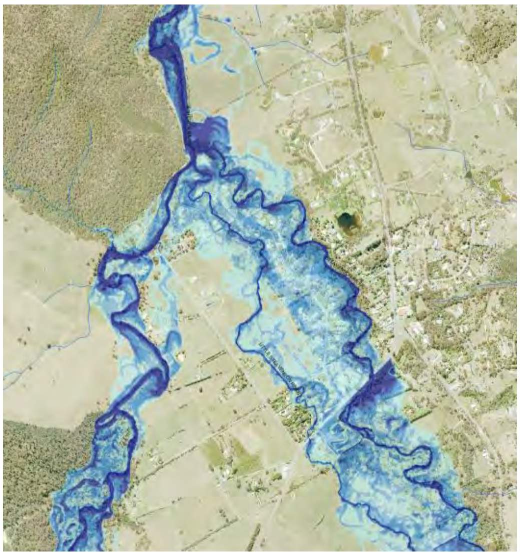

Acheron Valley Flood Study – Final Report

June 2019

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1 INTRODUCTION

The Goulburn Broken CMA, in association with Murrindindi Shire, has undertaken hydraulic modelling and mapping of flood flows along the Acheron, Little and Steavenson River valleys. The mapping area includes the townships of Taggerty, Buxton and Marysville.

Goulburn Broken CMA has prepared this report to outline the methodology used to model the hydraulics of the rivers and summarise the results of the flood mapping.

1.1 BACKGROUND

1.1.1 Description

The Acheron River rises on the great divide north of the Yarra Valley. The Acheron River has several major tributaries, the Taggerty, Steavenson and Little Rivers. These tributaries and the Acheron River are characterised by relatively narrow valleys (e.g. several hundred metres) and relatively steep longitudinal gradient, ranging from 2.5m to 8m per kilometre between Taggerty and Narbethong.

1.1.2 Previous work

There has not been previous flood modelling for the Acheron, Little or Steavenson River Valleys. Floodplain planning in the townships of Taggerty and Buxton has relied on historic flood levels (Section 5.2). In the many areas without historic flood levels, floodplain planning has relied on rudimentary site specific assessments of the topography and potential for flooding.

1.1.3 Requirement for current study

The current study is required to address the poor quality and paucity of floodplain planning information. It is also needed to improve flood intelligence for the towns and valleys and hence emergency response planning.

1.2 CURRENT STUDY

In support of this hydraulic and flood mapping study, the consultancy BMT was employed using Natural Disaster Resilience Grant Scheme (NDRGS) funding to study the hydrology of the Acheron River valley and provide flow data for the hydraulic model described herein. The Acheron Flood Hydrology report was completed in July 2018.

BMT, in association with Michael Cawood, was also funded to use the hydraulic model results to prepare a Total Flood Warning System (TFWS) discussion paper, develop a flood forecast tool and provide an update for the Municipal Flood Emergency Plan (MFEP).

1.2.1 Objectives

The objectives of this hydraulic and flood mapping component of the study were to reduce the impact of natural disasters on the local community by:

1. Establishing a hydraulic model and mapping the 1% annual exceedance probability (AEP, the 100-year average recurrence interval) flood extent.

2. Revising the floodway overlay and the land subject to inundation overlay in the Murrindindi Planning Scheme to more accurately reflect flood risk and thereby improve the planning of land use and the design of development.
3. Preparing flood level contours for the area to provide the information required for the design of developments in flood fringe areas, particularly the setting of floor levels.
4. Account for climate change and the impact of the projected intensification of rainfall on assets and hence the planning of development on and around floodplains.
5. Provide intelligence that informs the potential impact of floods on assets and road access along the rivers of the Acheron Valley.

1.2.2 Scope

The scope of this hydraulic component of the study is to:

1. Establish hydraulic model(s) of the Acheron, Little and Steavenson River valleys. Nominally hydraulic models are to:
    a. Extend upstream in a valley to either the limit of:
        i. available aerial laser survey (ALS);
        ii. potential development (e.g. public conservation and resource zone); or
        iii. the resolution of sub-catchments in the hydrology.
    b. Extend downstream to the Goulburn River.
2. Include hydraulic structures:
    a. public road bridges and any private access bridges that can be readily inspected;
    b. major and minor culverts down to approximately 300mm in diameter; and
    c. stormwater pit and pipe systems likely to be of significance to flood extent.
3. Calibrate the hydraulic model to the historic floods in Buxton and Taggerty for which there are recorded peak flood levels.
4. Ensure floodplain roughness for the 100 year ARI planning event includes the full extent of development described in the current planning zones or any township growth plan.
5. Test the influence of blocked hydraulic structures for the floodplain planning event.
6. Include downstream boundary conditions for the Goulburn River.

1.2.3 Hydraulic modelling

Given the significant area to be modelled, the hydraulic model was established using TUFLOW-HPC software with a grid size of 3x3m. LiDAR ground data was utilised together with hydraulic structures and features, such as bridges and culverts, ‘stamped’ into the hydraulic model. Refer to Section 4 for further detail.

2 HYDROLOGY

2.1 OVERVIEW

In July 2018, BMT completed the hydrologic flood analysis for the Acheron Valley with the purpose of providing input into the hydraulic model to produce flood mapping. This was completed for design flood events from the 20% AEP event to the 0.2% (1 in 500) AEP event and for the 1994, 1996, 1998 and 2010 calibration events.

For the 1% AEP climate change was considered in light of guideline outlined in Australian Rainfall & Runoff 2016. BMT recommended concentration pathway RCP 8.5 to be used, which results in a rainfall increase factor of 8.7% at year 2050. This was adopted as the 1% AEP standard for land-use and development considerations.

2.2 DESIGN INFLOWS

The calibrated URBS model was used to generate design inflow hydrographs for the hydraulic model using the parameters presented in Section 7.3.1 of the BMT report.

The design peak flows at the Taggerty Gauge is presented below.

AEP	20%	10%	5%	2%	1%	0.5%	0.2%
Peak Flow (m^3/s)	112	138	157	179	197	224	259

2.2.1 Climate Change Inflows

The design peak flows at the Taggerty gauge is with climate change to 2050 is presented below.

AEP	20%	10%	5%	2%	1%
Peak Flow (m^3/s)	144	176	203	237	255
Critical Event in hours	48	48	48	48	48

3 DATA COLLATION

3.1 TOPOGRAPHIC DATA

The topographic basis of the hydraulic models is primarily aerial laser survey (ALS, i.e. LiDAR), in the form of a gridded digital elevation model (DEM) with a 1 metre resolution. The TUFLOW hydraulic model then samples the DEM at the model grid size (Section 4.2). The accuracy of this LiDAR data was checked by comparing it to elevation data collected by a licensed surveyor.

The DEMs were checked against point ground survey taken on concrete and bitumen surfaces in July and August of 2014. This check indicated that the floodplain LiDAR available for each town was well within the specified accuracy and suitable for the hydraulic modelling. However the vertical accuracy of the ISC LiDAR that was available in town and rural areas did not meet the ISC LiDAR specification.

As the error in the ISC LiDAR was systematic the elevation of the LiDAR was adjusted vertically by the median difference to the ground survey in each local area. To ensure the DEM adjustment was transparent, the ISC DEM data was not altered but rather the ADD option was used in the Z Shape function to alter the DEM within TUFLOW.

The DEMs around each town were compiled within TUFLOW such that where the more accurate floodplain LiDAR was available it superseded the ISC LiDAR.

3.2 DEMS FOR TOWNS

3.2.1 Buxton

The hydraulic modelling around Buxton township utilised two different DEMS:

1. 2009-10 Victorian State Wide Floodplains LiDAR Project with a bare earth vertical accuracy of ±0.10m and a horizontal accuracy of ±0.20m.
2. Index of stream condition (ISC) LiDAR (February-October 2010) with a vertical accuracy of ±0.10m and a horizontal accuracy of ±0.19m.

The areas around Buxton covered by the Floodplain LiDAR are shown in Figure 3-1. The balance of the area is covered by the ISC LiDAR.

The analysis of the difference between the ground survey levels and LiDAR DEMS for Buxton is shown in Figure 3-2.

The median difference (DEM minus survey level) between the floodplains LiDAR and the survey was -0.004m (sample 119, standard deviation 0.046m) and the median difference for the ISC LiDAR was +0.176m (sample 119, standard deviation 0.046m).

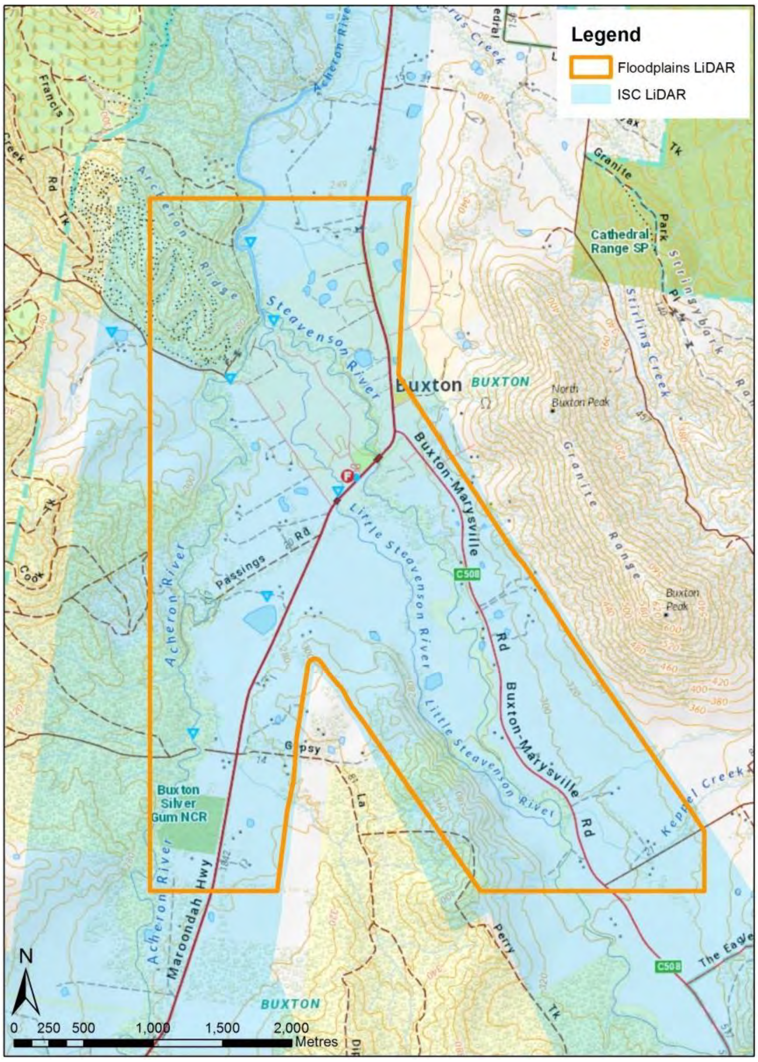

Figure 3-1 **The extent of the floodplains LiDAR and the surrounding ISC LiDAR that was used at Buxton.**

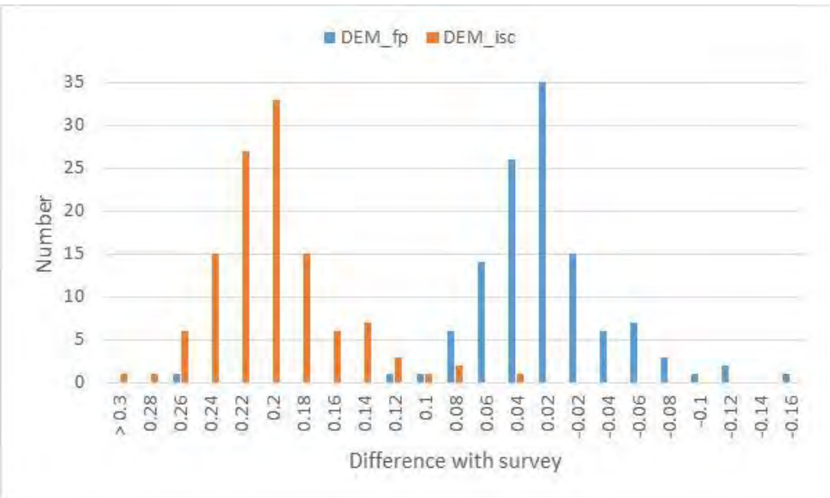

Figure 3-2 **Histogram of the difference between survey levels and DEMS at Buxton.**

3.2.2 Taggerty

The hydraulic modelling around Taggerty township utilised two different DEMS:

1. 2013-14 North East Towns Elevation LiDAR with a bare earth vertical accuracy of ±0.10m and a horizontal accuracy of ±0.18m.
2. Index of stream condition (ISC) LiDAR (February-October 2010) with a vertical accuracy of ±0.10m and a horizontal accuracy of ±0.19m.

The areas around Taggerty covered by the North East Towns LiDAR are shown in Figure 3-3. The balance of the area is covered by the ISC LiDAR.

The analysis of the difference between the ground survey levels and LiDAR DEMS for Taggerty is shown in Figure 3-4.

The median difference (DEM minus survey level) between the north east towns LiDAR and the survey was +0.01m (sample 118, standard deviation 0.045m) and the median difference for the ISC LiDAR was +0.155m (sample 108, standard deviation 0.043m).

Checking the Z points generated by TUFLOW, edge distortion was found along the southern extent of the 2013-14 North East Towns Elevation LiDAR for the Taggerty area. This created an artificial ridge across the Acheron River (Figure 3-5). This was addressed by cutting the distorted area out of the North East Towns LiDAR and allowing the ISC LiDAR to define the topography in this area.

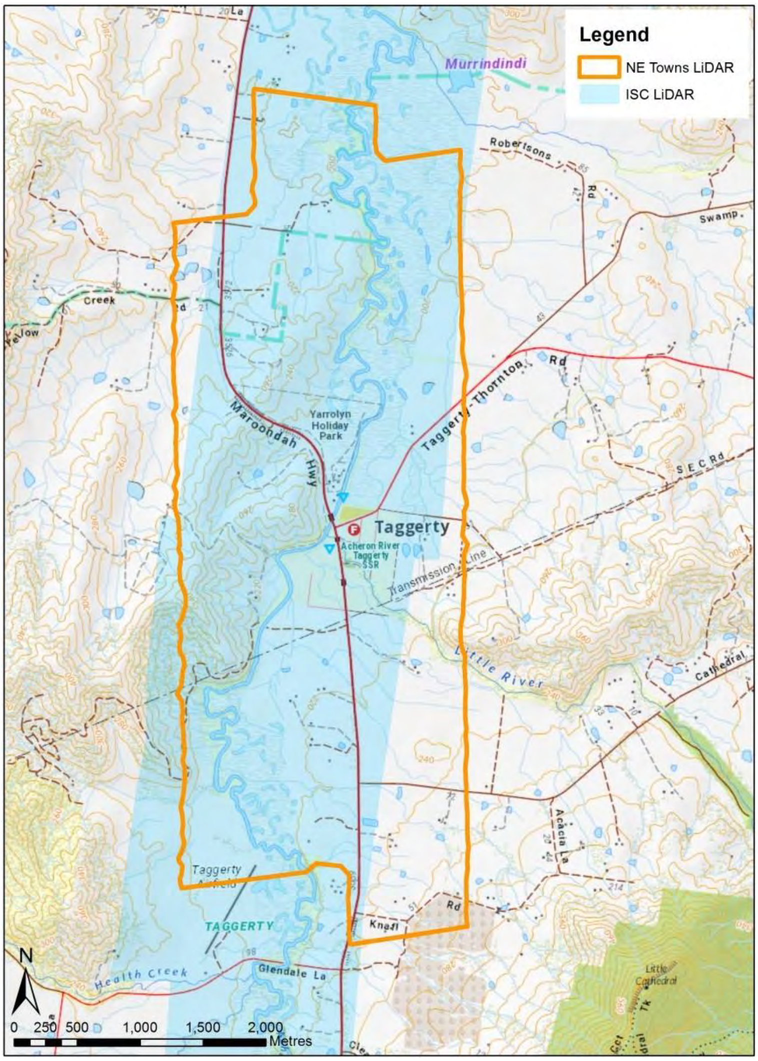

Figure 3-3 The extent of the North East Towns LiDAR and the surrounding ISC LiDAR that was used at Taggerty.

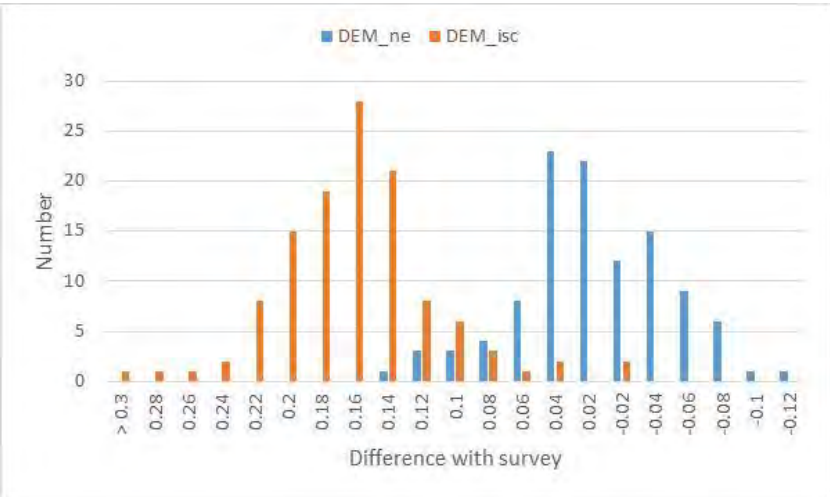

Figure 3-4 Histogram of the difference between survey levels and DEMS at Taggerty.

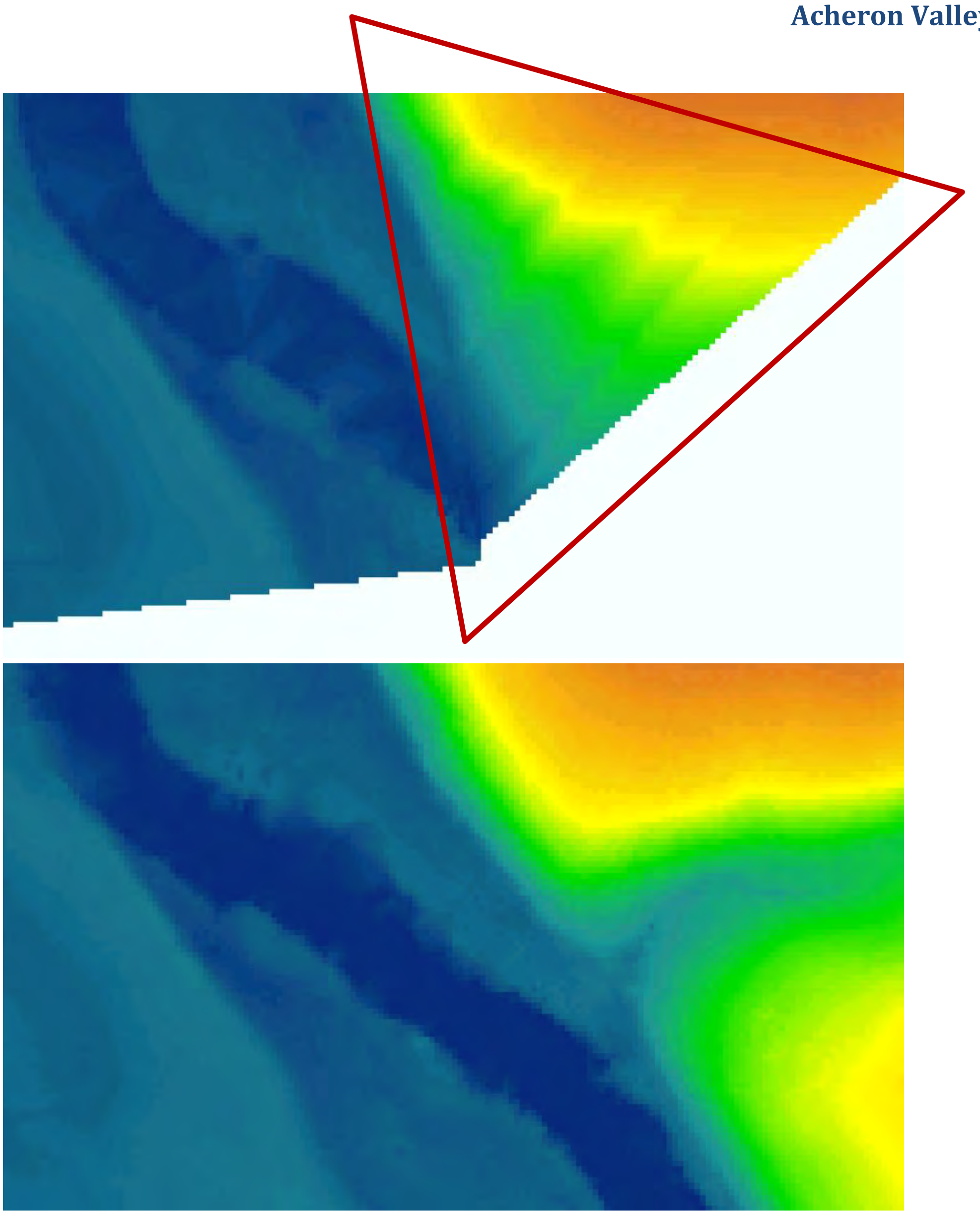

Figure 3-5 North East Towns LiDAR (top) and ISC LiDAR (below) on the Acheron River at E385640 N5865980. The red triangle shows the extent of the distorted LiDAR.

3.2.3 Marysville

The hydraulic modelling for the Marysville area utilised two different DEMS:

1. 2013-14 North East Towns Elevation LiDAR with a bare earth vertical accuracy of ±0.10m and a horizontal accuracy of ±0.18m.
2. Index of stream condition (ISC) LiDAR (February-October 2010) with a vertical accuracy of ±0.10m and a horizontal accuracy of ±0.19m.

The areas around Marysville covered by the North East Towns LiDAR are shown in Figure 3-6. The balance of the hydraulic modelling used the ISC LiDAR.

The analysis of the difference between the ground survey levels and LiDAR DEMS for the Marysville hydraulic model is shown in Figure 3-7.

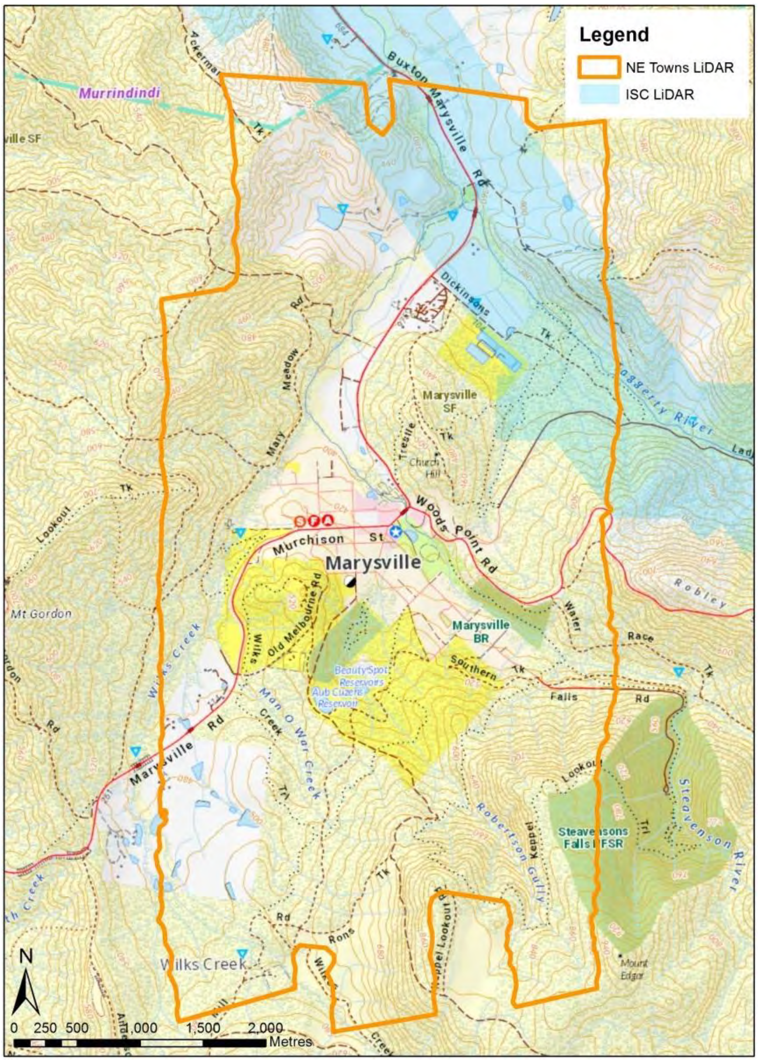

Figure 3-6 The extent of the North East Towns LiDAR and the surrounding ISC LiDAR that was used at Marysville.

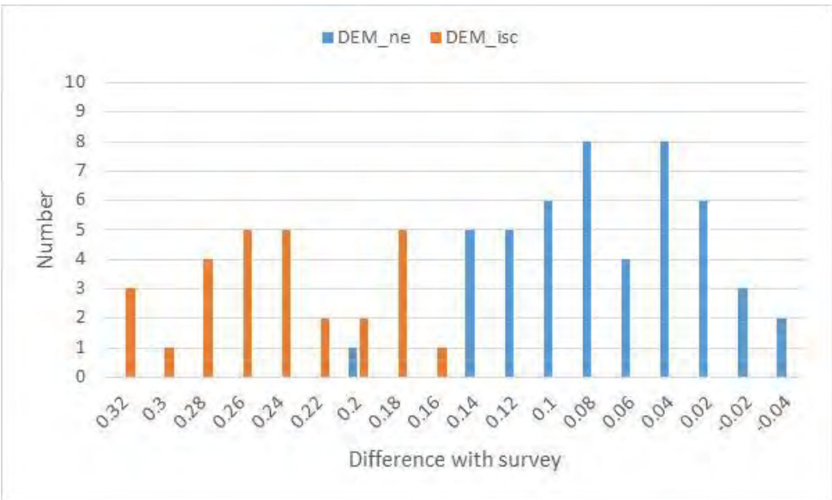

Figure 3-7 Histogram of the difference between survey levels and DEMS at Marysville.

The median difference (DEM minus survey level) between the north east towns LiDAR and the survey was +0.06m (sample 48, standard deviation 0.049m) and the median difference for the ISC LiDAR was +0.233m (sample 28, standard deviation 0.047m).

3.2.4 Goulburn River

The ISC LiDAR was used for the DEM of the lower Acheron downstream of Taggerty (Figure 3-3). However the ISC LiDAR does not provide terrain for the full width of the Goulburn Valley at the confluence with the Acheron. The Fugro Spatial Systems 2007 LiDAR with a vertical accuracy of ±0.10m was used along the Goulburn Valley.

4 HYDRAULIC MODEL DEVELOPMENT

The two-dimensional model TUFLOW, build 2017-09-AC, was used for the hydraulic modelling in single precision mode. A one-dimensional model in ESTRY was linked to TUFLOW to represent culverts and stormwater pipe networks.

4.1 DOWNSTREAM BOUNDARY CONDITIONS

The downstream boundary of the hydraulic model is at the Goulburn River. The downstream boundary conditions were based on the mapping of design floods (20, 50 and 100 year ARI events) by Water Technology for the Goulburn River Constraints Project.

The downstream end of the Acheron Valley is characterised by the approximate 2km wide Acheron River floodplain meeting the Goulburn Valley. The Goulburn Valley has a significant hydraulic gradient in this area with the water surface elevation dropping approximately 3 metres across the 2km wide (east to west) confluence of the valleys (Figure 4-1). Hence, boundary conditions replicating the east to west (upstream to downstream) hydraulic gradient along the Goulburn Valley were required for the Acheron model.

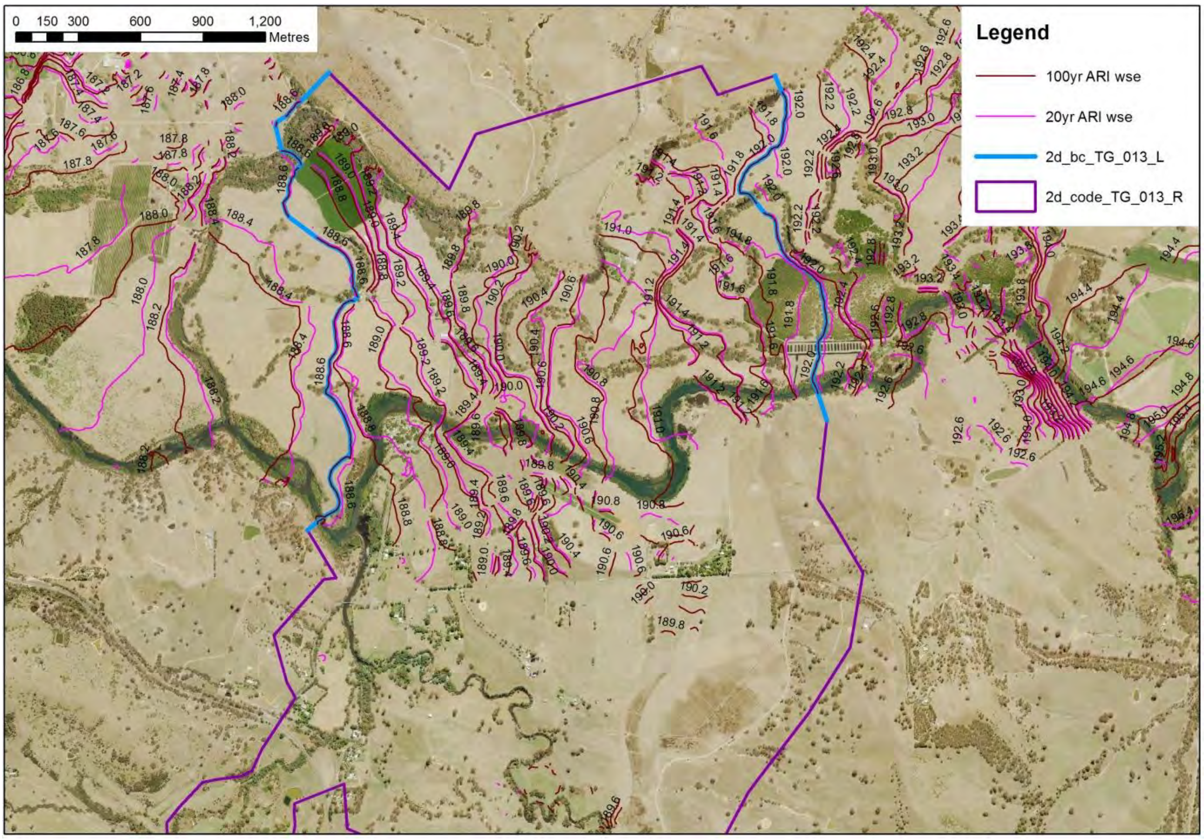

Figure 4-1 The confluence of the Acheron and Goulburn Valleys showing the Constraints Project 20 year and 100 year ARI water level contours and locations of inflow (right, u/s) and outflow (left, d/s) boundaries for the Acheron hydraulic model.

A review of the Constraints Project mapping found that there are water surface level contours across the Goulburn Valley, both upstream and downstream of the confluence with the Acheron Valley, where the contours for the 100 year and 20 year ARI events are only in the order of 10-

40 metres apart. The 50 year ARI contours falling between the 20 and 100 year levels. Hence downstream boundary conditions for the Acheron River model were set at these locations (Figure 4-1) as:

1. An inflow boundary across the Goulburn Valley along the 192.0m AHD water surface contour upstream of the Acheron River; and
2. An outflow boundary across the Goulburn Valley along the 188.6m AHD water surface contour downstream of the Acheron River.

The inflow and outflow boundaries on the Goulburn River, shown as "2d_bc_TG_013_L" in Figure 4-1, were set as height verses time (TUFLOW "HT") boundaries. Setting the water levels upstream and downstream of the confluence with the Acheron River ensured the correct water surface gradient across the confluence of the two river valleys without the need to calibrate the Goulburn River reach of the model.

The downstream water levels were established during the hydraulic model runs by setting an initial water level (TUFLOW "IWL") at the same level as the downstream boundary condition across the Goulburn Valley (188.6m AHD). The water level at the upstream boundary across the Goulburn Valley was increased from the IWL of 188.6m AHD to the upstream water level of 192.0m AHD over the first time-step in the flow inputs.

4.2 Hydraulic model grid size

The initial TUFLOW hydraulic model calibrations at Buxton and Taggerty were done in separate models with a 2 metre grid size. When the models were calibrating to essentially the same roughness they were combined to cover the whole valley and the model resolution reduced to a grid size of 3 metres. The calibration at Taggerty and Buxton was checked at the larger grid size.

4.3 Invert of the rivers

The aerial laser survey (ALS) used for the digital elevation model (DEM) provides the elevations of the water surface not the bed of the rivers. To address this issue the invert of the rivers was cut into the DEM using the TUFLOW "Z shape" model files.

The river invert levels were based on elevations surveyed along the thalweg in Buxton (Figure 4-2) and Taggerty (Figure 4-3) and from Taggerty to the Goulburn River (Figure 4-3). The thalweg survey was undertaken by Oxley and Partners P/L in 2014 and 2015.

The "Z shape" TUFLOW files were used to cut out the river invert by creating a breakline connecting the survey points along the thalweg/centreline of the river channel. The survey points and centreline were used with the surface area of the bed of the river to create a TIN (triangulated irregular network) and provide a DEM of the base of the river channels.

The centreline of the river thalweg and the surface area of the river bed were based on the Index of Stream Condition 3 centreline and bed width data files.

For the river reaches between or upstream of the bed survey (Figure 4-2 and Figure 4-3), the difference between the surveyed level and the DEM was tested for the 25 survey points closest to the reach. On average it was found that the difference between the bed survey level and the DEM was:

- -1.4 metres on the Acheron River at the upstream end of Taggerty;
- -0.8 metres on the Acheron River at the downstream end of Buxton;
- -0.8 metres on the Acheron River at the upstream end of Buxton;
- -0.6 metres on the Steavenson River at the upstream end of Buxton; and
- -0.5 metres on the Little Steavenson River at the upstream end of Buxton.

The above differences between the surveyed bed level and DEM increase with the size of the river channel and catchment area, a result that is to be expected.

For the river reaches where no bed survey is available the above differences were used, along with the ISC3 shapefiles for bed width and stream centreline, to lower the invert of the river channel. For instance, for the bed of the Acheron River between Taggerty and Buxton the ISC3 stream centreline was lowered by 0.8 metres and this was used with the bed width polygon to create a TIN of the river bed.

The lowering of the river inverts was not extended upstream of the confluence with Stony Creek on the upper Acheron River nor upstream of the confluence with the Taggerty River on the Steavenson River. It was judged that the differences between bed and DEM level measured at Buxton were unlikely to be valid upstream of these points.

The 2007 Goulburn River LiDAR has a number of "holes" cut in it where there was standing water at the time the LiDAR was flown. The ISC3 LiDAR was used to fill these "holes" on the southern side of the Goulburn floodplain. Beyond the northern extent of the ISC3 LiDAR the TUFLOW model files "Z shapes" were used to fill the DEM.

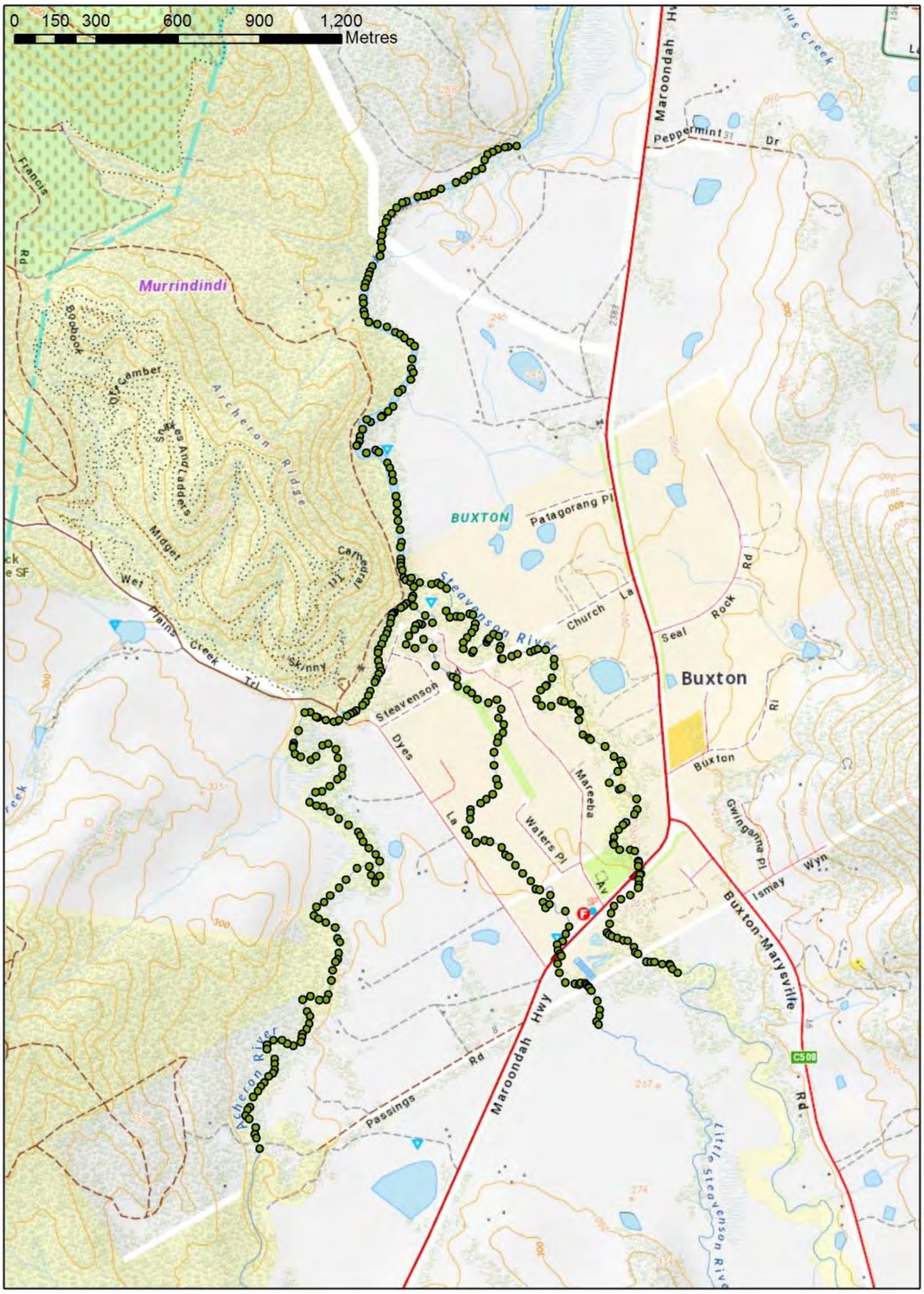

Figure 4-2 Map of the invert levels surveyed along the Acheron, Steavenson and Little Steavenson Rivers at Buxton.

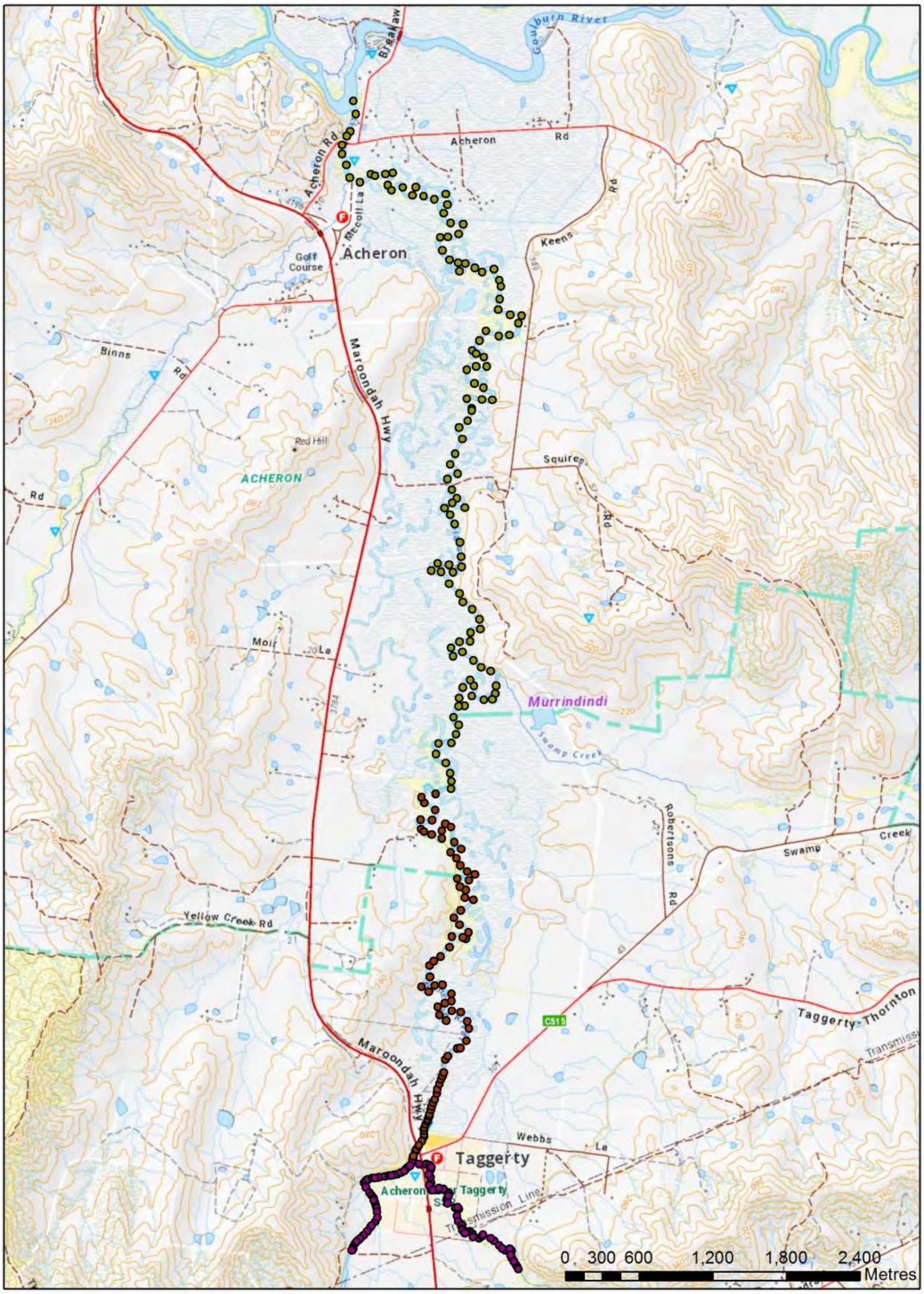

Figure 4-3 Map of the invert levels surveyed along the Acheron River from the Goulburn River to and upstream of Taggerty and along the Little River through and upstream of Taggerty.

4.4 BRIDGES AND CULVERTS

Layered 2-dimensional flow constrictions were used in TUFLOW to represent the hydraulic characteristics of the bridges over the Acheron River and its tributaries.

The sets of culverts on the floodplain of the Acheron River and its tributaries were represented in the 1-dimensional ESTRY hydraulic model that linked to the TUFLOW model.

At a number of the bridges the processing of the ALS to create the “bare earth” data has wholly or partially removed the abutments of the bridges. As the abutments can block a substantial part of the creek cross-section, it is important that they be accurately represented to replicate the hydraulic influence of the bridges. The abutments of bridges were included in the TUFLOW model using Z shapes with elevations that were based on the survey of the bridges and the raw ALS data.

4.5 BLOCKAGE OF PITS AND HYDRAULIC STRUCTURES

To model Scenario 2, pit and structure blockages have been applied to the hydraulic model. The blockage percentages adopted were based on:

1. Australian Rainfall and Runoff (AR&R) 2016 provides a procedure in Book 6, Chapter 6 to determine the blockage of hydraulic structures (Ball, et al. 2016); and
2. The Queensland Urban Drainage Manual (QUDM) provides recommendations on pit blockage values (DEWS 2013).

As per AR&R 2016, hydraulic structures (bridges and culverts) are individually assessed for blockage caused by debris or sedimentation. Debris blockage is a function of the availability, mobility and transportability of debris, determining the potential for debris to reach the hydraulic structure. The size and type of debris is also assessed to determine its interaction with the structure.

This determine a debris potential and then a debris blockage based on structure width. Sedimentation blockage is determined based on soil type.

Structure blockage was calculated for structures down the main flow paths in the study area. This allowed for the influence of blockage for all structures to be modelled with the influence of a blockage in an upstream structure.

4.5.1 Largest 10% of debris type

The average length of the longest 10% of debris likely to reach the site (L_{10}) was determined via site inspections and a review of previous photographs showing debris against hydraulic structures (e.g. Figure 4-4 and Figure 4-5). The L_{10} values adopted for the primary waterways in the study are shown in Table 4-1.

Table 4-1 Adopted lengths for largest 10% of debris.

River reach	Adopted L_{10} value
Acheron River d/s of Buxton	5m

River reach	Adopted L_{10} value
Acheron River u/s of Buxton	4m
Steavenson River d/s of Taggerty River	4m
Steavenson River u/s of Taggerty River	3m
Taggerty River	3m

4.5.2 Design blockage level

Based on the above L10 values and an assessment of debris potential at each structure the design blockage levels were determined for each of the design ARI events. Examples of the design blockage levels adopted at key hydraulic structures is shown in Table 4-2.

Table 4-2 Examples of design blockage levels at key hydraulic structures.

Blockage assessment variables	Steavenson River, C512 Marysville		Taggerty River, C508 Buxton-Marysville Rd		Steavenson River, B360 Maroondah Hwy, Buxton		Acheron River, C512 Marysville Rd, Narbethong	
Availability	High		High		Medium		High	
Mobility	High		High		Medium		High	
Transportability	Medium		Medium		Medium		High	
ARI (years)	Debris potential	Design blockage	Debris potential	Design blockage	Debris potential	Design blockage	Debris potential	Design blockage
5	Medium	10%	Medium	10%	Low	0%	Medium	10%
10	Medium	10%	Medium	10%	Low	0%	Medium	10%
20	High	20%	High	20%	Medium	10%	High	20%
50	High	20%	High	20%	Medium	10%	High	20%
100	High	20%	High	20%	Medium	10%	High	20%
200	High	20%	High	20%	Medium	10%	High	20%
500	High	20%	High	20%	High	20%	High	20%

Blockage assessment variables	**Acheron River, B360 Maroondah Hwy, Narbethong**		**Little River, B360 Maroondah Hwy, Taggerty**		**Acheron River, B360 Maroondah Hwy, Taggerty**		**Acheron River, Acheron Rd, Acheron**	
Availability	High		High		High		Medium	
Mobility	High		High		High		Medium	
Transportability	High		Medium		Medium		Medium	
ARI (years)	Debris potential	Design blockage	Debris potential	Design blockage	Debris potential	Design blockage	Debris potential	Design blockage
5	Medium	10%	Medium	10%	Medium	10%	Low	0%
10	Medium	10%	Medium	10%	Medium	10%	Low	0%
20	High	20%	High	20%	High	20%	Medium	10%
50	High	20%	High	20%	High	20%	Medium	10%
100	High	20%	High	20%	High	20%	Medium	10%
200	High	20%	High	20%	High	20%	Medium	10%
500	High	20%	High	20%	High	20%	High	20%

Figure 4-4 Debris on the pier of the bridge on the Buxton-Marysville Road near No.760. Photo by Oxley & Partners, July 2014.

Figure 4-5 Debris on the pier of the bridge on the Buxton-Marysville Road near No.562. Photo by Oxley & Partners, July 2014.

4.5.3 Blockage of pits

Design values for blockage are specified in Table 7.5.1 of QUDM. For the grated inlet pits in this hydraulic model a blockage value of 50% is recommended. This blockage was applied to the pipes downstream of any grated pits to ensure pit blockage did not increase the capacity of the stormwater system by allowing it to pressurise.

5 CALIBRATION

5.1 HYDRAULIC ROUGHNESS

The roughness values used in the hydraulic model are shown in

Table 5-1. Roughness values were set based on those commonly referenced in the literature and determined from the calibration process for the townships of Buxton and Taggerty (Section 5.2).

The roughness for built-up areas is inclusive of buildings, gardens and fences. Australian Rainfall and Runoff suggests this combined roughness should be in the range of 0.08-0.3 (AR&R, 2012). As parcels of land in Buxton and Taggerty have an area typically in the order of 4,000m^2 and typically have open type wire fences, the lower end of the range of roughness for built-up areas was adopted. For the design events the extent of development (residential and commercial) was expanded from existing conditions to reflect the full extent of the current zoning of land.

Figure 5-1 At Buxton looking downstream along the Acheron River with the Acheron River coming into the picture from the left and the confluence with the Steavenson River on the right.

Figure 5-2 At Taggerty looking upstream along the Acheron River towards the caravan park.

Table 5-1 Roughness values used in the TUFLOW model.

Materials layer	Manning's *n* roughness
timbered areas	0.070
built-up areas	0.080
roads	0.015
rivers	0.030
pasture	0.050

5.2 CALIBRATION PROCESS

This project developed hydraulic models for much of the Acheron and Steavenson River valleys. However, historic flood levels for hydraulic calibration were only available at Taggerty (one flood) and Buxton (three floods).

5.2.1 Calibration at Buxton

At Buxton there are peak flood levels for the 1996, 1998 and 2010 floods. The 1996 and 2010 floods were prioritised for the calibration and validation of the hydraulic model as:

1. The 1996 and 2010 floods had better hydrologic calibration results than the 1998 flood.
2. The 1996 and 2010 floods have 17 and 20 historic flood levels respectively. There are only 6 flood levels for the 1998 flood.
3. The 1996 flood is the only event with flood levels on the Acheron River.

The hydraulic model with the roughness values listed in

Table 5-1 produced the differences between modelled and observed water levels shown in Figure 5-3 for the 1996 flood and in Figure 5-4 for the 2010 flood.

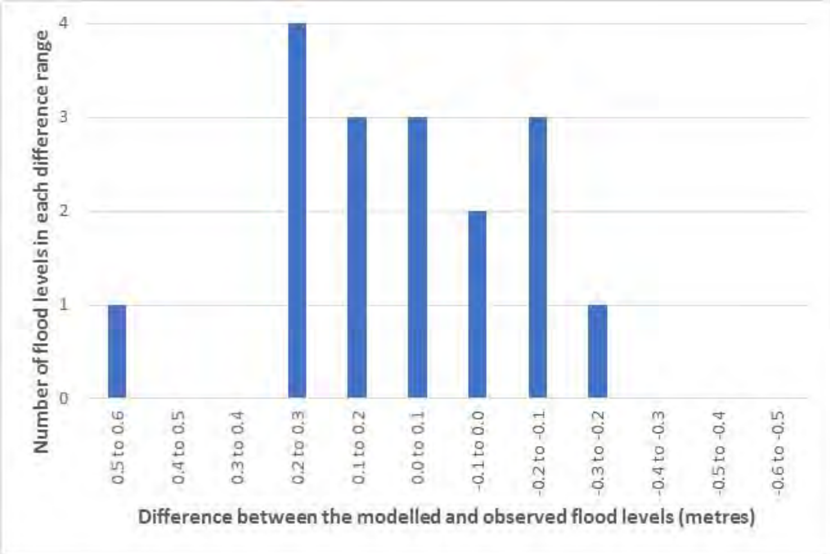

Figure 5-3 The number of flood levels in each range of difference for the 1996 flood at Buxton. The difference is the modelled flood level minus the surveyed (observed) flood level.

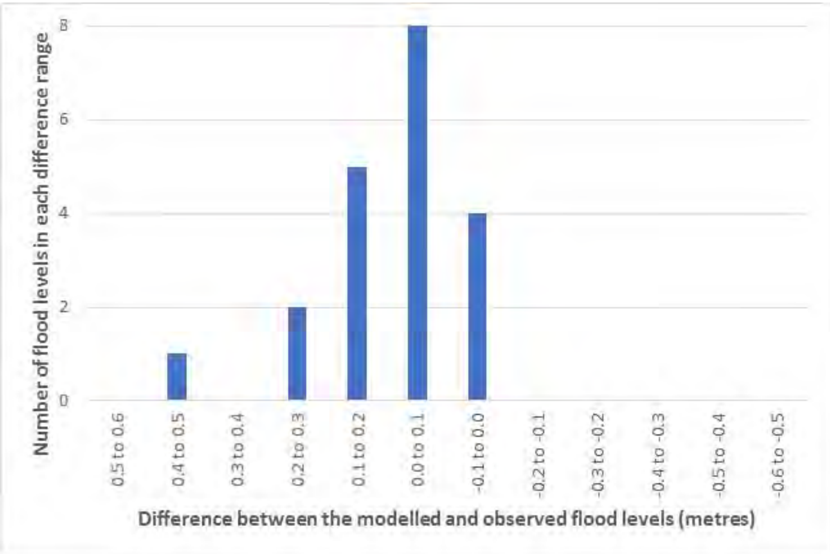

Figure 5-4 The number of flood levels in each range of difference for the 2010 flood at Buxton.

Based on the reliability of surveyed flood peaks the calibration tolerance is typically set at ± 0.2 metres. Overall it would be normal to get around 70% of flood marks within the ± 0.2 metres and often a large percentage of these are within 0.1 metres. For the 1996 and 2010 floods 71% and 85% respectively of modelled flood levels were within ± 0.2 metres of surveyed flood levels.

The spatial distribution of the modelled flood levels minus the observed levels for the 2010 flood at Buxton is shown in Figure 5-5.

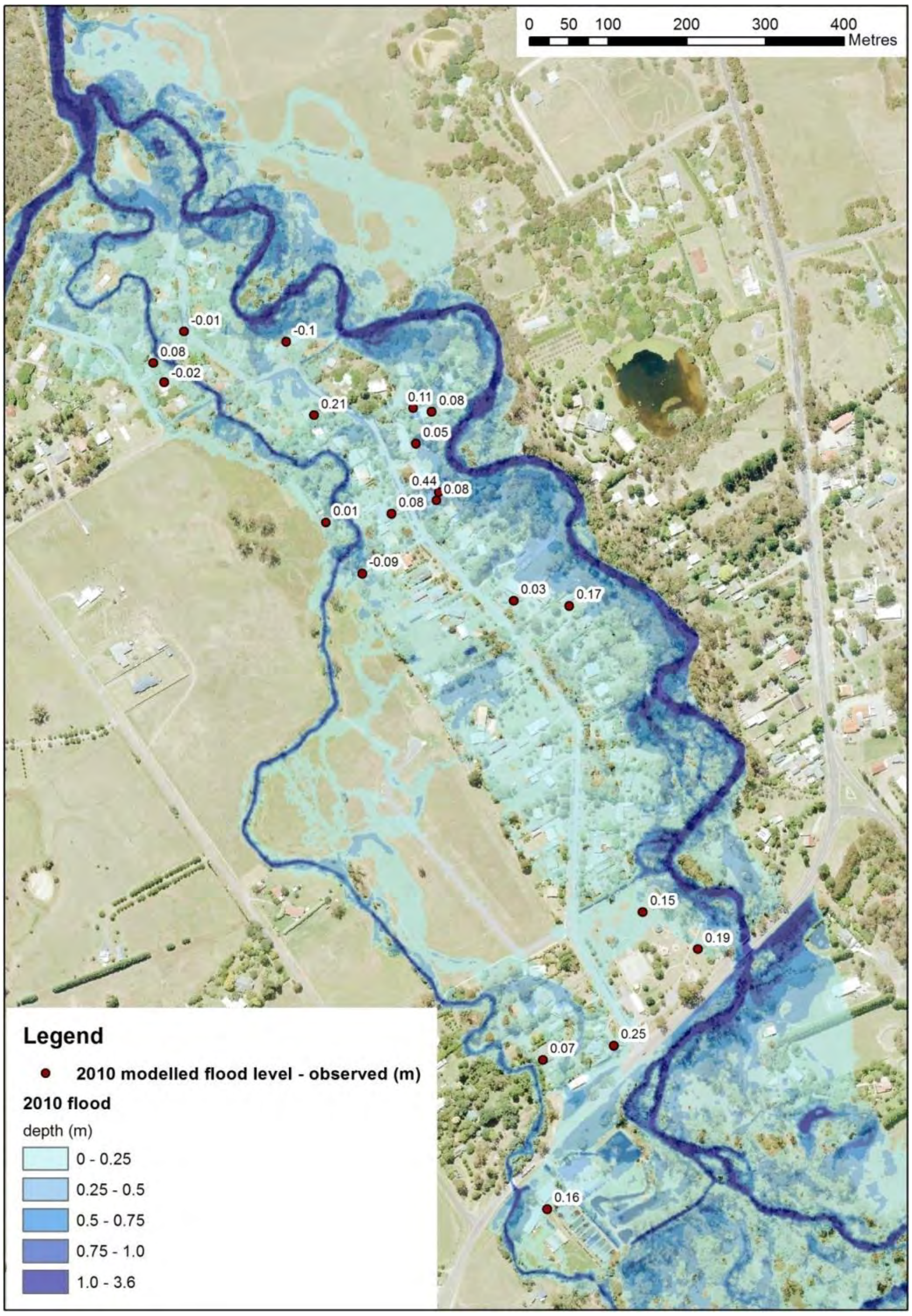

Figure 5-5 **The modelled flood extent and depths for the 2010 event at Buxton. Modelled flood levels minus the surveyed (observed) levels are also shown.**

The hydraulic model calibrated to the 2010 and 1996 floods was then tested against the 1998 flood levels. The differences between modelled and observed water levels shown in Figure 5-6 were generated for the 1998 flood. Though there are only six 1998 flood levels, 83% of them are in the range of ± 0.2 metres.

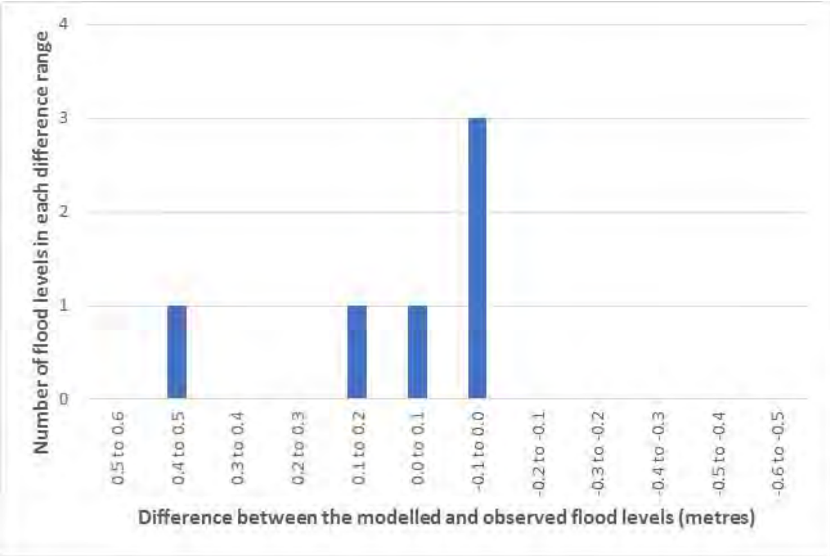

Figure 5-6 The number of flood levels in each range of difference for the 1998 flood at Buxton.

Overall, the above calibration results for the Buxton hydraulic model across three different floods validates the suitability of this model for mapping design events through the town.

Shifting the whole of valley model from a 2m to a 3m grid increased the20 flood levels for the 2010 event by a median of +1cm, with a 90th percentile increase of +2cm and a 10th percentile of -3cm.

5.2.2 Calibration at Taggerty

At Taggerty there are six peak flood levels for the 2010 flood plus the recording at the Taggerty gauge (gauge number 405209). The hydraulic model with the roughness values listed in

Table 5-1 produced the differences between modelled and observed water levels shown in Figure 5-7 for the 2010 flood. The spatial distribution of the modelled flood levels minus the observed levels for the 2010 flood at Taggerty is shown in Figure 5-8.

The water level modelled at the gauge is within 0.1 metres of the maximum level recorded on 5th September 2010. At four flood height survey locations the hydraulic model does not report water but the flood extent is still within 0.7-2.6 metres of the flood level. A further survey location is 17 metres from the modelled extent. At these sites the modelled water level closest to the survey site was used. Overall, the location of these flood levels suggests they were taken at the maximum extent of flooding in 2010.

The flood level at the rear of 3311 Maroondah Highway Taggerty is on a convex slope with the modelled flood water spilling around within 15 metres of the survey site. Due to the nature of the topography and flow down the slope the modelled water level does match the survey at one adjacent point but not at others. Hence the difference between modelled and observed flood levels is not recorded at this site in Figure 5-7 or Figure 5-8.

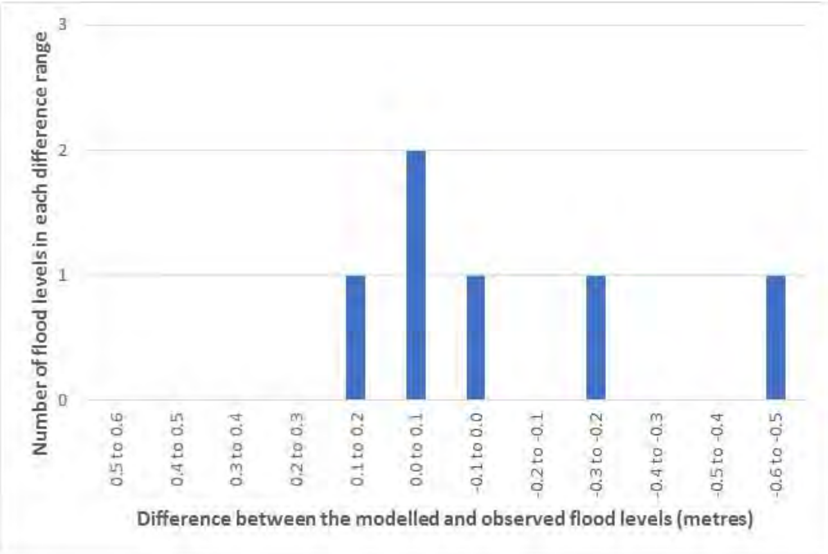

Figure 5-7 The number of flood levels in each range of difference for the 2010 flood at Taggerty.

For the full scale valley model the grid size was increased from 2m to 3m. This change in grid size resulted in an increase in water levels in both the Acheron River and on the floodplain but generally only by a few centimetres.

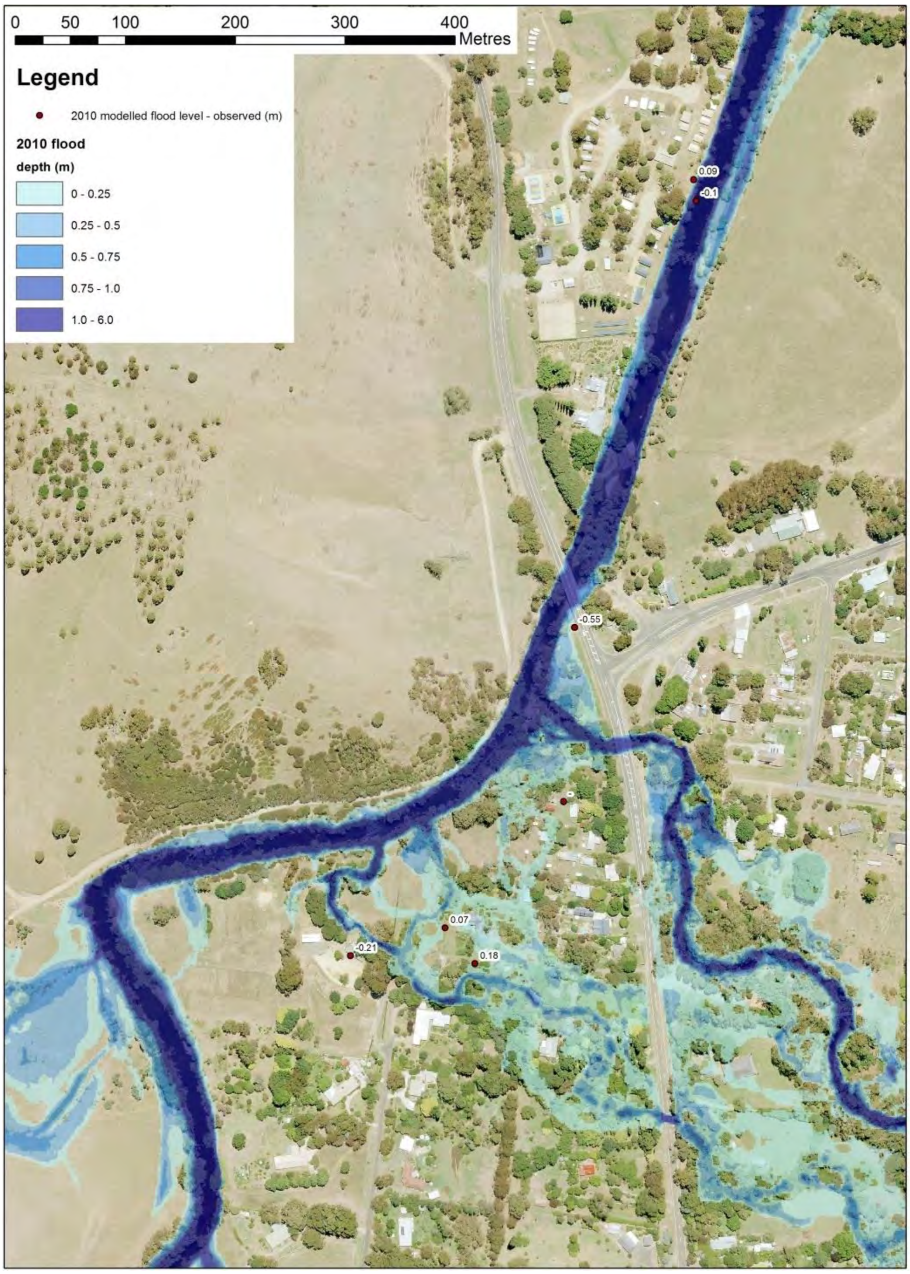

Figure 5-8 **The modelled flood extent and depths for the 2010 event at Taggerty. Modelled flood levels minus the surveyed (observed) levels are also shown.**

6 FLOOD INUNDATION

Flood mapping was carried out for the 0.1%, 0.2%, 0.5%, 1%, 2%, 5%, 10% and 20% AEP design flood events. The 1% AEP design event includes an allowance for climate change (see Section2.2.1).

The flood mapping included a number the raster (gridded) products as follows:

- Water surface elevation (m AHD)
- Depth (m)
- Velocity (m/s)
- Hazard (m^2/s)

Flood level contours were also generated.

These products were produced in ArcGIS format and delivered digitally.

Appendix A provides a set of maps for 1% AEP flood at a broad catchment scale. Appendices B, C and D provide enlarged maps for Taggerty, Buxton and Marysville.

7 RECOMMENDATIONS

The recommendations from this hydraulic and flood mapping project are set out in Sections 7.1, 7.2 and 7.3.

7.1 REVISED FLOOD LEVELS

It is recommended that the 1% AEP (100-year ARI) flood levels determined from this flood study are used to set appropriate floor heights for buildings and extensions proposed in the study area.

7.2 MUNICIPAL FLOOD EMERGENCY PLAN

It is recommended that the Municipal Flood Emergency Plan (MFEP) be updated by Murrindindi Shire Council to reflect the outcomes of this flood study.

7.3 FLOOD ZONES AND OVERLAYS IN THE MURRINDINDI PLANNING SCHEME

It is recommended that the flood overlays in the Murrindindi Planning Scheme be amended to reflect the findings of this study. The Floodway Overlay (FO) covers areas where, in the 100-year ARI flood, either the depth of flow exceeds 0.3 metres or the product of depth and velocity is 0.4 m^2/sec or greater. The depth of flooding of 0.3 metres was overwhelmingly the dominant criterion for determining the extent of the FO. The Land Subject to Inundation Overlay (LSIO) covers all other areas that are inundated in the 100-year ARI flood.

8 REFERENCES

BMT (2018). *Acheron Flood Hydrology: Final Report.*

BMT and Michael Cawood & Associates Pty Ltd (June 2019). *Acheron Basin Flood Hydrology – Flood Warning Discussion Paper*.

Murrindindi Shire Council and VICSES (June 2019) *Murrindindi Shire Council Flood Emergency Plan Version 2.1*