



Model Development and Calibration Report

Great Western Flood Investigation

Northern Grampians Shire Council

9 October 2026



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1 INTRODUCTION

1.1 Overview

Water Technology was commissioned by North Grampians Shire Council (NGSC) to undertake the Great Western Flood Investigation. The investigation area covers the Great Western township, situated on the Western Highway in the upper reaches of Concongella Creek, a tributary of the Wimmera River. The surrounding local catchments include Concongella Creek, Allanvale Creek and Hyde Park Creek. The study area is shown in Figure 1-1.

The study area includes the upstream tributaries that flow through the Great Western township, as well as hydraulic structures that may impact the overall flood extent. These features are detailed in Section 2 and 3 respectively.

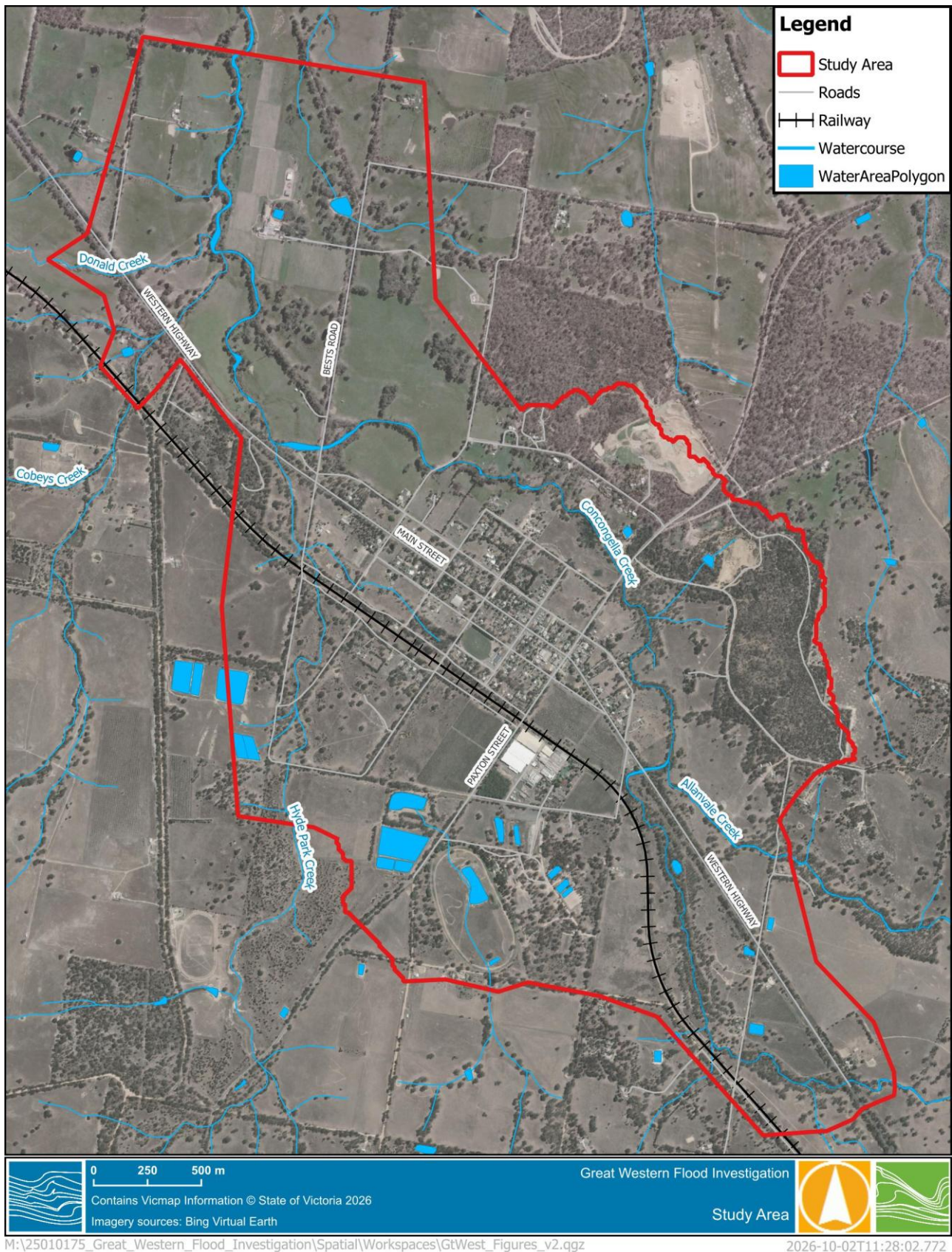


Figure 1-1 Study area



The study will produce reliable flood intelligence for use in emergency management situations, assess the current flood impact/exposure in terms of annual average damages caused by flooding in Great Western, investigate structural and non-structural mitigation options, and investigate and make recommendations for establishing a flood warning system for the town.

This report is one of a series documenting the outcomes of the Great Western Flood Investigation. Each reporting stage is shown below:

- R01 – Data Review Report
 - *This report documents a summary of the available streamflow, rainfall, topographic and structure data as well as the relevant previous projects and other information relevant to the study. The report also details verification of the available topographic datasets and the hydrologic and hydraulic modelling approach.*
- **R02 – Model Development and Calibration Report – This Report**
- R03 – Design Model Report
- R04 – Flood Intelligence Report
- R05 – Floodplain Management Plan
- R06 – Summary Report

This report details the hydrology and hydraulic modelling undertaken as part of the study. The report describes the hydrology and hydraulic model build, calibration process, and key modelling outputs of the existing conditions.



1.2 Objectives and Outputs

The Great Western Flood Investigation outputs are required to meet several floodplain management objectives as highlighted in the project brief prepared by NGSC. The objectives of the investigation are described below:

- Review the available data and identify where additional data is to be obtained to complete the study to the required degree of accuracy.
- Develop best-practice hydrological and hydraulic models for the study area, including Council's stormwater network.
- Determine flood information for a range of flood modelling scenarios.
- Develop flood intelligence and response documentation for inclusion in NGSC Municipal Flood Emergency Plan (MFEP).
- Analyse options for structural and non-structural flood mitigation to alleviate flooding.
- Analyse the deficiencies in the existing stormwater system.
- Deliver draft mapping updates (Land Subject to Inundation Overlay (LSIO) & Flood Overlay (FO)) and explanatory reports to be used to amend the planning scheme.
- Provide a complete and concise document outlining the study methodology and deliverables.
- Providing flood data in an appropriate format to the Victorian Government and the Wimmera CMA and produce mapping suitable for DEECA's FloodZoom, all to Australian Height Datum (AHD).
- Make recommendations, and where possible, develop a flood-warning system.



1.3 Study Area

Great Western is in the Wimmera region of western Victoria, located 16.1 km northwest of Ararat and 12.7 km southeast of Stawell. It is on the banks of Concongella Creek and Hyde Park Creek, with their confluence downstream of the township. The first European settlers of Great Western consisted of sheep graziers in mid 1800s, before the discovery of gold and then the later development of viticulture, which remains as Great Western's primary economic driver in the region today.

The upstream Concongella Creek catchment is south of Great Western and Hyde Park flows to the west, into Concongella Creek 1.7 km downstream, northwest of the township. Allanvale Creek located east of town, also joins into Concongella Creek upstream of Great Western, to the south east.

The catchment within and upstream of the study area is predominately agricultural land, including extensive viticulture and farming activities. There are also bushland reserves and a quarry which are included in the study area.

The study area is focused on the township of Great Western and includes the following key structures:

- Main waterway road crossings, formal or informal, at the following roads:
 - Western Highway
 - Paxton Road
 - Bests Road
- Road crossings at other locations than main waterways
- Underground pits and pipe drainage network within the township
- Railway located track southwest of the township and associated hydraulic structures
- Great Western Racecourse Dam.



2 HYDROLOGY MODEL UPDATE

2.1 Flood Frequency Analysis

A flood frequency analysis (FFA) was completed for the Concongella Creek at Stawell streamflow gauge (Gauge ID: 415237). This analysis considered all available complete calendar years of data, from 1976 to 2024. Maximum daily flows lower than 1.0 m³/s were censored (using the Multiple Grubbs Beck test). The analysis was completed in the RMC Best Fit software package as recommended by ARR2019.

The FFA distribution used for this study was the Log Pearson III distribution with Bayesian Inference providing the best fit to the observed data. The annual series of max flows utilised in the analysis, along with expected flood quantities from the results, are shown in Figure 2-1. The annual series is shown numerically in Table 2-1, with the censored values below 1 m³/s are highlighted.

A graph of the Log Pearson III distribution and the observed values is shown in Figure 2-2. The adopted FFA quantiles are shown in Table 2-2.

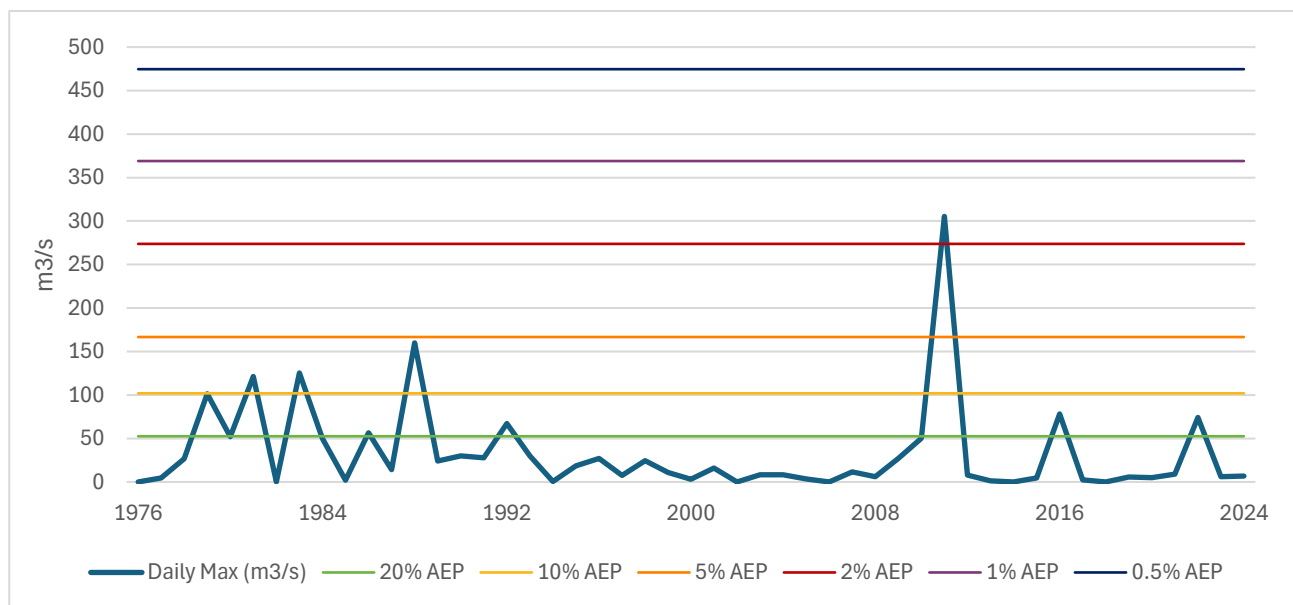


Figure 2-1 Daily flow with expected flood quantiles

Table 2-1 Adopted Annual Flow Series (Ordered by Flow Magnitude)

Year	Flow (m ³ /s)	Year	Flow (m ³ /s)	Year	Flow (m ³ /s)	Year	Flow (m ³ /s)
2011	305.4	1993	29.8	2004	8.4	2017	2.5
1988	159.9	1991	27.8	2003	8.1	1985	2.0
1983	125.2	1996	27.1	2012	7.7	2013	1.1
1981	121.4	2009	27.0	1997	7.3	1994	0.4
1979	101.3	1978	26.6	2024	6.8	1982	0
2016	78.1	1998	24.6	2008	6.1	1976	0
2022	74.2	1989	23.9	2023	6.0	2002	0
1992	67.2	1995	18.7	2019	5.7	2006	0
1986	56.6	2001	15.8	2020	5.0	2014	0



Year	Flow (m³/s)	Year	Flow (m³/s)	Year	Flow (m³/s)	Year	Flow (m³/s)
1980	52.0	1987	14.2	2015	4.6	2018	0
2010	50.1	2007	11.4	1977	4.5		
1984	49.9	1999	10.9	2005	3.5		
1990	30.0	2021	9.0	2000	3.2		

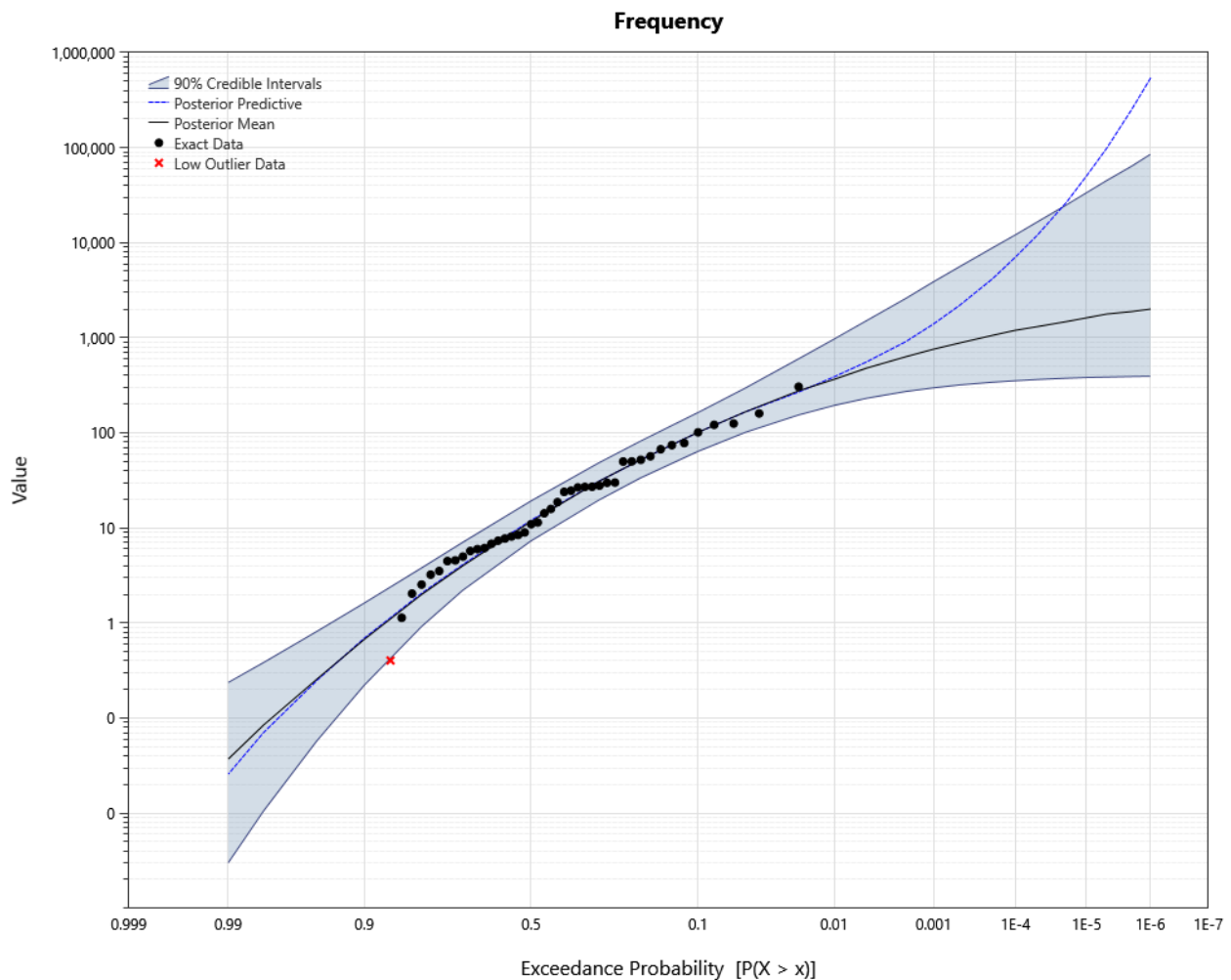


Figure 2-2 FFA: Log Pearson III with Bayesian Inference

Table 2-2 Adopted FFA Quantiles for Concongella Creek at Stawell (Guge ID: 415237)

AEP (%)	Peak Design Flow (m³/s)		
	Log Pearson III	LP3 5% Limit	LP3 95% Limit
20%	52.5	33.7	82.0
10%	101.9	63.9	163.6
5%	166.7	101.2	295.8
2%	273.7	154.2	600.1



AEP (%)	Peak Design Flow (m ³ /s)		
	Log Pearson III	LP3 5% Limit	LP3 95% Limit
1%	369.0	194.2	968.8
0.5%	474.6	230.9	1,514.7
0.2%	627.2	272.6	2,599.7
0.1%	750.2	297.8	3,883.5
0.05%	877.8	319.5	5,589.7

Table 2-3 Approximate AEP of the 4 Largest Recorded Flows

Year	Flow (m ³ /s)	Approximate AEP
2011	305.4	Between 2% to 5%
1988	159.9	Between 5% to 10%
2016	78.1	Between 10% to 20%
2022	74.2	Between 10% to 20%

2.2 Daily Rainfall

Table 2-4 summarises the daily rainfall information available within or near the upstream Concongella Creek catchment, using a 30 km radius from Great Western. The closest active rainfall gauge is the Great Western (Seppelt) gauge located approximately 3.5 km southwest of Great Western.

Table 2-4 Daily Rainfall Station Information

Station Name	Distance from Great Western	Station No.	Start	End
Great Western (Seppelt)	3.5 km SE	079019	1891	Current
Stawell Aerodrome	15.8 km NW	079105	1996	
Ararat Prison	16.3 km SE	089085	1996	
Moyston (Barton Estate)	16.8 km SW	079050	1906	
Grampians (Mount William)	21.7 km SW	079103	2005	
Halls Gap	27.4 km W	079074	1958	
Buangor (Biranga)	30.8 km SE	089045	1954	
Jallukar	10.6 km	079024	1901	1947
Stawell	11.2 km	079042	1865	1969
Moyston	12.2 km	079034	1886	2012
Stawell	14.4 km	079080	1969	1998
Ararat Post Office	14.7	089000	1863	1969
Bellellen	16.0 km	079004	1904	1984



2.3 Pluviograph Rainfall

Two of the available gauges also record sub daily rainfall. The Stawell Aerodrome (Gauge ID: 079015) typically records every 30 minutes and Ararat Prison (Gauge ID: 089085) is every 15 minutes. These gauges are highlighted in Figure 2-3.

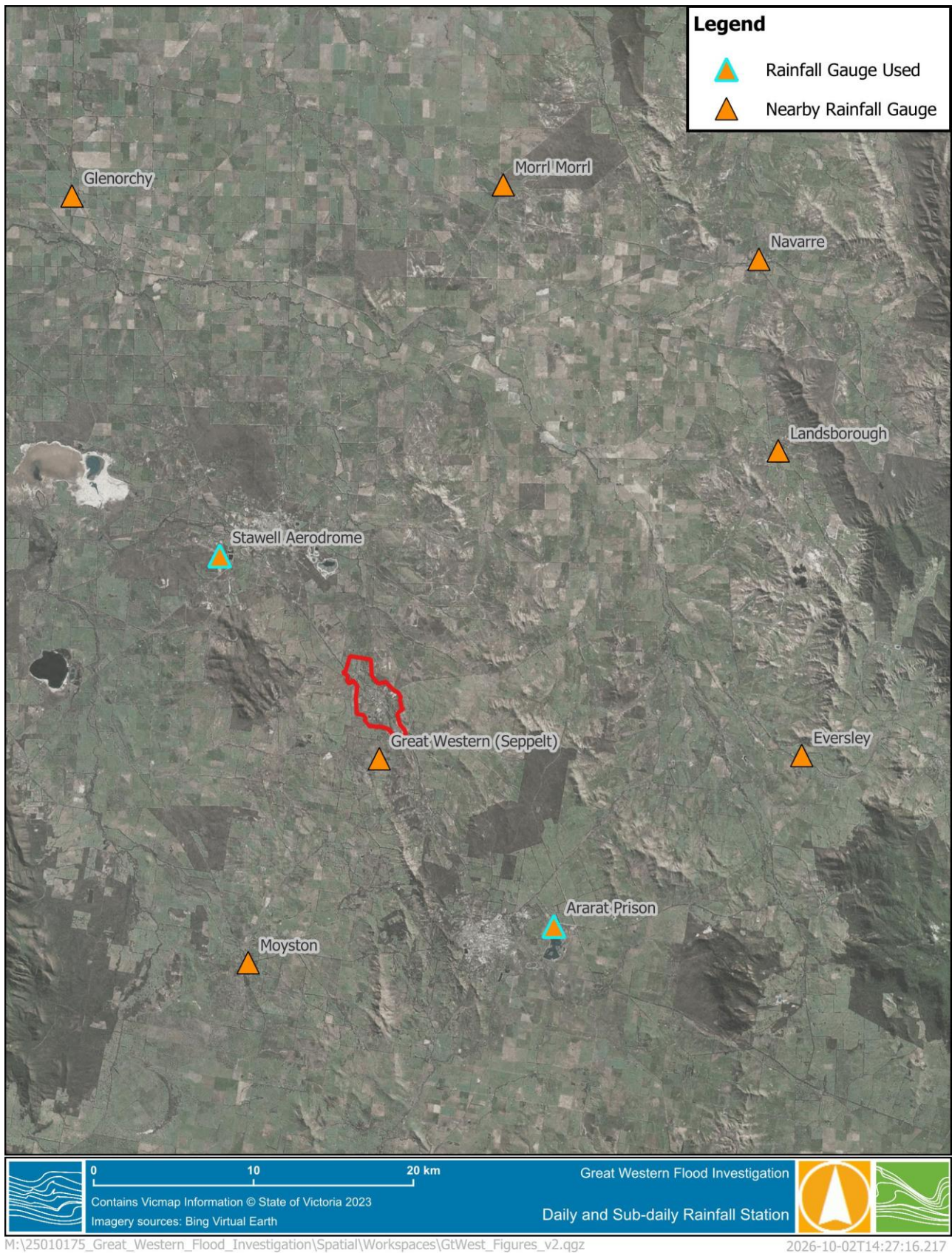


Figure 2-3 Daily Rainfall Station near the Concongella Creek Catchment



2.4 RORB model update

2.4.1 Overview

The hydrological assessment used a runoff routing approach, modelling using RORB software. The RORB model developed during the Western Highway Duplication Project¹ was reviewed to produce inflows in Congongella Creek and Allanvale Creek, upstream of Great Western. No structural changes were made to the RORB model.

The RORB model encompassed 87 sub-catchments with a total catchment area of approximately 238.0 km². Great Western is in the middle of the catchment, as shown in Figure 2-3. The reaches were all defined as 'natural', and impervious fractions were left unchanged.

2.4.2 Model Extent

The RORB flows were extracted at several inflow locations for the hydraulic model. The main inflow location at the upstream of Great Western was extracted from Congongella Creek and Allanvale Creek. Several other tributaries were also extracted for completeness. This included Hyde Park Creek that flows through the west end of the township from the southern boundary; and Cobey's Creek, Robinsons Creek and Donald Creek which form an inflow boundary near the end of the downstream model extent at the northwest.

These inflow locations are depicted in Figure 2-4.

¹ Western Highway Duplication Project (2017) – Water Technology

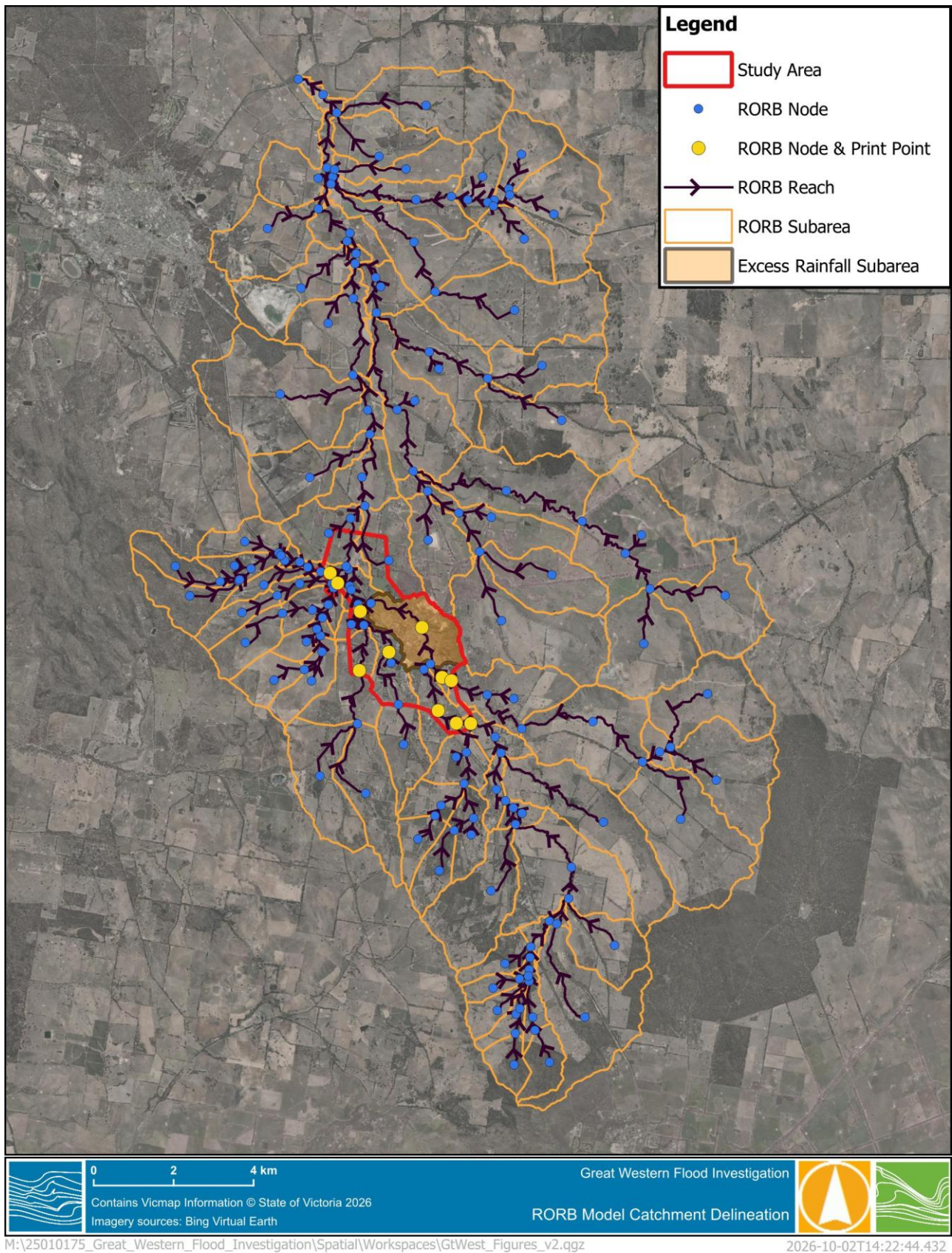


Figure 2-4 RORB Model Catchment Delineation

2.4.2.1 Model Inputs

The RORB model was run for the January 2011 and October 2022 flood events. Spatial patterns used during the Western Highway Duplication Project model calibration were based on the spatial distribution of rainfall observed at nine daily rainfall stations during January 2011. This pattern was maintained for calibration purposes. The same method was applied to generate rainfall spatial patterns for the October 2022 flood event.

The two-day rainfall depths for October 2022 (Oct 12 to 14) and January 2011 (Jan 12 to 14) are shown in Table 2-5, and the temporal pattern adopted from the Ararat Prison and Stawell Aerodrome gauges are shown in Figure 2-7 and Figure 2-6 respectively.

Table 2-5 Rainfall totals for January 2011 and October 2022 flood events

Station No.	Station Name	Rainfall Total (mm)	
		January 12 to 14 2011	October 12 to 14 2022
079019	Great Western (Seppelt)	86.4	60
079105	Stawell Aerodrome	86.8	47.4
089085	Ararat Prison	78.8	39.9
079050	Moyston (Barton Estate)	78.9	51.2
079014	Eversley	64.6	Closed in 2015
079015	Glenorchy	68.0	41.7
079074	Landsborough	72.4	109.4
079032	Morrl Morrl	67	62
079037	Navarre	76.2	75.6

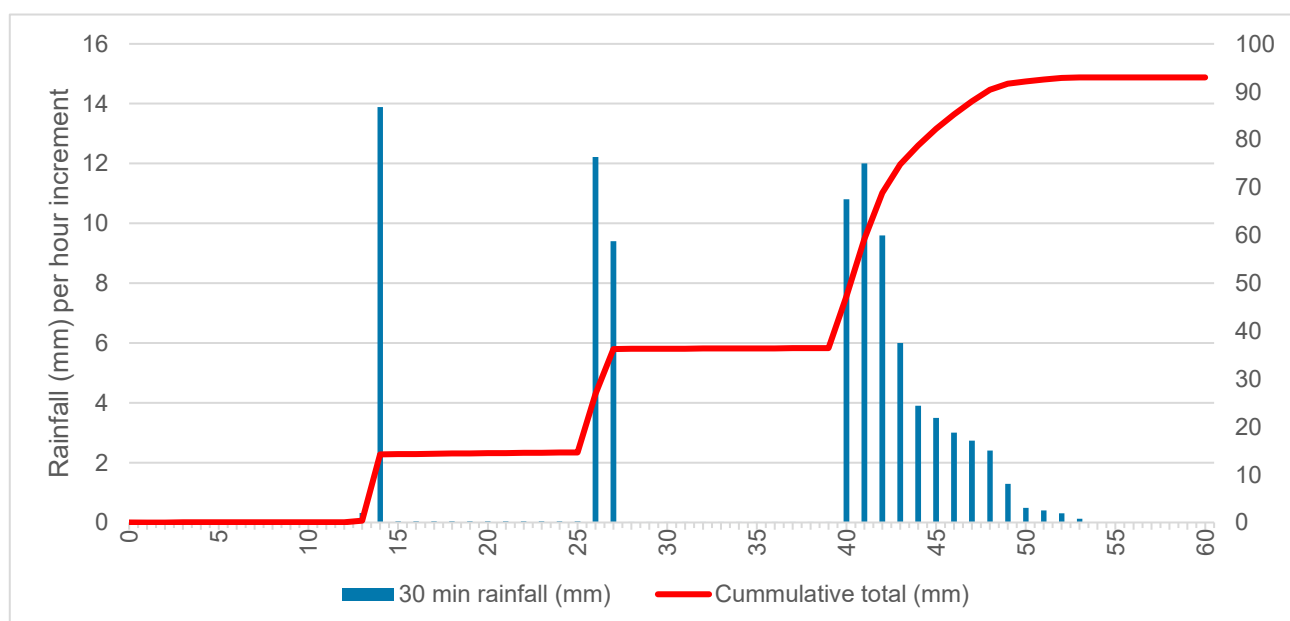


Figure 2-5 January 2011 Stawell Aerodrome (ID: 79105) temporal pattern

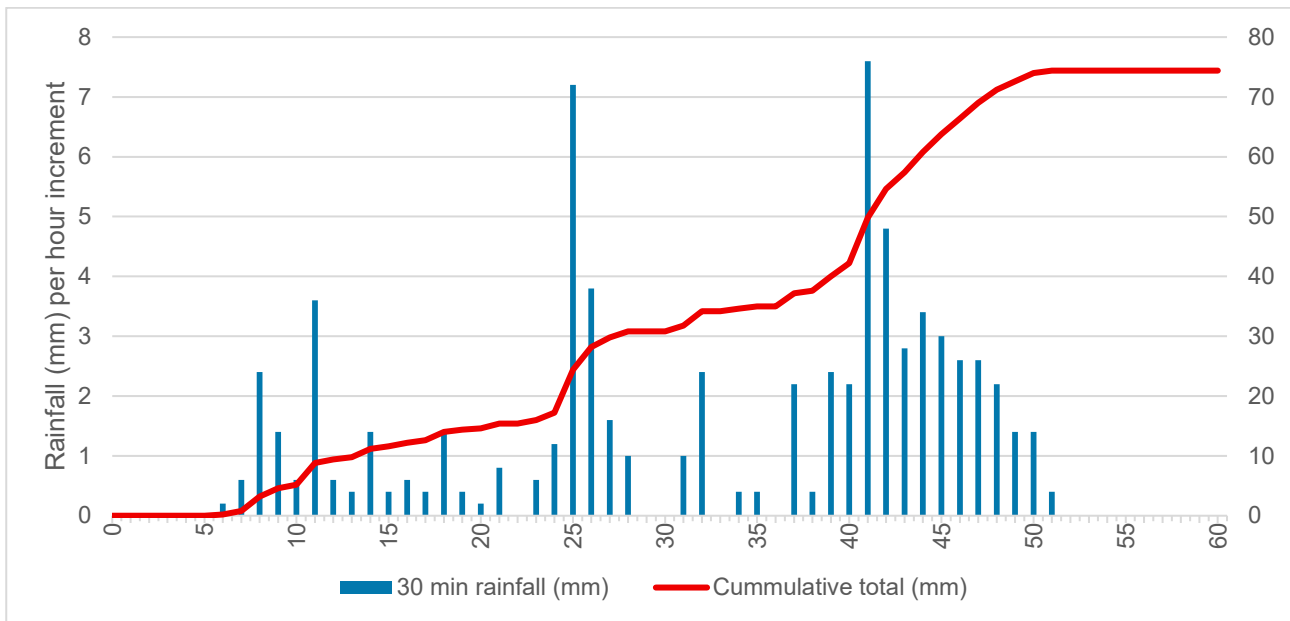


Figure 2-6 January 2011 Stawell Aerodrome (ID: 79105) temporal pattern

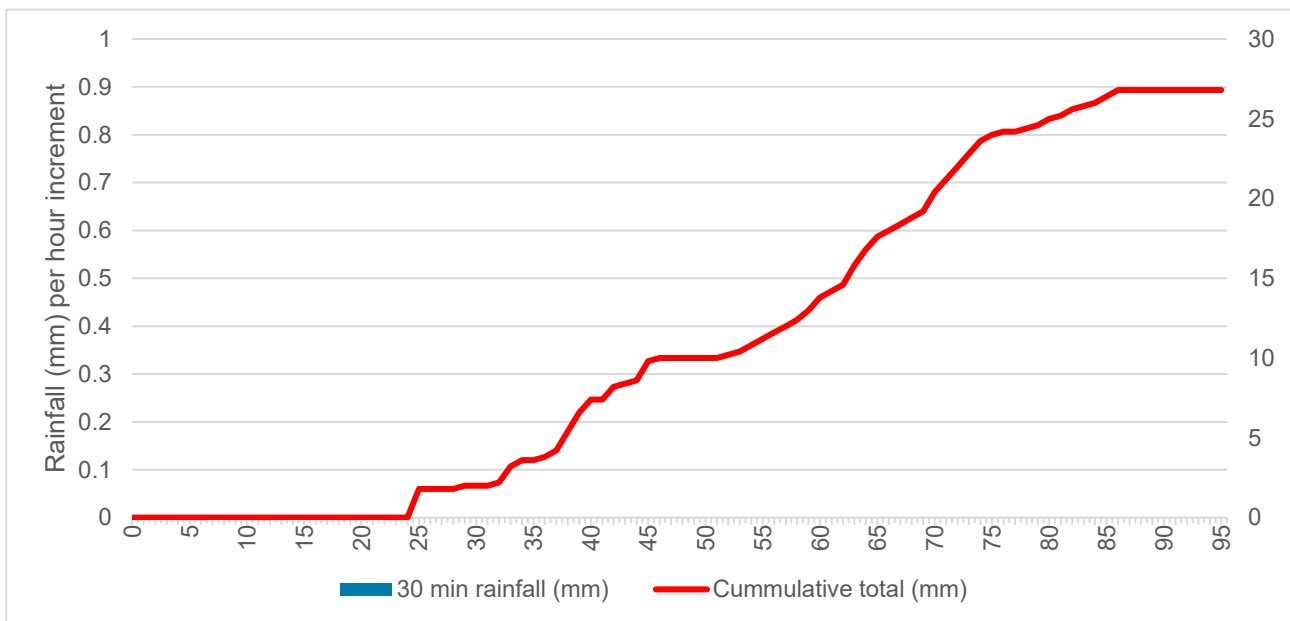


Figure 2-7 October 2022 Ararat Prison (ID: 89085) temporal pattern

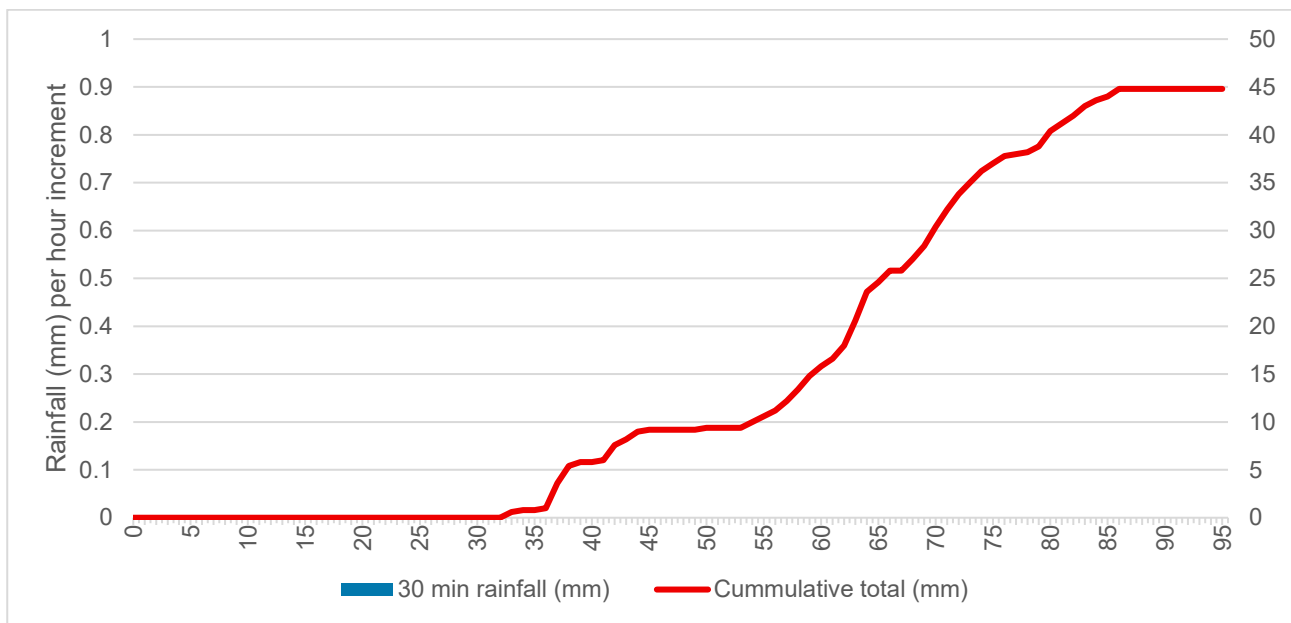


Figure 2-8 October 2022 Stawell Aerodrome (ID: 89085) temporal pattern

2.4.2.2 Fraction impervious

Fraction impervious values were allocated to each land parcel across the RORB model area based on land use zoning. The allocated parcel values were compared with aerial imagery and modified where necessary. Fraction impervious values were then allocated to each RORB subarea based on the parcel values using GIS software. The land use zones and applied fraction impervious values are shown in Table 2-6.

Table 2-6 Land Use Zones and Typical Fraction Impervious

Land Use Zone	Description	Adopted Fraction Impervious
Farming Zone	Agricultural Areas	0.1
Bushland/ conservation zones	Densely vegetated areas	0.1
Public Park and Recreation Zone	Open public space	0.1
Road Zone	Major road corridors and shoulders	0.35
Residential Zone	Normal range of densities	0.2
Commercial and Industrial	Varied commercial and industrial parcels	0.9

2.4.2.3 RORB Parameter Values

The Kc and m values adopted from the Western Highway Duplication Project were kept the same and are shown in Table 2-7.

Table 2-7 RORB Parameter Values

	Kc	m
Intersection Area 1	2.21	0.8
Intersection Area 2	3.09	
Intersection Area 3	4.17	



	Kc	m
Intersection Area 4	2.53	
Intersection Area 5	3.41	
Concongella Creek	18.64	



3 HYDRAULIC MODEL DEVELOPMENT

3.1 Overview

A hydraulic model of Great Western and local catchments was built using the TUFLOW HPC software modelling package. A gridded 3m model was developed with multiple in-channel and local catchment inflow boundaries applied to represent flows from the Concongella Creek and Allanvale Creek, as well as local catchments surrounding Great Western. Hydraulic structures such as culverts and the underground pit and pipe network within the township were incorporated into the model and modelled as 1D structures. The model topography was developed and modelled in 2D using the topographic datasets outlined in Section 3.3.

3.2 Model boundaries and extent

As discussed in Section 2.4, the existing RORB model constructed during the Western Highway Duplication Project¹ was used for the current study. Flows passing through the study area were extracted from the RORB model as inflows to the hydraulic model. These inflow locations were determined by the waterway flow paths and tributaries entering the study area. Figure 3-1 displays the hydraulic model extent and boundaries applied within the model. The hydraulic model extent was determined based on the topography, ensuring the local catchments directly upstream of Great Western were included in the modelling.

The upstream model inflow boundaries were located on Concongella Creek and Allanvale Creek, upstream of Great Western. Several other tributaries were also included, Hyde Park Creek through the west end of the township form the southern boundary; and Cobey's Creek, Robinsons Creek and Donald Creek from the boundary inflow near the end of the downstream mode extent at the northwest. These inflows were modelled as "2d_sa" with local inflows in within the model.

Excess rainfall hyetographs were extracted using ARR TUFLOW plugin tool over the Great Western township to model for surface runoffs in town. This is modelled as "2d_rf" with excess rainfall applied across the whole subarea, which would account for the initial and continuing losses applied on various surface type. A filtering cut-off depth and puddle size of 2 cm and 0.02 ha, respectively, were adopted for the post processing the excess rainfall.

A flowrate/height tailwater boundary ("HQ" type) with a slope of 0.0025 was applied downstream of the Great Western township to allow water to flow out of the model, with the rate of outflow dictated by the height.

The inflow and outflow boundaries are presented in Figure 3-1. Note that the inflow symbology in the figure was enlarged for visibility.

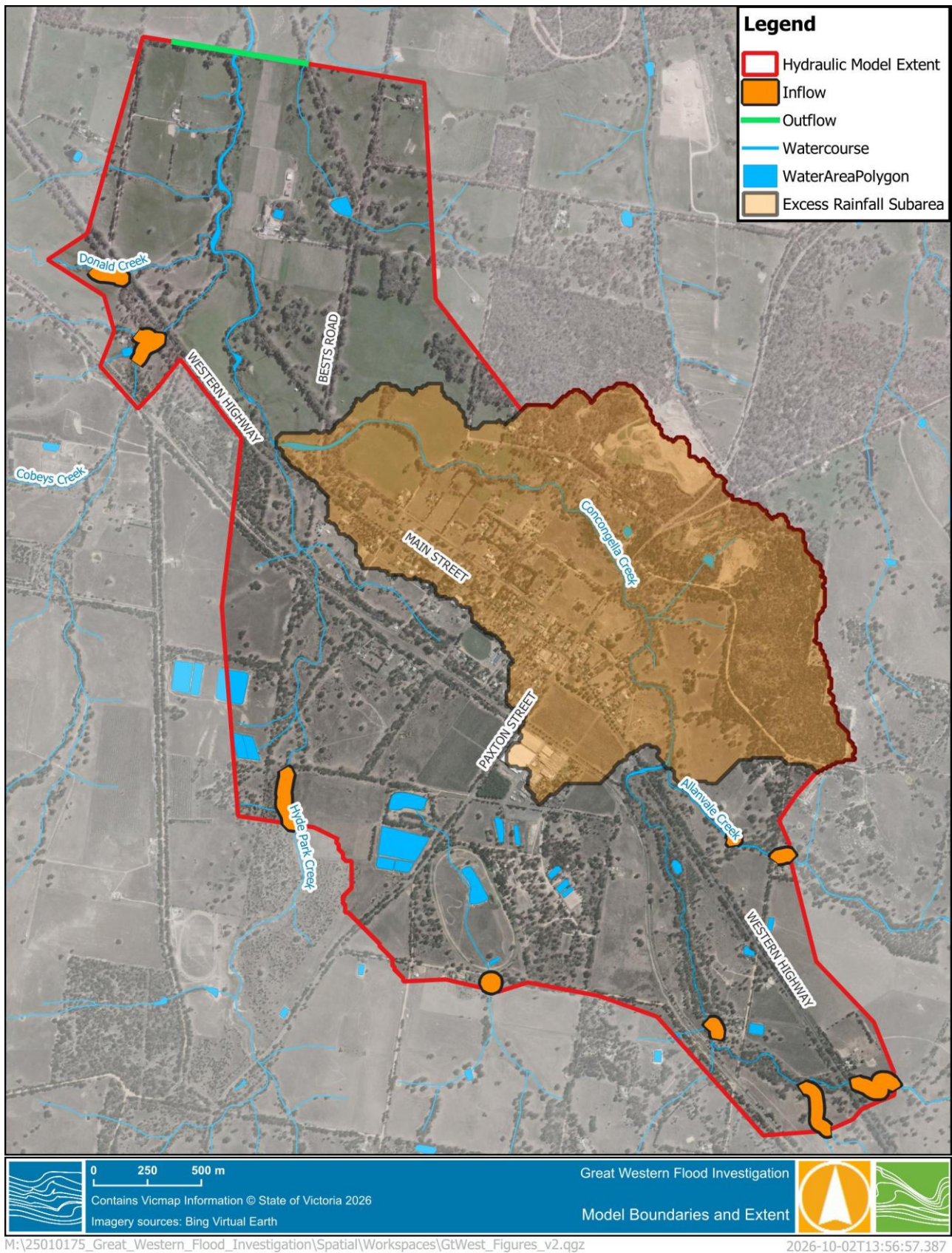


Figure 3-1 Model Extent and Inflow/Outflow Boundaries



3.3 Model topography

Three topographic Light Detection And Ranging datasets were available for the study area, including:

- 2010-11 Floodplains LiDAR Stage 2 - North Central CMA (flown Jun to Aug 2011)
 - 1m resolution with 0.1m vertical accuracy
- 2009-10 Victorian State Wide Rivers LiDAR Project – Wimmera CMA
 - 1m resolution with 0.2m vertical accuracy and a horizontal accuracy of 0.3m
- 2005 WCMA LiDAR (flown Jan 2005)
 - 0.5m vertical accuracy

All available datasets covered the entire hydraulic study area. The extent of coverage is presented in Figure 3-2.

The three datasets were verified against a photogrammetry provided by NGSC, flown in 2024 and converted into a Digital Terrain Model (DTM) by Water Technology. The transect comparison in Main Road, Paxton Street, Rennie Street and on the Western Highway are presented in Figure 3-4 to Figure 3-7.

The 2010-2011 Floodplains LiDAR Stage 2 dataset was adopted for the study. This dataset was generally best aligned with the photogrammetry, it is also most recent. The 2009-10 Victorian State Wide Rivers LiDAR has known accuracy issues detailed in other studies².

The 2010-2011 Floodplains LiDAR Stage 2 elevation transects are consistently lower than NGSC's photogrammetry. All roads (only) in Great Western township were replaced by the NGSC's photogrammetry given it represented the newest data and was considered the most accurate.

The topography of the study area is presented in Figure 3-8.

² Dunmunkle Creek Flood Investigation (Water Technology, 2014), Casterton Flood Investigation (Cardno, 2011)

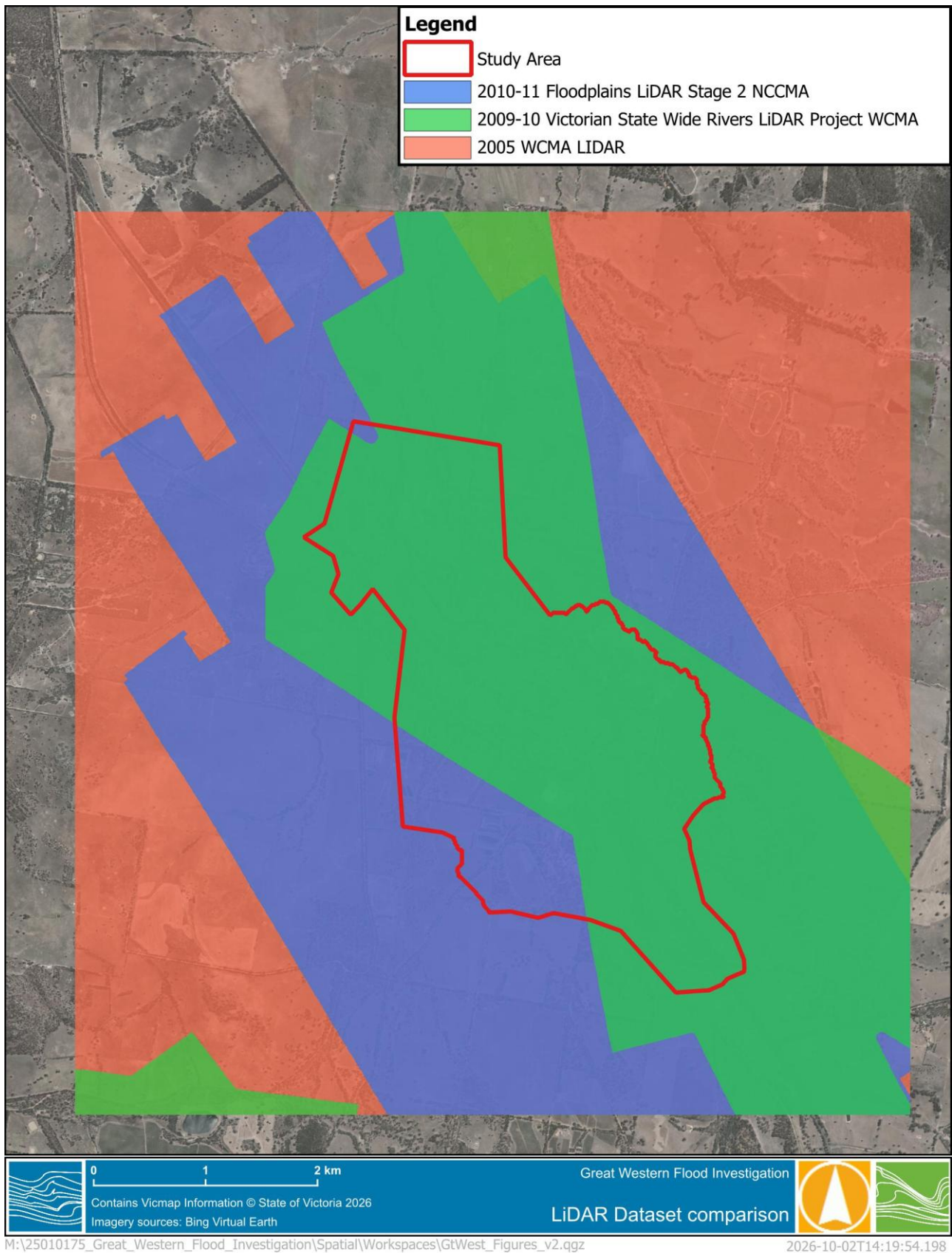


Figure 3-2 Available LiDAR Dataset Comparison



Figure 3-3 Transect Locations for Elevation Comparison

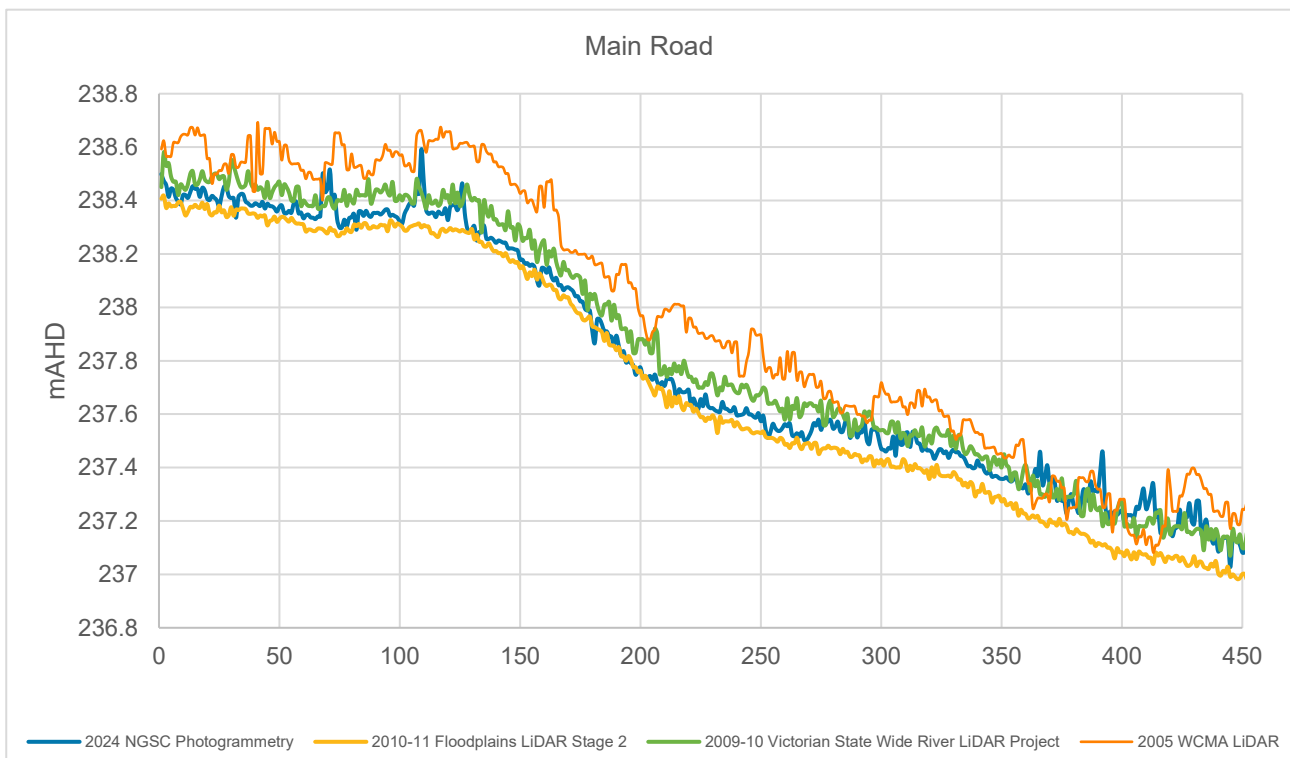


Figure 3-4 Available LiDAR Elevation Comparison at Main Road

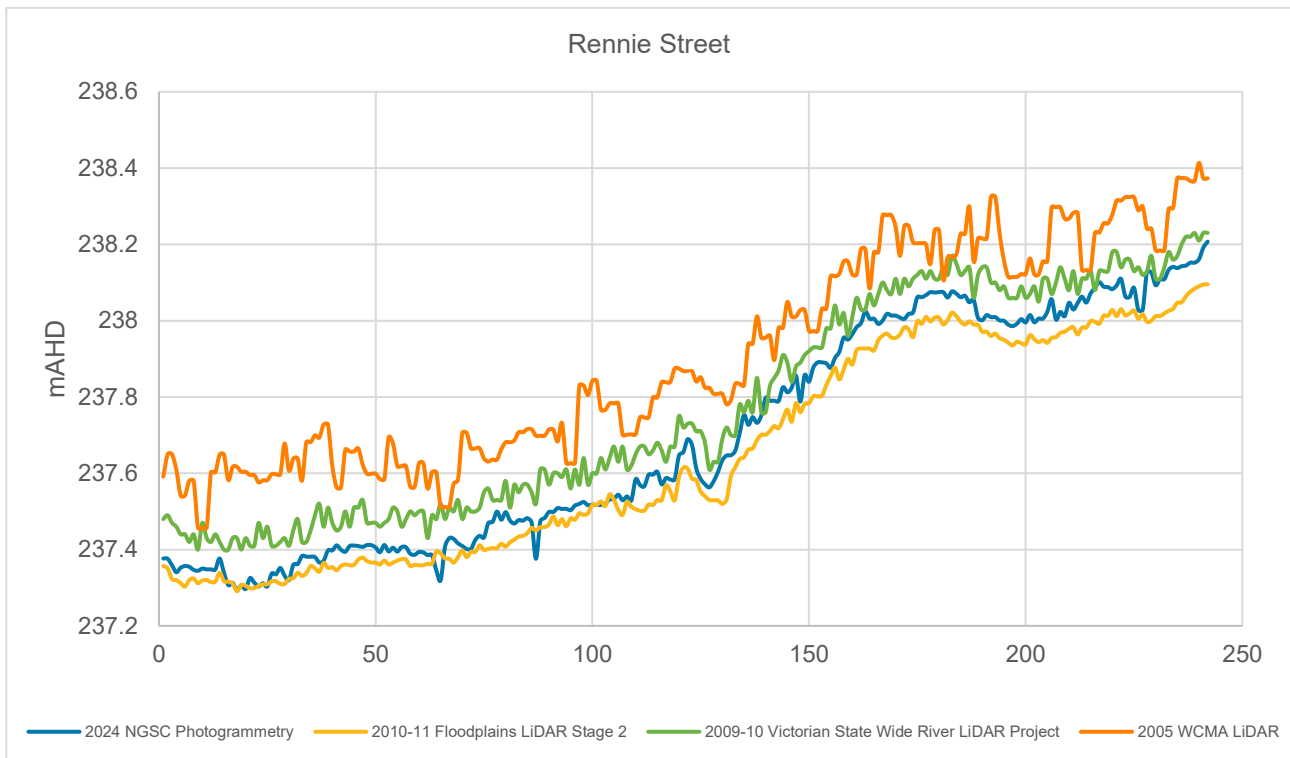


Figure 3-5 Available LiDAR Elevation Comparison at Rennie Street

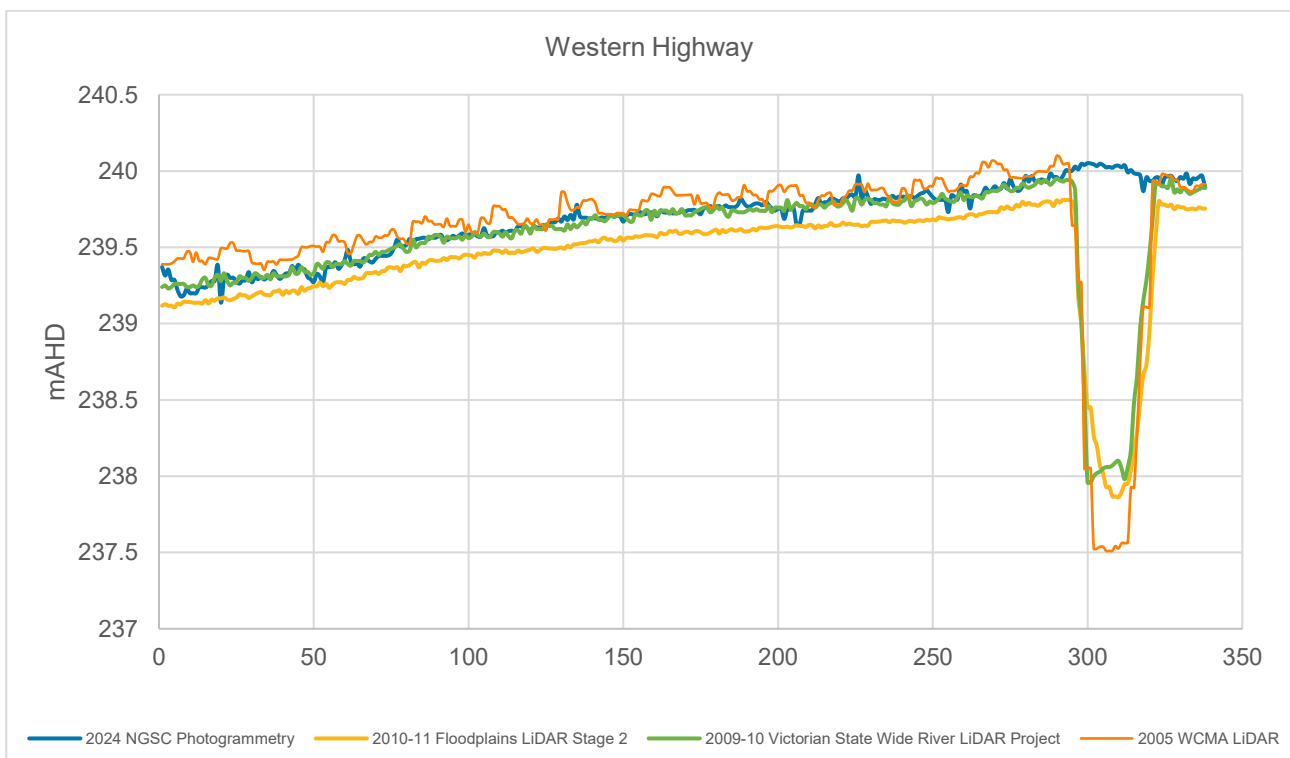


Figure 3-6 Available LiDAR Elevation Comparison at Western Highway over Concongella Creek, south of the township

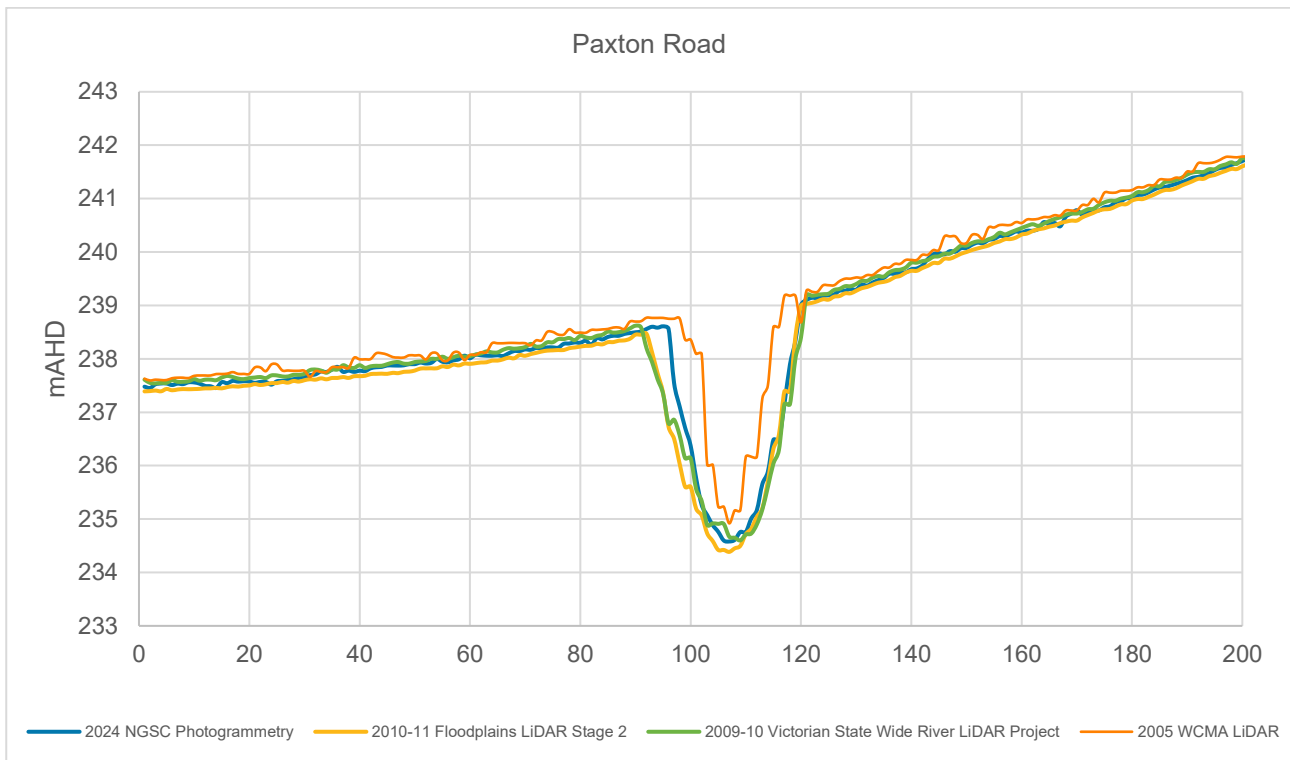


Figure 3-7 Available LiDAR Elevation Comparison at Paxton Street Bridge

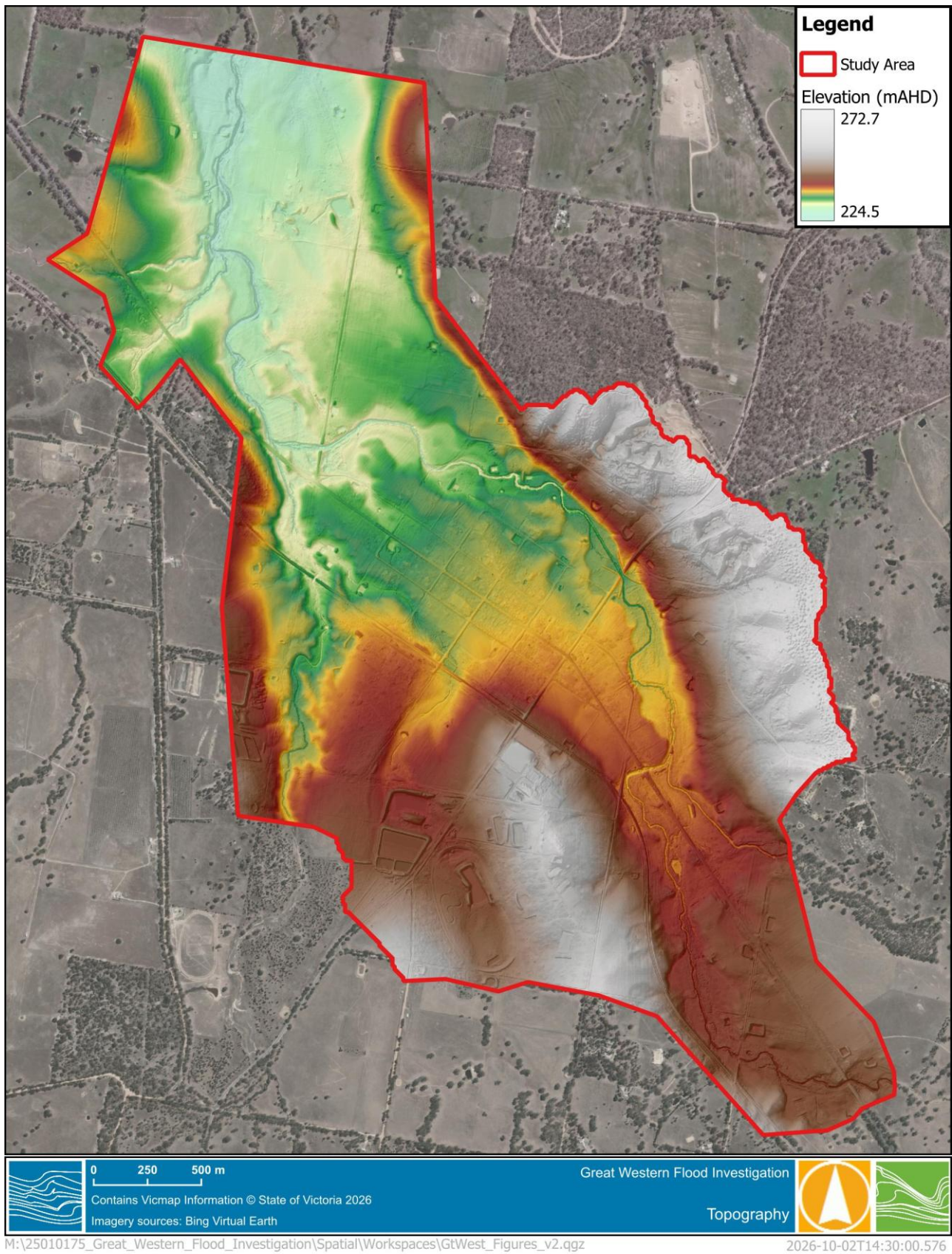


Figure 3-8 Local topography of Great Western



3.4 Hydraulic roughness

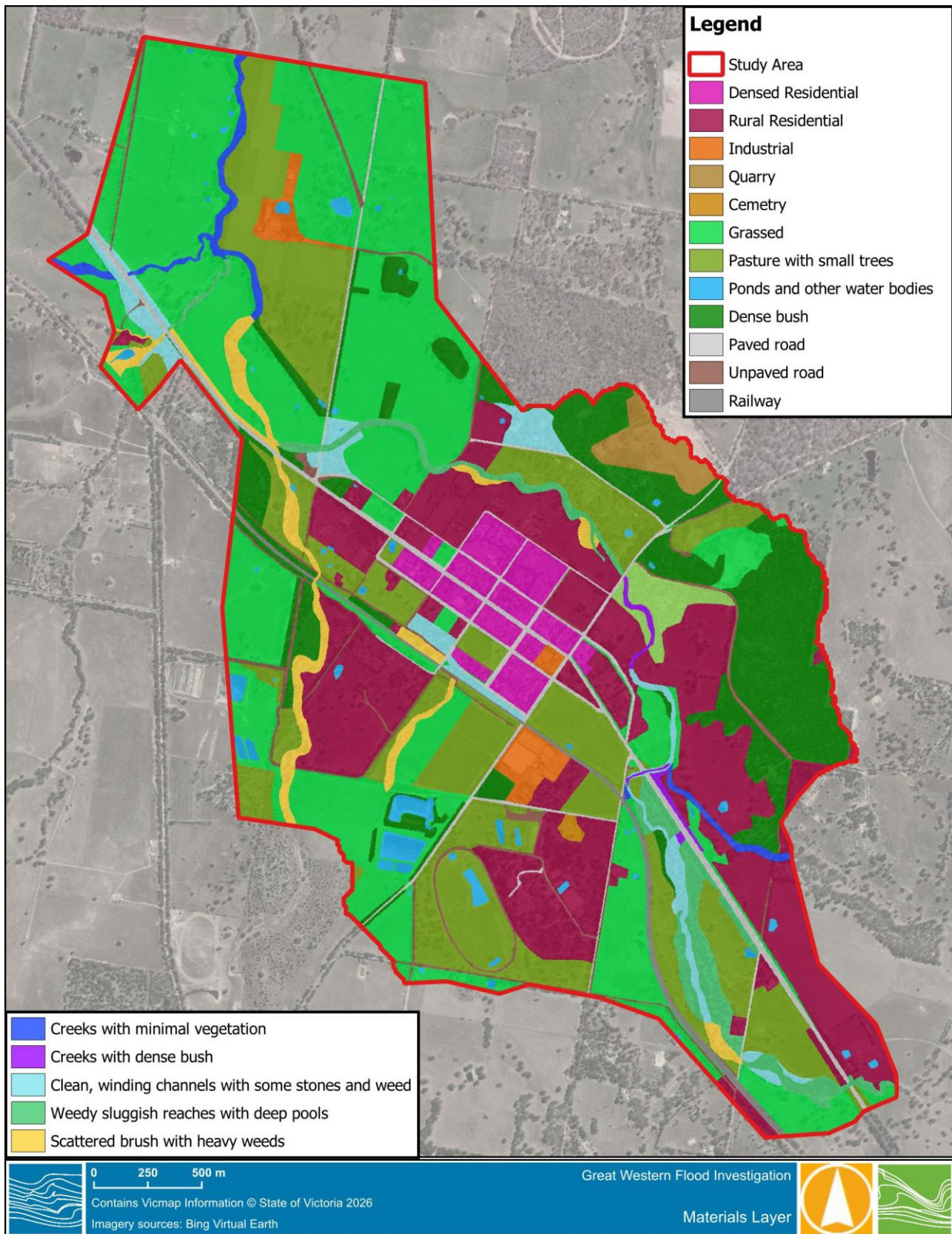
Hydraulic roughness within the 2D model was expressed as Manning's 'n'. For estimation of the floodplain Manning's n', this study assessed land-use and vegetation cover. Hydraulic roughness parameters were adopted using industry standard values that represent the channel and floodplain cover. The 2D model roughness values were produced based on Land Use Zones, with further refinement using aerial photographs. The final adopted Manning's 'n' roughness values are listed in Table 3-1 and shown graphically in Figure 3-9.

Roughness values used in the previous Western Highway Duplication project (2017) were initially adopted for the current study, with a list changes made in the roughness values as part of the model calibration is highlighted in Table 3-1.

The *Rural Residential* roughness value was lowered from 0.060 to 0.045 to allow more overland flow (as highlighted in Yellow in Table 3-1). The values for the creeks and tributaries were defined by four different roughness values: *Creeks with Minimal Vegetation*, *Creeks with Dense Bush*, *Clean, Winding Channels with some stones and weeds*, *Weedy sluggish reaches with deep pools*, and *Scattered bush with heavy weeds*, to reflect the respective characteristics of the waterways (as highlighted in Green in Table 3-1).

Table 3-1 Manning's 'n' roughness values

Land Use	Manning's n Roughness Coefficient
Residential	0.200
Rural Residential (Part Cleared, Part Treed)	0.045
Industrial	0.300
Quarry	0.030
Cemetery	0.15
Grassed	0.035
Scattered Bush with Heavy Weeds	0.050
Pasture with Small Trees	0.040
Open Space with Moderation Vegetation	0.060
Dense Bush	0.100
Paved Road	0.020
Unpaved Road	0.030
Railway	0.040
Ponds and Other Water Bodies	0.030
Creeks with Minimal Vegetation	0.030
Weedy Sluggish Reaches with Deep Pools	0.060
Clean, Winding Channels with Some Stones and Weeds	0.070
Creeks with Dense Bush	0.080



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Figure 3-9 Materials Layer



3.5 Hydraulic Structures

3.5.1 Bridges

There are 5 bridges within the hydraulic model extent, modelled as 2D BG to represent the energy losses due to piers and bridge decks. Three are within the Great Western township area, one located along the Western Highway, and the other one is located on the southern boundary of the township.

The location of the bridges is listed in Table 3-2 and location is presented in Figure 3-10.

Table 3-2 Bridge structures measurements and dimensions

Location	Length across bridge	Soffit
Paxton Street over Concongella Creek	34 m	237.8 mAHD
Bests Bridge over Concongella Creek	32 m	232.7 mAHD
Western Highway over Concongella Creek	34 m	239.6 mAHD
Western Highway over Robinsons Creek	21 m	245.3 mAHD
Railway Crossing between Railway and Bowtells Road	15 m	235.04 mAHD

3.5.2 Culverts

A total of 21 culverts were modelled in this flood study. Of the 21, asset data for 8 culverts was obtained from NGCS and incorporated into the hydraulic model as 1D structures directly connected to the 2D model domain. The remaining culverts were collected through several site surveys as the study area were expanded, and those that were not in the dataset provided by NGCS and instead identified through LiDAR. These culvert locations are shown in Figure 3-10.

Upon inspecting the data received from NGSC, several box culverts did not align with the topography and they were corrected using elevation data from the LiDAR data and measurements taken from a site survey. The corrected data are noted down in Table 3-3.

Table 3-3 Culvert structure measurements and dimensions

Location (ID)	Type	Dimension (WxH)	Data source	Comments
Brunel St v Main St (PP15)	Box Culvert	750 x 300 mm	NGSC	
Brunel St v Paxton St (PP16)	Box Culvert	400 x 240 mm	NGSC	
Paxton St v Main St (PP18)	Box Culvert	350 x 250 mm	NGSC	
Rennie St v Railway Rd (PP20)	Box Culvert	1600 x 700 mm	NGSC	
Railway Rd v Rennie St (PP22)	Box Culvert	1230 x 900 mm	NGSC, Site Survey	NGSC data do not align with LiDAR, corrected with site survey data
Stephenson St v Cubitt St (PP28)	Box Culvert	300 x 120 mm	NGSC	



Location (ID)	Type	Dimension (WxH)	Data source	Comments
Rennie St v St Peter Rd (PP29)	Box Culvert	400 x 200 mm	NGSC	
Rennie St v Railway Rd (PP37)	Box Culvert	400 x 200 mm	NGSC	
Bowtells Rd v Railway Track	Arch Culvert	1220 x 1100 mm (550 mm before the curve)	Site survey	Modelled as an irregular culvert with a cross-section measurement of the arch's curve
Western Hwy, south of township	Pipe Culvert	1200 mm (each)	Site Survey	2x culverts
Western Hwy, south of township and Concongella Ck	Box Culvert	1230 x 900 mm (each)	Site Survey	3x culverts
Bests Rd	Box Culvert	900 x 450 mm	Site Survey	
Western Hwy v Cobey's Ck	Box Culvert	1240 x 1240 mm	Site Survey	3x culverts
Western Hwy v Donalds Ck	Pipes & Box Culverts	1200 mm (each, pipe) 1500 x 2750 mm (box)	Site Survey	3x pipe and 1x box culverts
Western Hwy v Hyde Park Ck	Box Culverts	3200 x 3000 mm (each)	Site Survey	2x culverts
Moyston-Great Western Rd (CUL126344)	Pipe Culvert	1500 mm (each)	Site Survey	3x culverts
Racecourse Gate Entry	Box Culvert	1225 x 460 mm	Site Survey	Owned by Racecourse
Racecourse SE of Gate Entry	Pipe Culvert	Upstream: 450 mm (each) Downstream: 275 mm (each)	Site Survey	Owned by Racecourse Upstream and Downstream culvert diameters are different, modelled using the smallest value.
Grellet Rd	Box Culvert	450 x 225 mm	Site Survey	
Racecourse v Grellet Rd	Pipe Culvert	Upstream: 300 mm (each) Downstream: 450 mm (each)	Site Survey	Upstream and Downstream culvert diameters are different, modelled using the smallest value.
Private property, South side, near GWM Water on Moyston-Great Western Rd	Pipe Culvert	300 mm	Site Survey	

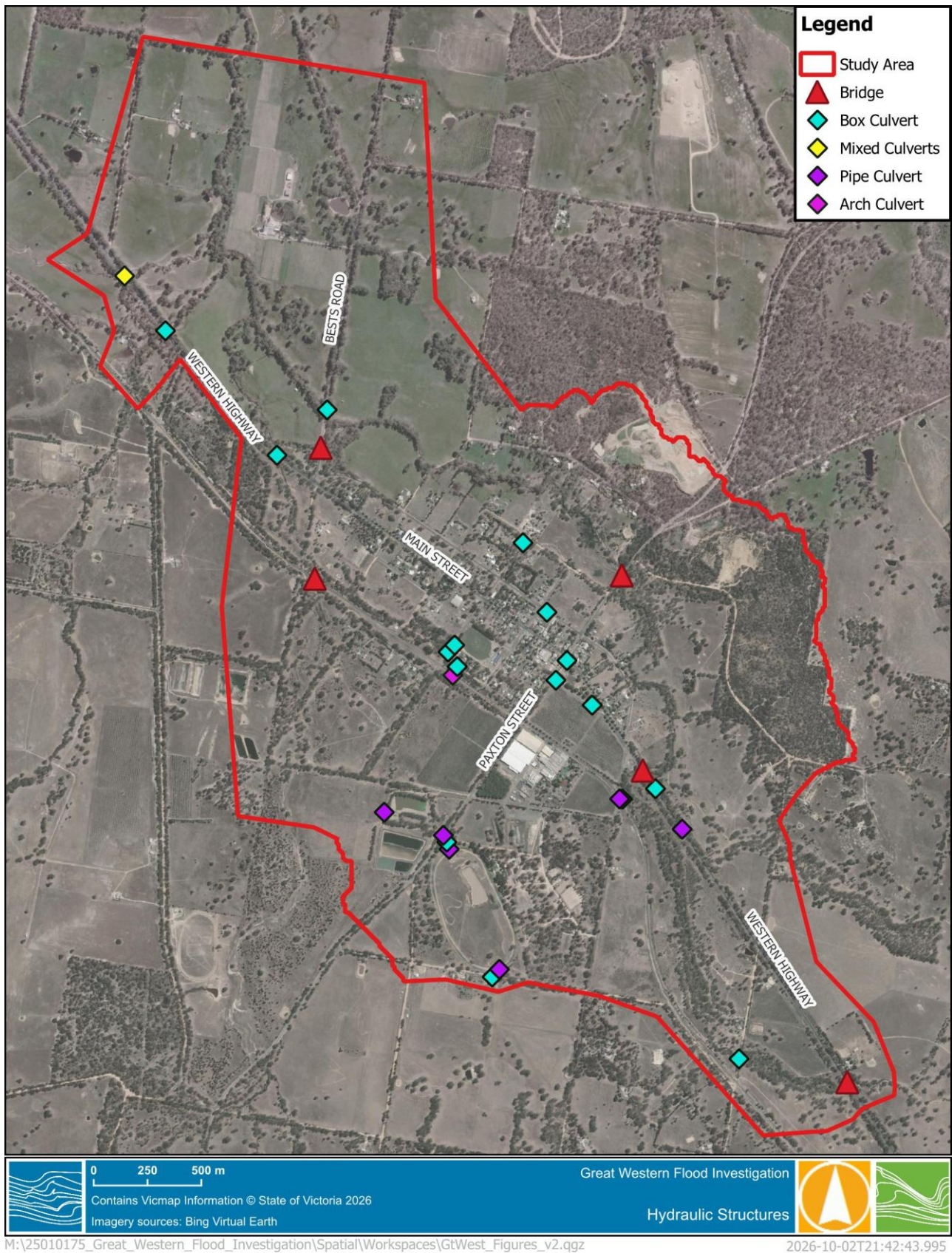


Figure 3-10 Bridges and Culverts



3.5.3 Pit and pipe network

The underground pit and pipe network in Great Western was surveyed by NGCS via RapidMap in 2024. The survey data, which included pit and pipe dimensions, upstream and downstream invert levels, was used to incorporate the network as 1D pit and pipe structures. Open pipe ends not connected to a pit were modelled as directly connected to the 2D domain. The township pipe network is shown in Figure 3-11.

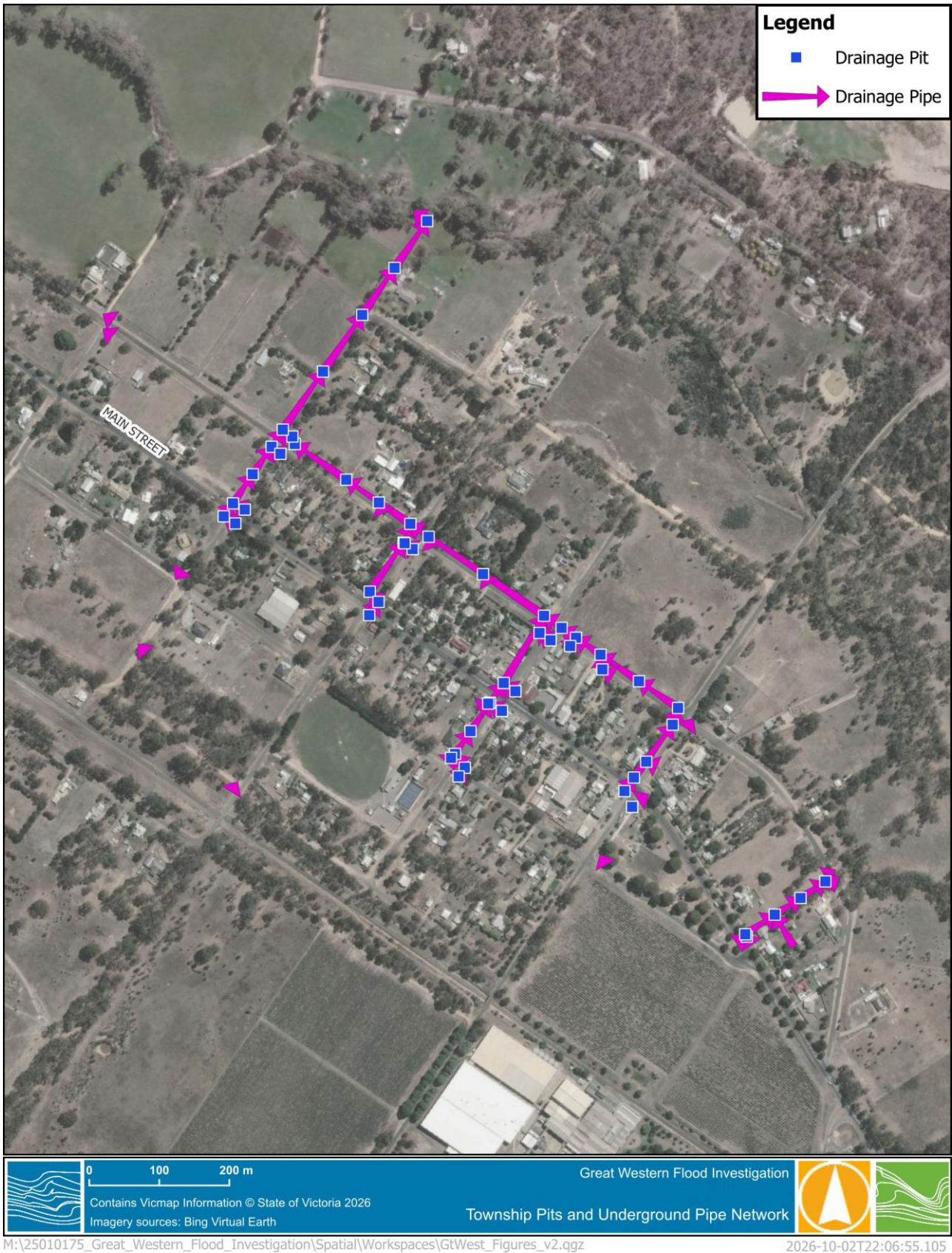


Figure 3-11 Township Pits and Underground Pipe Network



4 CALIBRATION AND VALIDATION

4.1 Overview

The model calibration and validation focused on the January 2011 and October 2022 events. The former event is the most recently recorded event, and the later event is the largest flood on record in Great Western.

Hydrology

The RORB model was calibrated to the January 2011 and October 2022 flood events at the Concongella Creek at Stawell gauge. The calibration was based on comparing the modelled hydrograph at this location to gauge recordings. The focus of the RORB model calibration was to determine the RORB parameters, specifically the initial loss and continuing loss values within the catchment.

Hydraulic

The TUFLOW model was calibrated to the January 2011 surveys and flood marks that were available from the Western Highway Duplication Project¹. The calibration process consisted of a systematic comparison of observed and modelled flood levels and flood extents based on the available survey data.

4.2 January 2011 Event

4.2.1 Available data

The calibration data for the hydrology component of the January 2011 event was primarily based on streamflow data at the Concongella Creek at Stawell streamflow gauge and the hydraulic model calibration.

Hydraulic model calibration data was collected during two community consultations on 13th August and 3rd December 2025, as well as data extracted from the previous Western Highway Duplication Project¹, and the *Wimmera Region Flood Report - January 2011*³ completed by Water Technology for Wimmera CMA in 2011.

These modelled calibration results were compared to the calibration points and the anecdotal evidence collected from the community consultation.

The following data was used to calibrate/validate the hydraulic model:

- A collage of photos and newspaper articles gathered by a member of the community which provided details on how the event unfolded. A comparison between the photos/news articles with the respective flood depths are shown in Section 4.2.3.6.
- 11 surveyed flood marks near Great Western were gathered following the January 2011 event, of which 8 of them is within the Study Area. The dataset has a reported survey accuracy of less than 50mm; however, it should be noted that peak water levels can be difficult to accurately define and therefore flood survey has inherent uncertainty. Surveyed levels also need to be used with judgment and caution.
- An aerial image flown on drone on Friday 14th January at 10am from the west side of the township. It should be noted that the imagery might be flown after the peak water levels.
- Pin locations of properties that were flooded above floor level.
- Verbal feedback from a community consultation attended by local community members on 13th August and 3rd December 2025.

³ Wimmera Region Flood Report (2011) – Water Technology



4.2.2 Hydrology

Inflows to the hydraulic model can be separated into direct application of rainfall within the township and hydrographs produced by RORB.

The direct rainfall was calculated by RORB using the spatially distributed rainfall totals listed in Table 4-1. The adopted rainfall losses for the January 2011 event, as listed in Table 4-2. The peak flow at Concongella Creek and Allanvale Creek are shown in Table 4-3.

The routed hydrographs for Concongella Creek and Allanvale Creek were extracted from the RORB model results. Figure 4-1 shows the creek flow hydrographs calculated using RORB and Figure 4-2 shows the hydrograph comparison at the downstream of the study area comparing the RORB calculated and actual recorded flows at the Concongella Creek at Stawell gauge.

Table 4-1 January 2011 Rainfall Totals

Gauge Number	Gauge Name	January 12 to 14 2011 Rainfall total (mm)
089085	Ararat Prison	84.2
079105	Stawell Aerodrome	154.2

Table 4-2 Adopted rainfall losses for January 2011 flood event

	Initial Losses (mm)	Continuing Losses (mm/h)
January 2011 flood event	5	1

Table 4-3 January 2011 Peak flows at inflow creeks

Inflow Location	Peak Flow (m ³ /s)
Concongella Creek	69.08
Allanvale Creek	39.4

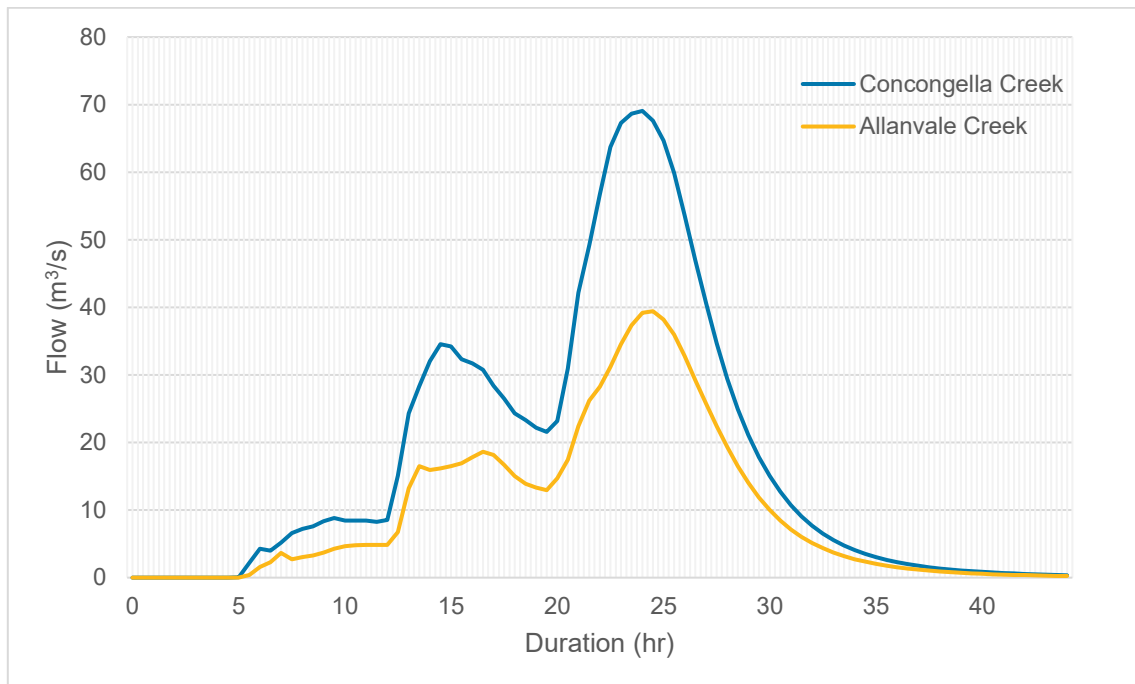


Figure 4-1 Creek Inflow Hydrographs for January 2011 event

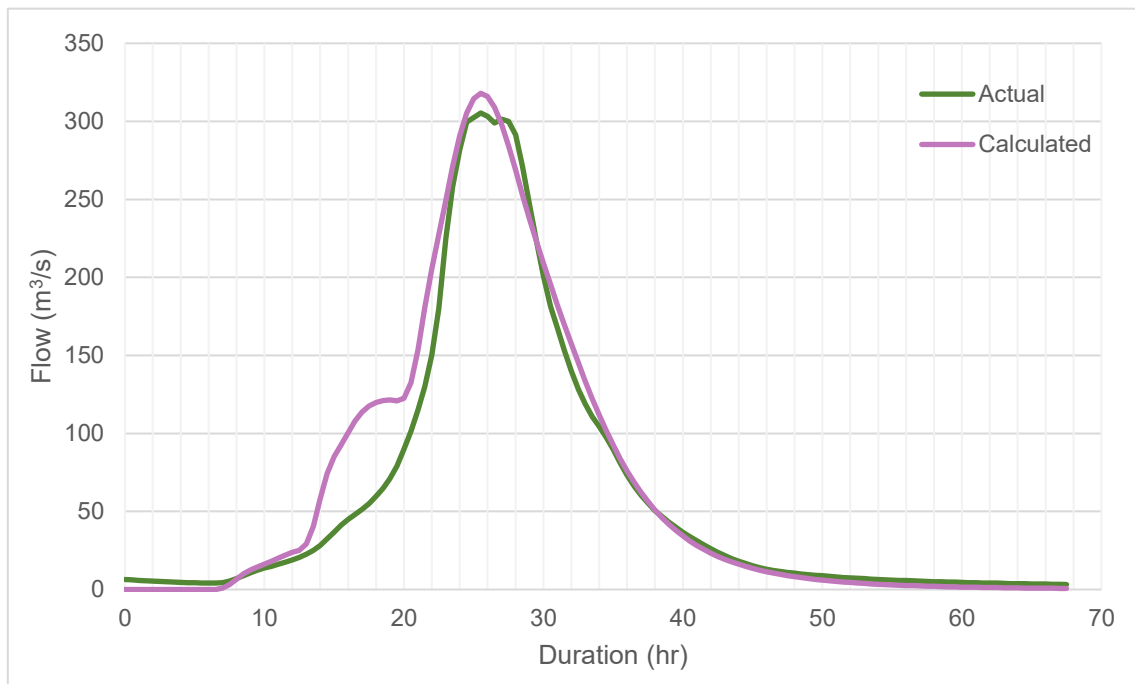


Figure 4-2 Concongella Creek at Stawell - Hydrographs for January 2011 event



4.2.3 Hydraulics

4.2.3.1 Overview

The flood depth and flood velocity mappings for the modelled January 2011 flood event are presented in Figure 4-3 and Figure 4-4. These maps are zoomed into the township to clearly show the area of interest, especially around the Western Highway Bridge over the Concongella Creek and Main Street.

Flood mapping for the full study area is presented in Appendix 5A-1.

The modelled flood extent and peak flood levels are compared to the various calibration data sources and discussed in the following sections.

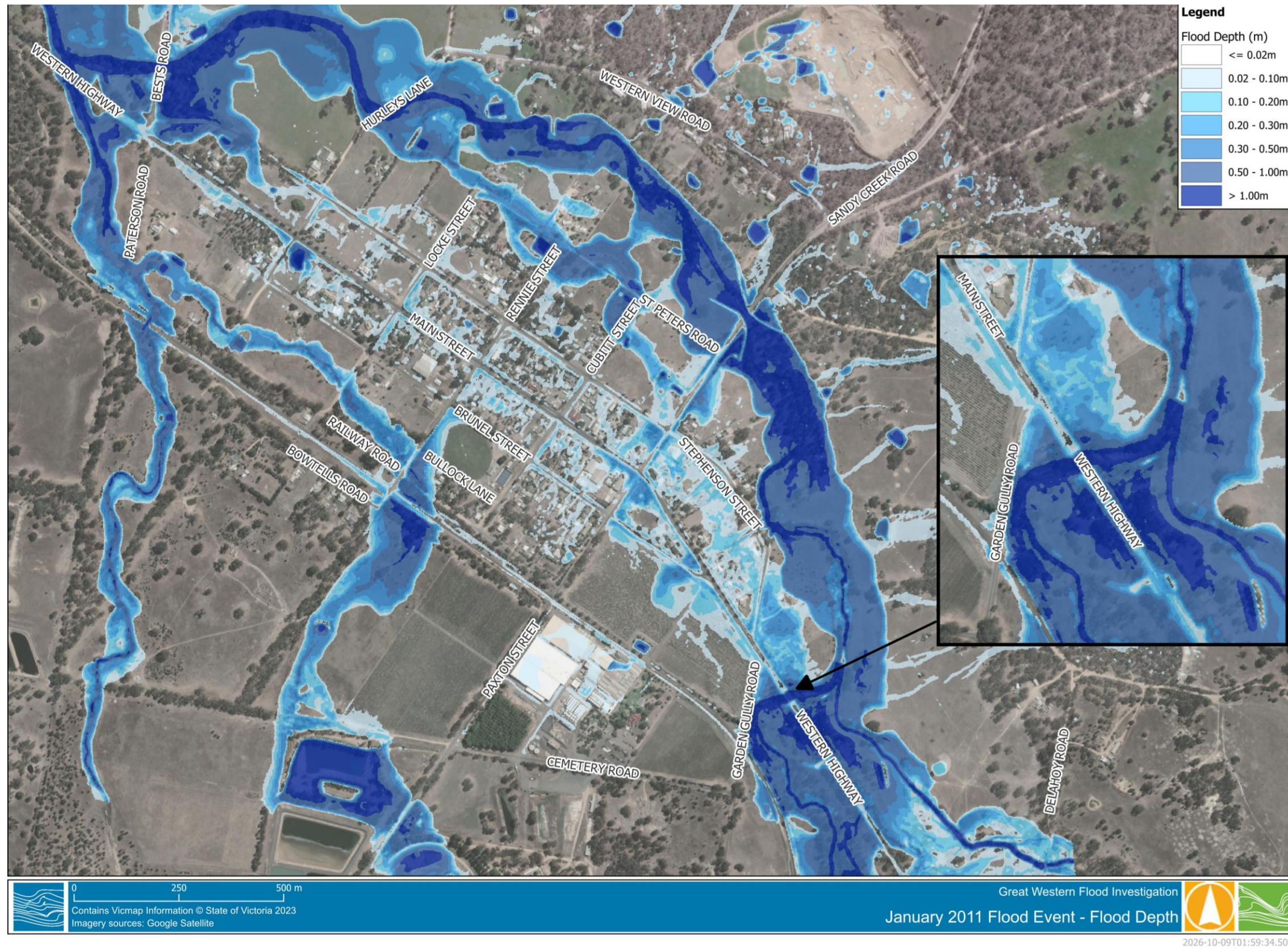


Figure 4-3 Zoomed in Township – January 2011 Flood Depth



Figure 4-4 Zoomed into Township - January 2011 Flood Velocity



4.2.3.2 Outlet Hydrographs

Figure 4-5 shows the modelled TUFLOW and RORB hydrographs at the downstream of the Study Area. The two modelled hydrographs agree very well magnitude, with about 30 minutes difference in timing, throughout the entire event.

There are no gauged water levels at the downstream of Concongella Creek of the Study Area to compare the hydrographs with.

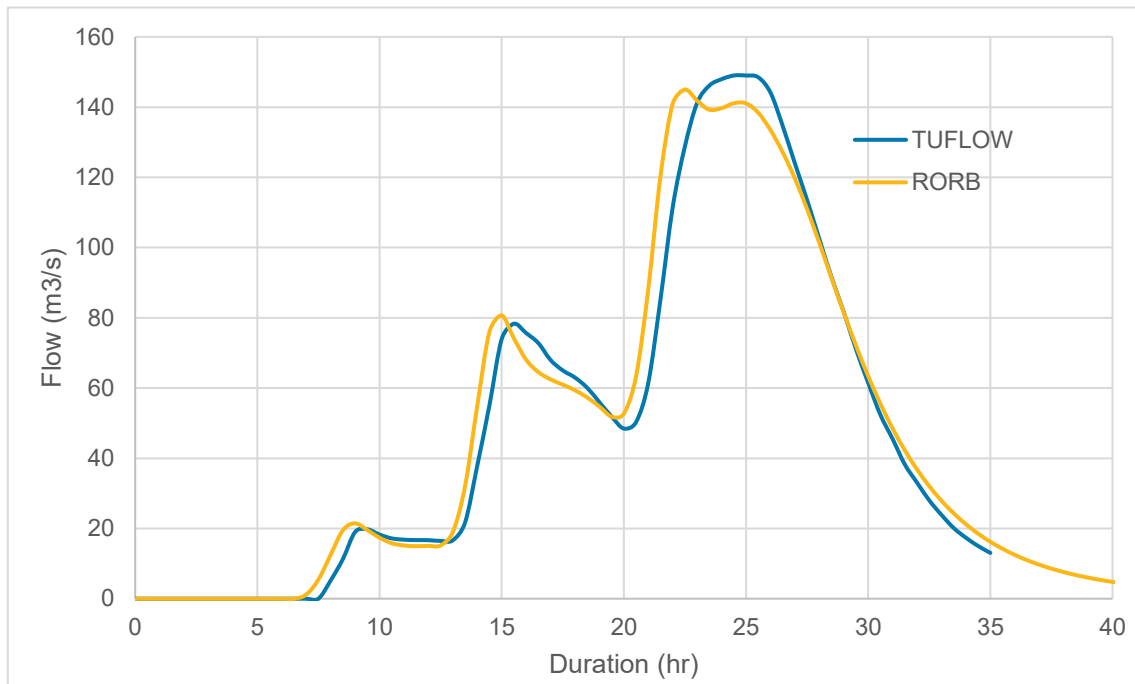


Figure 4-5 Hydrographs at the downstream of Study Area for January 2011

4.2.3.3 Surveyed Flood Points

Of the 8 survey points within the Study Area, 5 points align closely with the modelled water surface elevation, with a maximum difference of +/- 13 cm, as presented in Figure 4-6. 2 survey points, Point A and B, have a water surface elevation difference of 36 cm and 29 cm higher than the surveyed heights, respectively. The remaining point had a surveyed flood height lower than the modelled topography and was disregarded.

While points A and B are upstream of the Western Highway and showed modelled flood levels of around 0.3m above that surveyed, the flood extent in that area matched well with where the survey was taken (understood to be the inundation extent) and observations from the community showed strong agreement with between the observed inundation and that produced by the modelling. Numerous sensitivity tests were also undertaken to confirm if the modelled levels could be reduced to match that surveyed; however, this resulted in a disagreement between the modelled extent and observations made by the community.

It was determined the surveyed flood levels upstream of the Western Highway (Points A and B) likely underestimated flood levels.



4.2.3.4 Aerial Imagery taken during the flood event

Figure 4-7 shows the flood extent comparison between the aerial imagery and the modelled extent. The arrows demonstrate the corresponding area of flooding between the two extents. The extents agree closely, especially where the puddles are located.

4.2.3.5 Inundated Properties

Figure 4-8 shows the pin locations where the properties were flooded above floor level. These locations are within the modelled flood extent with high flood depths.



Figure 4-6 January 2011 Calibration Points (only showing 7 survey points that are close to township)



Figure 4-7 Aerial image flown on Friday 14th January 2011 at 10am from the west side of township

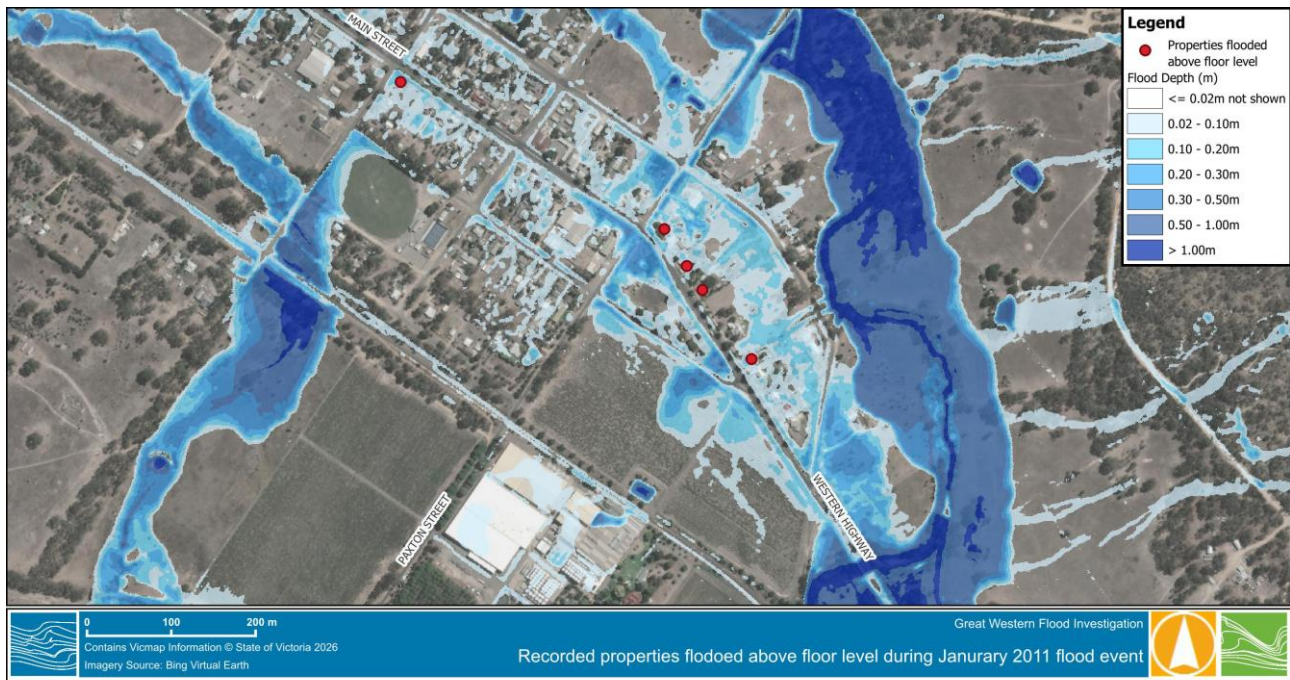


Figure 4-8 Recorded properties flooded above floor level during January 2011 flood event

4.2.3.6 Anecdotal Evidence

A member of the community had gathered and provided a collage of photos and newspaper articles that reported on the January 2011 flood event. The modelled flood extent overall aligns with the flood levels inspected visually from the photos and descriptions used in the newspaper articles, considering the photos might have been taken after the peak flood level occurred.

The modelled flood extent comparison with the relevant photos and newspaper articles is presented in Figure 4-9 to Figure 4-12.

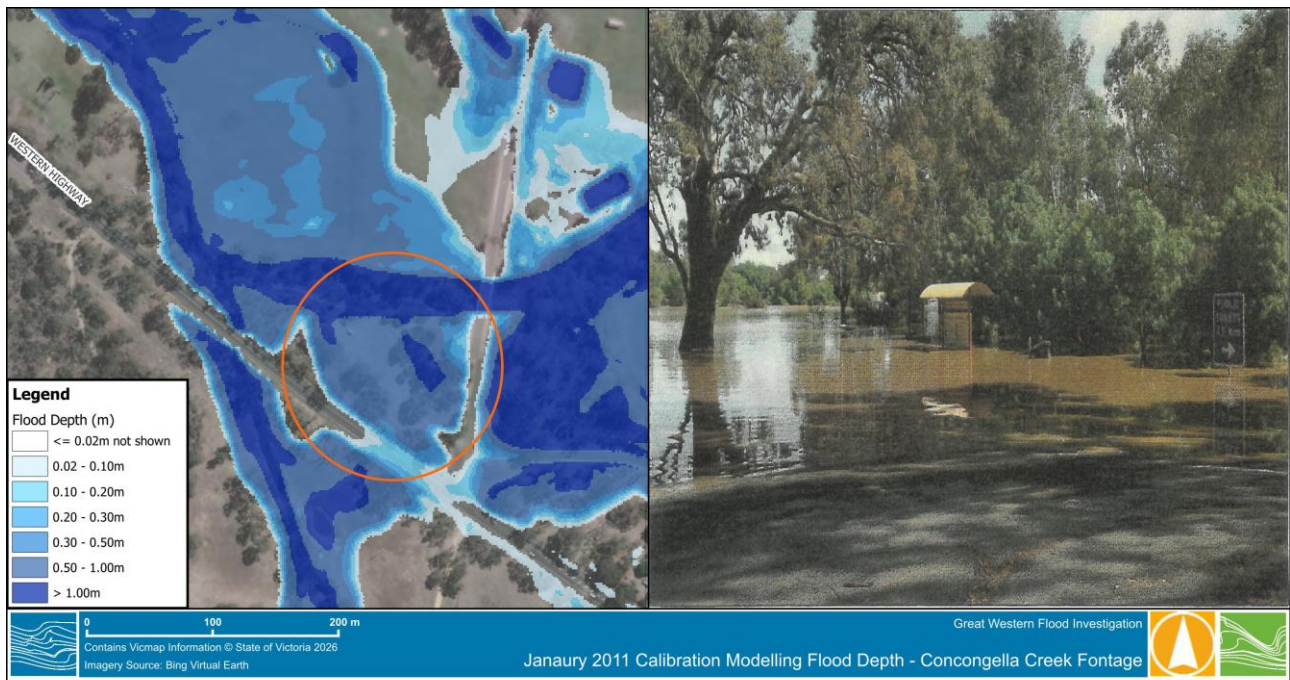


Figure 4-9 January 2011 Calibration Modelling Flood Depth at Concongella Creek Frontage



Figure 4-10 January 2011 Calibration Modelling Flood Depth at Salingers Café and Great Western Hotel, with particular focus on the shrub in front of the café



Figure 4-11 January 2011 Calibration Modelling Flood Depth at Salingers café looking onto Main Street, with particular focus on the shrub in front of the café

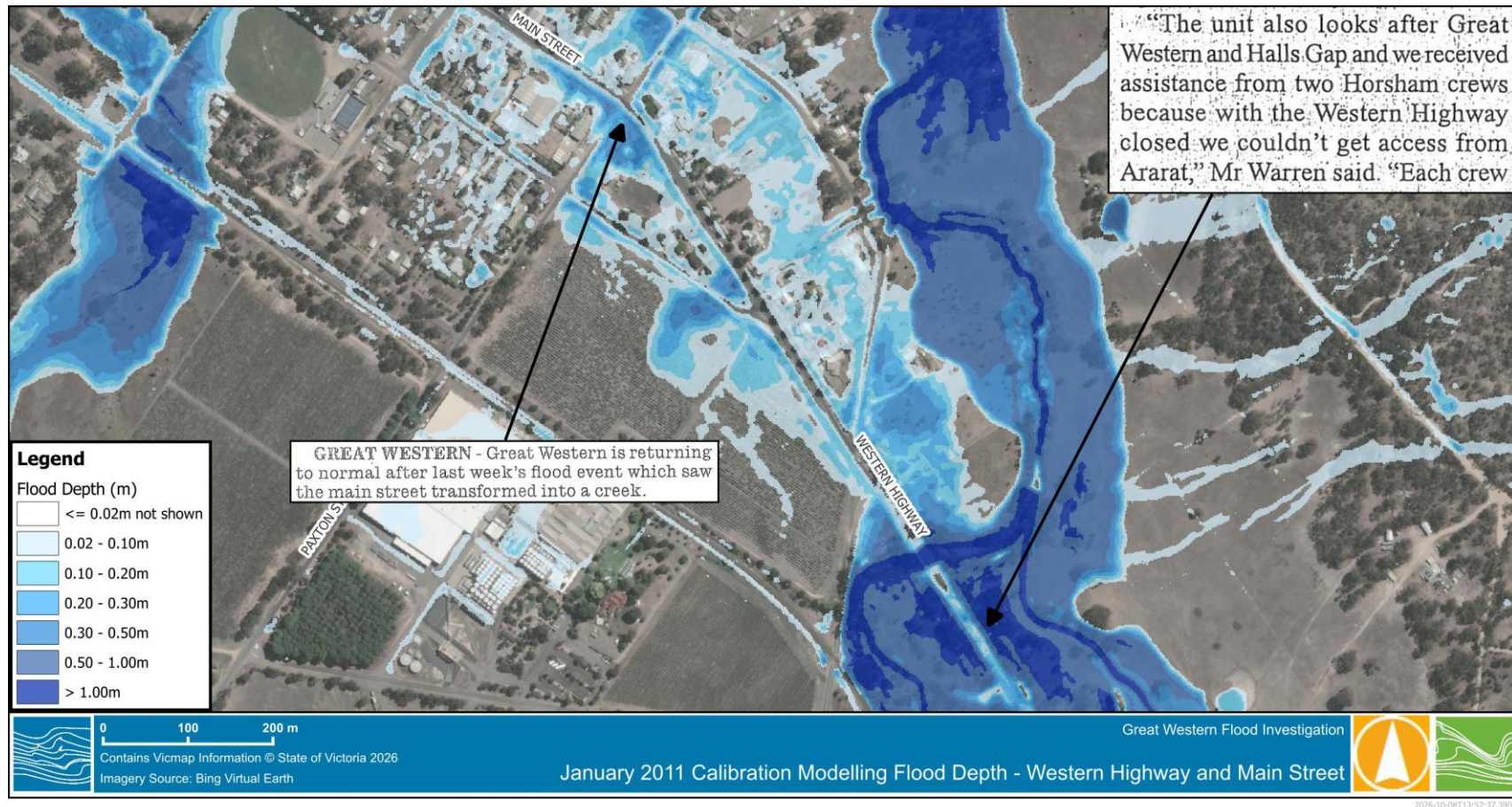


Figure 4-12 January 2011 Calibration Modelling Flood Depth at Western Highway Bridge over Concongella Creek and Main Street, articles gathered from the newspaper



4.3 October 2022 Event

4.3.1 Available Data

The October 2022 flood event is the most recent large magnitude flood event in Great Western, but smaller in magnitude compared to the January 2011 flood event.

The calibration inputs for the October 2022 event were based primarily on the January 2011 event, with the assumption that no significant changes or construction occurred between the two flood events that may have a hydraulic impact on the overland flow path.

Calibration data was not abundantly available in comparison to the January 2011 flood event. There was gauge flow data available at the Concongella Creek at Stawell streamflow gauge which was used to calibrate the RORB model.

The following data was used to calibrate/validate the hydraulic model:

- Photos and a drawing provided by a member of the community on the Concongella Creek and an overland flow path next to the town oval.
- Verbal feedback from a community consultation attended by local community members on 13th August 2025.

4.3.2 Hydrology

Similar to the January 2011 event, the direct rainfall inflow was calculated by RORB using the spatially distributed rainfall totals listed in Table 4-4. The adopted rainfall losses for the October 2022 event are listed in Table 4-5.

The routed hydrographs for Concongella Creek and Allanvale Creek were extracted from the RORB model results. Figure 4-13 shows the creek flow hydrographs calculated using RORB and Figure 4-14 shows a hydrograph comparison the RORB calculated and recorded flows at the Concongella Creek at Stawell streamflow gauge. .

Table 4-4 October 2022 Rainfall Totals

Gauge Number	Gauge Name	October 12 to 14 2022 Rainfall total (mm)
089085	Ararat Prison	42.3
079105	Stawell Aerodrome	47.4

Table 4-5 Adopted rainfall losses for October 2022 flood event

	Initial Losses (mm)	Continuing Losses (mm/h)
October 2022 flood event	29	0.65

Table 4-6 October 2022 Peak flows at inflow creeks

Inflow Location	Peak Flow (m ³ /s)
Concongella Creek	22.1
Allanvale Creek	10.9

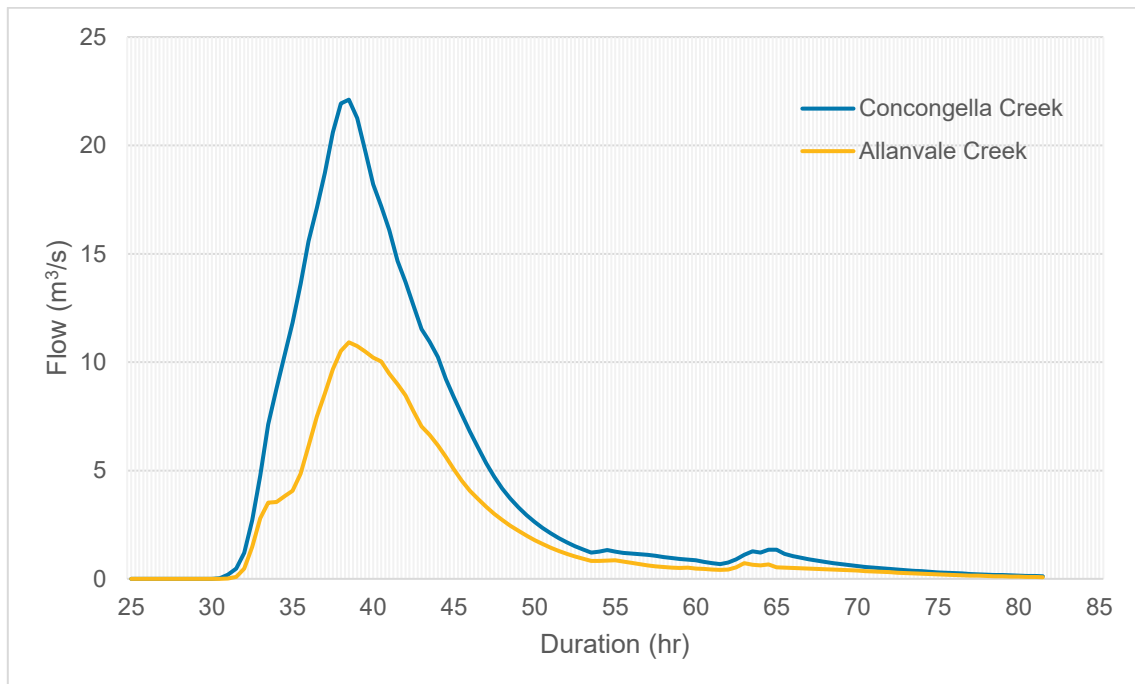


Figure 4-13 Creek Inflow Hydrographs for October 2022 event

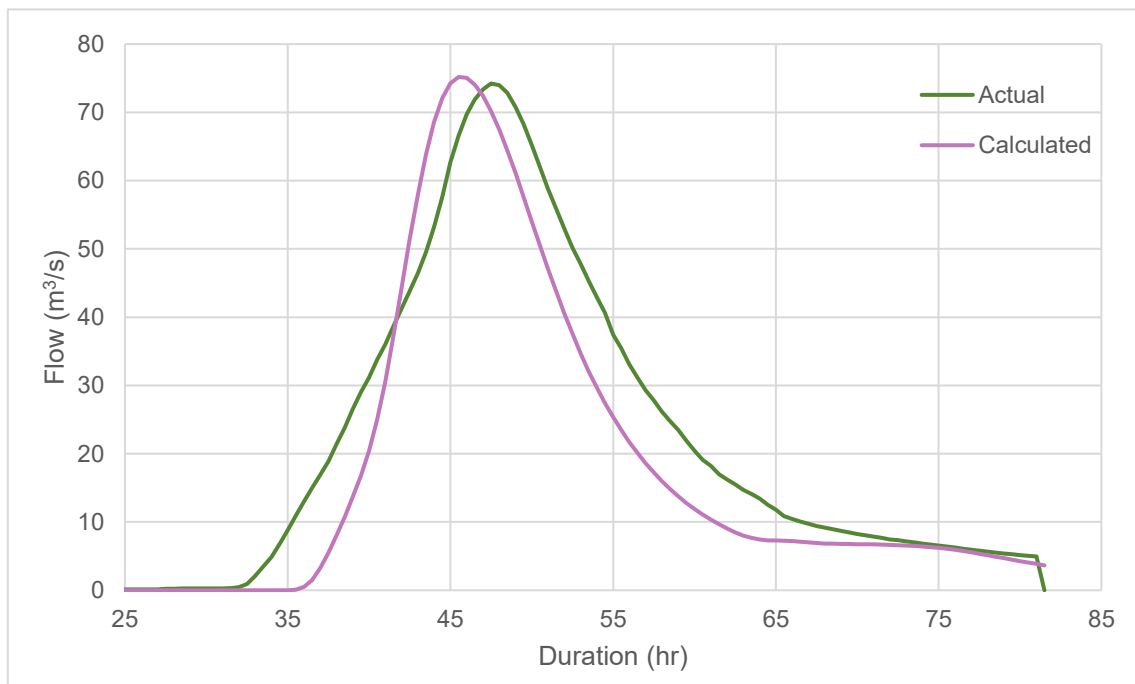


Figure 4-14 Concongella Creek at Stawell Hydrographs for October 2022



4.3.3 Hydraulics

The flood depth and flood velocity mapping for the modelled October 2022 flood event are presented in Figure 4-15 and Figure 4-16. These maps are zoomed into the township to clearly show the area of interest, especially around the Western Highway Bridge over the Concongella Creek and Main Street.

The full study area of the flood mapping is presented in Appendix 5A-2.

The modelled flood extent and peak flood levels are compared to the various calibration data sources are discussed in the following sections.

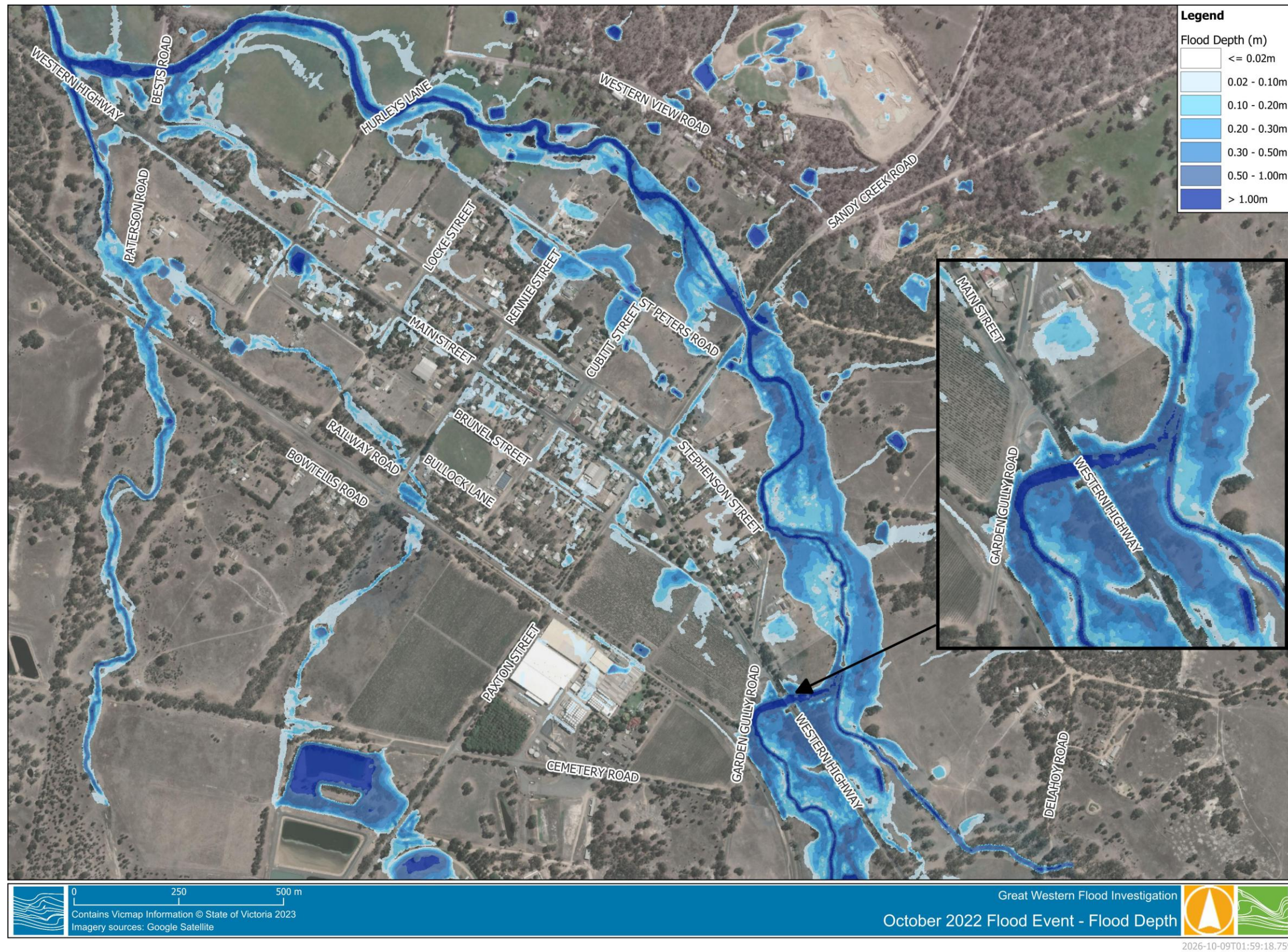


Figure 4-15 Zoomed into Township – October 2022 Flood Depth with 0.2 m Contour



Figure 4-16 Zoomed into Township – October 2022 Flood Velocity

4.3.3.1 Outlet Hydrographs

Figure 4-17 shows the modelled TUFLOW and RORB hydrographs at the downstream of the Study Area. The two modelled hydrographs agree well for magnitude throughout the entire event, with slight mismatch at the peak.

There are no gauged water levels at the downstream of Concongella Creek of the Study Area to compare the hydrographs with.

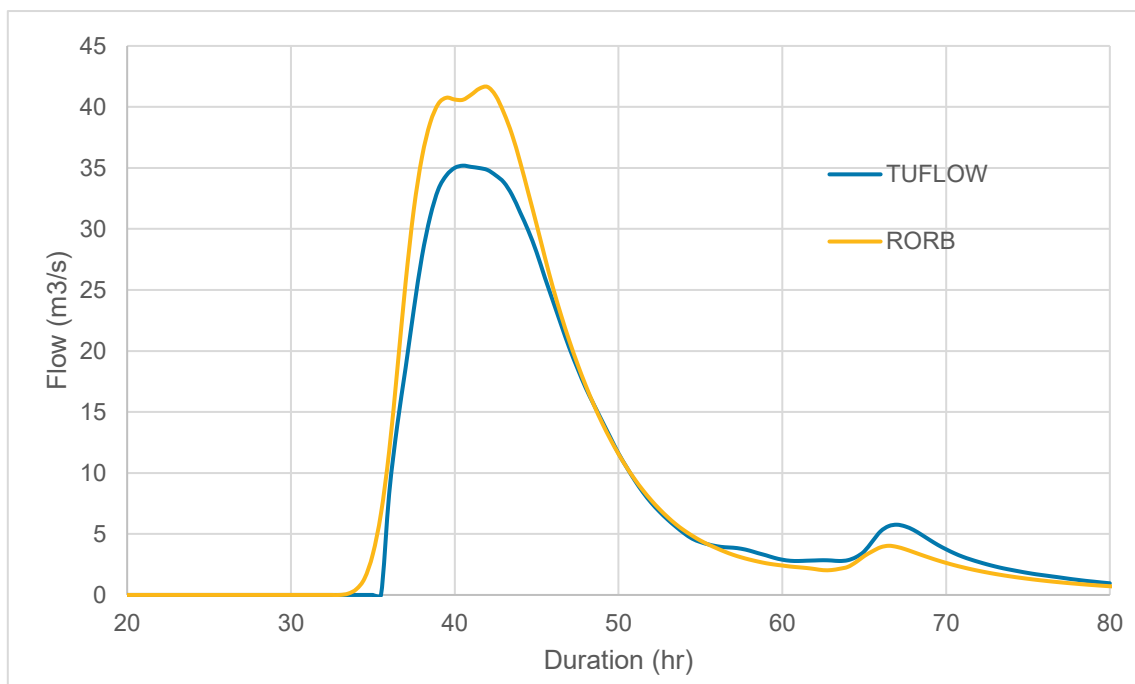
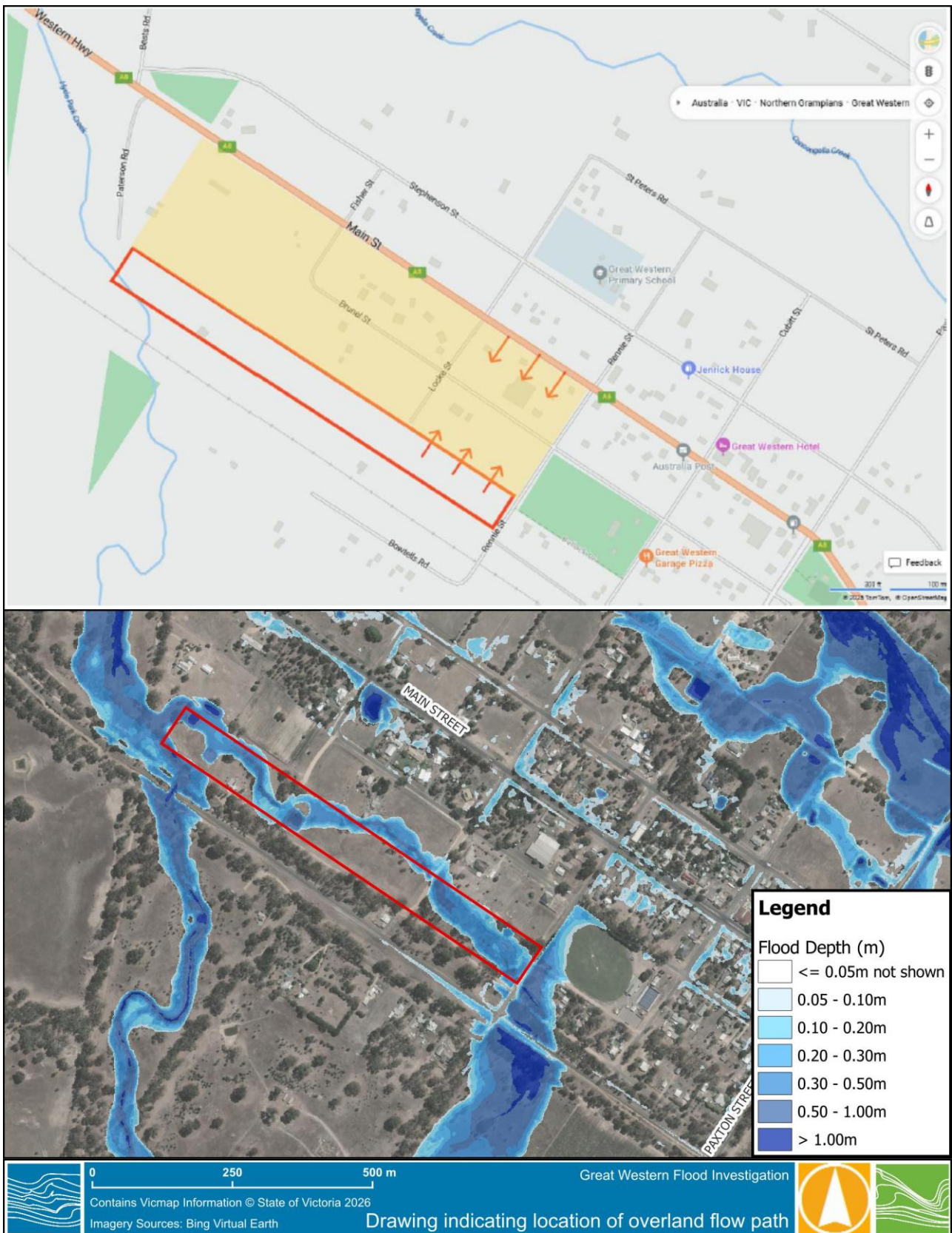


Figure 4-17 Hydrographs at downstream of Study Area for October 2022

4.3.3.2 Anecdotal Evidence

Most members of community recalled more details about the January 2011 flood event than the October 2022 event. Some recalled that the Western Highway Bridge over Concongella Creek was flooded, and vehicles were unsafe to drive through for several hours before the flood receded. This observation is aligned with the modelled flood level with the flood extent covering the Western Highway Bridge over Concongella Creek, as highlighted in Figure 4-15.

The drawing provided by a member of community, demonstrated in Figure 4-18, shows that the railway located south of the township acts as a hydraulic structure and diverts the water from an overland flow path, highlighted as a red box, into the residential area highlighted in yellow. The water from the overland flow path comes from the Great Western Racecourse dam, which is located south of the township, outside of Study Area. This inflow is captured as one of the inflow boundaries presented in Figure 3-1, just downstream of the racecourse.



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Figure 4-18 Drawing by a member of community indicating the overland flow path location



5 SUMMARY

This report provides details of the methodology and flood model calibration for Great Western. The calibration data, including a range of records from previous reports and anecdotal evidence collected through the community consultation, were valuable in assisting with the calibration process. The January 2011 flood event was used as the primary event to validate the hydraulic modelling, with the October 2022 event used to cross check the collected observations.

The findings from this report were be used to develop design modelling for the township. The design modelling also undertake sensitivity analysis to test the following parameters:

- Initial & Continuing Loss (RORB – hydrologic model)
- Land-use Roughness (TUFLOW – hydraulic model)
- Open Drain, Pit, Culvert and Bridge Blockage (TUFLOW – hydraulic model)
- Vegetation on Riverbanks Blockage (TUFLOW – hydraulic model)

Design events that were completed as part of this flood study includes 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2%, 1 in 2000 AEP, and Probable Maximum Flood (PMF). Design modelling was undertaken using Shard Socioeconomic Pathway (SSP) 3-7.0 for year 2030 (present day) and 2100 (future). Details of this modelling are outlined in the Design Modelling Report.



APPENDIX A FLOOD MAPPINGS – FULL STUDY AREA





A-1 Mappings for January 2011 Flood Event

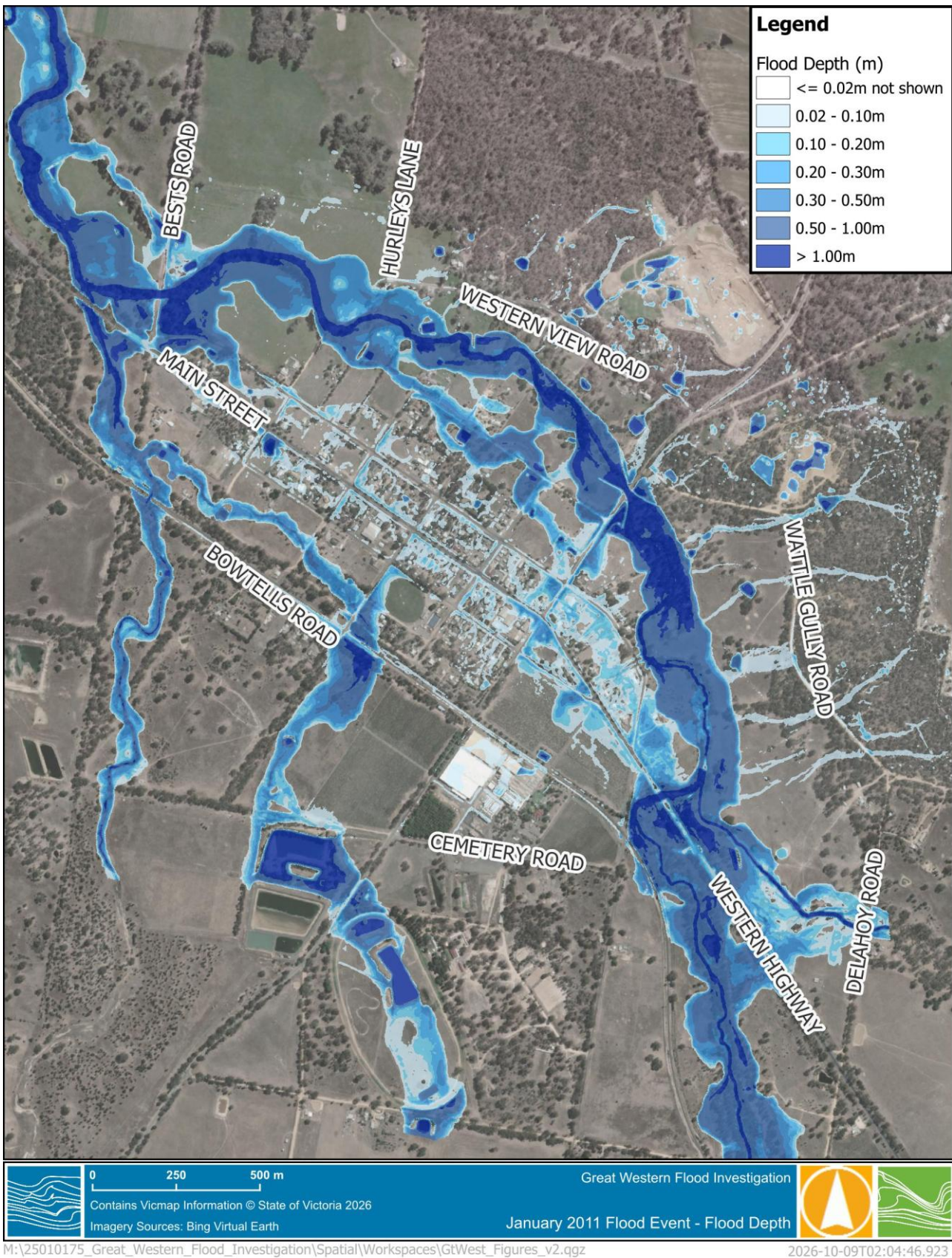


Figure 5-1 Full Study Area - January 2011 Flood Depth with 0.2 m Contours

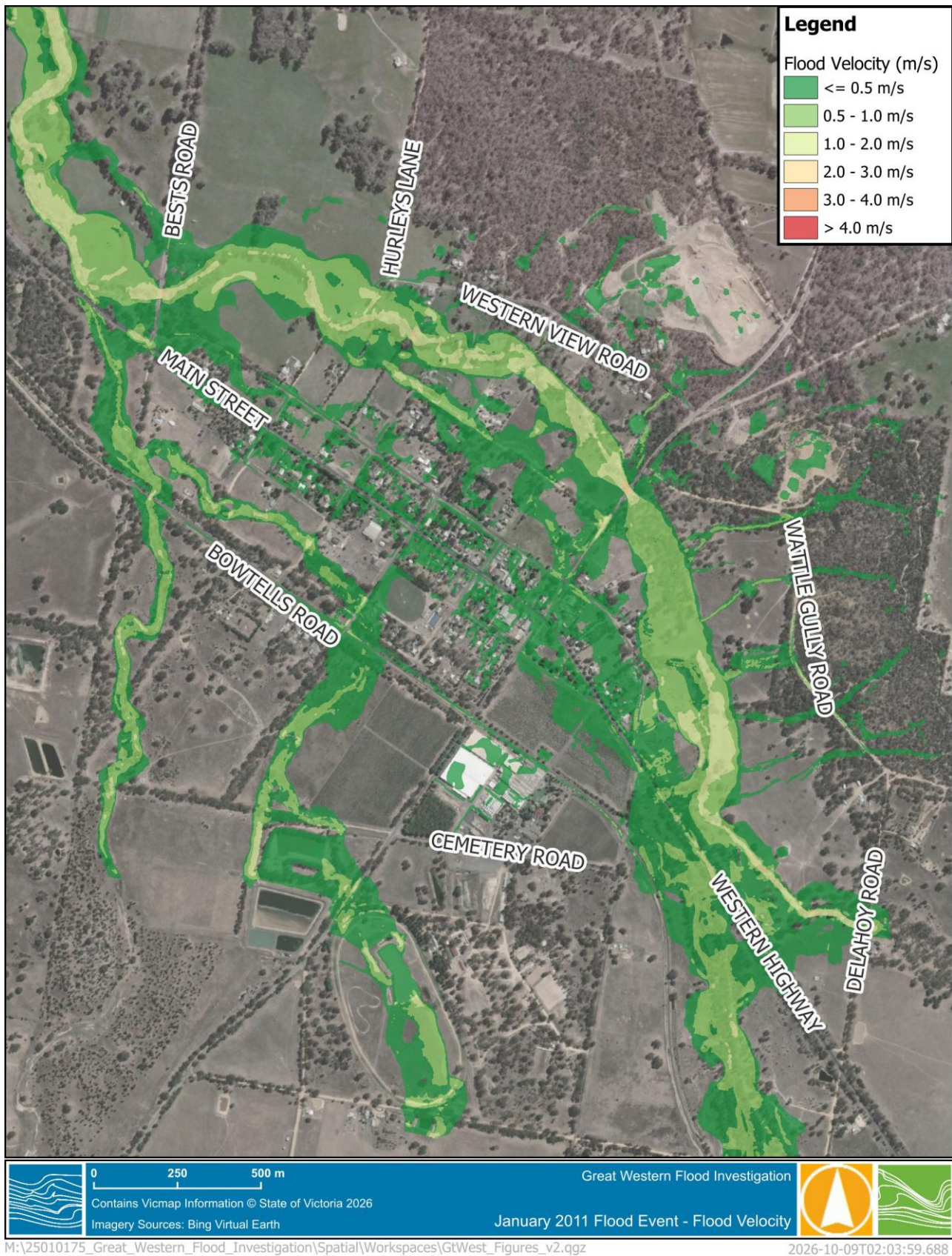


Figure 5-2 Full Study Area – January 2011 Flood Velocity



A-2 Mappings for October 2022 Flood Event

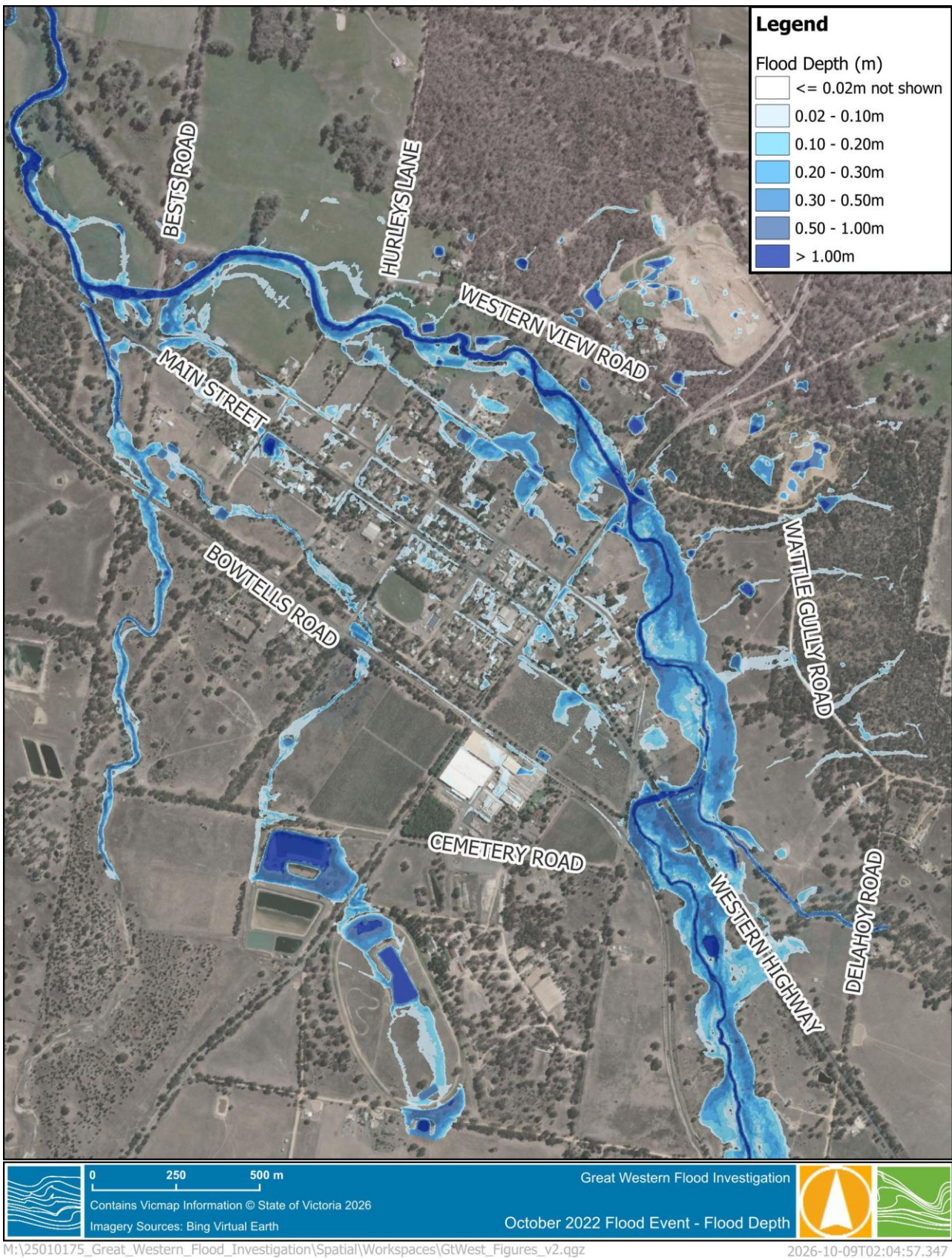


Figure 5-3 Full Study Area – October 2022 Flood Depth

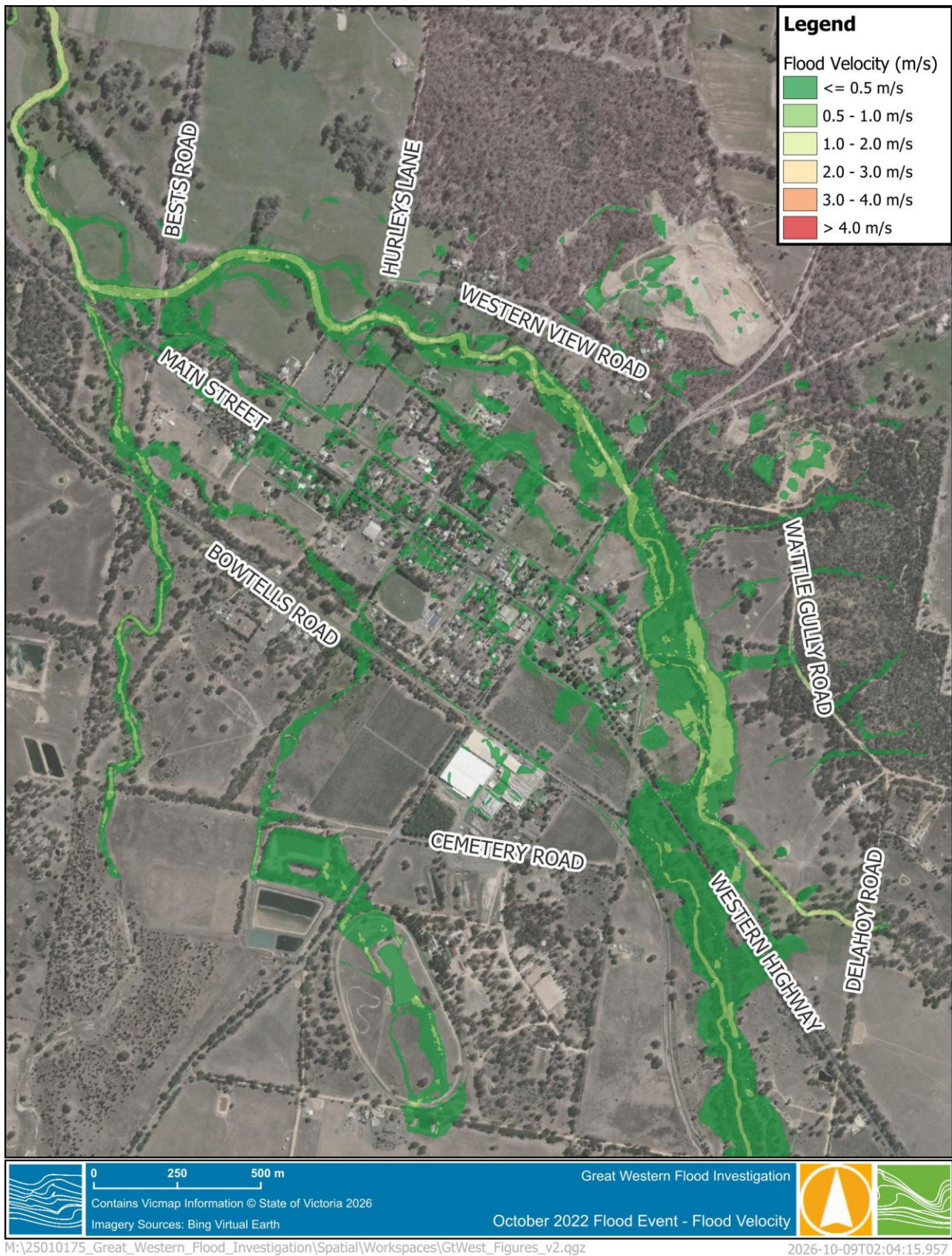


Figure 5-4 Full Study Area – October 2022 Flood Velocity

Melbourne

15 Business Park Drive
Notting Hill VIC 3168

Brisbane

Level 5, 43 Peel Street
South Brisbane QLD 4101

Perth

Level 1, 21 Adelaide Street
Fremantle WA 6160

Wangaratta

First Floor, 40 Rowan Street
Wangaratta VIC 3677

Wimmera

597 Joel South Road
Stawell VIC 3380

Darwin

5/5 Goyder Road
Parap NT 0820

Sydney

Suite 3, Level 1, 20 Wentworth Street
Parramatta NSW 2150

Adelaide

1/198 Greenhill Road
Eastwood SA 5063

New Zealand

7/3 Empire Street
Cambridge New Zealand 3434

Geelong

51 Little Fyans Street
Geelong VIC 3220

Gold Coast

Suite 37, Level 4, 194 Varsity Parade
Varsity Lakes QLD 4227

Sunshine Coast

Office #4 of the Regatta 1 Business Centre
2 Innovation Parkway
Birtinya QLD 4575

1300 198 413



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