Fernvale LFMP

Fernvale Local Floodplain Management Plan

Somerset Regional Council

15 January 2021

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Synergy Solutions

Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
01	Draft	ABM	RWS	16 June 2020
02	Draft	ABM	RWS	21 August 2020
03	Draft	CAB/CJW	RWS	30 September 2020
04	Final	CAB	RWS	13 November 2020
05	Final	CAB	RWS	15 January 2021

Project Details

Project Name	Fernvale Local Floodplain Management Plan
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Document Number	19020078_R01_V05_Fernvale_LFMP.docx

Somerset REGIONAL COUNCIL

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1 INTRODUCTION

Flooding in Queensland in the summer of 2010/2011 affected more than 2.5 million people as well as approximately 29,000 homes and businesses. In 2012, the Queensland Flood Commission of Inquiry (QFCI) was established to recommend how state and local governments should manage flooding including future development, emergency response procedures, dam operations and structural mitigation.

Following the QFCI, the Queensland Government and local governments committed to long-term floodplain management practices to reduce the impact of current and future flood risks, including the Brisbane River Flood Studies and Brisbane River Strategic Floodplain Management Plan (SFMP)[1], led by the Queensland Reconstruction Authority (QRA). The Flood Study was released in May 2017 and is the largest ever undertaken in Australia. The Flood Study informed the development of the SFMP to better understand current and future flood risks and identify regionally consistent approaches to strengthen flood resilience across the Brisbane River floodplain. The outcome of the SFMP includes a Technical Evidence Report, recommendations for local floodplain management plans (LFMPs) and guidance material for amending planning schemes to align with State Planning Policy state interest for natural hazard risk and resilience. This LFMP establishes strategies to deliver long term sustainable management of flood risk in Lowood, a township in the wider local government area (LGA) of Somerset.

The Fernvale catchment is located downstream of Wivenhoe Dam, with the Fernvale Township itself located in the downstream catchment extent and adjacent to the Brisbane River. The catchment is approximately 20 km long in a north to southwestern direction, and around 6 km wide from west to east. Ferny Gully is the western most tributary in the catchment which flows through Fernvale Township in a north-eastern direction before meeting at the confluence with the Brisbane River to the immediate north of the town. Black Snake Creek and Fairney Brook are the eastern most tributaries of the Brisbane River that drain the larger portion of the catchment and flow in a north-easterly direction approximately 3 km south of the Fernvale Township. These tributaries also confluence with the Brisbane River south of the town. Other than flooding which occurs from the local catchment tributaries, parts of Fernvale are also subject to inundation from the Brisbane River. The catchment locality is shown in Figure 1-1.

The catchment is traversed by several major roads as illustrated in Figure 2-1. Brisbane Valley Highway passes through Fernvale in the lower portion of the catchment. The catchment is also traversed by the Rosewood Marburg Road to Marburg from south to north where it intersects with the Warrego Highway. Rosewood Marburg Road continues as Marburg Road to Glamorgan Vale, approximately 6 km south of Fernvale. From there, Fernvale Road traverses north into Fernvale where it intersects with the Brisbane Valley Highway.

The majority of the existing development in the catchment is associated with the urbanised areas of the Fernvale Township in the lower catchment reaches. Existing development within Fernvale includes commercial and low/medium residential areas. The Marburg Township located to the south of the Warrego Highway in the Ipswich City Council LGA is the only other area of urbanised development within the catchment. Other than the discrete urbanised township areas, the catchment is dominated by rural and rural residential land uses.

[1] BMT 2018, *Brisbane River Strategic Floodplain Management Plan Technical Evidence Report.* Available: (Online) https://cloudstor.aarnet.edu.au/plus/s/o7L0vJD0Uo5UO4B.

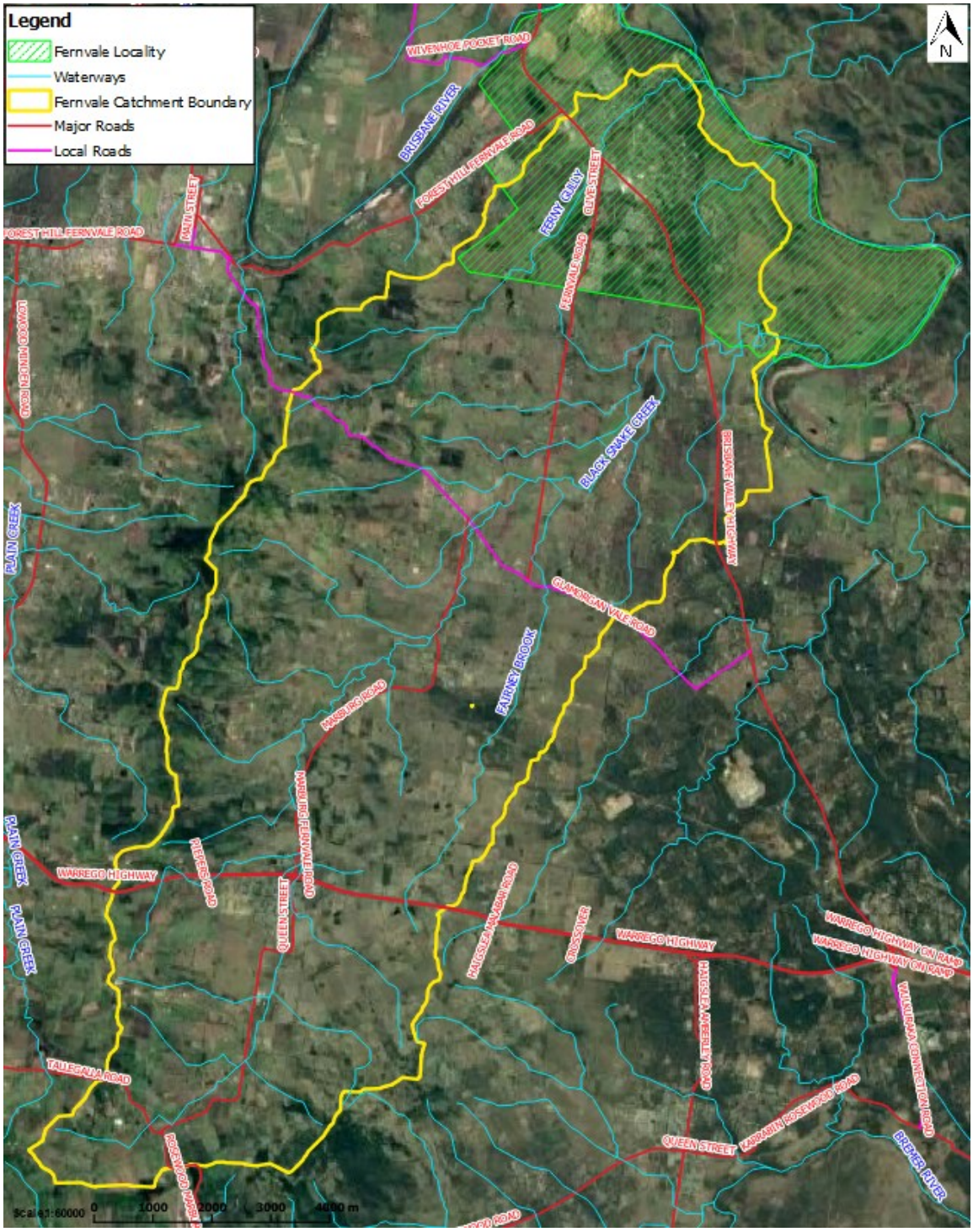

FIGURE 1-1 FERNVALE CATCHMENT LOCALITY MAP

2 CURRENT FLOOD RISK

The following information provides an overview and understanding of the flood exposure and current flood risk within the Fernvale catchment area. For further flood history of Fernvale and its catchments, the Somerset Flood Study Technical Report should be consulted for a detailed breakdown of any historical flooding and catchment characteristics.

2.1 Flood Risk Assessment

2.1.1 Overview

The approach taken to identify, document and analyse flood risk in the Fernvale Area for the Local Floodplain Management Plan (LFMP) follows the guidelines and strategic framework established in the Brisbane River Strategic Floodplain Management Plan (SFMP), which guides stakeholders to build flood resilience within the communities.

The risk assessment methodology established in the SFMP is in accordance with ISO 31000:2009 which summarises the process into four steps:

1) Risk identification
2) Risk analysis
3) Risk evaluation
4) Risk treatment

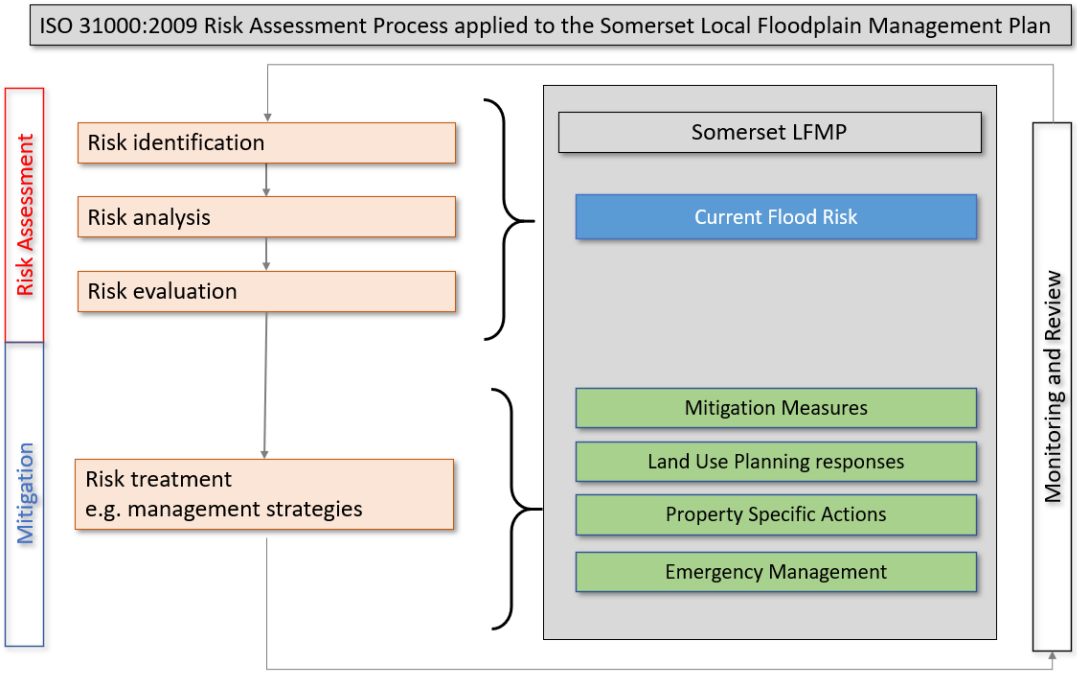

FIGURE 2-1 RISK ASSESSMENT PROCESS APPLIED TO THE LFMP

2.1.2 Risk Identification

Whilst the approach is reflecting the regionally consistent outcomes driven by the SFMP framework, the identification of flood risk in the Somerset Catchments has evolved to suit locally specific conditions associated with creek catchment and major tributaries to the Brisbane River Catchment.

Flood risk to the Fernvale Local Government Area (LGA) has due consideration of the following:

- Potential hydraulic risk.
- Direct and indirect damages caused by flooding.
- Isolation caused by flood waters creating flood islands.
- Time to Inundation of roads and buildings.
- Duration of Inundation of roads and buildings.

The SFMP provides the baseline methodology for identifying and calculating risks. However, where the LFMP has refined the methodology, this will be clearly stated in this document.

2.2 Risk Analysis

Risk is defined as a combination of **likelihood** and **consequence**.

Likelihood of flood risk has been kept consistent across all flood studies in the Local Floodplain Management Plans (LFMP) and is expressed as the hazard's Annual Exceedance Probability (AEP), representing the probability of a flood event to reach or exceed a given intensity in any year.

The following AEP events were considered when assessing risk:

- 1 in 10 (10% AEP)
- 1 in 20 (5% AEP)
- 1 in 50 (2% AEP)
- 1 in 100 (1% AEP)
- 1 in 500 (0.2% AEP)
- 1 in 2,000 (0.05% AEP)
- PMF (Probable Maximum Flood)

It should be noted that the PMF ranges in flood likelihood across the Somerset LGA due to the local creek catchment variance. The Brisbane River Catchment adopts a consistent 1 in 100,000 likelihood for the PMF.

Consequence examines the impact to exposed elements resulted by a flood event. This is both the physical impact of the event on an asset, as well as the economic, social, and environmental impacts on the same asset.

Potential Hydraulic Risk has been used in the Brisbane River Flood Studies and SFMP to define a regionally consistent definition of consequence using Potential Hydraulic Risk derived from hazard characteristics identified in the Australian Institute of Disaster Resilience (AIDR) guideline. These six characteristics are defined in the graphic taken from AIDR in Figure 2-2 and represented on the map shown in Figure 2-3.

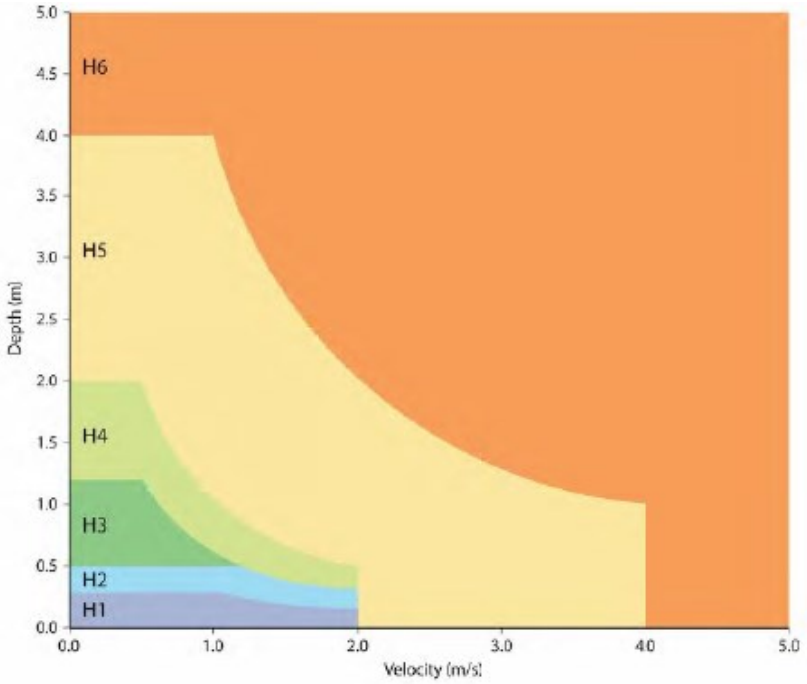

FIGURE 2-2 AIDR HAZARD CATEGORIES

These hazard categories are an important component of defining flood risk and breaking down hazards across the floodplain. Using different hazard categories across the catchment is helpful in designating appropriate flood risk management responses in areas exposed to hazard that is unsafe for children and the elderly; or on the other end of the scale, areas potentially exposed to hazard that threatens the structural integrity of buildings.

2.3 Hazard

Hazard is one of the most critical elements to defining overall flood risk. For the Fernvale area it enables assessment of particular hazards to different circumstances (risk to life, property and vehicles). As the Fernvale area is impacted by local and riverine flooding, these hazards are shown separately within the township area. The Hydraulic Risk outputs are better suited to understanding combined risk of local and regional flooding as both outputs are merged together for the worst case.

Figure 2-3 and Figure 2-4 show the 1 in 2,000 AEP hazard attributed to local flooding and regional flooding respectively. The following is noted with regards to the township local flooding:

- During the 1 in 100 AEP event, Nardoo gully begins flooding houses along Nardoo Street and the Brisbane Valley Highway. Hazard is generally a maximum of H2 (risk to small cars);
- During the 1 in 2,000 AEP event, the consequences of flooding only increase marginally from the 1 in 100 AEP event although the flooding is more widespread. Properties along Nardoo Street increase in numbers and some properties have a higher hazard of H3 (risk to life);
- The commercial area along Brisbane Valley Highway is affected by local flooding to fairly wide extent in the 1 in 100 AEP event however hazards remain low. High hazard flows are contained within drainage channels however in the 1 in 2,000 AEP event, some structures have slightly elevated hazard to H3; and
- Outside of the township there are several houses impacted with high hazard and the GIS datasets should be used to integrate individual flood risk.

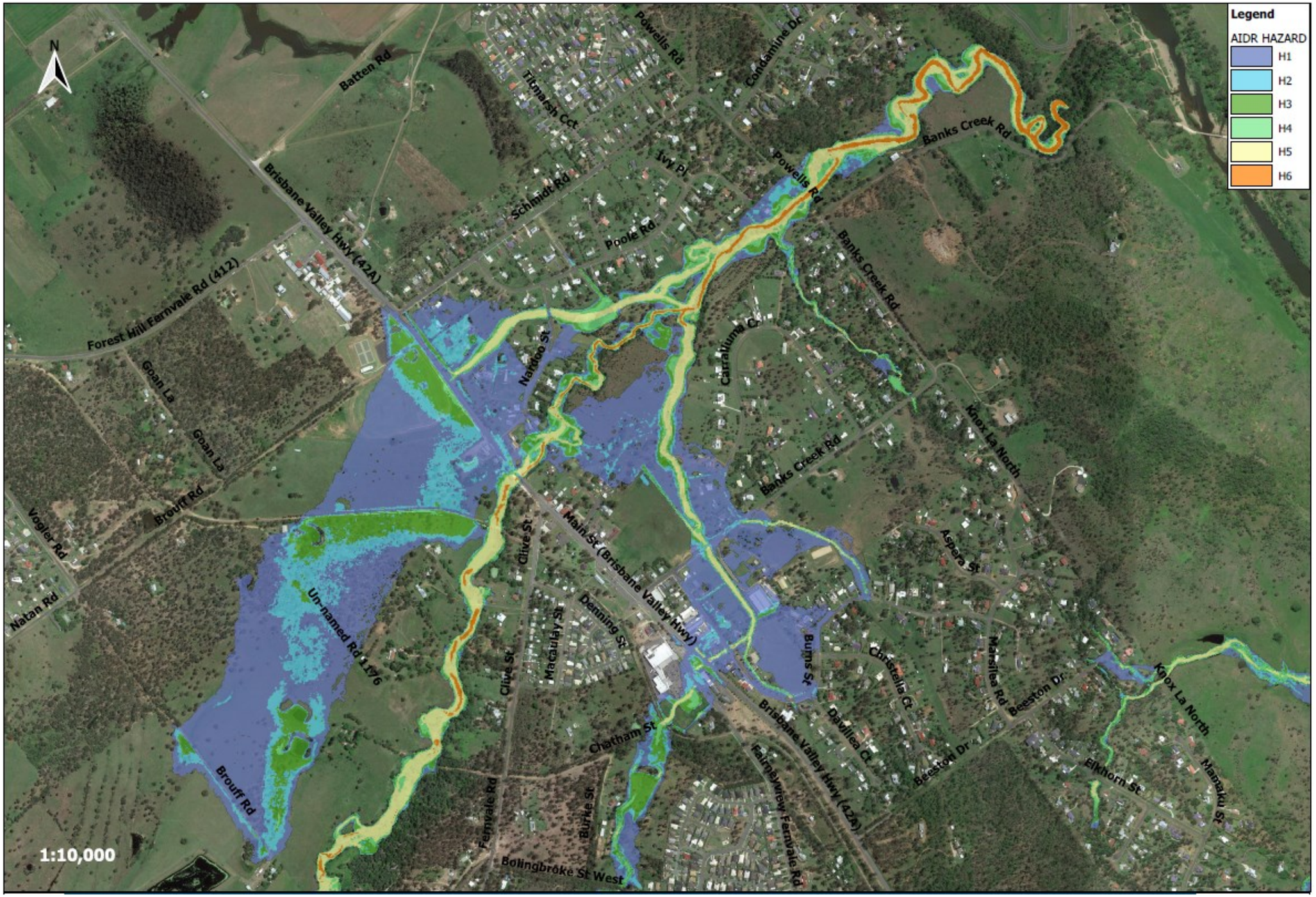

FIGURE 2-3 LOCAL FERNVALE 1 IN 2,000 AEP HAZARD

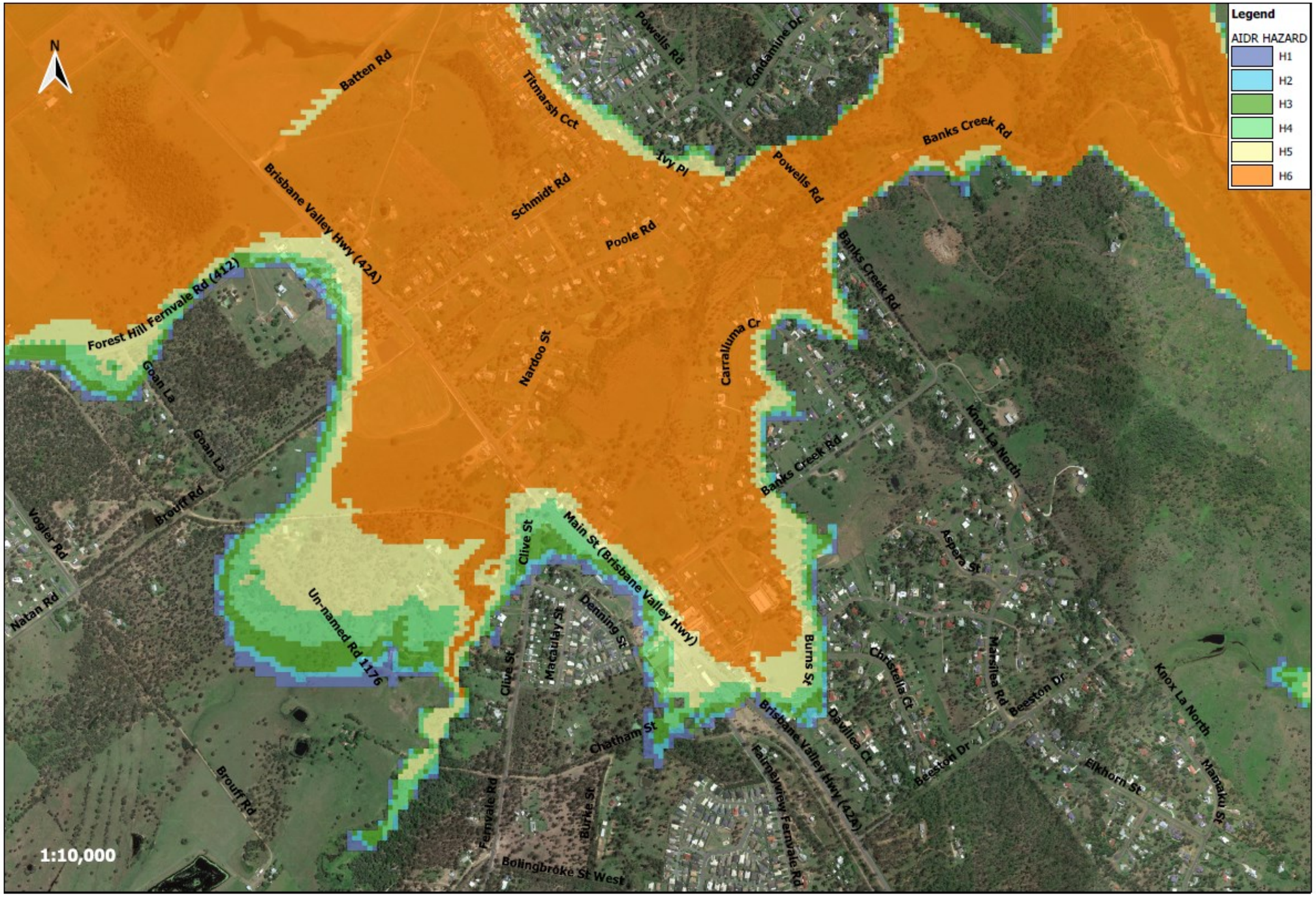

FIGURE 2-4 REGIONAL FERNVALE 1 IN 2,000 AEP HAZARD

The following is noted with regards to the township regional flooding:

- Flooding starts to become more severe during the 1 in 100 AEP with flooding of the Brisbane River beginning to occur. Nardoo gully begins backing up (along with other sections) flooding houses in the Nardoo Street area with general hazard of H3. However, there is one house near Powells Road that has a high H6 hazard (risk to structural failure). There are also houses outside of the township with this level of hazard.
- During the 1 in 2,000 AEP flood event, the consequences of flooding become very severe and life threatening. There is widespread inundation of the Fernvale Township with very high hazards (H6) widespread. This hazard also extends to much of the Fernvale main commercial area.

Flood events above the 1 in 100 AEP (similar to that experience in 2011) have severe consequences to the Fernvale community and additional recognition of these sudden hazards must be recognised in order to respond to rare events above the 1 in 100 AEP.

2.4 Potential Hydraulic Risk

Potential hydraulic risk (PHR) represents the hydraulic behaviour of floods and their likelihood to occur in a given floodplain. PHR is a useful tool to distinguish between degrees of risk (i.e. from low and high risks). For example, higher frequency, higher hazard flooding requires special consideration due to the elevated risks of both characteristics.

The methodology in the Brisbane River Strategic Flood Management Plan Technical Evidence Report (BRSFMP TER) Section 4.2 applies potential hydraulic risk across seven likelihood AEP events, providing a gradation of risk across five risk definitions. The mapping is sufficiently granular to pick up different bands of risk areas across the floodplain regionally. The output is five bands of relative hydraulic risk, derived from a matrix combining seven flood events.

The SFMP HR matrix identifies five bands of risk (HR1-HR5), with HR1 being the highest hydraulic risk to HR5 being the lowest hydraulic risk.

This is intended to be used for regional riverine flooding, but it disproportionally overrepresents areas of higher hazard (HR1 and HR2) across local creek floodplains, due to the frequency of events mapped in these categories. Through project team workshops, it was determined that more refinement and detail was needed to distinguish between low likelihood and hazard. Examples of this include:

- Defining low likelihood flooding (1 in 10 AEP) that has low hazard (H2):
  - The SFMP method defines this as HR1 (the highest risk category being low likelihood).
  - While this is true, understanding why risk is so high is also important.
- Defining low likelihood flooding (1 in 10 AEP) with extreme hazard (H6):
  - The SFMP method defines this as HR1.

It is useful to distinguish between the two examples above, as the second situation has a much higher risk and should be mitigated in areas within this category. To differentiate between risk categories, a new matrix was adopted that provided a way to distinguish between floods driven by frequency and hazard.

Three broader subcategories are used, vertically splitting the matrix to align with the three consequence thresholds (AIDR hazard categories). This creates three sub-classifications within the HR1 to HR3 bands to reflect low hazard (H1), moderate hazard (H2-H4) and High hazard (H5-H6) within each HR band. The revised Hydraulic Risk matrix includes 10 discrete bands of risk. The adopted Potential hydraulic risk matrix is in Table 2-1.

TABLE 2-1 REVISED POTENTIAL HYDRAULIC RISK MATRIX

AEP	H1	H2	H3	H4	H5	H6
PMF	HR5	HR5	HR5	HR5	HR5	HR5
1 in 2,000	HR5	HR5	HR4	HR4	HR4	HR4
1 in 500	HR5	HR4	HR4	HR3 (b)	HR3 (c)	HR3 (c)
1 in 100	HR4	HR4	HR3 (b)	HR2 (b)	HR2 (c)	HR2 (c)
1 in 50	HR4	HR3 (b)	HR2 (b)	HR2 (b)	HR1 (c)	HR1 (c)
1 in 20	HR3 (a)	HR2 (b)	HR2 (b)	HR1 (b)	HR1 (c)	HR1 (c)
1 in 10	HR2 (a)	HR1 (b)	HR1 (b)	HR1 (b)	HR1 (c)	HR1 (c)

The following can be derived from the new matrix:

- The (a) subcategories represent further distinction in catchments of a low hazard risk (i.e. of lesser consequence other than flood damage);
- The (b) subcategories represent the consequence range where there is risk to vehicles and life; and
- The (c) subcategories represent the consequence range where there is risk to structures.

It should be noted that hydraulic risk merely represents a portion of overall flood risk. Holistic flood risk includes a variety of other factors that are considered throughout the LFMP in conjunction with hydraulic risk.

The overview of the hydraulic risk output is shown below in Figure 2-5 and Figure 2-6. In addition, the Fernvale Township is also shown below and the following is noted:

- There is very high hydraulic risk in the area primarily associated with Brisbane River flooding. Within the township there is a mix of hydraulic risk throughout a very large area. The majority of these properties are exposed to HR3c hydraulic hazard with some exposed to HR2b.
- The majority of the township is also widely exposed to HR3 and HR4 hydraulic risk with all of the township in the HR5 hydraulic risk category.
- Outside of the township there are isolated properties with very high hydraulic risk (HR2c).

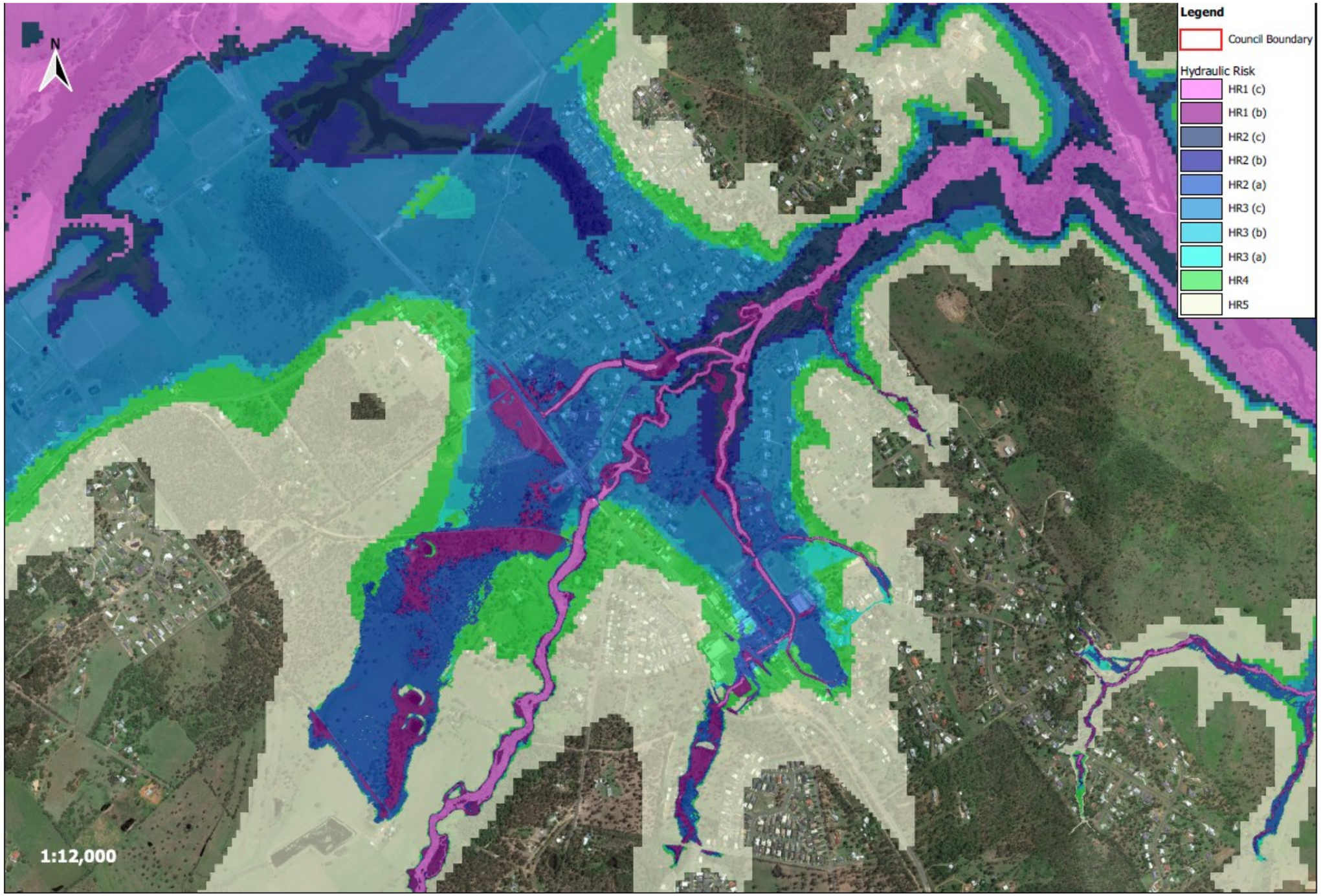

FIGURE 2-5 FERNVALE HYDRAULIC RISK OUTPUT

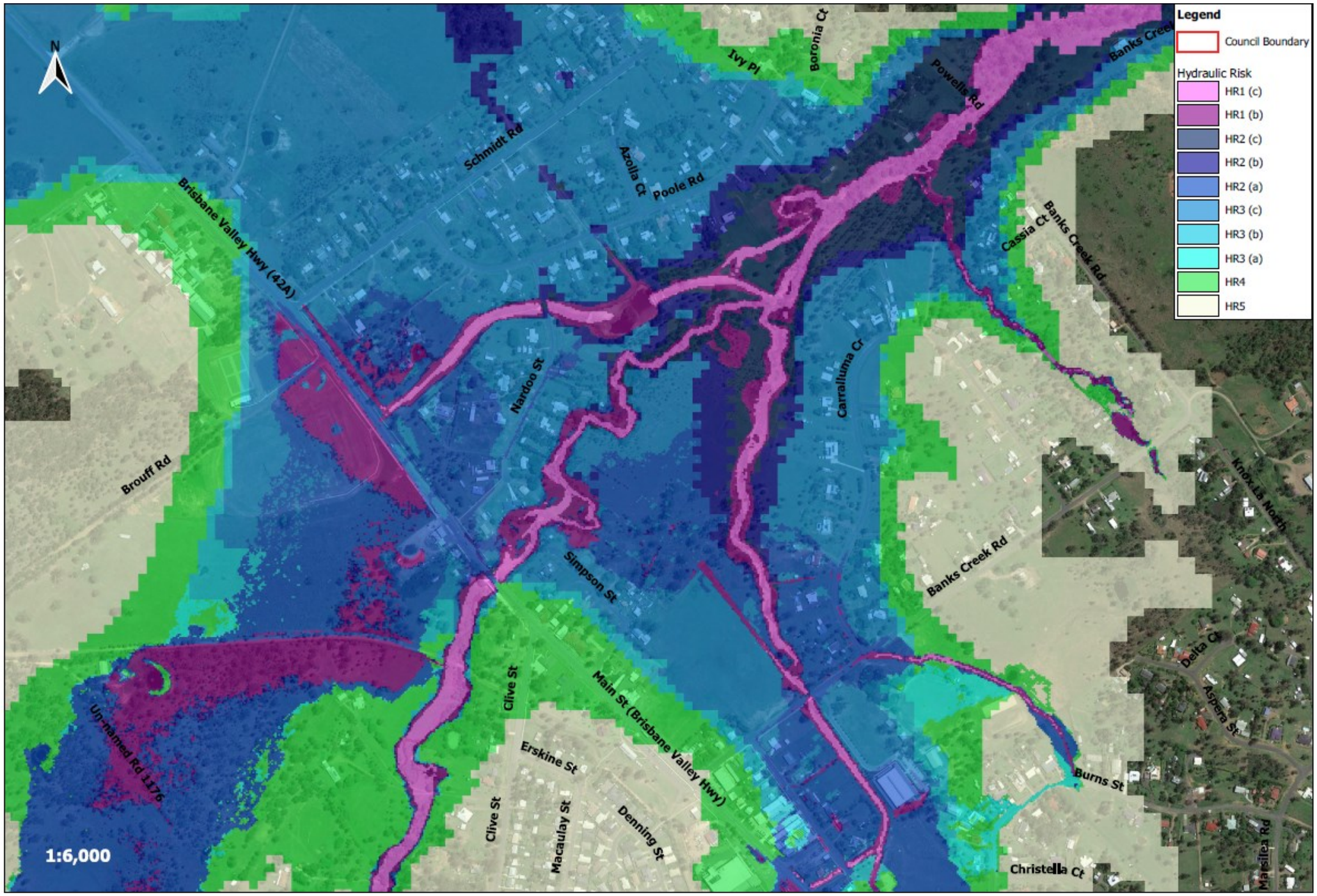

FIGURE 2-6 FERNVALE HYDRAULIC RISK OUTPUT (CLOSER EXTENT)

2.5 Current Flood Risk and Climate Change

The following provides a summary of the results of the Fernvale hydraulic model that was used in the Flood Study:

- According to the hydraulic model results, the Fernvale Indoor Sport Centre and some residences on Burns St are mapped as being affected in the 1 in 10 AEP event, however the flow is quite shallow and may not cause inundation to the properties.
- Main Street is also shown to be affected by the 1 in 10 AEP event, however, ARR19 hydrology models tend to overestimate frequent flows therefore we believe that flooding to Main Street will occur less frequently than the results suggest.
- The dominant source of flooding is riverine for areas close to the Brisbane River. This has not been represented in the local flooding hydraulic model.
- Inundation in the 1 in 100 AEP event generally affects residential dwellings on Schmidt Road, Burns Road and Carralluma Crescent.
- The PMF extent largely impacts residents near Schmidt Road and Burns Road.
- The Brisbane Valley Highway to the southeast is affected by flooding in the 1 in 20 AEP event, however we believe this is conservative for reasons stated earlier.
- The critical storm duration at Fernvale Gully generally tends to be the 60-min and 120-min events.
- Maximum 1 in 100 AEP flood velocities through the township are generally less than 1.5 m/s. Velocities up to 2.6 m/s are localised in the creek channels.

The climate change scenario considered as part of the Flood Study assessed an increase in rainfall intensity which was assessed based on the 1 in 100 AEP. The climate change scenario was completed based on the guidance provided in Book 1, Chapter 6 of ARR2019. Specifically, this included a factored increase in rainfall intensity of 11.5% which is consistent with the 6.0 RCP to the year 2090.

The differences between the 1 in 100 year AEP and 1 in 100 AEP plus climate change modelling results are displayed in Figure 2-7 for Fernvale. The map is displayed in two halves to provide more of a zoomed in view of both parts of the catchment that has been modelled. The extent on the left shows the extent of the water surface level difference between the two AEP's for the northern part of the catchment, whilst the extent on the right displays the extent for the southern part of the catchment. Water levels increase up to approximately 170 mm at the township, however the flood extent is not markedly affected, and impacts are largely contained to the existing flood extent.

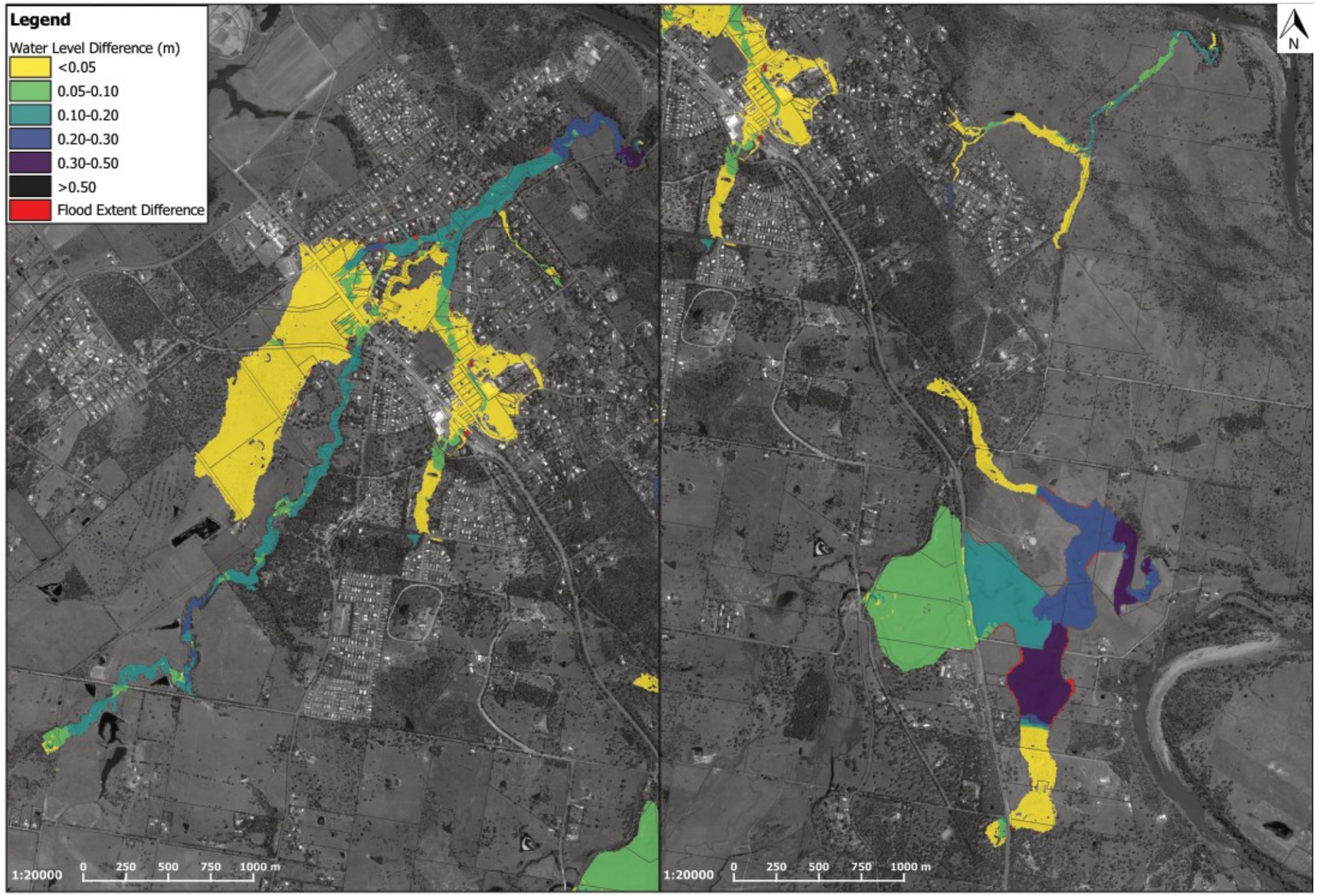

FIGURE 2-7 1 IN 100 AEP WATER LEVEL DIFFERENCE MAP FOR FERNVALE

2.6 Current Flood Exposure

Understanding the multi-faceted nature of vulnerability and exposure is a prerequisite for determining how weather and climate events contribute to the occurrence of disasters, and for designing and implementing effective risk management strategies (Cardona et al. 2012). Therefore, it is important to not only map assets, buildings and services, but also identify the community's vulnerability and exposure to flooding hazards.

This section explores the exposure of key built and community assets which are mapped within the floodplain, whereas later in the report, vulnerability of the community across the floodplain is summarised.

2.7 Building and Population Exposure

A spatial analysis of the land use zoning, buildings and flood information reveals the following exposure of existing land use across the Fernvale area.

2.7.1 Building Use Type Exposure Summary

An analysis of land use exposure based upon planning scheme zonings has been undertaken across the Fernvale Area and is shown in Table 2-2.

- The mapped extent of the floodplain reveals 716 residential and rural residential buildings are exposed to flooding in the PMF event. There are also 155 properties within the 1 in 100 AEP extent.
- There are fairly low numbers inundated in the more frequent events up to 1 in 50 AEP. However, there is a threefold increase in numbers to the 1 in 100 AEP when the floodplains engage on the Brisbane River.
- There are also large numbers of commercial buildings flooded, particularly after the 1 in 50 AEP.

TABLE 2-2 OVERALL ZONE EXPOSURE GROUND LEVEL FLOODING

AEP	Residential (Detached)	Residential (Multi-Dwelling)	Rural Living / Primary Production	Commercial / Business	Industrial	Community / Public Facilities	Public Utility (Critical or Sensitive)	Mining	Other (Mixed Use)	Vacant^
1	15	-	4	8	1	1	-	-	-	-
2	18	-	4	11	1	1	-	-	-	-
5	20	-	4	13	1	1	-	-	-	-
10	31	-	5	14	2	2	-	-	-	-
20	41	-	8	15	2	3	-	-	-	-
50	46	-	14	17	2	3	-	-	-	-
100	131	-	24	17	2	3	-	-	-	-
500	223	1	38	43	2	7	-	-	-	-
2,000	262	-	54	55	-	-	-	-	-	-
PMF	600	11	105	55	2	7	-	-	-	-

** Does not include regional flooding stats*

^ Estimated by finding all lots zoned as Emerging Community, General Residential, Rural Residential or Township within the flood extent that do not have a house-sized building (>80sqm)

2.7.2 Residential Building Type

A building database for the entire Somerset LGA has been created for analysis for the Somerset LFMP. The database contains all building-scale information collated from Somerset Regional Council and the datasets from the Department of Natural Resources and Mines to calculate building floor level heights based on building classifications. The SFMP process for calculating floor level heights[2] has been applied to the buildings in the Somerset LGA. The building database documents building classification types, shown in Table 2-3.

TABLE 2-3 BUILDING CLASSIFCATION

Description	Category
Low set Single Story Slab on Ground	FDSS-SOG
Low set Single Story on stumps	FDSS - Stumps
Highset	FDHS
Low set Single Story (slab on ground)	FDDS
Single Storey	MUSS
Double or More Stories	MUDS

This database has been used in the Somerset LFMP for calculating existing and mitigated flood damages, screening properties potentially eligible for property specific actions and prioritising properties for evacuation. The database will be provided to Council for use after completion of the LFMP project.

Further analysis of the residential building types as identified in Table **2-4** reveals, minor differences in buildings affected in each flood event at ground level. For example:

- There are relatively large numbers of buildings flooded in the more frequent events. A total of 69 properties are flooded during the 1 in 20 AEP.
- Numbers increase dramatically in the 1 in 100 AEP. The numbers gradually increase from this magnitude as the rest of the floodplain space is taken up across the township.

Further analysis shown in Table 2-5 was undertaken to determine the number of and type of buildings with over-floor flooding:

- There are no properties exposed to over floor flooding in events to the 1 in 50 AEP. Numbers remain relatively small to the 1 in 20 AEP, and then 11 houses become flooded above floor level in the 1 in 50 AEP event.
- Over floor flooding increases substantially in the 1 in 100 AEP event (3 times the number of houses than the 1 in 50 AEP event). Numbers also increase substantially in the 1 in 200 AEP, and this should be considered when facing flood events with increased magnitude.

[2] As documented in the report Building Floor Level Heights – Brisbane Strategic Floodplain Management Plan – Brisbane LGA, Ipswich LGA, Somerset LGA and Lockyer Valley LGA dated 16/06/2017.

TABLE 2-4 RESIDENTIAL BUILDING TYPE EXPOSURE GROUND LEVEL

AEP (1 in X)	FDSS-SOG	FDSS-Stumps	FDHS	FDDS	MUSS	MUDS	Total
1	20	9	-	-	-	-	29
2	24	11	-	-	-	-	35
5	26	13	-	-	-	-	39
10	40	13	1	-	-	-	54
20	51	17	1	-	-	-	69
50	62	19	1	1	-	-	83
100	130	45	3	1	-	-	179
500	204	99	11	2	-	-	316
2,000	238	142	17	2	-	-	399
PMF	447	295	51	4	-	1	798

Note: Includes Rural Residential Buildings and does not include 1 in 200 AEP or 1 in 1000 AEP due to results differences between regional and local flooding.

TABLE 2-5 RESIDENTIAL BUILDING TYPE EXPOSURE OVERFLOOR FLOODING

AEP (1 in X)	FDSS-SOG	FDSS- Stumps	FDHS	FDDS	MUSS	MUDS	Total
1	-	-	-	-	-	-	0
2	-	-	-	-	-	-	0
5	3	-	-	-	-	-	3
10	3	-	-	-	-	-	3
20	4	-	-	-	-	-	4
50	10	1	-	-	-	-	11
100	62	8	-	1	-	-	71
200	148	51	2	1	-	-	202
500	161	71	4	2	-	-	238
2,000	188	86	7	2	-	-	283
PMF	385	234	32	3	-	1	655

2.7.3 Building Use Type Hazard Exposure

There are only two properties exposed to the highest hydraulic risk (HR2c).

Key inferences and considerations to be drawn from this information include:

- There are only two properties exposed to the highest hydraulic risk (HR2c).
- There is a total of 716 residential properties within the mapped extent of the floodplain.

TABLE 2-6 OVERALL BUILDING EXPOSURE

Building Type	HR1 (c)	HR1 (b)	HR2 (c)	HR2 (b)	HR2 (a)	HR3 (c)	HR3 (b)	HR 3(a)	HR 4	HR 5	TOTAL
Residential		5	5	15	25	152	7	6	37	348	600
Residential Multi-Dwelling	-	-	-	-	-	-	1	-	-	10	11
Commercial	1	3	-	-	10	3	6	1	30	1	55
Industrial	-	-	-	-	2	-	-	-	-	-	2
Community and Public Facilities		1	-	-	1	2	1	-	2	-	7
Agriculture/Rural Living	2	4	14	-	-	12	3	-	11	59	105
Other	-	-	-	-	-	-	-	-	-	-	0
TOTAL	3	13	19	15	38	169	18	7	80	418	780

2.7.4 Suburb Building Exposure

Table 2-7 below shows the hydraulic risk exposure across all the suburbs in the Fernvale flood model. As it can be seen, the suburb of Fernvale has by far the greatest flood exposure primarily associated with the township population (Fairney View is rural in nature).

TABLE 2-7 SUBURB EXPOSURE

Suburb	HR1 (c)	HR1 (b)	HR2 (c)	HR2 (b)	HR2 (a)	HR3 (c)	HR3 (b)	HR3 (a)	HR4	HR5	Total
Fairney View	-	3	4	-	-	4	-	-	-	-	11
Fernvale	3	10	17	15	38	165	18	7	92	422	787
Total	3	13	21	15	38	169	18	7	92	422	798

2.7.5 Population Exposure

Information about the population within the floodplain has been derived from the Australian Bureau of Statistics (ABS) 2016 census data. The equivalent census data to reflect building information (9 August 2017 Census) indicates a total population in Fernvale of 3,209 people. For the exposure assessment, the existing residential building data is multiplied by the average equivalent residents per building for Fernvale (3.0), as identified in Table 2-8.This shows the exposure of residential population per hydraulic risk category. The analysis shows:

- Almost 2148 residents are mapped with the extent of the floodplain which indicates approximately 67% of the Fernvale residents are exposed to flooding of some nature. This is a very high exposure rate.
- There are 210 residents in the highest five potential hydraulic risk categories of HR1(c) to HR2(a), and 6 residents in the highest risk category.

Further analysis of the vulnerability of the exposed community is undertaken in the vulnerability section below.

TABLE 2-8 RESIDENTIAL POPULATION EXPOSURE

Building Type	HR1 (c)	HR1 (b)	HR2 (c)	HR2 (b)	HR2 (a)	HR3 (c)	HR3 (b)	HR3 (a)	HR4	HR5	TOTAL
Residential Buildings (combined)	2	9	19	15	25	164	11	6	48	417	716
Average Population	6	27	57	45	75	492	33	18	144	1251	2148

2.8 Critical and Sensitive Infrastructure

2.8.1 Critical Infrastructure Exposure

Critical infrastructure is an important component of flood exposure as this infrastructure performs an important life supporting role in flood events. It is critical to have infrastructure operational before, during and after flood events to increase operational preparedness, response, and recovery. The exposure analysis reveals there are two water infrastructure assets exposed to flooding within the datasets provided.

TABLE 2-9 CRITICAL INFRASTRUCTURE BUILDINGS EXPOSURE

Critical Infrastructure	HR1 (c)	HR1 (b)	HR2 (c)	HR2 (b)	HR2 (a)	HR3 (c)	HR3 (b)	HR3 (a)	HR4	HR5
Emergency management facilities (i.e. rural fire brigade)	-	-	-	-	-	-	-	-	-	1
Water infrastructure	-	-	2	-	-	-	-	-	-	-
Total	0	0	2	0	0	0	0	0	0	1

2.8.2 Evacuation Centres

Figure 2-8 shows the location of the two evacuation centres in Fernvale. The assessment of these buildings includes:

- The Fernvale State School and Fernvale Showgrounds are both heavily affected by flooding.

Further assessment of the evacuation centres and their overall flood risk is undertaken in the emergency management chapter of this report.

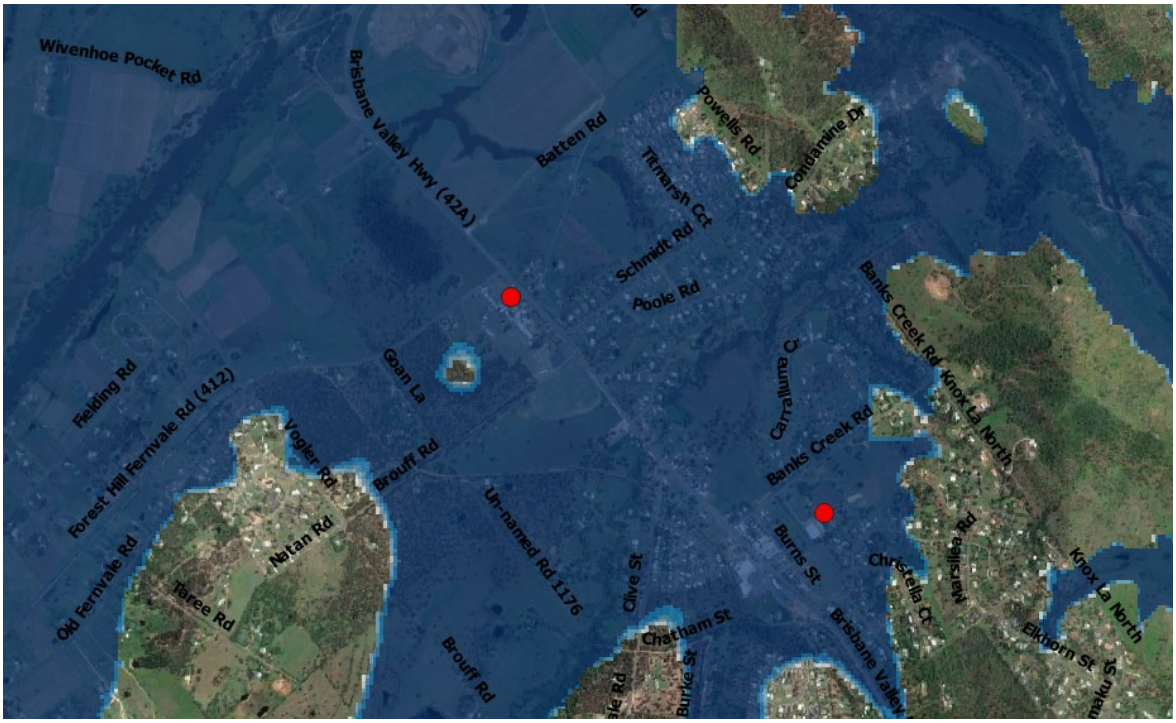

FIGURE 2-8 EVACUATION CENTRES IN PMF EVENT

2.8.3 Sensitive Infrastructure

Uses that are 'sensitive' are considered as such due to the heightened risk associated with the inherent vulnerability of the occupants associated with that particular land use. For example, educational and childcare facilities are considered a sensitive use due to the vulnerability of children and elderly persons in flood events who may need assistance or emergency services to support evacuation.

As identified in Table 2-10, there are 16 educational facilities and one childcare centre exposed to flooding within the supplied dataset. However, the risk of flooding is within the lower risk categories.

TABLE 2-10 SENSITIVE USE EXPOSURE

Sensitive Use	HR1 (c)	HR1 (b)	HR2 (c)	HR2 (b)	HR2 (a)	HR3 (c)	HR3 (b)	HR3 (a)	HR4	HR5
Childcare	-	-	-	-	-	-	-	-	1	-
Educational	-	-	-	-	-	-	-	-	11	4
Community Protection	-	-	-	-	-	-	-	-	-	-
Total	0	0	0	0	0	0	0	0	12	4

3 FLOOD ISOLATION

Isolation caused by flood waters can be a major risk especially for long durations, or where critical services are cut-off or if persons isolated need emergency assistance and evacuation. Areas of isolation are an important element of overall flood risk that must have due consideration. The LFMP has undertaken an analysis of isolation to provide flood intelligence to plan for pre-emptive evacuations during flooding, resupply operations, strategic land use planning responses and for community education and awareness. Isolation can be used in combination with other flood risk factors to prioritise for flood risk management treatment and to ensure suitable future land uses are commensurate with the risk. This section describes the process of identifying flood islands, time to and duration of inundation.

3.1.1 Flooded Road Immunity

The analysis of flooded roads identifies the first event in which the road is inundated. An overview map of the flood immunity is presented in Figure 3-1. The flooded road immunity shows locations across the Fernvale area which may be affected by poor road flood immunity.

An example of a close-up view of an area with low road immunity is shown in Figure 3-2. This output can be extremely useful at a high level for identifying drainage infrastructure that is below immunity standard and for evacuation considerations (i.e. where key routes may require further investigation for upgrade). There are several roads within the main township area that have less than a 1 in 1 AEP immunity including sections of the Brisbane Valley Highway. This road may isolate the township during flooding.

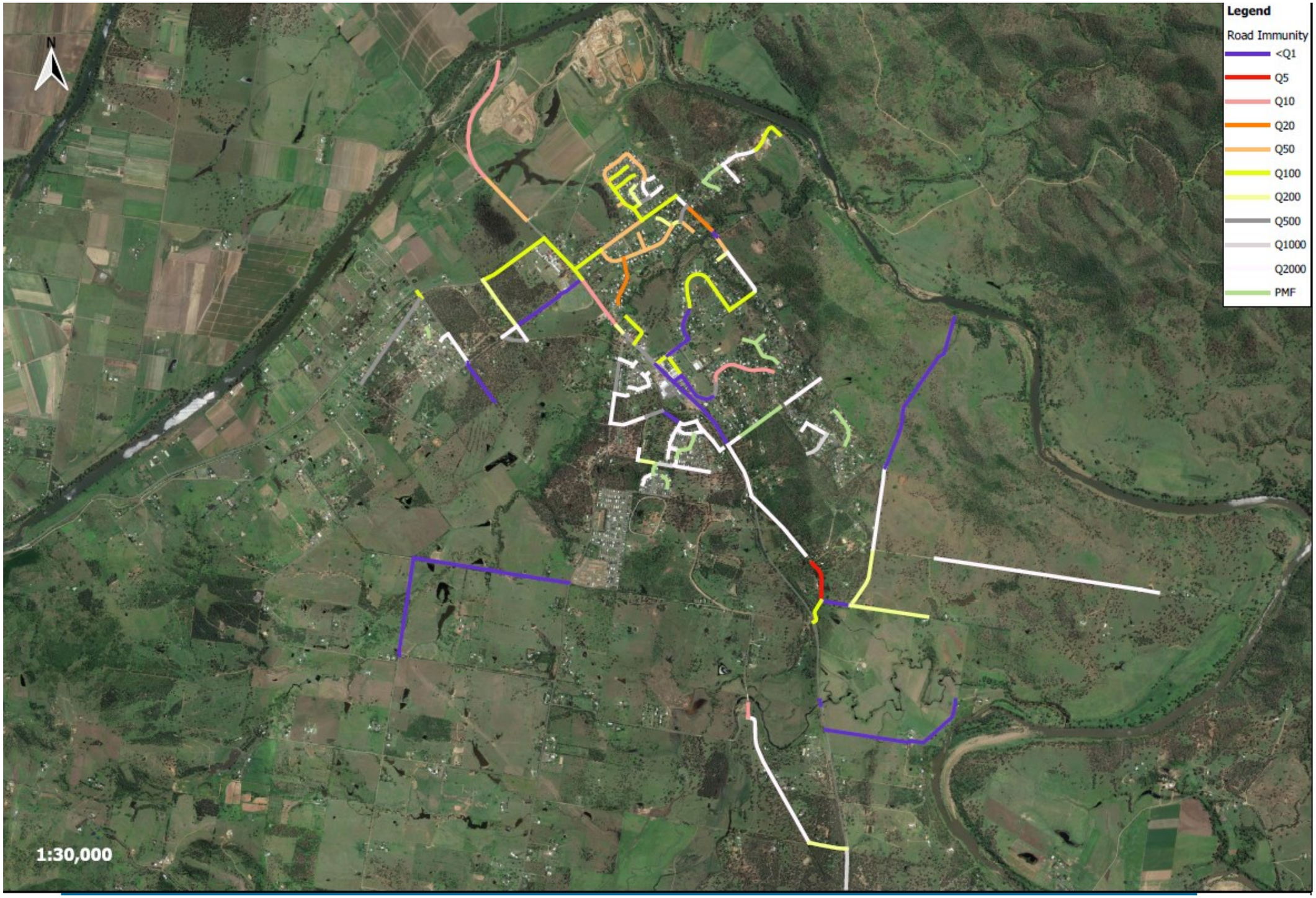

FIGURE 3-1 FLOODED ROAD IMMUNITY

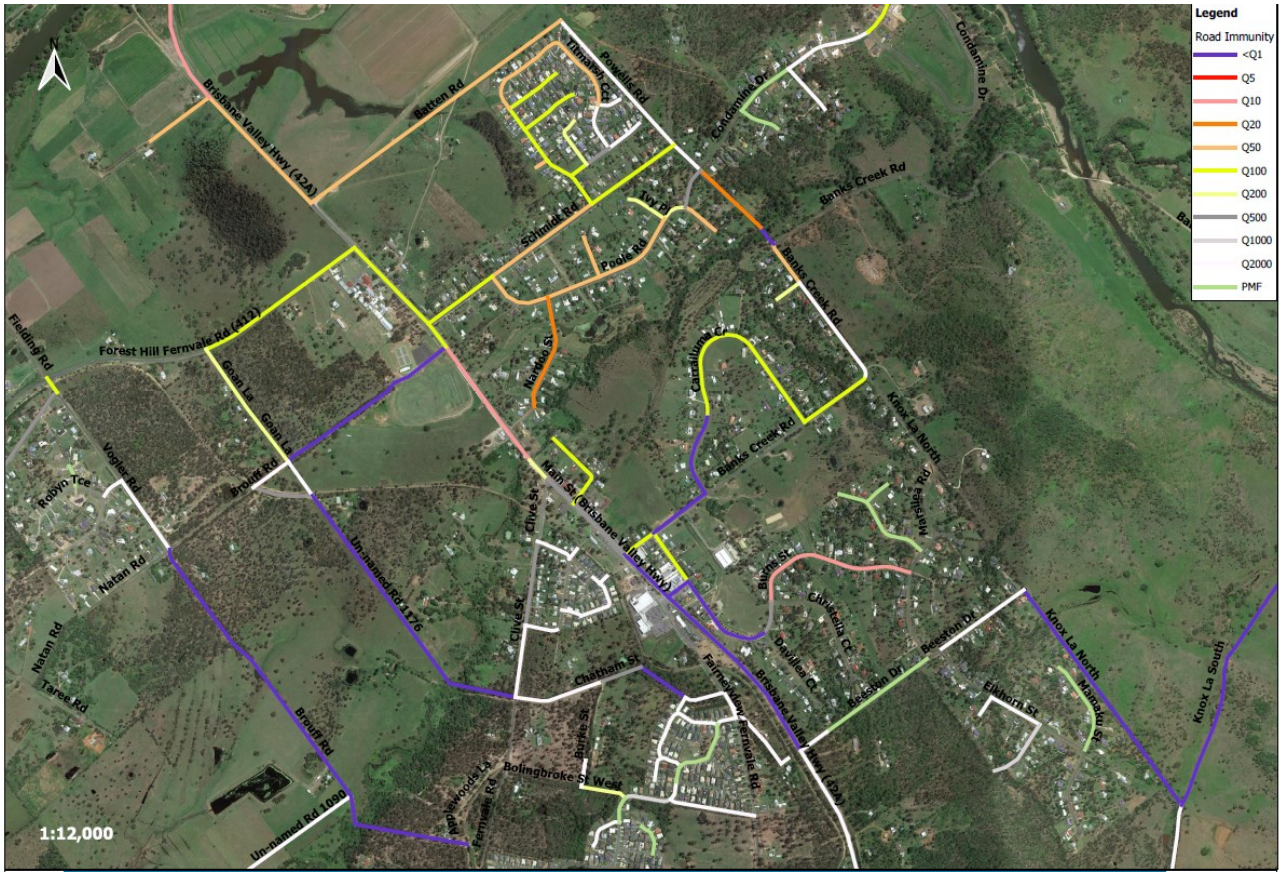

FIGURE 3-2 EXAMPLE ROAD IMMUNITY

3.2 Time to Flood Inundation Information

The earliest time the road, building or asset is inundated with floodwaters is known as Time to Inundation (TTI). The data informs several outputs that contributes to the picture of flood risk across the Fernvale area. The mapping produced uses TTI information for a high-level understanding across each catchment, TTI for buildings flooded above floor level and TTI for roads flooded above low points.

TTI information is particularly useful to provide another factor in flood risk in areas such as evacuation, isolation and community awareness. TTI information can also help understand exposed road assets and the need for earlier action on road closures. TTI when coupled with other flood risk outputs is an incredibly important factor in determining flood risk. TTI information can and should also be used in future land use planning and strategic decisions regarding the appropriateness of settlement and designation of uses.

The emergency management work package of the LFMP will explore the findings of this analysis. For example, flood intelligence could be used to develop and refine flood forecasting systems.

As it can be seen from Figure 3-3 and Figure 3-4, TTI varies across the catchment dependant on:

- The flooding type whether riverine, creek or overland flow/urban flooding.
- The location of the TTI (whether at the up or downstream sections of the catchment).
- Interactions between multiple sources of flooding.

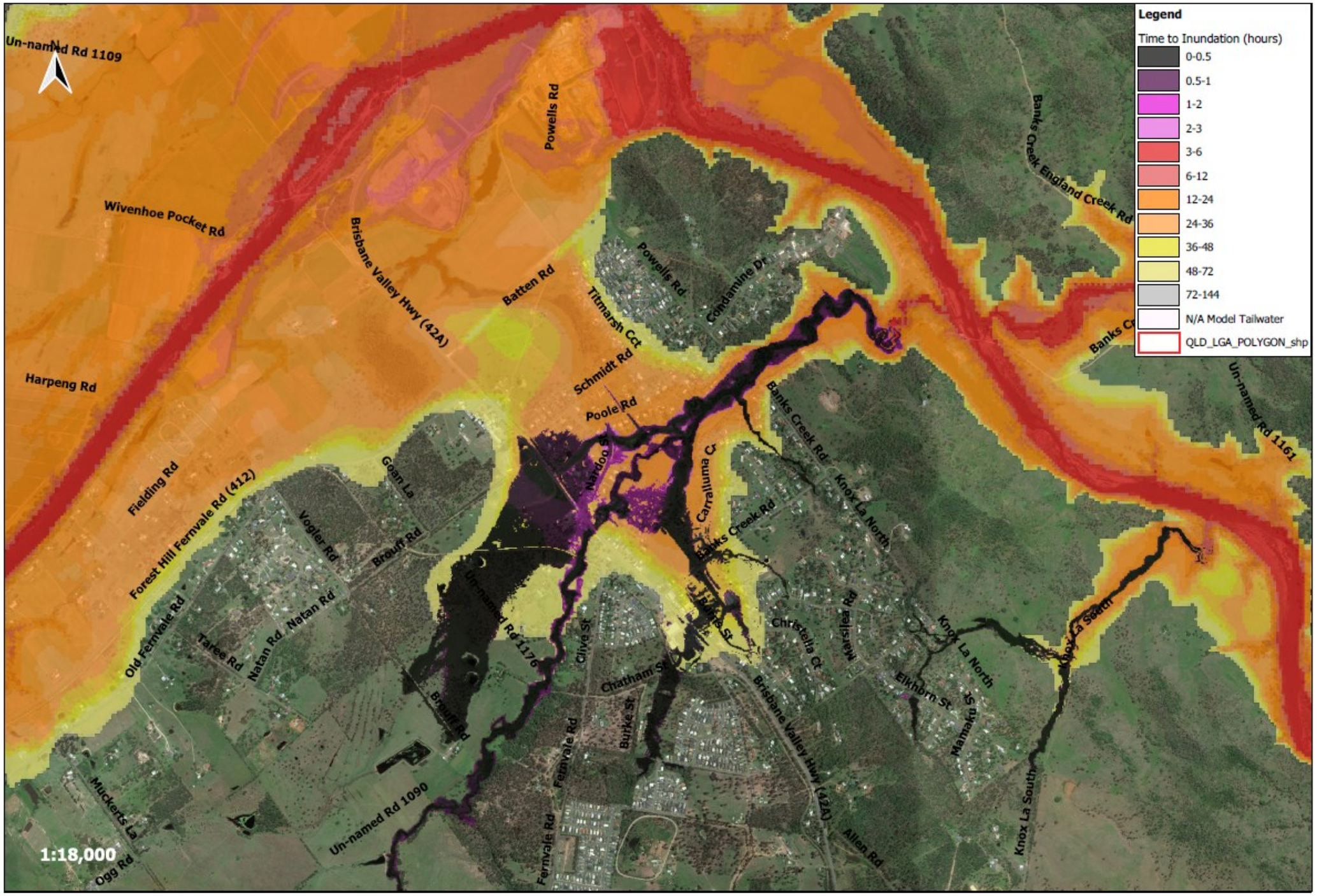

FIGURE 3-3 TIME TO INUNDATION (1 IN 2,000 AEP) GROUND SURFACE

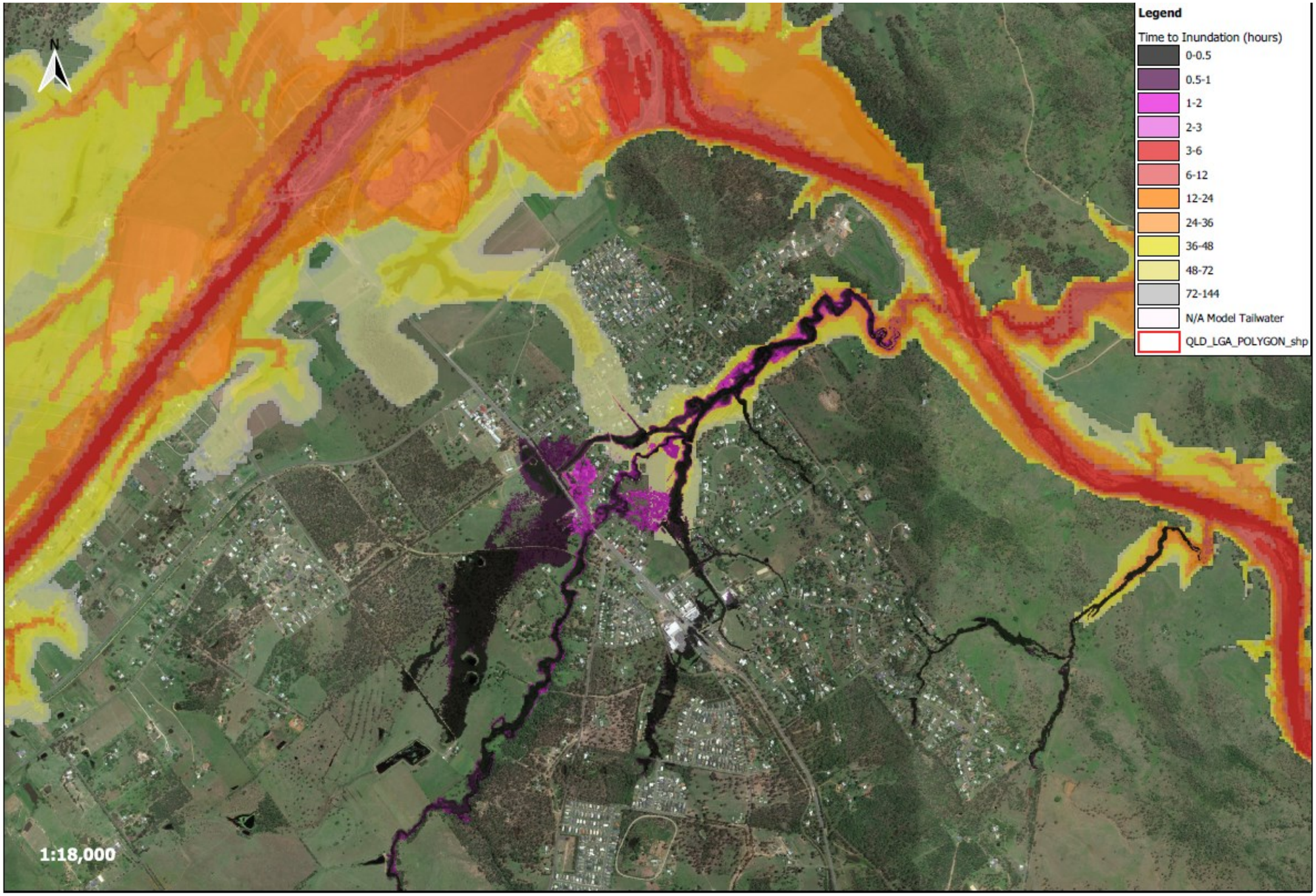

FIGURE 3-4 TIME TO INUNDATION (1 IN 100 AEP) GROUND SURFACE

The 1 in 2,000 AEP can be considered the “worst case” TTI. Speed of inundation increases significantly from the 1 in 100 AEP to the 1 in 2,000 AEP primarily due to flood storages being depleted at a quicker pace, less resistance because of lower roughness values on floodplains and an increase in velocity overall.

Figure 3-5 and Figure 3-6 show the change in TTI between the 1 in 100 AEP and 1 in 2,000 AEP. As it can be seen some areas of the floodplain decrease in TTI in the 1 in 2,000 AEP. This is an important concept to understand between low and high magnitude flooding. As the TTI decreases, the overall flood risk increases due to less time for residents and emergency services to respond. In addition, high magnitude floods also have higher hazard further increasing and compounding flood risk.

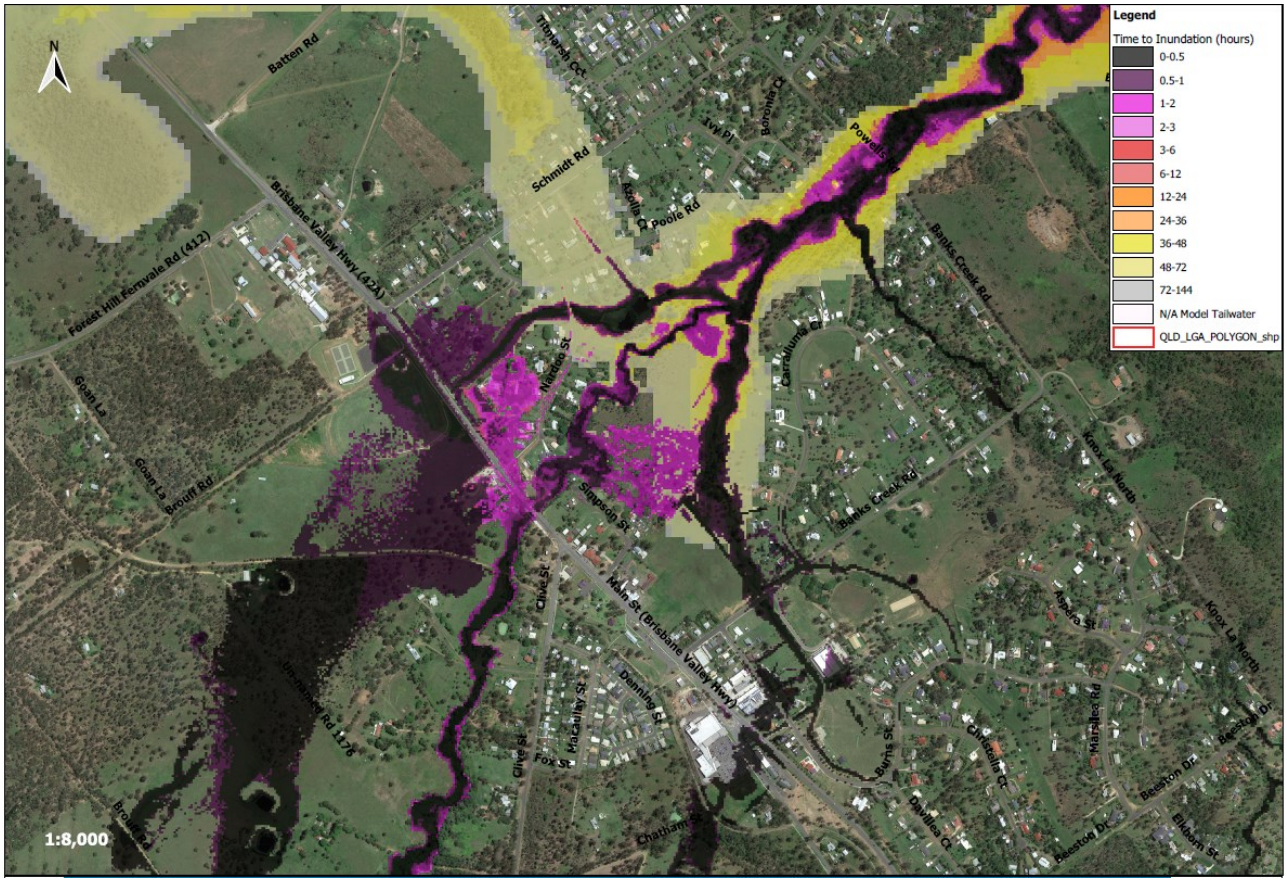

FIGURE 3-5 FERNVALE TOWNSHIP CATCHMENT TIME TO INUNDATION (1 IN 100 AEP)

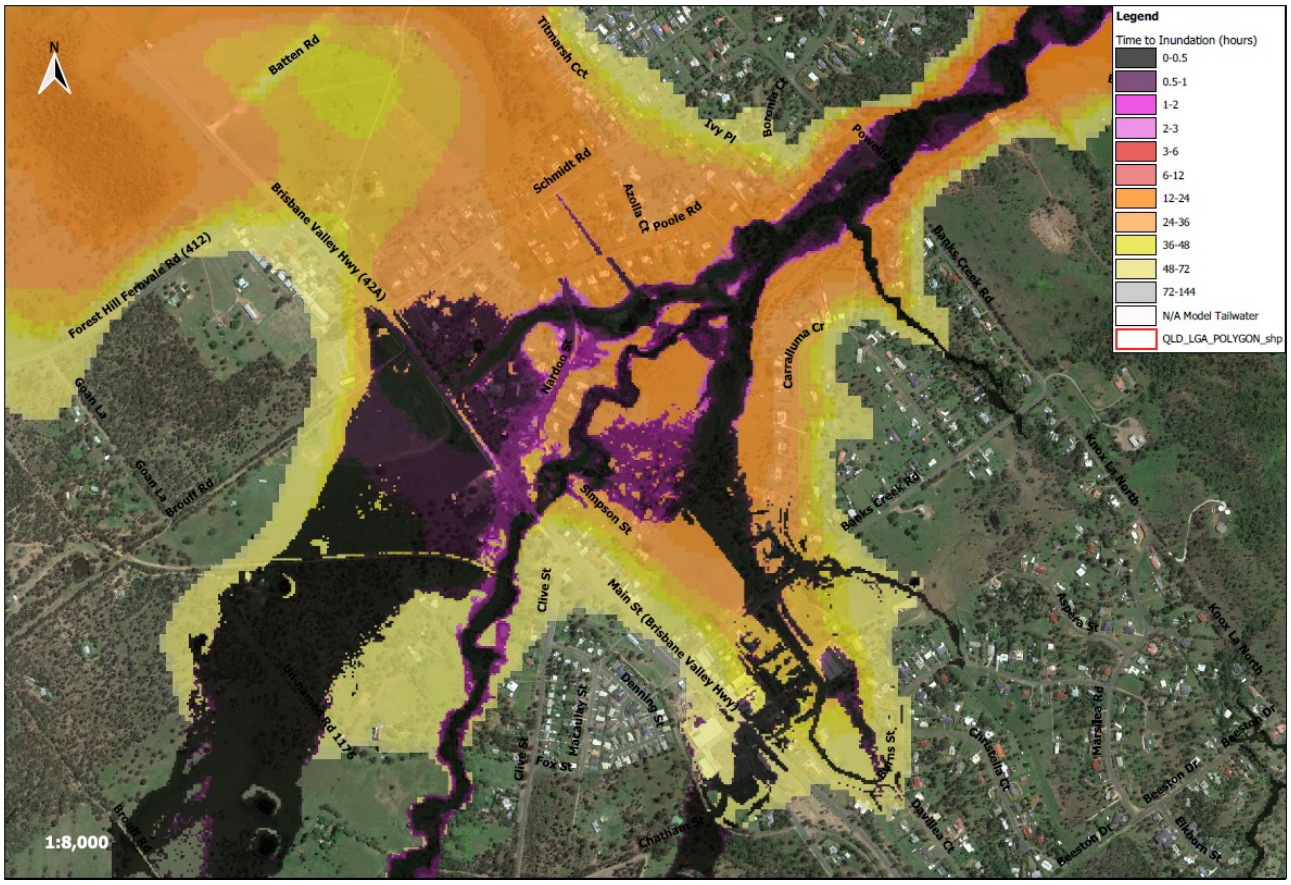

FIGURE 3-6 FERNVALE TOWNSHIP CATCHMENT TIME TO INUNDATION (1 IN 2,000 AEP)

The data shown in the mapping will provide Council further guidance on TTI in these areas, for example where TTI is as short as 1 hour for the 1 in 2,000 AEP event. A short TTI is associated with short response times to react to impending floodwaters which may inhibit emergency response operations. The bulk of houses flooded however are flooded by the Brisbane River which has a longer TTI of 12-24 hours in most cases.

Across Fernvale there are some buildings and residents highly exposed to quite fast flood response times and short times of inundation above floor level. The raw GIS dataset provides TTI for all buildings and is a useful tool for Council to further investigate and understand these risks.

3.2.1 Time to Inundation Roads

Detailed TTI mapping can be found with the electronic data pack. Examples of TTI to roads is shown in Figure 3-7. Many of the roads in Fernvale are inundated very fast in a 1 in 2,000 AEP event with many flooded in under 1 hour.

This dataset is useful in determining which roads may flood first and is also useful in undertaking evacuation capability assessments. The emergency management chapter draws on this information to determine likelihood of evacuation capability by comparing the time to inundation of the road and the time taken to evacuate.

This information and the process used to determine the time to inundation would also be useful in future flood forecasting upgrades to provide real time and far more accurate assessments of road closures than pre-cooked “synthetic” flood events.

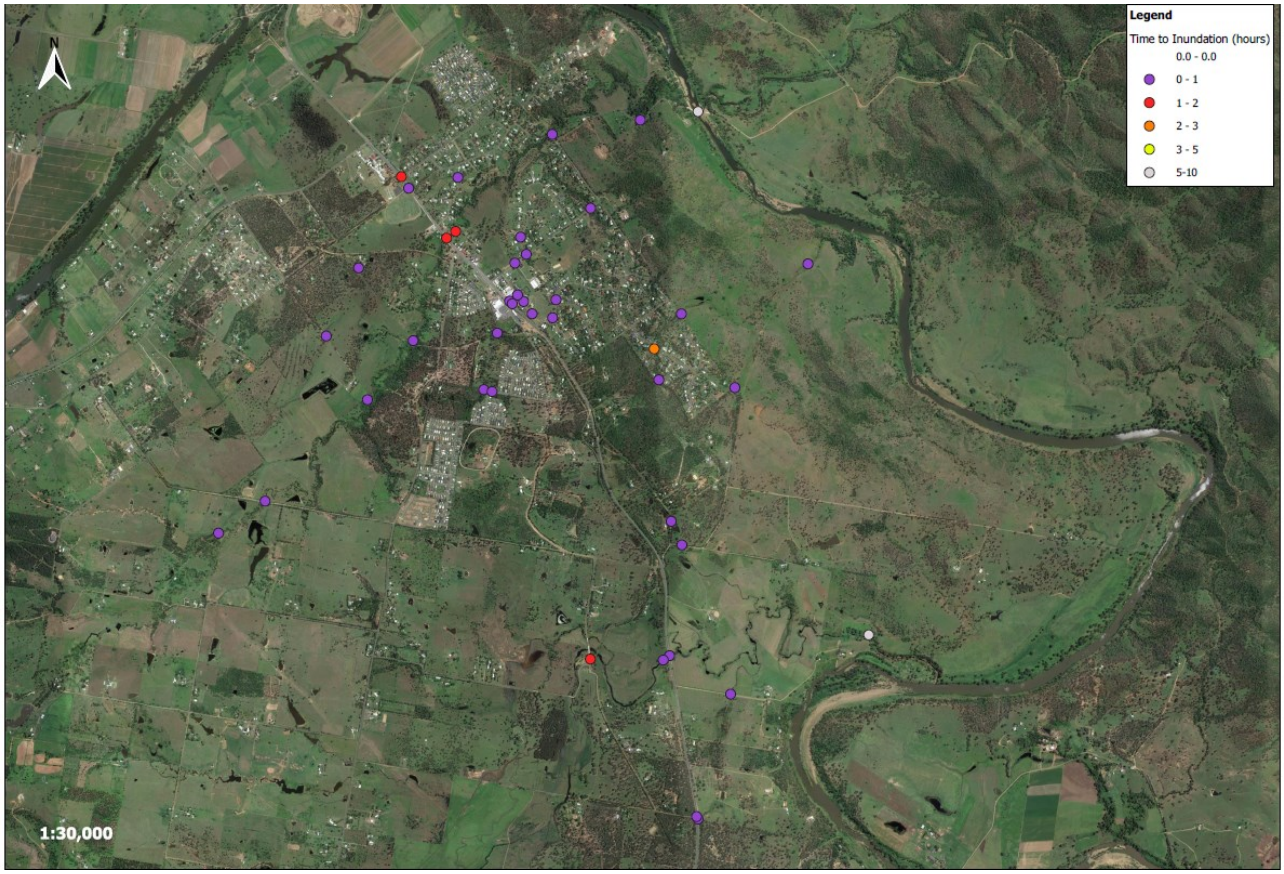

FIGURE 3-7 ROADS – TIME TO INUNDATION

3.2.2 Time to Inundation Property

Detailed TTI mapping can be found in the electronic data pack. This dataset is useful in determining which properties may flood first hampering evacuation and distinguishing different types of awareness and education required (flash flooding verse riverine). The emergency management chapter uses this information with other aspects (hazard and vulnerability etc) to help determine the priority overall of the most at risk residents.

This information and the process used to determine the TTI would also be useful in future flood forecasting upgrades to provide real time and far more accurate assessments of road closures than pre-cooked “synthetic” flood events. The outputs produced whilst somewhat useful for background information, are static and do not align to real events. Combining this methodology with a forecast system would produce powerful intelligence that could help prioritise high risk properties during events.

Figure 3-8 shows a wide range of time to inundation values in the Fernvale area. Of note is the very fast inundation times associated with overflow flooding in some parts of the township. This emphasises that there is very little time to respond to flooding in this catchment for residents. Other areas are exposed to Brisbane River regional flooding with much longer inundation times (above 20 hours).

FIGURE 3-8 BUILDINGS – TIME TO INUNDATION

3.3 Duration of Flooding Inundation Information

Duration of flood inundation (DFI) has been identified by calculating the time water exceeds a certain level. This has been calculated using the same events as the TTI methodology, i.e. 1 in 10 AEP, 1 in 100 AEP and 1 in 2,000 AEP.

As identified in Figure 3-9 and Figure 3-10, the following is noted:

- During the 1 in 100 AEP, flooding in the Fernvale Township has some DFI up to 12 hours.
- During the higher magnitude floods (1 in 2,000 AEP), flood duration increases up to 3 days and longer in isolated areas) from Brisbane River flooding and would cause significant issues associated with this.

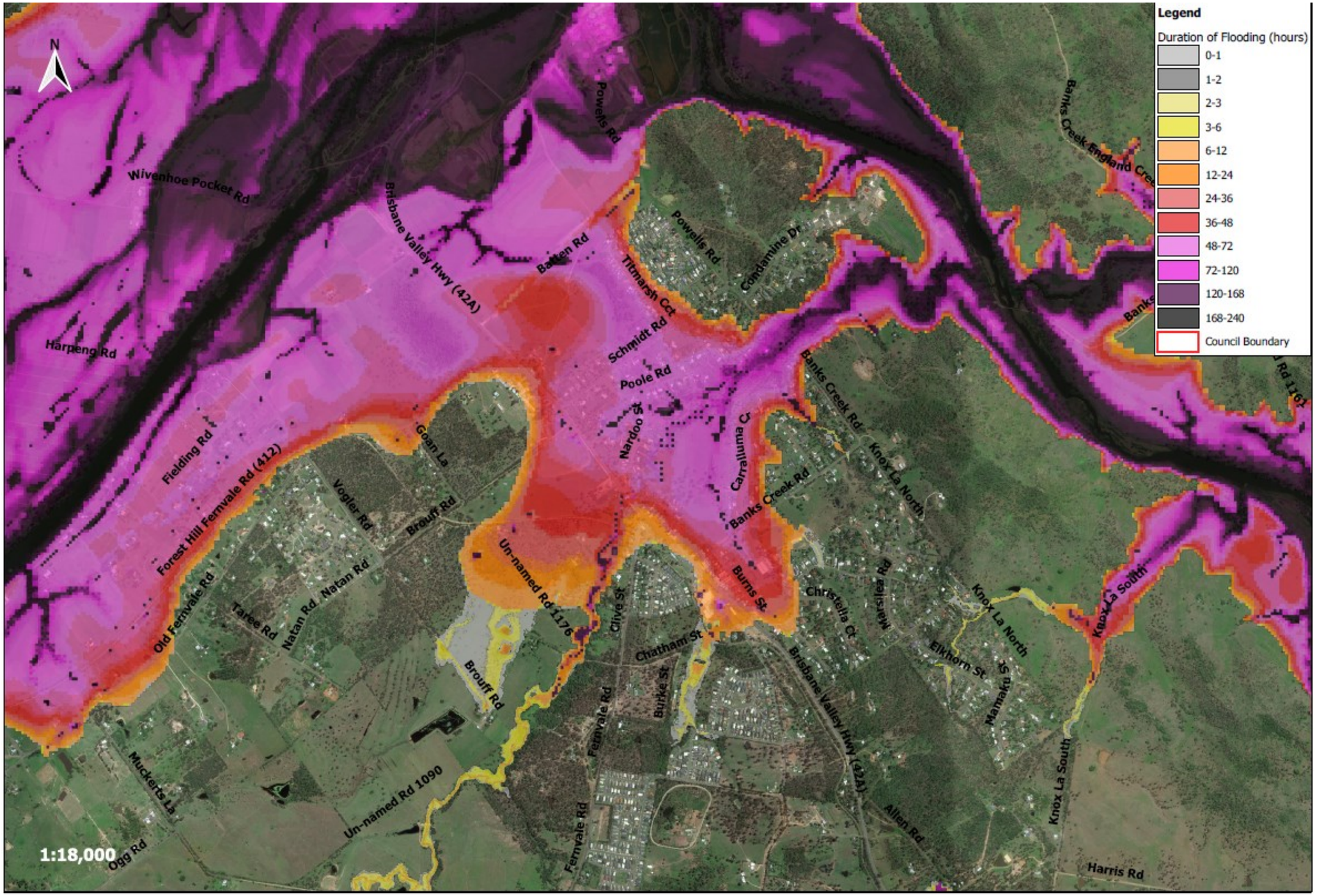

FIGURE 3-9 FERNVALE DURATION OF INUNDATION 1 IN 2,000 AEP

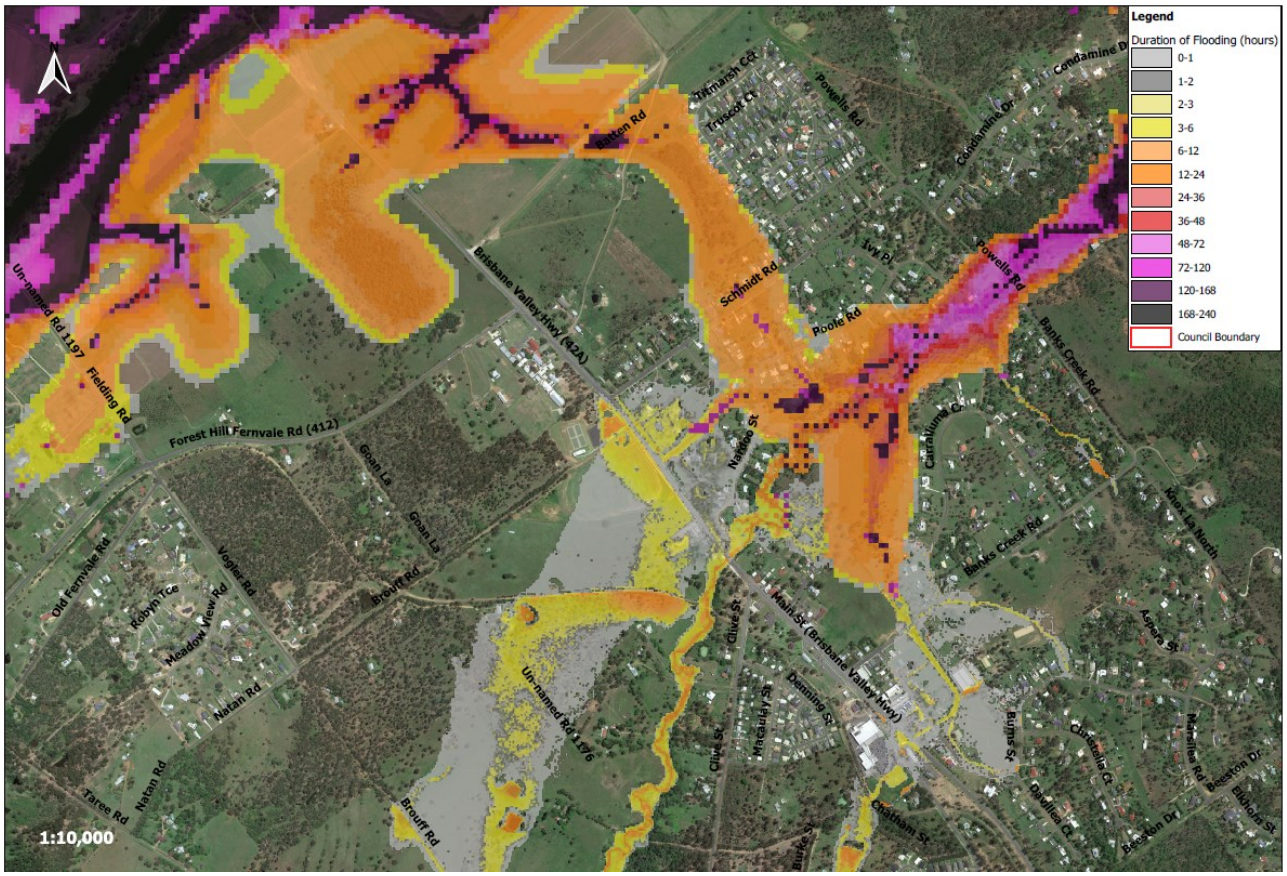

FIGURE 3-10 FERNVALE TOWNSHIP DURATION OF INUNDATION 1 IN 100 AEP

3.3.1 Duration of Inundation Roads

Detailed DFI mapping can be found in the electronic data pack. Examples of DFI time frames to roads is shown in Figure 3-11. This dataset is useful in determining which roads will flood the longest and could be considered for approximate information of road closure times and preparation for opening.

This information and the process used to determine the DFI would also be useful in future flood forecasting upgrades to provide real time and far more accurate assessments of road closures than pre-cooked “synthetic” flood events. The process would be useful in providing fairly accurate assessments within a forecast system of when roads are able to open again.

FIGURE 3-11 ROADS – DURATION OF INUNDATION

3.3.2 Duration of Inundation Property

Examples of DFI to buildings is shown in Figure 3-8. The emergency management chapter uses this information with other aspects to help determine residents that are exposed to long timeframes of flooding (beyond 12 hours) and is used in combination with vulnerability to make further determination of residents that may require assistance because of these constraints.

In a similar fashion, this information could be used within a flood forecasting system to make fairly accurate assessments of residents that are exposed to long flooding duration above floor levels.

FIGURE 3-12 BUILDINGS – DURATION OF INUNDATION

The example above shows long times of inundation within the Fernvale Township. There are some properties that are exposed to inundation timeframes of well over 72 hours which is worth noting with regards to the length of time residents may be exposed to dangerous flooding situations.

3.4 Flood Islands

Flood islands are a unique, complex, and relatively dangerous situation that can develop during flood events. Flood islands develop when servicing roads to areas are cut (often multiple) and the area is then isolated via no means of vehicle transportation and likely pedestrian mobility.

Two types of flood islands can develop during flood events: low and high flood islands and these scenarios are shown below in Figure 3-13 and Figure 3-14.

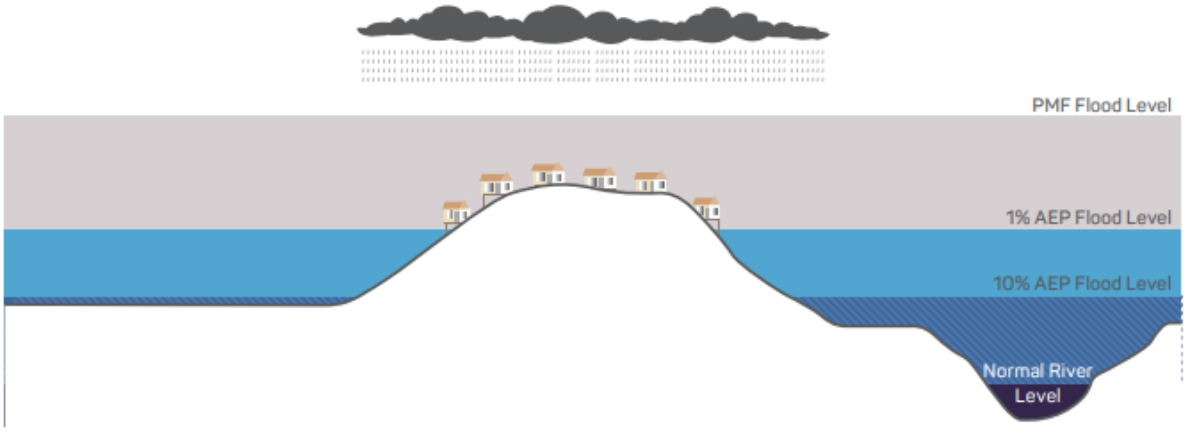

FIGURE 3-13 LOW FLOOD ISLAND (AIDR, 2017)

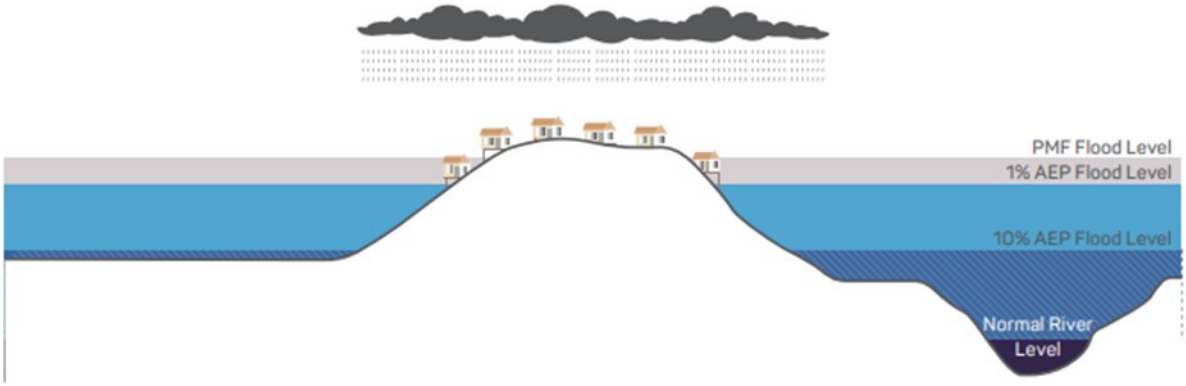

FIGURE 3-14 HIGH FLOOD ISLAND (AIDR, 2017)

3.4.1 Flood Island Distribution

Outputs of the flood island analysis areas are shown in Figure 3-15, the spatial data also contains further information on the respective AEP inundation events which can be useful in prioritising mitigation responses to flood islands combined with other outputs such as time to inundation, vulnerability and hazard.

Within Fernvale there are 4 low flood islands and one high flood island. There are buildings situated on some of these low flood islands and significant numbers of properties and buildings on the one high flood island.

FIGURE 3-15 FERNVALE FLOOD ISLANDS OVERVIEW

Figure 3-16 below shows an example of a low flood island at Nardoo Street. The island is a very high risk low flood island characterised by:

- The Low flood island contains eight residential buildings.
- Roads are cut in the 1 in 10 AEP flood event. This occurs on Nardoo Street.
- The island fully submerges in the 1 in 100 AEP event.
- Further layered information such as hydraulic risk and TTI can then be used to determine overall flood risk on these flood islands.

This island presents a very high risk due to the high hydraulic risk present in the area.

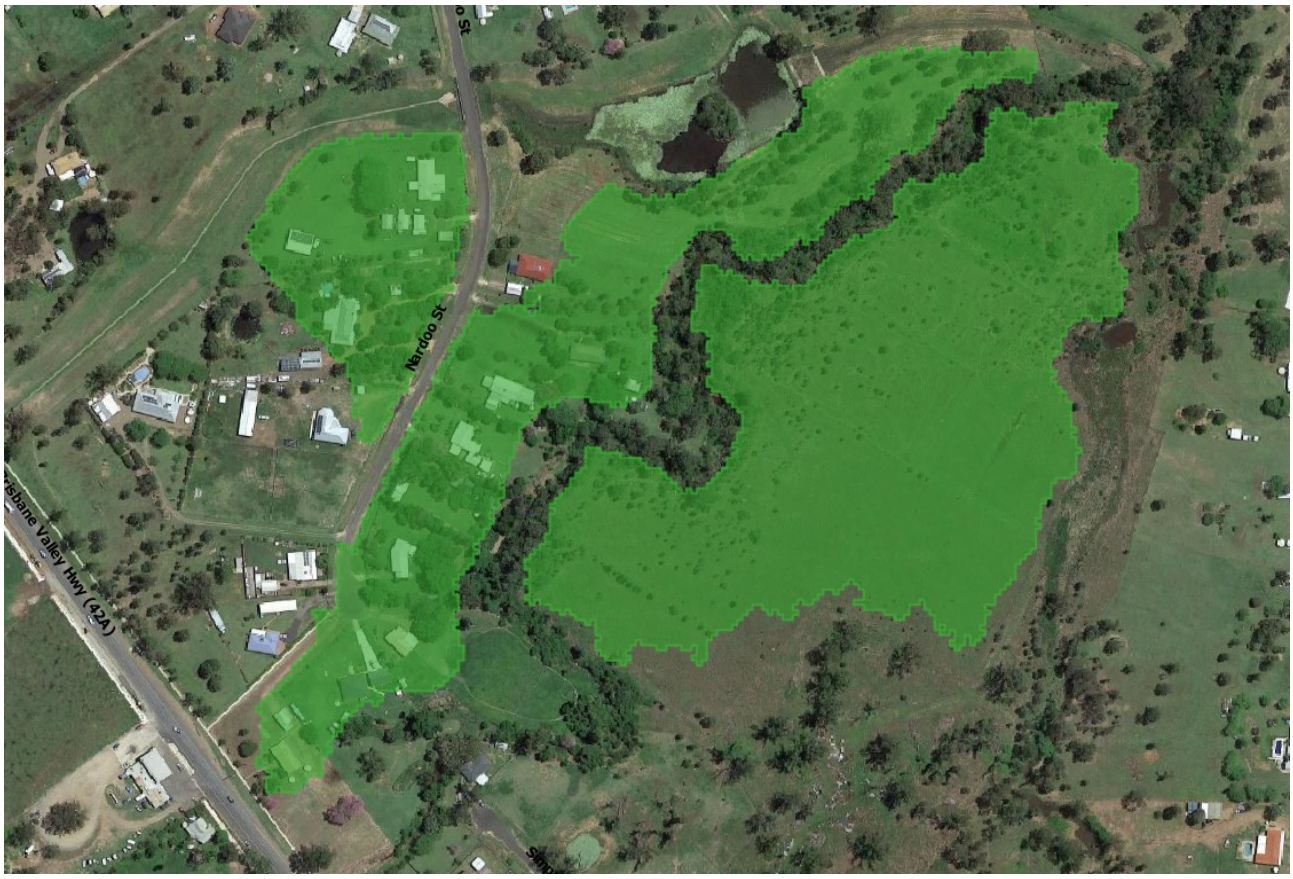

FIGURE 3-16 EXAMPLE FLOOD ISLAND NARDOO STREET

TABLE 3-1 FERNVALE TOWNSHIP FLOOD ISLAND ASSESSMENT

Group	Address	No. of Habitable Buildings	Island Type	Road First Cut (AEP)	Submerged (AEP)
1	21-42 Nardoo Street	8	Low	1 in 10	1 in 100
2	16 and 20 Nardoo Street	2	Low	1 in 50	1 in 100
3	81 Burns Street	1	Low	1 in 20	PMF
4*	Schimdt and Powells Road area	100+	High	1 in 100	-

Note there are flood islands outside of the main township not assessed.

**Special consideration should be given to this high flood island as it is isolated for over 3 days.*

4 VULNERABILITY

Including an assessment of social vulnerability goes beyond the conventional risk assessment by ensuring Council has a full understanding of the characteristics of the population which can affect their response and hence vulnerability during a flood event.

Factors such as awareness, physical vulnerability, socio-economic vulnerability, and mobility are social attributes that are most strongly related to vulnerability during floods. There are many aspects of social vulnerability to flooding, but these four vulnerability indices have been considered (SFMP) in detail. This suite of vulnerability indices recognises demographic characteristics, socio-economic status, health and access to information.

4.1 Fernvale Vulnerability

The vulnerability analysis highlights areas of the Fernvale area that are highly vulnerable to flood events. This is an important concept to understand in a spatial context as it affects the community's capacity to respond to flooding and reduces their overall resilience. A proportion of the vulnerability indices across the Fernvale area is shown in Table 4-1.

TABLE 4-1 PERCENTAGE OF FERNVALE POPULATION THAT ARE VULNERABLE

Categories	Vulnerability Indices	% of Somerset LGA population	QLD Average
Physical Vulnerability	Under 5 years	9.6%	6.3%
	Over 65 years	9.3%	15.1%
	Lone person household	15.1%	23.5%
Social & Economic Vulnerability	Renting (house tenure)	31.3%	34.1%
	Household income (<$650)	13.9%	19.5%
	Unemployed (seeking work)	7.1%	7.6%
Mobility Vulnerability	Without vehicle access	1.8%	6.0%
	One parent family	19.1%	16.5%
	Group households	3.4%	4.7%
Awareness Vulnerability	Speaks Language Other Than English (LOTE) at home	5.4%	13.5%
	Without internet access	11.6%	13.6%

Vulnerability indices have been calculated for the Fernvale area, the relative values for each of the indices is mapped in Figure 4-1 to Figure 4-5.

As identified in Table 4-2, highly vulnerable persons that represent the upper 20% of the relative vulnerability ranking for each indicator are exposed to hydraulic hazard. Population has been calculated by multiplying the number of buildings by 3.0 for the average population per household in Fernvale. it is also assumed that all residents within each statistical area boundary (SA1) has the same degree of vulnerability. The distribution of exposure of vulnerable persons show:

- Overall, the statistics suggest there are low numbers of vulnerable people in Fernvale, however there are substantial numbers exposed in the floodplain.
- There are nine people exposed to the second highest flood risk category.

TABLE 4-2 HYDRAULIC RISK VULNERABLE PERSONS

Vulnerability Index	HR1 (c)	HR1 (b)	HR2 (c)	HR2 (b)	HR2 (a)	HR3 (c)	HR3 (b)	HR3 (a)	HR4	HR5	Total
Physical	0	9	10	0	0	12	0	0	0	0	**31**
Social and Economic	0	0	0	0	0	0	0	0	0	0	**0**
Mobility	0	0	0	0	0	0	0	0	15	441	**456**
Awareness	0	0	0	0	0	0	0	0	0	0	**0**
Combined	0	0	0	0	0	0	0	0	15	447	**462**

4.1.1 Physical Vulnerability

There are 31 physically vulnerable people affected by flooding and 9 affected by the second highest flood risk. Figure 4-1 shows the distribution of the most vulnerable people across the Fernvale area affected by physical factors such as age and disability.

4.1.2 Social and Economic Vulnerability

There are zero people that are classified as highly vulnerable due to socio-economic factors that are exposed to flooding. Figure 4-2 shows the distribution of the most vulnerable people across the Fernvale area affected by social and economic factors such as household income and unemployment.

4.1.3 Mobility Vulnerability

There are 456 vulnerable people affected by flooding although these are in the lower hydraulic risk categories. Figure 4-3 shows the distribution of the most vulnerable people across the Fernvale area affected by mobility factors such as lack of vehicle access and group households with more than five residents.

4.1.4 Awareness Vulnerability

There are zero vulnerable people associated with awareness affected by flooding. Figure 4-4 shows the distribution of the most vulnerable people across the Fernvale area affected by awareness factors such as lack of access to the internet or language.

4.1.5 Combined Vulnerability

There are 462 people that are classified as highly vulnerable due to socio-economic factors that are exposed to flooding. Figure 4-5 shows the distribution of the most vulnerable people across the Fernvale area affected by a combination of vulnerability indicators.

FIGURE 4-1 PHYSICAL VULNERABILITY DISTRIBUTION FERNVALE TOWNSHIP

FIGURE 4-2 SOCIO-ECONOMIC VULNERABILITY DISTRIBUTION FERNVALE TOWNSHIP

FIGURE 4-3 MOBILITY VULNERABILITY DISTRIBUTION FERNVALE TOWNSHIP

FIGURE 4-4 AWARENESS VULNERABILITY DISTRIBUTION FERNVALE TOWNSHIP

FIGURE 4-5 COMBINED VULNERABILITY DISTRIBUTION FERNVALE TOWNSHIP

5 FLOOD DAMAGES

In order to maintain regional consistency and accord to the latest research and application within the flood damages space, the methodology used in the LFMP follows a similar process for categorising, analysing and displaying flood damages for the Somerset catchments to the SFMP[3]. For full refence to the research and application of the SFMP method please refer to the *Brisbane River Strategic Floodplain Management Plan Technical Evidence Report.* A summary of the method used, and the unmitigated flood damages results tables are provided in this section.

5.1 Existing Damage Overview

The following section presents the results of the damage assessment using the adopted SFMP methodology and the various outputs described above. Ultimately, whilst total damages per magnitude of flood event is an important aspect to consider and understand, the Average Annual Damages (AAD) is the defining factor of how much flood damages are expected to cost the Fernvale community each year on average.

Reducing these average annual damages is an important aspect of floodplain management to reduce the overall impact of flooding. This target is not an isolated goal however and is part of a multi-pronged approach to flood management across all work packages. Damages are used in the flood mitigation works and flood resilient materials prioritisation (where reducing damages is a primary aspect of these structural and non-structural measures).

5.1.1 Residential Damages

The results of the total residential tangible damages and average annual damage calculations are shown below in Table 5-1 and Table 5-2. Of note in the residential damages is the following:

- There are low damages within the high frequency events (1 in 1 AEP and 1 in 2 AEP). In the 1 in 5 AEP, damages increase substantially by fivefold.
- Damages gradually increase up to the 1 in 20 AEP, and as the Brisbane River begins to engage the floodplains the damages increase in the 1 in 50 AEP. Damages during the 1 in 100 AEP event increase substantially (eightfold) and this event is a very important benchmark for when major flood damages occur.
- The average annual damages for direct and indirect damages for residential is $513,273 which is quite large for a town of this size.

The 1 in 200 AEP and 1 in 1000 AEP is omitted from the LFMP for Fernvale, as these events were not included as part of the regional Brisbane River Flood Study.

[3] For full refence to the research and application of the SFMP damages calculation method please refer to the *Brisbane River Strategic Floodplain Management Plan Technical Evidence Report*

TABLE 5-1 TOTAL RESIDENTIAL DAMAGES

AEP (1 in X)	Direct Actual	Indirect	Total
1	$7,987	$1,198	$9,185
2	$28,041	$4,206	$32,247
5	$170,103	$25,515	$195,619
10	$216,798	$32,520	$249,318
20	$357,814	$53,672	$411,487
50	$828,917	$124,338	$953,254
100	$6,829,827	$1,024,474	$7,854,301
500	$42,050,409	$6,307,561	$48,357,970
2,000	$50,704,775	$7,605,716	$58,310,491
PMF	$119,309,456	$17,896,418	$137,205,875

TABLE 5-2 RESIDENTIAL AVERAGE ANNUAL DAMAGE

AEP (1 in X)"	Direct Actual	Indirect	Total
2	$7,010	$1,052	$8,062
5	$29,722	$4,458	$34,180
10	$19,345	$2,902	$22,247
20	$14,365	$2,155	$16,520
50	$17,801	$2,670	$20,471
100	$38,294	$5,744	$44,038
500	$111,232	$16,685	$127,917
2,000	$69,566	$10,435	$80,001
PMF	$41,653	$6,248	$47,902
AAD	$446,324	$66,949	$513,273

5.1.2 Commercial and Industrial Damages

The results of the total commercial and industrial tangible damages and AAD calculations are shown below in Table 5-3. A notable flood event is the 1 in 500 AEP where damages increase substantially.

TABLE 5-3 TOTAL COMMERCIAL AND INDUSTRIAL DAMAGES

AEP (1 in X)"	Direct Actual	Indirect	Total
1	$794	$436	$1,230
2	$5,333	$2,933	$8,266
5	$15,410	$8,476	$23,886
10	$21,589	$11,874	$33,463
20	$29,878	$16,433	$46,310
50	$53,773	$29,575	$83,348
100	$87,712	$48,242	$135,954
500	$3,579,626	$1,968,794	$5,548,420
2,000	$14,624,526	$8,043,490	$22,668,016
PMF	$32,461,909	$17,854,050	$50,315,959

5.1.3 Other Building Damage

A similar characteristic in the 1 in 500 AEP is also present in the other building damages as shown in Table 5-4.

TABLE 5-4 OTHER BUILDING TOTAL DAMAGES

AEP (1 in X)"	Direct Actual	Indirect	Total
1	$0	$0	$0
2	$0	$0	$0
5	$0	$0	$0
10	$0	$0	$0
20	$0	$0	$0
50	$0	$0	$0
100	$365,848	$201,216	$567,064
500	$3,167,282	$1,742,005	$4,909,286
2,000	$7,839,638	$4,311,801	$12,151,440
PMF	$23,445,544	$12,895,049	$36,340,593

5.1.4 Road Infrastructure Damages

The results of the road infrastructure damages are shown below in Table 5-5. Of note with the road damages includes:

- There are 119 km of roads affected in total on the floodplain which in general is a considerable amount. There are damages in high frequency events (1 in 2 AEP and 1 in 5 AEP) indicating that some roads have very low flood immunity.

TABLE 5-5 ROAD DAMAGES

AEP (1 in X)"	Length of Minor Road (kms)	Total Damages	AAD
2	2.07	$156,483	$67,379
5	2.69	$203,571	$54,008
10	3.20	$242,098	$22,283
20	4.52	$341,841	$14,598
50	5.66	$427,516	$11,540
100	8.55	$645,971	$5,367
500	16.96	$1,281,908	$3,516
2,000	21.67	$1,637,596	$2,190
PMF	37.66	$2,846,064	$1,098
Total	119	$8,845,080	$186,251

5.1.5 Total Tangible Damages

Total Tangible damages have been calculated across the LFMP area and are shown below in Table 5-6 and Table 5-7. Of note with tangible damages includes:

- Transport and other building damages make up the highest portion of flood damages and are substantially more than residential damages in the 1 in 1 AEP and 1 in 2 AEP events.
- Residential damages far exceed other damages in events all the way to PMF.

TABLE 5-6 TOTAL TANGIBLE DAMAGES

AEP (1 in X)"	Residential	Commercial-Industrial	Other Buildings	Transport	Utilities	Clean up	Total
1	$9,185	$1,230	$0.00	$113,035	$689	$9,310	$133,451
2	$32,247	$8,266	$0.00	$156,483	$2,419	$14,956	$214,372
5	$195,619	$23,886	$0.00	$203,571	$14,671	$32,831	$470,583
10	$249,318	$33,463	$0.00	$242,098	$18,699	$40,768	$584,356
20	$411,487	$46,310	$0.00	$341,841	$30,861	$62,287	$892,806
50	$953,254	$83,348	$0.00	$427,516	$71,494	$115,171	$1,650,833
100	$7,854,301	$135,954	$567,064	$645,971	$589,073	$734,427	$10,526,890
500	$48,357,970	$5,548,420	$4,909,286	$1,281,908	$3,626,848	$4,779,332	$68,504,264
2,000	$58,310,491	$22,668,016	$12,151,440	$1,637,596	$4,373,287	$7,435,562	$106,578,391
PMF	$137,205,875	$50,315,959	$36,340,593	$2,846,064	$10,290,441	$17,774,920	$254,873,851
AAD	**$515,569**	**$63,652**	**$38,622**	**$186,251**	**$38,668**	**$63,207**	**$906,003**

TABLE 5-7 TANGIBLE AAD

AEP (1 in X)"	Residential	Commercial-Industrial	Other Buildings	Transport	Utilities	Clean up	Total	%AAD
2	$10,358	$2,374	$0.00	$67,379	$777	$6,067	$86,956	9.60%
5	$34,180	$4,823	$0.00	$54,008	$2,563	$7,168	$102,743	11.34%
10	$22,247	$2,867	$0.00	$22,283	$1,669	$3,680	$52,747	5.81%
20	$16,520	$1,994	$0.00	$14,598	$1,239	$2,576	$36,929	4.08%
50	$20,471	$1,945	$0.00	$11,540	$1,535	$2,662	$38,155	4.21%
100	$44,038	$1,097	$2,835	$5,367	$3,303	$4,248	$60,889	6.71%
500	$127,917	$8,640	$8,237	$3,516	$9,594	$11,843	$169,748	18.74%
2,000	$80,001	$21,162	$12,796	$2,190	$6,000	$9,161	$131,312	14.49%
PMF	$47,902	$17,881	$11,881	$1,098	$3,593	$6,177	$88,556	9.77%
AAD	**$515,569**	**$63,652**	**$38,622**	**$186,251**	**$38,668**	**$63,207**	**$906,003**	

5.1.6 Total Intangible Damages

The total intangible damages were calculated in accordance with the BRSFMP method and are shown below for residential intangible damages in Table 5-8.

TABLE 5-8 INTANGIBLE AAD

AEP (1 in X)"	Residential
1	$0
2	$0
5	$0
10	$0
20	$0
50	$667,278
100	$9,425,161
500	$111,223,331
2,000	$180,762,522
PMF	$631,147,024
AAD	$919,832

5.1.7 Average Annual Damages

The final average annual damages have been calculated for the LFMP and are shown below in Table 5-9 and Table 5-10. Like past comments the following is noted:

- There are some damages in the very high frequency events associated with infrastructure damage and this accounts for high AAD as a result in these events. AAD decreases in events up to the 1 in 50 AEP event.
- Of note is the high AAD associated with events above the 1 in 100 AEP. This should be considered carefully for the impact considering the widescale damage caused by the 2011 flood event and these events only being slightly above this magnitude. High magnitude flood events in Fernvale could be considered catastrophic and the scale of damage difficult to comprehend. These statistics provide some understanding of this potential impact.

TABLE 5-9 TOTAL DAMAGES

AEP (1 in X)"	Tangible	Intangible	Total
1	$133,451	$0.00	$133,451
2	$214,372	$0.00	$214,372
5	$470,583	$0.00	$470,583
10	$584,356	$0.00	$584,356
20	$892,806	$0.00	$892,806
50	$1,650,833	$667,278	$2,318,111
100	$10,526,890	$9,425,161	$19,952,051
500	$68,504,264	$111,223,331	$179,727,595
2,000	$106,578,391	$180,762,522	$287,340,913
PMF	$254,873,851	$631,147,024	$886,020,875

TABLE 5-10 AVERAGE ANNUAL DAMAGES

AEP (1 in X)"	Tangible	Intangible	AAD Total
2	$86,956	$0.00	$86,956
5	$102,743	$0.00	$102,743
10	$52,747	$0.00	$52,747
20	$36,929	$0.00	$36,929
50	$38,155	$10,009	$48,164
100	$60,889	$50,462	$111,351
500	$169,748	$260,981	$430,728
2,000	$131,312	$218,989	$350,301
PMF	$88,556	$198,918	$287,474
AAD	$906,003	$919,832	$1,825,835

5.1.8 Individual Property Damages

Another powerful way to understand and leverage on the use of damages is to utilise the information available in the master database. This database has assigned AAD to each property and this can be used in a variety of ways to visually understand damage hotspots as shown below in Figure 5-1. This information is also being used in the property specific measures work package to provide greater understanding of how to prioritise flood resilient materials programs (as damage is the primary mechanism being targeted for mitigation). As it can be seen below, there are widespread damages across the township. These damages are moderate (up to $10,000 AAD generally) however there are some houses with damages up to $20,000 AAD.

FIGURE 5-1 INDIVIDUAL RESIDENTIAL PROPERTY AVERAGE ANNUAL DAMAGE

6 FERNVALE – OVERALL FLOOD RISK

Traditionally, flood risk has been defined by simplistic assessment based around frequency of flooding (level of immunity). Over time, flood risk assessments look at the consequence of these flood events such as an understanding of hazard across the floodplain.

Outputs of this project seek to extend the understanding and detail of flood risk factors which will further influence the responses to flood risk exposure of built assets and residents and ultimately inform a more refined and detailed understanding of overall flood risk.

By examining layers of flood risk information, appropriate mitigation response for any built asset or community can be identified. The master database built for the LFMP contains all the flood risk factors critical for this analysis.

This section provides a summary of the overall current flood risk by examining examples around Fernvale. These examples consider critical infrastructure, sensitive institutions, and residential flood risks. The examples in this section show a combination of the following factors:

- Hydraulic risk (combination of flood frequency and hazard);
- Vulnerability (special circumstances that introduce further risk through social and economic functions);
- Time to inundation (an understanding of how long it takes for an area, asset or residence to inundate);
- Duration of flooding (an understanding of how long an area, asset or residence may be flooded for); and
- Isolation (and understanding of whether residents are isolated on low or high flood islands).

This section also provides several limitations for due consideration when using the data presented in this report.

6.1 Nardoo Street Residential Area

An example of a residential use area is shown in Figure 6-1. This shows the flood exposure of the Nardoo Street residential area. The area is exposed to generally very high risks overall. However, a handful of houses are exposed to a higher risk category of HR2 (b). It should be noted that during the 1 in 2,000 AEP there are houses with very high flood depths of over 2 metres of water in this flood event with an extreme hazard rating of H6 (risk to structural failure and extreme risk to life).

In addition, the following is noted about the area:

- The area is slowly inundated during the 1 in 100 AEP event from the Brisbane River, however there are some isolated properties that are rapidly exposed to local flooding (up to an hour TTI). During the 1 in 2,000 AEP event, inundation from the Brisbane River can occur faster (30 hours), however there are more properties exposed to 1 hour TTI from the local flood event in Nardoo Gully.
- The area is inundated during major events for very long periods (12 hours in a 1 in 100 AEP and 72 hours in a 1 in 2,000 AEP event).
- As some of these houses are also located on low and high flood islands, the time and duration of flooding increases the risk substantially.

This area could be considered to have a very high flood risk overall due to the combination of short inundation times, long duration times, very high hazard, some vulnerability, and residents on flood islands.

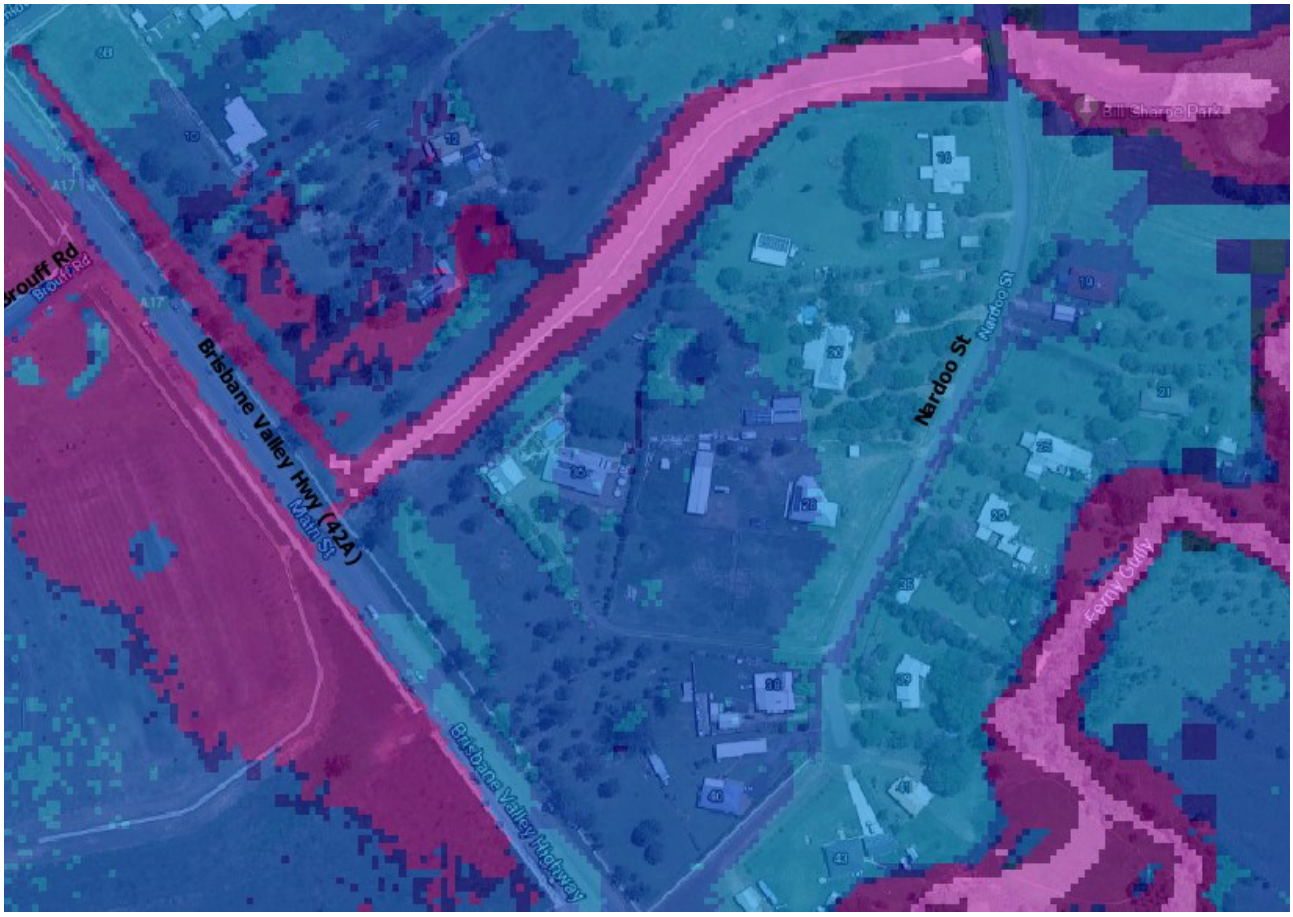

FIGURE 6-1 NARDOO STREET AREA HYDRAULIC RISK

7 FLOOD MITIGATION MEASURES

This section presents the structural flood mitigation measures that were assessed through detailed flood modelling, damage assessment, costings, cost benefit assessment and multi-criteria analysis (MCA). It should be noted that non-structural mitigation options are also presented in the property specific actions chapter and can be readily compared with the structural options.

7.1 Options Identified

The list of flood mitigation options identified for Fernvale are shown in Table 7-1. A description is also provided with a recommendation of whether further detailed assessment by Council should be undertaken. The mitigation options considered were:

- Whether the option would be cost effective. This considers the potential cost verse likely damages reduced. Large costs and small damage reduction would render the option not cost beneficial.
- The ability to significantly reduce flooding as these options are targeted for major regional flood mitigation.
- Practicalities of design and construction and consideration of the likely impact to private property.
- Other components of the MCA including primarily the residual risk leftover from these assets and the asset management burden and ongoing cost to Council.

TABLE 7-1 OPTION ASSESSMENT

Option	Description	Comments	Detailed Assessment?
Fernvale Levee	This is the option as per the Brisbane River Strategic Floodplain Management Plan.	This option will not be re-modelled but will be reassessed through the MCA to compare with other local options.	Yes
Nardoo Gully Detention Basin	There is a broad floodplain that aligns with the rail trail which does not have any drainage structures. This potentially redirects flows into other catchments and floods properties.	Due to the flooding downstream of this area, this option will be taken forward to detailed assessment.	Yes
Banks Creek Detention Basin	Flooding affects areas of Burns Street and properties along Carramala Street.	This option was taken forward to detailed assessment.	Yes
Fairneyview catchment	The gully breaches and floods some areas downstream.	As this was associated primarily with road immunity issues, this option was not taken forward.	No
Property Specific Actions	A program of works to be developed based on flood characteristic criteria and prioritising programs for flood resilient building materials and potential voluntary house purchase.	Further detail is provided in the Property Specific Actions chapter.	Yes

7.2 Options Analysis and Costings

A description and assessment of each of the Fernvale Structural Flood Mitigation Options is shown below. For a full description of the process undertaken for this component please refer to the Somerset Regional Council Local Floodplain Management Plan Technical Evidence Report.

7.2.1 Option 1 Nardoo Gully Detention Basin

An overview of the Nardoo Gully Detention Basin is provided below.

7.2.1.1 Description

Figure 7-1 shows the general layout of the proposed Nardoo Gully Detention Basin. This option is primarily aimed at mitigating flow from the gully and preventing breakout at some locations which floods some properties downstream in Nardoo Street and Poole Road area. The components of mitigation option include:

1. Excavation in the sporting fields area to create storage.
2. Raised bunds to prevent breakouts into neighbouring gullies.
3. Installation of new box culverts and road raising.

It is expected there will be significant reductions in flood levels downstream as a result of the major storage introduced from this option.

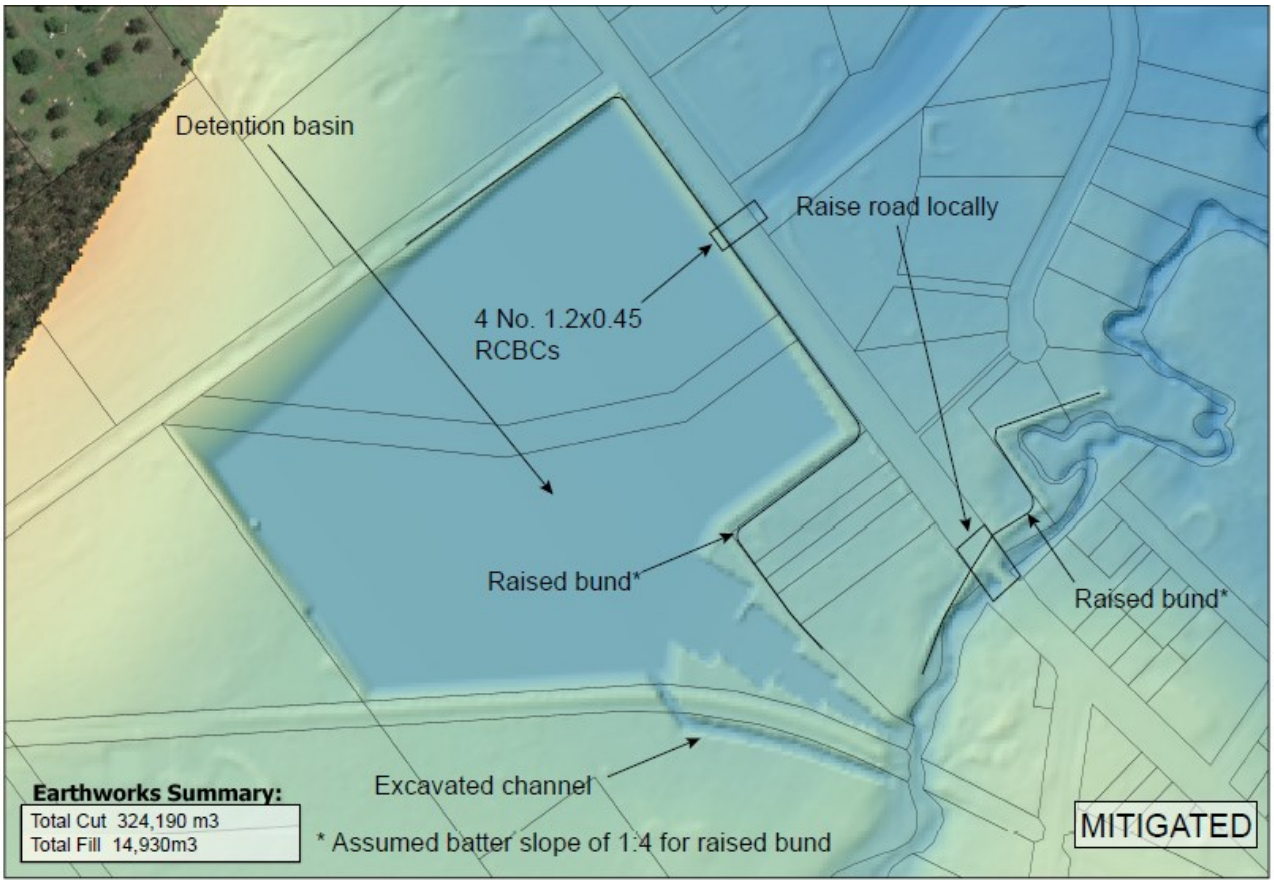

FIGURE 7-1 BASIN ARRANGEMENT

7.2.1.2 Flood Modelling Results

As it can be seen from the results in Figure 7-2, there is a large change to water levels and flood characteristics across the area and these include:

- Significant positive afflux occurs within the detention basin, however this is generally contained within the parklands area;
- Flooding is prevented in the 1 in 100 AEP for around six properties; and
- There are some minor decreases on houses and largescale reductions on property.

7.2.1.3 Costings

Table 7-2 shows the costs associated with Fernvale Option 1. The total cost is estimated at $10,603,803.

TABLE 7-2 OPTION COSTINGS

Items	Unit	Quantity	Unit Rate ($)	Amount ($)
Clearing and Preparation	M2	85,000	1.5	127,500
Imported Basin Core	M3	14,930	25	373,250
Additional levee requirements	M3	5,000	50	250,000
Excavation to Spoil	M3	324,190	20	6,483,800
Spillway Rock	M3	300	120	36,000
Spillway Concrete	M3	75	200	15,000
Seeding and turf	M2	42,500	5	212,500
Culverts	m	60	1500	90,000
Headwalls and Apron	item	1	15,000	15,000
Spillway Downstream channels	M2	500	80	40,000
Road Reconstruction	item	1	200,000	200,000
Total Construction Cost				**$7,843,050**
Pre-Construction Items				
Mobilisation, Traffic Control, Erosion and Sediment Control, Environmental Plans and Setup	%	1		78,430.50
Design, Survey and Modelling	%	2		156,861
Project Management, Applications and other costs	%	1		78,430.50
Sub Total				**$313,722**
Total				**$8,156,772**
Contingency	%	30		$2,447,031
Grand Total				**$10,603,803**

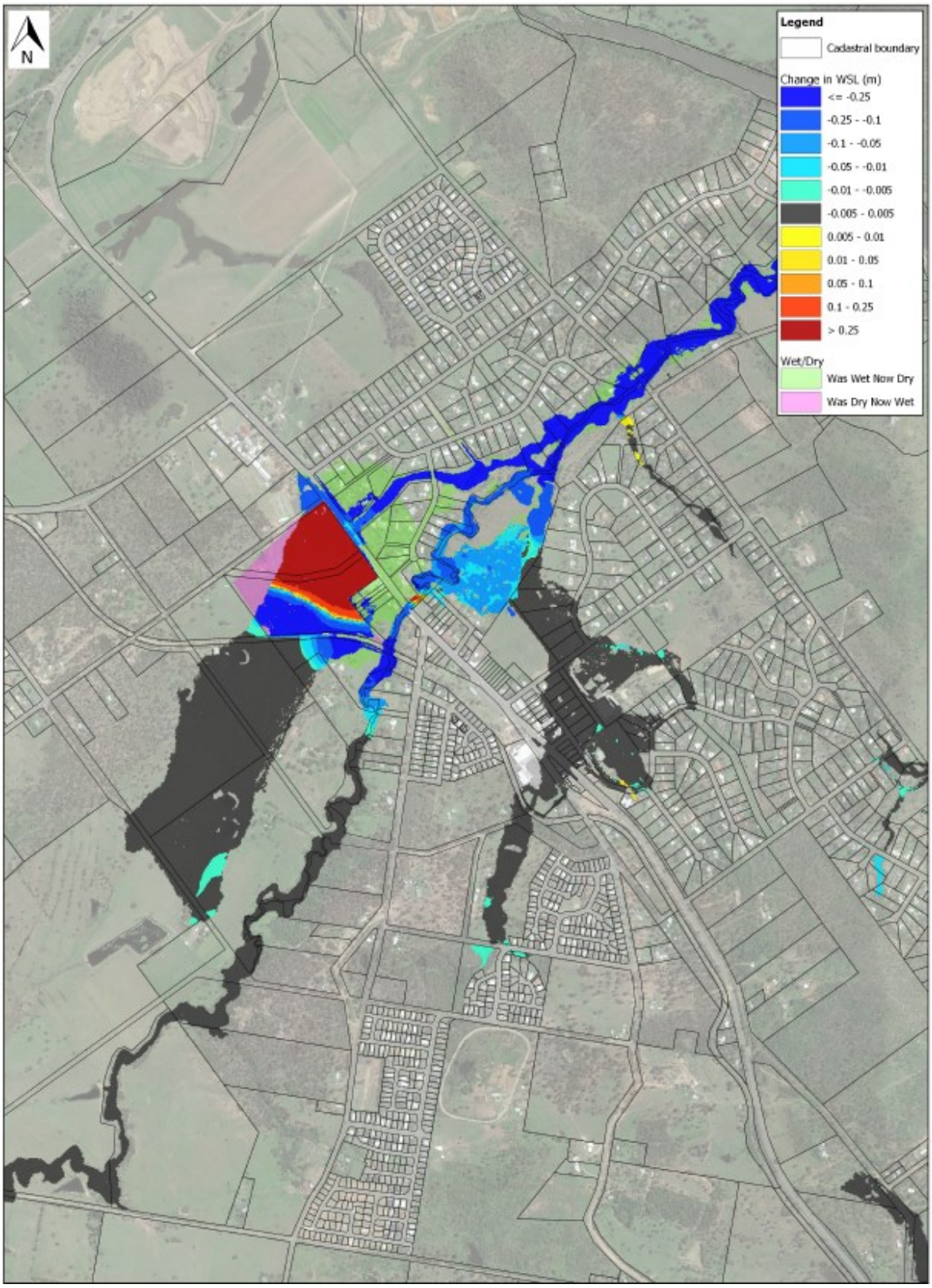

FIGURE 7-2 NARDOO GULLY DETENTION BASIN 1 IN 100 AEP AFFLUX

7.2.1.4 Benefit Cost Assessment

The damages associated with a variety of flood events with the proposed mitigation in place has been simulated and the resultant Average Annual Reduction (AAD) is shown in Table 7-3.

TABLE 7-3 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Option	Total AAD without option in place	Total AAD with option in place	Reduction in AAD	Option Benefit over 100-year lifespan (NPV)
Fernvale Option 1	$354,017	$351,820	$2,197	$31,364

When assessing the financial cost and benefit of the Fernvale Levee Option 1, the benefit to cost ratio (BCR) was found to be 0.01 (see Table 7-4). As a result, the option does not return a high benefit from a flooding and economics point of view.

TABLE 7-4 BCR CALCULATION

Option Benefit over 100-year lifespan (NPV)	Total Capital Cost	Benefit / Cost Ratio (BCR)
$31,364	$10,603,803.60	**0.01**

Sensitivity of the parameters for this option included:

- The maintenance cost was reduced by half and this still returned a 0.01 BCR.
- Adjusting the discount rate still returned a BCR of 0.01.

A benefit cost assessment that show a BCR value of below 0.5 are not recommended to proceed as little economic benefit is provided. As the sensitivity testing also returned BCR values below 0.5, the option is recommended not to proceed forward for further detailed assessment.

7.2.2 Option 2 Banks Creek Detention Basin

An overview of the Banks Creek detention basin along Fairneyview Fernvale Road is provided below.

7.2.2.1 Description

Figure 7-3 shows the general layout of the proposed Banks Creek detention basin. This levee option is primarily aimed at mitigating flow from the gully and preventing breakout at locations which floods some residential properties as well as the main Fernvale commercial areas in the township. The components of the mitigation option include:

1. Excavation in the gully area to create storage.
2. Raised bunds and channels to prevent breakouts.
3. Installation of new box culverts and road raising.

It is expected there will be fairly significant flood level reductions downstream as a result of the major storage introduced from this option.

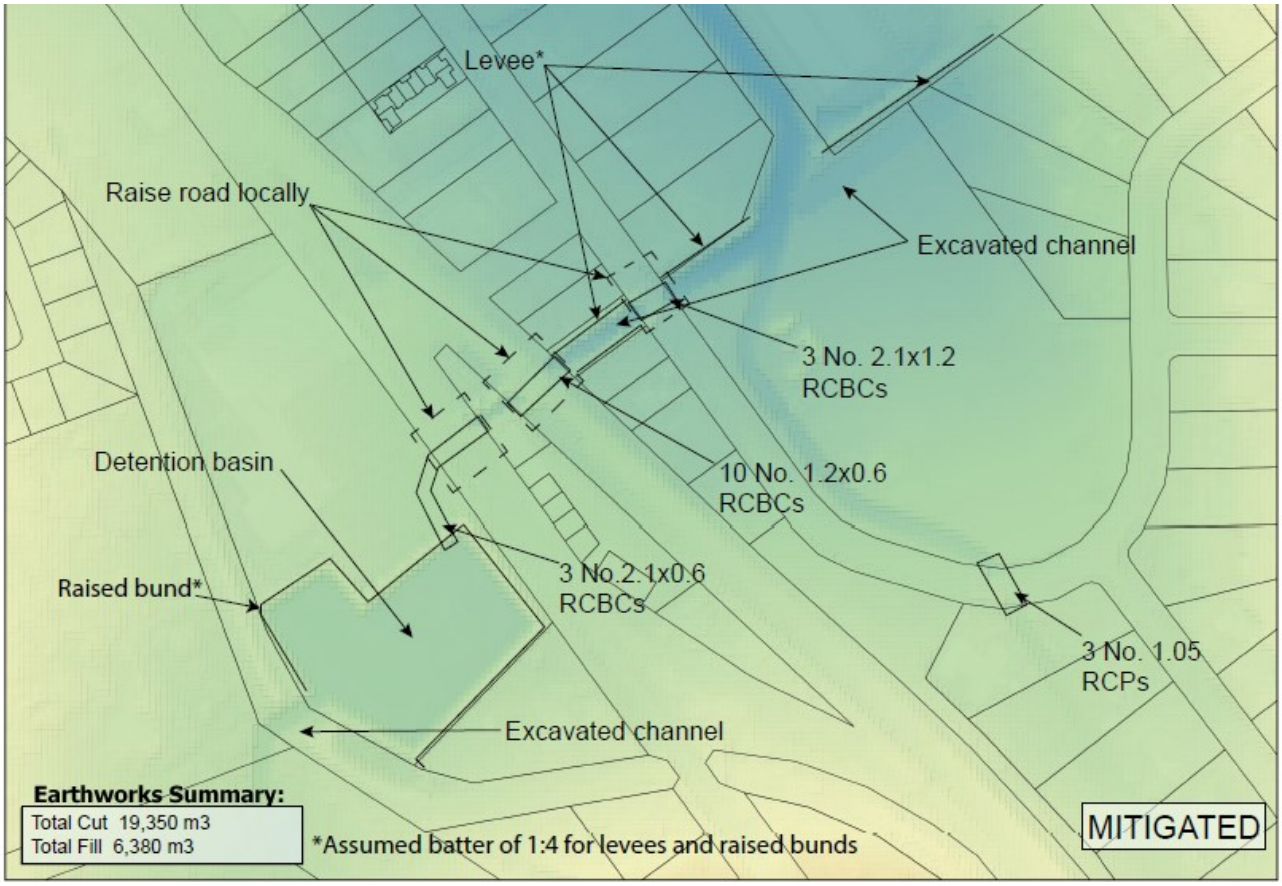

FIGURE 7-3 MITIGATED WORKS ARRANGEMENT

7.2.2.2 Flood Modelling Results

Figure 7-4 shows the 1 in 100 AEP afflux modelled for this option. As it can be seen from the results there is a large change to water levels and flood characteristics across the area and these include:

- Significant positive afflux occurs within the detention basin and upstream of the basin, however this is generally contained within the parklands area.
- Flooding is prevented in the 1 in 100 AEP for around 15 properties.
- There are some significant reductions in flood levels at properties further downstream, however this is restricted to property rather than houses.

Overall, the number of properties provided flood mitigation is moderate, the cost of the basin is moderate and there is an opportunity to provide a higher BCR score in this instance.

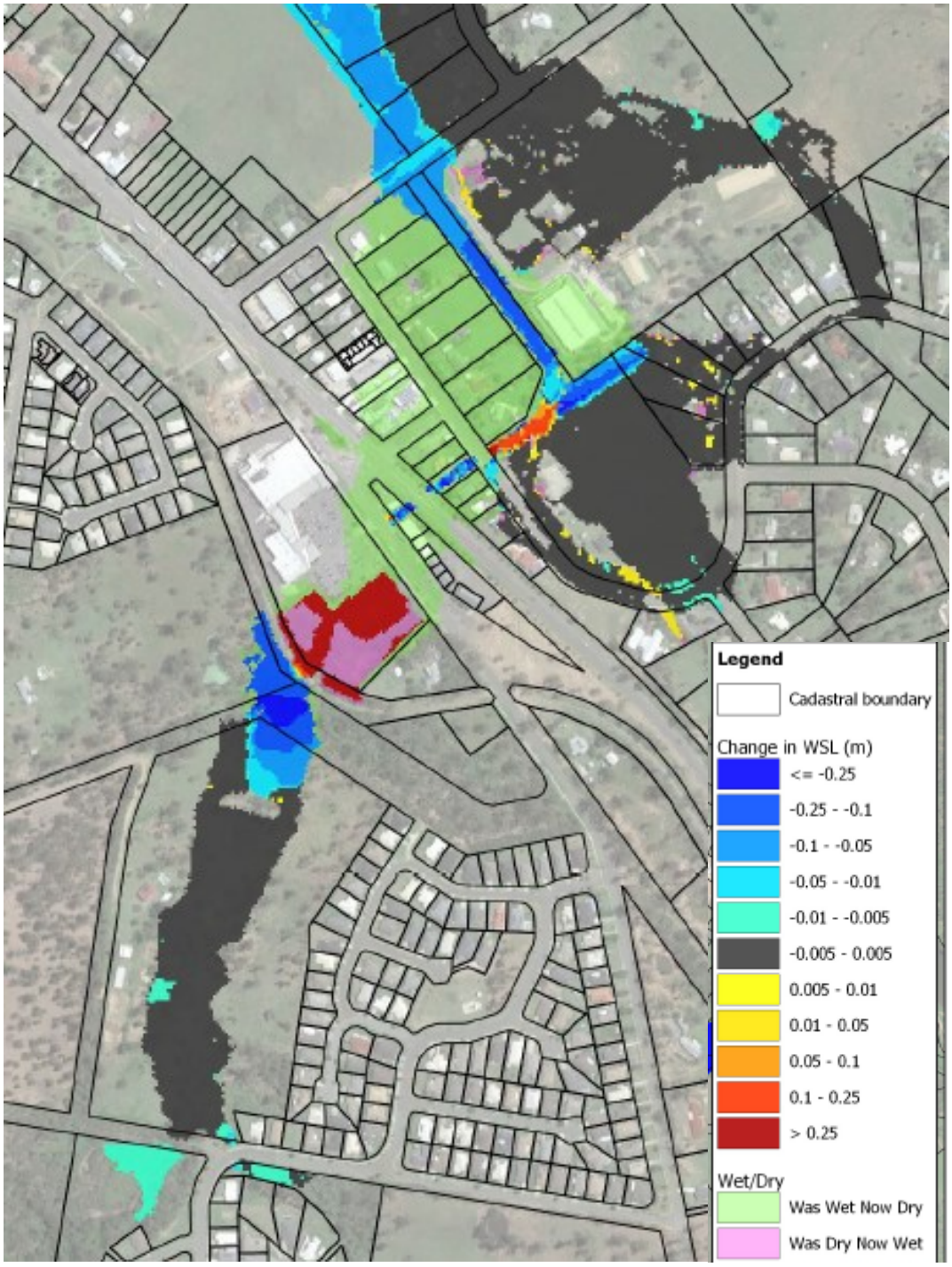

FIGURE 7-4 BANKS CREEK BASIN 1 IN 100 AEP AFFLUX

7.2.2.3 Costings

Table 7-5 shows the costs associated with the Fernvale Township Option 2. The total cost for this project is estimated at $1,859,208.

TABLE 7-5 OPTION COSTINGS

Items	Unit	Quantity	Unit Rate ($)	Amount ($)
Clearing and Preparation	M2	5,000	4	20,000
Imported Basin Core	M3	6,380	25	223,300
Additional Levee Requirements	M3	2,000	50	100,000
Excavation to Spoil	M3	19,350	30	580,500
Spillway Rock	M3	150	130	19,500
Spillway Concrete	M3	30	250	7,500
Seeding and turf	M2	5,000	5	25,000
Culverts 2.1 x 1.2	m	20	1800	36,000
Culverts 1.2 x 0.6	m	150	1000	150,000
Headwalls and Apron	item	2	15,000	30,000
Total Construction Cost				**$1,191,800**
Pre-Construction Items				
Mobilisation, Traffic Control, Erosion and Sediment Control, Environmental Plans and Setup	%	8		95,344
Design, Survey and Modelling	%	8		95,344
Project Management, Applications and other costs	%	4		47,672
Sub Total				**$238,360**
Total				**$1,430,160**
Contingency	%	30		$429,048
Grand Total				**$1,859,208**

7.2.2.4 Benefit Cost Assessment

The damages associated with a variety of flood events with the proposed mitigation in place has been simulated and the resultant AAD is shown Table 7-6.

TABLE 7-6 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Option	Total AAD without option in place	Total AAD with option in place	Reduction in AAD	Option Benefit over 100-year lifespan (NPV)
Fernvale Option 1	$354,017	$280,761	$55,776	$1,045,776

When assessing the financial cost and benefit of the Fernvale Basin Option 2, the BCR was found to be 0.39 (see Table 7-7). This is considered a relatively high score in comparison to the other options in the Somerset LFMP's.

TABLE 7-7 BCR CALCULATION

Option Benefit over 100-year lifespan (NPV)	Total Capital Cost	Benefit / Cost Ratio (BCR)
$1,045,776	$1,859,208	**0.39**

Sensitivity of the parameters for this option included:

- The maintenance cost was reduced by half and this returned a BCR of 0.46.
- Adjusting the discount rate still returned a BCR of 0.68.

This option scores below 0.5 and the sensitivity still does not lift this value close to 1.0. As the option has a score above 0.5, this should be considered further in the MCA for other benefits and limitations for final consideration.

7.3 Multi Criteria Assessment

Generally, for flood mitigation options only costs and benefits are utilised to make determination of the overall scoring of mitigation options. The LFMP has followed the SFMP process to provide additional consideration of a wide range of tangible and intangible benefits and costs. The MCA is used to further assess and score the options to provide a further prioritised list for Council to consider. Table 7-8 shows the MCA results for the three options considered.

7.3.1 Fernvale Levee SFMP option

The Brisbane River SFMP investigated a flood levee near Fernvale to prevent a floodplain connection of the Brisbane River joining Ferny Gully. The option was estimated to cost $3,165,500 and provide protection to 51 properties in the area. This option has been included in the MCA assessment to be analysed together with the options for Fernvale and to also consider other issues not considered in the SFMP such as asset management risks. The same scores have been transferred from the SFMP and the damages and BCR scoring adjusted to suit the local context.

7.3.2 Fernvale Option 1 Scoring

Fernvale Option 1 scores relatively low in all parameters due to the low damages' reduction overall. The following points are noted about this option:

- The option scores neutral in safety and social issues due to a limited flood reduction downstream and overall benefit.
- The option has scored low in the cost benefit and damages score reflective of the assessment undertaken which shows limited benefit.
- The option scores highly in feasibility as it is located on public land and there are no major issues with physical construction of the asset.
- The option scores high for improvement key infrastructure as it provides flood benefit to a major highway.
- The option scores neutral as there is no impact to creeks and ecosystems, however there is also no benefit associated with this option.

TABLE 7-8 MULTI CRITERIA ASSESSMENT

Criteria Category	Criteria Detail	Overall Weighting	Fernvale Option 1	Fernvale Option 2	Fernvale Levee (SFMP)
Safety of people	Reduce hydraulic risk rating (now and future)	18.8%	2.5	3	2.5
	Improve time for evacuation (now and future)	6.3%	2.5	3	2.5
Social	Targets vulnerable community members or areas	2.5%	2.5	2.5	4
	Social health benefits	1.5%	2.5	3	3
	Improves community flood resilience (now and future)	3.0%	3	3	3
	Recreation and amenity	1.5%	2	2.5	2.5
	Connection and collaboration	1.5%	2.5	2.5	2.5
	Community Attitude	2.0%	2.5	2.5	2.5
Economic	Reduce damages and costs to residential property (now and future)	9.0%	2.5	3	3
	Reduce damages and costs to business and industry (now and future)	5.0%	3	3	3
	Option likely to be cost beneficial (now and future)	6.0%	1	1.5	1.5
Feasibility	Physical / technical (now and future)	9.0%	3.5	3	3
	Legal / approval risk	5.0%	4	2	4
	Residual Risk/Asset Management	9.0%	3	3	2.5
Key infrastructure and transport	Improve availability and function (now and future)	5.0%	4	4	3
	Protection of regional water supply quality and security - catchment protection (quality and yield)	5.0%	2.5	2.5	2.5
Environment and natural resource management	Species impacts	2.0%	2.5	2.5	2.5
	Vegetation and habitat impacts	2.0%	2.5	2.5	2.5
	Ecosystem health and connectivity (fish passage/fauna movement)	2.0%	2.5	2.5	2.5
	Reduction in landscape salinity / improved moisture retention and groundwater recharge	2.0%	2.5	2.5	2.5
	Reduction in erosive capacity / soil movement - channel stability / geomorphology	2.0%	2.5	2.5	2.5

7.3.3 Fernvale Option 2 Scoring

The basin option 2 scores slightly higher than Option 1 but still relatively low overall. The following points are noted about this option:

- The option scores slightly higher than Option 1 due to the increased flood reduction downstream from a safety factor point of view. As flood reductions help with social outcomes, the score is slightly more elevated in the positive.
- The option has scored low in the cost benefit and slightly higher in the damages score.
- There are no major issues with physical construction of the asset but the option is located on private land.
- The option scores high for improvement key infrastructure as it provides flood benefit to a major highway.
- The option scores neutral as there is no impact to creeks and ecosystems, however there is also no benefit associated with this option.

7.3.4 Combined MCA

As it can be seen from Table 7-9, all options score in the positive territory, however are still returning a low MCA value. In addition to the overall scoring, Council would also be burdened with a referable levee or basin, ongoing maintenance costs and residual risks associated with events above the 1 in 100 AEP and the impact of potential structural failure. Considering the low MCA score and BCA scores below 0.5, it is not recommended that any of these options proceed forward on consideration of all outcomes.

It should be noted however, that these options do produce flood benefit and design and worsening issues may be able to be overcome. As there are no other solutions for Fernvale flooding, options could be considered outside of the process for implementation if desired by Council.

TABLE 7-9 COMBINED MCA RESULT

Criteria Category	No Change Value	Fernvale Option 1	Fernvale Option 2	Fernvale Levee (SFMP)
Safety of people	0.63	0.63	0.75	0.63
Social	0.29	0.30	0.31	0.35
Economic	0.50	0.44	0.51	0.51
Feasibility	0.58	0.79	0.74	0.70
Key infrastructure	0.25	0.33	0.33	0.28
Environment & NRM	0.25	0.25	0.25	0.25
Total	2.50	2.72	2.89	2.70
Result	-	0.22	0.29	0.20
Rank	-	2	1	3

8 PROPERTY SPECIFIC ACTIONS

8.1 Introduction

While the onus to enact these measures will predominately reside with home owners within the region, Council can facilitate this process by considering the recommendations made at the end of this chapter; and will be effective when implementation is coordinated between the suite of flood mitigation options presented as a part of the floodplain management plan.

There are several actions house owners can take to increase flood resilience, including: residential property buy-back and voluntary purchase, house raising and flood-proofing (via retrofitting flood resilient building materials).

8.1.1 House Purchase

House purchase programs are costly to implement, and while applied to local government areas, rely on state and federal funding. These programs are used in areas that are susceptible to frequent and severe flooding, to mitigate the risk posed to life and property, referred to as property buy-back schemes, voluntary house purchase, or compulsory resumption programs.

8.1.2 Retrofitting Flood Resilient Materials

There are a range of building techniques and materials that can be retrofitted to homes in flood risk areas aimed at improving the resilience of buildings and their contents. Materials that are resistant to inundation damage such as double-brick, brick veneer, tiling or water-proof flooring and lining, water-resistant timber framing, closed-cell insulation, and eliminating cavities behind stairs and wall spaces. Also included is the movement of internal services such as electricity power points, air conditioning units and/or hot-water units above a certain flood level.

8.2 Methodology

Properties will be screened for their exposure to hazard, i.e. those properties that are subject to a higher hazard H5 and H6 in a 1 in 100 AEP event are exposed to potential structural failure and therefore will be put forward as suitable for voluntary house purchase.

The next group of properties which are exposed to habitable floor flooding in a 1 in 20 AEP will be screened for hazard. Those exposed to H1 to H4 hazard category in a 1 in 100 AEP will be suitable for potential retrofitting of resilient building materials.

The properties listed as suitable for either potential voluntary house purchase or retrofitting building materials will undergo a damages assessment to compare expected reductions in damages resulting from flooding after property specific actions have been implemented. The cost-benefit analysis uses flood damage assessment to determine the economic viability of an option.

8.2.1 Cost Benefit Ratio

Cost Assumption

The median house prices shown in Table 8-1 will be used to price a potential voluntary house purchase program and used to assess the cost benefit to Council.

TABLE 8-1 MEDIAN HOUSE PRICE BY SUBURB IN SOMERSET LGA

Locality	Median house price[4]
Fernvale	$387,000

The expected cost of retrofitting materials to create resilient buildings has been established by NCEconomics as part of the Brisbane River SFMP program. Table 8-2 shows the average cost square metre to establish a resilient building. The cost of 'like for like' rebuilding and incremental cost of resilient build from the study by NCEconomics is also shown in Table 8-2.

TABLE 8-2 THE COST OF LIKE FOR LIKE REBUILDING AND THE INCREMENTAL COST OF RESILIENT BUILD

Building type	Average Cost[5] per m^2
Fully detached single story on stumps (FDSS – stumps)	$239
FDSS – stumps (raise)	$401
Fully detached single story – slab on ground (FDSS – SOG),	$171
Fully detached double story – slab on ground for the bottom floor only (FDDS – SOG)	$171

These costs will be used to assess whether retrofitting building materials is an economically viable option for Council.

Benefits

An estimate of the reduction in AAD will be calculated for the whole catchment over the lifetime of a property. The assumptions for AAD reduction are based upon the NCEconomics study as part of the Brisbane River SFMP program (see Table 8-3). 70% reduction of internal damages will be applied to each residential building and aggregated across the study area.

TABLE 8-3 CLASSIFICATIONS OF FLOOD DAMAGE REDUCED BY RETROFITTING BUILDING MATERIALS

Building Type	Internal[6]	External	Structural	Indirect	Intangible
FDSS - SOG	70%	No	No	Partial	Partial

8.3 Results

A cost benefit analysis of each property specific action type is presented in this section. Each potential program is summarised to give an overview of property numbers, hazard exposure, costing and further analysis of suitability of the options available to Council. For example, a combination of priority properties and the full list of suitable properties placed through the cost benefit analysis to provide an overall picture of the economic viability.

[4] Source: Realestate.com.au date: 25th June 2020
[5] Cost per m2 assumption from NCEconomics study for the Brisbane River SFMP (2016)
[6] Reduction to AAD assumption from NCEconomics study for the Brisbane River SFMP (2016)

8.3.1 Voluntary House Purchase (VHP)

Potential voluntary house purchase (VHP) of residential buildings has been considered across the Fernvale township. The implementation of a VHP program must considered across the Somerset LGA as a whole, the methods and results presented in this report are for consideration only.

In the Fernvale township there are three residential buildings that are exposed to both frequent flooding (i.e. 1 in 10 AEP) and high hazard categories in a 1 in 100 AEP (H5 or H6). Distribution of properties that may be eligible for a voluntary house purchase program is presented in Table 8-4. A summary of the property attributes is shown in Table 8-5.

TABLE 8-4 DISTRIBUTION OF PROPERTIES ELIGIBLE FOR HOUSE PURCHASE

Priority Group	AEP	Hazard Category	Number of Properties
1	1 in 10 AEP	H6	2
2	1 in 10 AEP	H5	1

TABLE 8-5 SUMMARY OF PROPERTIES ELIGIBLE FOR HOUSE PURCHASE

Priority Group	Type		FL	AAD	MEDIAN HOUSE PRICE
1	FDSS-SOG	H6	33.11	$58,929	$387,000
	FDSS-SOG	H6	33.11	$53,106	$387,000
2	FDSS-SOG	H5	33.2	$58,996	$387,000
Total				$171,030	$1,161,000

VHP would be a fully effective measure of removing people and property from the risks of flooding including reduction in damages including partial and intangible damages. The lots have the potential to be turned into open space and an enjoyable recreational area for residents. The social impact of removing homes from the community are not insignificant on an individual scale and these impacts are to be considered by Council on a case by case basis.

Given the low number of properties exposed to the criteria in Fernvale, a BCR has been applied to all properties suitable for VHP.

8.3.2 BCR for VHP all Properties

In summary this option would:

- Remove all suitable properties from the risks associated from exposure frequent nuisance flooding associated within the 1 in 10 AEP events.
- Prevent a total of $85,110 in AAD across the Fernvale township.
- Properties potentially eligible are shown in Figure 8-1.

When assessing the financial cost and benefit of buying back properties across Fernvale, the BCR was found to be 1 (see Table 8-6 and Table 8-7). That is the costs of buying the property in current market conditions, are approximately 10 times more than the benefits that could be achieved over a 50-year lifespan.

TABLE 8-6 OPTION BENEFIT RELATIVE TO CURRENT CONDITION

Property Specific Action	Total AAD without option in place	Total AAD with option in place	Reduction in AAD	Option Benefit over 50-year lifespan (NPV)
VHP All Properties	$171,030	$85,920	$85,110	$1,183,574

TABLE 8-7 BCR CALCULATION

Option Benefit over 50-year lifespan (NPV)	Total Cost (Based on median house price)	Benefit / Cost Ratio (BCR)
$1,183,574	$1,161,000	1

8.3.3 Voluntary House Purchase – Summary and Recommendation

It is recommended that Council consider implementation of a VHP program in Fernvale. Despite the BCR, there are other benefits that can be realised, such as removing the risk to life completely. The damages reduction is costed over a 50-year lifespan of the property, however, if the lot is converted and contributes to open space, the risk is removed in perpetuity.

An analysis of the all the potentially eligible properties has a BCR of 1. The cost of this option for properties is approximately $1,183,574 and the estimated benefits accumulated over a 50-year lifespan is $1,161,000.

The timing of flood hazard impacts means that planning for a range of options needs to commence immediately, focusing on VHP and retrofitting building materials. The way in which these options are implemented, either individually or as a combined package of solutions, requires further investigation during the planning stage with input from the local community.

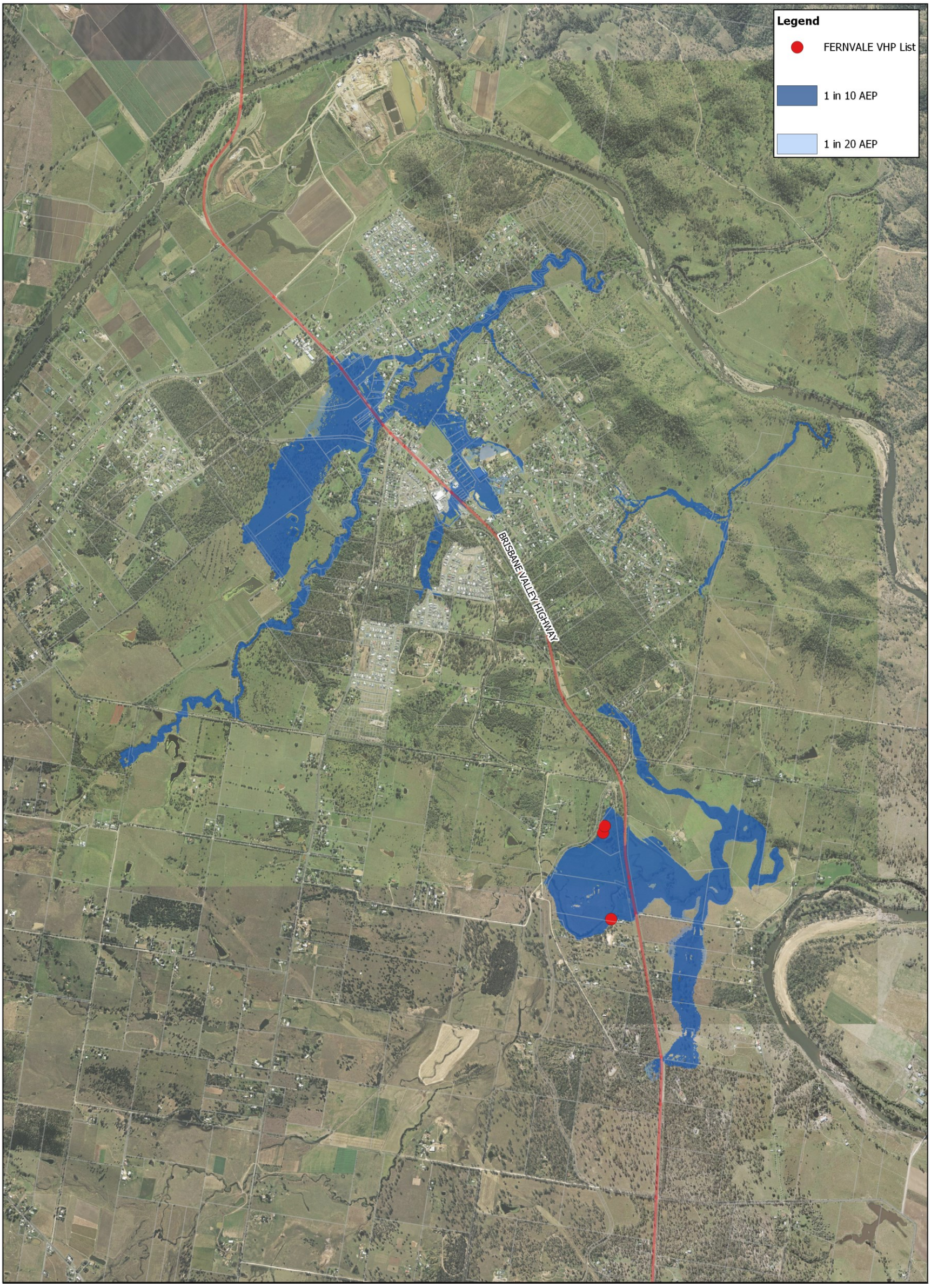

FIGURE 8-1 PROPERTIES POTENTIALLY ELIGIBLE FOR PROPERTY SPECIFIC ACTION IN FERNVALE

8.3.4 Retrofitting Building Materials

In the catchment of Fernvale, at the time of the study, there are no properties that meet the criteria to make a property eligible for retrofitting building materials. The screening for this assessment undertook the following method. The eligibility of buildings had to meet the following filters outlined in Table 8-8.

TABLE 8-8 RETROFITTING BUILDING MATERIALS – ELIGIBILITY

Filter	Description
Residential zone properties only	Retrofitting building materials will only be open to property owners of residential properties.
1 in 20 AEP	Floodwaters of the 1 in 20 AEP must be considered to inundate habitable-floor level. Those that do not meet this criterion will not be eligible for retrofit of building materials or house raising.
H1 to H4 in a 1 in 100 AEP	Properties here must NOT be exposed to potential structural failure associated with H5 and H6. Therefore, are more suited for retrofitting resilient building materials to reduce flood damages. Properties subject to hazard H1 and H2.
Voluntary participation only	Priority properties will be invited to participate in the retrofitting building materials.
Building Type: FDHS FDSS – Stumps	Only properties that are Fully Detached Single Storey raised on stumps and Fully Detached High Set may be eligible for house raising.

Further prioritisation of properties eligible for the retrofitting building materials used the AAD that have been calculated for that property and categorised into the following:

- Priority Group 1: Above $10,000
- Priority Group 2: $5,000 to $10,000
- Priority Group 3: <$5,000

No properties in Fernvale met these criteria, thus a BCR could not be calculated. Please refer to the TER report for more information on the methodology.

8.4 Summary of Property Specific Actions in Fernvale

A detailed economic assessment of property specific actions has been undertaken, considering the reduction AAD across the groups of potentially eligible properties. The findings seem to align with commentary in this field that suggests implementing property specific actions is generally a viable option for reducing the impacts of flood events up to 1 in 100 AEP.

VHP presents a challenge as it is reasonable to assume that property owners may expect a pre-hazard market value for a property. Pre-hazard values have been used in this economic appraisal, however over time and continued to exposure to flooding risks this market value is likely to be adversely impacted as a result of the identified flood hazards.

Given the potential intolerable risks associated with flood hazards, there is a clear priority to plan for a range of options focusing on flood mitigation, property specific actions and emergency management. The way in which these options are implemented, either individually or as a combined package of solutions, requires further investigation during the planning stage with input from the local community.

The following recommendations are put to Council for consideration as part of a wider floodplain management strategy for Fernvale and the Somerset LGA:

- It is recommended that Council consider implementation of a Voluntary House Purchase program to all properties potentially eligible as this has a BCR of 1.
- It is not recommended that Council consider implementation of a program of retrofitting building materials in Fernvale as no properties are eligible or met the criteria.

Implementation of two possible programs based on the hazard and damages-based prioritisation highlighted in this report may not be economically viable. However, there are a number of further considerations:

- Council should follow up each property to understand the true flood risk to the property, i.e. is there a laundry or storage area that is flooded not habitable floor.
- Council should seek to ensure that residents most affected by flooding hazards are given the first opportunity to take part in a program.
- The order of priority should be regularly reassessed, based on updated information, to ensure that it is as accurate as possible.
- Each financial year, for as long as the program(s) continue, Council should allocate funding for offers to the highest priority eligible properties. These are properties that meet all eligibility criteria. It should be communicated that there is no forced resumption of properties under the VHP Program. It should be the choice of the property owner whether to sell to Council if an offer is made.
- Each financial year, for as long as the program(s) continue, all properties that meet the criteria for purchase, whether identified by Council or offered by the owner, should be prioritised for purchase based on the seriousness of anticipated flooding. This priority may change through the financial year depending on the number of Council offers accepted or declined.
- Advice on the programs should be linked to an existing flood awareness, education, and communications program as part of Get Ready Queensland or getting ready for summer campaigns.
- Offers to buy property or installation resilient materials should be judged on a case by case basis – the programs should be voluntary, but how and when a site-specific measure is implemented depends on the length of the waiting list, whether the property owner approached Council or vice versa. For example, after making an offer to purchase property, Council may wait four weeks for a response before advising in writing that '*as the owner haven't accepted an offer to purchase that it was being withdrawn and with no guarantee that they would be approached again.'* Longer than three months can require a new property valuation.
- Initial communication to homeowners to buy property should include a caveat explaining that property **may** be eligible for consideration under this scheme. Some may be eligible under the criteria explained in this report and considered but ultimately not purchased or offered resilient building materials (e.g. due to budget or unable to agree reasonable works, etc).

9 EMERGENCY MANAGEMENT

Effective floodplain management planning requires a vast array of consideration and implementation of different techniques and tools to reduce flood risk to a tolerable or acceptable level. Measures such as flood mitigation aim to remove the risk altogether whereas emergency management measures are aimed at providing management techniques to better prepare and respond to flooding.

Emergency management overall is a complex arrangement through local government, state and federal government and is centred around PPRR: prevention, preparedness, response and recovery. Whilst the scope of this project is limited, the datasets provided have opportunity to help increase the preparedness, planning and response to flood events.

9.1 Introduction

The scope of the LFMP has been limited in the emergency management and community awareness components. Further detailed investigation would be required to provide useful outputs in the flood forecasting and intelligence space, evacuation planning and in particularly the community awareness component.

It is recommended that Council use the outputs of this project to further inform scope in these areas particularly in specific high flood risk areas to target. It should be noted that the Fernvale area is covered by the existing Brisbane River Flood Forecasting system.

9.2 Flood Forecasting and Intelligence

As per the LFMP TER, the process to determine a suitable flood forecasting and intelligence system is based on the level of risk in each township. Ultimately, a flood forecasting system in each LFMP area would be ideal, and this should be the end goal for Council where resources and funding become available.

9.2.1 Flood Forecast System Local Assessment

The main township of Fernvale has the following characteristics when assessing its suitability towards the required flash flooding system:

- The Fernvale township is generally not inundated to a major degree below the 1 in 100 AEP for the local event which reduces the risk with the frequency of flooding.
- There are several properties inundated in the 1 in 100 AEP event within the Nardoo Street area.
- During the 1 in 2,000 AEP flooding within the Fernvale township from the local flood event only increases marginally. Flood hazards increase to around H3 for some isolated properties.
- There is a very rapid time to inundation for all properties in the floodplain making warning and evacuation difficult.

Because of the level of hazard and number of properties, an advanced warning system is likely not required and a low or medium risk system sufficient for this catchment generally. Caution should be applied outside of the township however for isolated properties impacted during flood events.

9.2.1.1 Low Risk Flash Flood Warning System

As above, a low risk flood warning system can be implemented as part of the deliverables in the LFMP using the developed rainfall and road trigger mapping as shown in Figure 9-1. This simplified method utilises the road deck heights as a reference point.

A full suite of rainfall and water level trigger maps for the Nardoo Gully bridge on the Brisbane Valley Highway have been provided in the electronic data pack for immediate use during flood events.

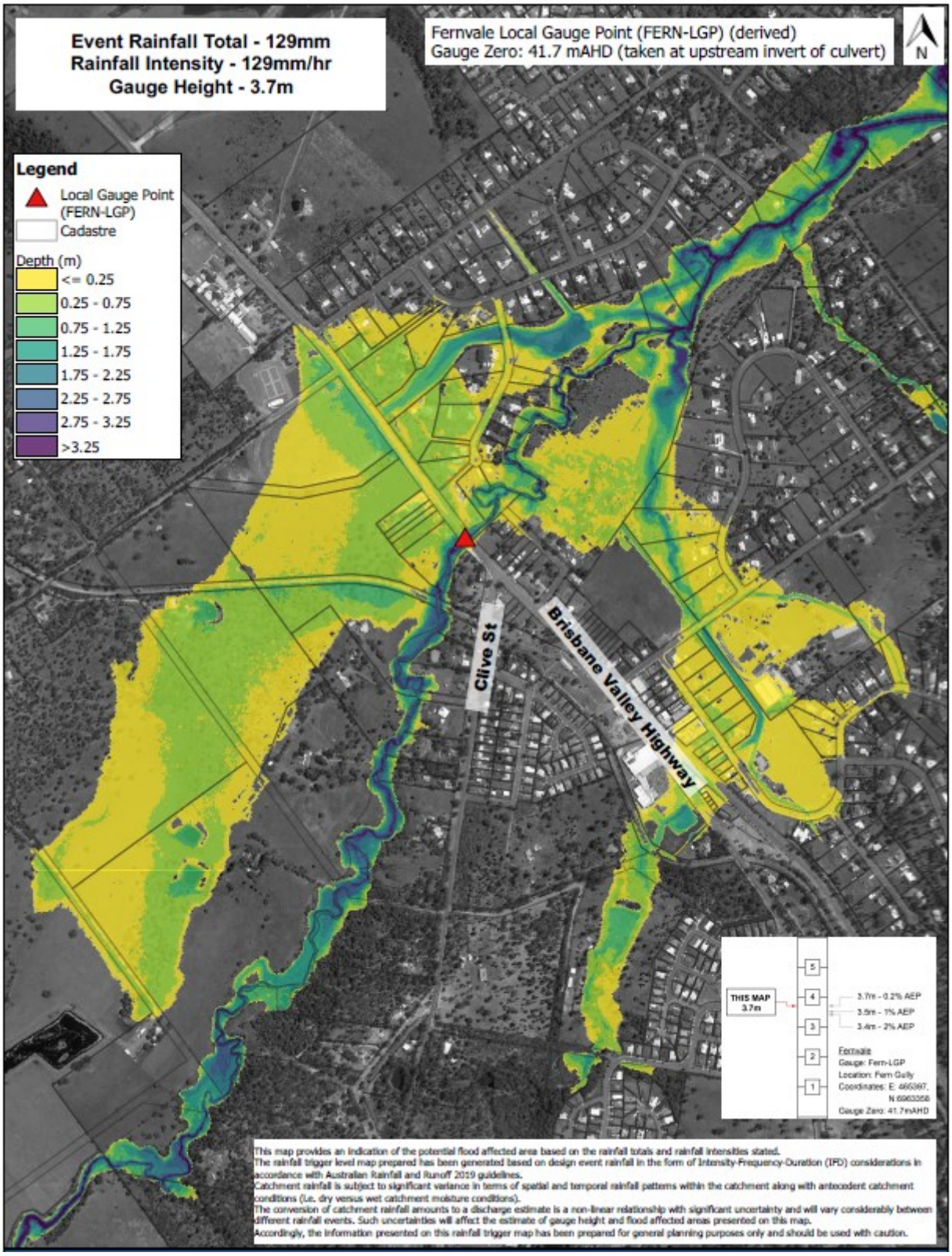

FIGURE 9-1 RAINFALL AND WATER LEVEL TRIGGER MAP FERNVALE TOWNSHIP

9.2.1.2 Future Medium Risk Flash Flood Warning System

In order to increase the reliability, sophistication and responsiveness of the low risk system, the following measures could be implemented:

- Construction of a rain and river gauge on Nardoo Gully at the Brisbane Valley Highway. This gauge will then be able to reference the rainfall intensity and predicted flood levels for each type of event. Alternatively, another rain gauge could also be provided higher in the catchment to determine spatial variation of rainfall. Similarly, a water level gauge could be installed in other parts of the catchment, however the level trigger maps would also need to be changed.
- Utilising the rainfall and water level trigger maps developed for this project and linking these to the gauge data in the future. In the interim, the maps have been developed to use the bridge deck as a reference.
- Using the flood intelligence developed as part of this project to indicate high risk properties and associate these with the rainfall and water level trigger maps.

In the context of relative flood risk (compared to other catchments), the low risk system may be sufficient to respond to the threat of flooding in this area. The upgraded medium risk system is however recommended to provide further flood intelligence if resources become available.

9.2.1.3 Brisbane River Forecasting System Intelligence

As the area of Fernvale is dominated by the Brisbane River flooding and the hazards associated with this flooding are extremely high, it is recommended that the following flood intelligence improvements are made to the system:

- The information and datasets from this project can be utilised and incorporated into the flood forecasting system. This could include identifying high priority evacuation residents in a similar manner as used in the LFMP. As the datasets are already compiled, the information within the GIS files can be used as fields when assessing flood intelligence and publications from the WaterRIDE outputs.
- Special consideration should be given to the evacuation requirements above, but also the evacuation centres if they continue to be used in high magnitude flooding. The forecasting system should be updated to include the evacuation centres and the road low point datasets to make determinations about the viability of these centres (particularly the showgrounds) in high magnitude flooding. The forecasting system can be updated to include road breaches associated with evacuation paths to the secondary evacuation centre on the Fernvale State School site.

The datasets developed from the LFMP project can be directly utilised in the existing riverine WaterRIDE flood forecasting system. Some additional work would be required from the vendor to include these and publish the required datasets if desired.

9.3 Evacuation Prioritisation

The major component of scope for emergency management was the identification and development of an evacuation screening and prioritisation approach. It is important to understand the limitations and risks during evacuation and consider:

- Evacuation is limited by resources and needs to be targeted to the highest risk properties and prioritised.
- Flood events are response based due to the complexities of events and how they pan out during the event.
- Evacuation is often far more dangerous than sheltering in place due to being swept away in floodwaters etc and the hazards and complexity associated with human behaviour during events.

- Sheltering in place (if safe to do so) is often the recommended measure during flood events because of the complexities and risks associated with evacuation. It is also preferable for many reasons that people stay at home, with friends and not in formal evacuation centres. Considering recent pandemic events associated with COVID-19 it is also possible that evacuation centres will be unable to open or open with decreased capacity due to social distancing rules.

In the first instance effective flood warning and intelligence must be provided to the community to enable members to voluntarily evacuate. It is always preferable that residents stay with family and friends outside of flood areas well before flood events happen. This requires effective warning, forecasting and flood intelligence measures as well as community awareness and education programs which is outside of the scope to develop these aspects for the project.

Whereby residents have not evacuated, the complexities of evacuating entire suburbs are made clear by the sheer numbers and resources required. Whilst this is the overall preference where significant risk is involved, this project has documented a prioritisation method to attempt to locate properties at great flood risk due to a number of factors (flood hazard, vulnerability and warning time).

9.3.1 Evacuation Screening Process

The screening process developed and explained within the LFMP TER has prioritised the following property triage locations. The distribution of properties is shown below in Figure 9-2. It was noted that there were 5 properties that had a very high risk with regards to fast inundation and very high hazards.

TABLE 9-1 PRIORITISATION RESULTS

Screen	Detail	Number of Properties	Priority
1	1 in 2,000 AEP H5|H6	275	High
1a	1 in 2,000 AEP H5|H6 and TTI <6 hours	270	Higher
1b	1 in 2,000 AEP H5|H6 and Vulnerable	0	Higher
1c	1 in 2,000 AEP H5|H6and TTI <6 hours and Vulnerable	0	Highest
2	1 in 2,000 AEP H3|H4	7	Medium
2a	1 in 2,000 AEP H3|H4 and TTI <6 hours	0	High
2b	1 in 2,000 AEP H3|H4 and Vulnerable	0	High
2c	1 in 2,000 AEP H3|H4 and TTI <6 hours and Vulnerable	1	Higher
3	1 in 2,000 AEP H1|H2	1	Low
3a	1 in 2,000 AEP H1|H2, low set property, longer than 6 hours flooding	0	Medium
3b	1 in 2,000 AEP H1|H2, high set property, longer than 12 hours flooding	0	Medium
3c	1 in 2,000 AEP H1|H2 and vulnerable	0	High

FIGURE 9-2 EVACUATION PRIORITISATION LOCATIONS

9.4 Evacuation Centre Assessment

9.4.1 Overview

Evacuation centres are a critical element of preparing, responding and recovery from flood events. Whilst it is generally preferential for residents to take up shelter with family and friends, this is not always possible and high flood risks in areas may also generally prevent residents from navigating to relatives' homes. Thus, establishment of secure and safe evacuation centres becomes critical as a last resort to protect and houses residents during floods.

9.4.2 Evacuation Centres in Fernvale

Council have established two evacuation centres in the Fernvale township at the following locations:

- Fernvale State School 1605 Brisbane Valley Highway Fernvale.
- Fernvale Showgrounds 32 Banks Creek Road Fernvale.

These evacuation centres are shown below in Figure 9-3.

FIGURE 9-3 EVACUATION CENTRE LOCATIONS

9.4.3 Flood Risk Assessment

The location of evacuation centres is often selected with only minimal, historical flooding or no consideration for flood risk. The LFMP now presents a wealth of information that locates high risk residents requiring priority evacuation and the flood risks associated with particularly parcels of land and indeed established centres.

The following provides an assessment of each of the centre locations, their suitability considering flood risk, locations of high-risk residents requiring priority evacuation and the suitability of site selection to service these residents.

9.4.3.1 Fernvale Showgrounds

This evacuation centre location appears to have been placed to service the main Fernvale Township east of the Brisbane Valley Highway and south of gullies cutting the highway as a result of flooding. The location in general is heavily affected by flooding due to:

- The centre begins to inundate during the 1 in 2,000 AEP event. The centre has immunity for the 1 in 100 AEP event. The centre is suitable only for events up to the 1 in 100 AEP immunity level and could only be used as a staging centre to relocate residents in larger floods.
- In the 1 in 2,000 AEP event, the centre is heavily exposed to flooding and affected by Hazard H6 which could cause structural failure of the buildings. During events above the 1 in 100 AEP, this centre is not suitable for evacuation.
- The Fernvale showgrounds is also located on a low flood island which dictates that if this area is being used as a staged evacuation ground in larger floods, residents must be relocated quickly before road inundation occurs in the area. If a low flood island were to form, this would create a very dangerous situation at this evacuation centre.

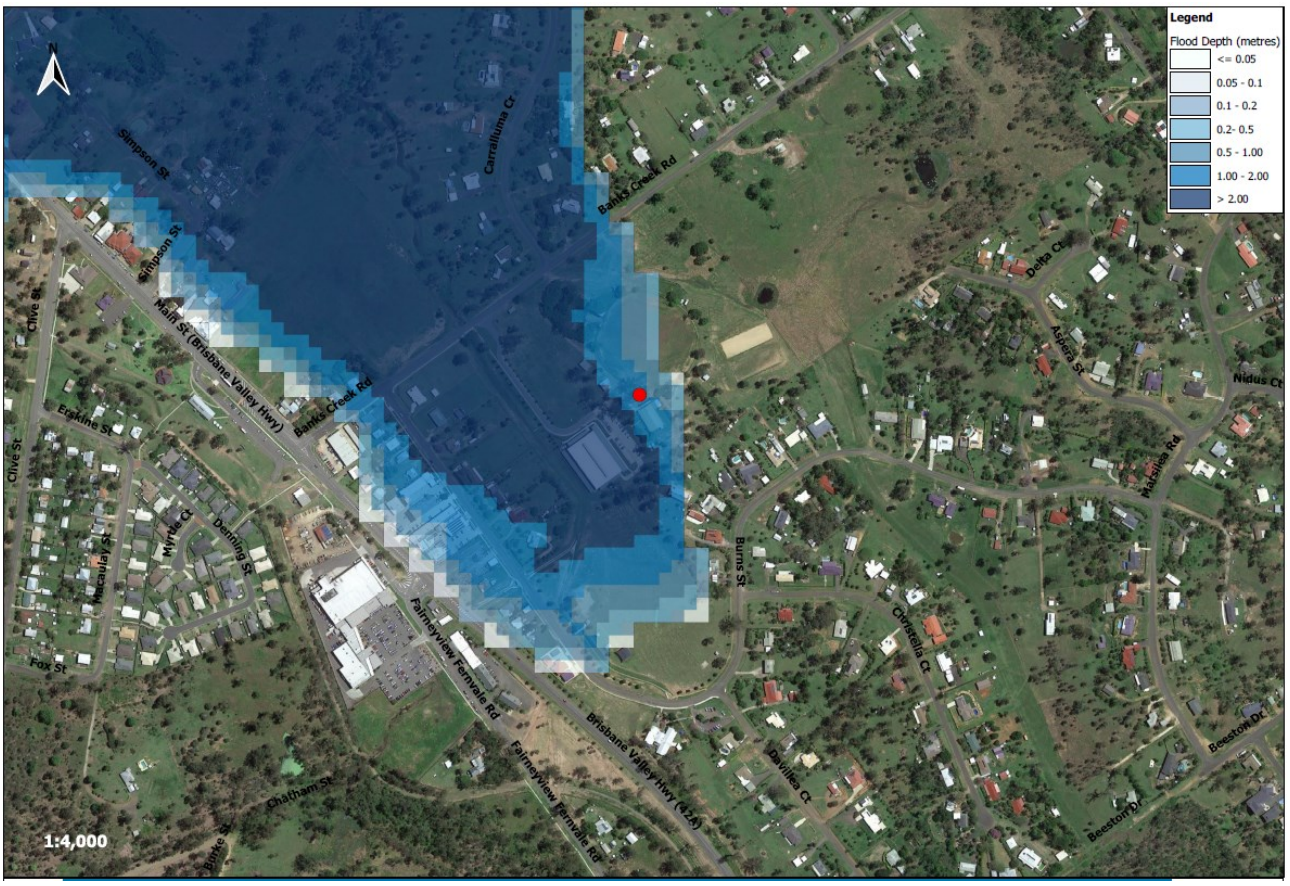

FIGURE 9-4 FERNVALE SHOWGROUNDS 1 IN 50 AEP FLOOD DEPTH

9.4.3.2 Fernvale State School

This evacuation centre location appears to have been placed to service the main Fernvale Township west of the Brisbane Valley Highway and north of gullies cutting the highway. The location is affected by flooding with the following characteristics:

- The centre begins to inundate during the 1 in 500 AEP event.
- In the 1 in 2,000 AEP event the centre is exposed to flooding and affected by Hazard H5 in some portions of the school buildings. The back portions of the school buildings have less flood depth and hazard and should be used in higher magnitude events such as the 1 in 2,000 AEP event.
- In the PMF event, the entire school grounds are inundated, however there is high ground situated behind the school area which can be used as refuge. In extreme circumstances such as this, consideration would need to be given to recovery by boat or aerial support.

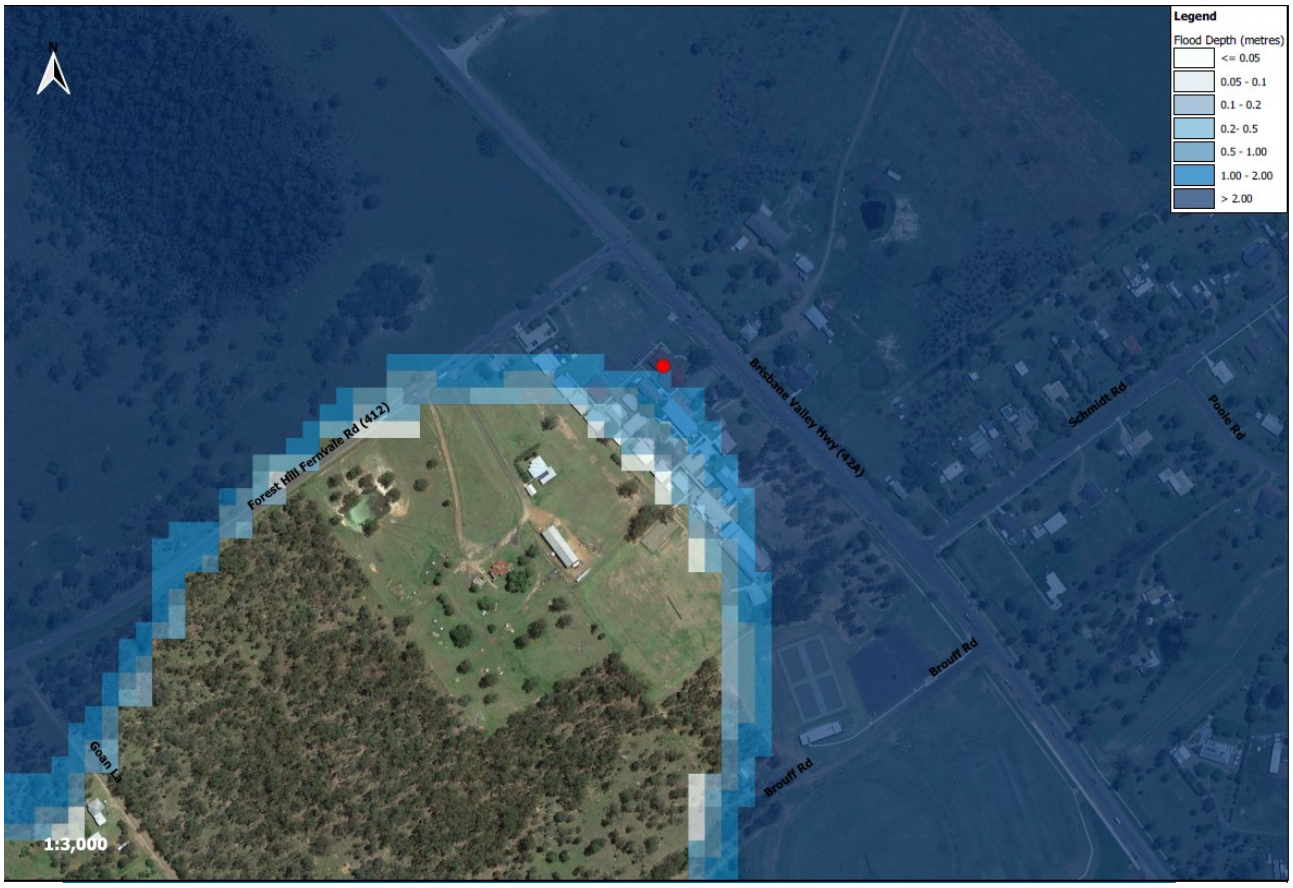

FIGURE 9-5 FERNVALE STATE SCHOOL 1 IN 2,000 AEP FLOOD DEPTH

9.4.4 Evacuation Centre Recommendations

Based on the flood risk assessment of evacuation centres in the Fernvale area, the following is recommended:

1. The Fernvale Showgrounds require close monitoring of flood warning and forecast flood levels. The evacuation centre should only be used if necessary and in floods up to the 1 in 100 AEP event. In addition, if this centre is used as a staging centre, careful monitoring of flood levels will be required to ensure evacuees can be transferred to the Fernvale State School. Overall, it is recommended that an alternative evacuation site is sourced using the LFMP outputs for flooding purposes.

2. The Fernvale State School is generally a suitable evacuation site but must also be monitored for events in the 1 in 2,000 AEP event where the location inundates, and hazards increase substantially. Where flood events are forecast above this, it is critical that high ground is able to be reached towards the back of the property and that special rescue services are on standby as the centre would be inundated for many days.

3. The Fernvale Futures Centre (Information Centre) at 1483 Brisbane Valley Highway is a good potential candidate for an evacuation centre as it provides flood immunity to the 1 in 2000 AEP event.

The assessment above has provided an assessment of the suitability of the current evacuation centre locations.

9.5 Evacuation Route Planning

With the prioritised results, these areas were grouped into clusters and evacuation paths mapped out for each of the clusters as shown in Figure 9-6. It should be noted that assessment of the evacuation centres showed that two centres were generally not appropriately located for high magnitude flooding and thus evacuation planning has not directed residents to these centres.

It should also be noted that there are other high risk properties not accounted for in the evacuation planning below and the electronic datasets should be consulted to provide more awareness of all properties (outside of the main Fernvale township). A description of each of these routes is described below.

9.5.1 Cluster 1 | Schimdt and Powells Road Area

This area has many residents requiring priority evacuation. These residents are exposed to very high hazards (H5/6) although most have long times to inundation to evacuate. It should also be noted that many of the roads leading to the Fernvale State School evacuation centre have restricted paths due to low road immunities and thus residents must be evacuated early to prevent issues with safe passage.

9.5.2 Cluster 2 | Carrauma / Burns / Banks Creek Road

This area also has residents requiring priority evacuation although less than cluster 1. These residents are exposed to very high hazards (H5/6) although most have long times to inundation to evacuate (some properties are however affected by local flooding as well with very short inundation times).

It should be noted also that many of the roads leading to the Fernvale showgrounds evacuation centre have restricted paths due to low road immunities and thus residents must be evacuated early to prevent issues with safe passage.

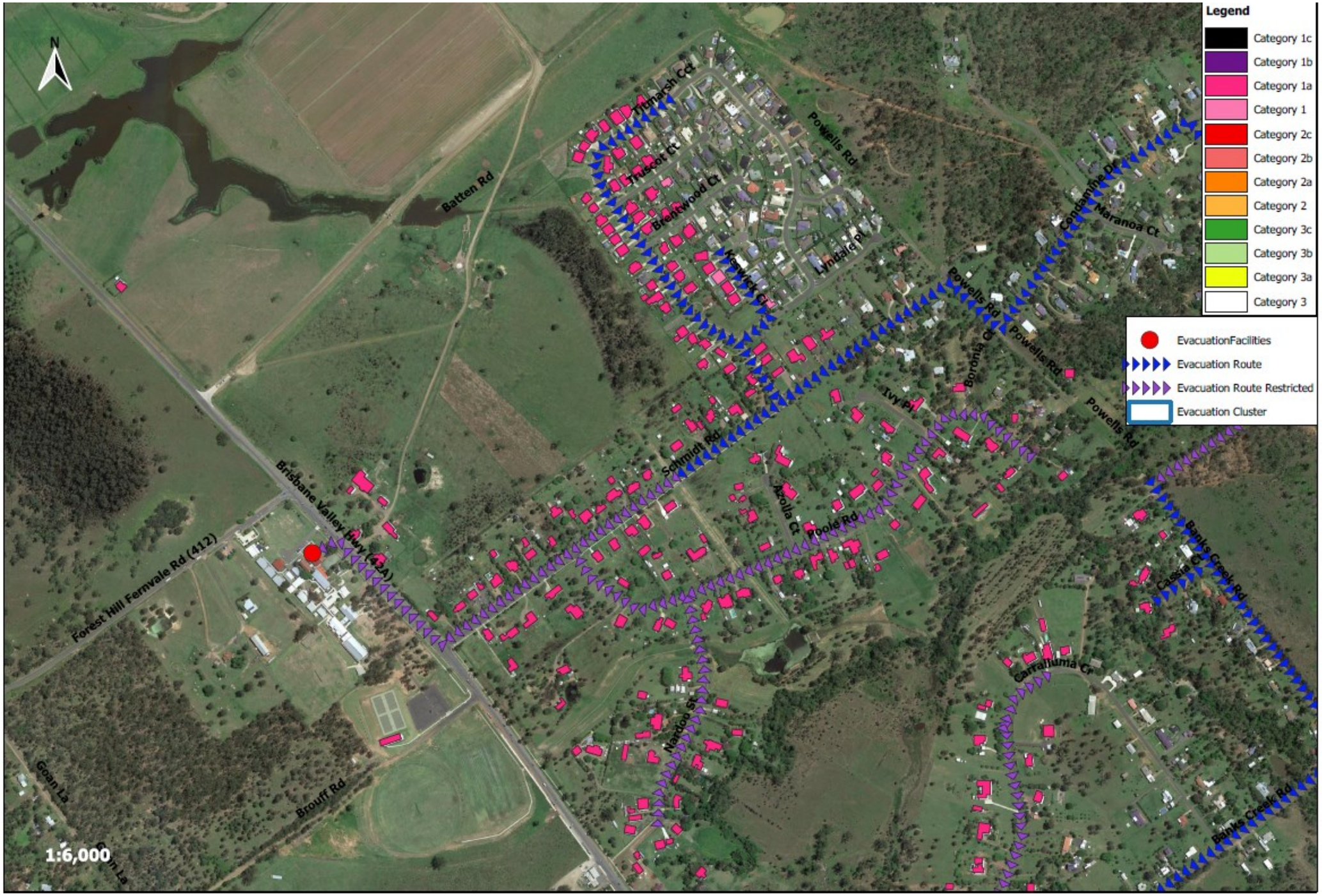

FIGURE 9-6 EVACUATION ROUTES AREA 1 FERNVALE TOWNSHIP

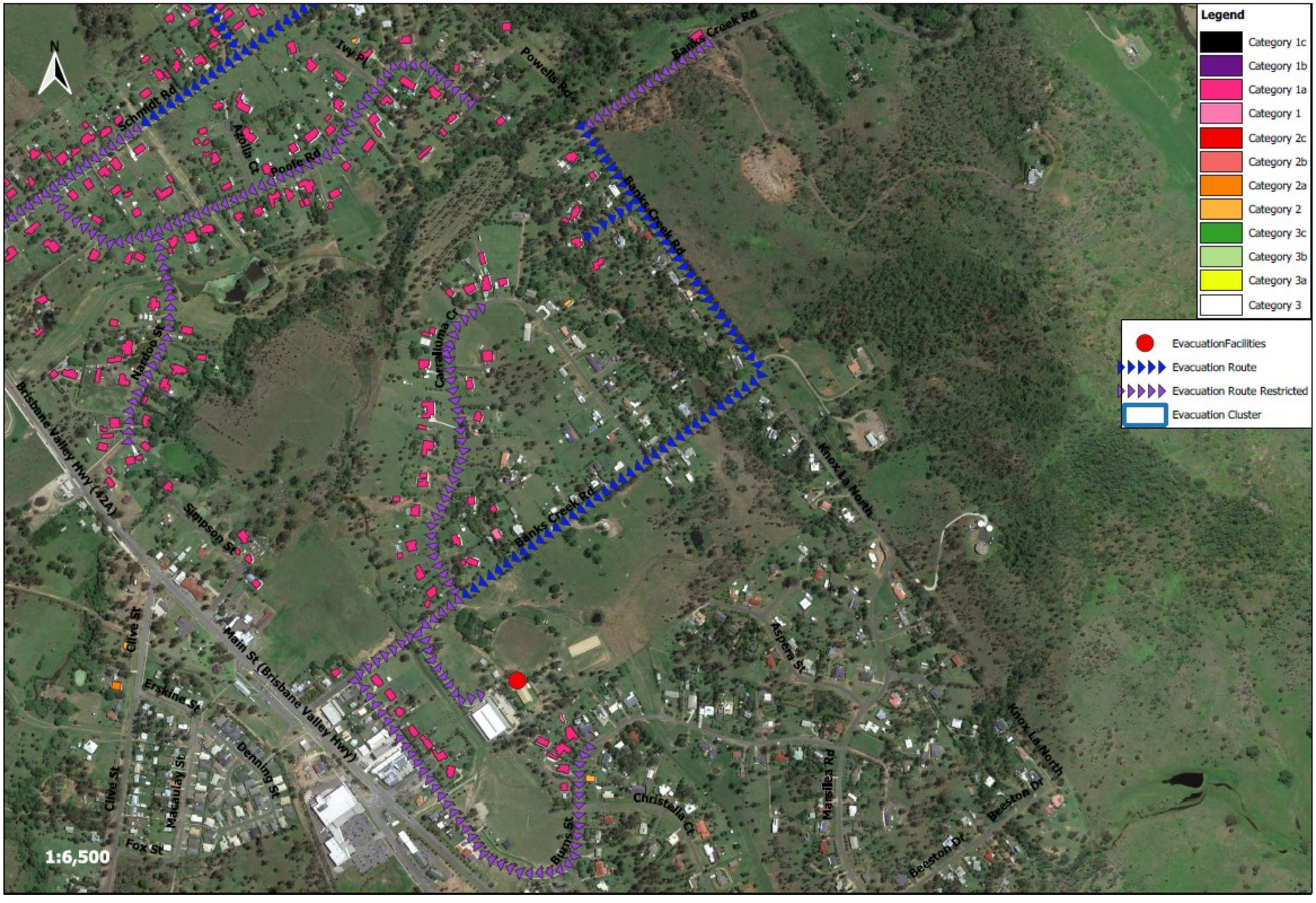

FIGURE 9-7 EVACUATION ROUTES AREA 2 FERNVALE TOWNSHIP

10 SUMMARY

10.1 Flood Risk Overview

The LFMP for Fernvale has been used to understand the extent and scale of flooding and to set policies for managing risks associated with flooding within the catchment. The plan can be used to guide capital investment, land use planning activities, disaster management planning and raise community awareness and understanding of flood risk and how it will be managed. The LFMP used the outputs from the Brisbane River Flood Studies, SFMP and Somerset Flood Studies which provides the data to help understand the flood behaviour of the catchments, to assess and characterise the nature of flood risk across the floodplain and how to best manage the risk.

Flooding in Fernvale starts to become serious during the 1 in 100 AEP with flooding of the Brisbane River beginning to occur. The Nardoo gully begins backing up (along with other sections) flooding houses in the Nardoo Street area with general hazard of H3. There is however 1 house near Powells Road that has a high H6 hazard (risk to structural failure). There are also houses outside of the township with this level of hazard.

During the 1 in 2,000 AEP event, the consequences of flooding become very severe and life threatening. There is widespread inundation of the Fernvale Township with very high hazards (H6) widespread. This hazard also extends to much of the Fernvale main commercial area. Flood events above the 1 in 100 AEP (similar to that experienced in 2011) have severe consequences to the Fernvale community and additional recognition of these sudden hazards must be recognised in order to respond to rare events above the 1 in 100 AEP.

The mapped extent of the floodplain reveals 716 residential and rural residential buildings are exposed to flooding in the PMF event. There are also 155 properties within the 1 in 100 AEP extent. There are fairly low numbers inundated in the more frequent events up to 1 in 50 AEP. However, there is a threefold increase in numbers to the 1 in 100 AEP when the floodplains engage on the Brisbane River. Almost 2,148 residents are mapped within the extent of the floodplain which indicates approximately 67% of the Fernvale residents are exposed to flooding of some nature.

This is a very high exposure rate. Within Fernvale there are four low flood islands and 1 high flood island. There are buildings situated on some of these low flood islands and significant numbers of properties and buildings on the 1 high flood island.

Various levels of vulnerability are faced by the township of Fernvale, with a total of 462 people being at risk from one or more of the four types of vulnerability: physical, social and economic, mobility and awareness. Overall, the statistics suggest there are low numbers of vulnerable people in Fernvale, however there are substantial numbers exposed in the floodplain. There are 9 people exposed to the second highest flood risk category. These vulnerabilities arise over all HR categories, with the highest number of people at risk under the HR2(b) and HR3(a) categories. Analysing this in the context of evaluating flood damages; a total of $513,273 AAD can be associated with direct and indirect residential damage, and a total of $186,251 for road infrastructure.

10.2 Flood Mitigation Responses

To address the flood risk faced by Fernvale and the community, several mitigation options have been explored. Detailed assessments of options were undertaken for Council's consideration, including cost benefit analysis and multicriteria assessment.

In Fernvale, the following options were assessed in detail:

- Nardoo Street residential area:
- Levee option is primarily aimed at mitigating flow from the gully and preventing breakout at some locations which floods some properties downstream in Nardoo Street and Poole Road area.
  - Cost benefit ratio 0.22
- Banks Creek detention basin:
  - Levee option to address the flooding that affects areas of Burns Street and properties along Carramala Street. This option would mitigate flow from the gully and preventing breakout at some locations which floods some properties and main Fernvale commercial areas in the township.
  - Cost benefit ratio 0.29.
- Fernvale Levee SFMP Option:
  - Flood levee located near Fernvale to prevent a floodplain connection of the Brisbane River joining Ferny Gully.
  - Cost benefit ratio 0.20.
- Property specific actions were considered including:
  - Residential properties eligible for a potential Voluntary House Purchase program:
    - Cost benefit ratio of 1.
  - Residential properties eligible for Retrofitting Building Materials to create flood resilient properties:
    - Cost benefit ratio of 0 as no properties met the eligibility criteria.

The results suggest that Council should consider implementation of a Voluntary House Purchase program to all properties potentially eligible as there is a benefit cost ratio of 1. It is not recommended that Council consider the implementation of a program for retrofitting building materials as no properties in Fernvale met the criteria for this.

10.3 Emergency Management

Effective floodplain management planning requires a vast array of consideration and implementation of different techniques and tools to reduce flood risk to a tolerable or acceptable level. Because of the level of hazard and number of properties, an advanced warning system is likely not required and a low or medium risk system sufficient for this catchment generally. Caution should be applied outside of the township however for isolated properties impacted during flood events. Assessment of evacuation prioritisation as part of the emergency management works, results show that there are 5 properties that have a very high risk with regards to fast inundation and very high hazards.

Assessment of the flood risk at the two evacuation centres (Fernvale State School and Fernvale Showgrounds), has shown that the Fernvale Showground centre requires close monitoring of flood warning and forecasted levels, and the centre should only be used if necessary and in floods up to 1 in 100 AEP. The Fernvale State School has been considered a suitable evacuation centre; and should be monitored for events in the 1 in 2,000 AEP where the location is subject to inundation.

10.4 Recommendations

A summary of the wider recommendations for the township of Fernvale include and are detailed in Table 10-1. In summary, Council may consider:

- Updating Flood Levels with more accurate methods such as survey.

- Providing values classes for commercial damages.
- No structural flood mitigation options have been recommended as part of this project and thus other management measures are critical to reduce flood risk in the area.
- Utilise the risk-based examples in the TER and other outputs of the LFMP to update land use planning outcomes in Fernvale.
- Utilise the details from the flood mitigation options to inform any zoning changes with No Feasible Alternatives Assessment Reports.
- The recommendations within the local flood forecasting section of the report should be considered for further investigation.
- The recommendations within the riverine flood forecasting section should be considered further.
- The developed evacuation prioritisation lists should be reviewed and utilised to provide a better understanding of high-risk residents.
- The evacuation centres at Fernvale State School and the Fernvale Showgrounds require special consideration in high magnitude flooding as described in the report.
- The Fernvale Futures Centre (Information Centre) should be considered further by Council as a formal evacuation centre due to its higher level of flood immunity (1 in 2000 AEP).

TABLE 10-1 SUMMARY OF LFMP RECOMMENDATIONS FOR FERNVALE

Category	**Recommendation**	Description
Monitoring and Review	LFMP Updates.	As flood information is updated over time, the LFMP should be reviewed in the context of the current understanding of flood risk. Council may consider, due to the scale of the project, updating the LFMP on a 5 to 10-year timeline.
Existing Risk	Updating Flood Levels with more accurate methods such as survey.	Floor levels have a substantial impact on overall flood damages and can skew results significantly. As the LFMP relies on estimated floor levels and overall damages are very high in the study area overall, it is recommended that high risk areas are investigated in more detail. This should also extend to where detailed implementation of mitigation options is being undertaken to ensure accurate cost benefit assessments are realised.
Existing Risk	Providing values classes for commercial damages.	The SFMP uses value classes to define different commercial damages based on how valuable the building contents may be. Unfortunately, this information was not made available and an average value class was used. Council may consider updating the commercial value damages after the LFMP is complete.

Category	Recommendation	Description
Flood Mitigation	No structural flood mitigation options have been recommended as part of this project and thus other management measures are critical to reduce flood risk in the area.	All of the investigated structural flood mitigation measures are not cost beneficial for Fernvale. As high residual risk of flooding generally remains, it is recommended that emergency management recommendations are implemented and a community education and awareness program is developed and undertaken for Fernvale.
Land Use Planning	Utilise the risk-based examples in the TER and other outputs of the LFMP to update land use planning outcomes in Fernvale.	The SPP requires all Councils to update planning schemes and transition to a risk-based approach to flooding. This project has provided example approaches to risk based planning and also other outputs such as flood islands, vulnerability assessment, time to and duration of flooding and emergency management aspects that will be useful to transition to a full risk based approach to flooding.
Land Use Planning	Utilise the details from the flood mitigation options to inform any zoning changes with No Feasible Alternatives Assessment Reports.	When any zoning changes are considered to land, a No FAAR report must be undertaken to assess all of the alternatives to these zoning changes. A key component of this is investigating structural flood mitigation options which has been undertaken in this project. As there are generally no feasible alternatives, this will assist in the development of No FAAR reports.

Category	Recommendation	Description
Emergency Management	The recommendations within the local flood forecasting section of the report should be considered for further investigation.	The trigger-based maps provided with this project may be utilised as a method for flood warning in the township. A combined water level and rainfall gauge is also recommended to be installed at the Brisbane Valley Highway to provide a higher level of flood warning and flood intelligence should resources permit. The rainfall and water level trigger maps would need to be updated with any new gauge install. It should be noted however that in general, the risk from flooding in the local catchment is considered low and installation of flood gauges would be a low priority in Fernvale inconsideration of other areas.
Emergency Management	The recommendations within the riverine flood forecasting section should be considered further.	Consideration should be given to upgrade the Brisbane River Flood Forecasting WaterRIDE system to better capture the issues with evacuation and evacuation centres in Fernvale. Flood intelligence from this project could be incorporated into the system with the features in WaterRIDE for publishing intelligence.
Emergency Management	The developed evacuation prioritisation lists should be reviewed and utilised to provide a better understanding of high-risk residents.	The developed prioritisation lists provide a “triage” style of priority evacuations where sheltering in place is not safe to do so. In addition, the process developed could also be replicated to be utilised in flood forecasting systems to provide real time information and flood intelligence.
Emergency Management	The evacuation centres at Fernvale State School and the Fernvale Showgrounds require special consideration in high magnitude flooding as described in the report.	As both centres are inundated in the 1 in 2,000 AEP event (particularly the showgrounds) additional information should be incorporated in the Local Disaster Management Plans. Consideration should also begiven to flood forecasting intelligence upgrades as described in a previous recommendation to allow more confident use of both centres.

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