WRC) of NSW in 1979 indicating that the 1971 regional flood event had an equivalent occurrence frequency of 138-year ARI. A further flood frequency analysis of levels from the gauging station at Bega undertaken as part of the current study indicated that the February 1971 event was equivalent or greater than the 1% AEP flood event, while the final results of detailed modelling with a comparison of regional water levels confirmed that the February 1971 event was smaller than the 1% AEP regional flood event.

Due to historical flooding, much of the developed areas of Bega are outside the regional 1% AEP flood extent, although some low-lying areas at the edges of the township are affected by this event (Cardno 2018). The lower lying areas of the town are typically utilised for open space and recreational purposes. Although flooding of the Bega Township is largely driven by overbank flows from the Bega River, the Bega Township is also affected by local catchment flooding and overland flow, which can result in local flooding issues and loss of access, independent of regional flooding in the Bega River.

3.2 Riparian Corridors

There are several local tributaries draining to the Bega River in the vicinity of the proposed rezoning lands. These are unnamed tributaries west of the Pacific Highway. East of the highway, Parbery Creek and associated tributaries bisect the proposed lands to be rezoned.

Strahler stream order classifies the hierarchy of streams and rivers in a river system from smallest to largest (NSW DPIE, https://water.dpie.nsw.gov.au/).

– First-order stream: A first order stream starts at the top of a catchment and has no other streams flowing into it. First-order streams are the smallest in a river system.

– Second-order stream: Second-order streams form when 2 first-order streams join. They are bigger in size due to the water from both first-order streams combining.
– Third-order stream: Third-order streams form when 2 or more second-order streams join. And so on.

The stream order keeps increasing as streams and rivers of the same order confluence. The highest stream order is found on the river's main stem in the downstream section of a river system. By knowing the order of a stream, we can better understand our rivers and how to best protect and manage them.

Higher-order streams often include wider channels, deeper water, and slower velocities. They often convey larger flow rates because they receive inflow from many tributaries. This makes them important for maintaining water supply for various uses, including drinking water, agriculture and industry. Higher-order streams also provide habitat for biodiversity. Because of their typically larger size and slower moving flow, they can support a diverse range of plant and animal species. Higher-order rivers are also more prone to flooding. Understanding stream order can help predict where floods might happen and plan flood prevention measures.

NSW DPIE (**https://water.dpie.nsw.gov.au/**) provides controlled activities guidelines for development, with relation to riparian corridors on waterfront land, which are regulated by the Water Management Act 2000 (WM Act). The Department of Planning and Environment administers the WM Act and is required to assess the impact of any proposed development to ensure that no more than minimal harm will be done to waterfront land as a consequence of carrying out the controlled activity. Guidelines on riparian corridors recommend riparian corridor widths (each side of a watercourse) for each stream order type.

Bega Valley Council has provided the stream order and riparian corridor widths associated with each of the key tributaries (Figure B01, Appendix B).

3.3 Flooding Environment

3.3.1 Waterway versus Overland Flooding

The NSW Flood Prone Land Policy (DPE 2023) applies to urban and rural floodplains in New South Wales and to both flooding from waterways and local overland flooding. The Policy acknowledges that flooding can result from relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flow paths associated with major drainage, and/or oceanic inundation resulting from super-elevated ocean levels. Since the local overland flooding is a function of the local topography and design within the rezoned areas, which was unknown at the time of the report, this report only applies to the flooding from Bega River and local tributaries where the stream order is 3 and greater. Lower stream order local creeks and overland flooding matters will need to be addressed in future planning and design stages, when the local design within the rezoned precincts is confirmed.

3.3.2 Rainfall-runoff and flood models

This assessment has used the flood modelling results from the Floodplain Risk Management Study and Plan Bega & Brogo Rivers 2009 (Cardno, 2018). No model simulations were undertaken as part of this assessment. All flood models and flood model results were provided by Council.

3.3.3 Flood Depth and Levels

Flood maps for pre-development flood depths and levels are provided in Appendix B for the 1% AEP (Figure B02) and the PMF floods (Figure B03). The maps show the maximum envelope of both regional and local flood levels. In reality the timing of the two floods could differ. For the local flood levels, a 30mm filter has been applied and only flooding depths greater than 50mm are shown. In terms of the proposed rezoning, the mapping shows that:

– The proposed rezoned areas are located outside the PMF flood envelope associated with regional flooding of the Bega River.
– The proposed rezoning areas provide riparian corridors, with riparian waterway widths accommodating third- and higher-order tributaries and waterways.

– There are some areas that appear inundated within the areas to be rezoned, and these areas would need to be managed as part of the stormwater management system.
– Flood depths within the tributary waterways between rezoning areas are generally shallow, and mostly less than 0.5m with some areas up to 1m depth.

3.3.4 Flood Velocity

The flood maps in Appendix B show that flood velocities associated with Bega River and the local tributaries comprise generally slow flowing flood water (Figure B04 and Figure B05). Flow velocities are typically less than 1.0 m/s on the edges of the floodplain and associated with the local tributaries. Elevated flow velocities are noted for the Bega River deeper channel sections.

3.3.5 Flood Hazard

Flood mapping showing hydraulic flood hazard according to the Australian NSW Floodplain Management Manual 2005 hazard categories is provided in Appendix B. It is acknowledged that this manual has been updated (NSW Flood Risk Management Manual, 2023), however the flood hazard data provided by Council is presented under the now outdated manual. The hydraulic hazard has been categorized as shown in Figure 3.1. In the 1% AEP and PMF floods, the results show elevated flood hazard (greater than 2) within the deeper flowing areas of the Bega River and local tributaries.

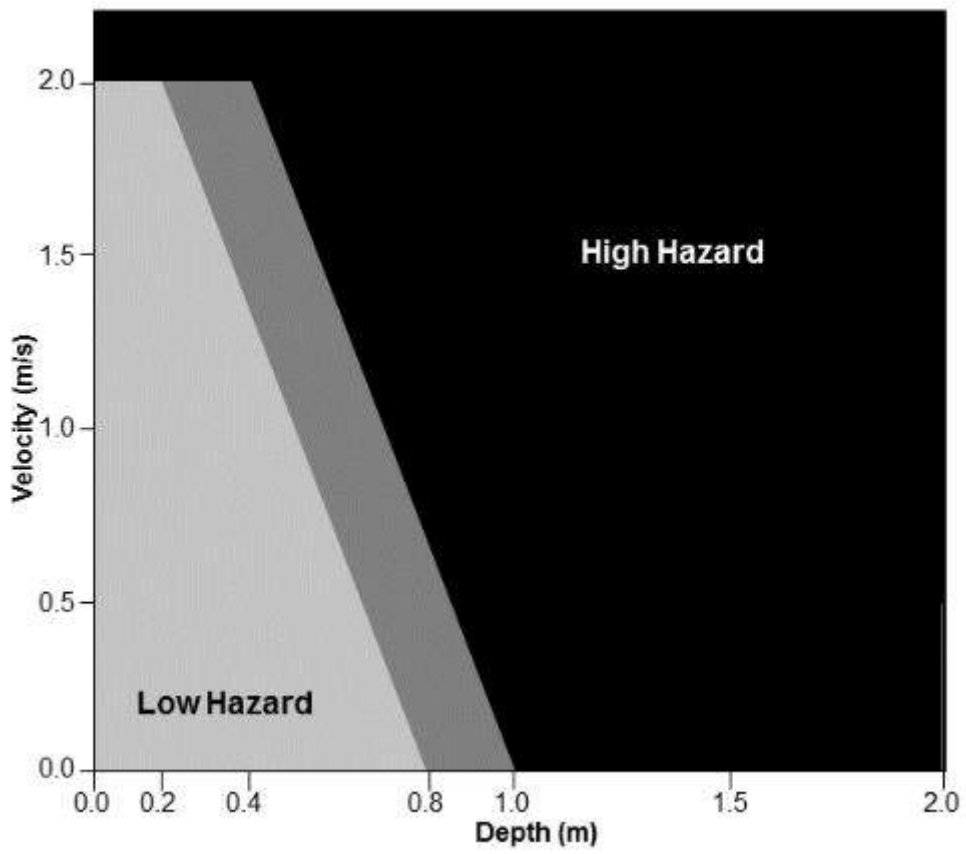


Figure 3.1 Australian NSW Floodplain Management Manual 2005 hazard categories

3.3.6 Flood Function

Flood function is defined as three categories under NSW Flood Risk Management Manual FB02 flood function:

– Floodways are generally areas which convey a significant portion of water during floods and are particularly sensitive to changes that impact flow conveyance. They often align with naturally defined channels. For this assessment, the flood function has been defined generally according to Howells et al 2003:
  - The velocity * depth product is > 0.25 m2/s and the velocity > 0.25 m/s or the velocity is greater than 1 m/s
  - Review of the creek channel banks
– Flood storage areas, which are areas outside of floodways, are generally areas that store a significant proportion of the volume of water and where flood behaviour is sensitive to changes that impact on the storage of water during a flood:
  - Land outside of the floodway if the depth is greater than 0.5 m.
– Flood fringe areas are areas within the extent of flooding for the event but which are outside floodways and flood storage areas. Flood fringe areas are not sensitive to changes in either flow conveyance or storage.
  - Land beyond the flood storage area where the depth is less than 0.5 m

Since the proposed rezoning lands are located outside the PMF flood extent associated with the Bega River and riparian corridors are provided for tributaries with stream order higher than 3, flood function was not relevant and was not determined.

3.3.7 Flood Rate of Rise

The flood level rate of rise data was not available for local tributary flooding, however this is expected to be short duration (flash flooding) due to the small contributing catchments. Figure 3.2 shows that flood levels associated with the Bega River typically rise over 12 to 18 hours, due to the slower response of the large catchment areas upstream of the Bega township.

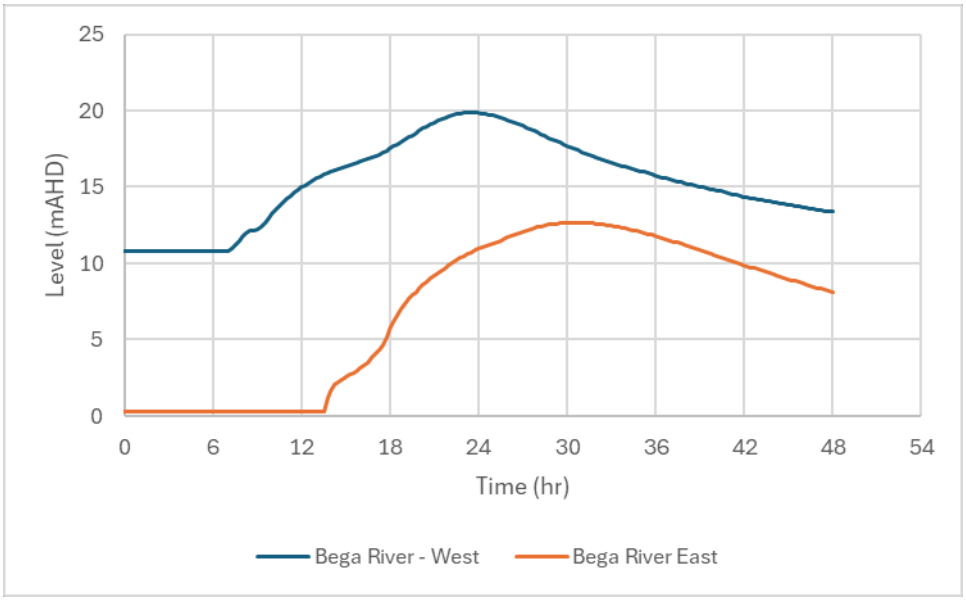


Figure 3.2 Flood Level Rate of Rise Regional

4. Proposed Development

The location of the rezoning areas is shown on Figure 4.1. The planning within the rezoning areas area lands is to provide a mix of rural residential, residential, local centres and a commercial centre, with the intended outcome listed in Table 4.1. This information was provided to GHD by ADW Johnson on the 04/02/2025 and may be subject to change. It is noted that this report is compiled on the basis that the development layouts and design topography within individual rezoning blocks are not confirmed.

Table 4.1 Rezoning Data (received 04/02/2025, ADW Johnson)

Revised Developable Area and Proposed Yield

Precinct	Gross Developable Area	Sub-precinct	Area	Dwellings/ha (average lot size)	Dwellings	Projected population	Zoning
Western	108.4ha	East of Ravenswood	81ha	2 dwellings/ha (5,000m^2)	162	356	R5
		West of Ravenswood	22.1ha	12 dwellings/Ha (600m^2)	265	999	R2
Central	16.2ha	Local Centre	0.5ha	NA	NA	NA	E1
		Commercial Centre	11ha	5 dwellings/ha (assumption)	55	121	E2
		Productivity Support	4.7ha	NA	NA	NA	E3
Eastern	158.83ha	Low Density Residential	145.4ha	12 dwellings/ha (600m^2)	1,745	3,839	R2
		Local Centre	0.3ha	NA	NA	NA	E1
Total	283.43ha				2,227	5,315	

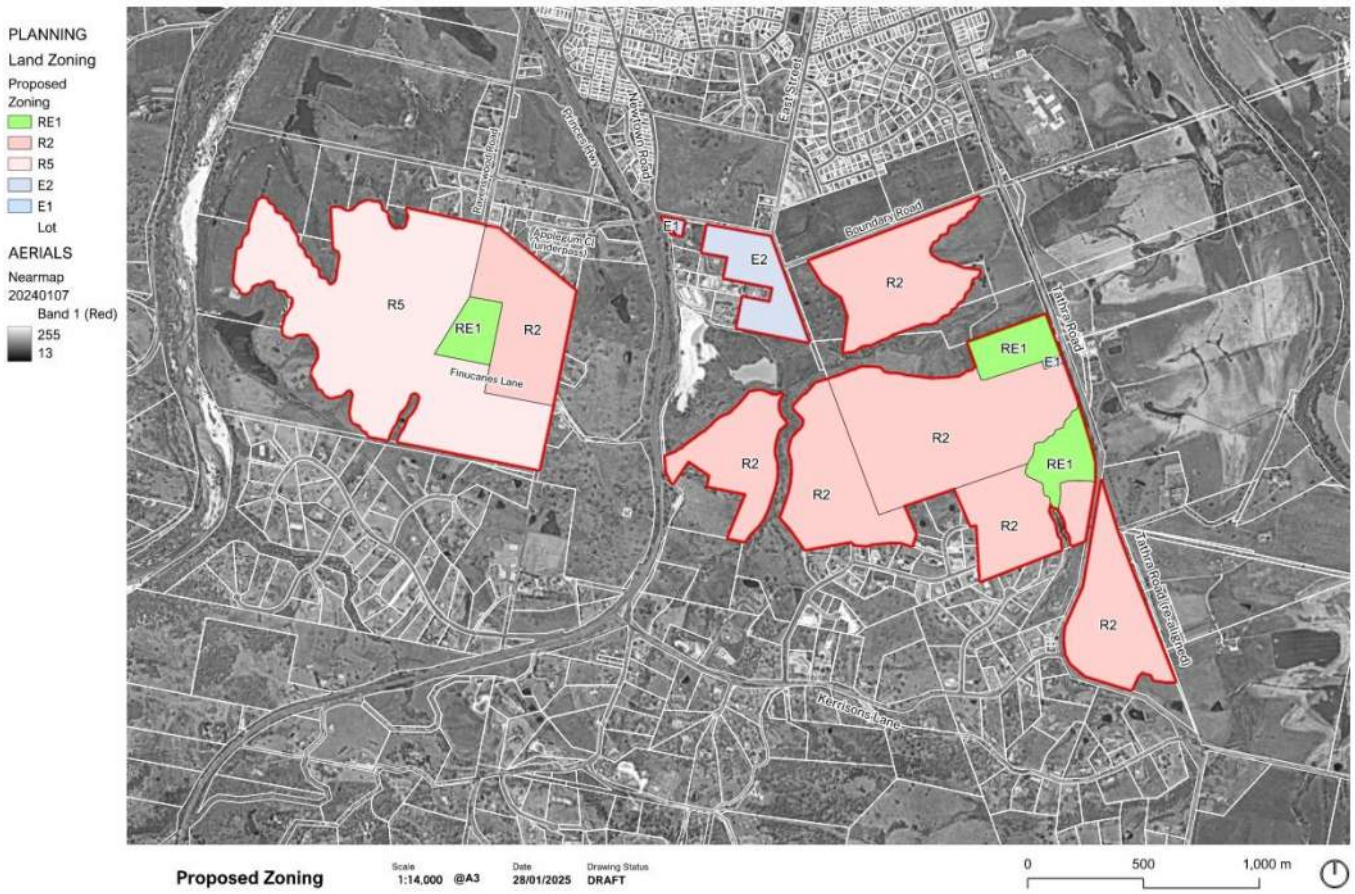


Figure 4.1 Rezoning Areas (received 04/02/2025, ADW Johnson)

5. Development Impacts

5.1.1 Flood Impacts

It is noted that this report is compiled on the basis that the development layouts and design topography within individual rezoning blocks are not confirmed. Further, no flood modelling was undertaken. Flood impacts are therefore not determined. However, in this regard:

– The proposed rezoned areas are located outside and higher than the PMF flood level as determined by the Brogo Rivers Floodplain Risk Management Study (FRMS) (Cardno, 2018).

– The proposed rezoning areas, do not impinge on tributary waterway setbacks associated with 3rd and higher order creeks, as determined by Council. In this regard it is noted that the drainage of the local PMF flood associated with these higher order tributaries is generally accommodated within these recommend riparian corridor widths.

5.1.2 DFE, Flood Planning Level and Area

The Flood Risk Management (FRM) framework and process provide the basis for understanding variability and uncertainty and considering these in decision-making. An example of accounting for uncertainty in management is the use of freeboard above the level of the Defined Flood Event (DFE) or design flood. Freeboard provides more certainty that the desired reduction in frequency of exposure to flooding chosen by this selection of a DFE is achieved.

Flood Planning Levels (FPLs) are recommended by the Bega Valley Council DCP 2013 and through the FRM process. FPLs are based on the DFE plus a freeboard. Different FPLs apply in different areas as the DFE and freeboard selected for an area may be different due to the varying flood behaviour (e.g. shallow flooding from local overland flooding rather than deep flooding from regional waterways) and risks. In addition, different FPLs are recommended for different types of development in DCP 2013, given the varying vulnerability of developments and their users to flooding and the use of community facilities during a flood.

The Flood Planning Area (FPA) is the area below the FPL. It is the area in which the majority of flood related development controls apply to most types of development.

5.1.3 Global Temperature Rise and Climate Change

It is noted in Section 2.2.3, Council's instruction to use the flood modelling results from the Floodplain Risk Management Study and Plan Bega & Brogo Rivers (Cardno, 2018), which predated the latest version of Australian Rainfall and Runoff 2019 Version 4.2. Under Australian Rainfall and Runoff 2019 Version 4.2, there would be a requirement to adjust design rainfall to reflect the impacts of rising global temperatures, to present day and into the future. Australian Rainfall and Runoff 2019 Version 4.2 recommends that this be undertaken for all design flood events including the PMF. Noting that the proposed development footprint is constrained by the PMF flood extent associated with the Bega River, it is possible that the Bega River PMF flood level could increase under future global temperatures. The magnitude of increase would require significant updates to the Floodplain Risk Management Study and Plan Bega & Brogo Rivers (Cardno, 2018) rainfall-runoff routing, and flood models which were beyond the scope of the current project.

6. Management Plan – Water Sensitive Urban Design – Flood Risk

The design of infrastructure within rezoning areas of the Bega Urban Land Release must be performed following the requirements of the NSW Flood Risk Management Manual 2023 (particularly Guideline FB01) and in consultation with Council requirements. Under the Guideline FB01 the following management considerations would apply, which are documented in DCP 2013:

– Floor Level: Allows for varying floor levels for different development types and parts of a development considering flood constraints as well as the cost of future flood damages and disruption.
– Flood Proofing: Flood compatible building considerations for varying development types. This is a means of reducing flood damages to individual properties.
– Structural Soundness: Identifies the scale of assessment required to demonstrate structural soundness to minimise cost of future damages and potential for development components to become floating debris.
– Flood affectation: Identifies how the impacts of the development are to be managed and the risks to the development and its users are to be assessed and considered based on the scale and type of development, its impacts on the existing community and the risk.
– Emergency Response: Considers the availability of existing EM arrangements including flood warning, evacuation routes, evacuation capacity, etc. and potential impacts of the development on evacuation capability of existing development.
– Management and Design: Considers additional factors needed to manage ongoing flood risk

Additional controls, as set out in engineering design guidelines, Council design standards, and planning controls will provide more prescriptive controls to manage flood risk for developments. These controls will generally include:

– Consideration of flood planning levels in design:
    - Flood Planning Levels for the future development of the Bega Urban Land Release areas may not be governed by flood levels in adjacent creeks, but by the overland flows through the precinct within the public road corridors and other areas. Council's DCP 2013 requires that a minimum freeboard of 0.5m shall be provided between the 1% AEP flood level and habitable floor levels. Depending on the nature of the development within the Bega Urban Land Release areas, sensitive facilities may require a higher level of flood protection. The exception to this is non-habitable public reserve areas, which may potentially be filled to achieve a reduced clearance to flood levels if desired.
    - Based on the above, Flood Planning Levels applicable to future development of proposed lots could be the higher of either the 1% AEP flood level in the adjacent creeks plus 0.5 m freeboard or the 1% AEP overland flow flood level plus 0.5m freeboard. Where overland flow levels vary around or within a proposed lot, the Flood Planning Level for future development should be based on the overland flow level at a particular location. An overland flow assessment will need to be undertaken during design development of the proposed lot areas to ascertain overland flooding flow depths in the 1% AEP event. These overland flow depths will subsequently be used to inform the Flood Planning Levels for the future development of each proposed lot.
    - In consideration of future climate, flood planning levels are likely to increase due to global temperature rises. Section 5.1.2 discusses matters related to climate change.
– Land use compatibility within the floodplain:
    - Some land uses, such as public open space, car parks or recreation areas within the proposed Bega Urban Land Release areas may be considered more compatible with the floodplain and suitable for use without the levels of flood protection afforded to habitable dwellings. These areas may be lower set, providing a broader stormwater and water quality management functions for the Bega Urban Land Release area and allowing some flooding to occur with due consideration of flood risk and safety to the public. Conversely, critical infrastructure may need a higher level of flood immunity.
– Sizing and location trunk drainage infrastructure and overland flow routes:

- Most councils nominate a “major”/”minor” concept of operations for the sizing of trunk drainage and stormwater infrastructure. Trunk drainage is traditionally sized to safely manage the “minor” storm event, typically the 10% or 5% AEP event, however in some cases, it may be appropriate to size trunk drainage to include additional capacity, to manage future development or mitigate flood impacts.
- Overland flow paths are typically sized to handle the “major” storm event, typically the 1% AEP event, in order to manage flood risk and public safety in events where the capacity of the local stormwater network is exceeded. Overland flows are typically directed through developed areas through open space/park areas and via the road network.

– Consideration of safe evacuation and egress routes
  - Design of the Bega Urban Land Release areas should consider provisions for safe evacuation or egress from the area to the adjoining local road networks in the event of flooding in rare to extreme flood events. This may require additional fill to mitigate flood risk, consideration of higher levels of flood immunity to the Bega Urban Land Release road network for facilitate safe evacuation from potentially flood effected areas, or consideration of additional capacity within the trunk drainage network to manage overland flows.
– On-Site Detention (OSD)
  - On site detention may be required to manage the predicted stormwater peak discharge from the Bega Urban Land Release areas and manage flood impacts within the receiving watercourse(s). OSD is typically size in order to manage flows up to and including the 1% AEP event. These matters are addressed in ensuing stages of development.

7. Summary, Conclusions and Recommendations

This report presents the stormwater and flood risk management strategy for the Bega Urban Land Release. It sets out the flood risk and stormwater management. Land use changes that result from the rezoning have the potential to alter the existing stormwater quantity and quality, and the flood risk environment. Based on the available planning information at the time of this report, it is considered that stormwater and flood risk can be managed in Bega Urban Land Release precincts, provided the management strategies documented in this report are implemented. Key to this conclusion is :

– Regional waterway flooding: That the Bega Urban Land Release areas are located outside and higher than the regional PMF flood level as determined by the Brogo Rivers Floodplain Risk Management Study (FRMS) (Cardno, 2018).
– Local flooding in tributaries: That the Bega Urban Land Release areas, do not impinge on tributary waterway setbacks associated with 3rd and higher order creeks. In this regard it is noted that the drainage of the local PMF flood associated with these higher order tributaries is generally accommodated within these recommend riparian corridor widths.
– Overland flow flooding: That future development within the Bega Urban Land Release is provided with stormwater management strategies to manage overland flow flood risk.
– That future development within the Bega Urban Land Release areas adopt the requirements and controls documented in the Bega Valley LEP 2103 and DCP 2013 and addresses the requirements of the Flood Risk Management Manual 2023.

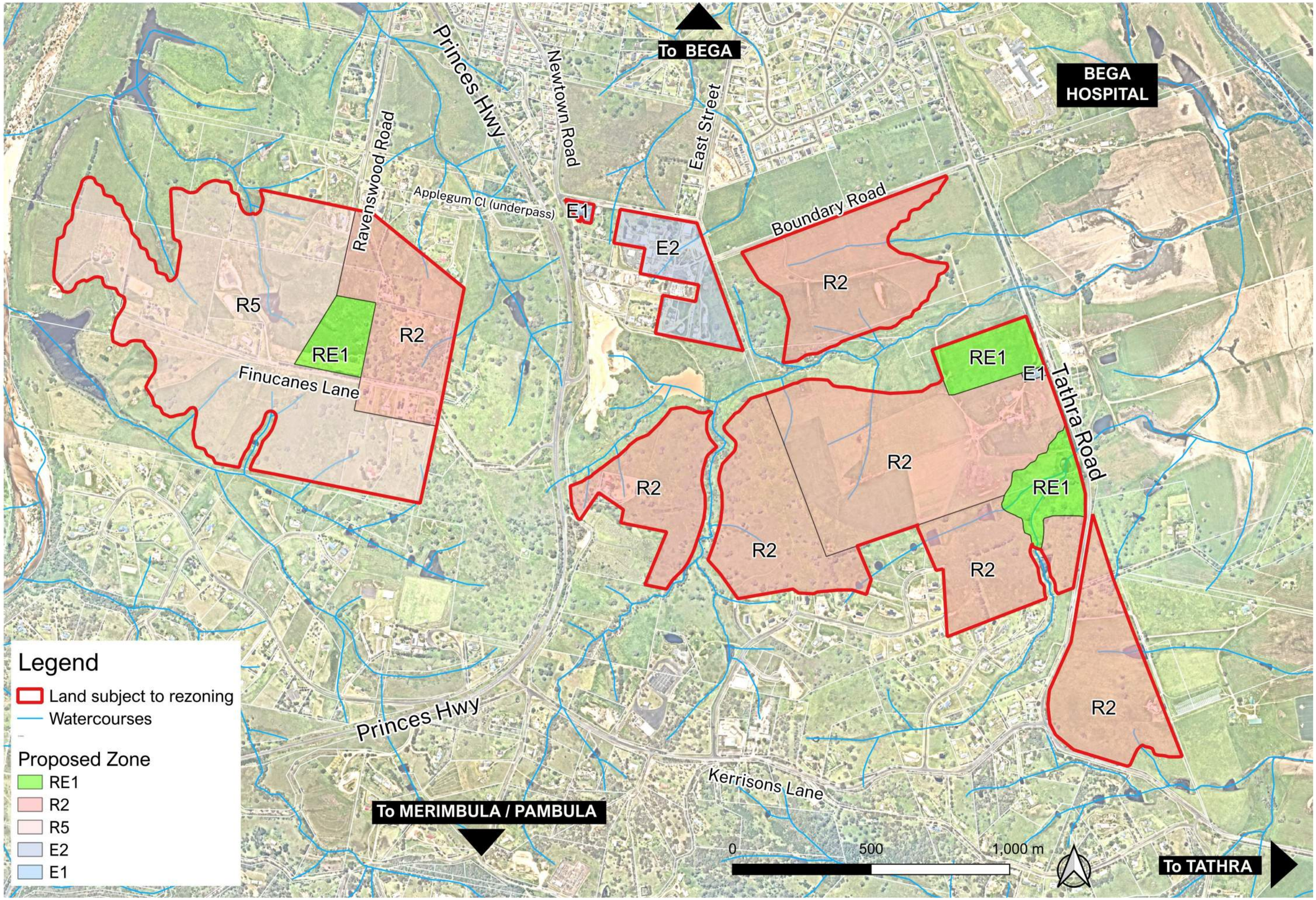
This report was compiled using flooding data compiled before the issue of the revised version of Australian Rainfall and Runoff Version 4.2 guideline (published 27/08/2024). The climate change matters presented in Australian Rainfall and Runoff Version 4.2 is based on emerging science and has wide ranging implications to the prediction of future flooding as a result of global temperature increases. Council has instructed that the update of the flood modelling into the current assessment, was beyond the scope of the project. It is strongly recommended that ensuing planning stages incorporate forecast predicted impacts on rainfall due to global climate temperature increases, and the recommendations under Australian Rainfall and Runoff 2019 Version 4.2.

8. References

- Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2019, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia
- Bega 2013a, Bega Valley Local Environmental Plan, Bega Valley Shire Council, 2013
- Bega 2013b, Bega Valley Development Control Plan, Bega Valley Shire Council, 2013 (amended July 2024)
- DPE 2023, *Flood Risk Management Manual, the policy and manual for the management of flood liable land*, NSW Department of Planning and Environment 2023
- DPHI 2024, NSW Department of Planning Housing and Infrastructure 2024, *Planning Circular PS24-001*
- Cardno (now Stantec) 2018, *Floodplain Risk Management Study and Plan Bega & Brogo Rivers, prepared for Bega Valley Shire Council 26 March 2018, adopted by Bega Valley Shire Council*
- Howells L, McLuckie D, Collings G and Lawson N (2003) 'Defining the floodway – can one size fit all?', Floodplain Management Authorities of NSW 43rd Annual Conference, Forbes, February 2003.
- SMEC 2014, *Bega and Brogo Rivers Flood Study at Bega*, SMEC Ref. 30011228-REP-Fina, l06 June 2014

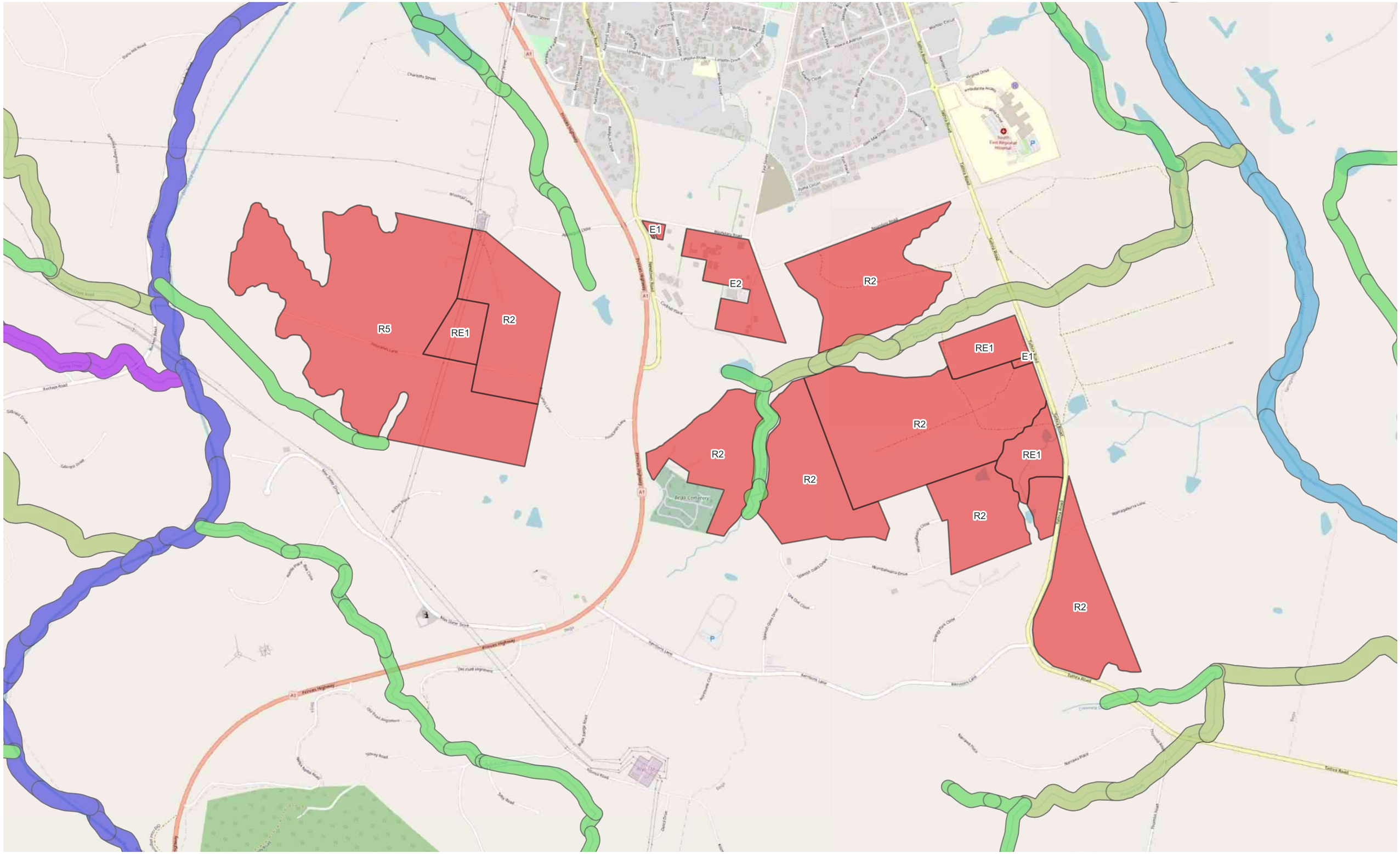
Appendix A

Rezoning Proposal


To BEGA
BEGA HOSPITAL
Princes Hwy
Newtown Road
East Street
Ravenswood Road
Applegum Cl (underpass)
E1
E2
Boundary Road
R2
R5
RE1
R2
Finucanes Lane
RE1
E1
Tathra Road
R2
R2
R2
R2
RE1
R2
Princes Hwy
Kerrisons Lane
To MERIMBULA / PAMBULA
To TATHRA
0
500
1,000 m
Legend
Land subject to rezoning
Watercourses
Proposed Zone
RE1
R2
R5
E2
E1

Appendix B

Mapping



Scale 15 000

Paper Size A3

N

Map projection: Transverse Mecator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND

Proposed Land Zoning

Strahler Order
3 4 5 6 7 8

ADW Johnson and Bega Valley Shire Council
Bega Urban Land Release Planning Proposal

Flooding Assessment - Existing Conditions
Riparian Corridors

Job Number 12646390
Revision
Date Feb 2025

Figure B01

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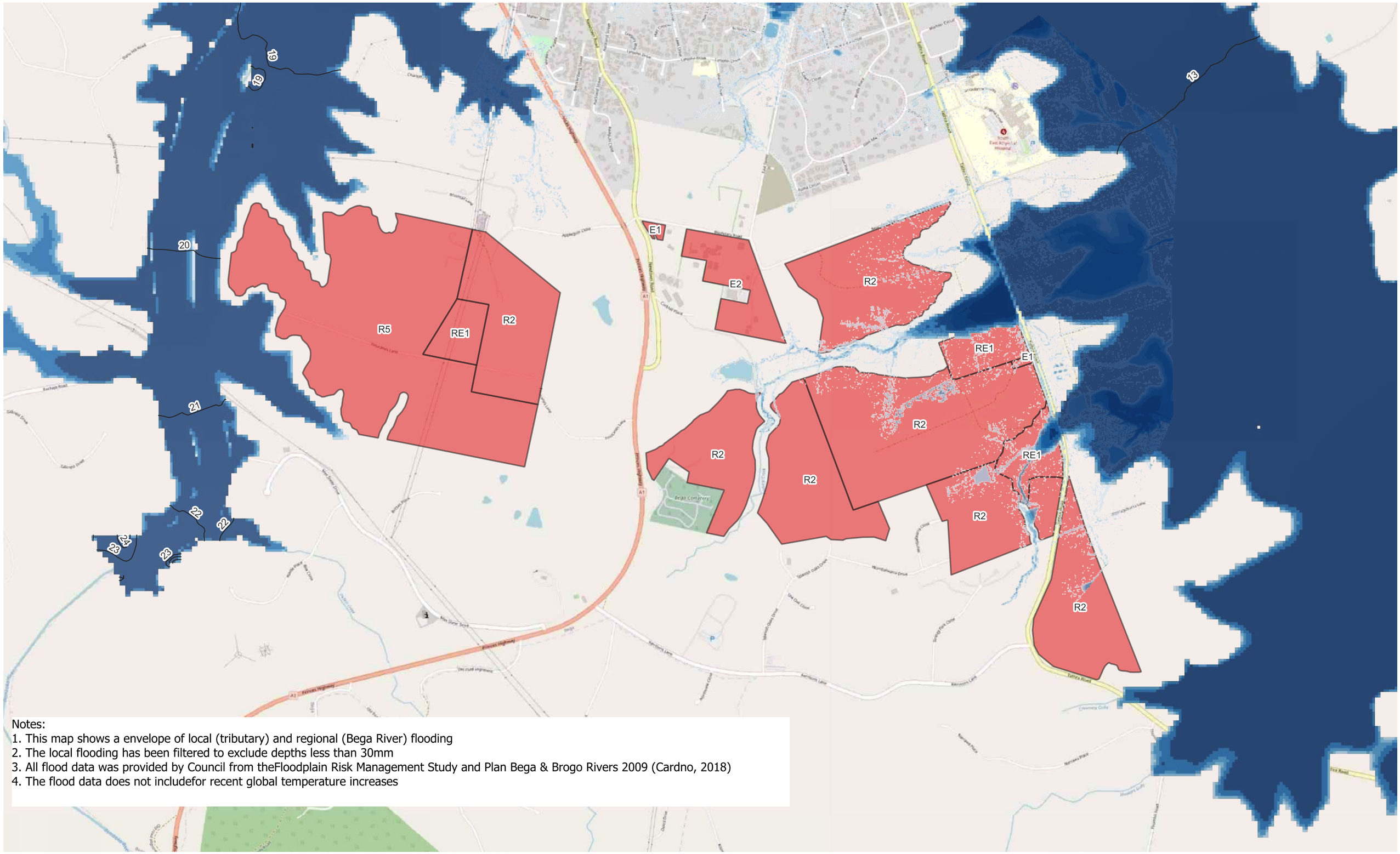

Notes:
1. This map shows a envelope of local (tributary) and regional (Bega River) flooding
2. The local flooding has been filtered to exclude depths less than 30mm
3. All flood data was provided by Council from theFloodplain Risk Management Study and Plan Bega & Brogo Rivers 2009 (Cardno, 2018)
4. The flood data does not includefor recent global temperature increases

Scale 15 000

Paper Size A3

N

Map projection: Transverse Mecator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND

- Proposed Land Zoning
- Flood Level (mAHD)

Depth (m)
- 0.015
- 0.1
- 0.3
- 0.5
- 1
- 2
- >2

ADW Johnson and Bega Valley Shire Council
Bega Urban Land Release Planning Proposal

Flooding Assessment - Existing Conditions
1% AEP Flood Depth and Level

Job Number	12646390
Revision	
Date	Feb 2025

Figure B02

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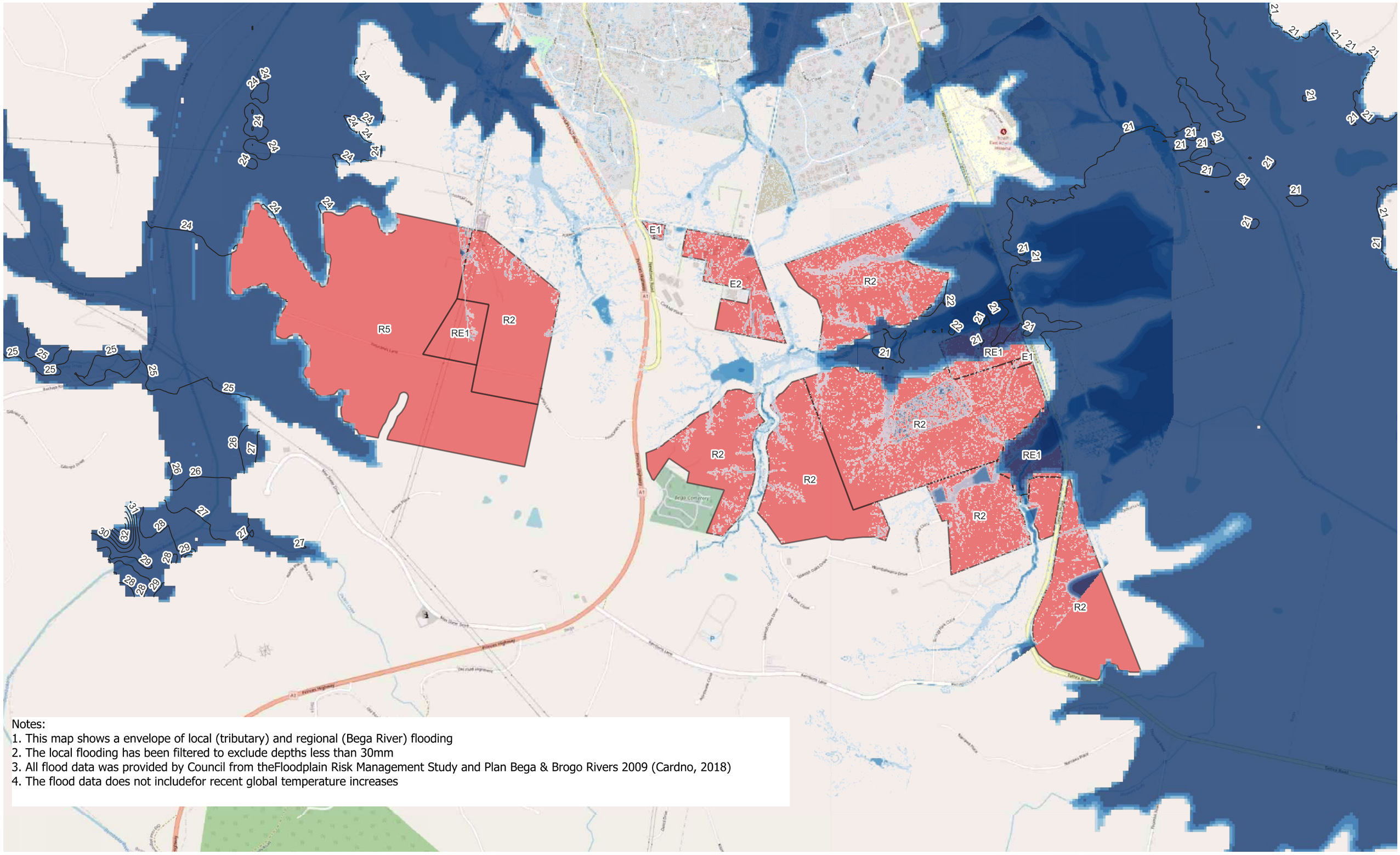

Notes:
1. This map shows a envelope of local (tributary) and regional (Bega River) flooding
2. The local flooding has been filtered to exclude depths less than 30mm
3. All flood data was provided by Council from theFloodplain Risk Management Study and Plan Bega & Brogo Rivers 2009 (Cardno, 2018)
4. The flood data does not includefor recent global temperature increases

Scale 15 000

Paper Size A3

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Map projection: Transverse Mecator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND

Proposed Land Zoning
Flood Level (mAHD)
Depth (m)
0.015
0.1
0.3
0.5
1
2
>2

ADW Johnson and Bega Valley Shire Council
Bega Urban Land Release Planning Proposal

GHD

Flooding Assessment - Existing Conditions
PMF Flood Depth and Level

Job Number 12646390
Revision
Date Feb 2025

Figure B03

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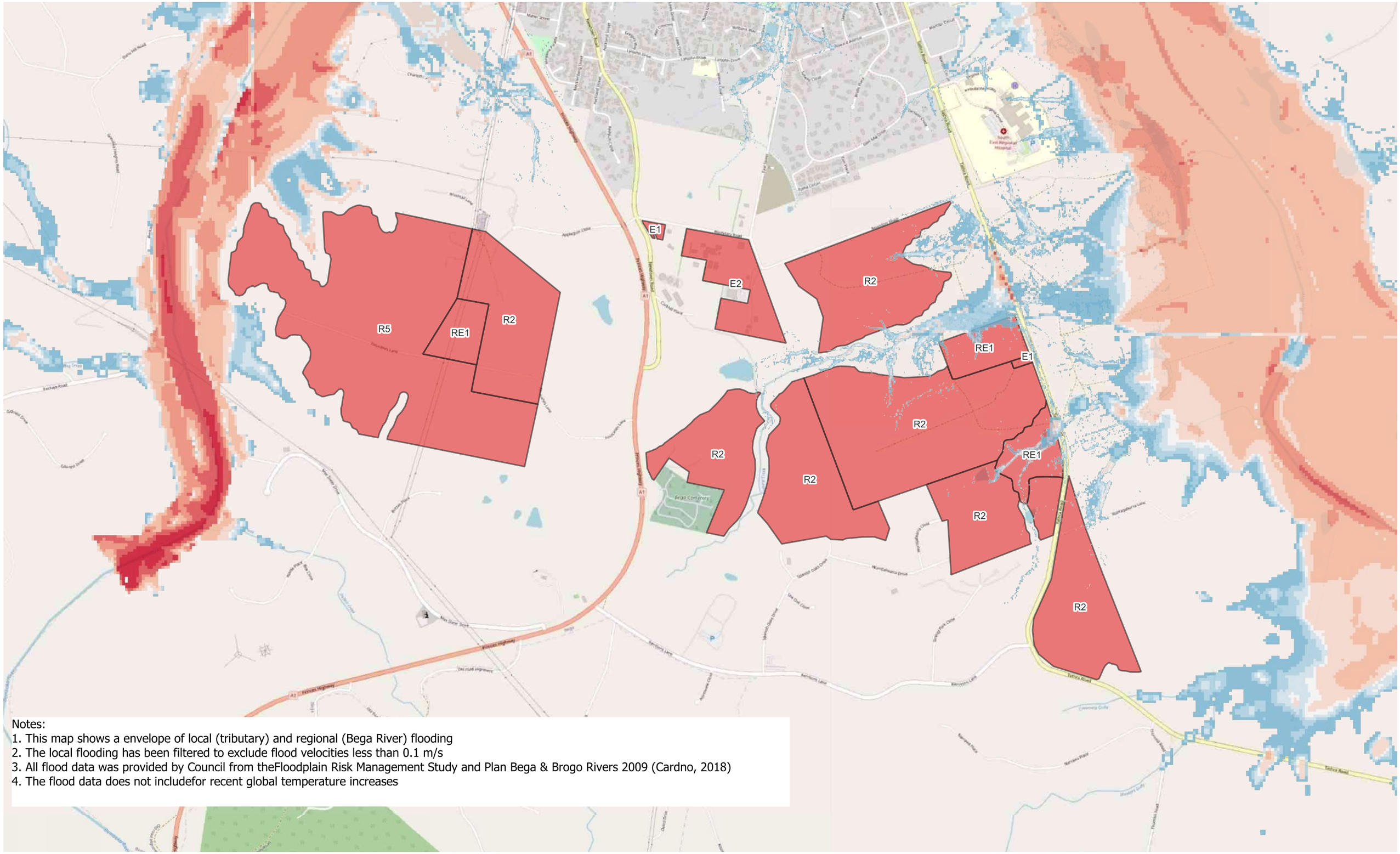

Notes:
1. This map shows a envelope of local (tributary) and regional (Bega River) flooding
2. The local flooding has been filtered to exclude flood velocities less than 0.1 m/s
3. All flood data was provided by Council from theFloodplain Risk Management Study and Plan Bega & Brogo Rivers 2009 (Cardno, 2018)
4. The flood data does not includefor recent global temperature increases

Scale 15 000

Paper Size A3

N

Map projection: Transverse Mecator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND

Proposed Land Zoning

Velocity (m/s)
- <0.1
- 0.1-0.2
- 0.2-0.3
- 0.3-0.4
- 0.4-0.5
- 0.5-1.0
- 1.0-2.0
- 2.0-3.0
- 3.0-5.0
- >5.0

ADW Johnson and Bega Valley Shire Council
Bega Urban Land Release Planning Proposal

Flooding Assessment - Existing Conditions
1% AEP Flood Velocity

Job Number 12646390
Revision
Date Feb 2025

Figure B04

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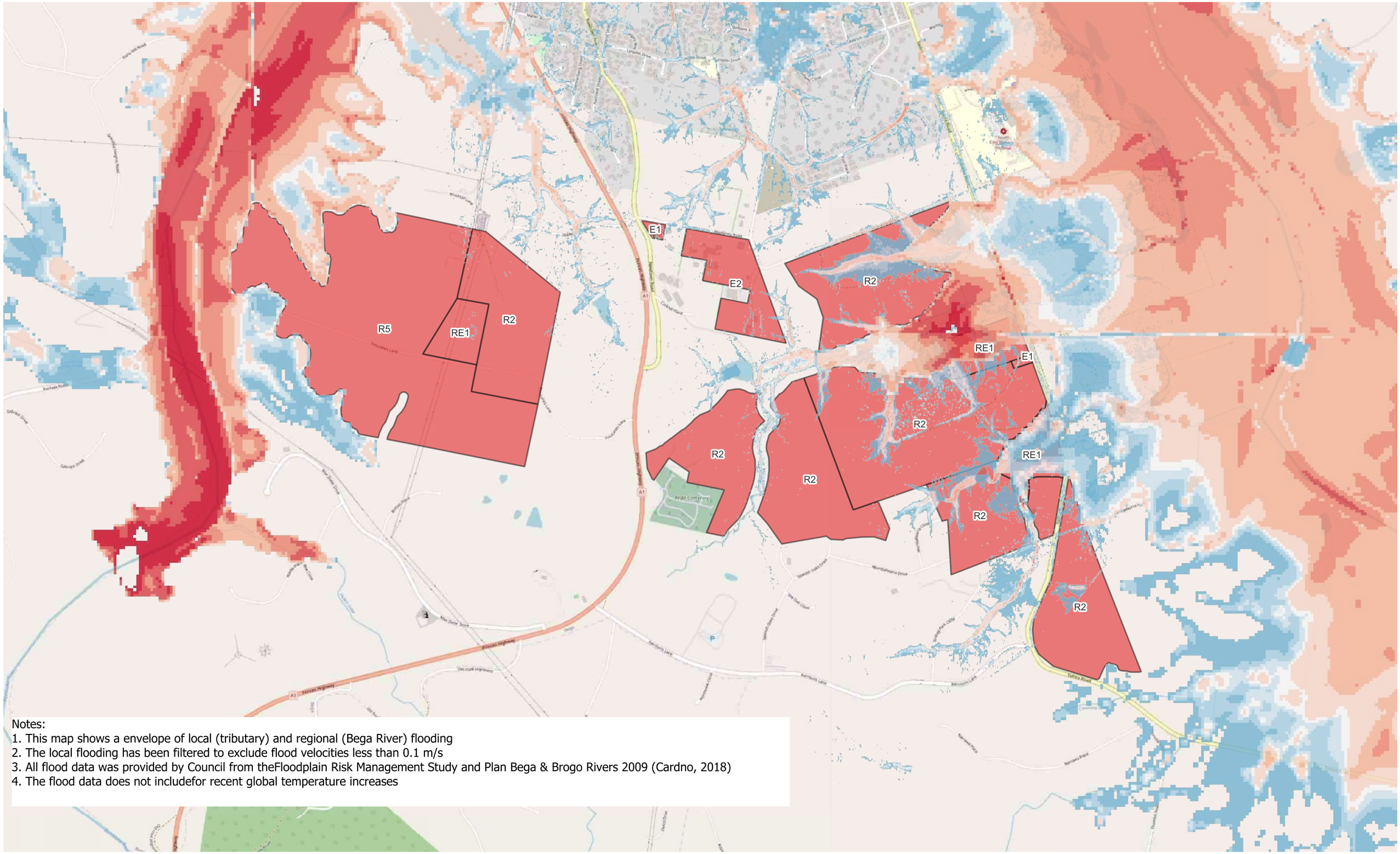

Notes:
1. This map shows a envelope of local (tributary) and regional (Bega River) flooding
2. The local flooding has been filtered to exclude flood velocities less than 0.1 m/s
3. All flood data was provided by Council from theFloodplain Risk Management Study and Plan Bega & Brogo Rivers 2009 (Cardno, 2018)
4. The flood data does not includefor recent global temperature increases

Scale 15 000

Paper Size A3

N

Map projection: Transverse Mecator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND

Proposed Land Zoning

Velocity (m/s)
- <0.1
- 0.1-0.2
- 0.2-0.3
- 0.3-0.4
- 0.4-0.5
- 0.5-1.0
- 1.0-2.0
- 2.0-3.0
- 3.0-5.0
- >5.0

ADW Johnson and Bega Valley Shire Council
Bega Urban Land Release Planning Proposal

Flooding Assessment - Existing Conditions PMF Flood Velocity

Job Number 12646390
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Date Feb 2025

Figure B05

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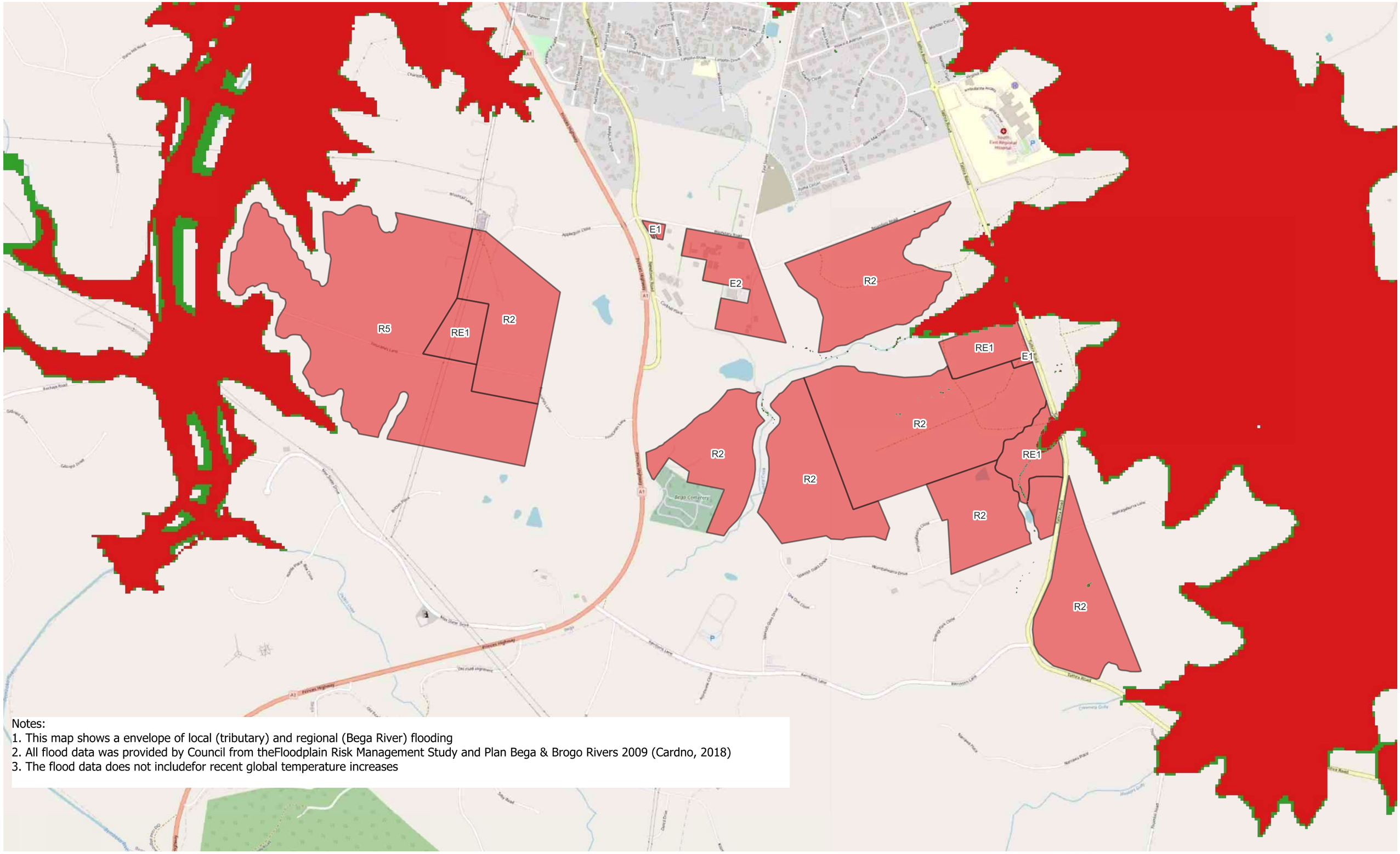

Scale 15 000

Paper Size A3

N

Map projection: Transverse Mecator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND

Proposed Land Zoning
Hazard
Intermediate Hazard
High Hazard
Low Hazard not shown

ADW Johnson and Bega Valley Shire Council
Bega Urban Land Release Planning Proposal

GHD

Flooding Assessment - Existing Conditions 1% AEP Flood Hazard

Job Number 12646390
Revision
Date Feb 2025

Figure B06

Data Source: Openstreetmap, GHD Flood Mapping (2025) Created by RRB

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Notes:
1. This map shows a envelope of local (tributary) and regional (Bega River) flooding
2. All flood data was provided by Council from theFloodplain Risk Management Study and Plan Bega & Brogo Rivers 2009 (Cardno, 2018)
3. The flood data does not includefor recent global temperature increases

Scale 15 000

Paper Size A3

N

Map projection: Transverse Mecator
Horizontal datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND

Proposed Land Zoning
Hazard
Intermediate Hazard
High Hazard
Low Hazard not shown

ADW Johnson and Bega Valley Shire Council
Bega Urban Land Release Planning Proposal

Flooding Assessment - Existing Conditions
PMF Flood Hazard

Job Number 12646390
Revision
Date Feb 2025

Figure B07

Data Source: Openstreetmap, GHD Flood Mapping (2025) Created by RRB

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