WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Rosedale Flood Study – Data Review (R01)

May 2016

Australian Government

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WELLINGTON SHIRE COUNCIL
The Heart of Gippsland

West Gippsland Catchment Management Authority

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

15 Business Park Drive
Notting Hill VIC 3168

Telephone (03) 8526 0800
Fax (03) 9558 9365

ACN No. 093 377 283
ABN No. 60 093 377 283

Quality ISO 9001 SAI GLOBAL | Environment ISO 14001 SAI GLOBAL | Health & Safety AS 4801 SAI GLOBAL

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1. INTRODUCTION

Water Technology was 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 from 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

This report documents the information and data that were available for use in the Rosedale Flood Study. It also documents the major data gaps and how these gaps were overcome. This report is one of a series of reports documenting the outcomes of the Rosedale Flood Study.

- **R01 - Data Review Report (Water Technology 2016a) – this report**
- R02 - Hydrology and Hydraulics Report (Water Technology 2016b)
- R03 - Assess and Treat Risk Report (Water Technology 2016c)
- R04 - Summary Report (Water Technology 2016d)

2. STUDY AREA

Rosedale is a small regional town within the Wellington Shire Council district. It has 4,683 permanent residents (ABS, 2012). The township lies between the regional cities of Sale and Traralgon and is 184 km east of Melbourne. With limited employment in the town itself, most residents commute to Sale or Traralgon for work. In recent times, Rosedale has seen an increase in demand for residential land and this has led to investigations into developing land currently zoned as flood prone at the western edge of the township.

The town is located at the downstream end of the Blind Joes Creek catchment, with the Creek flowing along the western and northern boundary of the township, before discharging in to the Latrobe River east of the main town. In times of significant flooding, the Latrobe River can engage all of the floodplain north of the town, including backing up into the end of the Blind Joes Creek system. The study area and significant watercourses are shown in Figure 2-1.

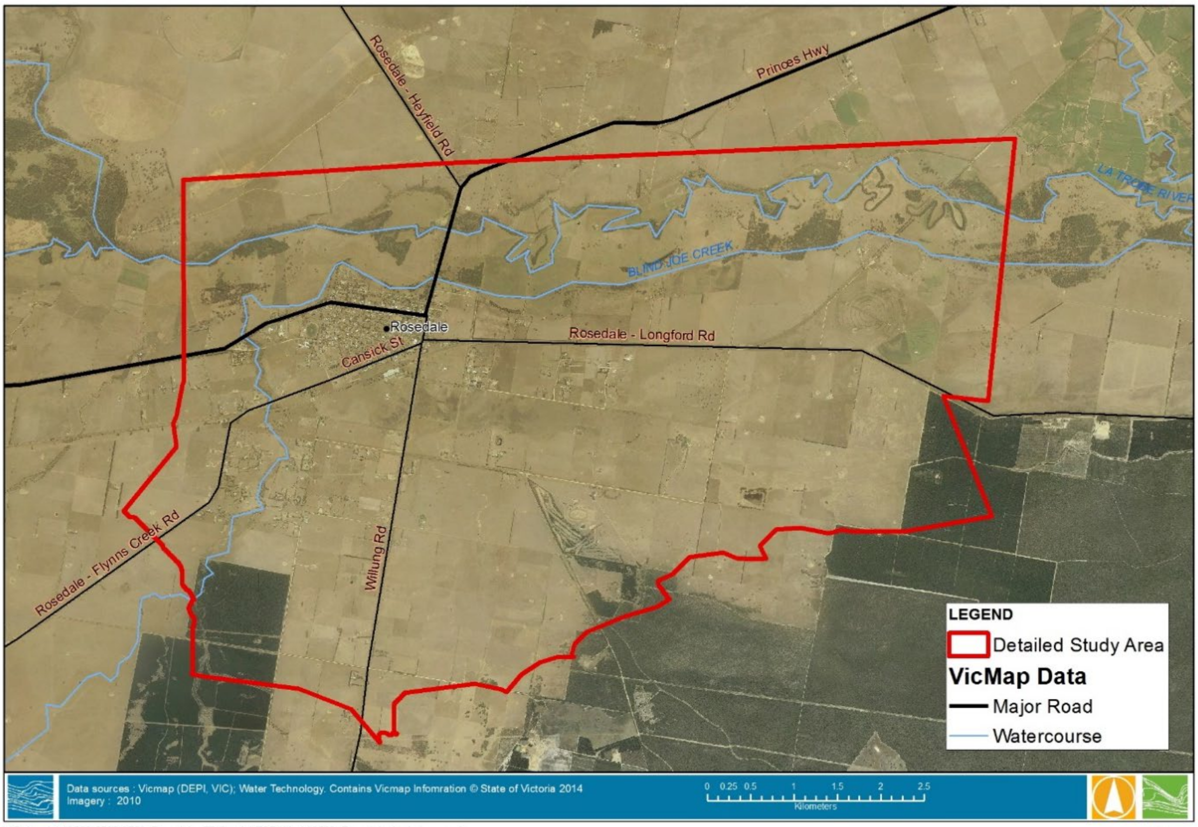

Figure 2-1 Rosedale Study Area

3. FLOOD RELATED STUDIES

Since 1934, several official flood investigations have been undertaken on the Rosedale Township. Several common threads are noted in each study, broadly they fit under the following themes:

- Is flooding in Rosedale driven by the Latrobe River or Blind Joes Creek or a combination of the two?;
- What was the magnitude of the 1934 event (biggest flood in living memory), is it equivalent to a 100 year ARI event?;
- Can the town have an effective flood warning system – what should it focus on?; and,
- Mitigation – can the town be protected with levees, where should they go?

The majority of the major flood studies have been completed by the Victorian Government (under various departmental names) and by [redacted]. A historic flood information timeline was compiled using available historical flood studies and associated information provided by stakeholders. Table 3-1 identifies significant events and associated changes in the floodplain and nominates when key studies were completed.

Table 3-1 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).	

Event	Description	Relevant information
1961	Lake Narracan (Latrobe River – 2,730 ML) & Moondarra Reservoir (Tyers River – 29,700 ML) constructed	
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	[redacted] "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	1934 Flood represented the 100 year ARI;

Event	Description	Relevant information
	(Stage 1)" released to the Shire of Wellington.	100 year ARI flow in the Latrobe 3,500 m^3/s and 100 m^3/s in Blind Joes Creek; 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	[redacted] "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	[redacted] 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	[redacted] 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

Event	Description	Relevant information
2013	Latrobe Flood Study completed by Cardno. Larger flood study covering Yarragon to Sale. Flooding of the Latrobe and all major tributaries considered (inc. Blind Joes Creek).	New Flood Frequency Analysis, new/revised hydrology (BoM URBS model), new hydraulic model (SOBEK). Latrobe 100 year ARI flow very different to all other historic studies (1,875 m^3/s), Blind Joes Creek inflows not reported. The coarse grid (40x40m) 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.

3.1 The Latrobe Flood Study 2013

WGCMA recently completed the Latrobe River flood study which included updated hydrology and hydraulics. 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.

This study initially separated the influence of both the Latrobe River and Blind Joes Creek and then later considered the impact of concurrent flooding. Consequently the Water Surface Elevation (WSE) results from the Latrobe Flood Study were reviewed to assess the impact flooding from the Latrobe River in isolation to Blind Joes Creek would have on Rosedale.

This was achieved by determining the WSE data at locations where designated waterways flow into the Latrobe River floodplain. The LiDAR topography was then highlighted at levels equal to or less than that WSE, effectively showing how far the Latrobe River would "backup" into fringing waterways in large flood events. This information was useful in two ways, it helped understand what a flood only from the Latrobe River might look like, and helped drive tailwater estimates and sensitivity ranges for the hydraulic modelling. The results of this analysis are shown in Figure 3-1.

While this analysis was simplistic in nature (often referred to as a "bath tub" analysis), it does provide some interesting information. 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.

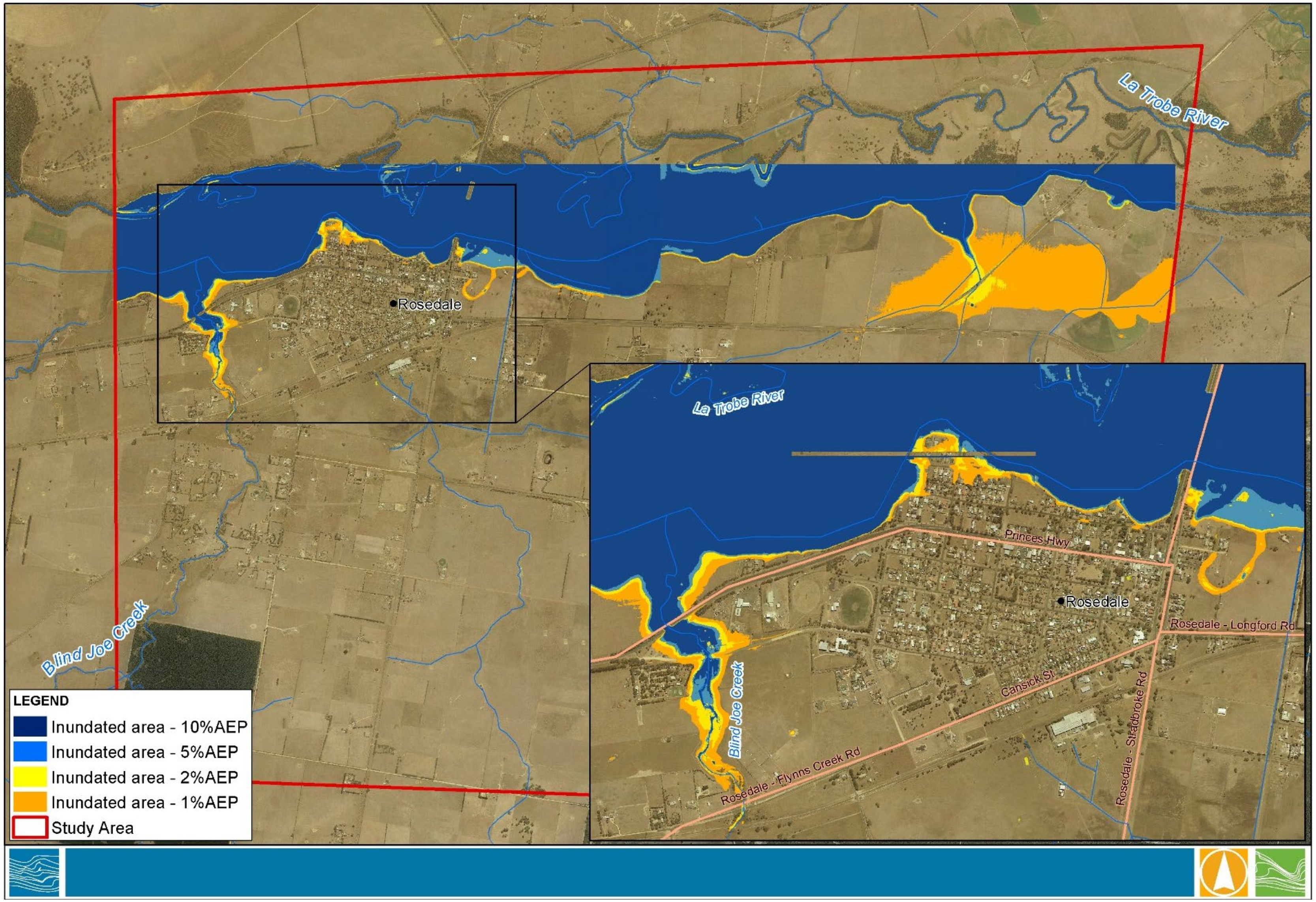

Figure 3-1 Latrobe Flood Study Results – Estimated area inundated by the Latrobe River (excludes Blind Joes Creek flooding)

4. HYDROLOGICAL DATA

4.1 Rainfall Data

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 in and around the catchment. Key stations, including current stations and stations operating over the 1934, 1978 and 1993 floods, are listed in Table 4-1.

Table 4-1 Daily rainfall stations around Blind Joes Creek catchment

Gauge No.	Location	Distance from township	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

Pluviograph (sub-daily rainfall) stations in and around the Blind Joes Creek catchment are listed in Table 4-2. The 1993 event was captured at East Sale Airport, Morwell and Calignee North pluviographs. The 1978 events were captured at all listed stations. Key event totals from major flood events are shown in Table 4-3.

Table 4-2 Pluviograph stations around Blind Joes Creek catchment

Gauge No.	Location	Distance from township	Year Opened	End of Record	Years of Data
85236	Callignee North	26.38	1956 Jan	2014 Aug	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	2014 Nov	71

Key event totals from both daily and instantaneous rainfall stations are shown in Table 4-3.

Table 4-3 Rainfall totals for major flood events in Rosedale area

Gauge No.	Location	Event Depth (mm)				
		December 1934	June 1952	October 1953	June 1978	September 1993
85071	Rosedale	131 (3 days)	164 (8 days)	97.5 (2 days)	109 (9 days)	No data
85236	Callignee North		-	-	140 (8 days)	190 (15 days)
85076	Stradbroke West (Inglenook)	119.2 (6 days)-	192 (11 days)	90 (2 days)	178 (10 days)	-
85017	Callignee South	193.3 (3 days)	513 (18 days)^	104.4 (2 days)	324.5 (13 days)*	-
85072	East Sale Airport	-	118.5 (11 days)	82 (2 days)	105.6 (6 days)	174.2 (14 days)

* Including 277mm is two days
^ Including 246.6mm in two days

4.2 Streamflow Data

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 4-4). While both sites are identified as representing Latrobe River flows, this is only true in times of significant flow in the catchment. 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.

The recent Latrobe River flood study has shown all of the Latrobe River floodplain north of Rosedale engaged in events ≥ 10 year ARI suggesting that using the Latrobe River Anabranch site to represent flooding in Blind Joes creek would not be appropriate.

A review of flood level information at both sites was undertaken with assistance from Thiess Services. No definitive conclusions were reached regarding at what level the Latrobe River Anabranch site becomes dominated by the Latrobe River. This is because the Latrobe River's primary reach tends to breakout upstream of the township at relatively frequent intervals. Analysis of the gauging station data suggests this occurs when the flood level at Latrobe River at Rosedale (main stream gauging station) level is greater than 3.8 m which is below the current minor flood level at the site. Peak flows from major flood events are shown in Table 4-5.

Table 4-4 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

The rating curve for both the main stream (Figure 4-2) and the anabranch (Figure 4-1) are shown below. The rating curve for the main stream site is considered reliable up to 4.8 m (17,600 ML/d) and looks to have a very strong history of gaugings across a large range of flows. The current rating curve for the Anabranch station nominates data to be reliable up to 3.5 m (2,720 ML/d), however it is clear that there is considerable scatter in the gauging below this level.

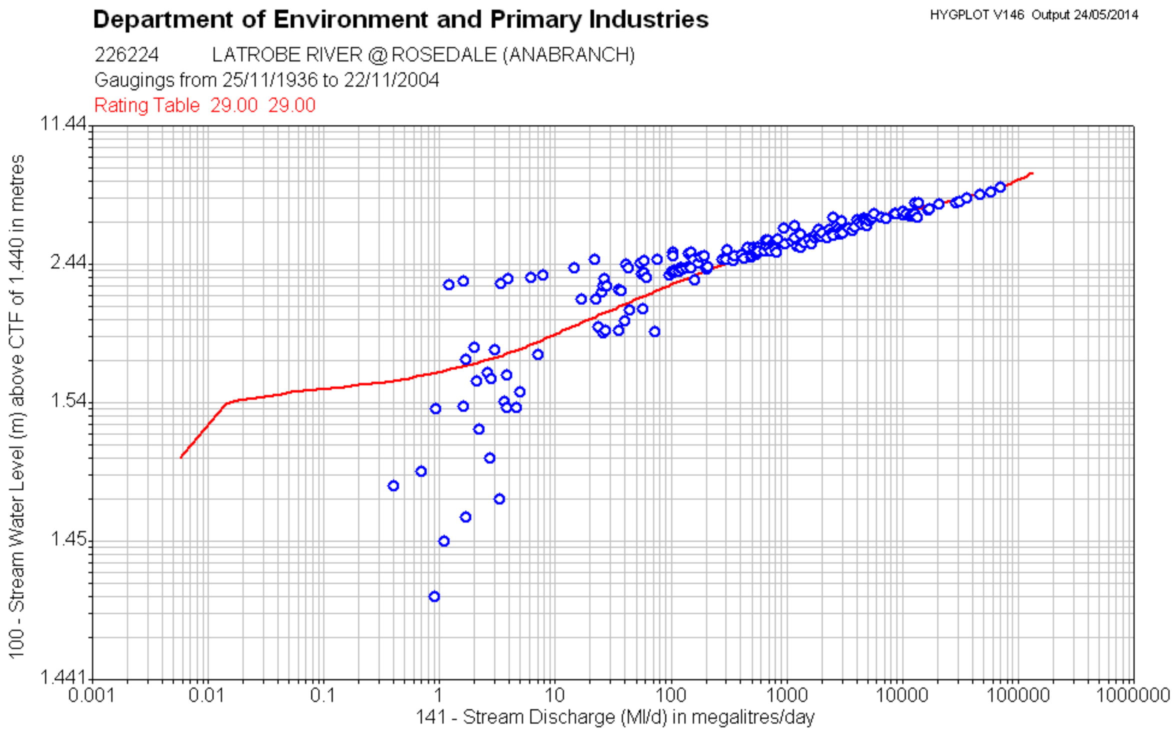

Figure 4-1 **Rating Curve for 226224 LATROBE RIVER (Blind Joes Creek) @ ROSEDALE (ANABRANCH)**

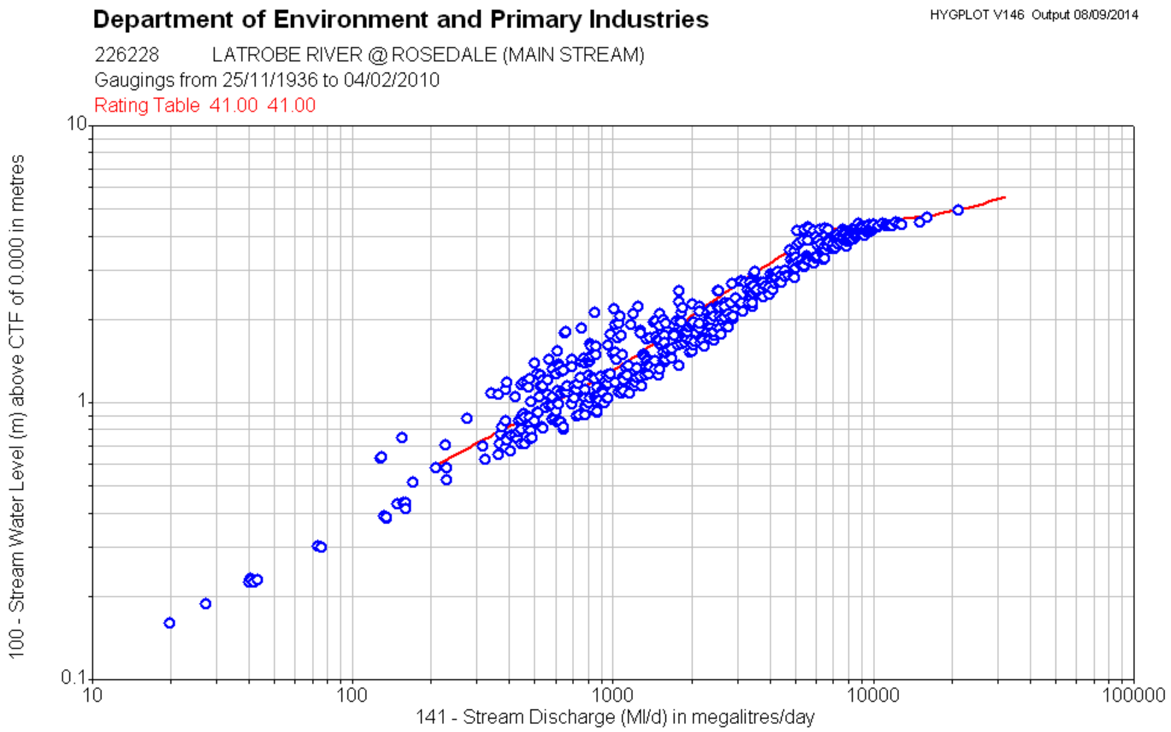

Figure 4-2 **Rating Curve for 226228 LATROBE RIVER @ ROSEDALE (MAIN STREAM)**

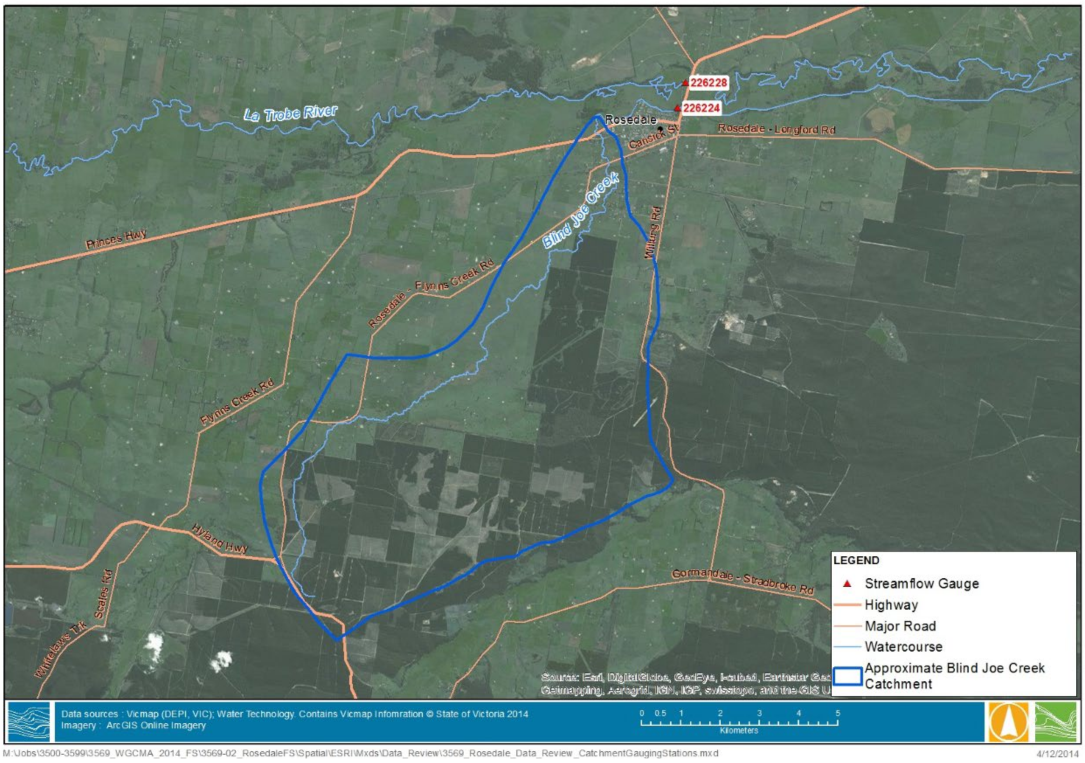

Figure 4-3 Blind Joes Creek Catchment and significant Gauging Stations

Given a comprehensive investigation into the Latrobe River hydrology was completed in the Latrobe Flood Study and that the focus of this study is not on the Latrobe River, it was not proposed that gauging station data would be intensively reviewed in this study. Instead assumptions and key findings from the Latrobe Flood Study were reviewed and adopted as boundary conditions.

Table 4-5 Key event peak flows

Station ID	***Station Name***	Peak Flow (ML/d)			
		June 1952	October 1953	June 1978	September 1993
226228	*Latrobe River @ Rosedale (Main Stream)*	27,578	30,527	21,787	16,051
226228	*Latrobe River @ Rosedale (Anabranch)*	104,969	86,985	87,460	71,610

5. FLOOD RECORDS

5.1 Historic Flood Information

Significant historic flood events have been compiled from available sources and are listed in Table 3-1. The largest flood on record (since 1863) was in December 1934, with flows in the Latrobe River estimated to be between a 150 and 200 year ARI 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 is also available for the 1934 and 1978 events.

Historic flood data recorded in the Victorian Flood Database (VFD) is summarised in Figure 5-1, Figure 5-2 and Figure 5-3 below.

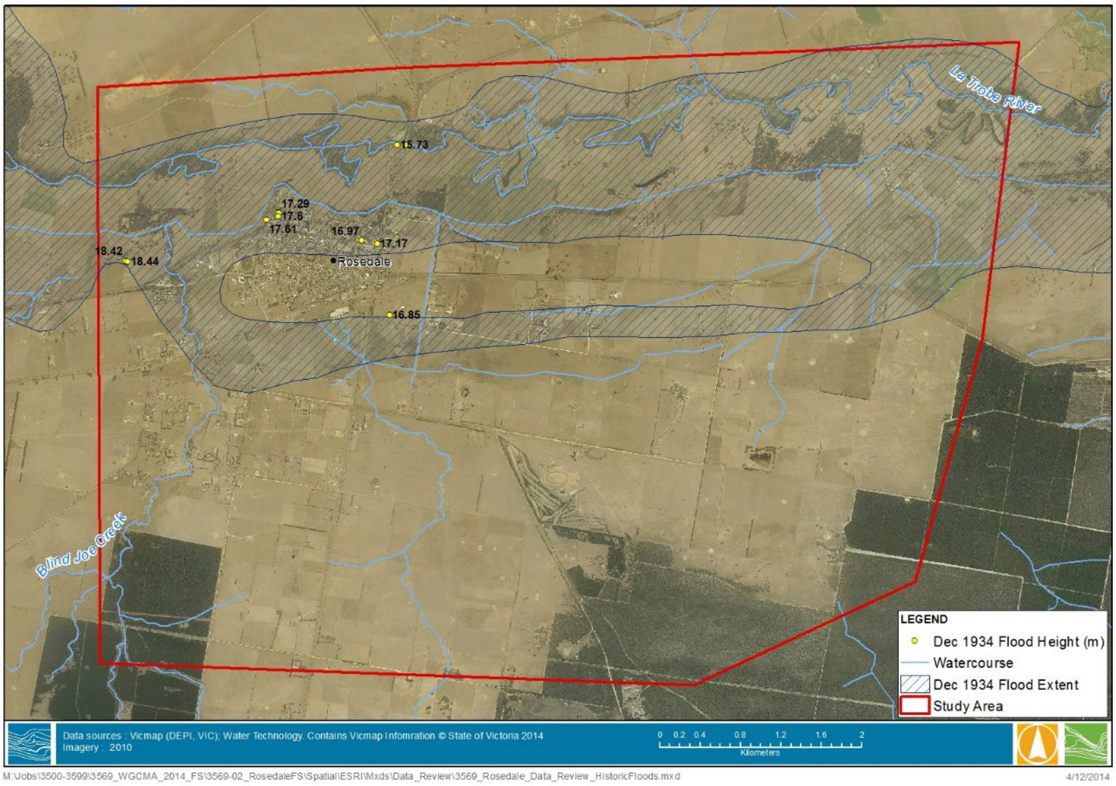

Figure 5-1 December 1934 flood information in VFD

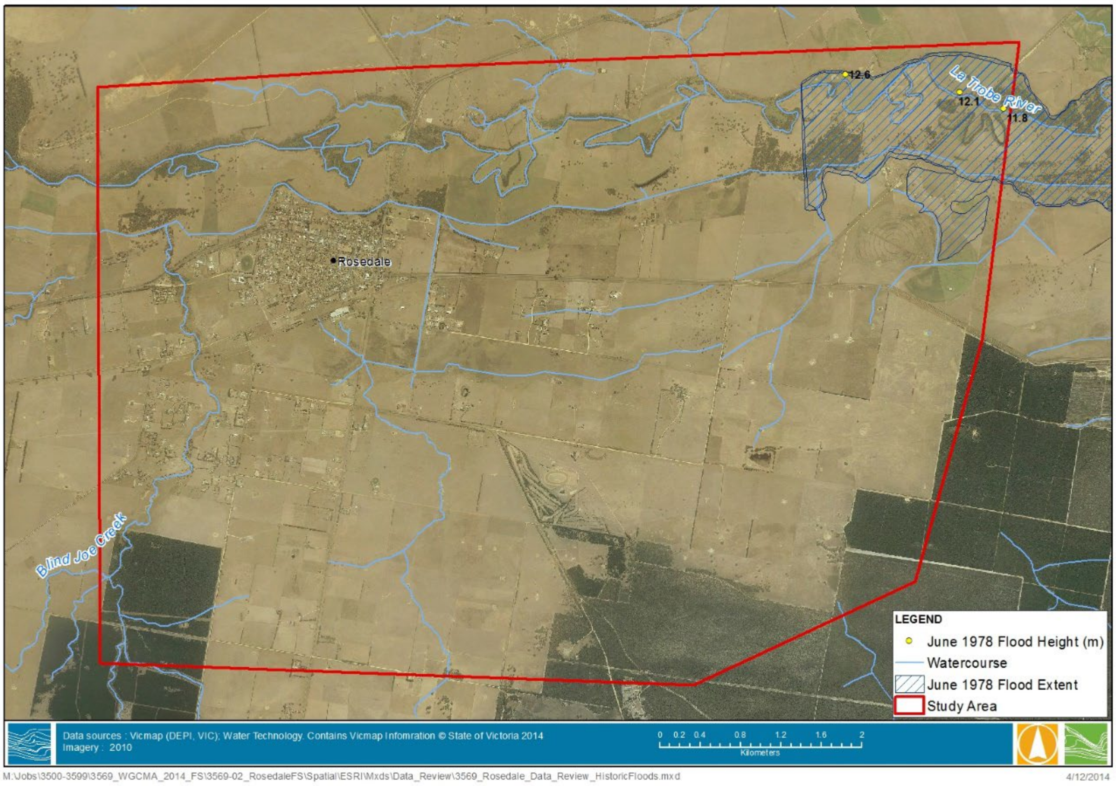

Figure 5-2 June 1978 flood information in VFD

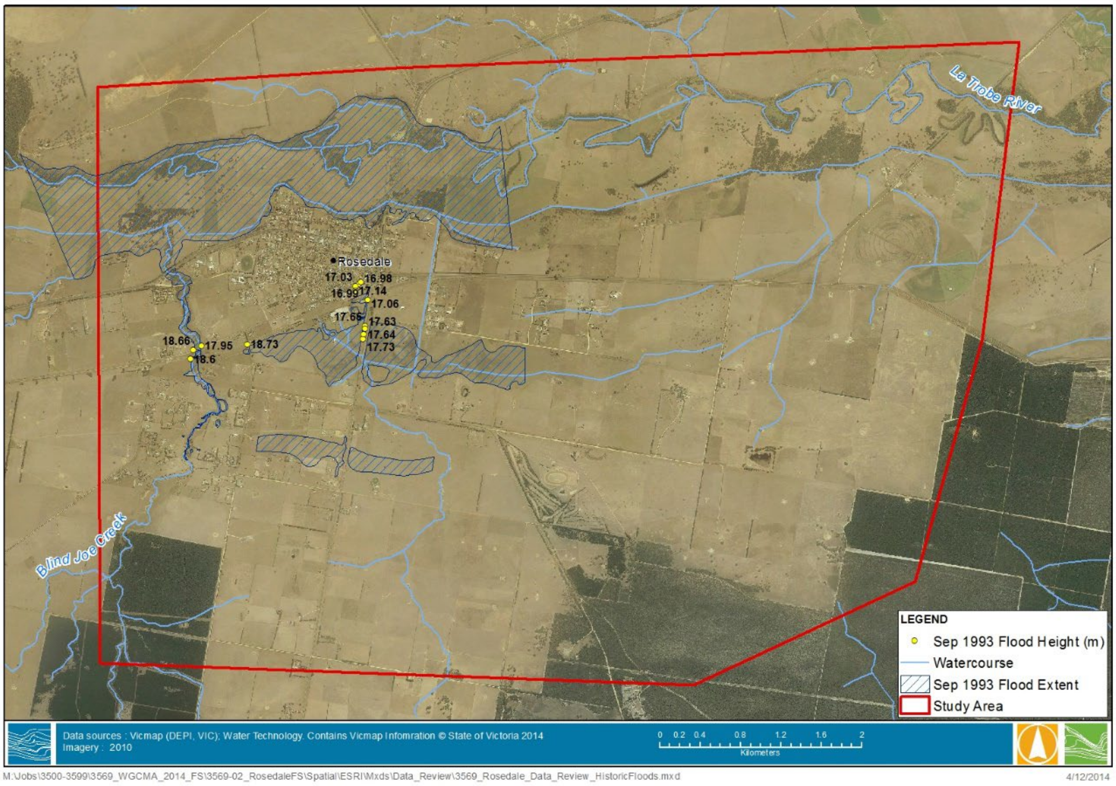

Figure 5-3 September 1993 flood information in VFD

5.2 Imagery

Oblique flood aerial photography was available for the June 1978 event in black and white and colour for 1993, 2011 and 2012. An example is shown in Figure 5-4 below. Aerial photography was also available for the aftermath of the 1993 event (28 September 1993) in the Hydrotechnology (1995) flood review. Table 5-1 gives a summary of flood imagery available by event.

Table 5-1 Historic Flood imagery available

Year	Type of Image			
	Ground based images	Aerial Image (oblique)	Aerial Image (otho-rectified)	Video footage
December 1934	√ (limited)			
June 1952	√ (limited)			
October 1953	√ (limited)	√		
September 1993	√	√		
July 2011	√	√		√
June 2012	√	√		√

Figure 5-4 September 1993 oblique flood image

6. PHYSICAL FEATURES

6.1 Topographic and Physical Survey

6.1.1 Existing LiDAR Datasets

Initially aerial LiDAR (Light Detection and Ranging) survey was available for the Rosedale area from two difference sources:

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

Extents of the two datasets are shown in Figure 6-1. A comparison of the two datasets where they overlap (Rivers ISC minus SRW DEM) is shown in Figure 6-2. A slight vertical offset was discernible between the two datasets in flat floodplain areas. In these areas, the River's DEM is around 0.1 m lower than the SRW DEM. Site survey was undertaken to verify the LiDAR datasets and assist in the selection of datasets for modelling. Key metadata for the two datasets is given in Table 6-1.

A coarse (10 x 10 meter resolution) DEM is available from VicMap for the whole Blind Joes Creek catchment for catchment delineation purposes.

Table 6-1 Key metadata for LiDAR datasets

Dataset	Source	Date of Capture	Vertical accuracy (1 sigma)	Resolution
Index of Stream Condition (ISC) Rivers LiDAR	LiDAR	Sep 2007-Sep 2009	0.10 m	1 m
SRW-90MB LiDAR	LiDAR	Feb-Nov 2010	0.20 m	1 m

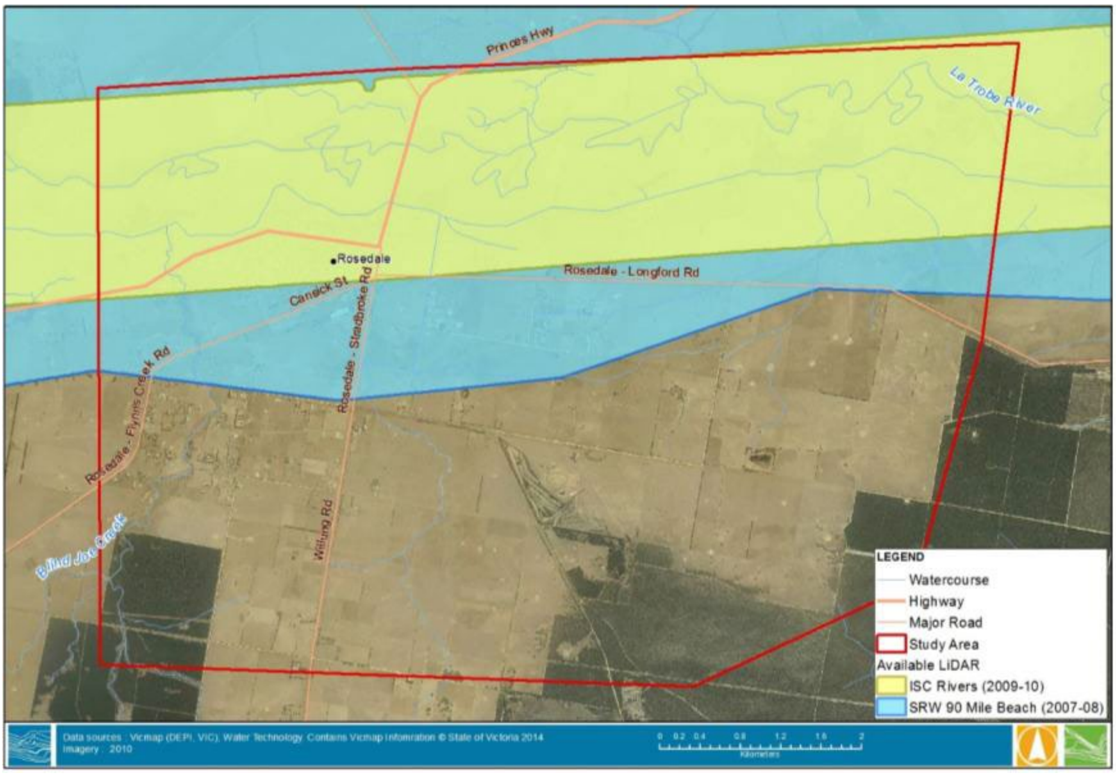

Figure 6-1 Vicmap LiDAR data extents

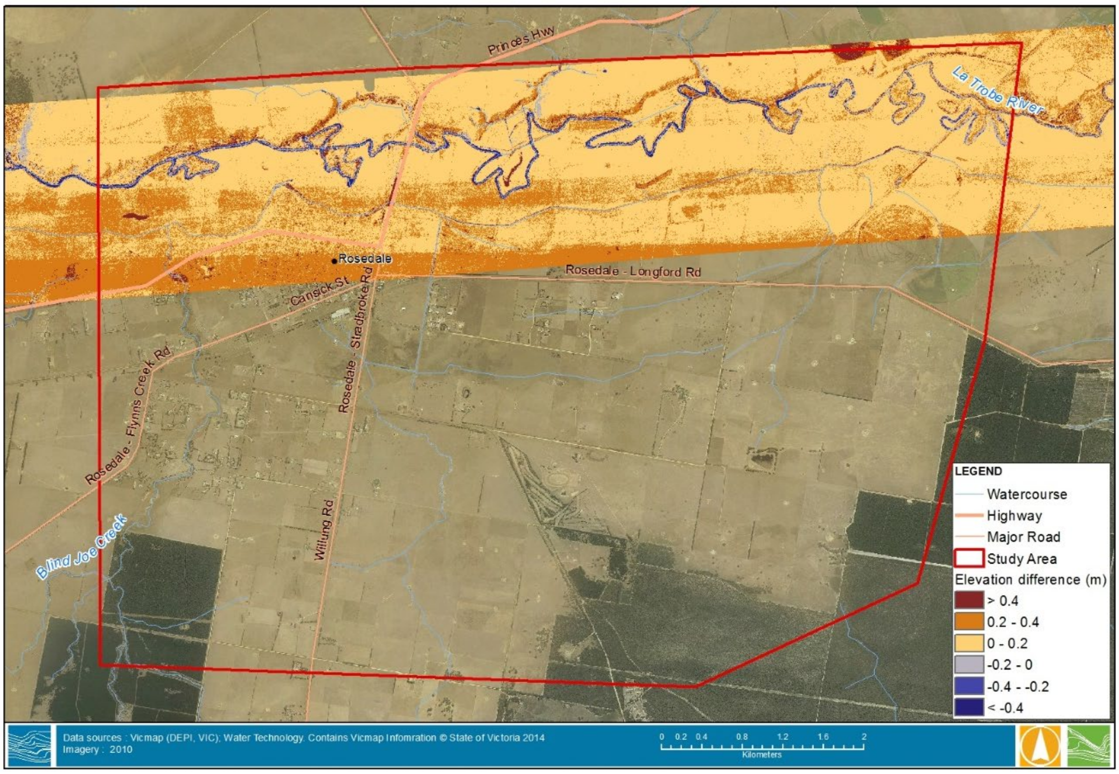

Figure 6-2 LiDAR comparison - Rivers LiDAR DEM minus SRW DEM

LiDAR Validation

The two LiDAR data sets were validated against survey collected by VicRoads as part of the Princes Highway Extension project (PHE). This survey was collected in November 2012 and is assumed to be vertically accurate to 10-20 mm.

The location of the validation survey is shown in Figure 6-3 with the statistical results presented in Table 6-1. The LiDAR validation process showed the data was accurate to its reported tolerance, giving sufficient confidence to use the data in this study.

It is proposed to use the SRW 90MB data as the primary data set in this study. This data was complimented by the new LiDAR captured by the WGCMA for this project (discussed in section 0). Additional validation of the SRW 90MB LiDAR was completed with the new LiDAR captured for this project.

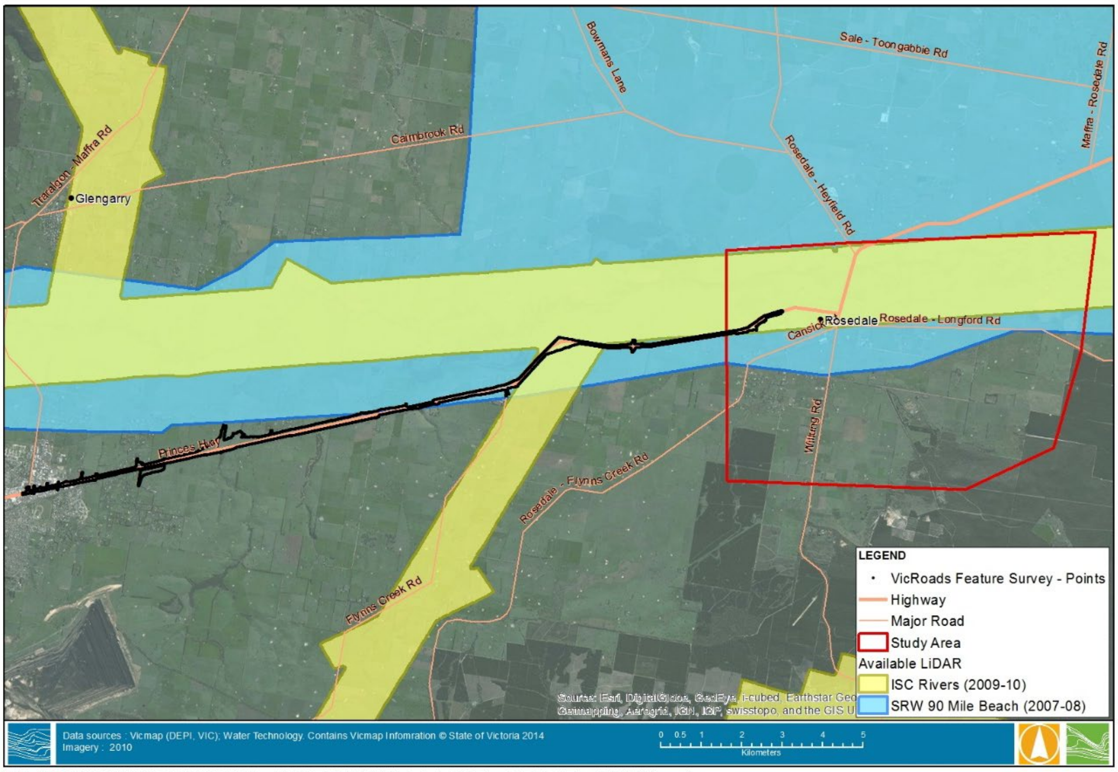

Figure 6-3 LiDAR comparison – VicRoads Survey & LiDAR

Table 6-2 LiDAR Validation results

	Feature survey – Rivers LiDAR (m)	Feature survey – SRW-90MB LiDAR (m)
Minimum	-1.550947	-0.763256
Maximum	0.252527	0.717713
Mean	-0.080881	0.114129
Std. Dev.	0.117919	0.098181

LiDAR Data Request

It was identified in the WGCMA project brief that there was insufficient LiDAR to flood map the southern portion of the study area. To inform what infill LiDAR was required, Water Technology created a preliminary rain-on-grid hydraulic model of the Blind Joes Creek and its adjacent catchments to the east. This modelling was undertaken using the VicMap 10 x 10 m DEM which is only vertically accurate to 5 m. The purpose of this modelling was to identify key inflow points and help understand where flow paths are. Using this information, Water Technology provided a recommended survey area to WGCMA, this area was then further refined by WGCMA. The area adopted for infill survey is show in Figure 6-4.

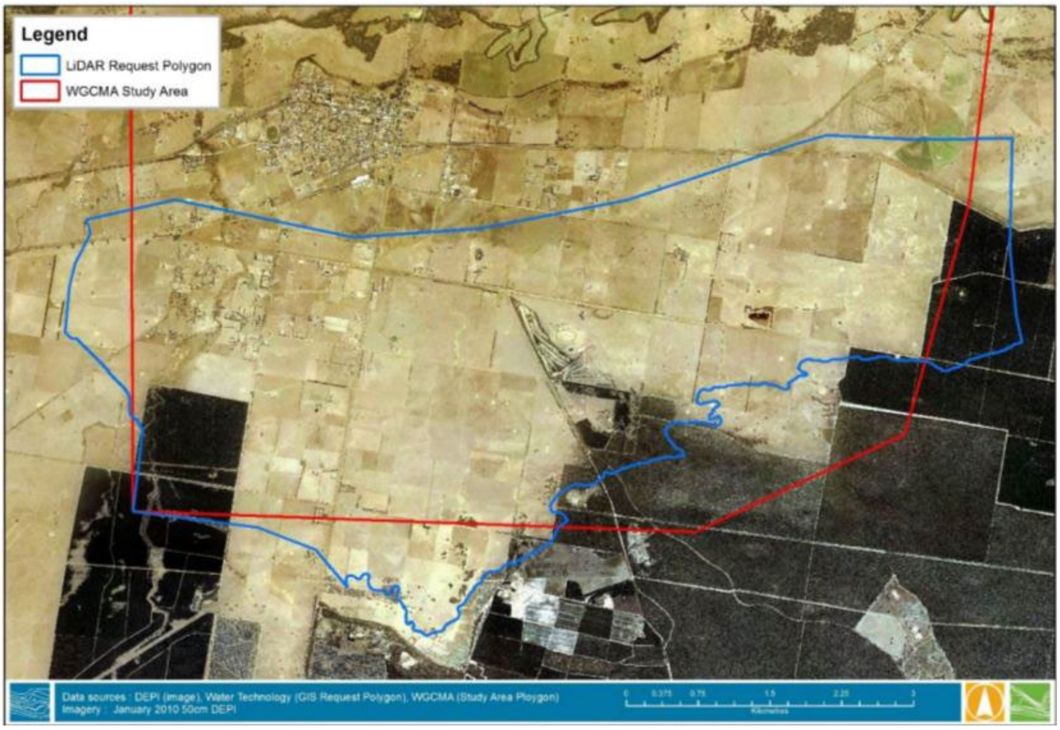

Figure 6-4 LiDAR survey request area

6.1.2 New LiDAR Capture

The new LiDAR was flown in January 2015. The LiDAR was purposely overlapped with the existing SRW 90MB data so comparisons could be made between the two datasets. Compared to each other the two LiDAR data sets showed an acceptable mean error (Table 6-3). Suggesting the new LiDAR data could be used with the old without any modification.

Table 6-3 New LiDAR Validation results

Rosedale LiDAR – SRW-90MB LiDAR	
Minimum	-2.870
Maximum	3.330
Mean	**0.069**
Std. Dev.	0.103

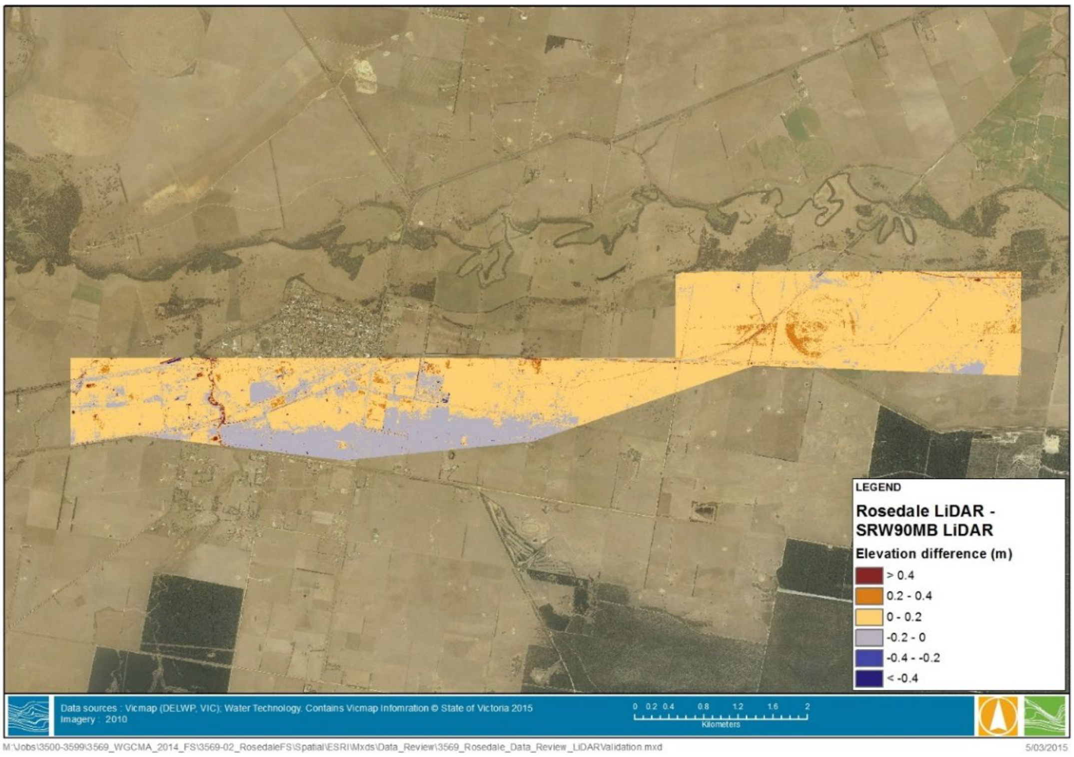

Figure 6-5 LiDAR comparison – New LiDAR 2015 DEM minus SRW DEM

6.1.3 Feature Survey

To further validate both LiDAR datasets they were compared to linear sections captured by Beveridge Williams along generally flat sections of road. One section fell within the new LiDAR area and two sections fell inside the older SRW LiDAR. In each instance the Beveridge Williams survey was higher than the LiDAR data (200mm+). As both LiDAR data sets were generally in agreement with each other it was not proposed to modify them. Further investigation into why the feature survey was generally higher than the LiDAR could be warranted but considered outside the scope of the current project.

Table 6-4 LiDAR Validation against Beveridge Williams feature survey

	Survey - Rosedale LiDAR (one section of road)	Survey - SRW-90MB LiDAR (two sections of road)
Minimum	0.263	0.152
Maximum	0.338	0.309
Mean	**0.297**	**0.226**
Std. Dev.	0.019	0.060

6.2 Drainage Information

GIS layers of local pits and pipes were provided by Wellington Shire (Figure 6-6). [redacted] from Wellington Shire provided advice on the reliability of the pipe layer and additional/altered pipes. Broadly, the township is drained via three main drainage systems. A fourth system is found on the eastern edge of the township and forms part of the Holy Plains Drainage Scheme. A review of the data showed it is suitable for use in the hydraulic model of the township.

Figure 6-6 Drainage GIS layers (Wellington Shire Council)

7. FLOOD MITIGATION AND WARNING

7.1 Proposed Flood Mitigation Scheme

In the past several investigations into mitigation schemes have been undertaken for the township of Rosedale. To date, no major schemes have been implemented. Favoured mitigation schemes tended to include structural and non-structural measures, with most including levees which achieved one of two outcomes:

- Keeping Blind Joes Creek flowing north to the Latrobe Floodplain; or,
- Allowing Blind Joes Creek breakout flows to move east while protecting flows entering the town with levees.

Different levee options recommended by GHD in 1995 are shown in Figure 7-1. A very similar levee system was recommended by the Department of Conservation and Natural Resources in 1995. Other mitigation measures included in past investigations included:

Structural measures:

- Bridge enlargement at Cansick Street (completed by WSC approximately 5 years ago);
- Road lowering of floodway crossings at Friends and Willung Roads;
- Floodway improvements;
- Blind Joes Creek conveyance improvements; and,
- Retarding basins.

Non Structural measures:

- Land use planning controls;
- Public education and awareness programs; and,
- Flood warning and emergency response plans.

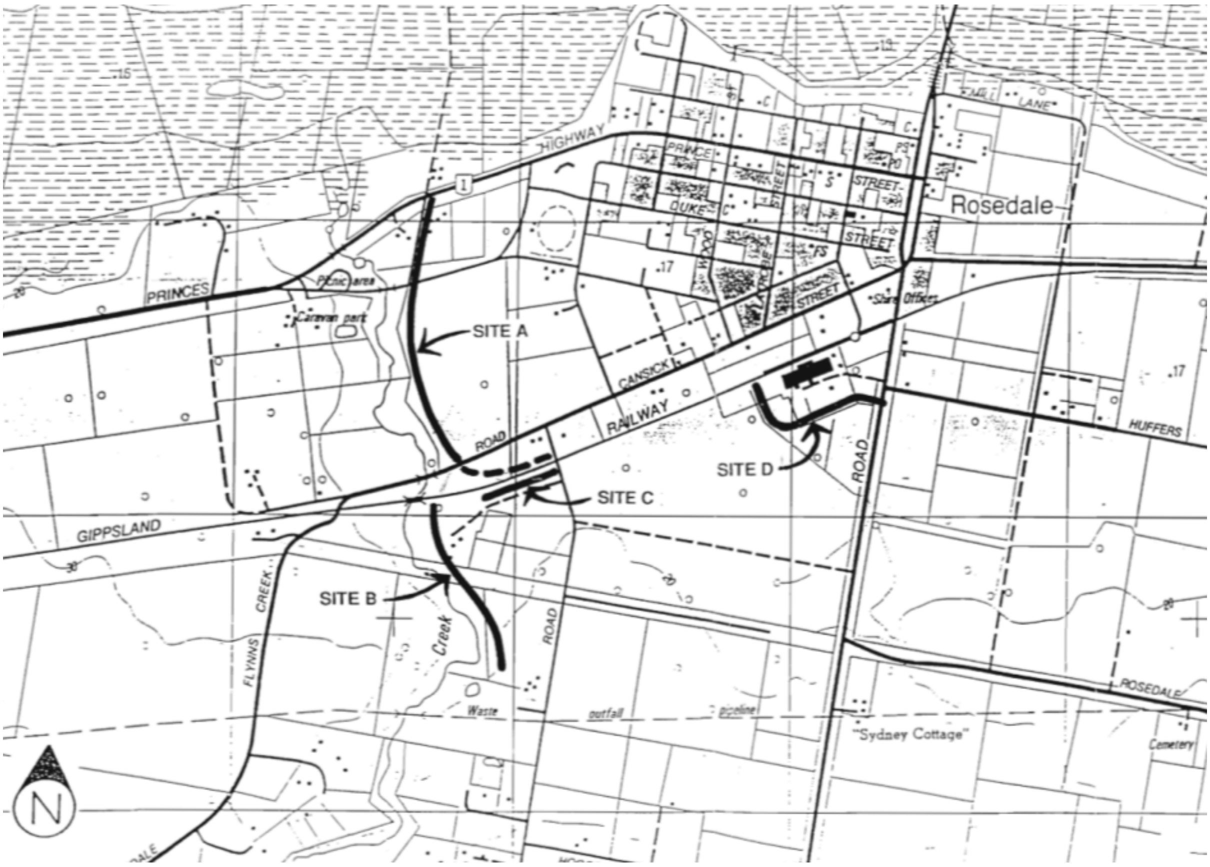

Figure 7-1 **Levees recommended in 1995**

7.2 Flood Warning Arrangements

The Bureau of Meteorology gauge on the Latrobe River at Rosedale has declared flood heights for minor, moderate and major events. Flood class triggers are set at 4.0 m for minor, 4.8 m for moderate and 5.5 m for Major flood classes. Currently there is no VicSES flood guide for Rosedale. Similarly the Wellington Municipal Flood Emergency Plan (MFEP) discusses adjacent catchments but does not specifically provide flood warning arrangements for Rosedale.

8. SITE INSPECTION

A site inspection was undertaken by representatives from Water Technology, West Gippsland CMA and Wellington Shire Council on 16 October 2014. Key locations visited are shown in Table 8-1.

Table 8-1 Key locations visited by project staff, 16 October 2014

Location/Notes	Photo

Major Waterway Crossings
• Princes Highway bridge works currently being completed;
  ○ WGCMA to provide the "as designed" drawings;
  ○ RTL/Hyder opted to construct the bridge using the Water Technology recommended waterway area (unlike Flynns Creek);
• Cricket Street bridge (Floodway);
  ○ Lots of reeds on the Floodplain (Phragmites);
  ○ WGCMA noted local residents have asked for the floodplain between Cricket Street and Flynns Creek Road to be cleaned up, and believe this will reduce flooding.
• Flynns Creek Road;
  ○ Bridge recently replaced (last 5-10 years);
  ○ Wellington Shire Council did the works;
  ○ Works included increasing waterway area on the floodplain between the new bridge and the railway bridge;
  ○ It appears the cut material from these works were left in the floodplain (west bank);
	NA

Location/Notes	Photo
Railway bridge (Blind Joes Creek); • Capacity of railway bridge was significantly greater than the Flynns Creek Road bridge; • It appeared the waterway upstream of the railway bridge had been fenced and re-vegetated, possibly by the local Landcare group; • Currently modelling shows the creek breaking out upstream of the railway bridge and flowing east (sitting behind the railway embankment); and, • A number of the railway openings were partially blocked with sediment, potential to increase capacity by excavating out material from under bridge with transition upstream and downstream.	
Old drainage scheme works; Mill Lane (Railway line culvert and channel downstream of Mill Lane); • Significant northerly flowing drain feature; • Rosedale-Longford Road culvert 3.00 x 1.95 m RCP's; • Railway line culvert 3 x 1.5 m RCPs; and • Huffers Road 3x 1.2x1.2 box culverts.	
	

Location/Notes	Photo
Eastern Breakout - Rosedale floodway; Friends Road; • Current modelling shows flood water ponding behind Friends Road controlled by a single 0.9 x 0.6 m box culvert; • Current modelling shows breakout flows crossing the railway crossing (with Friends Road) and flowing into the vacant land proposed for R1Z development; and, • Adam Dunn (WGCMA) posed the question could more floodwater flow east, could this protect the land proposed for development. Willung Road; • Overland flow appears shallow and broad; • Willung Road inundated in June 2012, Adam Dunn (WGCMA) was pretty sure this was not from Blind Joes Creek - but more from local runoff; • 3 x 750 mm RCPs convey water under Willung Road; and • Minimal development on the floodplain, tannery or timber mill sits on a fill pad on the northern boundary of the floodplain.	

Location/Notes	Photo
Rosedale-Longford Road (Railway crossing); • Flows from the Rosedale Floodway (and other catchments) connect back to the Latrobe River floodplain near Mullocky Lane - 2 crossings under Rosedale-Longford Road and the railway; and, • Cut off drain observed on Mullocky Lane moving flow back to Rosedale-Longford Road.	

9. MODEL DEVELOPMENT AND SCHEMATISATION

9.1 Hydrologic Modelling Approach

Hydrologic modelling was undertaken to quantify the catchment generated flows in Blind Joes Creek and in adjacent tributaries to the east at the hydraulic model boundaries as well as stormwater inflows within the hydraulic model extent.

9.1.1 Model Build / Development

A RORB hydrological model was developed of the entire Blind Joes Creek catchment to the creek entrance, which includes the hydraulic model extent. ESRI's ArcHydro was used to delineate the catchment, with a minimum of 3 to 5 sub-areas schematised upstream of any required streamflow hydrograph. Print locations were included at all locations where flow is required such as at tributaries, streamflow gauges and model boundaries.

9.1.2 Model Validation

Given the lack of stream flow gauges in the upper catchment and the fact that the Latrobe River connects with the Anabranch flow in floods greater than 10% AEP, the use of the Latrobe River Anabranch streamflow gauge for a typical model calibration is not possible. The study area was treated as an ungauged catchment, with hydrology and hydraulic modelling being developed in tandem. Output from the hydrology model was input to the hydraulic model, and the resulting extents/timing/peak flows compared to observed data. Where significant over and/or under estimations occur in water level and extent in the hydraulic model, the hydrological model parameters were 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 hydraulic model parameters were used to fine tune the model results. Model validation in this way is an iterative process. This methodology is summarised in the flow chart shown in Figure 9-1.

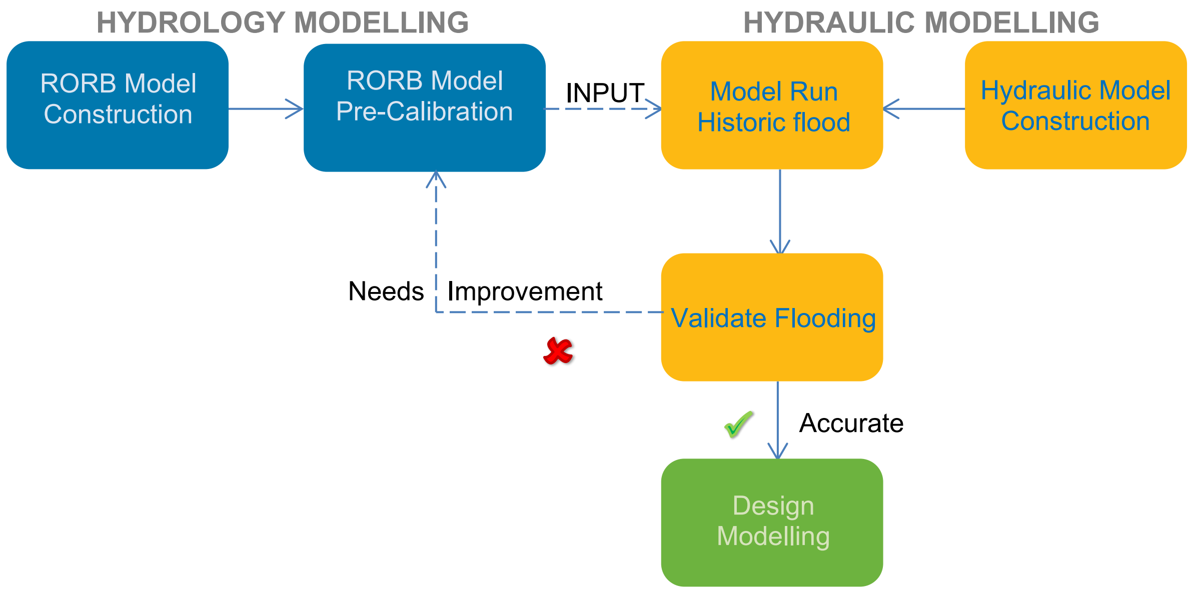

Figure 9-1 Modelling approach flow diagram

The model was validated in this way using 2 historical floods, including the September 1993 flood and June 2012 events.

Local daily rainfall gauges were used to construct a spatial pattern of rainfall for the historic events. Local sub-daily rainfall gauges were used as temporal patterns for the historic storm event. Model parameters *kc*, *m*, *IL* and *CL* were then be developed for each event through prediction methods and validation. A range of methods were adopted for predicting these parameters and provided a starting point for the iterative validation process. *Kc* values were compared to nearby calibrated RORB models (i.e. Traralgon Creek, previous Blind Joes Creek modelling, Trafalgar modelling, etc.), using a *Dav* scaling technique.

The *kc* and *m* were consistent across events with the losses varied to represent different antecedent conditions.

The design events 0.5%, 1%, 2%, 5% and 10% AEP were simulated for a range of storm durations.

9.1.3 Hydrological Design Modelling

It was proposed that the current IFD curves be utilised for design rainfalls. Presently, the revised curves are not recommended to be used in practice until the revised AR&R manual is finalised. The revised IFD curves were used as part of a sensitivity analysis.

RORB model design parameters (*kc, m, IL, CL*) were determined. The *kc* and *m* values adopted for design modelling were the same as that adopted for verification, and were compared to nearby model values as well as values from Australian Rainfall and Runoff and the RORB *kc* prediction equations.

A number of estimation techniques were tested for design losses, with the flows at Rosedale compared for the various methods:

- Hill *et. al.;*
- Australian Rainfall and Runoff;
- Other models from nearby catchments; and,
- Losses from verification historic events.

Further verification of design flows was undertaken using regional prediction equations and methods such as the Probabilistic Rational Method. However it was noted that the recently released draft version of the updated Australian Rainfall and Runoff – A Guide to Flood Estimation, recommends that the Probabilistic Rational Method is no longer used, and goes on to provide an alternative approach. Both methods were used to provide verification for the RORB design flow estimates.

The design events considered a range of durations with a focus on critical durations for Blind Joes Creek at Rosedale. The catchment critical duration was simulated in the hydraulic model.

The final adopted design model parameters were utilised to produce hydrographs at all hydraulic model boundaries for the 0.5%, 1%, 2%, 5%, and 10%, AEP flood events.

The probable maximum flood (PMF) discharge was estimated using the rapid assessment method developed by Nathan *et. al.* (1994).

The impacts of Climate Change were also be tested by increasing the rainfall intensity by an agreed amount in line with available literature, i.e. an increase of 32% as advised in the report *Climate Change in Australia* (CSIRO, 2007).

The impacts of bushfires were tested by adjusting the fraction impervious of the Blind Joes Creek sub-catchments to reflect an agreed severity of bushfire. In this study Blackham et al (2012) was adopted which nominates values of equivalent percentage impervious for different levels of burn severity, based on BAER (2009).

9.1.4 Stormwater

Stormwater modelling used ARR87 IFD and temporal pattern information for input to the direct rainfall model.

No calibration data is available for stormwater flooding.

Loss values adopted were based on RORB modelling and values adopted in in nearby catchments e.g. Warragul and Trafalgar.

9.2 Hydraulic Modelling Approach

9.2.1 Overview

A 1D-2D unsteady state hydraulic model of the study area was developed in TUFLOW. The hydraulic model consisted primarily of a 2D grid model of the township, creeks and floodplains, with hydraulic structures incorporated as dynamically coupled 1D elements.

9.2.2 2D Model Schematisation

The proposed extent of the 2D model area is shown in Figure 9-2. The model is approximately 8 by 6.5 km in size. It is proposed to split the model into two domains to provide adequate resolution within the urban areas whilst maintaining manageable run times. A grid size of 4 x 4 m was adopted for the township, while the Latrobe River floodplain area was modelled at a coarser 12 x 12 m grid resolution. This was similar to the grid resolution combination adopted for Traralgon.

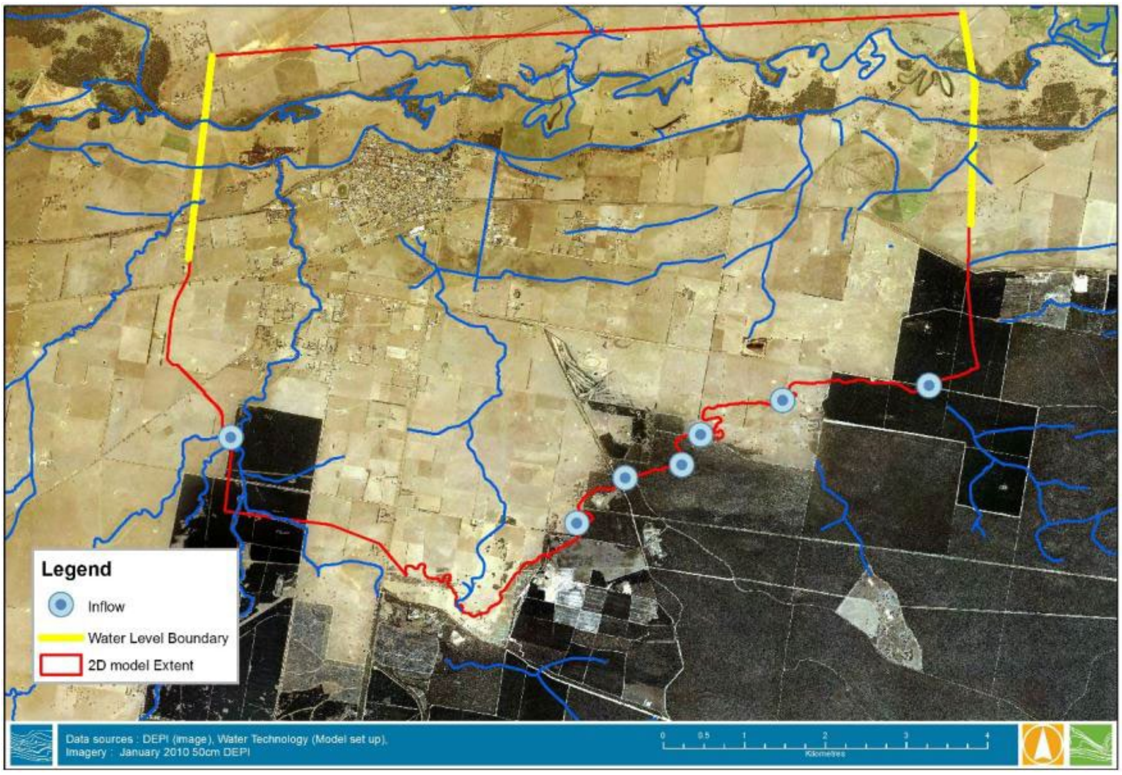

Figure 9-2 2D modelling extent and key features

An inflow hydrograph boundary was applied at the upstream end of Blind Joes Creek, along with all other adjacent catchments to the east. An inflow boundary was applied on the Latrobe River to provide a realistic hydraulic gradient and backwater effect of coincidental flooding.

A water level boundary was applied to the downstream end of the model, on the Latrobe River.

Land cover types were assessed using aerial photography and industry standard roughness values adopted.

9.2.3 1D Model Elements

Bridge, culvert and pipe structures were incorporated in the model as 1D structures. These were coupled to the 2D grid at their upstream and downstream ends. Standard roughness values, inlet and outlet losses were applied based on the material, geometry and inlet condition of the structures.

9.2.4 Stormwater Modelling

Stormwater modelling was undertaken using a direct rainfall on grid approach. For this type of hydraulic modelling the design rainfall estimates are applied directly to the hydraulic model surface. Land planning layers, cadastral and aerial imagery were used to identify unique fraction impervious and loss characteristics for each land parcel in the study area. A representation of Wellington Shire Council's pipe and pit network was included in the model as 1D elements.

9.2.5 Model Validation

The hydraulic model was validated in conjunction with the hydrology model, as discussed in Section 9.1.2. Surveyed water levels, flood photography, gauge readings and anecdotal evidence were used to validate the model for two historic floods.

10. DATA GAPS

Following initial data review the following data gaps were identified.

- LiDAR coverage in the southern portion of the study area.
  - ➔ LiDAR data was captured in January 2015.

- Lack of gauging data in the Blind Joes Creek catchment.
  - ➔ This was resolved by adopting an ungauged catchment methodology. The adopted approach recognises that the major source of uncertainty is in the hydrology estimates. The iterative approach to hydrology and hydraulics results in improved model accuracy as it allows a feedback loop to improve the hydrology prior to final adoption of inflows to the hydraulic model.

- It is understood that no current floor level survey is available for the town.
  - ➔ Floor level survey was collected by the WGCMA in December 2015.

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