Summary Report

Briagolong Flood and Drainage Study

Wellington Shire Council

19 April 2021

Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
V01	Report			19/04/2021

Project Details

Project Name	Briagolong Flood and Drainage Study
Client	Wellington Shire Council
Client Project Manager	
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Document Number	5556-01_R04v01

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1 INTRODUCTION

Water Technology was commissioned by Wellington Shire Council (Council) to undertake flood mapping for the town of Briagolong. This project includes detailed hydrological and hydraulic modelling of the township, and its upstream catchment. This flood mapping will be used to satisfy a range of requirements from land use planning, emergency response, community awareness and for insurance purposes.

This is the fourth of four study reports (see list below) and provides a summary of the study and its outcomes. For details regarding the available data, the modelling and the risk assessment the reader is referred to the first three study reports. It is envisaged that this report would be read by people looking for a short summary of the study and its outcomes.

- R01 – Preliminary Report (data review, survey, proposed methodology)
- R02 – Modelling Report (hydrology and hydraulic validation, design modelling approach)
- R03 – Assess and Treat Risk Report (design mapping, flood intelligence information)
- **R04 – Summary Report (summarises key aspects of all reports providing a concise summary)**

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2 BACKGROUND

Briagolong is a small regional township within the Wellington Shire Council local government area. Anecdotally, population growth has been slow over the last 100 years or more. Figure 2-1 shows the changes in the streetscape between 1910 and present day.

FIGURE 2-1 BRIAGOLONG MAIN STREET; 1910 (LEFT) AND CURRENT DAY (RIGHT)

More recently, there has been increased development within the township leading to concern that homes may be built in inappropriate locations that are subject to overland flooding. The township has a history of inundation from local storm events, producing shallow inundation across the town. With no flood related planning controls currently in place, it has been difficult to control development in potentially flood prone areas.

The Briagolong Flood and Drainage Study was commissioned by Wellington Shire Council in collaboration with West Gippsland CMA. The project had important contributions from both organisations along with VIC SES and members of the Briagolong community who provided invaluable assistance on understanding past flooding within the township.

2.1 Data Availability

The preliminary report discussed the availability of data, this is summarised below:

- The available topographic data (LiDAR) was fit for purpose.
- Initial modelling was undertaken to establish likely overland flow paths and regions with ponding expected.
- Gauging and rainfall data was reviewed to understand significant events which have occurred in the past:
  - Significant recent events in Briagolong include June 1998, January 1999, November 2002, February 2005, June 2012 and July 2016;

2.2 Initial Engagement and Site Visit

On the 28th August 2018 a meeting was held in Briagolong with members of the project team listening to community members experiences of flooding in past events. Community members led the team around the town pointing out how previous storm events have impacted the town, where water flows etc. During this site inspection, preliminary flood maps were compared to observation, receiving encouraging feedback from community members.

A site visit followed the meeting with community steering group members showing the project team around the town, pointing out areas of past inundation, direction of water flow etc. This was extremely helpful in explaining the observed historic flooding they had experienced, and proved to be valuable information for the next stage of the project, the model validation.

FIGURE 2-2 GROUND TRUTHING PRELIMINANY FLOOD MAPPING DURING SITE VISIT

3 MODELLING REPORT / MODEL VALIDATION

3.1 Overview

A significant body of work was completed to develop, test and validate the hydrologic / hydraulic model of the Briagolong study area. A TUFLOW direct rainfall (Rain-on-Grid) model was used to describe overland flow over an area of 14.8 km². Model development included consideration of:

- Local rainfall;
- Local stormwater infrastructure (predominantly culvert crossings);
- Historical flood photos and anecdotal accounts of flood impacts;
- Changes in land use / landform; and
- Emerging best practice modelling approaches (ARR2016) and its practical application.

Modelling results and study reporting were submitted to the steering group and local Briagolong residents for feedback. These groups agreed the TUFLOW model was able to replicate past flood events and our recommendations for design modelling where practical and appropriate to be adopted.

3.2 Model Validation

After considering all the available information, the model validation runs were completed for the 2013 and 2016 events as they were recent events with many flood photos and had other necessary model input data was available. Changes in loss values (initial loss and continuing loss) were trialled to determine which combination best reproduced the observed flood impacts. An example validation figure is reproduced in Figure 3-1.

In both cases the modelling suggested Initial Loss 38 mm and Continuing Loss 6 mm/hr produced the most accurate reproduction of the events. It is noted that the Continuing Loss rate is quite high. However, the calibration effort was extensive, trialling many different loss rates, and this rate resulted in the best calibration across both historic events modelled.

3.2.1 ESRI Online Portal

Water Technology was very fortunate to be provided an initial review of our validation mapping by Trevor Gartung. Trevor is both a long time Briagolong resident and a former Council employee. This has given him a strong understanding of flooding and its management over the years. Trevor's feedback was submitted via the online flood mapping portal set up for this project. A screen shot of the portal is provided in Figure 3-2.

FIGURE 3-1 2016 MODEL RESULTS COMPARISON AT 1300 ON THE 6TH OF JULY 2016

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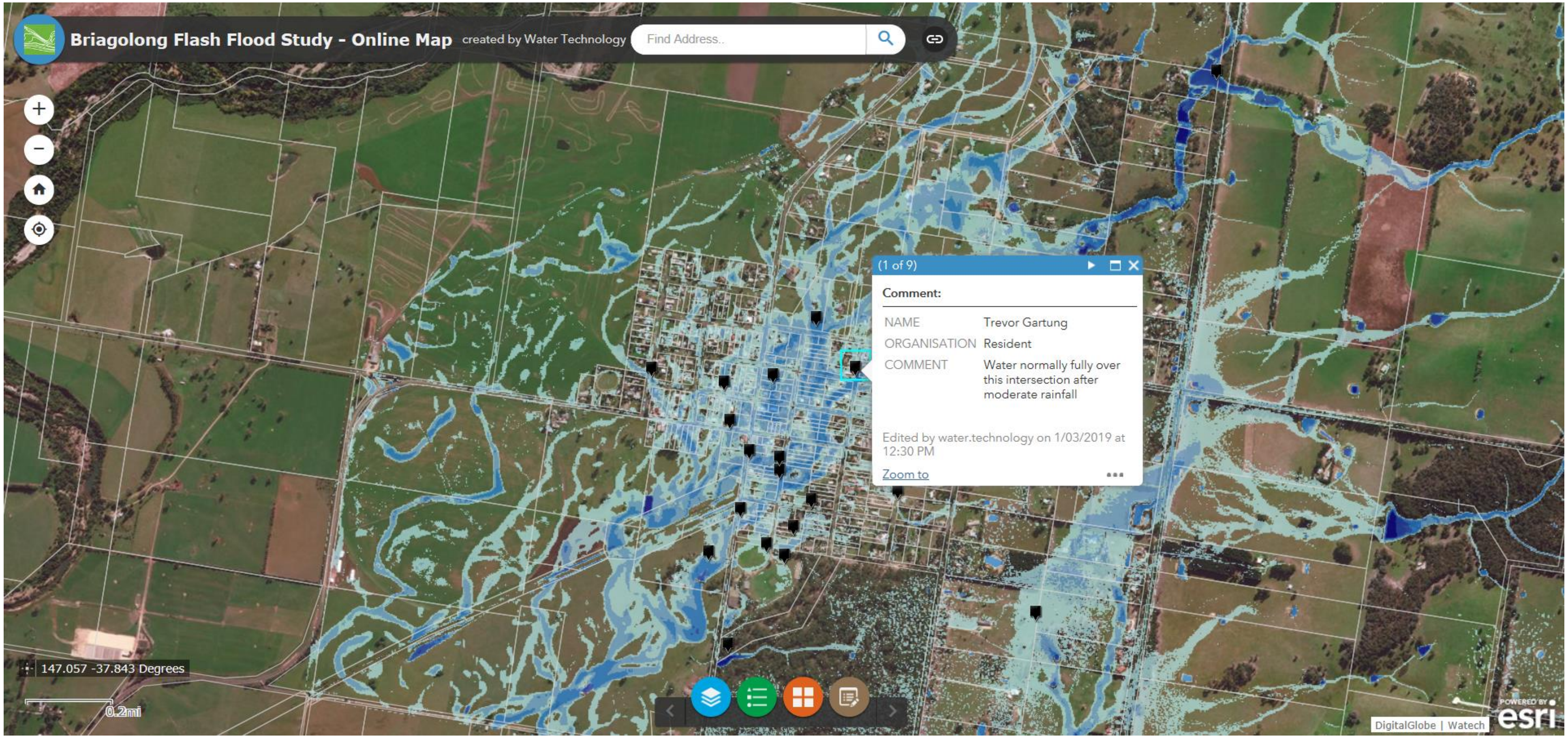

FIGURE 3-2 DATA CAPTURED ON THE ESRI ONLINE FLOOD MAPPING PORTAL

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3.2.2 Design Model Testing

Every storm event is different, with real storms having variations in the storm duration, the pattern of rainfall intensity across the event and the distribution of rainfall geographically. A significant amount of modelling was conducted to understand the implications of adopted event duration and temporal patterns for the 1% AEP event. Figure 3-3 shows an example of the critical duration analysis completed in the design model testing. While Figure 3-4 and Figure 3-5 show temporal pattern testing results. Design model testing also included sensitivity on roughness parameters and initial water levels in large rural dams. Finally the model catchment peak flows were checked in the upstream (confined) segment of the model against regional peak flow estimates. At the conclusion of this extensive testing process the following parameters were recommended for the design modelling.

- Design Losses (rural conditions) – Initial Loss 38 mm and Continuing Loss of 6 mm/hr
- Event durations
  - 1% AEP 2 Hour, 3 hour and 6 hour. All other AEP's just the 3 hour and 6 hour.
- Dam conditions – Set initial water level to have minimal freeboard possibly 100 mm from the top of the dam wall.
- Temporal Patterns - use TP4, TP5 and TP6 as they produced flood levels closest to the mean depth.

The following post processing approach was recommended:

1. Take the median of the temporal pattern results for each AEP and duration combination.
2. Take the maximum of the durations from step 1 to provide a final flood model result for each AEP.
3. Filter this final flood model result to remove shallow inactive portions of the study area.
   a. Remove area where depth is less than 0.05 m or the VxD is less than 0.008 m^2/s.
   b. Remove small, isolated puddles, with some iteration on the puddle size area to see what is right for the study area and grid cell size. Begin with trialling the removal of puddles of less than 100 m^2 in area.

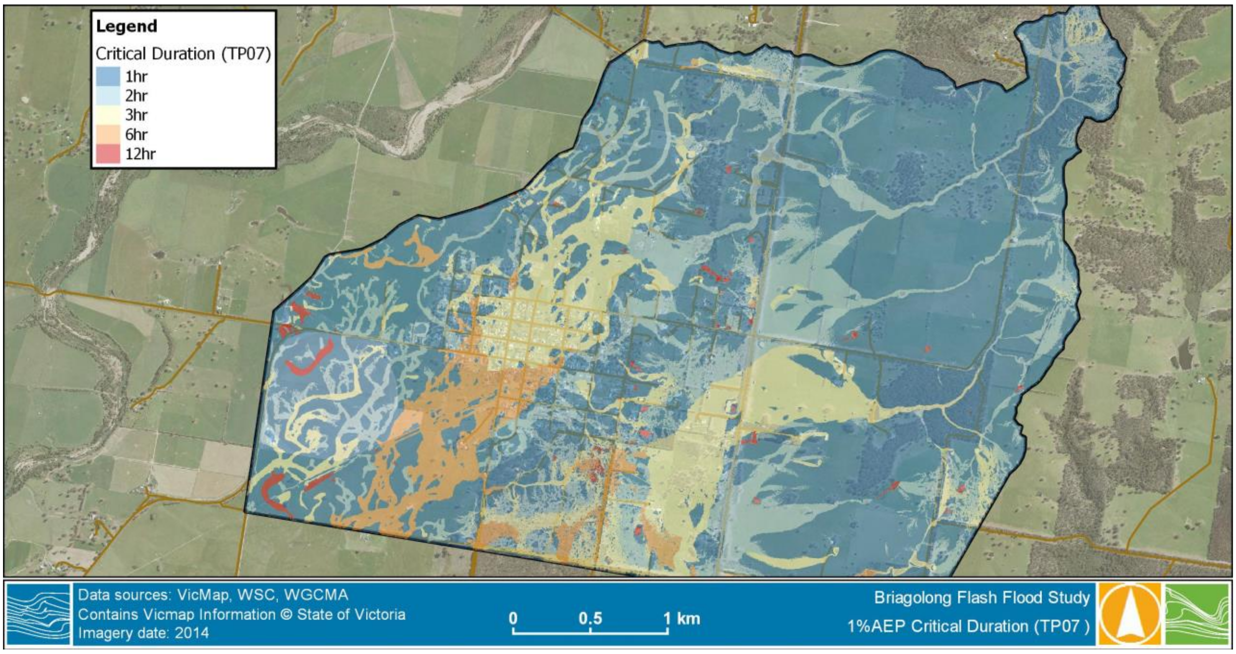
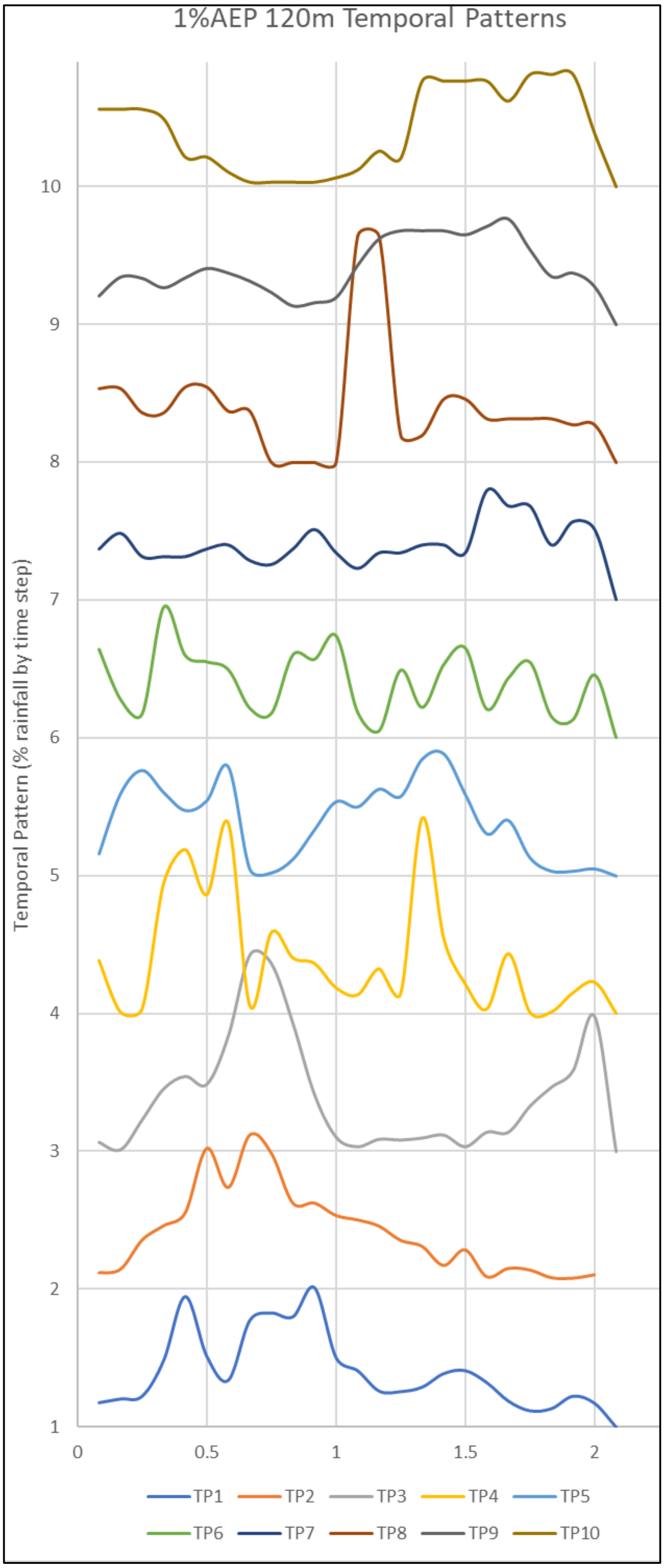


FIGURE 3-3 STORM DURATION PRODUCING MAXIMUM FLOOD LEVEL FOR 1% AEP TP7 EVENT



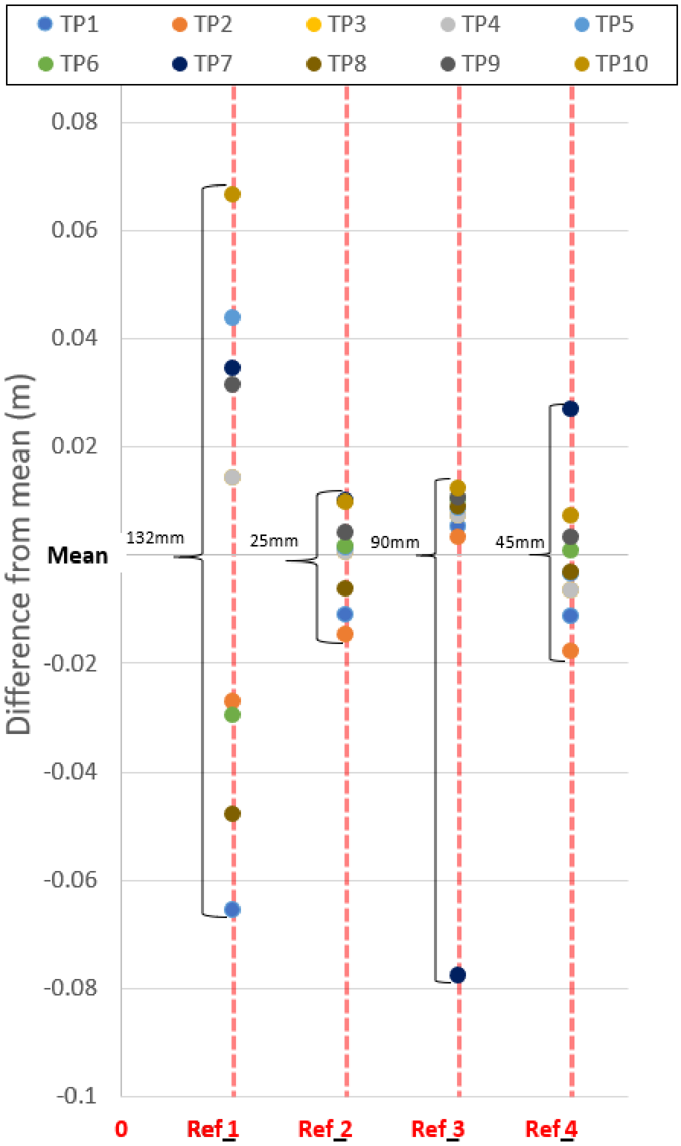


FIGURE 3-4 RANGE IN FLOOD LEVELS BY TEMPORAL PATTERN

FIGURE 3-5 TEMPORAL PATTERNS APPLIED TO DESIGN MODELLING

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3.3 Model Validation Engagement

The second steering committee meeting was held on the Wednesday, 21 August 2019. This meeting was attended by VicSES, Wellington Shire Council and 2 Briagolong residents. The meeting presented the findings of the modelling report.

At the conclusion for the meeting the committee agreed the model was representing past floods well and the committee was generally supportive of the recommended design modelling approach. Given the design modelling approach was a deviation from the specific ARR2016 guidelines (a method developed for hydrologic modelling not direct rainfall modelling) a peer review was recommended.

3.4 Peer Review

A peer review of the hydrologic / hydraulic modelling and associated recommendations was commissioned by West Gippsland Catchment Management Authority. The review was completed by Dr Mark Jempson of Venant Solutions.

Overall, the review was supportive of the work completed and the overall rigor applied to reach the recommendations. Several points of clarification were sought, and these were worked though with the project Steering Committee.

Upon review of the peer review findings and the response from Water Technology, Wellington Shire Council resolved that the recommended approach should be progressed for the design modelling of Briagolong.

4 DESIGN MODELLING

4.1 Model Runs Completed

The initial 1% AEP design flood mapping results were reviewed and approved by the project steering group. This review included considerations from the independent reviewer. With an agreed approach the other events where modelled. This included flood mapping of the events and durations shown in Table 4-1.

TABLE 4-1 DESIGN MODELLING COMPLETED - INCLUDING EVENT DEPTHS

AEP (%)	2hr Storm (mm)			3hr Storm (mm)			6hr Storm (mm)			Run Totals
	TP 4	TP 5	TP 6	TP 4	TP 5	TP 6	TP 4	TP 5	TP 6	
10	-	-	-	46.3	46.3	46.3	62.1	62.1	62.1	6
5	-	-	-	55.4	55.4	55.4	73.8	73.8	73.8	6
2	-	-	-	68.4	68.4	68.4	90.4	90.4	90.4	6
1	68.5	68.5	68.5	79.4	79.4	79.4	104	104	104	9
0.5	-	-	-	88.7	88.7	88.7	117	117	117	6
PMP	-	-	-	494 - 411	494 - 411	494 - 411	658 - 547	658 - 547	658 - 547	6
Total design model runs										39

4.2 Results Post Processing

TUFLOW provides times-series of depths (m), water surface elevations (m AHD), flow velocities (m/s) and flood hazard (m^2/s) at all grid points within the 2D domain. The raw model output data was processed in order for it to be easily viewed in GIS. Processing occurred in two stages – firstly processing the raw data using TUFLOW utilities and then processing the resulting data within a GIS environment.

The results were checked to ensure that larger events corresponded with increased depths, flood level and velocity in each cell.

In consultation with Wellington Shire Council, the following post processing approach was undertaken.

- Take the median of the temporal pattern results for each AEP and duration combination (See Figure 4-1).
- Take the maximum of the durations from step 1 to provide a final flood model result for each AEP.
- Filter this final flood model result to remove shallow inactive portions of the study area.
  - Remove area where depth is less than 0.05 m or the VxD is less than 0.008 m^2/s.
  - Remove small isolated puddles based on surface area threshold.

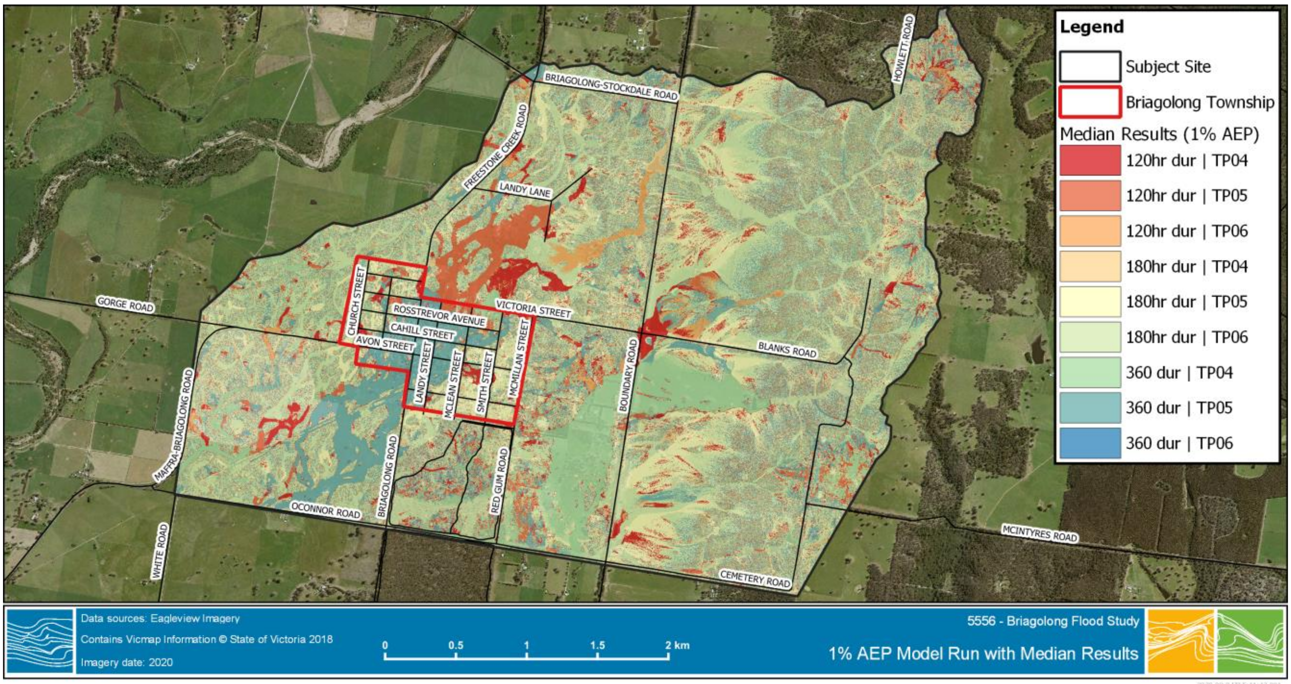

FIGURE 4-1 1% AEP MODEL RUN WITH MEDIAN RESULT

Removal of small isolated puddles is an important step in the filtering process. It is the final processing step, and it removes small isolated and disconnected "puddles" from the results. As you would expect the larger the puddle size adopted the smaller the flood extent. Previous testing has shown in some instances this assumption (puddle size) can have a dramatic impact on flood extent size.

To test the sensitivity to puddle assumptions the 1% AEP results were filtered with 3 puddles sizes 100, 500 and 1,000 m². Changes in flood extents between these different filtering processes are shown in Figure 4-2. This figure shows negligible difference in flood extent between the three puddle sizes. Specifically, there is no difference in flood extent within the active flow path through the main township of Briagolong.

Upon review of these results and after discussions with Wellington Shire Council, it was agreed to proceed with removing inactive puddles <1,000 m².

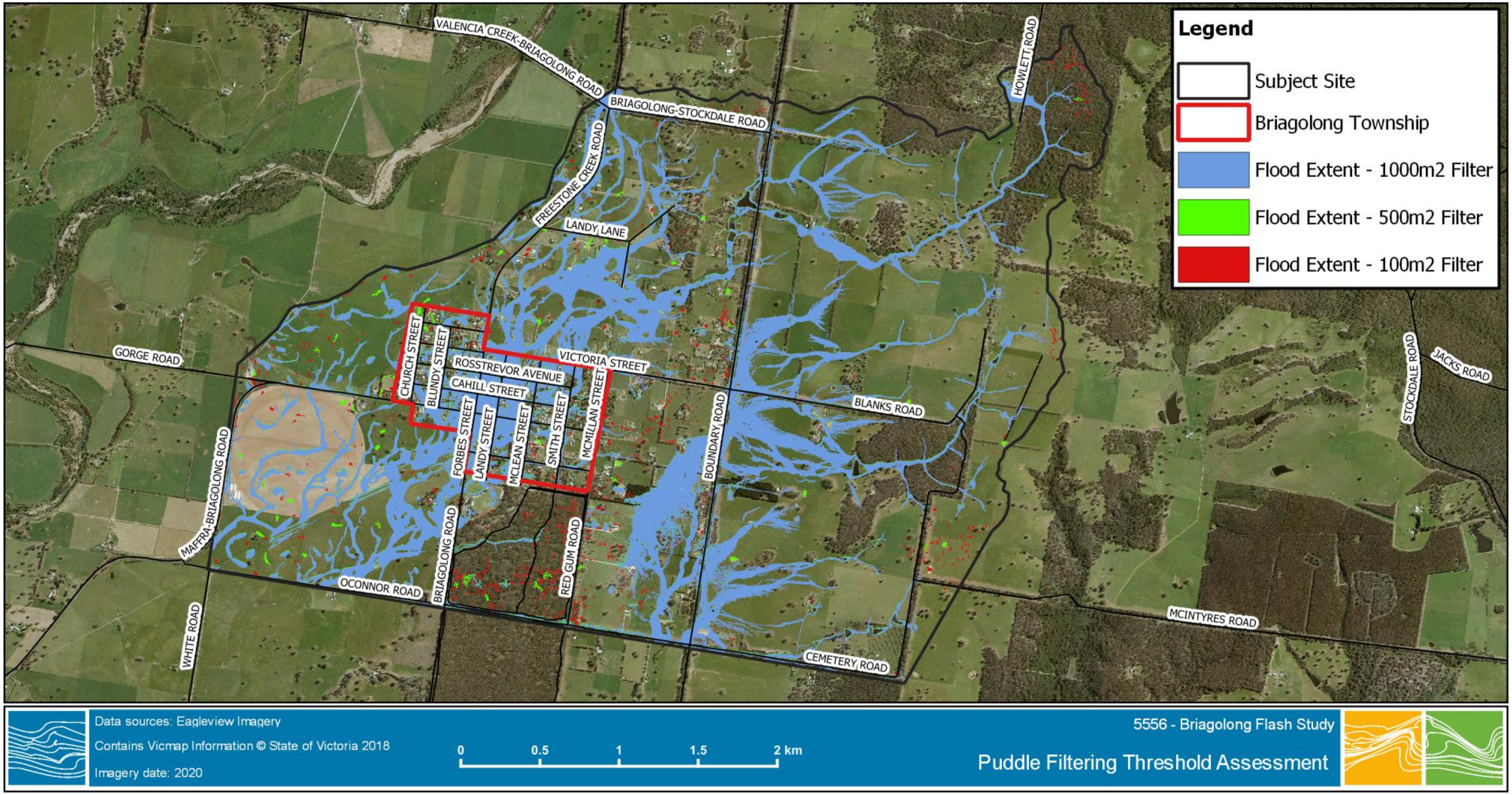

FIGURE 4-2 1%AEP PUDDLE FILTERING THRESHOLD ASSESSMENT

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4.3 Flood Impacts

Maps covering the model extent (Figure 4-3) and the Briagolong Township (Figure 4-4) are shown on the following pages with all AEP design events overlayed. These results show there are two distinct and independent flow paths within the model domain. In both cases the direction of flow is consistently from the north east towards the south west.

The more easterly flow path flows through farmland before intersecting Blanks and Boundary Roads. The roads create an impoundment with flood waters tending to back up behind the raised roads and relatively small crossings. Once these overland flow paths leave Boundary Road they tend to become wider and flow in a more southerly direction to Cemetery Road (the model boundary). The modelling in this study has shown this flow path does not impact the main township of Briagolong.

The second major flow path begins at the northern end of Howlett's Road. This flow path has a clear drainage line from its headwaters. The drainage line picks up significant catchment flow from the surrounding farmland before reaching the lower density residential area to the north of the main Briagolong township (North of Victoria Street). Once the flow path enters the urban area (south of Victoria Street) the flow tends to split into several overland flow paths. It would appear these paths tend to follow historical ephemeral drainage lines but are regularly interrupted by manmade constrictions from roads, land re-forming and filling. The area inundated withing the main township tends to stretch from Blundy Street to Smith Street (west to east), with the most significant flow paths found between Forbes Street and Smith Street.

Spatial analysis suggests the extent of flooding within the built up area of Briagolong (see red polygon in Figure 4-4) ranges between 25% (10% AEP) to 50% (0.5% AEP) of the total urbanised area (~99 ha), with the Probable Maximum Flood (PMF) inundating approximately 90% of the main township. Table 4-2 shows the land inundated by the various design events considered. It shows that the 0.5% AEP event inundates approximately double that of the 10% AEP event.

TABLE 4-2 AREA INDUDATED BY DESIGN FLOODS IN BRIAGOLONG

AEP	Township Area Inundated (Ha) *(Total Township Area ~99Ha)*	Additional Area Inundated above 10%AEP Extent
10%	24.13	-
5%	31.41	30%
2%	39.3	63%
1%	42.08	74%
0.50%	49.69	106%
PMF	90.25	274%

Analysis of the modelling showed that flood levels and depths do not change significantly as the event magnitude increases across the range of design events considered (10% AEP to 0.5% AEP), with only about a 200 mm increase in flood depths. The PMP event shows significantly more flooding than all the other events considered, with flood depths typically 1 m greater than the 0.5% AEP event.

Design flood depths were compared to the validation model runs, with both events falling around a 5% AEP magnitude. For the rarer events >2% AEP, the highest flood flows tended to be observed in the 3 hour storm duration event. This finding validated the event duration selections recommended in the modelling report.

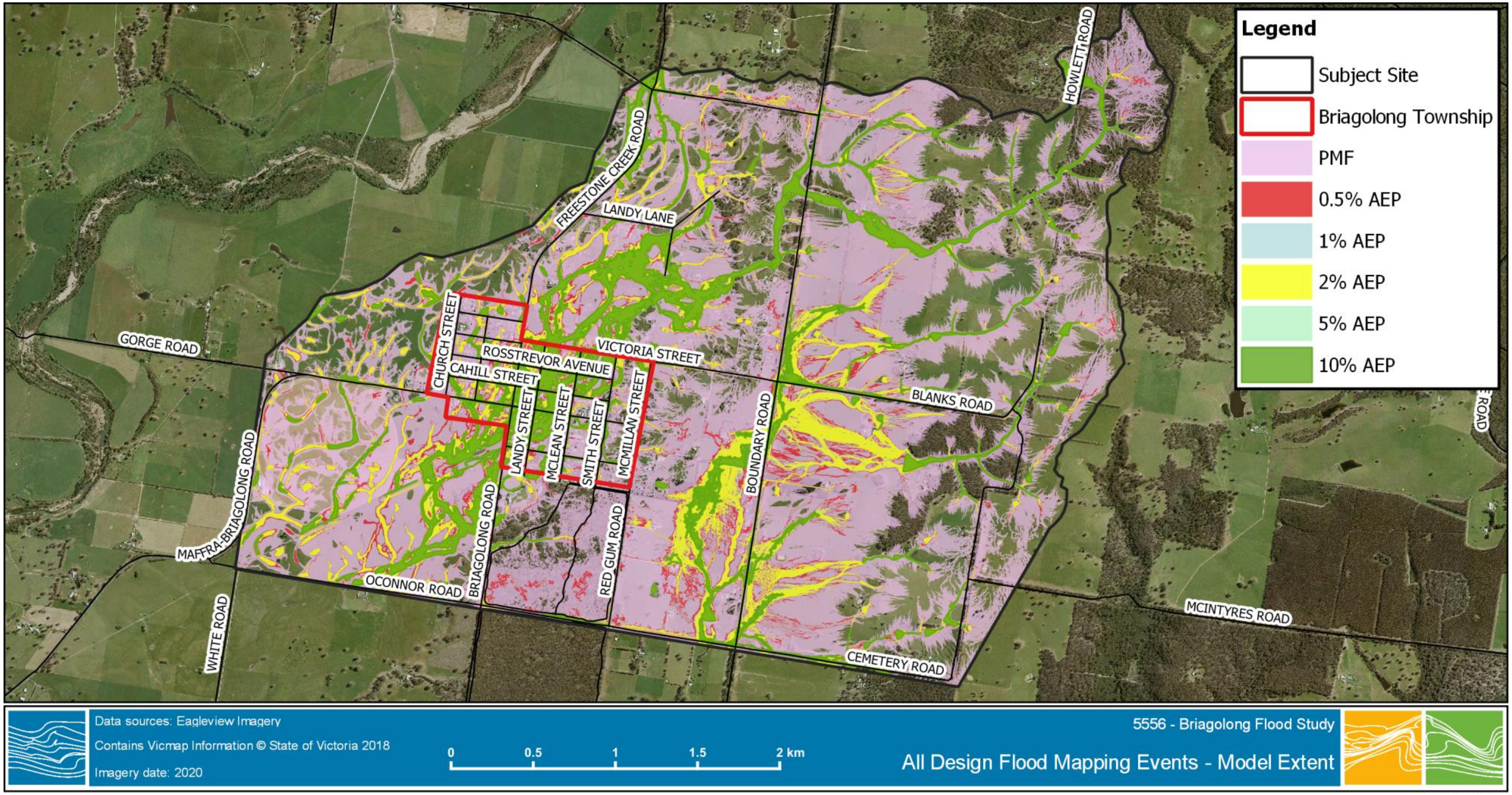

FIGURE 4-3 DESIGN MODELLING EXTENT COMPARISON (MODEL EXTENT)

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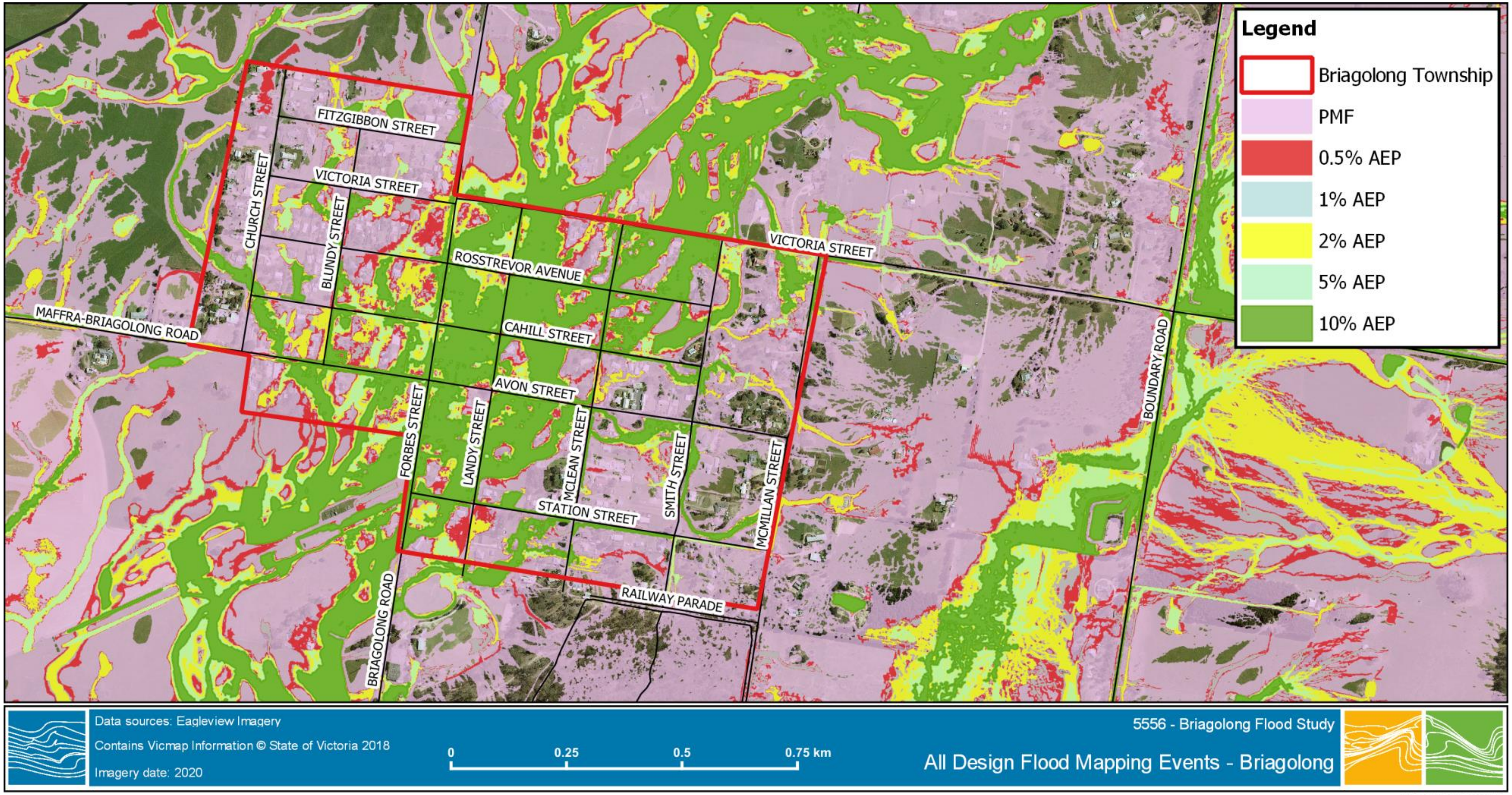

FIGURE 4-4 DESIGN MODELLING EXTENT COMPARISON (TOWNSHIP)

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5 FLOOD INTELLIGENCE

Every flood is different, with the temporal and spatial distribution of rain and the catchment wetness prior to the storm resulting in different flood behaviour.

Table 5-1 can be used to cross reference the rainfall depths modelled with various impacts identified from the mapped flood extents and can be used to predict future flood impacts given a forecasted or observed rainfall depth and intensity. Flood intelligence products presented here were informed by the VicSES, East Gippsland Flood Mapping and Intelligence Project, with map styling and impact tables intended to be suitable for direct incorporation into the Wellington Shire Council Municipal Flood Emergency Management Plan (MFEP) Appendices. The 1% AEP event has been provided here with mapping provided separately as a deliverable for all events shown in Table 5-1.

Table 5-1 lists the historic and design events in order of magnitude (lowest to highest). It is noted that the historic events have recorded higher rainfall totals than some of the design events of great magnitude, but the long duration the rainfall was recorded over means that the flood impact was lessened.

TABLE 5-1 MODELLED STORMS IN THE BRIAGOLONG FLOOD STUDY

Event	2hr Storm (mm)	3hr Storm (mm)	6hr Storm (mm)	39hr Storm (mm)	59Hr Storm (mm)
10%AEP	-	46.3	62.1	-	-
June 2013				-	142.8
5%AEP	-	55.4	73.8	-	-
July 2016				145.2	-
2%AEP	-	68.4	90.4	-	-
1%AEP	68.5	79.4	104	-	-
0.5%AEP	-	88.7	117	-	-
PMP		494 - 411	658 - 547	-	-

5.1 Flood Risk

Flood Risk is the product of the likelihood of a certain event occurring and the consequence of that event. To assess the flood risk within Briagolong, the hydraulic modelling outputs (depth, velocity and flood hazard mapping) can be used to identify both the likelihood of the event happening (in terms of annual exceedance probability) and the consequence of such an event happening. Depth maps are useful in showing the areas impacted by the flooding, while the velocity and flood hazard mapping provides more detail for the areas which pose a higher consequence. Flood hazard is based on criteria including depth, velocity and depth x velocity and is explained further below.

When considering the emergency response for Briagolong during a flood event, it is important to consider the areas that are flooded first within the township, not just areas of high consequence (high hazard). Areas first flooded are often areas that have a higher likelihood of occurring and will be inundated more frequently.

5.1.1 Flood Depths & Hazard

Mapping products were produced in alignment with those requested in the VicSES East Gippsland Flood Mapping and Intelligence Project. Specifically, the mapping included:

1. **Depth-Class Maps:** with three flood depth categories identified where depths exceed the value ranges in Table 5-2.
2. **Hazard-Class Maps:** with three hazard categories, based on scenarios where either depth *or* velocity exceeds the value range listed in Table 5-3.

TABLE 5-2 VICSES DEPTH CLASS MAPPING PARAMETERS, ADAPTED FROM VICSES (2018)

DEPTH CLASSIFICATION	DEPTH (D)
Low	< 0.3 m
Moderate	0.3 m – 0.6 m
High-Extreme	> 0.6 m

TABLE 5-3 VICSES HAZARD CLASS MAPPING PARAMETERS, ADAPTED FROM VICSES (2018)

HAZARD CLASSIFICATION	DEPTH (D)	VELOCITY (V)
Low	< 0.3 m	0.05 m/s – 0.4 m/s
Moderate	0.3 m – 0.6 m	0.4 m/s – 0.8 m/s
High-Extreme	> 0.6 m	> 0.8 m/s

Hazard maps following the Australian Rainfall & Runoff (ARR) 2019 guidelines have also been produced for the 1% AEP event. The updated hazard guidelines describe hazard as the "*source of potential harm*" or a "*situation with potential to result in loss",* and is represented in six categories of escalating hazard, shown in Table 5-4 (ARR, 2019). The resulting hazard category is highlighted on a map when any of the category ranges are exceeded.

TABLE 5-4 COMBINED HAZARD CURVES – VULNERABILITY THRESHOLDS AND CLASSIFICATION LIMITS. ADAPTED FROM ARR (2019) AFTER SMITH ET. AL. (2014)

HAZARD VULNERABILITY CLASSIFICATION	CLASS LIMIT (D & V IN COMBINATION)	LIMITING STILL WATER DEPTH (D)	LIMITING VELOCITY (V)	DESCRIPTION
H1	$D*V \leq 0.3\ m^2/s$	0.3 m	2 m/s	Generally safe for vehicles, people and buildings.
H2	$D*V \leq 0.6\ m^2/s$	0.5 m	2 m/s	Unsafe for small vehicles.
H3	$D*V \leq 0.6\ m^2/s$	1.2 m	2 m/s	Unsafe for vehicles. children and the elderly.
H4	$D*V \leq 1.0\ m^2/s$	2.0 m	2 m/s	Unsafe for vehicles and people.
H5	$D*V \leq 4.0\ m^2/s$	4.0 m	4 m/s	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
H6	$D*V > 4.0\ m^2/s$	-	-	Unsafe for vehicles and people. All building types considered vulnerable to failure.

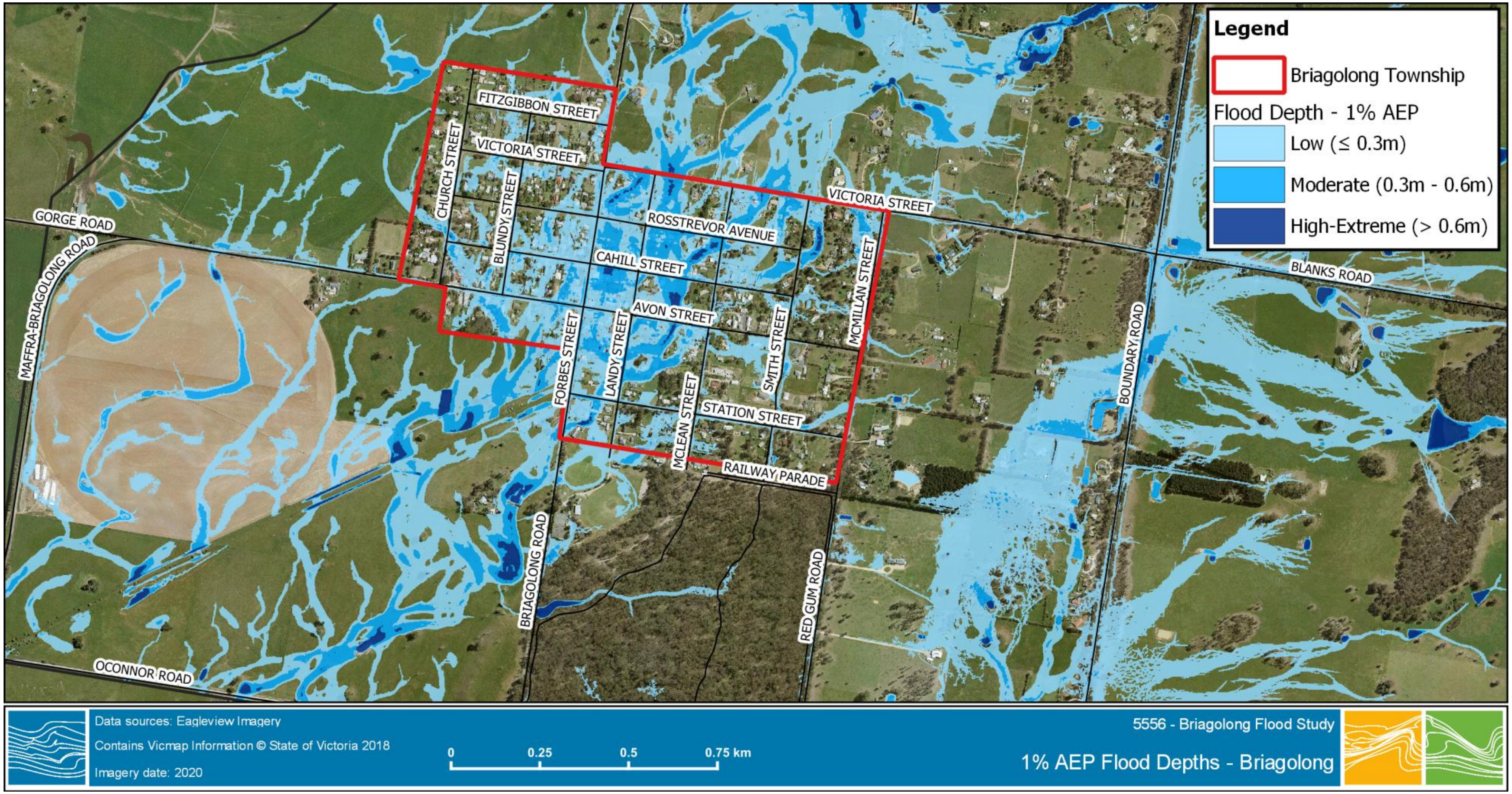

FIGURE 5-1 1% AEP FLOOD DEPTH (TOWNSHIP)

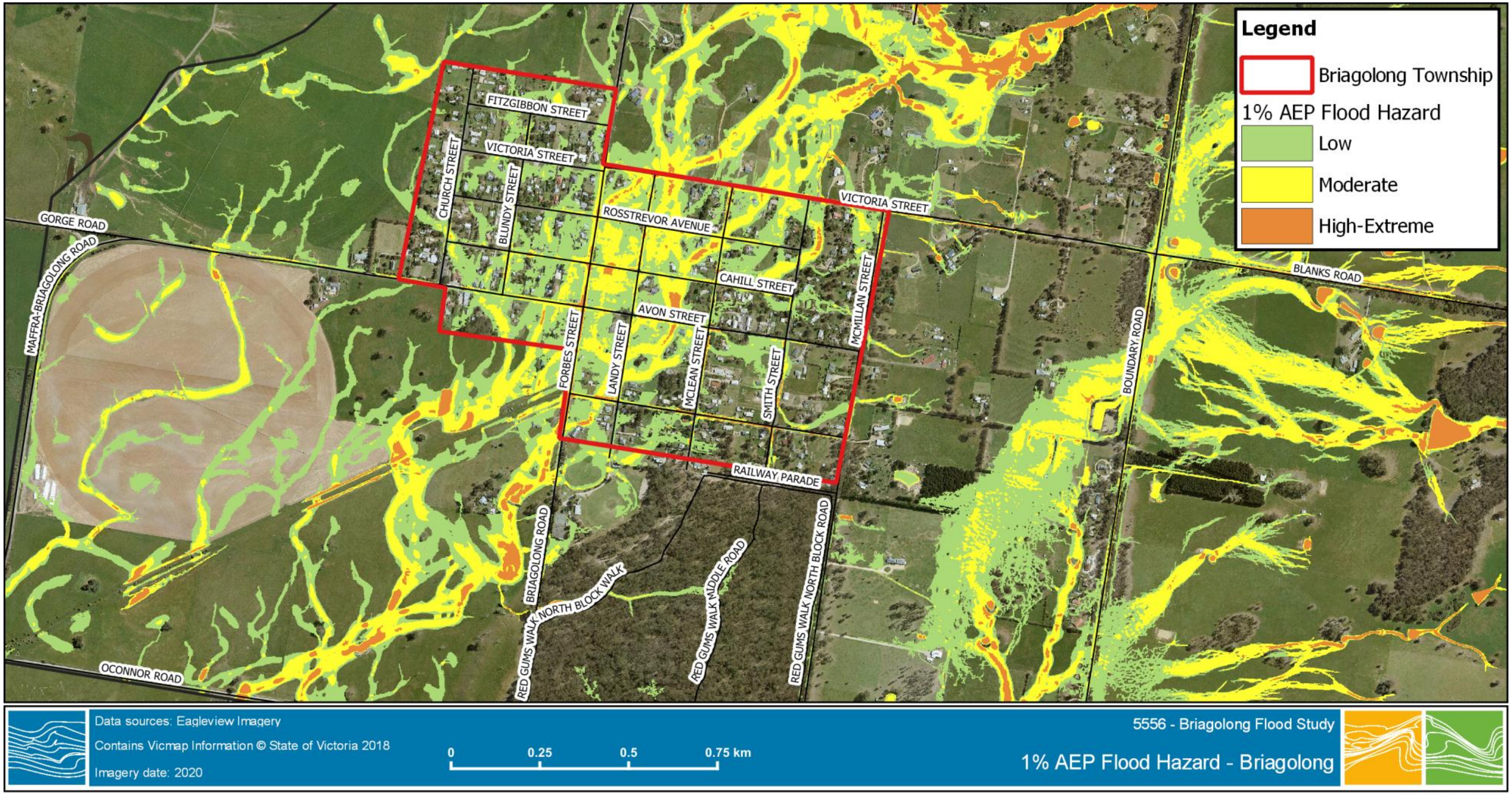

FIGURE 5-2 1% AEP FLOOD HAZARD (TOWNSHIP) – VICSES SYMBOLOGY

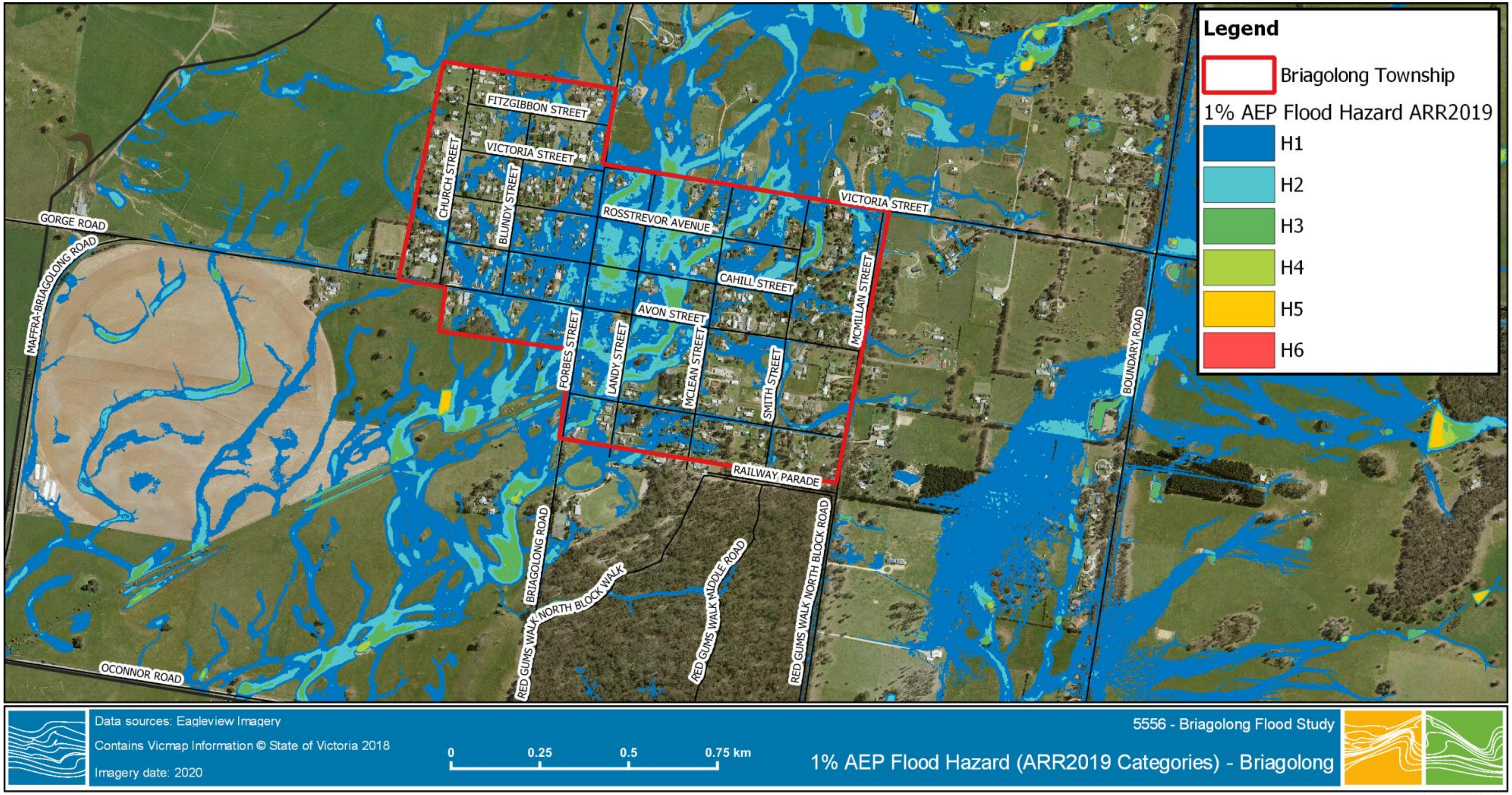

FIGURE 5-3 1% AEP FLOOD HAZARD (TOWNSHIP) – ARR2019 SYMBOLOGY

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5.2 Flood Impacts

As required in the current MFEP template (*Appendix A Intelligence Flood Threats*) a list of flood threats (history of flooding) has been extracted from the data review and flood modelling. Flood threats have been presented in two forms, a flash flood look up card in Figure 5-4 and a table of historical and design rainfall totals in Table 5-5.

Because the catchment is ungauged all flood impacts are linked to rainfall depths and durations. The closest real time rainfall records are available from the gauging station **225218 FREESTONE CREEK @ BRIAGALONG.** The location of the 225218 gauge and other adjacent gauges are shown in Figure 5-5.

Table 5-5 and Figure 5-4 should be used as a guide only. Monitoring rainfall records against elapsed event time (anecdotal and official) as well as the rainfall radar if available will help understand catchment rainfall conditions during a storm event. With an understanding of catchment wide rainfall totals a rapid determination on flood magnitude can be made. Additionally, consideration of antecedent conditions (the wetness of the catchment before the flood) is an important factor in estimating flood magnitude. Floods following dry periods verses floods following fire or above average rainfall will all generate different flood responses.

It is noted that the time between the peak of the rainfall and the onset and peak of inundation in town is short, a mere matter of hours. It is important that those responsible for responding to a flood emergency are familiar with the potential impacts and have a clear plan for how they will respond prior to an event occurring.

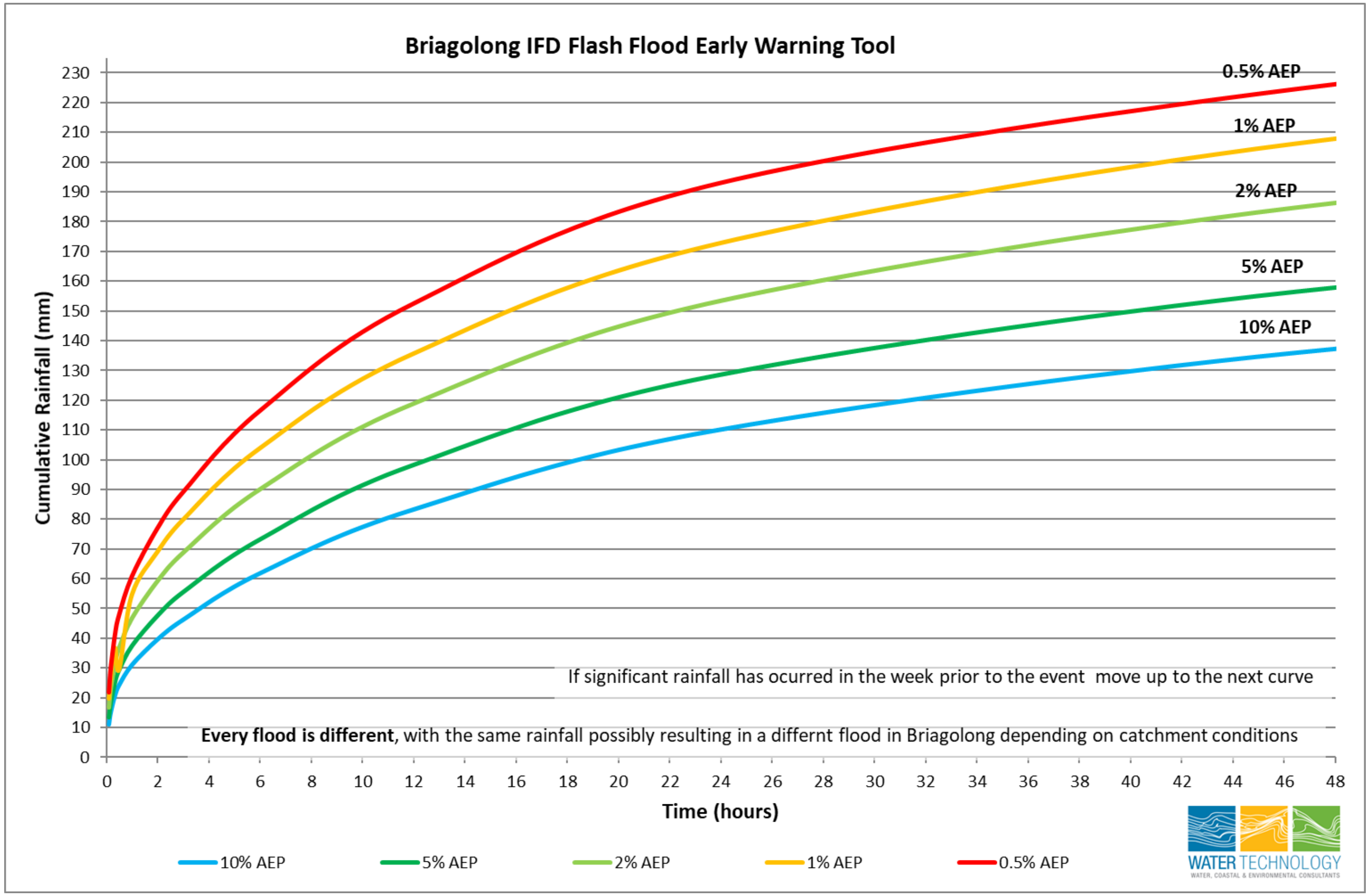

FIGURE 5-4 FLASH FLOOD LOOK UP CARD FOR BRIAGOLONG

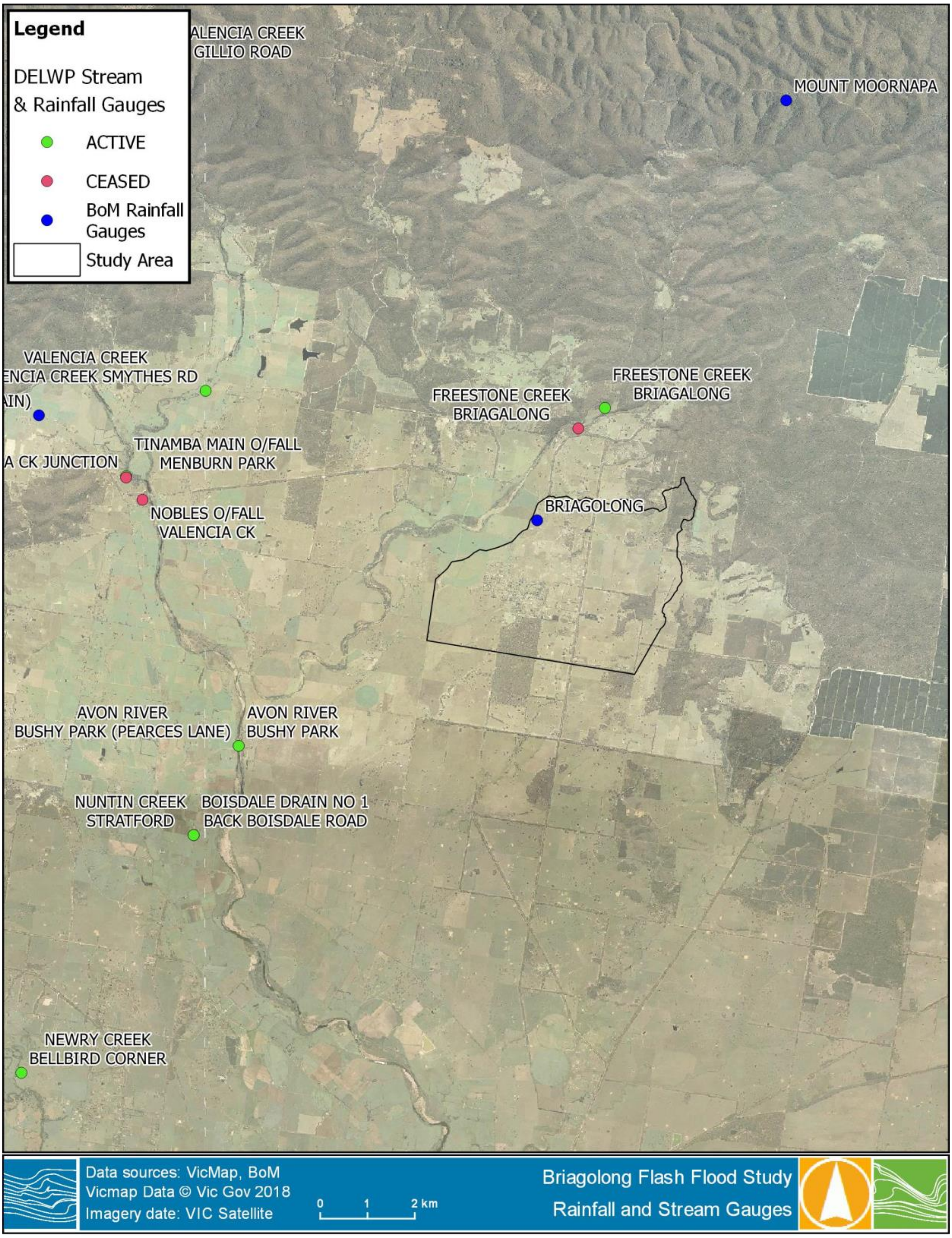

FIGURE 5-5 RAINFALL STATIONS NEAR BRIAGOLONG

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TABLE 5-5 RANKED FLOOD EVENTS BY RAINFALL TOTAL IN BRIAGOLONG

Event	Rainfall	Duration (hrs)	Comment
PMP	658 - 547	6	
PMP	494 - 411	3	
0.5%AEP	117	6	
0.5%AEP	88.7	3	
1%AEP	104	6	
1%AEP	79.4	3	
1%AEP	68.5	2	
2%AEP	90.4	6	
2%AEP	68.4	3	
5%AEP	73.8	6	
5%AEP	55.4	3	
June 2007	150	46	5% and 10% AEP*.
February 2005	107.4	18	10% and 5% AEP*. Significant 11 hour burst of 98.4 mm (5% and 2% AEP).
July 2016	144.6	35	10% and 5% AEP
June 2012	146	48	5% and 10% AEP*. Burst estimates 2% and 5% AEP
10%AEP	62.1	6	
10%AEP	43	3	
April 2004	129.8	36	~10% AEP*
June 2013	143	62	20% and 10% AEP*.
December 2014	134.2	41	20% and 10% AEP*.
November 2008	101.6	26	10% and 20% AEP*.
June 1998	67.9		130 mm in 43 hrs, between 20% and 10% AEP.
November 2002	93.6	25	~20% AEP*. Burst of 83.2 mm in 6hrs (5% and 2% AEP*) Including 47.8 mm in 1 hour (1% and 2% AEP*)

* ARR2019 approach used to estimate event magnitude.

Table 5-6 below provides a description of the flood impact observed for a range of possible future floods.

TABLE 5-6 OVERVIEW OF POTENTIAL FLOOD IMPACTS FROM FUTURE (DESIGN) FLOOD EVENTS

AEP Event	Number Buildings Impacted	Number of Properties Impacted	Number of Roads Impacted	Description of risk	Road Closure Description
10% AEP **62 mm in 6hr or** **43 mm in 3hr**	164	370	28	Slight Inundation of Anzac Park, encroaching into the park at the southern and northern section. Depths within the park vary between 0.05 - 0.25 m. **Roads affected by the 10% AEP event are listed below:** Red Gums Walk Middle Road, Landy Street, Freestone Creek Road, O'connor Road, Station Street, Blundy Street, Mclean Street, Rosstrevor Avenue, Landy Lane, Smith Street, Red Gums Walk North Block Road, Red Gumd Walk North Block Walk, Cahill Street, Redwood Court, Mcmillan Street, Briagolong Road, Howlett Road, Cemetery Road, Blanks Road, Victoria Street, Briagolong-Stockdale Road, Valencia Creek-Briagolong Road, Maffra-Briagolong Road, Avon Streetm Forbes Street, Boundary Road and Church Street	The intersection on Rosstrevor Avenue and Mclean Street is unsafe for small vehicles.
5% AEP **74 mm in 6hr or** **55 mm in 3hr**	229	430	29	Slightly larger inundation extent at Anzac Park compared to the 10% AEP event. The depths are only marginally higher. Large portion of the Briagolong fire station inundated, with depths varying from 0.05- 0.2 m. **Additional roads affected:** Fitzgibbon Street	Small sections on Victoria Street, Rosstrevor Avenue, and Landy Street, which intersect with the main overland flow path are unsafe for small vehicles.

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AEP Event	Number Buildings Impacted	Number of Properties Impacted	Number of Roads Impacted	Description of risk	Road Closure Description
2% AEP **90 mm in 6hr or** **68 mm in 3hr**	300	471	32	Large extent of Anzac Park is inundated with only the higher middle section being free of flood waters. Small sections within Anzac Park exceed water depths of 0.3 m. Similar inundation extent at the fire station compared to the 5% AEP event. Flood waters reach the Briagolong telephone exchange with flood depths in the immediate vicinity being between 0.05-0.1 m. **Additional roads affected:** Mcintyres Road, Red Gums Walk North Block Walk, Red Gum Road	Small sections on Victoria Street, Rosstrevor Avenue, Cahill Street, Landy Street and Station Street, which intersect with the main overland flow path are unsafe for small vehicles.
1% AEP **104 mm in 6hr or** **79 mm in 3hr or** **69 mm in 2hr**	331	486	32	Similar inundation extent at Anzac Park compared to the 2% AEP event, however, sections where flood depths exceed 0.3 m have expanded. Briagolong fire station almost completely inundated with flood depths between 0.05-0.25 m. Flood waters reach the Briagolong telephone exchange with flood depths in the immediate vicinity being between 0.05-0.1 m.	Slight expansion of hazardous sections on Victoria Street, Rosstrevor Avenue, Cahill Street, Landy Street and Station Street, compared to the 2% AEP event.
0.5% AEP	382	505	33	Similar inundation extent at Anzac Park compared to the 1% AEP event, however, sections where flood depths exceed 0.3 m have expanded.	Small sections on Victoria Street, Rosstrevor Avenue, Cahill Street, Landy Street and Station Street, which intersect with the main overland flow path are unsafe for small

AEP Event	Number Buildings Impacted	Number of Properties Impacted	Number of Roads Impacted	Description of risk	Road Closure Description
117 mm in 6hr or **89 mm in 3hr**				Briagolong fire station is completely inundated with flood depths between 0.05-0.25 m. Briagolong Kindergarten is not completely inundated but access is cut off with the northern and southern section being flooded. Flood waters reach into the northern and southern section of Briagolong Kindergarten. Flood waters also reach the Briagolong telephone exchange with flood depths in the immediate vicinity being approximately 0.1 m. The Briagolong community house is also partially inundated with flood depths ranging from 0.05-0.32m. **Additional roads affected:** Gorge Road	vehicles. The intersection on Rosstrevor Avenue and Mclean Street is unsafe for vehicles, children, and the elderly.
PMF **550-660 mm in 6hr** **or** **410-490 mm in 3hr**	851	565	35	Complete inundation of all points of interest, except for Briagolong primary school which is only partially inundated. The south-eastern section of the primary school, which is largely comprised of the sporting ground, is flooded with depths up to 0.6m. Flood depths greater than 0.6m are occurring at Anzac Park, Briagolong- Fire Station, Kindergarten, Police Station and the Telephone Exchange. Much smaller flood depths (<0.3m) are occurring at the Catholic Church on Maffra-Briagolong Road. **Additional roads affected:** Railway Parade, White Road	Many additional roads inundated. All roads within the Briagolong Township with the exception to McMillan Street and the majority of Smith Street, are inundated and unsafe for vehicles, children and the elderly. A large section of Boundary road, near the intersection with Victoria Street is unsafe as well.

6 LAND USE PLANNING

The Victoria Planning Provisions (VPPs) contain a number of controls that can be employed to provide guidance for the use and development of land that is affected by inundation from floodwaters. These controls include the Floodway Overlay (FO), the Land Subject to Inundation Overlay (LSIO), the Special Building Overlay (SBO) and the Urban Floodway Zone (UFZ).

Section 6(e) of the Planning and Environment Act 1987 enables planning schemes to 'regulate or prohibit any use or development in hazardous areas, or likely to be hazardous'. As a result, planning schemes contain State planning policy for floodplain management requiring, among other things, that flood risk be considered in the preparation of planning schemes and in land use decisions.

Guidance for applying flood controls to Planning Schemes is available from the Department of Planning and Community Development's (DPCD) Practice Note on Applying Flood Controls in Planning Schemes.

Planning Schemes can be viewed online at http://services.land.vic.gov.au/maps/pmo.jsp. It is recommended that the planning scheme for Briagolong be amended to reflect the flood risk identified by this project. It is understood that Wellington Shire Council are interested in considering the implementation of LSIO and FO in the Planning Scheme at Briagolong.

In the recent WGCMA *Guidelines for development in flood prone areas* (2020) they provide a description of both FO and LSIO layers:

> ***Floodway Overlay– Clause 44.03 of the Victoria Planning Provisions***
>
> *The Floodway Overlay (FO) applies to riverine flooding in both rural and urban areas where there is a flood risk and there is less need to control land use. Most types of development are not encouraged but buildings and works associated with low intensity uses such as agriculture may be permitted. Key considerations are whether the development will obstruct flood flows or increase flood risk.*
>
> ***Land Subject to Inundation Overlay – Clause 44.04 of the Victoria Planning Provisions***
>
> *The Land Subject to Inundation Overlay (LSIO) applies to riverine flooding in both rural and urban areas, as well as coastal inundation. Areas covered by the LSIO may have similar or lower flood risk than those covered by UFZ or FO, depending on whether mapping has been developed to delineate the floodway. The planning permit process ensures that the use and development of land in this overlay is compatible with the level of flood risk at the site.*

The LSIO is typically based on the 1% AEP extent. Should a FO delineation be pursued, the method used to delineate a FO would broadly be based on the new Australian Rainfall and Runoff Project 10 'Appropriate Safety Criteria for People'. Criterion for delineating the Floodway Overlay considers both vehicle and people safety, and are as follows, based on the 1% AEP flood and in areas where either of the following criteria thresholds are exceeded: **Depth > 0.3 m; Velocity > 1.5 m/s; Depth x velocity > 0.3 m^2/s.**

Small, disconnected puddles such as farm dams and stormwater ponding was removed from the flood mapping. It is commonplace for small islands in flood overlays to be infilled, so that development applications on shrinking islands that may have no access during a flood event are triggered during the application process and they are referred to the Catchment Management Authority for advice.

Figure 6-1 shows the preliminary LSIO and FO using the above categories. It is suggested that prior to moving to a planning scheme amendment, that the LSIO and FO be refined so that small islands in the overlays are infilled and the FO forms a continuous flow path. Small isolated bits of FO within farm dams etc should also be removed and left as LSIO.

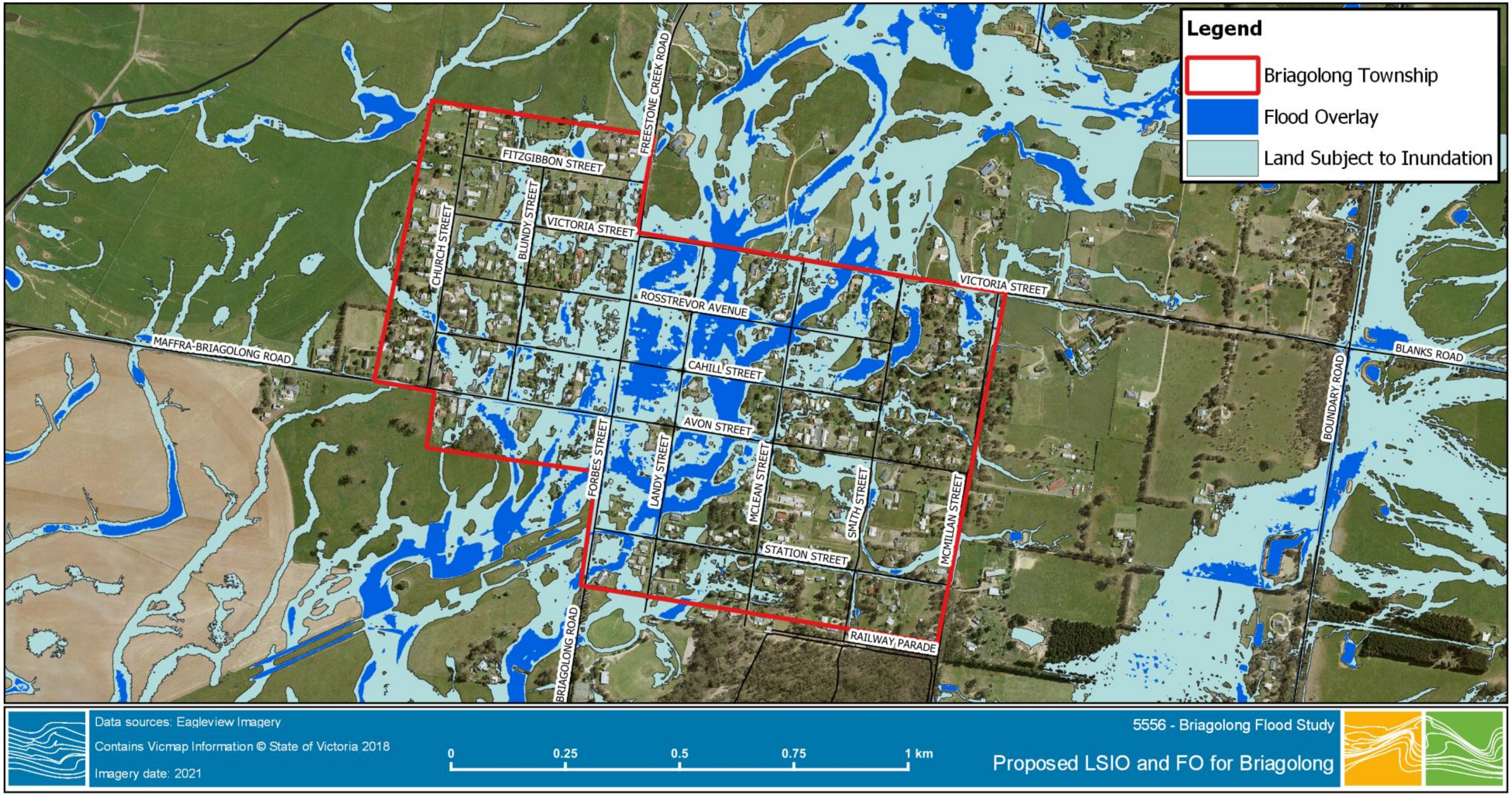

FIGURE 6-1 PRELIMINARY LSIO AND FO (REQUIRES FURTHER REFINING) FOR BRIAGOLONG (ZOOM TO TOWN)

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7 FLOOD MITIGATION

This section provides an overview of the mitigation options considered to reduce the flood risk and flood damages in Briagolong. The aim of any structural mitigation works is to reduce the flood risk and protect, where feasible, vulnerable buildings and infrastructure. Protection from a 1% AEP event is typical the aim, but often lesser design standards ae adopted.

Possible mitigation options were discussed with the project Steering Committee and community members during the study. The community has previously considered a flow diversion scheme, to capture flow from the north-east prior to it entering the town and diverting it to the west of town. This scheme was not universally supported and did not proceed. This idea of diverting flows is one of only two options that is likely to produce reduced flood inundation on a scale large enough to benefit the wider community. The other option that could have some benefit would be large flood retarding basins / dams in the catchment upstream of Victoria Street.

Both of these options are likely to be infeasible due to cost constraints and the need for compensation of landholders on who's land the works would be sited on, and in the case of the diversion, compensation to downstream landholders who's flood risk would likely increase due to the diversion of flood water onto their land.

In the case of the diversion channel, it is estimated that in the 1% AEP event, a peak flow of approximately 18 m^3/s enters the town from the north-east. For this flow rate a channel with a top width of 10 m, bottom width of 2 m, flow depth of 1 m at a slope of 1 in 200 would convey roughly the 1% AEP peak flow rate. This is a very large channel and would be quite expensive to construct.

For the retarding basin / dam option, any structure would need to be significantly large to have a notable impact in the flood risk reduction. This would be an ANCOLD listed dam, and would require expensive engineering design, with a spillway large enough to cope with an extreme flood and would certainly require routine annual maintenance. It is unlikely that this option would be feasible from a cost perspective.

If Council wishes to further consider either of these ideas, it is suggested that floor level survey be captured of all buildings impacted in the 0.5% AEP event, so that the true costs of the flood impacts can be estimated using a thorough flood damages assessment. Before doing any further modelling or benefit-cost investigations into the two potential mitigation options, Council could consider the likelihood of obtaining landholder approvals and cost of compensation for the works and adverse impacts due to diversion of flood waters. This factor alone is likely to render the options not feasible.

Several minor works were recommended by Council engineers and community members during the study. These works on roadside drains and culverts are likely to improve low risk nuisance flooding but are unlikely to have any significant impact on broader flooding within the township for larger events.

It is suggested that the best course of action for reducing flood risk at Briagolong is to implement appropriate flood overlays into the Planning Scheme to manage and control future development in flood prone areas, and to raise community awareness regarding flooding. Raising community awareness can help to prepare the community for future events and build a more flood resilient community that can respond to a flood emergency and recover quickly after the event.

Further consideration could also be given to developing a flash flood warning system. This system could be based on rainfall forecasts and telemetered rainfall gauges. The system could provide a rapid warning product to alert the community to a potential flash flood event, with the aim being to allow them time to prepare their property for imminent flooding, and if required to evacuate prior to the flood arriving. The flood warning time is very short, so detecting a potential event and getting the message to community would need to happen rapidly to achieve the intended benefits.

8 SUMMARY AND NEXT STEPS

Briagolong is subject to flash flooding from overland flows, has experienced past flooding events, and the modelling in this study has confirmed that large areas of the township are likely to continue to experience flooding in the future.

The modelling has shown that during large storm events a significant portion of the town is flood prone, although much of it experiences quite shallow inundation. The flood models were calibrated to two historic flood events, making use of flood photos and anecdotal accounts from community members. The level of calibration was determined to be good despite the lack of gauged data or historic surveyed flood marks. The model was deemed to be fit for purpose and was used to model a range of design flood scenarios.

Design flood modelling assessed the sensitivity of a range of model parameters, including rainfall-runoff losses, storm duration and temporal patterns. Significant effort was placed in the design approach, adapting the latest Australian Rainfall and Runoff (2019) procedures for rainfall runoff modelling to a direct rainfall on grid modelling approach. The design results provide the best available flood risk information for Briagolong.

The flood modelling results were carefully assessed to develop flood intelligence products for incorporation into the Wellington Municipal Flood Emergency Plan. The model results were also used to develop proposed LSIO and FO layers for Council to consider for updating the Planning Scheme.

Flood mitigation options were considered at a high level. It is possible that a flood diversions scheme to the north and west of the township or large retarding basins in the upper catchment may be able to reduce flood risk within the township. It is suggested that cost of such options may be an issue, and Council may find it difficult to attract funding for the design and construction of the options. Further thinking regarding the likelihood of successfully negotiating with landholders and the cost of compensation to have works located on private land could be undertaken as the first step to assessing these options. The cost of compensation for adverse impacts on downstream landholders who will receive increased flooding due to the diverted water should also be considered.

Given structural flood mitigation may be difficult for Briagolong, implementing a planning scheme amendment, raising community flood awareness, and investigating the feasibility of a flash flood warning messaging system could be practical options to increasing the flood resilience of the Briagolong community.

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