Rosedale Flood Study – Summary Report

May 2016

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PROJECT DETAILS

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Cover Photo: Community supplied image from 1934 floods – Main Street of Rosedale (Newsagent).

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- Wayne Gilmour (West Gippsland CMA & Project Manager)
- Adam Dunn (West Gippsland CMA)
- John Inglis (Wellington Shire Council)
- Rebecca Lett (Department of Environment Land Water and Planning)
- Bodye Darvill (Rosedale Neighbourhood House -Community Representative)
- Phillip Logan (Community Representative)

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GLOSSARY OF TERMS

Annual Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded; it would occur quite often and would be relatively small. A 1% AEP flood has a low probability of occurrence or being exceeded; it would be fairly rare but it would be of extreme magnitude.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level. Introduced in 1971 to eventually supersede all earlier datums.
Average Recurrence Interval (ARI)	Refers to the average time interval between a given flood magnitude occurring or being exceeded. A 10 year ARI flood is expected to be exceeded on average once every 10 years. A 100 year ARI flood is expected to be exceeded on average once every 100 years. The AEP is the ARI expressed as a percentage.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Design flood	A design flood is a probabilistic or statistical estimate, being generally based on some form of probability analysis of flood or rainfall data. An average recurrence interval or exceedance probability is attributed to the estimate.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from elevated sea levels and/or waves overtopping coastline defences.
Flood frequency analysis	A statistical analysis of observed flood magnitudes to determine the probability of a given flood magnitude.
Flood hazard	Potential risk to life and limb caused by flooding. Flood hazard combines the flood depth and velocity.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Flood storages	Those parts of the floodplain that are important for the temporary storage, of floodwaters during the passage of a flood.
Geographical information systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.

Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Intensity frequency duration (IFD) analysis	Statistical analysis of rainfall, describing the rainfall intensity (mm/hr), frequency (probability measured by the AEP), duration (hrs). This analysis is used to generate design rainfall estimates.
LiDAR	Spot land surface heights collected via aerial light detection and ranging (LiDAR) survey. The spot heights are converted to a gridded digital elevation model dataset for use in modelling and mapping.
Peak flow	The maximum discharge occurring during a flood event.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Average Recurrence Interval.
Probable Maximum Flood	The flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular drainage area.
RORB	A hydrological modelling tool used in this study to calculate the runoff generated from historic and design rainfall events.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
Topography	A surface which defines the ground level of a chosen area.

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1. INTRODUCTION

1.1 Overview

Following the recent Latrobe River flood study, it was identified that a flood intelligence gap existed in Rosedale and Water Technology was subsequently commissioned by the West Gippsland CMA to undertake the Rosedale Flood Study. This study included detailed hydrological and hydraulic modelling of Blind Joes Creek, taking into account the adjacent catchments (east of Blind Joes Creek) and stormwater runoff within the Rosedale Township itself. The project produced flood mapping of the Rosedale Township and provided recommendations for flood mitigation works, land use planning and flood warning, and generated flood intelligence for emergency response purposes

The following Summary Report (R04), provides a summary of three detailed standalone reports produced earlier in the project. This report acts as an executive summary of the entire study. A description of each of the staged reports is included below.

R01 - Rosedale Flood Study – Data Review (Water Technology 2016a)

Review of flood related information for the study area, a review of available topographic and structure data (bridges and culvert information), and verification of topographic data. The report also provided a proposed outline of the hydrologic analysis and hydraulic modelling methodology.

R02 - Rosedale Flood Study – Hydrology & Hydraulics (Water Technology 2016b)

Hydrologic modelling and analysis report, summarising results of RORB modelling, estimation of design event, and probable maximum flood hydrographs**.** Hydraulic modelling report providing details of hydraulic model construction and calibration, sensitivity tests, and results of design event simulations.

R03 - Rosedale Flood Study – Assess and Treat Risk (Water Technology 2016c)

Includes mitigation prefeasibility and modelling, flood intelligence, flood warning and planning control review.

R04 - Traralgon Flood Study – Summary Report (Water Technology 2016d)

This report which provides a summary of the three reports described above.

These four reports detail the approaches adopted, the findings and the recommendations of the Rosedale Flood Study. The four reports are supported by a number of standalone PDF flood maps and digital deliverables.

1.2 Study Catchment and Floodplain

The Blind Joes Creek and its adjacent catchments to the east have a combined catchment area of approximately 149 km^2. Higher up in the catchment, the contributing waterways are confined to steep valleys, with the headwaters at an elevation of approximately 240 m AHD. As many as nine defined catchments flow off the Strzelecki ranges towards Rosedale. Further down in the floodplain, approximately 3 km south of Rosedale, the contributing waterways and floodplain flatten out. Figure 1-1 shows the contributing catchment upstream of Rosedale. Flows from the Strzelecki ranges and along the flatter floodplain country behind the township have been noted by many residents as causing much of the nuisance flooding in recent events as opposed to flows from Blind Joes Creek.

Flows move through Rosedale to the Latrobe River floodplain via two locations; at the western edge of the township, via the highway bridge over Blind Joes Creek and at the eastern edge of town with shallow flows moving through the streets before finding their way back into the Latrobe River either side of the Princes Highway Bridge. A significant portion of overland flow also continues east sitting behind the Rosedale–Longford Road (and the Railway Line) before flowing north to the Latrobe River near Mullocky Lane.

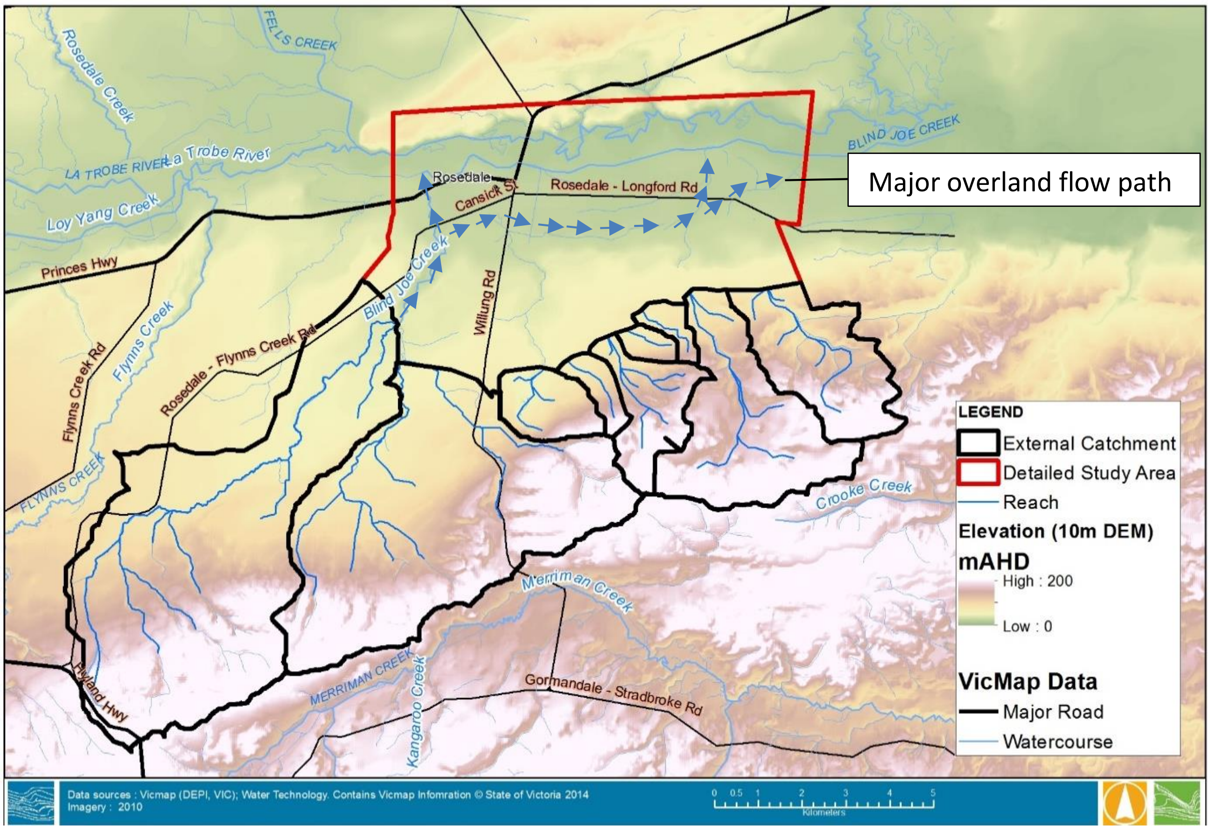

Figure 1-1 Rosedale Contributing Catchments

2. DATA REVIEW

Shortly after the project inception meeting, a detailed review was undertaken of all available flood related information as well as topographic data, structure information, and hydrological data. Details of this review are provided in the Data Review (R01), while a short overview is provided below.

2.1 Flood Related Studies

Rosedale has been the subject of numerous flood related studies and associated mitigation works on the Blind Joes Creek and Latrobe River from the 1930s. Table 2-1 summarises the available reports that were reviewed as well as significant changes within the study area over time.

Table 2-1 Historic Flood information timeline

Event	Description	Relevant information
1863	First river levels (unofficial) collected (EJ Crooke)	Data printed in the Gippsland Times 1934 - confirmed 1934 as biggest flood in this period.
December 1934	Largest flood on record (Latrobe River). Anecdotal evidence suggests that the railway crossing (at Glengarry) failed causing backed up water to be released (like a dam break). Railway bridge/embankment failure downstream of Rosedale.	Peak flow estimate (RWC, 1989) 3,500 m^3/s (150 – 200 year ARI Event) Anecdotal evidence suggests the Latrobe River "backed up" Blind Joes Creek. Flood Level at railway near Willung Road 17.45 m AHD (12 Inches above the railway line)
Post 1934 Floods	Cansick Street Bridge moved Cricket Street Bridge replaced with 5 box culverts (900 x 1,200 mm) Friends & Willung Roads raised by ~300 mm.	
June 1935	Dare report written discussing railway bridge failures in 1934.	Description of bridge failure mechanism and hydrologic implications (flood travel times etc).
1938	New Highway bridge complete	
June 1952	Large flow in Latrobe River (1,874 m^3/s - ~40 year ARI)	
1952 (date unknown)	Large flow in Blind Joes Creek, limited flooding in Latrobe River. Floodway south of town engaged. Little impact on township.	
October 1953	Large flow in the Latrobe River (1,701 m^3/s – ~40 year ARI).	
1961	Lake Narracan (Latrobe River – 2,730 ML) & Moondarra Reservoir (Tyers River – 29,700 ML) constructed	

Event	Description	Relevant information
1966-68	Holy Plains drainage scheme constructed. System designed to drain land south and east of the town.	
June 1978	Significant flooding throughout Gippsland. Large flow in the Latrobe River (1,500 m^3/s - ~ 30 year ARI). Anecdotal evidence suggests the Cansick Street bridge was blocked by debris and the floodway south of town became engaged.	
1983	Residents request a significant maintenance program be undertaken on the Holy Plain drainage system. Council holds community meetings to discuss solutions.	
1984	Blue Rock Dam constructed (Tanjil River - 208,000 ML)	
October 1987	RWC wrote to council nominating the 1934 flood as equivalent to 100 year ARI event (3,500 m^3/s peak flow in the Latrobe River).	
1989	RWC complete the "Rosedale Flood Study Frequency Analysis" 100 year ARI flow in the Latrobe River is revised down to 3,010 m^3/s. Flood levels are dropped by ~200 mm.	90 m^3/s adopted as the 100 year ARI flow in Blind Joes Creek (catchment comparison method with Traralgon Creek).
1992	RWC revise the 100 year ARI flows back to the 1934 flood estimate (3,500 m^3/s).	
September 1993	Significant rain in the Strzelecki Ranges (up to 300 mm in 24 hours) resulted in major flooding in Blind Joes Creek. Flooding not as significant in the Latrobe River (980 m^3/s – 20 year ARI).	Shire of Wellington collect flooding images and flood levels (level data possibly not peak heights).
November 1993	Gutteridge Haskins & Davey (GHD) "Rosedale Flood Management Plan (Stage 1)" released to the Shire of Wellington.	1934 Flood > 100 year ARI (150 year ARI); 100 year ARI flow in the Latrobe 2,730 m^3/s & 90 – 100 m^3/s in Blind Joes Creek; Flood levels at Rosedale in 1934 were not significantly impacted by the railway embankment failure at Glengarry.
April 1995	Dept. of Conservation & Natural Resources "Rosedale Flood Investigation (Stage 1)" released to the Shire of Wellington.	1934 Flood represented the 100 year ARI; 100 year ARI flow in the Latrobe 3,500 m^3/s and 100 m^3/s in Blind Joes Creek;

Event	Description	Relevant information
		Blind Joes Creek flows Split at the railway bridge with 40% flowing north and the balance flowing east. HEC2 hydraulic modelling defined a 100 year ARI flood extent, the hydraulic model was calibrated to the 1993 event flood levels, Latrobe TWL sensitivity applied. Mitigation options presented including levees.
June 1995	Gutteridge Haskins & Davey (GHD) "Rosedale Flood Management Plan (Stage 2)" released to the Shire of Wellington.	Dept. of Conservation & Natural Resources 1993 hydrology and Blind Joes Creek flow split adopted. HEC2 model revisited and updated including additional mitigation analysis. Flood level from the Latrobe of 17.6 m AHD (33 year ARI) was determined to be the threshold level at which breakout north of the railway could occur. This happened in 1934. Community consultation undertaken. Community were pro levees.
February 2000	Shepherd Round Consultants Report released "Rosedale Flood Management Plan"	The report noted: "Primary mechanism of flooding within in Rosedale township is produced by flood levels in the Latrobe River". Flood Warning system for Blind Joes Creek not justifiable. New alignment of the GHD levee proposed, geotech investigation completed and mitigation costings revisited. Further investigations recommended. Funding application completed on behalf of the Shire of Wellington.
September 2001	GHD report "Rosedale Flood Warning System – Hydrology Report" released to the Shire of Wellington.	Flood frequency revisited, 100 year ARI flow revised down to 2,610 m^3/s. New hydrology – URBS model New photogrammetry New hydraulic model (DELFT) Model calibrated to the 1934 and 1993 events
2013	Latrobe Flood Study completed by Cardno. Larger flood study covering Yarragon to Sale. Flooding of the Latrobe	New Flood Frequency Analysis, new/revised hydrology (BoM URBS model), new hydraulic model (SOBEK). Latrobe 100 year ARI flow very different

Event	Description	Relevant information
	and all major tributaries considered (inc. Blind Joes Creek).	to all other historic studies (1,875 m^3/s), Blind Joes Creek inflows not reported. The coarse grid (~40 x40m) in the hydraulic modelling resulted in much of the Rosedale Township being shown as flooded in a 100 year ARI event.
2014	New Princes Highway bridge over Blind Joes Creek (highway duplication works).	Water Technology complete waterway investigations for VicRoads. Study includes new hydrology for Blind Joes Creek (RORB Model), limited hydraulic analysis (MIKE FLOOD) focused on Princes Highway bridge.

2.2 The Latrobe Flood Study 2013

WGCMA recently completed the Latrobe River Flood Study (Cardno, 2013), which included updated hydrology and hydraulics for the river. The study generated detailed results throughout the Latrobe River Floodplain including north of Rosedale. This study included inflows from Flynn's, Middle and Blind Joes Creeks but didn't consider the other smaller catchments south of the township.

Due to the grid size applied (40x40m) in the hydraulic modelling of Blind Joes Creek, it is not considered an accurate representation of current flood behaviour. The study did provide a significant amount of information on flood levels on the Latrobe River Floodplain.

Using the Latrobe River flood study results, Water Technology was able to demonstrate how far the Latrobe River can "back up" into the town during different events. The results of this analysis are shown in Figure 2-1. It suggests that very few homes would be inundated if a large flood occurred only in the Latrobe River, with the worst flood prone areas being Allen Court, Mackay Street (northern end), Queen Street and Mill Lane. At the western edge of the township, it suggested that both Blind Joes Creek and the Latrobe River must interact to cause flooding on the land between Cansick Street and the Princes Highway.

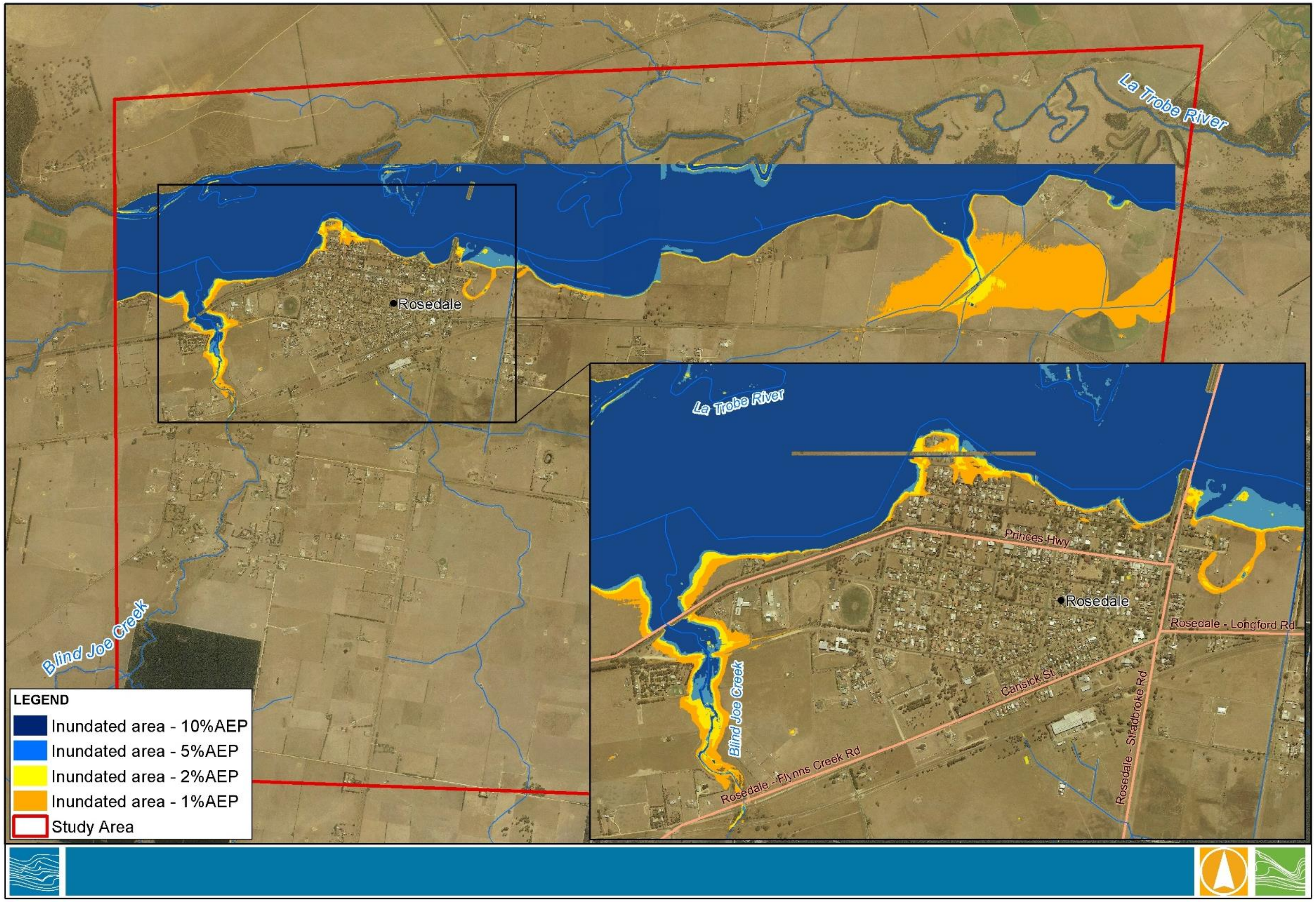

Figure 2-1 Latrobe Flood Study Results – Estimated area inundated by the Latrobe River (excludes Blind Joes Creek flooding)

2.3 Historic Flood Information

Significant historic flood events have been compiled from available sources and are listed in Table 2-1. The largest flood on record (since 1863) was in December 1934, with flows in the Latrobe River estimated to be close to a 0.5% AEP event. After this event, two gauging stations were established at Rosedale, with one on the Latrobe River and the other on the Latrobe Anabranch. Review of both rainfall and gauging data have suggested that the next biggest floods on record occurred in the 50's (1952 and 1953), followed by 1978 and 1993.

The most comprehensive historic flood information is available for the 1993 event, including digitised flood extent, surveyed flood levels and numerous flood photographs, collated for Hydrotechnology's report on the 1993 Gippsland floods. Some data was also available for the 1934 and 1978 events.

2.4 Topographic Data

2.4.1 Available Datasets

Initially, two Aerial LiDAR (Light Detection and Ranging) survey datasets were available for use in this study (listed below); however, between them they did not cover the entire area of interest.

- Index of Stream Condition (ISC) Rivers LiDAR
- SRW-90MB LiDAR

Additional LiDAR data was captured as part of the project to fill the gap. Upon review of the available LiDAR it was decided to use the SRW-90MB LiDAR and the "new LiDAR" in the hydraulic model build. Additional field survey including several transects, river cross sections and culverts was carried out to verify the LiDAR data, provide an estimate of channel capacity and fill data gaps of important hydraulic structures.

2.4.2 Data Verification

The two LiDAR datasets that were used for the construction of the hydraulic model were compared against the field survey data and each other. The survey data included several cross sections of the creek and two transects located at Willung Road and Dawson Street.

Compared to each other the two LiDAR data set were generally very accurate, with a mean difference of 0.069 m. Compared to the transect survey sections, the survey was higher than the LiDAR data (200 mm+). As both LiDAR data sets were generally in agreement with each other it was not proposed to modify them.

2.4.3 DEM Development

As mentioned previously, the SRW-90MB LiDAR and "new LiDAR" were combined and used to generate the digital elevation model for the hydraulic model. Initially, the Latrobe River was modelled at a 12 m grid resolution while the Rosedale Township was modelled with a 4 m grid resolution.

For the validation modelling of 1993 and 2012 events, the SRW-90MB LiDAR (2008) was used in preference (sat on top) over the "new LiDAR", however this arrangement was reversed in the design modelling as the new LiDAR better reflected current conditions.

2.5 Structure Information

There are several key hydraulic structures within the Rosedale Township located on Blind Joes Creek. These hydraulic structures play an important role in flood events ranging from small, frequent events through to large, rarer flood events. Several of these structures within and around the township include; the Melbourne-Bairnsdale Railway line; Cansick Street and Princes Highway. Information on these structures was obtained through the Wellington Shire Council, West Gippsland CMA as well as a site visit on October 16, 2014. Bridge piers, deck heights and culvert dimensions were sourced and added to the hydraulic model.

2.5.1 Pit and Pipe Network

The Rosedale stormwater drainage network was incorporated in the 1D/2D hydraulic model using pipe and pit information provided by the Wellington Shire Council. A significant data gap was identified in the pit and pipe network, therefore considerable engineering judgement was applied to the drainage network. The changes made to the existing database ensure the pit and pipe network functioned within the hydraulic model and were noted in the GIS database.

2.6 Hydrological Data

2.6.1 Australian Bureau of Meteorology

The average annual rainfall at Rosedale is approximately 650 mm. A steep rainfall gradient exists over the catchment with average annual rainfall reaching around 1,100 mm in the headwaters.

Numerous daily rainfall sites are in operation around the region. Key stations, including current stations and stations operating over the 1993 and 2012 floods, are listed in Table 2-2. Unfortunately, no daily rainfall stations exist within the Blind Joes Creek catchment for both the 1993 and 2012 flood events.

Table 2-2 Daily rainfall stations around Blind Joes Creek catchment

Gauge No.	Location	Distance from township (km)	Year opened	End of Record	Years of Data
85071*	Rosedale	0.7	1878 Sep	2005 Aug	123.9
85126	Nambrok	11.8	1908 Mar	1931 Dec	23.8
85271	Nambrok Murray	14.3	1979 Oct	1980 Mar	0.5
85076	Stradbroke West (Inglenook)	17.5	1891 Aug	1982 Nov	91.1
85022	Denison (Wandocka State School)	17.8	1933 Aug	1993 Nov	55.7
85009	Traralgon Epa	22.4	2000 Dec	2014 Nov	14
85170	Traralgon L.v.w.& S.b.	23.7	1967 Jul	1990 Dec	23.4
85236	Callignee North	26.4	1956 Jan	2014 Aug	57.1
85297	Maffra	26.6	1993 Oct	2012 Dec	19.3
85034	Glenmaggie Weir	26.8	1938 Jan	2014 Nov	76.8
85280	Morwell (Latrobe Valley Airport)	27.3	1984 Jan	2014 Nov	30.9
85083	Tinamba West	27.7	1905 Oct	1950 Jun	44.7
85299	Koornalla Traralgon Ck Rd	28.8	1994 Apr	2014 Sep	20.5
85281	Traralgon Creek at Koornalla	29.0	2000 Dec	2014 Nov	14
85105	Hazelwood North	29.5	1939 Jan	1990 Aug	36.8
85035	Glenmaggie (The Laurels)	29.6	1905 Oct	1957 Dec	51.8
85011	Blackwarry	29.9	1888 Oct	1974 Apr	85.3
85017	Callignee South	30.2	1932 Mar	1985 Nov	53.8

* No data available for September 1993

Pluviograph (sub-daily rainfall) stations around the Blind Joes Creek catchment are listed in Table 2-3. The 1993 event was captured at East Sale Airport, Morwell and Caligneе North pluviographs. The 2012 event was captured at all listed stations except East Sale.

Table 2-3 Pluviograph stations around Blind Joes Creek catchment

Gauge No.	Location	Distance from township (km)	Year Opened	End of Record	Years of Data
227239	Stradbroke West	17.5	June 2006	-	9
85236	Callignee North	26.38	1956 Jan	-	57.1
85170	Traralgon L.v.w.& S.b.	23.7	1967 Jul	1990 Dec	23.4
85280	Morwell (Latrobe Valley Airport)	27.34	1984 Jan	2014 Nov	30.9
85072	East Sale Airport	30.87	1943	2011 Sept	71

2.6.2 Other rainfall sources

It was identified in the data review stage of this project that limited rainfall data existed inside the study area for the 1993 and 2012 events. It was also noted that rainfall totals are expected to vary significantly from the upper reaches to the flatter valley country were the township is found. To fill this data gap, community rainfall information was requested for the 1993 and 2012 events. Steering committee representative and Coordinator at Rosedale Neighbourhood House, Bodye Darvill, was instrumental in this process. Daily rainfall totals collected are detailed in Table 2-4 and Table 2-5.

Community rainfall records were cross checked (where possible) and combined with the official BoM records to provide a more accurate spatial spread of rainfall event depths throughout the study area. The rainfall depth information (combining community and BoM records) was then used in the hydrologic model (RORB) to estimate runoff from the ranges south of the township. Hydraulic modelling outputs using the community and BoM rainfall information was then compared to observed flood information. This approach is common in catchments where limited data is available.

Table 2-4 Community supplied daily rainfall for September 1993

Source	Location	Location (GDA94 MGA 55)	Daily rainfall depth (mm) in September 1993						
			12th	13th	14th	15th	16th	17th	18th
Colin Stuckey	1580 Princes Highway Flynn Vic 3844	474,097.4 5,775,757.9	1.5	5.6	3.3	37.6	32.5	1.3	2.0
Willohra Station	8140 Willung Rd Willung Vic 3847	482,637.6 5,767,093.6		3.5	15	75	14.5	8.5	

Table 2-5 Community supplied daily rainfall for June 2012

Source	Location	Location (GDA94 MGA 55)	Daily rainfall depth (mm) in June 2012			
			3rd	4th	5th	6th
Colin Rowse	18 Queen Street Rosedale	481,379.3 5,777,560.7	4.5	5	74	
Willung Farm Products	8140 Willung Rd Willung Vic 3847	482,637.6 5,767,093.6	12	38.5	56.5	
Noel Schroeder	1/33 Dawson Street, Rosedale	481,087.9 5,776,925.2		6.5	73	2.5
Wayne Gilmour	Princes Highway Flynn Vic 3844	473,761.0 5,774,926.0	4.25		71.5	

2.6.3 Streamflow Data

Gauge Locations

As many as 18 active gauging stations are found in the Latrobe River catchment upstream of the Rosedale Township. Of most relevance to this study are two sites immediately north of the township (shown in Table 2-6). While both sites are identified as representing Latrobe River flows, this is only true in times of significant flow in the Latrobe River. Under typical conditions the Latrobe River Anabranch site represents flows from the Blind Joes and Middle Creek catchments as well as the Rosedale township urban runoff.

Table 2-6 Relevant Stream flow gauges in the Rosedale area

Gauge No.	Location	Period	Years	Catchment Area (km^2)
226224	LATROBE RIVER (Blind Joes Creek) @ ROSEDALE (ANABRANCH)	1936-2014	78	4,144
226228	LATROBE RIVER @ ROSEDALE (MAIN STREAM)	1936-2014	78	4,144

Given a comprehensive investigation into the Latrobe River hydrology was completed in the Latrobe River Flood Study and that the focus of this study was not on the Latrobe River, gauging station data on the Latrobe River was not intensively reviewed in this study. Instead, assumptions and key findings from the Latrobe River Flood Study were reviewed and adopted as boundary conditions. Peak flows were extracted from the available gauging data with the results of this analysis shown in Table 2-7.

Table 2-7 Key event peak flows

Station ID	*Station Name*	Peak Flow (m^3/s)					
		June 1952	October 1953	June 1978	September 1993	November 1995	June 2012
226228	*Latrobe River @ Rosedale* (Main Stream)*	319	353	252	186	160	101
226224	*Latrobe River @ Rosedale* (Anabranch)*	1,215	1,007	1,012	829	821	353
Combined flow+ Latrobe Flood Study 2012		1636	823	1499	1015	980	NA

* Data extracted from the DELWP water portal March 2015 (http://data.water.vic.gov.au/monitoring.htm)
+ Cardno hydrology report states their data source as "combined flows from 226228 and 2 26224. Data Warehouse predominantly, in-filled with Red Book data if higher values". It is unclear why this data is not equal to the sum of the data extacted from the DELWP water portal.

2.6.4 Latrobe River Flood Study – Design Flow estimates

Table 2-8 represent combined flow at both the Latrobe River and the Latrobe River Anabranch gauging stations. These flows were estimated during the Latrobe River Flood Study. This information was used to represent concurrent flooding in the Latrobe River when significant rainfall occurred in the ranges south of the Rosedale Township.

Table 2-8 Latrobe River Flood Study FFA results and historic peaks from 226228 & 226224 (combined)

Design AEP and Historic Year	Peak Flow (m^3/s)*	Upper 95% Confidence Limit	Lower 95% Confidence Limit
10%	327	410	269
5%	567	750	448
1953	823		
1995	980		
1993	1015		
2%	1132	1614	845
1978	1499		
1952	1636		
1%	1875	2832	1339
0.5%	3071	4912	2097

* Data reproduced from Latrobe Flood Study - Hydrology report 2012

3. PROJECT CONSULTATION

3.1 Overview

An important element of the flood mapping study was the active engagement of residents in the study area. This engagement was developed over the course of the study through community consultation sessions and meetings with a Steering Committee. The aims of the community consultation were as follows:

- To raise awareness of the study and to identify key community concerns; and
- To provide information to the community and seek their feedback/input regarding the study outcomes including the existing flood behaviour and proposed flood mapping extents.

3.2 Steering Committee

The flood mapping study was led by a Steering Committee consisting of representatives from West Gippsland Catchment Management Authority (WGCMA), Wellington Shire Council (WSC), Department of Environment Land Water and Planning (DELWP), Victorian State Emergency Service (VicSES), Ventia (the current Gippsland Regional Water Monitoring Partnership contractor) and community members from Rosedale.

The Steering Committee met on three occasions at key points throughout the study, to review study progress, provide comments regarding results, and manage the development of the study.

3.3 Community Consultation

The main aim of the community engagement process was to provide information regarding the development of the study and to seek feedback, both verbally and through the use of online methods. All community meetings were supported by media releases to local papers and meeting notices.

The public consultation process was coordinated by West Gippsland CMA. The following community meetings were held as part of the consultation process:

- Initial community meeting, 25 November 2014 at the Rosedale Community Hub – The first public meeting was held to outline the objectives of the study to the community and to receive any flood information the community may be able to provide;
- Second community meeting, 30st March, 2015 at the same venue – This meeting presented the results of the flood modelling. Community feedback was sought on the flood modelling results.
- Final Community meeting 16th of September 2015 at the same venue – This meeting discussed potential future flooding and mitigation options to manage flood risk into the future.

The community provided knowledge of a range of previous floods. Most data was anecdotal (personal accounts opposed to photos or physical flood marks or locations of direct impact) and related to the 1993 and 2012 flood. Never the less this information was useful in validating the 1993 and 2012 events. In the first meeting we were lucky enough to have a 94 year old resident attend who lived in Rosedale during the 1934 flood (the largest in living memory). Listening to his accounts of this event were both interesting and informative.

An ArcGIS online portal presenting the flood mapping was published allowing for public comment. Four comments were left on the site. Three suggested that the mapping was over estimating flood depths in both events, while the fourth suggested some of the urban mapping was accurate.

As a result of this feedback mechanism and the community consultation process, additional rainfall data was requested from the community. It became apparent that the official gauges located on higher elevation to the north and south of our study catchment were all recording higher rainfall estimates than the community rainfall records located lower in the Latrobe River valley. These community rainfall records are most likely more representative of the rainfall that actually occurred in our study catchment. Hydrologic and hydraulic modelling combining the BoM records with the additional community rainfall record resulted in a reduction in extent and depth of flooding throughout the study area for the historic calibration events, this led to a better estimate of the observed flood marks and other data such as oblique flood images. Note that these community rainfall estimates do not influence the design rainfall estimates used to produce the design flood mapping.

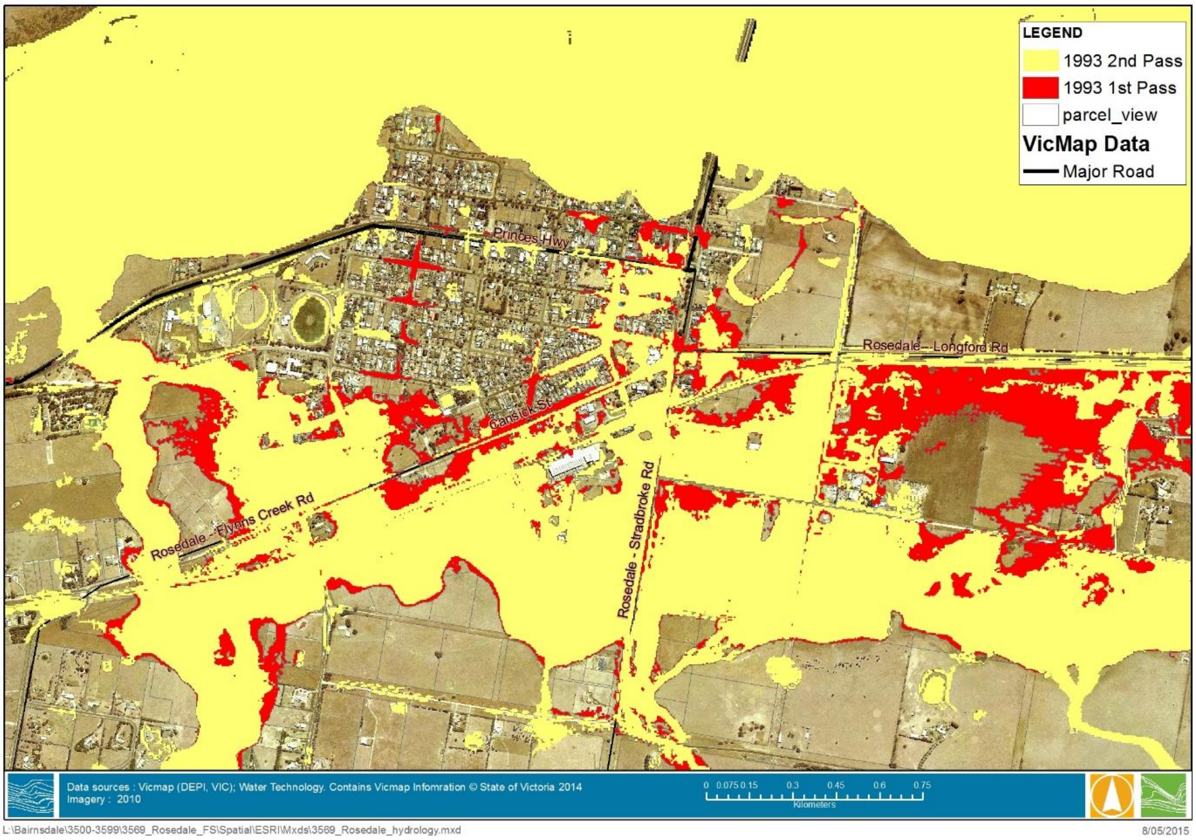

Figure 3-1 Approximate change in flood extent after using community rainfall records

4. FLOOD BEHAVIOUR

4.1 Overview

Flooding in and around Rosedale can occur via three independent mechanisms:

- Flooding from the Latrobe River. Latrobe River has a large upstream catchment area approximately 4,150 km² so can generate larger flows and take longer to reach Rosedale after rainfall occurs.
- Flooding from the smaller catchments south of the township including Blind Joes Creek. Relatively small catchment area of approximately 150 km², generates less flow than the Latrobe River and will arrive quicker than Latrobe River flows after intense rainfall.
- Localised flooding within the town itself from high intensity short duration rainfall generating stormwater flooding.

Flooding from each of these mechanisms can occur independently or often at the same time. As the main portion of town sits above the Latrobe River floodplain direct flooding from the Latrobe River is relatively limited with the Latrobe River Flood Study (Cardno 2013) showing only Mackay, King and Queen Streets seeing direct inundation from the Latrobe River and only in very rare events (1% and 2% AEP floods). Similarly stormwater flooding can cause significant localised nuisance flooding but is unlikely to cause inundation above floor levels or isolation for extended periods (road closures). The major driver of significant flooding in Rosedale is the smaller catchments found to the south of the township including Blind Joes Creek. Whilst flooding from these catchments doesn't inundate a lot of dwellings above floor, inundation is widespread and can cause isolation.

The flood behaviour associated with catchment flooding mechanisms has been assessed using a range of industry standard approaches and tools:

- Hydrological analysis – this involves the analysis of the magnitude of previous flood events in the catchment, the development of a rainfall-runoff model for the entire catchment, and the prediction of the likelihood of future flood events of a given magnitude.
- Hydraulic analysis – the physical understanding of how a given flood event may behave as the flood flows break out of Blind Joes Creek and flow from the various minor waterways and overland flow paths south of town. A hydraulic model was used to predict the extent of flooding, flood depths and flow velocities for a range of possible future flood events.

The hydrological analysis for Rosedale consisted of a review of the hydrological context of the study area followed by hydrologic modelling using RORB. Given the lack of stream flow gauges in the upper catchment and the fact that the Latrobe River flow combines with Blind Joes Creek flow as measured by the Anabranch gauge in Latrobe River floods greater than 10% AEP, the use of the Latrobe River Anabranch streamflow gauge for a typical model calibration was not possible. The study area was therefore treated as an ungauged catchment, with hydrology and hydraulic modelling being developed in tandem.

Outputs from the hydrology model were input to the hydraulic model, and the resulting extents/timing/peak flows were compared to observed data. Where significant discrepancies occurred in water level and extent in the hydraulic model, the hydrological model parameters were modified/refined. Once a close agreement was achieved in both the anecdotal timing of the peak flow and the modelled water levels and extents within Rosedale, the RORB modelling was considered validated and suitable for design flood estimates.

The lack of data on Blind Joes Creek and its adjacent catchments meant the bulk of the validation work focused on the 1993 event. It was assumed that if a suitable match could be achieved with the 1993 event then the parameters adopted could be applied to other historic events to see if representative flooding could be replicated.

The different flood mechanisms and the results of the hydrologic and hydraulic analysis for the study area are discussed in detail in the following sections.

4.2 Hydrology

Detailed information on the hydrology can be found in the Hydrology & Hydraulics Report (R02).

4.2.1 Streamflow Gauging

The data review report identified that current existing gauging data inside the study area was only useful for identifying flows within the Latrobe River. This information was used to inform boundary conditions within the hydraulic model.

4.2.2 Hydrologic Modelling

A hydrological model of the catchment was developed for the purpose of extracting design flows to be used as boundary conditions in the Rosedale hydraulic model. The rainfall-runoff program, RORB (Version 6) was used for this study.

RORB is a non-linear rainfall runoff and streamflow routing model which is used for calculation of flow hydrographs in drainage and stream networks. The model requires catchments to be divided into subareas, connected by a series of conceptual reach storages. Design storm rainfall is input to the centroid of each subarea. Specified losses are then deducted, and the excess routed through the reach network. The RORB model setup is shown in Figure 4-1.

The catchment was split into 9 independent drainage systems (Figure 4-1). These catchments were then split into 51 sub-catchments with areas ranging from 0.2 to 6 km^2. Each of the nine catchments were set up in RORB with interstation areas, this enabled unique RORB modelling parameter to be applied to each catchment. The Blind Joes Creek catchment was used as the reference catchment, with all other catchment parameters scaled using catchment area and average flow distance relationship. The hydrological contribution from the study area downstream of the RORB outlets shown in Figure 4-1 was included via the direct rainfall-on-grid approach in the hydraulic model.

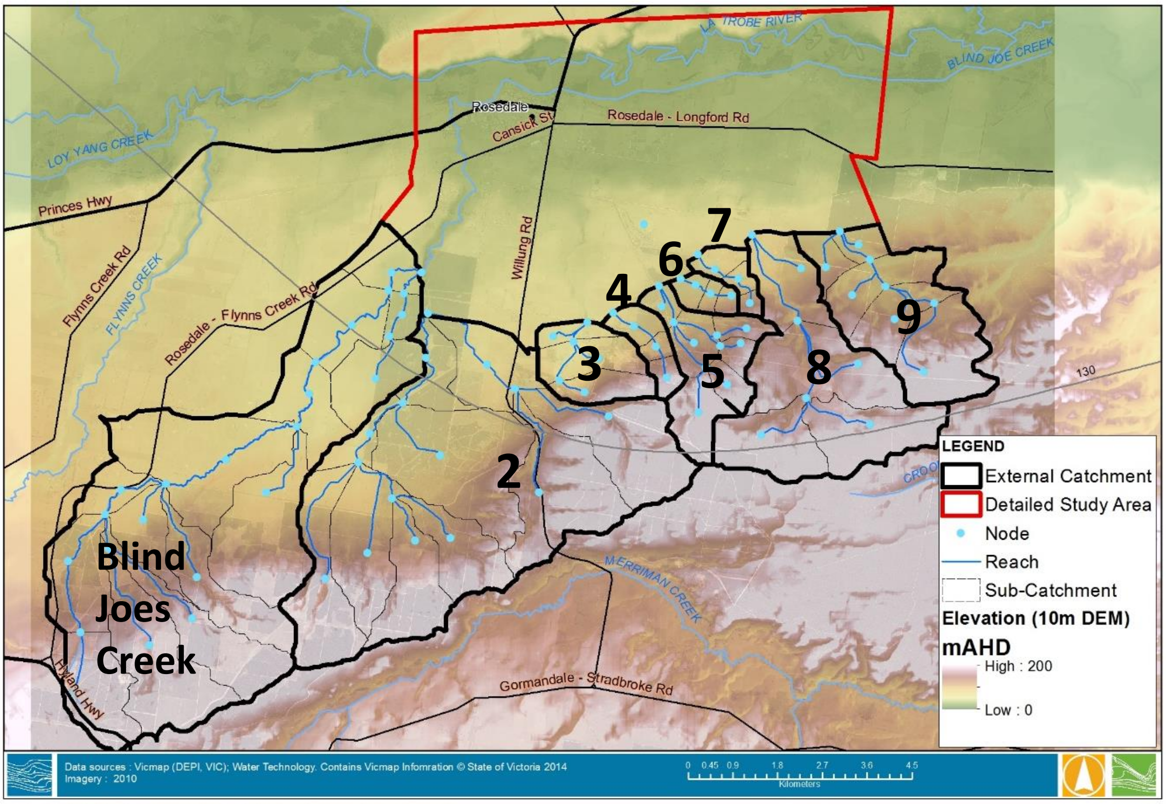

Figure 4-1 RORB Model Structure

Two recorded events were used for the validation of the RORB hydrologic model; September 1993 and June 2012. Each of these events was represented with a unique temporal and spatial rainfall pattern generated from local rainfall gauge records. The spatial pattern incorporated both Bureau of Meteorology and community supplied rainfall depth estimates.

Given the lack of any Bureau of Meteorology rainfall records within the Blind Joes Creek catchment, the community rainfall records were very important for understanding rainfall within the catchment. The records clearly showed the official gauges located higher up in the catchment to the south received higher rainfall totals than the valley floor. Having a more complete understanding of the rainfall with these community rainfall records has led to improved hydrological estimates for Rosedale.

Figure 4-2 and Figure 4-3 shows the spatial rainfall pattern across the catchment for the two calibration events. Less community supplied rainfall was available for the 1993 event. Spatial distribution rainfall identified in the 2012 event was reviewed against the 1993 data. This analysis identified that without a point within the Rosedale township, rainfall depths in that area became dominated by the Stradbroke and Willung data (overestimating depth). To rectify this, an interpolated 1993 rainfall depth was included inside the Rosedale Township spatial distribution. The depth applied was consistent with the 2012 relationship between Flynn and Rosedale rainfall depths.

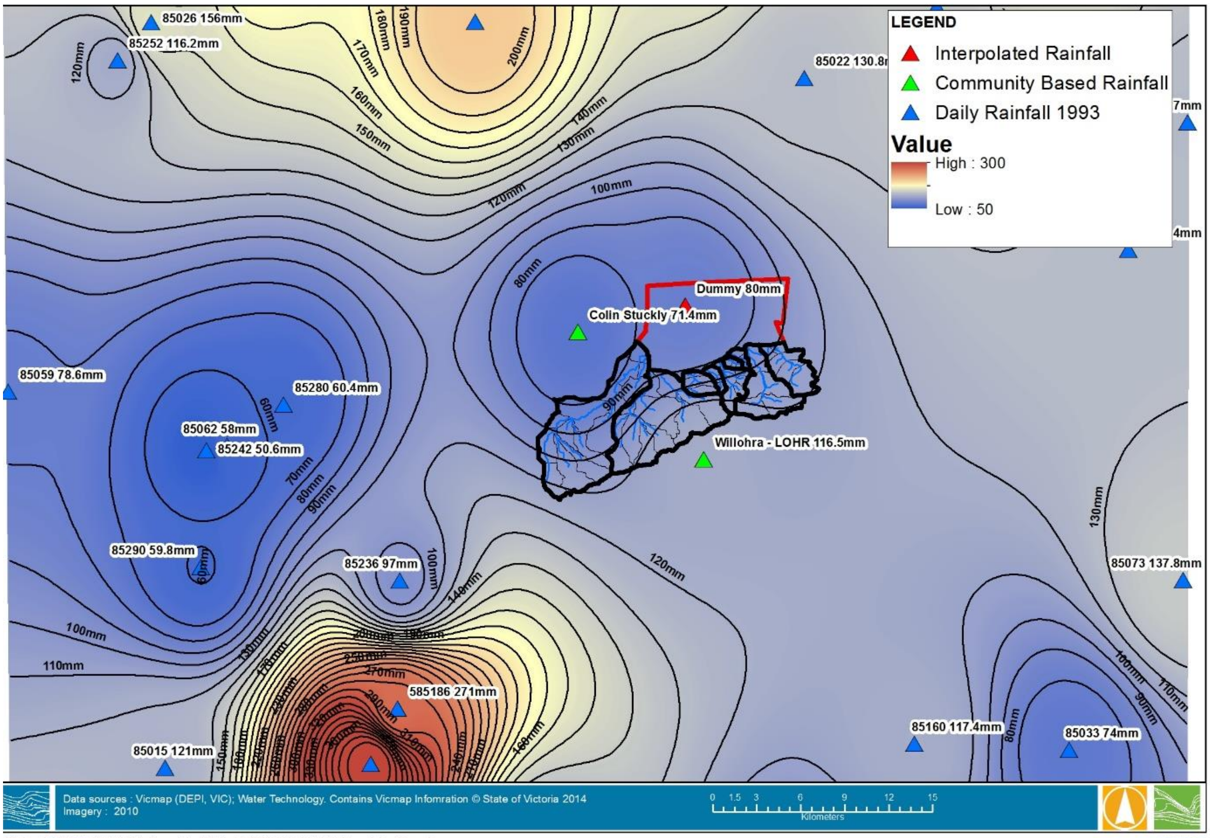

Figure 4-2 Total rainfall across the catchment for the September 1993 calibration event

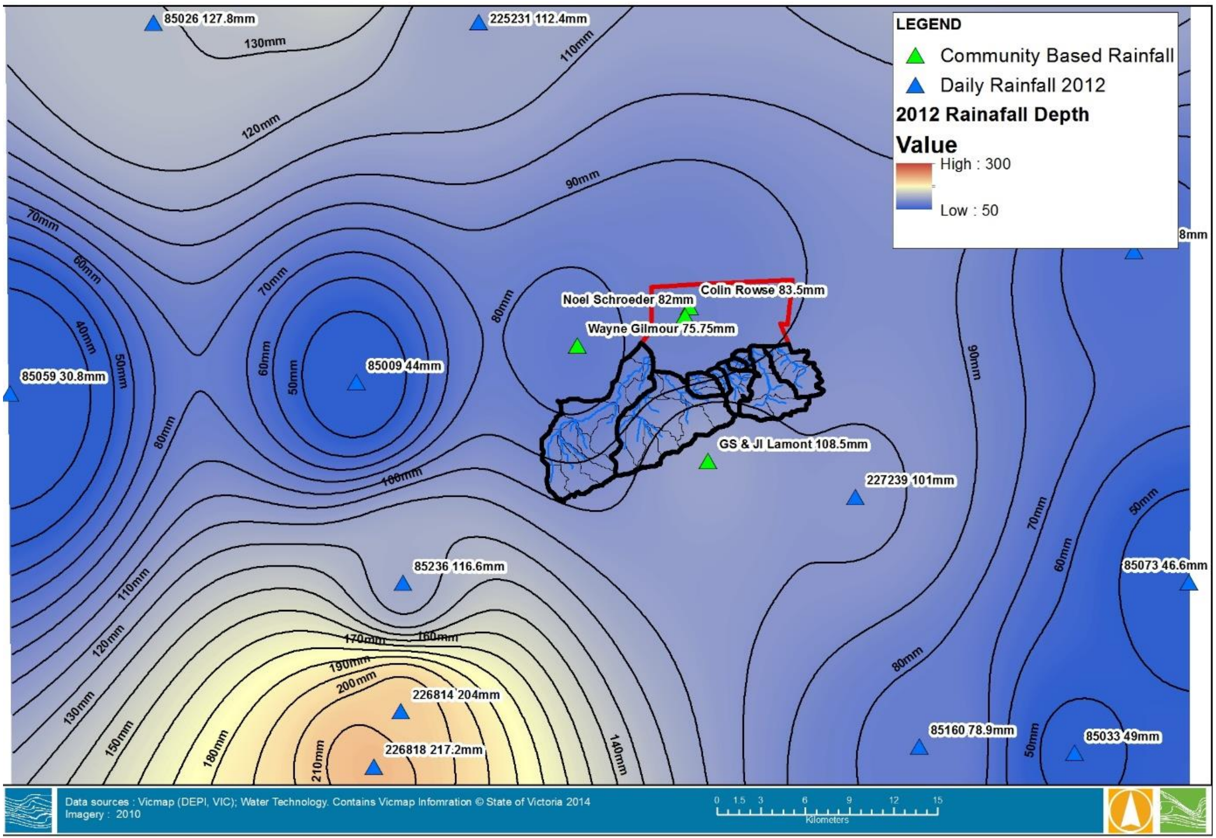

Figure 4-3 Total rainfall across the catchment for the June 2012 calibration event

RORB modelling parameters were initially estimated using Regional equations. Losses were informed by recent studies in adjacent catchments.

As there were no streamflow gauges on either Blind Joes Creek or the smaller catchments to the east, the predicted flows from the RORB model were input into the hydraulic model and verified against observed flood levels and extents during the September 1993 flood event. In addition, the June 2012 event was modelled and compared to video footage (WGCMA) and flood images provided by Wellington Shire Council.

The RORB model was run using a range of kc model parameters and loss values (initial and continuing loss) to understand the sensitivity of predicted peak flow and volume to these model parameters. Based on the results, a selection of the RORB model results were run in the hydraulic model to understand the sensitivity of peak water level and extent to the estimated flows. This was completed for both the September 1993 event and June 2012 events. As there was greater information available for the September 1993 event it was used as the primary event for validation of model parameters, with the June 2012 event used for comparison and to provide additional verification.

The process was iterative, and model parameters were modified to match the modelled water levels and extents to observations during September 1993 event and June 2012 events.

4.3 Hydraulic Modelling

This section discusses the application of the hydraulic model to simulate flood behaviour (extents, depth, velocities) for a range of flood magnitudes.

The hydrologic analysis previously discussed, provided flood inflow hydrographs for the hydraulic model. The hydraulic model was then used as a tool to validate the hydrology against the limited available data (flood marks and photography).

A detailed description of the hydraulic model setup, validation, sensitivity tests and design event simulation is provided in the Hydrology & Hydraulic Report (R02). This section summarises the general model development and key outcomes from the hydraulic modelling investigation.

Initially a multi domain model using a 4 m grid resolution for Rosedale and the surrounding land, combined with a 12 m grid resolution for the large Latrobe River floodplain was adopted. The Latrobe River floodplain was modelled using a larger grid size as the level of detail required for the Latrobe River was less and the waterway features are wider and are able to be resolved in a coarser grid.

This setup was used in the validation modelling and initial design modelling. With the validation modelling complete and approved, sensitivity to initial flood levels in the Latrobe River was undertaken, this analysis showed that with higher levels in the Latrobe changes in peak flood levels and extents within the town were largely unchanged. At the conclusion of this process it was agreed to modify the flood model to a single domain covering only the Rosedale Township and its surrounds. In this modelling the Latrobe River levels were represented with a static water level consistent with a smaller flood occurring concurrently with the localised flooding.

The modelling process involved the following stages:

- Model setup and calibration to the two calibration events (1993 and 2012).
- Validation and sensitivity tests (boundary conditions and materials roughness).
- Design flood simulations (events from 10% AEP through to 0.5% AEP).

The calibration, validation, and sensitivity assessments are an iterative investigative process and all outcomes from these stages inform the final design flood simulations.

4.4 Hydrologic & Hydraulic Model Validation

Various RORB model runs were completed to determine the final kc and initial and continuing loss. The parameters trialled were selected based on regional estimates or empirical equations

Various flow regimes associated with different RORB model parameter estimates were routed through the hydraulic model to allow for a comparison to be made to flood heights surveyed during the September 1993 event. In addition to this, flood extents were compared to a series of oblique images captured from a flight on the 16th of September 1993

Using the final adopted combination of hydrology modelling parameters, the model results were checked against 30 surveyed heights across the model area. Twelve of the survey heights matched within 0.10 m, a further seven are within 0.3m of the surveyed flood marks. This is considered to be within the level of accuracy deemed appropriate for the study.

Considering the limited amount of meteorological data available within the catchment and the limited amount and quality of observations to validate this flood modelling, the results were considered to be representative of the 1993 historic event.

2012 modelling results (depths and extents) were compared to video footage captured from the air on 6th of June 2012 at about 2:00PM and a series of land based photo's collected by Wellington Shire council. Both the community and steering group found these comparisons useful and suggested the modelling was accurate.

Using key learnings from the 1993 and 2012 validation, modelling was used to generate design flows in the RORB model. Table 4-1 documents the peak flows applied at the southern boundary of the hydraulic model (refer to Figure 4-1) representing catchment flows from Blind Joes Creek and its adjacent catchments to the east. These flows were then combined in the hydraulic model with "direct rainfall" within the study area to determine the design flooding conditions for the various AEP events considered.

Table 4-1 Design peak flows for Blind Joes Creek and its adjacent catchments to the east

AEP	Blind Joes Creek (m^3/s)	Trib 2 (m^3/s)	Trib 3 (m^3/s)	Trib 4 (m^3/s)	Trib 5 (m^3/s)	Trib 6 (m^3/s)	Trib 7 (m^3/s)	Trib 8 (m^3/s)	Trib 9 (m^3/s)
10%	14	21	4	2	4	2	2	8	6
5%	23	33	7	3	7	3	3	13	11
2%	38	51	11	4	11	4	4	20	17
1%	50	65	13	6	14	5	5	26	22
0.5%	65	83	16	7	18	5	6	33	28

4.4.1 Understanding Flood Behaviour

This study has shown that rainfall in the ranges south of the Rosedale is a major driver of flooding in the town. For example, for the Blind Joes Creek floodway south of the township to be engaged flood water from the Blind Joes Creek catchment must break its banks south of the railway line and flow east. This phenomenon cannot occur with only Latrobe River flooding. Once flood water breaks out south of the railway line it tends to combine with the other adjacent catchment flows from the ranges south of town and begins to inundate the low land south of the township. Some of this flood water can make its way into the township via flow paths over the railway line at Friends Road, two culvert crossings between Friends Road and the Tannery and at Willung Road. Some flood water also leaves the Blind Joes Creek and moves up an open drain on the north side of the railway eventually flowing over Cansick Street and inundating some of the residential land on the western boundary of the township.

Table 4-2 below gives an overview of at what design flood level certain areas are likely to begin to experience flooding. The table has been set out to be read from the top down to include all flood consequences identified at lower design flows.

When using Table 4-2 to identify particular consequences for a given flood event, the reader should read all rows of consequences above the selected magnitude design event.

Table 4-2 Design flood events and associated flooding areas

AEP Design Event	Flood Consequences
10% AEP	Blind Joes Creek floodway engaged, ponding behind Friends, Rosedale-Longford and Willung Roads. Moore Street, McLeod Street, Cricket Street and Cansick Streets cut by flood water. Localised ponding (stormwater impacts) in the low lying land between Princes highway and Albert Street. **Residential Buildings Flooded Above Floor 0** **Commercial Buildings Flooded Above Floor 0** **Properties Flooded Below Floor 177**
5% AEP	Blind Joes Creek floodway flows enter the township via Friends and Willung Road. Ponding behind Wilung road, Friends and Rosedale-Longford roads over a 1 m deep in sections. Newer sections of the western edge of the town between Cansick and Cricket Street are inundated from breakout flows from Blind Joes Creek. Larger portions of land on the township fringes inundated such as land between Cansick street and the railway line (east of Blind Joes creek), and Huffers and Mill Lane area. Ponding in the low lying land between Princes highway and Albert Street is now more significant with one residential lot flooded above floor level. **Residential Buildings Flooded Above Floor 1** **Commercial Buildings Flooded Above Floor 1 (depth less than 10 mm)** **Properties Flooded Below Floor 212**
2% AEP	Most of the Blind Joes Creek Floodway is deeper than 0.5 m. Residents in some of the newer streets (e.g. Macleod Street) west of the main township may be isolated by floodwater. Flooding east of Willung Road is more significant with deeper flooding observed in the industrial estate east of Mill Lane. Mill Lane itself would likely be cut with flood water. Deep flooding (>0.5 m) is observed on the low density residential land north of Huffers Lane. Flooding in the CBD is much more significant with some streets inundated up to 0.5 m deep. The riverine and stormwater flooding combine likely cutting the Princes highway between Willung Road and Latrobe Street. The car park north of the Princes Highway is inundated with flood water making it to Queen Street. Ponding in the low lying land between Princes Highway and Albert Street is significant with one residential lot and 5 commercial lots flooded above floor level. **Residential Buildings Flooded Above Floor 1** **Commercial Buildings Flooded Above Floor 5** **Properties Flooded Below Floor 219**

1% AEP	Generally flood extents between the 1% AEP and 2% AEP are not significantly different but flood depths tend to be significantly deeper. A large portion of the Blind Joes Creek floodway is now deeper than 1 m. Ponding at the intersection of Willung and Rosedale-Longford Roads is deep (up to a 1 m). Most homes east of Willung Road and south of the Rosedale-Longford Road would lose access to the main township (for several hours) during this flood. Much of the low density residential land north of Huffers Lane is between 250 mm and 500 mm deep. **Residential Buildings Flooded Above Floor 2** **Commercial Buildings Flooded Above Floor 7** **Properties Flooded Below Floor 234**
0.5% AEP	The flood extent is similar to the 2% and 1% AEP events, but flood depths throughout the township are now hazardous at many locations. The majority of the land on the western fringe of the main township (east of Blind Joes Creek) is inundated. Residential land north of Cansick Street and west of Willung Road and east of Hood Street is significantly impacted by riverine flooding. Additional flooding is observed north of the Princes Highway in Queen Street. People living east of Willung Road would expect to be isolated from the Rosedale township for extended periods during this event. **Residential Buildings Flooded Above Floor 7** **Commercial Buildings Flooded Above Floor 8** **Properties Flooded Below Floor 239**

4.4.2 Flood Damages

A flood damages assessment was undertaken for the study area under existing conditions. The flood damages assessment determined the monetary flood damages for design floods (20%, 10%, 5%, 2%, 1% and 0.5% AEP events). The flood damage assessment was also undertaken for the final mitigation package.

Water Technology has developed an industry best practice damage assessment methodology that has been utilised for a number of studies in Victoria, combining aspects of the Rapid Appraisal Method, ANUFLOOD, more recent damage curves from the NSW Office of Environment and Heritage, and other relevant flood damage literature. The model results for all mapped flood events were processed to calculate the numbers and locations of properties affected. This included properties with buildings inundated above floor, properties with buildings inundated below floor and properties where the building was not impacted but the grounds of the property were. In addition to the flood affected properties, lengths of flood affected roads for each event were also calculated.

Under existing conditions, the 1% AEP damage was calculated at $ 1.4M with 2 residential properties flooded above floor and 7 commercial properties also flooded above floor. The average annual damage (AAD), a measure of the average flood damage, per year over an extended period was estimated for existing conditions to be **$ 76,000**. The AAD is an estimate of the average annual cost of flooding to the community that includes both public and privately owned assets.

5. ASSESS AND TREAT RISK

5.1 Flood Mitigation

A report detailing the flood risk and options to treat the flood risk within Rosedale was produced following design mapping (R03). Six mitigation concepts were presented to the steering committee at a meeting held in September 2015. Feedback from the steering committee was that two of the options were favourable and these were presented to the community at the September meeting. At the same meeting the community were offered the opportunity to add additional options for consideration. No new ideas were mentioned. The two options listed below were the most favoured.

1. Increasing the conveyance in the Blind Joes Creek Waterway through to Latrobe River via increasing capacity of the railway bridge and confining riverine flooding to the main waterway using levee banks (More Flow to the North option); and
2. Allowing the flow that breaks out of bank from Blind Joes Creek south of the railway line to continue to flow east around the back of the main township unimpeded (More Flow to the East option).

A prefeasibility assessment was carried out on the original 6 options. This analysis showed the same two options favoured by the steering group were the most viable and were consequently chosen to be investigated further including hydraulic modelling and costing. Flood damage assessments and a benefit-cost analysis were also carried out for the two mitigation options, with the results shown below in Table 5-1.

The Benefit Cost Analysis showed that if the more flow to the north option was implemented it would actually cause a net annual liability (cost) of around $117,000 per year. More flow east showed better results but not at a level which would likely attract State and Federal funding. This option may be further considered if development north of the railway line and Huffers Lane is required into the future to enable growth within Rosedale.

Table 5-1 Mitigation Impacts and Cost - Benefit

	More Flow North	More Flow East
Average Annual Damage	**$41,000**.	**$42,000**
Annual Maintenance Cost	$152,000	$28,000
Annual Cost Saving	-$117,000	$6000
Net Present Value (6%)	-$1,642,000	$81,000
Capital Cost of Mitigation	$10,989,000	$2,011,000
Benefit – Cost Ratio	-0.15	0.04

5.2 Planning Controls

An assessment of the existing planning controls for Rosedale was undertaken by Edwin Irvine resulting in a document outlining a number of recommended planning scheme amendments which could be implemented to further treat flood risk within Rosedale. Further planning outputs for the project include a Floodway Overlay and a Land Subject to Inundation Overlay produced in the Treat and Assess Risk Report (R03).

The report also recommends the WGCMA and Latrobe City Council undertake a planning scheme amendment process to incorporate new LSIO and FO mapping into the Latrobe Planning Scheme as soon as possible.

6. FLOOD BEHAVIOUR AND INTELLIGENCE OUTPUTS

6.1 Overview

The flood behaviour and intelligence outputs developed as part of the Rosedale Flood Study are described in this section.

6.2 Model Result Outputs

The model result data including grids and extents have been provided in specified Victorian Flood Database (VFD) format for each flood event. The following result components were generated:

- Flood level, flood depth, flood velocity and flood hazard grids
- Flood elevation contours
- Flood extent data
- Hydrographs at key locations
- Long-section of river water levels

Grids and shapefiles (ESRI/VFD format), and Data tables (Excel csv/xlsx format) were provided on a Study USB on completion of the study.

6.2.1 Data Sets

The following datasets were provided as shown in Figure 6-1.

Grids

Gridded datasets of model results were provided for the following:

- Design events (10%, 5%, 2%, 1%, 0.5%AEP and PMF events) – maximum depth, hazard, velocity and water surface elevation.
- Calibration events (1993, 2012, and 2013 events) – maximum depth and water surface elevation.
- Model Topography

The hydraulic analysis provides a regular grid of flood elevations across the hydraulic model study area. The flood extent was defined by converting the 3 m grid flood elevations grid to an extent polygon. The extent was smoothed to remove the sharp edges of the grid cells for cartographic / presentation purposes.

Flood depths were classified for mapping using the following classifications:

- 0 m to 0.25 m
- 0.25 m to 0.50 m
- 0.50 m to 1.00 m
- 1.00 m to 2.00 m
- Greater than 2.00 m

Vector Data

ERSI shapefiles in VFD format were provided for the following:

- Peak flood extents
- Peak flood elevation contours
- Mapping limits
- Recommended Flood Overlay & Land Subject to Inundation Overlay

Data Tables

Data tables in excel CSV format were provided for the following:

- A list of all properties impacted by the design flood events detailing property location, address and maximum depth of flooding at each property.
- Flood damages for all design events under existing conditions as well as the two mitigation options modelled (1 and 0.5% AEP events). This allowed for the average annual damages to be assessed.

6.2.2 Maps

The flood response inundation maps have been produced for the following design flood events:

- 10%, 5%, 2%, 1% and 0.5% AEP events – maximum depth.

Each map includes:

- Flood extent,
- Flood level contour at 1m intervals,
- Depth of inundation,
- Identification of essential services,
- Major Road/street names
- Cadastral base

Copies of the maps were provided as PDFs, and in Appendix A of the Hydraulics Report (R02). A mapping limits layer was provided in the vector data. An example maximum depth plot for the 1% AEP flood event is shown in Figure 6-1.

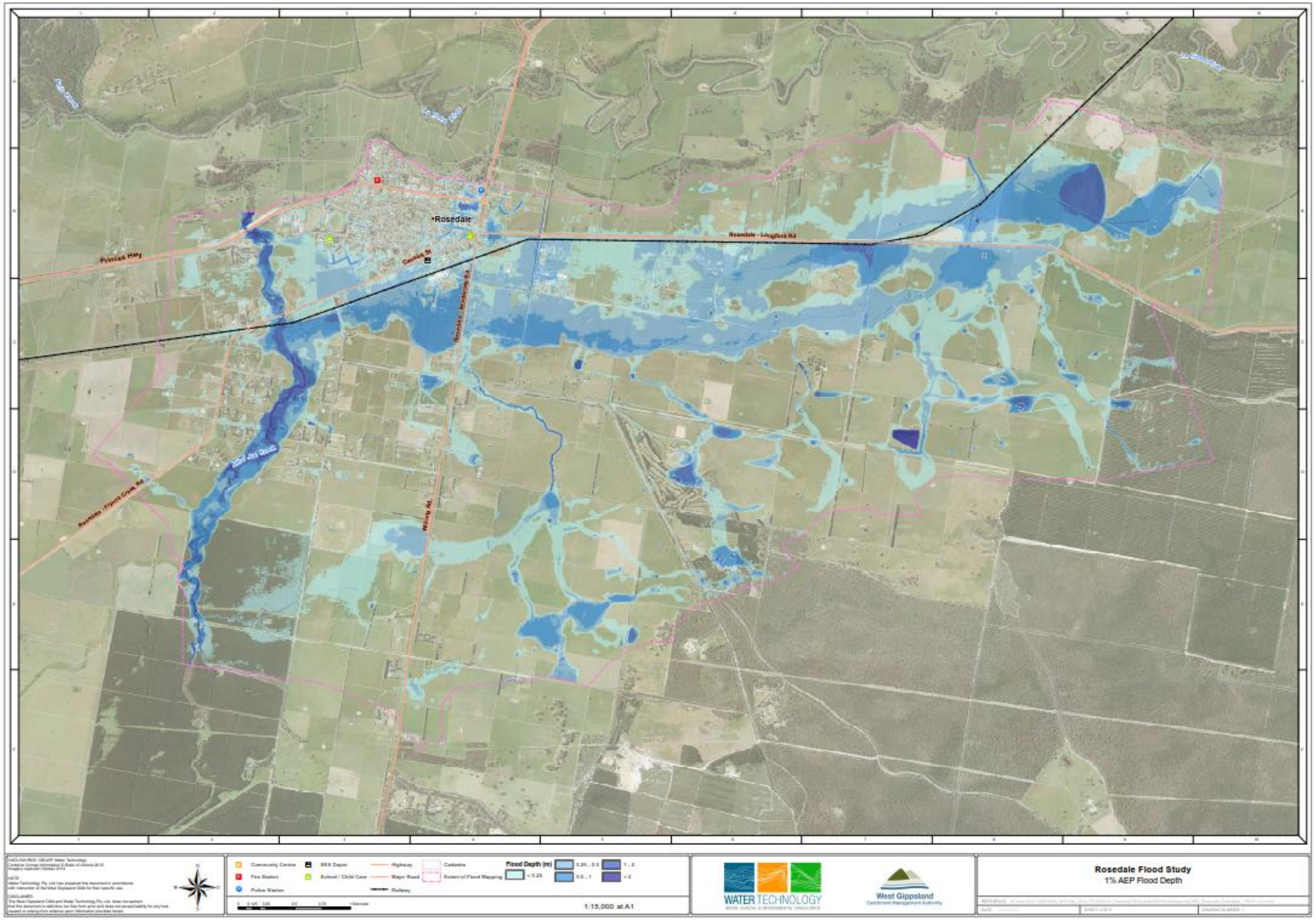

Figure 6-1 1% AEP Maximum Flood Depth Map

6.3 Flood Warning

As previously discussed, it has been identified that one of the main drivers for significant flooding in Rosedale is from intense rainfall in the ranges south of the township. Due to Rosedale's proximity to these ranges, the onset of flooding can potentially happen quite soon after heavy rainfall. The hydrological modelling showed that a 12 hour storm duration is generally the critical duration for a range of design storms. The onset of flooding can occur before the peak of the flood, so this means that the available flood warning time is significantly less than 12 hours after the start of the storm event, once the processes of detection, forecasting, interpretation and messaging are completed.

The major challenge in managing flood warning in Rosedale is the complete lack of localised information to base a warning from. Currently there is no stream flow gauging or government operated rain gauges with the catchment south of the township.

There is currently no flood warning service provided by the Bureau of Meteorology for the Blind Joes Creek catchment, and given the short available warning time the Bureau would most likely classify this as flash flooding so would not be covered under the traditional flood warning service. The Bureau of Meteorology has a responsibility to provide predictions of weather conditions likely to lead to flash flooding (e.g. thunderstorms), while Local Government has prime responsibility for flash flood warning extending from system establishment and operation through to the provision of predictions of stream levels if required.

It is recommended that Wellington Shire Council investigate and document the feasibility of a flash flood warning service for Rosedale. While it was not within the scope of this project to develop a comprehensive flash flood warning system for the township, it has been considered at a high level. To better manage and understand flood warning in Rosedale, it was recommended that two rain gauges with telemetry be established. One within the township of Rosedale and the other towards the top of the Blind Joes Creek catchment.

This information could be combined with a simple tool such as that shown in Figure 6-2 to help emergency management authorities and the general public better predict the magnitude of an event based on rainfall alone. Using the estimate of the AEP, the reference design flood maps could be used to estimate flood risk and consequences.

6.4 Study Deliverables

The study deliverables provide a comprehensive set of data that support the study outcomes. The deliverables were supplied on a study USB and consisted of background data and outputs as listed below:

- Digital copies of study reports in PDF format.
- Digital copies of the maps (PDF format)
- GIS datasets for the model results (ArcGIS VFD format and Excel csv format)
- Digital elevation models

There is a readme.txt file on the USB that describes the directory structure of the data contained on the USB.

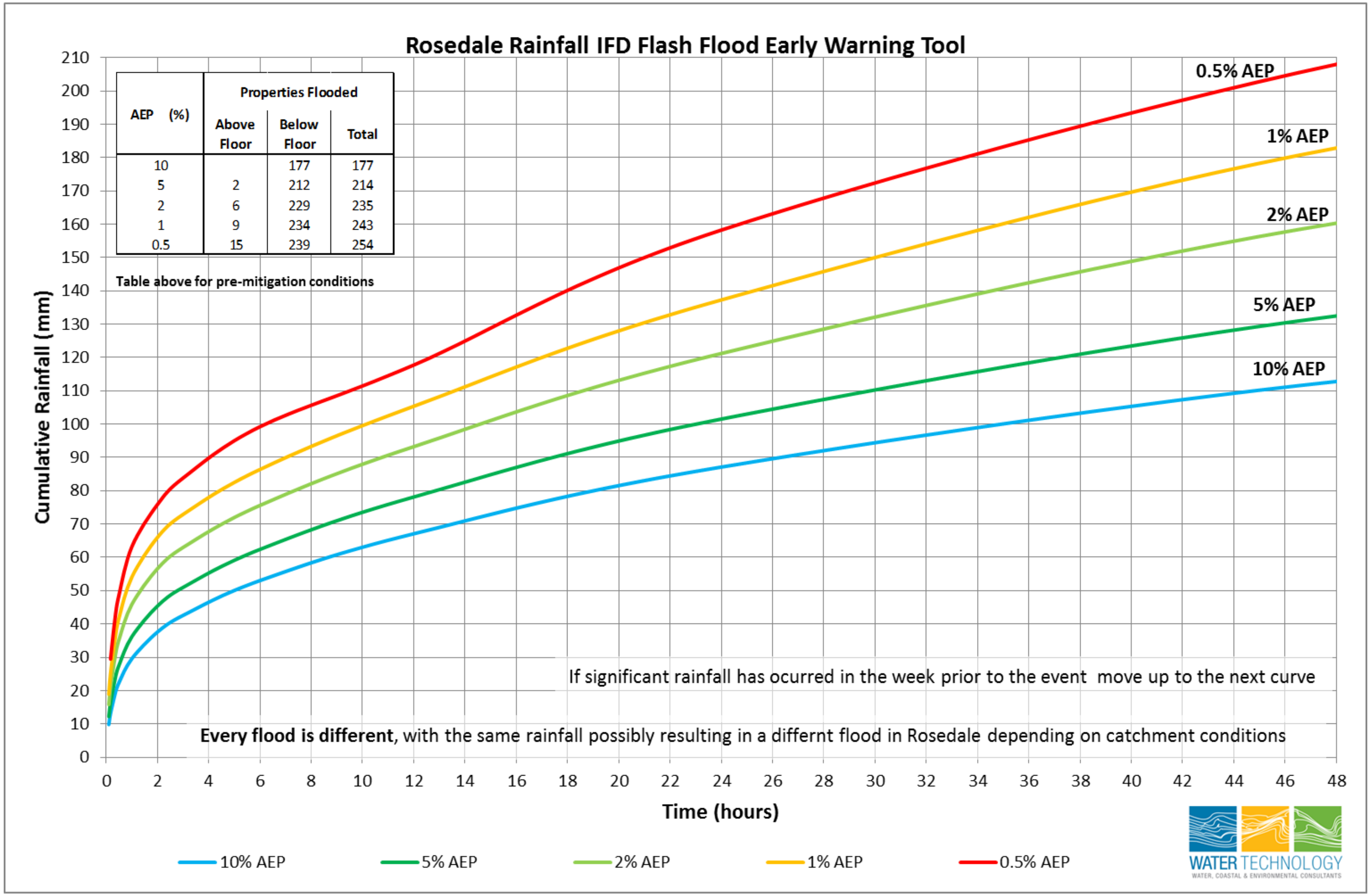

Figure 6-2 Flash Flooding Early Warning Tool

7. SUMMARY OF THE INVESTIGATION

7.1 Overview

The hydraulic modelling undertaken for the Rosedale flood study identified locations within Rosedale and its surrounds which are subject to high flood risk. The modelling has also identified potential mitigation options to reduce flood risk, reducing the frequency and magnitude of flooding. The mitigation options identified along with the updated planning information aim to treat the existing risk.

7.2 Key Outcomes

In undertaking this study, a number of important aspects of flood risk relevant to the Rosedale area (Blind Joes Creek catchment and other smaller local catchments) were determined. These are summarised as follows.

Local Hydrology – A thorough investigation into the hydrology of Blind Joes Creek and adjacent catchments to the east was undertaken using the best data available. This work provided estimates of design flows and hydrographs for a range of AEP events. The effective warning time for the catchment is limited, with travel times from the upstream catchment relatively short.

Hydraulic Characteristics – While the Latrobe River can impact the Rosedale area, these effects are relatively minor. Major flood impacts within the town tend to be driven by local catchment rainfall and runoff from Blind Joes Creek and the other minor catchments to the east of Blind Joes Creek. Overland flow paths from these minor catchments impacting Rosedale were mapped for the first time in this study.

Assess and Treat Risk - Using the hydraulic modelling results, several mitigation options were investigated, costed and modelled to assess the impact on flooding. A flood damages assessment was completed on the existing flood conditions as well as the proposed mitigation options. This allowed for a cost-benefit analysis to be undertaken for the mitigation options. Proposed flood related planning scheme mapping was produced, and flood warning recommendations made.

7.3 Conclusions & Recommendations

Based on the study process and outcomes, the following conclusions and recommendations are made.

- Parts of Rosedale are susceptible to out of bank flooding within the Blind Joes Creek floodplain. Private properties are inundated (above floor level) at flows greater than 5% AEP.
- The lack of local rainfall data was identified as a major knowledge gap limiting any future flood warnings. The installation of multiple instantaneous rain gauges (with telemetry), would be useful to local resident and emergency management authorities. It is suggested that, subject to further investigation of capital and ongoing costs, rainfall gauges be installed in Rosedale and in the Blind Joes Creek upper catchment.
- Some practical mitigation options exist for the township. Implementing these would need to be considered against the observed impacts on current and potential future land use.
    - Overall the mitigation options assessed within this study have a positive impact on reducing flood risk within Rosedale.
    - The benefit cost analysis (based on current conditions) suggest both options are not viable from an economic perspective alone.
    - It is recommended that Wellington Shire Council and West Gippsland CMA discuss the potential for joint funding of additional mitigation analysis which considers other external factors such as potential future land use.

- A review of the existing planning scheme was undertaken, with suggested LSIO and FO planning maps produced. It is recommended that Wellington Shire Council implement a planning scheme amendment reflecting the current mapping as soon as possible.
- The Municipal Flood Emergency Plan (MFEP) was updated with flood intelligence from this study. This should be utilised during future floods. It is recommended that the current format of the MFEP be revised. It is different to other MFEPs across the State. The flood intelligence section of the Assess and Treat Risk Report (R03), would provide a valuable resource during a flood emergency.

8. REFERENCES

Please note the references listed below is a combination of references from all reports mentioned within this study.

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