Somerset Regional Council

Report for January 2011 Flood Event

Fernvale Flooding Investigation

May 2011

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Glossary

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
BCC	Brisbane City Council
BOM	Commonwealth Bureau of Meteorology
DFE	Defined flood event
DFL	Defined flood Level
IDAS	Integrated Development Approval System
IEAust	The Institution of Engineers, Australia
IFD	Intensity Frequency Duration
JFT	Joint Flood Taskforce
PMF	Probable maximum flood
PRM	Probabilistic Rational Method
QRT	Quantile Regression Technique
SPP	State Planning Policy
SPA	Sustainable Planning Act
SRC	Somerset Regional Council

Executive Summary

The township of Fernvale experienced extensive flooding on January 11 and 12, 2011 as a result of intense rainfall in the area, and also backwater flooding from the Brisbane River. There were two flood peaks, one due to rainfall during the day, and a second peak due to backwater flooding from the Brisbane River during the evening and into the night of January 11 and the early hours of January 12. The ensuing inundation extents were significantly wider than the 100 year ARI flood extents predicted by the previous studies.

Somerset Regional Council (SRC) engaged GHD Pty Ltd to undertake a flooding and drainage investigation for the lower half of the Ferny Gully catchment. Ferny Gully is a small tributary of the Brisbane River catchment and is approximately 17 km downstream of Wivenhoe Dam. The purpose of this investigation is to assess the behaviour of the January 2011 flood event, to extend and refine the flood inundation estimate for the 100 year ARI event based on more accurate topographical information, and to make a preliminary assessment of drainage improvement options proposed by SRC to improve the conveyance capacity of flow paths investigated in this study. The basis for assessing Council's option was to reduce the risk of flooding for the 100 year ARI event where possible, and only considers local flood events and not riverine flooding. Due to the preliminary nature of this study, this is not a comprehensive flood study that quantifies the flood risk in Fernvale or undertakes a cost-benefit analysis of other floodplain management practices such as voluntary property acquisition, and structural measures.

The January 2011 rainfall was significantly larger than any rainfall previously recorded in the region since records began in 1887. While the January 2011 rainfall was only 10% larger for the previous highest one day total (1965), it was 30 to 43% higher for the two and three day totals (from January 1974). An analysis of the peak rainfall bursts at the Savages Crossing gauge indicated that the ARI of the January 2011 event was very large; at least 500 years and possibly exceeding 2,000 years. Hydrological modelling of this event demonstrated the event generally appears to have an ARI of around 2,000 years.

The closest water level gauge to Fernvale is Savages Crossing on the Brisbane River, just upstream of the Ferny Gully confluence. The peak water level at Savages Crossing was 42.48 m AHD occurred at 2:12 am on 12 January 2011. This is slightly higher than the peak level of 42.22 m AHD in the January 1974 flood (Seqwater, 2011). Seqwater (2011) concluded that below Wivenhoe Dam, the flood had an ARI similar to that of the post-Wivenhoe 1974 flood and may be as high as 1,000 years.

A new hydraulic model was developed for this study which took advantage of the higher resolution topography data now available. The cross section locations were largely retained from the earlier Fernvale Master Drainage Plan, and additional sections added for those watercourses, apart from Ferny Gully, upstream of the Brisbane Valley Highway.

Based on the results of the hydraulic modelling, flooding due to the intense rainfall was the major cause of any inundation in Banks Creek upstream of Burns Road and backwater flooding from the Brisbane River did not encroach on this area. A similar situation existed for the Lagoon tributary in the vicinity of the Brisbane Valley Highway, though in this instance there were minor increases due to backwater flooding from the Brisbane River during the recession.

The Brisbane River backwater flooding resulted in higher flood levels than the rainfall-induced flooding in the vicinity of Banks Creek Road, and the areas near Poole Road. At Banks Creek Road it appears the rainfall-induced flood peak is similar to the backwater river flood peak. However, along the Lagoon Tributary and Ferny Gully near Poole Road, it appears from the simulation result that the backwater flooding from the Brisbane River resulted in a flood peak that is approximately two metres higher at chainage 3988 (to the south of the Titmarsh Gully), and nearly 5 metres higher further to the north along Poole Road at chainage 5878 (in the vicinity of Powells Road) than their respective rainfall-induced flooding peaks.

Hydraulic modelling of design flood events (ARIs from 5 years to 100 years) indicated that the estimated capacity of the existing drainage paths in the Ferny Gully catchment downstream of the Brisbane Valley Highway varies from location to location. Based on the preliminary assessment undertaken for this study, the Banks Creek (upstream of Banks Creek Road), Ferny Gully, and Titmarsh Gully watercourses all have an estimated 5 year ARI capacity. The ARI capacity of the Lagoon Tributary is approximately 10 years, while in Banks Creek downstream of Banks Creek Road, the estimated capacity is around 50 years. The preliminary drainage improvement works presented in this study provide a 100 year ARI capacity.

SRC's Planning Scheme Policy 12 has some guidance on the development of floodprone land and floodplain management. While this policy provides some guidance on flood inundation areas for the 100 year ARI event, the information is based on flooding along Brisbane River floodplain and does not consider localised creek flooding. This means the true extent of the 100 year ARI flood extent is not entirely defined, though Council does take into consideration local flood study information where it exists. The State Planning Policy 1/03 (SPP) essentially recommends the adoption of historical flood levels for the DFE where the 100 year ARI flood extent is not known, or it circumstances suggest historical values are more appropriate. The issue for SRC with adopting historical peak flood levels is that the 1974 flood occurred before the construction of Wivenhoe Dam, and the January 2011 event has a probability much lower than the 100 year ARI probability nominated for the DFE. Adopting the January 2011 flood extent for local watercourse flooding may unnecessarily preclude land from future development. That is, a flood risk standard may be enforced which is inconsistent with the river flooding inundation adopted under Scheme Policy 12.

Council should consider historical flood events and how they impact on the Planning Scheme. However, adopting the January 2011 event (an ARI of approximately 2,000 years) as the DFE for residential areas of Fernvale is considered excessive as the SPP considers the 100 year an appropriate risk level for residential areas. It may be appropriate to adopt the January 2011 flood level when considering the siting of any emergency community facilities in lieu of any detailed flood studies quantifying the flood risk for the 200, 500, 1000, and 2000 year ARI events.

A number of recommendations are made for Council's consideration to improve the flooding immunity in Fernvale:

- Undertake a detailed design of the preliminary drainage improvement options discussed in Section 6.2 of this report and shown in Figure 6.1.
- Adopt the design criteria listed in Section 6.1 of this report when undertaking the detailed design.
- Maintain the existing drainage paths and keep them free from debris or anything that will impede flow.

- Establish low-flow concrete drains to allow quick drainage, minimise ponding of water so that drains dry out more efficiently in order to facilitate access by maintenance vehicles without damaging the drainage channel.

It is further recommended that Council give consideration to adopting the following floodplain management measures:

- the 100 year ARI local flooding extent based on a 100 year ARI tailwater flood level in the Brisbane River.
- the largest of the 100 year ARI river and local flooding extents at all locations across the Ferny Gully catchment floodplain as the minimum lot level for residential developments, with a freeboard of at least 500 mm for defining the minimum habitable floor level.
- the January 2011 peak flood extent for any emergency community facilities until the results from additional flood studies are compiled for larger to rare flood events (i.e. the 200, 500, 1,000, and 2,000 year ARI events).
- Material belonging to habitable structures damaged by flood waters from the January 2011 flood is replaced by materials not adversely affected by flood water.
- New dwellings located within the January 2011 flood extent have all material of any habitable dwelling up to that level to be of a type that is not adversely affected by flood water.

It is recommended that Council give consideration for the following additional studies to be undertaken to provide clarification to Council's floodplain management policy:

- a detailed flood study using a linked one-dimensional/two-dimensional model be established to assess the DFE and the flood extents for larger to rarer flood events for quantifying the flood risk in Fernvale and facilitating future planning of residential and emergency community facilities, and climate change impacts should be assessed as part of this study.
- a cost-benefit analysis of the preliminary drainage improvement options, where other floodplain management practices such as voluntary property acquisition, house raising are assessed.

1. Introduction

The township of Fernvale experienced extensive flooding during on January 11 and 12, 2011 as a result of intense rainfall in the area, and also backwater flooding from the Brisbane River. The ensuing inundation was significantly more severe than the 100 year ARI flood extents predicted by earlier studies. The 100 year ARI event is Somerset Regional Council's (SRC's) Defined Flood Event (DFE) for their planning scheme.

SRC engaged GHD Pty Ltd to undertake a flooding and drainage investigation for the lower half of the Ferny Gully catchment. Ferny Gully is a small tributary of the Brisbane River catchment and is approximately 17 km downstream of Wivenhoe Dam. The purpose of this investigation is to assess the behaviour of the January 2011 flood event, to extend and refine the flood inundation estimate for the 100 year ARI event based on more accurate topographical information, and to make a preliminary assessment of drainage improvement options proposed by SRC to improve the conveyance capacity of flow paths investigated in this study. The location of the study area considered by this current investigation is shown in Figure 1.1.

The basis for assessing Council's option was to reduce the risk of flooding for the 100 year ARI event where possible, and only considers local flood events and not riverine flooding. Due to the preliminary nature of this study, this is not a comprehensive flood study that quantifies the flood risk in Fernvale or undertakes a cost-benefit analysis of other floodplain management practices such as voluntary property acquisition, and structural measures.

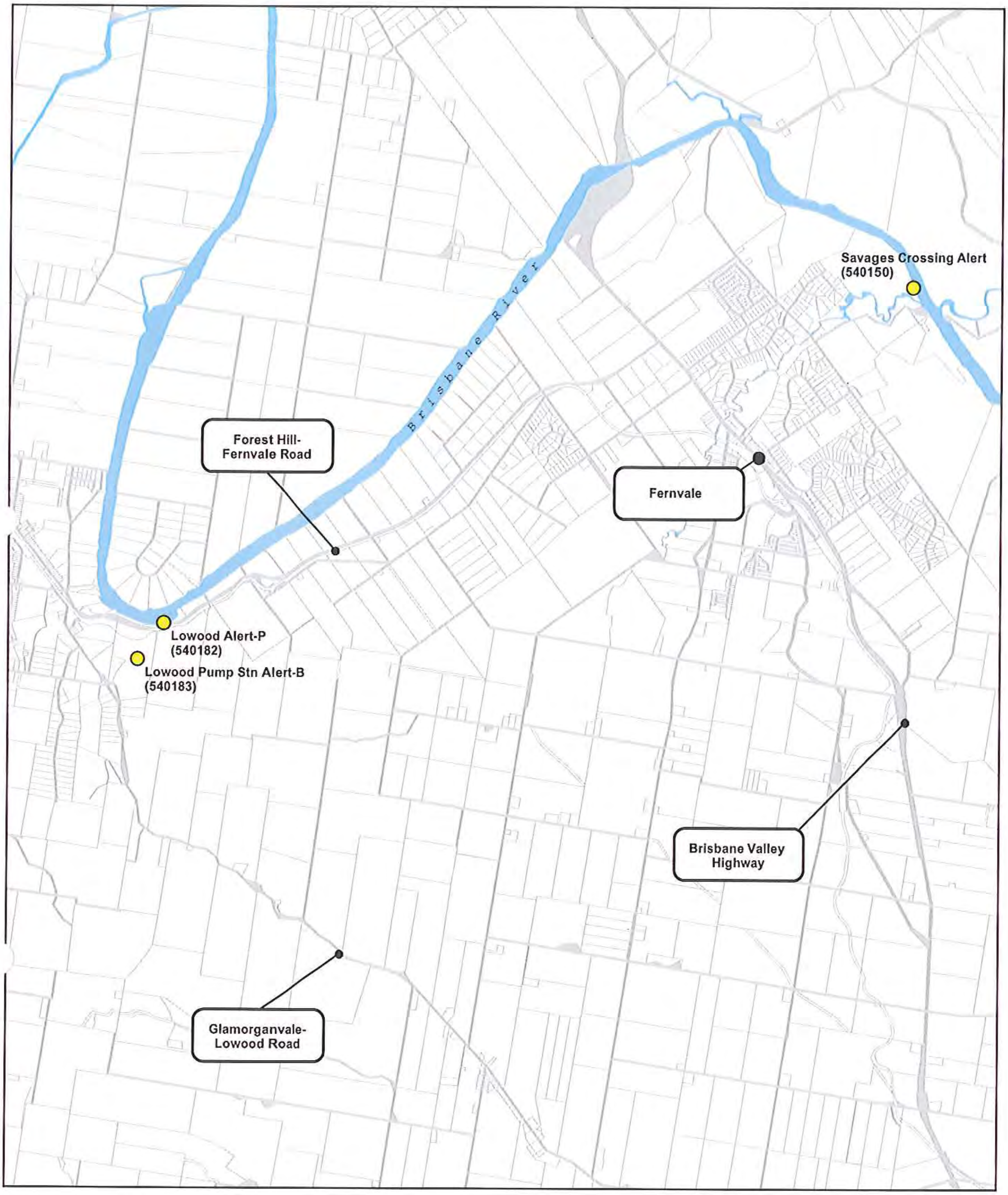
There are a three un-named watercourses or flow paths within the Ferny Gully catchment that are of relevance to this investigation. These are called (for the purposes of this report); Titmarsh Gully, Lagoon Tributary, and Banks Creek, and their locations are shown in Figure 1.2. The flow paths representing Titmarsh Gully and Banks Creek in this investigation are not natural watercourses, nor is Lagoon Tributary downstream of the Brisbane Valley Highway. The only natural watercourse of significance to this study is Ferny Gully.

A number of recent flooding investigations of varying degrees of detail were undertaken for the Fernvale area. The first of these investigations was the preparation of a Master Drainage Plan (GHD, 2000) which established a hydrological model and an unsteady-flow one-dimensional hydraulic model for the major watercourses in the Ferny Gully Catchment. These models assessed the 2 year and 100 year Average Recurrence Interval (ARI) events. That study generally focussed on flow paths downstream of the Brisbane Valley Highway.

As part of the Fernvale and Lowood Local Area Plan (SKM, 2006), the estimated 100 year ARI flood inundation area was extended further upstream of the highway. The peak water level estimates upstream of the Brisbane Valley Highway were based on a steady-state model. Topographical information used to determine the cross sectional information was based on a combination of 1 metre resolution and 5 metre resolution contours and hence the resulting flood corridors widths should be considered indicative and suitable for planning purposes only (SKM, 2006).

More recently, a flood study for Fernvale and Lowood (BCC, 2009) was undertaken as part of the Brisbane Valley Flood Damage Minimisation project. That study provided flood level and discharge information and inundation extents for floods along the Brisbane River and Lockyer Creek floodplains and covered the towns of Lowood and Fernvale. A linked one-dimensional/two-dimensional fully hydrodynamic model was established. This model focussed on river flooding and did not consider flood levels along local drainage paths such as Ferny Gully.

This report documents the findings of this investigation. Section 2 of this report presents the available information at the time of this investigation, while Section 3 gives an overview of the January 2011 flood. The hydrological modelling to estimate peak flow rates in the watercourses throughout the Fernvale catchment is provided in Section 4, and Section 5 discusses the hydraulic modelling performed to estimate the peak water levels. A range of preliminary drainage improvement options are given in Section 6 for Council's consideration. Section 7 reviews the SRC floodplain management policies or associated documentation for planning and development in the area, the State Planning Policy (SPP), and the interim policy adopted by Brisbane City Council (BCC) in the wake of the January 2011 flood. . The conclusions and recommendations arising from this study are given in Section 8.



LEGEND

Catchment Boundary

Pluviograph Station

1:50,000

0 0.5 1

kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

CLIENTS PEOPLE PERFORMANCE

Somerset Regional Council
Fernvale Drainage Investigation

Job Number	41-23656
Revision	0
Date	23 May 2011

Locality Plan

Figure 1.1

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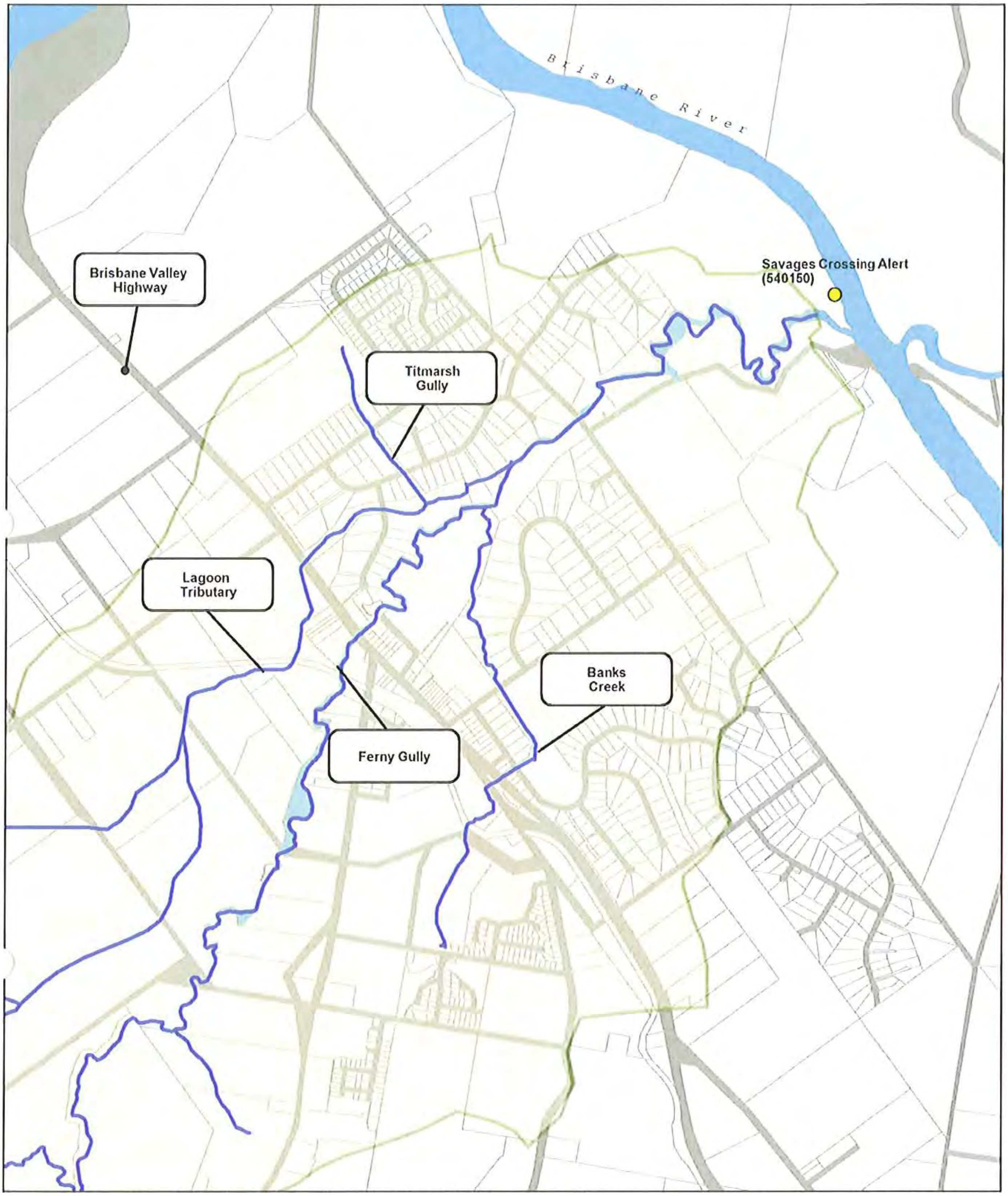
Suite 4, 1-3 Annand Street Toowoomba QLD 4350 Australia T 61 7 4633 8000 F 61 7 4163 1687 E tbamail@ghd.com.au W www.ghd.com.au



LEGEND

Catchment Boundary

Pluviograph Station

1:20,000

0 250 500

metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Somerset Regional Council
Fernvale Drainage Investigation

Job Number | 41-23656
Revision | 0
Date | 23 May 2011

Watercourses of Interest

Figure 1.2

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Suite 4, 1-3 Annand Street Toowoomba QLD 4350 Australia T 61 7 4633 8000 F 61 7 4163 1687 E tbamail@ghd.com.au W www.ghd.com.au

Data source: DERM, Digital Cadastre Database, May 2010. Created by: TL

2. Available Information

SRC made available a variety of information for this investigation, including:

- LIDAR for more accurate and current topographical information,
- Aerial Imagery,
- Flood mapping of the January 2011 flood extent based on flood debris marks,
- Detailed survey of Sports Hall upstream of Banks Creek Road,
- Fernvale and Lowood Local Area Plans (SKM, 2006), and,
- Flood Study of Fernvale and Lowood (BCC, 2009).

Rainfall and river level data from the flooding period were obtained from the Bureau of Meteorology. This data is from gauges owned by Seqwater; however the Bureau acted as supply agents for Seqwater at the time of this study.

The Master Drainage Plan for Fernvale (GHD, 2000) and the associated hydrologic and hydraulic modelling files were retrieved from GHD's archive system for use in this investigation.

2.1 Site Visits

Site visits were made to assess the nature of the flow paths and to gain an appreciation of the catchment in February and March, 2011. Selected photographs from the site visit are provided in Appendix A.

A small detention basin exists immediately upstream of a shopping centre car park that lies on the flow path of Banks Creek. For the purposes of this report, the name of Banks Creek was adopted for the watercourse that flows past Burns Road, then under Banks Creek Road to join Ferny Gully. It is understood from discussions with SRC that this basin is a temporary arrangement and that a larger, permanent basin will be established in the vicinity. The existing basin comprised an 850 mm earth embankment overlying a set of culverts. No design drawings of this basin were available. The culverts that drain the basin pass underneath a supermarket car park and an adjacent road to discharge into an open channel immediately upstream of the Brisbane Valley Highway. During the January 2011 flood event, the earth embankment above the culverts was breached and washed away.

During the site visit it was determined that extensive erosion had occurred along the rail trail which is the old Brisbane Valley Rail Line between Clive Street and Brouff Road. Discussions with Council indicated it is Council's intent to reinstate the formation, although the hydraulic structure to the west of Ferny Gully was washed out.

2.2 Assumptions

This investigation assumes that the data provided by the various suppliers for this study is correct. It is beyond the scope of the study to check the validity of the data. At the time of this investigation it is known that some rainfall data was supplied by the Bureau in good faith, even though the usual quality controls for data checking are yet to be completed.

While there was a breach of the small detention basin, and a washout of a hydraulic structure on the Old Brisbane Valley Highway, no attempt has been made to estimate the peak flow rates as a result of any breaching as this is beyond the scope of work for this study.

A Mike 11 model was used for the Fernvale Master Drainage Plan study and it was assumed that this modelling approach was suitable for the current investigation. This approach was adopted due to the time constraints associated with the study, and Council's desire for a preliminary assessment of drainage improvement works for local floods with an ARI of 100 years.

3. January 2011 Flood Information

This section of the report summarises the significant climate condition that prevailed around the time of flooding. Information relating to local rainfall and Brisbane River water levels is presented to give an indication on the behaviour of the flood event and to provide an estimate of the event probability.

3.1 Regional Climate Conditions

It was the wettest December on record for Queensland and for eastern Australia as a whole. An upper-level low combined with a humid easterly flow to bring very heavy rain to southeast Queensland and northeast New South Wales. The heaviest falls were in the areas north and west of Brisbane (see Figures C2 and C4 in Appendix C). Three-day totals exceeded 200 mm over most of the area bounded by Brisbane, Gympie and Toowoomba, including the majority of the Brisbane River Catchment. The highest daily totals observed in the Bureau's regular network were 298 mm at Peachester and 283 mm at Maleny on 10 January, while the highest three-day totals were 648 mm at Mount Glorious and 618 mm at Peachester. Intense short-period falls also occurred during the event, with one-hour falls in excess of 60 mm occurring on both 10 and 11 January at numerous stations in various locations north and west of Brisbane. It is possible that higher short-period falls occurred in areas between observing sites. There was major flooding through most of the Brisbane River catchment, most severely in the Lockyer and Bremer catchments where numerous flood height records were set (BOM, 2011).

In December 2010, rainfall in South East Queensland had been well above the December average. In some areas, rainfall exceeded the December average by as much as 400 mm. Figures C5 to C8 in Appendix C illustrate these aspects.

There had already been two significant rainfall events in mid and late December 2010 which required large releases from Somerset and Wivenhoe Dams. As a result of these events and the above average rainfall that had been experienced, the Brisbane catchment was wetter than would normally be expected at this time of year and primed to generate runoff from relatively low rainfall events. This was particularly relevant for the January 2011 Flood Event as the catchment was already close to full saturation at the beginning of the event (Seqwater, 2011).

Seqwater (2011) drew the following conclusions about the significance of the January 2011 flood event:

- The rainfall intensities varied significantly in the catchment areas above Somerset Dam and Wivenhoe Dam, although at some locations (especially around Wivenhoe Dam) the AEP of the short duration rainfalls may be classified as extreme,
- The AEPs for the Wivenhoe Dam average catchment rainfall were between the 1 in 100 and the 1 in 200 range for durations between 72 hours and 120 hours, clearly highlighting the significance of the event,
- When compared with historical events, the volume of the January 2011 Event was almost double that of the January 1974 flood, and rivals the February 1893 flood,
- Peak water levels at gauging stations in the Brisbane River above Wivenhoe Dam were the highest on record. In the Lockyer Valley, peak water levels exceeded the 1974 levels and may well have been larger than those of 1893,

- A comparison of the recorded peaks, volumes and peak levels at Somerset and Wivenhoe Dams indicate the January 2011 Flood Event easily exceeds 1 in 100 AEP,
- Below Wivenhoe Dam, the flood had an AEP similar to that of the post-Wivenhoe 1974 flood and may be as high as 1 in 1,000.

Overall, the January 2011 Flood Event is considered to represent a rare event as defined by ARR (IEAust, 1999) in terms of rainfall, flood peaks, inflow volume and peak heights (Seqwater, 2011).

3.2 Local Rainfall and River Level Information

Two types of rainfall data are considered: pluviograph data which measures rainfall intensity, and long-term daily rainfall records. This data was analysed to assign a notional probability to the event, and to place the local rainfall in the context of historical values. River level data from the Savages Crossing gauge on the Brisbane River was assessed to understand the behaviour of the flood event in the Fernvale area.

3.2.1 Rainfall Data

The closest rainfall station to Fernvale is at Savages Crossing (540 150) where a pluviograph recording device measures rainfall intensity throughout the day. The next two closest pluviograph sites are located at Lowood (Lowood Pump Station Alert B - 540 183) and Lowood Pump Station Alert P – 540 182), slightly west of the headwaters for the Ferny Gully catchment. All three sites are owned by Seqwater and their locations are shown in Figure 1.1 while the recorded rainfall totals are listed in Table 3.1.

The rainfall totals recorded at Savages Crossing and Lowood B Pump Station Alert are nearly identical which suggests the rainfall event was quite uniform across the Ferny Gully catchment. A slightly higher 24 hour total to 9 am was recorded at Savages Crossing. Based on these 24 hour totals, the two day total and three day total rainfall at Savages Crossing were 390 mm and 503 mm respectively.

The closest station to the study area where rainfall data has been recorded for an extended period of time is at Lowood (station number 040 120). Daily rainfall totals have been recorded at this site since June 1887 and a review of the record was conducted in order to compare the January 2011 rainfall with significant historical rainfall periods. Daily rainfall totals represent the 24 hour total to 9 am. Rainfall at Lowood is considered to be representative of the rainfall at Ferrnvale as both locations lie within the same rainfall district delineated by the Bureau of Meteorology.

A comparison of the one, two, and three days from the January 2011 event is made with the maximum totals from over 100 years of daily rainfall records at Lowood in Table 3.2. This table demonstrates that the January 2011 rainfall was significantly larger than any rainfall previously recorded in the region. While the January 2011 rainfall was only 10% larger for the one day total (1965), it was 30 to 43% higher for the two and three day totals (from January 1974).

Table 3.1 Recorded 24 Hour Rainfall Totals (mm) to 9 am

Date	Savages Crossing	Lowood B	Lowood P
6th January	4	8	6
7th January	27	29	22
8th January	5	7	8
9th January	5	4	9
10th January	113	104	99
11th January	246	183	163
12th January	114	210	194
13th January	0	0	0
Total	**544**	**545**	**501**

Table 3.2 Historical Peak Rainfall Totals, Lowood

Period	Peak Total (mm)	Date	January 2011 Rainfall Larger By
One Day	223	20/7/1965	10%
Two Days	299	26 & 27/1/1974	30%
Three Days	352	25-27/1/1974	43%

The hourly totals derived from the Savages Crossing pluviograph data are shown in Table 3.3. This table indicates that the bulk of the rainfall was recorded on the 11th of January. Most of the rain fell between 7 am and 10 am and the hourly totals listed in Table 3.3 were 31 mm, 86 mm, and 92 mm. A further 139 mm fell between 10 am and 3 pm.

An analysis of the Savages Crossing rainfall data was made to estimate the probability of the various bursts of rainfall throughout the event. Rainfall bursts ranging from 15 minutes to 5 days were considered and these rainfall bursts are listed in Table 3.4. The rainfall analysis suggests the ARI for this event was very large; at least 500 years based on the ARR IFD data for peak storm bursts with durations from 90 minutes to 72 hours. A plot of the IFD chart and the January 2011 rainfall bursts are shown in Figure 3.1. There is another rainfall intensity data set called the CRC-Forge method applied to Queensland that was developed by the Department of Natural Resources and Water in 2005. Using this data set, the estimated ARI for some durations exceeded 2,000 years. Either way, it appears that the rainfall ARI was well in excess of the State Planning Policy (DLGP and DES, 2003) default DFE ARI of 100 years for residential areas in a local planning scheme.

Table 3.3 Hourly Rainfall Totals, January 11 2011, Savages Crossing Gauge

Time Period	Rainfall (mm)	Time Period	Rainfall (mm)
0 – 1 am	0.5	0 – 1 pm	18.3
1 am – 2 am	0.3	1 pm – 2 pm	33.3
2 am – 3 am	0.7	2 pm – 3 pm	33.1
3 am – 4 am	1.1	3 pm – 4 pm	1.5
4 am – 5 am	1.0	4 pm – 5 pm	0.4
5 am - 6 am	0.9	5 pm - 6 pm	1.3
6 am – 7 am	15.9	6 pm – 7 pm	0.4
7 am - 8 am	31.3	7 pm - 8 pm	0.5
8 am – 9 am	85.9	8 pm – 9 pm	0.6
9 am – 10 am	92.8	9 pm – 10 pm	0.2
10 am – 11 am	17.6	10 pm – 11 pm	0.2
11 am - Noon	36.3	11 pm - Midnight	0.2

Table 3.4 Savages Crossing Peak Rainfall Bursts Summary

Duration (h)	Rainfall (mm)	Intensity (mm/h)	IFD ARI	Forge ARI
0.25	31	122.1	5-10	10
0.5	56	112.7	20	20-50
1	104	104.0	100	100-200
1.5	154	102.7	500	100-200
2	186	93.2	> 500	100-200
3	212	70.6	> 500	> 2,000
6	289	48.1	> 500	> 2,000
12	369	30.7	> 500	> 2,000
24	378	15.7	> 500	2,000
36	410	11.4	500	1,000-2,000
48	486	10.1	> 500	1,000-2,000
72	507	7.0	500	500-1,000
96	510	5.3	n/a	500
120	529	4.4	n/a	500

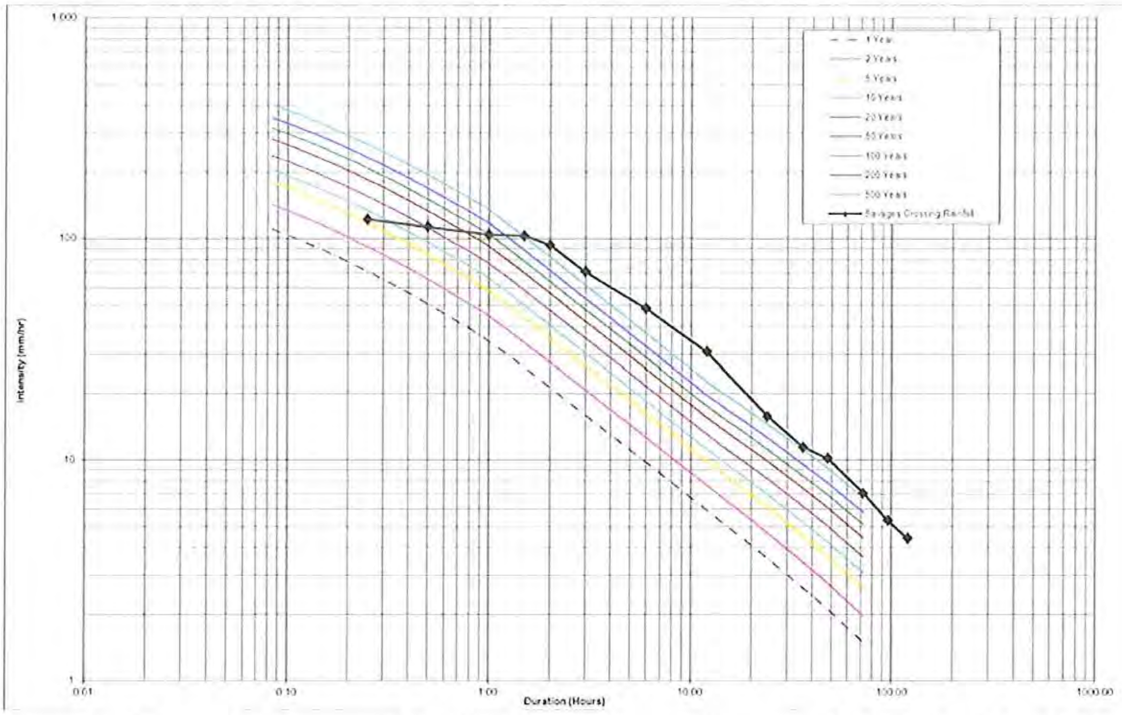


Figure 3.1 Intensity-Frequency-Duration Chart, Savages Crossing Rainfall (Based on ARR Guidelines)

3.2.2 Water Level Data

The closest gauge to Fernvale is Savages Crossing Gauge (540 150) on the Brisbane River, just upstream of the Ferny Gully confluence. This gauge is owned and operated by Seqwater.

The peak recorded water level at Savages Crossing was 42.48 m AHD and occurred at 2:12 am on 12 January 2011. This is slightly higher than the peak level of 42.22 m AHD in the January 1974 flood (Seqwater, 2011).

Peak design event water levels for the Brisbane River were sourced from the Lowood and Fernvale Flood Study (BCC, 2009). The aim of that study was to provide flood risk data to inform land use planning, development and emergency planning. The study used the existing calibrated WT42D hydrology model of the Brisbane River catchment and developed a 1D/2D linked fully hydrodynamic model (TUFLOW) which was calibrated to the 1974 and 1996 flood events. A range of storm events were considered where the storm was centred over the Lockyer Creek catchment or over the entire Brisbane River catchment. An envelope of maximum water levels was derived for design flood events ranging from 2 year ARI to 100 year ARI, and for the Probable Maximum Flood (PMF). A comparison of peak water levels from historical flood events and estimated design flood events (probabilistic estimates) from the Lowood and Fernvale Flood Study (BCC, 2009) is made in Table 3.5. This table also lists the estimated design event peak water levels in the lower Ferny Gully. There are no tabulated peak water levels nominated in BCC's report for the PMF, and there are no predicted design event peak water levels exist for rare to extreme floods to assign a notional probability of the January 2011 flood.

The estimated peak water levels at Savages Crossing are slightly higher than those estimated for the lower Ferny Gully as Savages Crossing is slightly upstream of the river junction with Ferny Gully. Appendix E contains a copy of the map from the Lowood and Fernvale Flood Study showing the relative location of Savages Crossing and the levels estimates in lower Ferny Gully. The levels shown on this map for the Brisbane River are not correct and the true values were obtained from the tabulated results in Table D1 of the BCC report.

Table 3.5 Comparison of Recorded and Predicted Peak Water Levels, Savages Crossing

Event	Level (m AHD)	
	Savages Crossing Brisbane River*	Lower Ferny Gully
2011	42.48	42.48**
100 year ARI	40.41	40.32
50 year ARI	38.21	38.12
20 year ARI	36.18	36.10
10 year ARI	34.86	31.78
5 year ARI	29.87	29.81

* Hydraulic model reporting node is "H Bris 01.05.1" (Appendix D, BCC 2009)

** From SRC Survey

Figure 3.2 is a plot of the water level versus rainfall at Savages Crossing for the period from January 7 to 14. At the beginning of January 11 the peak water at Savages Crossing was around 34 m AHD, and after about 7 am, the water level starts to increase sharply. This was due to the heavy rainfall over the Lockyer Creek catchment. The intense rainfall over the Ferny Gully catchment is seen to commence around 6 am and essentially conclude by 3pm at which time the river level had risen to approximately 39 m AHD. For the remainder of the day the water level continued to rise in the absence of any local rainfall. The peak water level recorded at Savages Crossing was in the early hours of January 12. Therefore, Fernvale experienced two flood peaks, one due to rainfall during the day, and a second peak during the night due to backwater flooding from the Brisbane River.

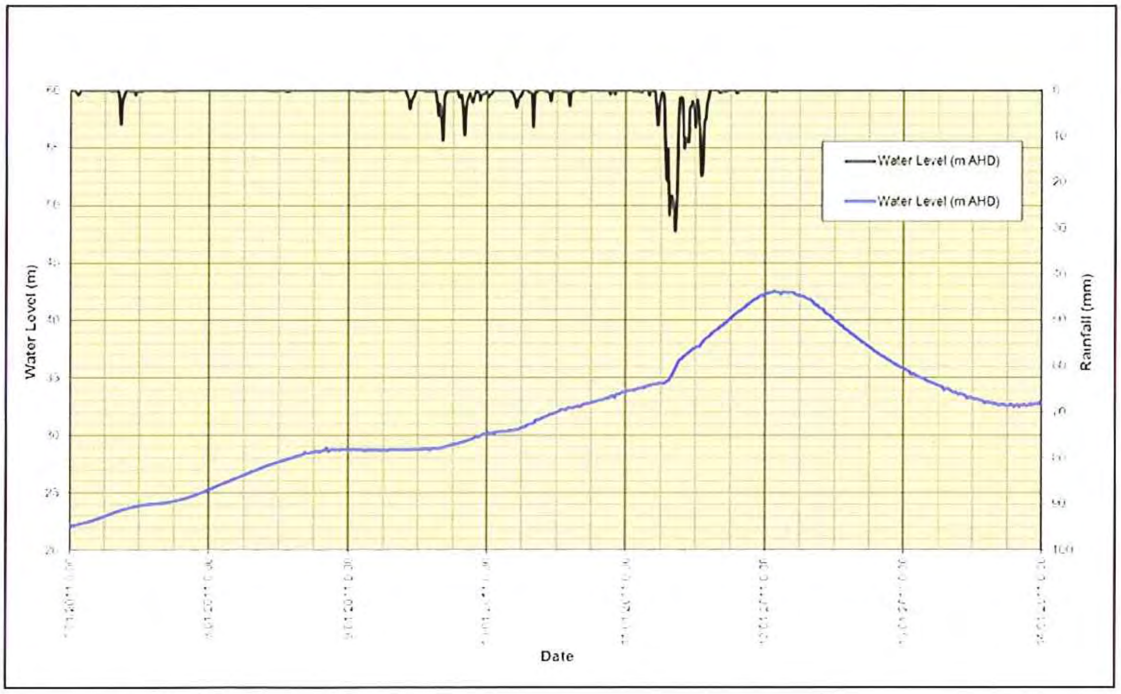


Figure 3.2 Savages Crossing Water Level Trace, January 2011 Flood Event

4. Hydrologic Modelling

GHD developed a hydrological model for the Fernvale catchment as part of the Fernvale Master Drainage Plan (GHD, 2000) and the catchment subdivision is shown in Appendix B. This model was revised to add resolution to a number of catchments in the urban area. The revised delineation of the catchment is shown in Figure 4.1. Figure 4.2 shows the catchment delineation in greater details near the Brisbane Valley Highway and further downstream.

4.1 Catchment Description

Ferny Gully is a small tributary of the Brisbane River catchment downstream of Wivenhoe Dam. The Ferny Gully catchment is slender in nature and relatively flat except for some steeper areas at the upstream end of the catchment, and some large hills near the mouth of Ferny Gully adjacent to the Brisbane River. The land use is largely rural properties in the western part of the catchment. The town of Fernvale is towards the eastern end of the catchment and has a mixture of rural-residential properties on acreage and higher density residential areas.

4.2 Hydrologic Model Description

The rainfall-runoff routing model RAFTS was used to predict flood hydrographs throughout the catchment. RAFTS is a runoff-routing model which simulates runoff hydrographs at defined points throughout a catchment for a set of catchment conditions and specific rainfall events. In a RAFTS model the catchment is subdivided into a number of sub-catchments from which runoff hydrographs are produced. These hydrographs are routed through a network of storages, channels and pipes. RAFTS is suitable for application on catchments ranging from rural to fully urbanised. The model is capable of analysing catchments comprising natural waterways, formalised channels, or pipes, dams, and any combination of these.

Catchment data used in the RAFTS model include:

- Impervious percentage in the sub-catchment;
- Average sub-catchment slope of the main channel;
- Mannings 'n' or sub-catchment roughness factor; and,
- Sub-catchment area.

The default sub-catchment roughness factor is 0.025 and recommended values are listed in Table 4.1.

Table 4.1 Recommended Sub-Catchment Roughness Factors (XP-Software, 2001)

Value	Description
0.015	Impervious area
0.025	Urban pervious area
0.05 to 0.07	Rural pastures
0.10	Forested catchments

4.3 Hydrologic Model Parameters

The Ferny Gully catchment was divided into 48 sub-catchments in the existing RAFTS model. The sub-catchment parameters for this model are shown in Table C1 of Appendix C.

The Manning's n values and fraction impervious estimates from the existing model were retained and redistributed on an areal basis. Ultimate development land use areas were based on the Fernvale Local Area Plan (SKM, 2006). A copy of the local area plan map showing the anticipated future land use is provided in Appendix C. It is estimated that the fraction pervious is likely to increase from 9% for the existing catchment to 25% with ultimate development.

4.3.1 Design Rainfall and Temporal Patterns

Rainfall estimates for small to large events (i.e. up to and including the 100 year ARI) were based on the IFD parameters nominated in ARR (IEAust, 1999). The IFD table and associated parameters is provided in Appendix C. The default temporal patterns for Zone 3 nominated in ARR (IEAust, 1999) were adopted for this assessment.

Rare event rainfall estimates (e.g. 1,000 year and 2,000 year ARI) were made using the DNRW Rainfall program (2005) and these estimates are provided in Appendix D. Estimates for Probable Maximum Precipitation (PMP) events were made using the Generalised Short Duration Method (GSDM) developed by the Commonwealth Bureau of Meteorology (BOM) for durations up to and including 6 hours, and these estimates are also contained in Appendix D. Rainfall totals for AEPs between 1 in 2,000 and the PMP were estimated using the parabolic function procedure described in ARR (IEAust, 1999).

Temporal patterns for rare and extreme flood events are based on the recommended patterns associated with the GSDM PMP storms.

4.3.2 Adopted Loss Model

An initial loss-continuing loss model was adopted for this study. No losses were assumed to occur from the impervious parts of the catchment. For pervious catchments, a continuing loss rate of 2.5 mm/hr was used for all events as this is a typical value for Queensland catchments (IEAust, 1999). The adopted initial losses for pervious catchments were assumed to vary according to the probability of the rainfall event. It was considered that large ARI events are likely to occur during the wet season when the catchment is likely to be wetter than normal. By contrast, it is more likely that smaller ARI events can occur at any time of the year, and therefore the rain could fall on catchments with low antecedent moisture during the dry season. The adopted initial losses are given in Table 4.2.

The above average rainfall during December 2010 resulted in saturated catchment conditions at the start of the January 2011 flood event. Therefore, no initial loss was adopted for estimating flood hydrographs for this event.

Table 4.2 Adopted Initial Rainfall Losses for Pervious Catchments

ARI Event	Initial Loss (mm)
5 year	20
10 year	10
20 year	5
50 and rarer	0

4.4 Estimated Peak Flow Rates

Peak flow rates were estimated for the January 2011 event, and for the 2,000 year and 5,000 year ARI design events to assess the probability of January event. The results are summarised in Table 4.3 and demonstrate that the event generally appears to have an ARI of around 2,000 years. This is consistent with the findings from the analysis of rainfall probabilities in Section 3.2.1. The difference in peak flow rates between the 2,000 and 5,000 year ARI events is considered to be less than the accuracy of hydrological modelling for ungauged catchments. Hydrological models calibrated directly from hydrological records have an estimated error of 14%. Those models based on transposition of parameters from gauged to adjacent ungauged catchments and methods calibrated regionally have an average error usually no better than 25% (IEAust, 1999).

Table 4.3 also shows the estimated peak flow rates for the 100 year ARI event for the existing catchment and the ultimate development of the catchment. It was assumed for the purposes of this investigation that the temporary detention basin upstream of the shopping centre carpark (node 14) will not be functional. This approach was adopted as no design documentation appears to exist for that basin. The results show potentially significant increases in peak flow rate along Banks Creek and the Lagoon tributary upstream of the Brisbane Valley Highway due to the location and extent of the proposed land use shown in the local area plan. Although there is a potential increase computed, any increase in peak flow rate due to urbanisation is expected to be attenuated to existing (or pre-developed) peak flow rate through appropriately designed infrastructure when the development is built. A complete listing of the peak flow rates for all sub-catchments are provided in Table C2 of Appendix C.

Table 4.3 shows a slight decrease in peak flow rates as a result of development for Ferny Gully at the Brisbane Valley Highway (Node 7) or at the junction of Ferny Gully and Banks Creek (Junction 6a). This is attributed to the timing of the peak flows generated by the urbanised areas with the undeveloped areas. In the case of Ferny Gully at the highway, all of the land to be developed is downstream of the undeveloped area, and therefore, the urban runoff component discharges before the undeveloped catchment hydrograph arrives at the point of interest.

Table 4.3 Estimated Peak Flow Rates (m^3/s), Ferny Gully Catchment

Location	Rafts Location	January 2011	2,000 Year ARI	5,000 Year ARI	100 Year ARI Existing	100 Year ARI Developed
Ferny Gully at Brisbane Valley Highway	Node 7	170	160	190	99	94
Banks Creek at Brisbane Valley Highway	Node 14	28	37	43	23	40
Lagoon Tributary at Brisbane Valley Highway	Node 31	64			39	70
Burns Road	Junc 5	63	83	96	52	68
Ferny Gully – Banks Creek Junction	Junc 6a	200	180	210	110	110
Outlet	Node 48	270	230	270	150	207

4.5 Validation of Hydrology Model

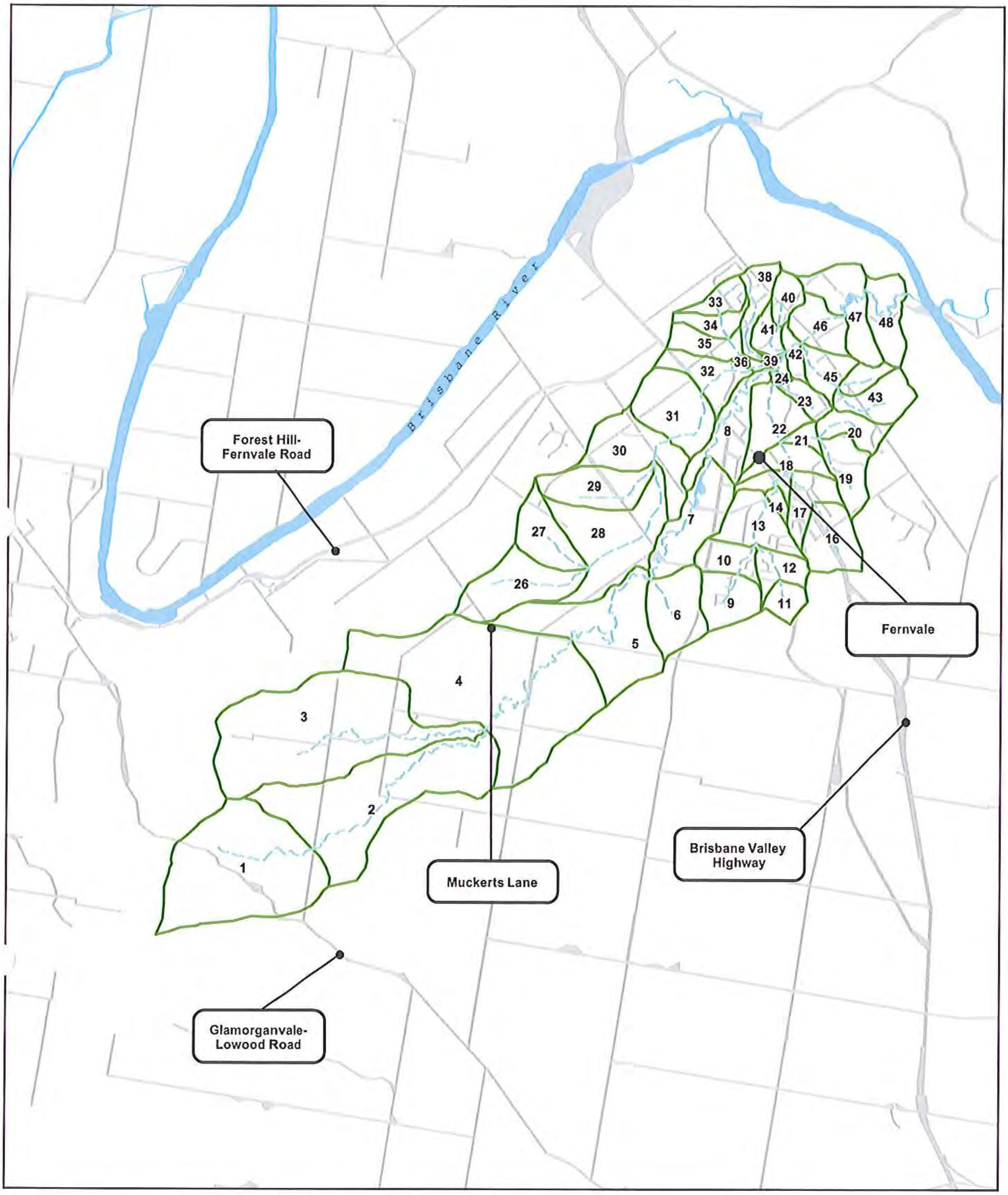
The latest approach to the calculation of design floods for small to medium sized catchments throughout Queensland is based on statistical analysis of all suitable stream gauging stations in the state. Overall, the developed QRT predictions are considered better than the Main Road Rational Method estimates (Palmen and Weeks, 2009) given their reliance on better data sets to derive the relationship. Therefore, it is considered at this time that the QRT predictions are the most appropriate independent estimators for comparison to the RAFTS model results. This approach is considered acceptable for the Ferny Gully catchment as the fraction impervious is approximately 9% for the existing catchment (see Table C1).

The flow rate estimates ignored the presence of any dams for the purposes of comparing the results with the QRT. The validation result from the QRT method is within 10% of the peak flow rates estimated using the RAFTS program. Results from the hydrology model can be found in Appendix C.

Climate change impacts on peak flow rates were not considered as part of this study as it is only a preliminary investigation. However, climate change impacts should be assessed as part of any detailed design investigation.

Table 4.4 Validation of Peak Flow Rate Estimates, 100 Year ARI, Existing Ferny Gully Catchment

Catchment	Area (ha)	Estimated Discharge (m^3/s)	
		RAFTS	QRT
Entire Catchment	1669.0	152	163
To Burns Rd	86.9	26	24
To Banks Creek Rd	137.4	38	33



LEGEND

Catchment Boundary

1:50,000

0 0.5 1

kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Fernvale Drainage Investigation

Hydrological Model
Catchment Subdivision

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Figure 4.1

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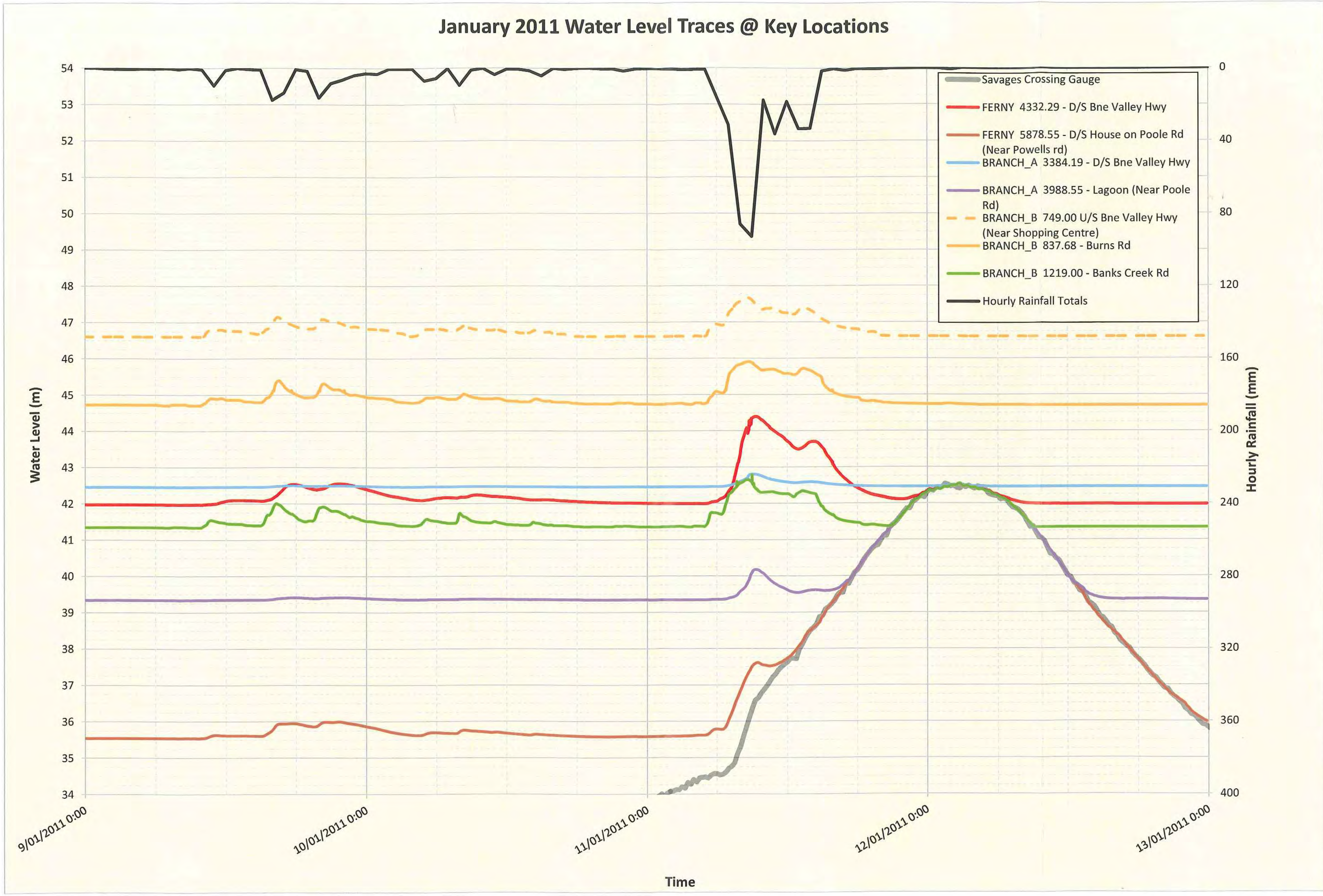
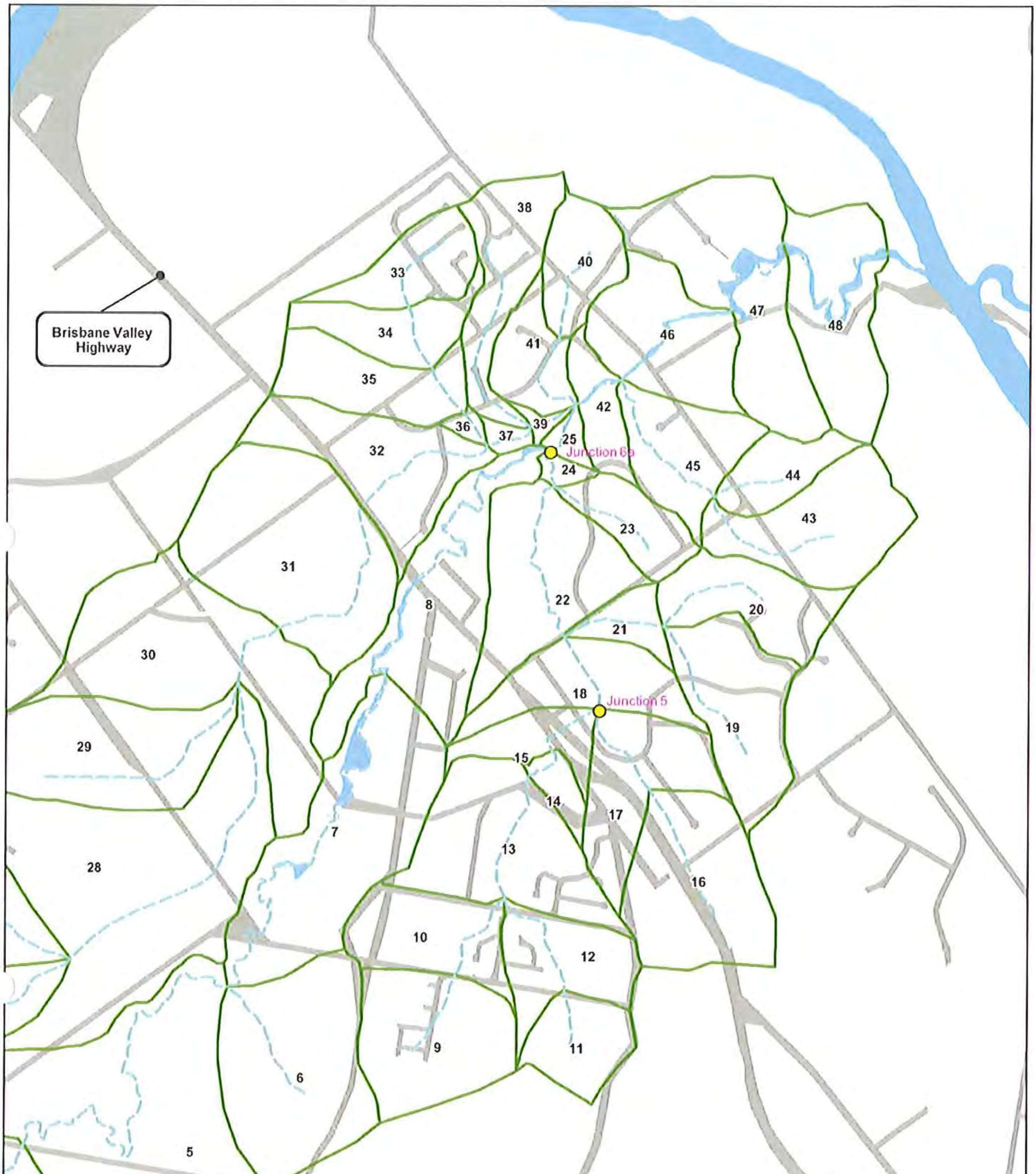
Suite 4, 1-3 Annand Street Toowoomba QLD 4350 Australia T 61 7 4633 8000 F 61 7 4163 1687 E tbamail@ghd.com.au W www.ghd.com.au



G:\41\23656\Tech\Hydraulics\Mike 11\GHD\Jan 2011 Water Level Plots.xlsx

Figure 5.5 - January 2011 Simulated Water Level Traces at Key Locations, Ferny Gully Catchment



LEGEND

Catchment Boundary

Rafts Model Junction

1:20,000

0 250 500

metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Date 23 May 2011

Catchment Delineation in Lower Ferny Gully

Figure 4.2

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Suite 4, 1-3 Annand Street Toowoomba QLD 4350 Australia T 61 7 4633 8000 F 61 7 4163 1687 E tbamail@ghd.com.au W www.ghd.com.au

Data source: DERM, Digital Cadastre Database, May 2010, SKM, 100 Year ARI Waterway Corridor, Local Area Plan, Fernvale and Lowood, May 2006. Created by: TL

5. Hydraulic Modelling

5.1 Overview

The Fernvale Master Drainage Plan study (GHD, 2000) developed an unsteady flow one-dimensional hydraulic model using the Mike 11 platform. This model was based on one metre contour data which was the most accurate broad-scale topographic data that existed for the area at that time. The model area covered the floodplain downstream of the Brisbane Valley Highway, though a reach of Ferny Gully upstream of the highway was covered. The model extent is shown in Appendix B.

A new Mike 11 hydraulic model was developed for this current investigation which takes advantage of the higher resolution topography data (LIDAR) now available. The cross section locations were largely retained, and additional sections added for those watercourses, apart from Ferny Gully, upstream of the Brisbane Valley Highway.

The extended model incorporates the Titmarsh Gully, and Banks Creek tributaries. Titmarsh Gully conveys runoff to the south of Titmarsh Circuit, and passes Schmidt Road and Poole Road along the way to the Lagoon tributary. The Banks Creek section of the model carries surface runoff from the Brisbane Valley Highway (near the eastern end of the catchment) past Burns Road, then Banks Creek Road to join with Ferny Gully.

These additions and extensions tie in with the additional sub-catchments included in the hydrological modelling to provide better resolution and distribution of flows in the catchment, particularly in the urban areas.

5.2 Model Description

MIKE11 is a hydrodynamic model which uses an implicit, finite-difference computation scheme for unsteady flows in rivers and estuaries. The results of a hydrodynamic simulation consist of a time series of water levels and discharges. Mike 11 Release 2009 was used in this study.

Data requirements for such a model include:

- definition of the watercourse network schematic,
- cross-sectional information at various locations along the reach of the watercourse,
- surface roughness values,
- definition of upstream and downstream boundary conditions, and,
- inflow hydrographs at various locations along the reach of the watercourse.

Each of these requirements is discussed below.

5.2.1 Network Schematic and Cross Sectional Information

The new network extent and cross section locations used in the model are shown in Figure 5.1. These cross section extents are based on the LIDAR data provided by SRC. Cross sections were extracted from the LIDAR data. No additional survey was undertaken.

The road crossing structures used in the existing model were confirmed by a site visit and configured in the extended model. A table of existing hydraulic structures can be found in Appendix D.

The embankment from the old railway line upstream of the Brisbane Valley Highway was also included in the extended model. This embankment was heavily eroded following the recent flood, and would require extensive repair to reinstate the formation. The erosion resulted in a rectangular shape with a base width of approximately 5 metres at this location. While Council is responsible for the rail trail, and intends to reinstate the formation, Council indicated that the hydraulic structure that was washed out would not be replaced.

Council wished to consider additional potential openings along the rail trail as part of the future development in the area. The nature of future development is unknown (e.g. layout of roads, lots, and drainage paths) and given the preliminary nature of this investigation for drainage works, a notional trapezoidal profile was adopted. This profile has a base width of 50 metres and 1V:15H to 1V:20H side slopes to provide a gentle slope for rail trail users.

5.2.2 Surface Roughness Values

Surface roughness is represented in the model by Manning's n. Estimates of 'n' values were based on aerial imagery provided by SRC. Table 5.1 lists the typical 'n' values using for the modelling. These values were based on values recommended by Chow (1959) for various cross sectional geometries and vegetation.

Table 5.1 Typical Surface Roughness Values

Position	Description	Manning's 'n' Value
Channel	Grass lined	0.030
	Saplings or shrubs	0.045
	Trees on embankment	0.080 to 0.100
Floodplain	Pasture/Open space	0.045
	Tall grass/buildings	0.055
	Scattered trees	0.080
	Dense cluster of trees	0.120
	High Density Houses	0.16

5.2.3 Upstream and Downstream Boundary Conditions and Inflows

The upstream boundary condition for all reaches was the most upstream hydrograph for that reach determined from the hydrological model. The downstream boundary condition for the 100 year ARI design event was a constant water level of 26 m AHD adopted from the previous GHD study (2000). This level is approximately 5 m above the invert of the Brisbane River where Ferny Gully as it enters the Brisbane River and is approximately a 2 year ARI event. The low ARI for the downstream boundary was adopted to reflect the plausible scenario that a large regional flood is unlikely to coincide with a large local flood.

Recent modelling by Brisbane City Council (2009) confirms that this level is lower than the estimated 5 year ARI event peak water level in the Brisbane River. This boundary condition was changed in one of the scenarios to 40.32 m AHD to reflect a 100 year ARI flood event in the Brisbane River coinciding with a 100 year ARI event in the Ferny Gully Catchment. Table D1 (Appendix D) lists the locations where each sub-catchment hydrograph from the RAFTS model are added as an inflow hydrograph to the hydraulic model.

5.3 Titmarsh Gully Hydraulic Model

A HEC-RAS hydraulic model of Titmarsh Gully was constructed to model the local flows conveyed by this drain. The gully is included in the MIKE 11 model, however because it is perpendicular to and located on the floodplain of the Lagoon Tributary, water levels are not specifically calculated for the drain as the MIKE 11 model cross sections extend to the extents of the flood plain. The purpose of the HEC-RAS model is to gain a better understanding of the nature and extent of localised flooding in the drain and surrounding properties. The hydraulic model layout for this reach is illustrated in Figure 5.2.

5.4 January 2011 Flooding

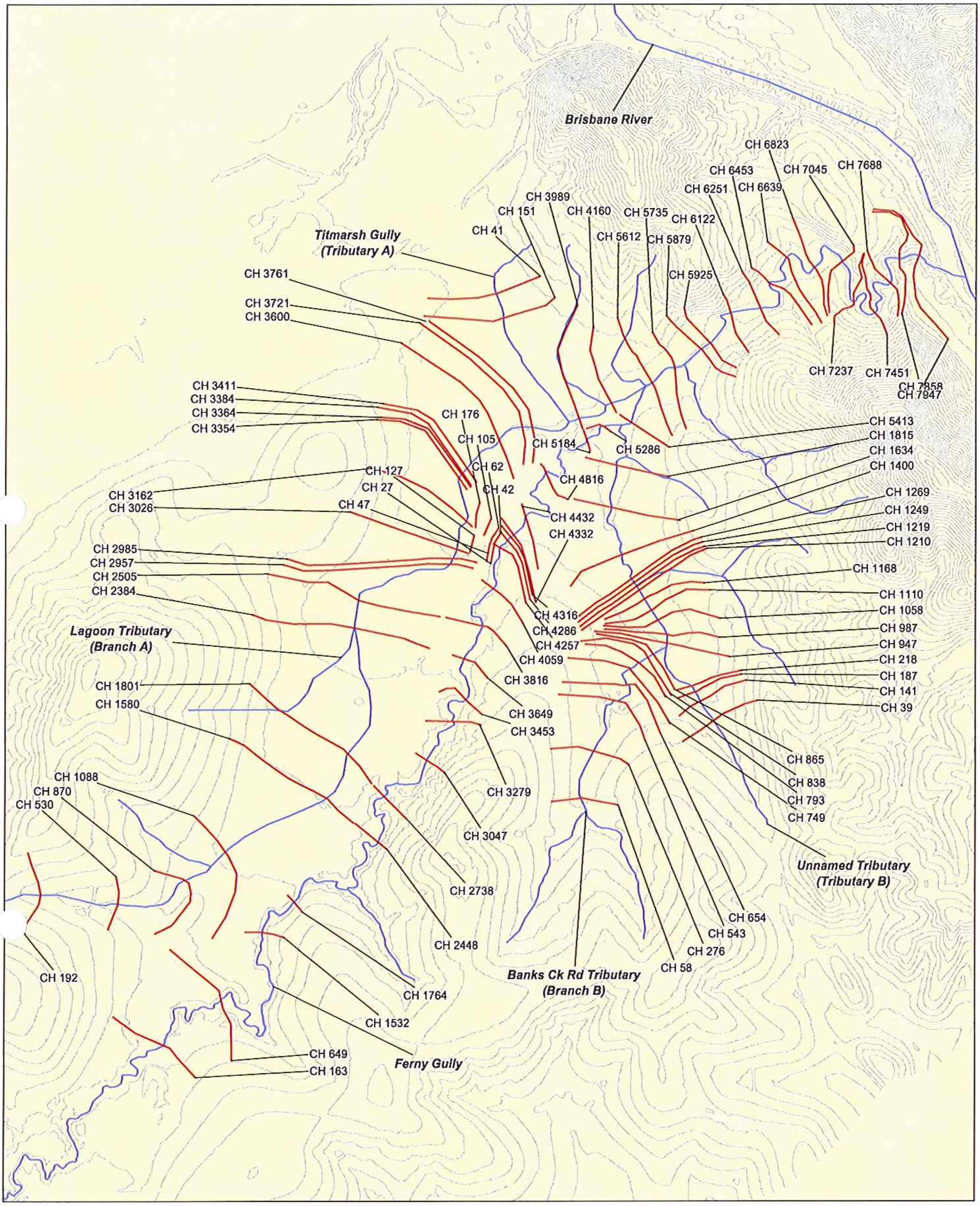
5.4.1 Comparison of Simulated and Recorded Flood Extents

The runoff flood hydrographs for the January 2011 event simulated by the RAFTS hydrology model were used as inflows for the hydraulic model. The recorded water level time series trace at Savages Crossing (see Figure 3.2) was adopted as the downstream boundary condition. The simulated flood inundation extent for this event is shown in Figure 5.3.

The results indicated a reasonably good fit to the inundation extent mapped by SRC. This was largely attained due to the heavy backwater flooding from the Brisbane River. However, there are a number of small discrepancies. The largest of these is the simulated flood extent along Titmarsh Gully. There is a natural saddle in this area, and during the January 2011 event, floodwaters from the Brisbane River broke out across this saddle to flow into Titmarsh Gully to then reach Ferny Gully before re-joining the Brisbane River. This additional flow volume that entered the system is the reason why the recorded inundation extent is not mimicked in this area. Accounting for this breakout is beyond the scope of this study as it requires modelling of the Brisbane River in conjunction with the Ferny Gully Catchment.

There are also a number of locations where it appears flow breaks out of flow paths in the Ferny Gully catchment and essentially sheet flow to another watercourse. One example is an overflowing of the left bank of Ferny Gully upstream of the Brisbane Valley Highway. This overflow travels west in the general direction of the Brisbane Valley Highway to eventually flow into the Lagoon tributary. The shallow nature and broad nature of the overflow paths test the capabilities of the unsteady one-dimensional model to accurately simulate the flooding processes, as there no well-defined channel cross section can be identified. A two-dimensional model is probably better suited to analysing the flow regime in areas such as this.

Other smaller discrepancies exist which may be due to some uncertainty with identifying the flood peak from debris marks. In some locations the model result appears to underestimate the peak, but overestimates the peak on the opposite of the watercourse (e.g. see Banks Creek downstream of Banks Creek Road). Overall, it was considered that the hydrology model and hydraulic models provide a reasonable estimation of surface runoff and peak water levels for the Ferny Gully catchment.



LEGEND

Watercourse	Cross Section & Chainage (m)
5 m Contour	DCDB

1:15,000

0 250 500

metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Hydraulic Model Layout

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Figure 5.1

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Data source: GHD, Watercourses & Cross Sections, SRC, Contours. Created by: PJM

LEGEND

Watercourse

Cross Section & Chainage (m)

1:5,000
0 100 200
metres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Titmarsh Tributary Hydraulic Model Layout

Figure 5.2

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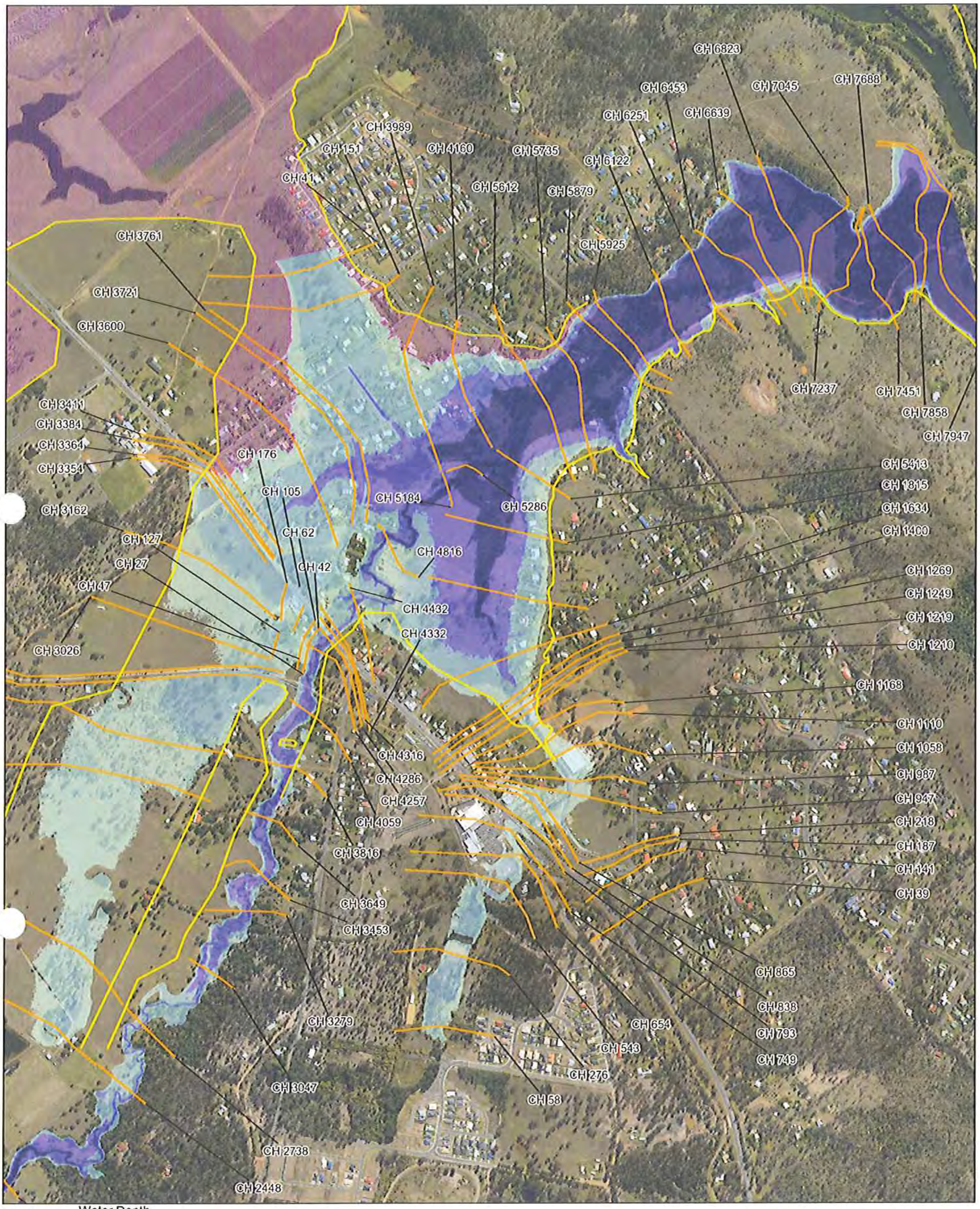
Data source: GHD: Watercourses & Cross Sections, SRC: Aerial Image undated. Created by: PJM



LEGEND

Water Depth

- 0 - 0.5 m
- 0.5 - 1.5 m
- 1.5 - 3 m
- >3 m

- Hydraulic Model Cross Section
- Flood Extent as recorded by SRC

Known area of flooding due to breakout from Brisbane River. (A more detailed hydraulic model is required to reflect this flood behaviour)

1:10,000

0 100 200
metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Comparison to Simulated and Recorded Flood Extents, January 2011 Event

Figure 5.3

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Data source: GHD: Flood Extent & Cross Sections. SRC: Aerial Image undated. Created by: PJM

5.4.2 Analysis of Flooding

The simulated water surface profile along Ferny Gully is shown in Figure 5.4, which shows the influence of the backwater from the Brisbane River, which extends approximately 3 km upstream. The backwater flooding influence ceased just downstream of the Brisbane Valley Highway.

As discussed in Section 3.2.2, Fernvale experienced two flood peaks, one due to rainfall during the day, and a second peak during the night due to backwater flooding from the Brisbane River. This situation is illustrated in Figure 5.5 which shows the simulated water level traces at key locations across the Ferny Gully catchment. This figure shows clearly how flooding due to rainfall was the major cause of any inundation in Banks Creek upstream of Burns Road and how the backwater flooding from the Brisbane River did not encroach on this area (Branch B 837.68 – Burns Road, and Branch B 749.00 – U/S Bne Valley Hwy near Shopping Centre). A similar situation exists for the Lagoon tributary in the vicinity of the Brisbane Valley Highway (Branch A 3384.19 – D/S Bne Valley Hwy), though in this instance there were minor increases due to backwater flooding from the Brisbane River during the recession.

The Brisbane River backwater flooding is seen to result in higher flood levels than the rainfall-induced flooding in the vicinity of Banks Creek Road, and the areas near Poole Road. At Banks Creek Road (Branch B 1219.00 – Banks Ck Rd) it appears the rainfall-induced flood peak is similar to the backwater river flood peak. However, along the Lagoon Tributary and Ferny Gully near Poole Road, it appears from the simulation result that the backwater flooding from the Brisbane River resulted in a flood peak that is approximately two metres higher at Branch A Chainage 3988 (to the south of the Titmarsh Gully), and nearly 5 metres higher further to the north along Poole Road at Branch A Chainage 5878 (in the vicinity of Powells Road) than their respective rainfall-induced flood peaks.

The estimated January 2011 flooding extent due to rainfall-induced flooding is shown in Figure 5.6 which is based on the peak water simulated before 6 pm on January 11, by which time the rainfall over the Ferny Gully catchment ceased. The peak flood extent associated with the backwater flooding from the Brisbane River is shown in Figure 5.7 and is based on the peak water levels after 6 pm on January 11.

In summary, local rainfall-induced flooding dominates upstream of the Brisbane Valley Highway. On Banks Creek, the local-rainfall induced peak is estimated to be similar to the Brisbane River backwater flood peak, and the backwater flooding becomes more pronounced further downstream. Backwater flooding appears to dominate downstream of the Brisbane Valley Highway for the Lagoon Tributary and Titmarsh Gully flow paths.

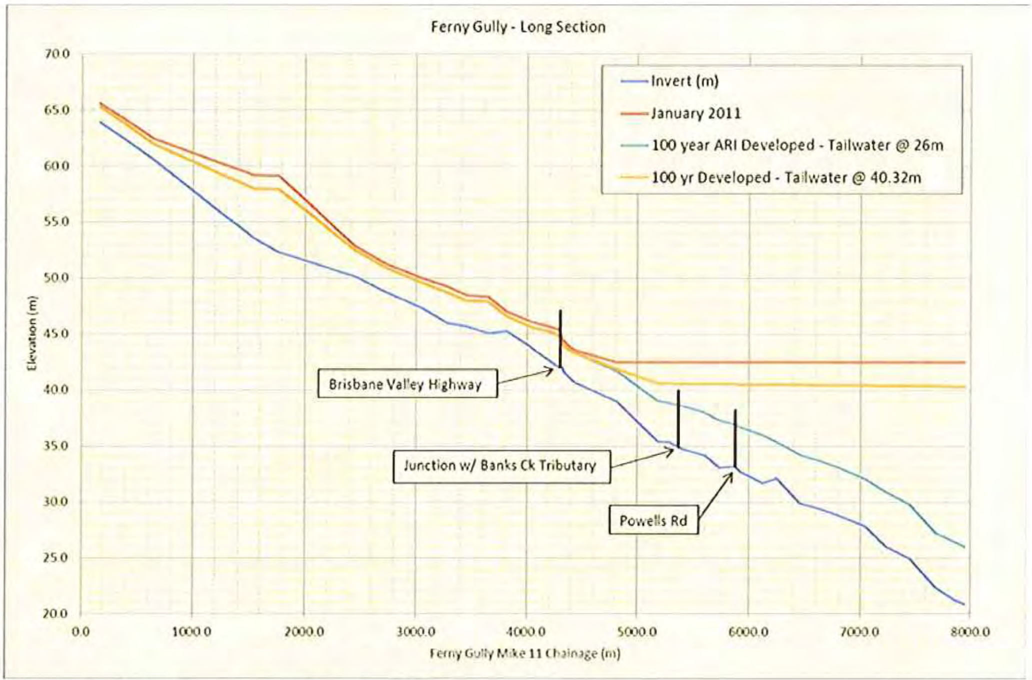
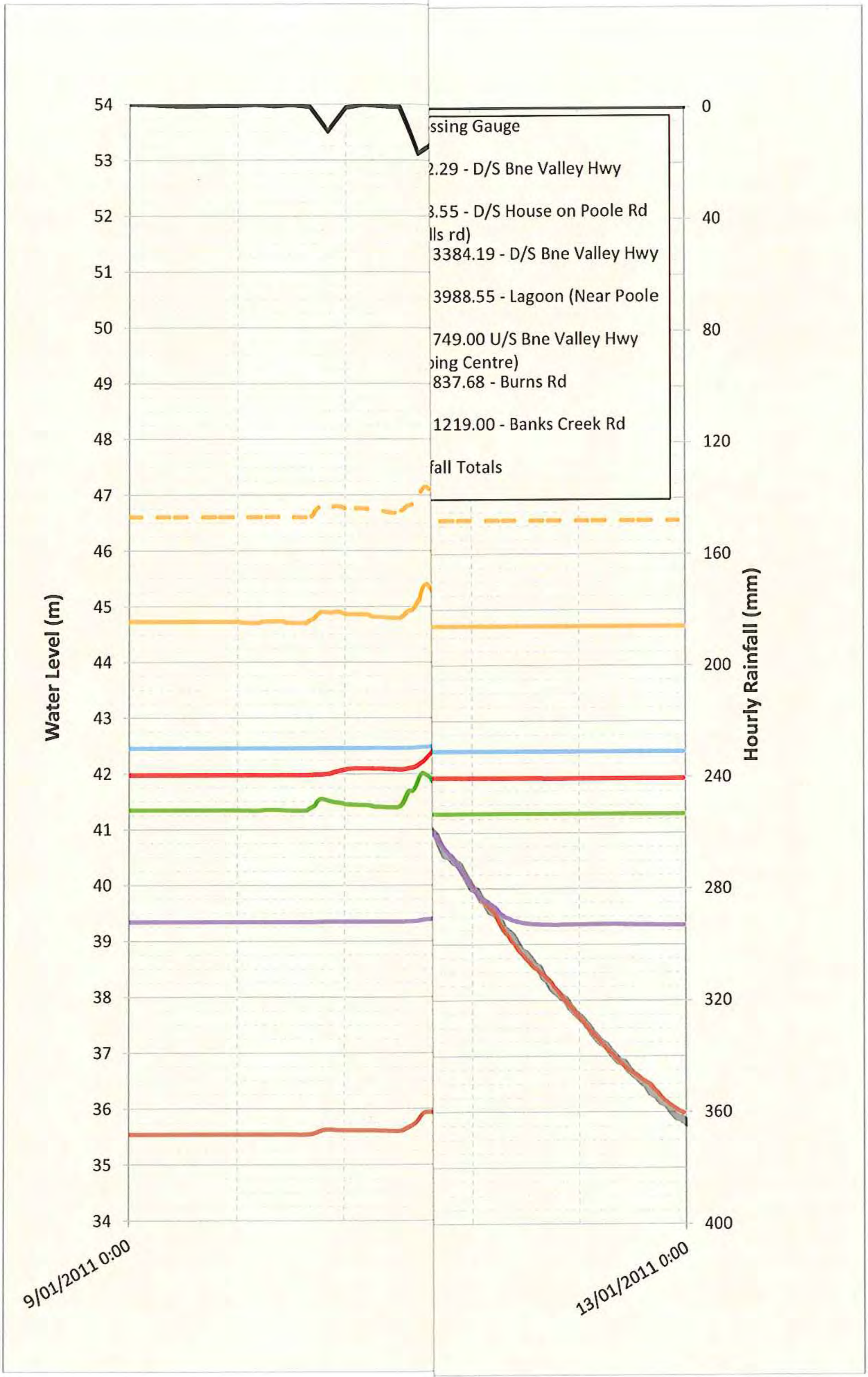
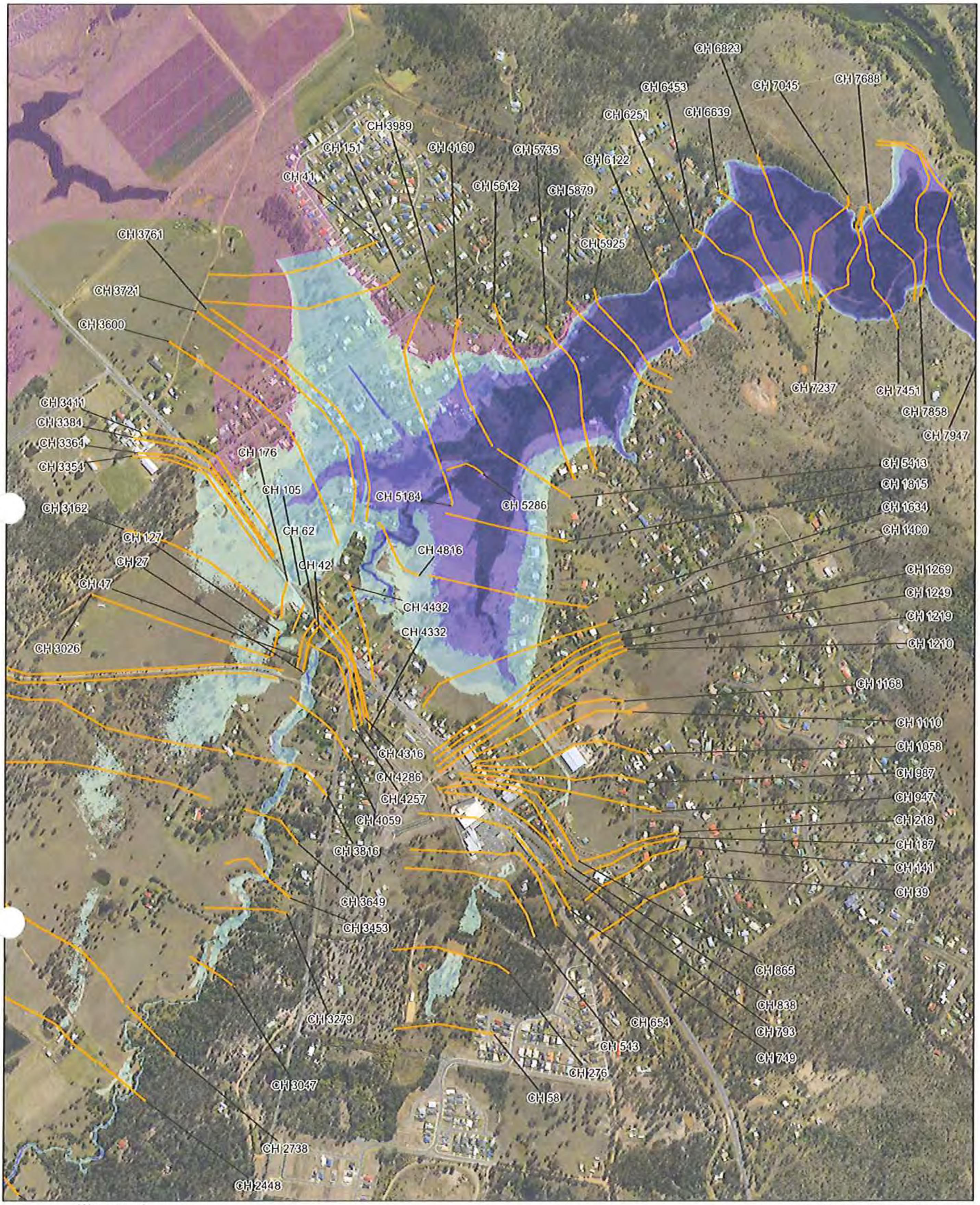


Figure 5.4 Ferny Gully Water Surface Profiles



G:\41\23656\Tech\Hydraulics\Mike 11\GHD\Jan 2011 Water Level Plot

Figure 5.5 - January 2011 Simulated Water Level Traces at Key Locations, Ferny Gully Catchment



LEGEND

Water Depth
- 0 - 0.5 m
- 0.5 - 1.5 m
- 1.5 - 3 m
- >3 m

Hydraulic Model Section

Known area of flooding due to breakout from Brisbane River. (A more detailed hudraulic model is required to reflect this flood behaviour)

NOTE: Mapping scale displays full extent of aerial imagery. Peak Water Level for the time spanning 11/1/2011 6:00 PM to 13/1/2011 0:00 AM.

1:10,000

0 100 200
metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Date	23 May 2011

Estimated Flood Extent During Brisbane River Backwater Period Only, January 2011 Event

Figure 5.7

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Data source: GHD: Flood Extent & Cross Sections; SRC: Aerial Image undated. Created by: PJM

5.5 100 Year ARI Peak Flood Levels

The 100 year ARI peak water levels from the earlier Fernvale Master Drainage study are presented in Table 5.2 for the existing catchment and the ultimate development scenarios. The results from that model indicate there was very little difference in peak flood levels due to the influence of urbanisation. The results from the extended and updated hydraulic model prepared for this study are also shown in this table and confirm there is little change between existing and ultimate development scenarios.

There are some minor changes in the estimated peak water levels estimated in the earlier Fernvale Master Drainage study and those from extended model from this study. These differences are attributed to the higher quality of topographic information available now that was not available previously, and also on the more detailed hydrological model developed for this investigation.

While the hydraulic modelling suggests small increases in peak water levels, the hydrological assessment (Section 4) determined larges increases in peak flow rates are expected to occur in areas of urbanisation. As discussed previously, it is anticipated that these peak flow rates as a result of urbanisation will be attenuate to pre-development (or existing) peak flow rates.

In undertaking the assessment of ultimate development, no changes were made to the channel dimensions of watercourses through future development areas. That is, the existing watercourse or drainage path was assumed to remain with any development. There may be areas of very shallow flooding which may be eliminated during a future development by constructing an appropriately sized drain or filling of adjacent land. It is recommended that any alternative flow paths be assessed using a hydraulic model to confirm there is a no-worsening of the flooding.

The results presented so far assume a minor flood in the Brisbane River with a large flood in the Ferny Gully catchment. As the January 2011 event has shown, there is a chance that a large flood regionally can coincide with a large local flood. A sensitivity analysis was done where a 100 year ARI flood level was adopted in the Brisbane River for the scenario where a 100 year ARI flood occurs over the Ferny Gully catchment. Figure 5.4 shows the peak water levels from the different downstream boundary conditions.

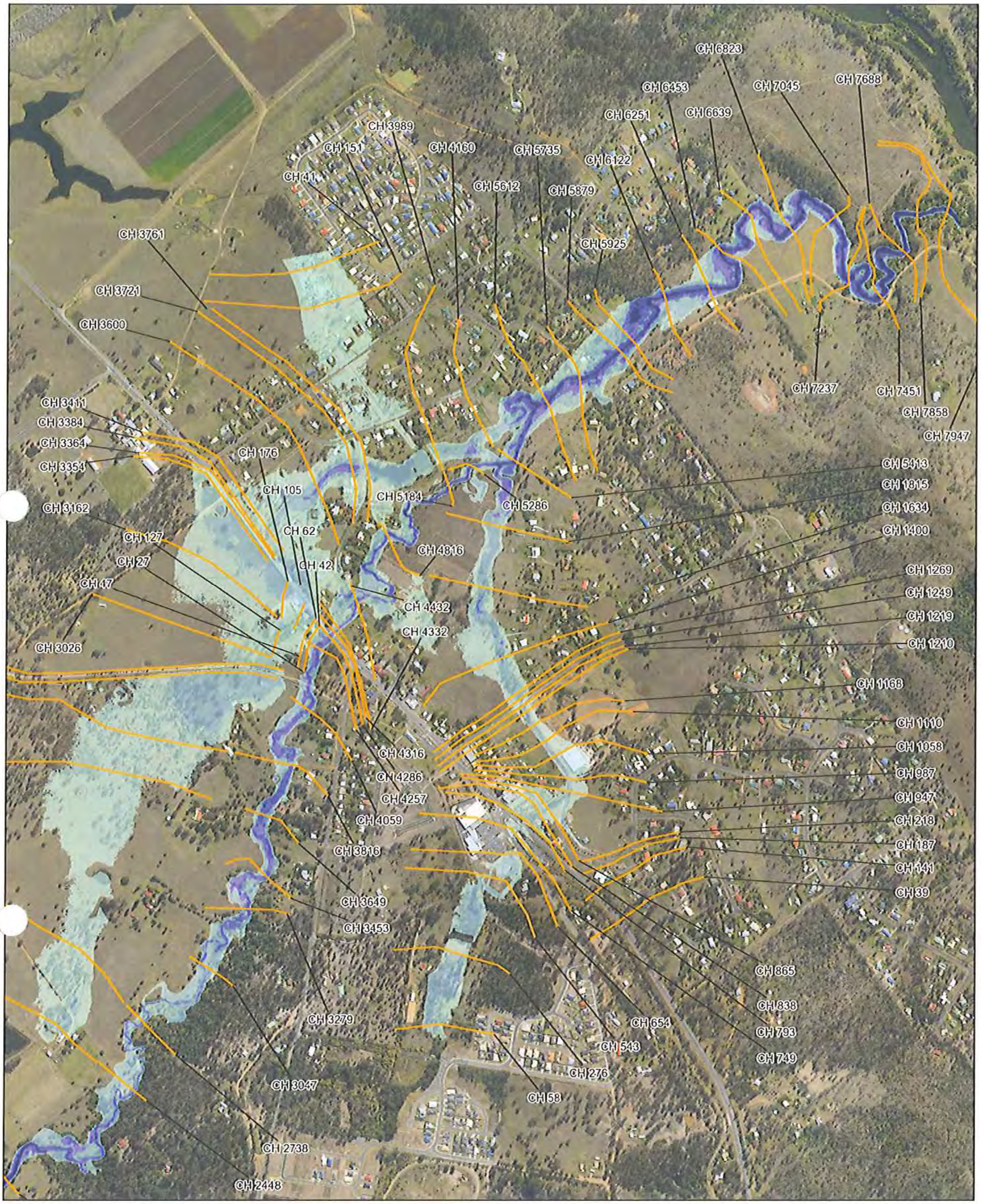
The flood inundation mapping shows the new Sports Hall complex upstream of Banks Creek Road is likely to experience shallow flooding during the 100 year ARI event. The flood inundation mapping is based solely on the LIDAR information provided for this study. SRC also provided a detailed survey of ground levels in the immediate vicinity of the Sports Hall and a comparison with the LIDAR information shows the LIDAR information is 100 to 200 mm lower than the detailed survey levels. To adequately predict flood levels specifically for this area will require additional resolution to be added to the hydraulic model.

Table 5.2 Estimated Peak Water Levels (m AHD), 100 Year ARI Event

Mike 11 Reach	Chainage (m)	Location	Existing Case 2000 Model*	Ultimate Development 2000 Model*	Increase in Water Level (m)	Existing Case 2011 Model**	Ultimate Development 2011 Model**
Ferny	3000	Upstream of disused railway line	45.9	45.9	0.0	45.6	45.6
	3220	Upstream of Brisbane Valley Hwy	45.3	45.3	0.0	45.2	45.0
	3400	Downstream of Brisbane Valley Hwy	43.4	43.4	0.0	43.3	43.3
	4050	Junction of Ferny Gully and Lagoon Tributary	40.2	40.2	0.0	-	-
	4250	Junction of Ferny Gully and Banks Ck Rd	38.5	38.5	0.0	38.1	38.1
	4750	Downstream end of existing Rural Res	36.4	36.4	0.0	36.9	36.9
	6400	Near junction with the Brisbane River	29.4	29.3	0.1	29.8	29.8
Lagoon Tributary (also known as Branch A)	1400	Upstream of Brisbane Valley Hwy	43.2	43.2	0.0	43.3	43.3
	1770	Upstream of Nardoo St	41.4	41.4	0.0	41.5	41.5
Banks Ck Rd Tributary (also known as Branch B)	1040	Upstream of Burns Rd	45.9	45.9	0.0	45.9	46.0
	1420	Upstream of Banks Ck Rd	42.7	42.7	0.0	42.7	42.8
	2000	Near junction with Ferny Gully	38.8	38.8	0.0	38.6	38.7

* based on 1 metre contour data

** based on ALS data



LEGEND

Water Depth

- 0 - 0.5 m
- 0.5 - 1.5 m
- 1.5 - 3 m
- >3 m

Hydraulic Model Cross Section

NOTE: Mapping scale displays full extent of aerial imagery. Flood inundation is based on the LIDAR coverage provided for this study. The Sports Hall is shown being inundated by shallow flooding, however a detailed survey in the immediate vicinity of the hall indicates slightly different levels exist and therefore this Sports Hall may not be inundated by this event

1:10,000

0 100 200
metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Somerset Regional Council
Fernvale Flooding Investigation

Estimated 100 Year ARI Peak Flood Extent

Job Number	41-23656-01
Revision	0
Date	23 May 2011

Figure 5.8

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Data source: GHD: Flood Extent & Cross Sections. SRC: Aerial Image undated. Created by: PJM

5.6 Preliminary Estimate of Existing Drainage Paths Capacity

Peak flood levels were estimated for the existing drainage paths for the 5, 10, 20, and 50 year ARI events as part of a preliminary estimate of their drainage capacity downstream. For the purposes of this exercise, the two hour duration storm was chosen as this was the critical duration for the majority of locations in the 100 year ARI analysis. It is recommended that additional modelling be undertaken if a comprehensive assessment of drainage capacity is required.

A typical section on each of the watercourses investigated in this study downstream of the Brisbane Valley Highway was used for the capacity assessment. The estimated peak water levels, and lowest bank levels are given in Table 5.3. Based on the results in this table, the Banks Creek (upstream of Banks Creek Road), Ferny Gully, and Titmarsh Gully watercourses all have an estimated 5 year ARI capacity. The capacity of the Lagoon Tributary is approximately 10 years, while in Banks Creek downstream of Banks Creek Road, the estimated capacity is around 50 years.

Table 5.3 Estimated Design Event Peak Water Levels (m) and Ground Levels (m) at Typical Watercourse Sections

Location		ARI					Lowest Bank Level*
		5 Year	10 Year	20 Year	50 Year	100 Year	
Banks Creek	1100	42.6	43.3	43.3	43.4	43.6	43.0
	1634.19	38.6	39.6	39.7	39.8	40.1	40.0
Ferny Gully	4815.76	41.0	41.1	41.4	41.5	41.7	41.1
Lagoon Tributary	3600.49	40.2	41.5	41.5	41.6	41.8	41.5
Titmarsh Gully	262	41.6	41.6	41.6	41.6	41.7	41.6

* Either inferred from the cross section shape or is the level at an adjacent property boundary.

A similar exercise was performed at road crossings throughout the study area. The estimated peak water levels are listed in Table 5.4. The results in this table suggest that most crossings have limited immunity and are most likely to overtopped, or be very close to overtopped, by the 5 year ARI event. The exceptions are the Ferny Gully crossing of the Brisbane Valley Highway (a 20 year ARI immunity), and possibly Banks Creek Road.

These road crossing immunity estimates are considered preliminary as the culvert invert levels and road centreline levels were largely inferred from the LIDAR infomation provided for this study. Should a more detailed assessment be required, then it is recommended that a detailed survey of all hydraulic structures be undertaken.

Table 5.4 Estimated Upstream Design Event Peak Flood Levels (m) and Ground Levels (m) at Road Crossings

Location		ARI					Road Centreline Level
Branch	Road	5 Year	10 Year	20 Year	50 Year	100 Year	
Ferny Gully	BVH	44.0	44.6	44.5	44.8	44.9	44.8
Lagoon Tributary	BVH	43.2	43.2	43.2	43.3	43.3	43.0
	Nardoo St	41.4	41.4	41.4	41.4	41.5	40.7
Banks Creek	BVH	47.3	47.4	47.4	47.5	47.5	47.3
	Burns Rd	45.7	45.7	45.7	45.8	45.8	45.4
	Banks Ck Rd	42.3	42.3	42.4	42.4	42.5	42.6
Titmarsh Gully	Schmidt Road	41.8	41.8	41.9	41.9	41.9	41.8
	Poole Rd	41.5	41.5	41.5	41.5	41.5	41.5

BVH: Brisbane Valley Highway

6. Drainage Improvement Options

SRC has sought potential capacity improvements to the existing drainage paths through Fernvale. Preliminary drainage improvement options were considered as part of this investigation to seek opportunities to reduce the flood risk during the 100 year ARI event. In carrying out this assessment, only local flooding within the Ferny Gully catchment is considered, and in areas free of flooding from the Brisbane River during the 100 year ARI event.

The proposed design criteria are provided in this section and the option details are described. A comment is provided on those properties where it is though any flood immunity improvement works are considered impractical.

6.1 Design Criteria

In development of drainage options for Fernvale, a number of criteria, assumptions and recommendations have been used which are based on guidelines in QUDM (DNRW, 2007). Those adopted here are:

- To contain the 100 year ARI design event with 300 mm freeboard where possible.
- To have side slopes no steeper than 1V:4H for safety reasons (overturning of equipment on the banks) and preferably 1V:6H.'
- Well-maintained free of debris and anything that will impede flow.
- To have bed gradients that minimise the prospect of significant erosion during more frequent runoff events.
- Concrete inverts for low flow only.

QUDM has additional criteria for open channel and stormwater drainage design and these will need to be considered as part of any detailed design.

QUDM recognises a number of different types of constructed drainage channels and it is recommended that the basic types nominated in the manual be adopted. Here, it is proposed that a low-flow channel be incorporated into the design so that stormwater does not unnecessarily pond within stomwater outlets, and that the ephemeral open channels freely drain if stagnant or offensive waters would otherwise occur. The benefits of this approach is to allow efficient drainage of the greater channel or floodway area to minimise the risk of undesirable waterlogging of the soil, control erosion along the invert of large drainage channels. This may also provide necessary ecological features (e.g. habitat and passage) within waterway habitats (DNRW, 2007).

6.2 Option Details

Preliminary drainage options were assessed for four key areas to contain the 100 year ARI design event flow where possible. It was assumed that the drainage sizing accommodated the estimated peak flow rates from the existing catchment as any increase in peak flow rates as a result of future urbanisation is likely to be attenuated to pre-development peak flow rates as part of any such future development. However, the effects of climate change should be considered as part of any detailed design.

The proposed locations for, and details of, those drainage works are shown in Figure 6.1 and a table summary of hydraulic structures is provided in Table 6.1. The estimated 100 year ARI extent with the improvement works in place is shown in Figure 6.2.

6.2.1 Titmarsh Gully

Currently this is quite a shallow drain. It is proposed to widen the existing drain to utilise the full width of the corridor, leaving 4 m access on one side and 1 m access on the other. Approximate bed width is 17 m. Suggested side slopes are 1V:4H and upgrade the culvert crossings at Schmidt Road and Poole Road.

There appears to be insufficient grade upstream of Schmidt Road to construct a drainage channel with sufficient capacity to convey the 100 year ARI flow. The flood inundation extent in this area is likely to be quite shallow and broad, and it is recommended that consideration be given to creating some small embankments to channel the flow into the start of the proposed drainage channel rather than allowing overland flow through the properties fronting the northem side of Schmidt Road. However, any detailed design will verify there are no adverse changes in flood levels at upstream buildings.

6.2.2 Lagoon Tributary

Widen the existing tributary to utilise the full width of the corridor, leaving 4 m access on either side. Regrade the bed from Nardoo St to upstream of the highway at a grade of approximately 1 in 150. A drop structure may be required at the upstream end as the new bed level will be lower than the surrounding area. Suggested side slopes are 1V:4H and install as upgrade the culvert crossings.

6.2.3 Ferny Gully

This is a natural watercourse and any modifications to the channel geometry (i.e. bed and banks) is likely to subject to approval from DERM. DERM approvals are also likely to be necessary to remove any accumulated debris in the watercourse, or if the watercourse were to be regularly maintained.

If works were permissible to reduce the 100 year ARI peak flood level downstream of the Brisbane Valley Highway such that the risk of flooding properties is minimised, then some widening of the existing flowpath is required. The preliminary analysis suggests uniformly widening the existing watercourse to have a 9 m base width while retaining the existing bed slope. The practicality of this option has not been investigated.

6.2.4 Banks Creek Road Tributary

Widen the existing drain to utilise the full width of the corridor, leaving no access on one side (the road leading to the Sports Hall) and 1 m access on the other. The limited access was adopted as there is open space immediately upstream of Banks Creek Road for vehicles to gain access to the drainage channel. Regrade the channel bed from Banks Creek Road to Burns Rd at a grade of approximately 1 in 250. From this point, widen the channel as wide as practically possible up to the Brisbane Valley Highway and regrade at approximately 1 in 60. This steeper part of the channel will most likely have to be concrete lined. Install as many culverts as practical at road crossings to minimise the effect of the road crossing. Modelling has shown that the Fernvale Sports Hall has at least 300 mm freeboard above the estimated 100 year flood level if these works are carried out.

There is no natural watercourse immediately upstream of the Brisbane Valley Highway. If a 100 year ARI immunity were to be provided in the reach between the upstream end of the shopping centre carpark and the Brisbane Valley Highway, then culvert arrangement shown in Table 6.1 to convey the entire flow is likely to be required. Alternatively, an open channel could be re-established with an approximate base width of 10 metres with 1V:4H side sloped at the grade that currently exists between the upstream invert level of the culvert at the shopping centre and the downstream invert level at the Brisbane Valley Highway.

Further investigation for the drainage channel in the vicinity of Burns Street is recommended due to the potentially erosive velocities and the need for energy dissipation if a vegetated channel is to be retained downstream of Burns Street.

Table 6.1 Existing and Proposed Hydraulic Structures

Branch	Location	Existing	Proposed*
Lagoon Tributary	Brisbane Valley Highway	3x450 RCP	6x2100x1200 RCBC; Drop structure 1m high upstream of crossing
	Nardoo St	1x2400x1200 RCBC	8x2400x1200 RCBC
Ferny Gully	Brisbane Valley Highway	2x2100x2100 RCBC	Not Assessed
Banks Ck Rd Tributary	Shopping Centre Detention Basin	3x2100x560 RCBC	7/2400x600
	Brisbane Valley Hwy	4x1200x580 RCBC	7/2400x600
	Burns Rd	4x1200x600 RCBC	1x3000x1800 RCBC
	Banks Ck Rd	5x1200x900 RCBC	No Change
Titmarsh Gully	Schmidt Rd	3x600 RCP	2x2400x600
	Poole Rd	4x450 RCP	3x2400x450

* To provide 100 year ARI immunity; all dimensions are in millimetres

6.3 Legislative Considerations

A number of statutory requirements need to be addressed during any detailed design of stormwater drainage improvement works. Modifications to drainage paths often involve the need for a development permit (usually rolled into Sustainable Planning Act (SPA) and sought using the Integrated Development Approval System (IDAS) process).

The Sustainable Planning Act (2009) seeks to seek to achieve ecological sustainability in three ways:

- managing the process by which development takes place including ensuring the process is accountable, effective and efficient and delivers sustainable outcomes,

- managing the effects of development on the environment (including managing the use of premises), and,
- continuing to coordinate and integrate planning at local, regional and state levels

The Act emphasises the coordination and integration of planning at the three levels at which it occurs in Queensland namely: local (government) planning, regional planning, and state planning.

The key legislative acts to address include, but are not limited to, the:

- Sustainability Planning Act (2009)
- Environmental Protection Act (1994)
- Native Title Act (1993)
- Aboriginal Cultural Heritage Act (2003)
- Water Act (2000)

Under the EP Act, it is an offence for a person to cause serious or material environmental harm. Environmental harm is any adverse effect, or potential adverse effect (whether temporary or permanent and of whatever magnitude, duration or frequency) on an environmental value. An environmental value is a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety. It is possible that a failure to adequately manage stormwater and drainage at a site could give rise to liability for an offence under the EP Act if that failure has an off-site impact which causes serious or material environmental harm (DNRW, 2007).

Under the Native Title Act, 1993 (Native Title Act) any person (including a local government) that undertakes an activity so as to affect native title cannot validly do so unless the activity is covered by certain compliance provisions in the legislation. Such activities can include both physical construction activities (such as the construction of stomwater or drainage works) and nonphysical activities (such as tenure grants and statutory approvals required for the works) (DNRW, 2007).

Under the Water Act 2000, the Department of Environment and Resource Management (DERM) may require approval of the in-stream works, possibly including the acquisition of a Water Licence or Riverine Protection Permit. If the works are to be carried out within tidal waters, then approval may be required. In some cases local governments can conduct such works under a self-assessment system based on an agreed set of management principles (DNRW, 2007).

Sometimes however, separate specific statutory approvals or permits are required under other legislation (e.g. a tree clearing permit may be required for works on State land including reserves under the Land Act). In other cases (for example, Native Title compliance and compliance with statutory duties of care), legislation will not require approvals or permits. Rather the proponent itself needs to satisfy prescribed compliance processes and procedures on a "self-regulation" basis (DNRW, 2007).

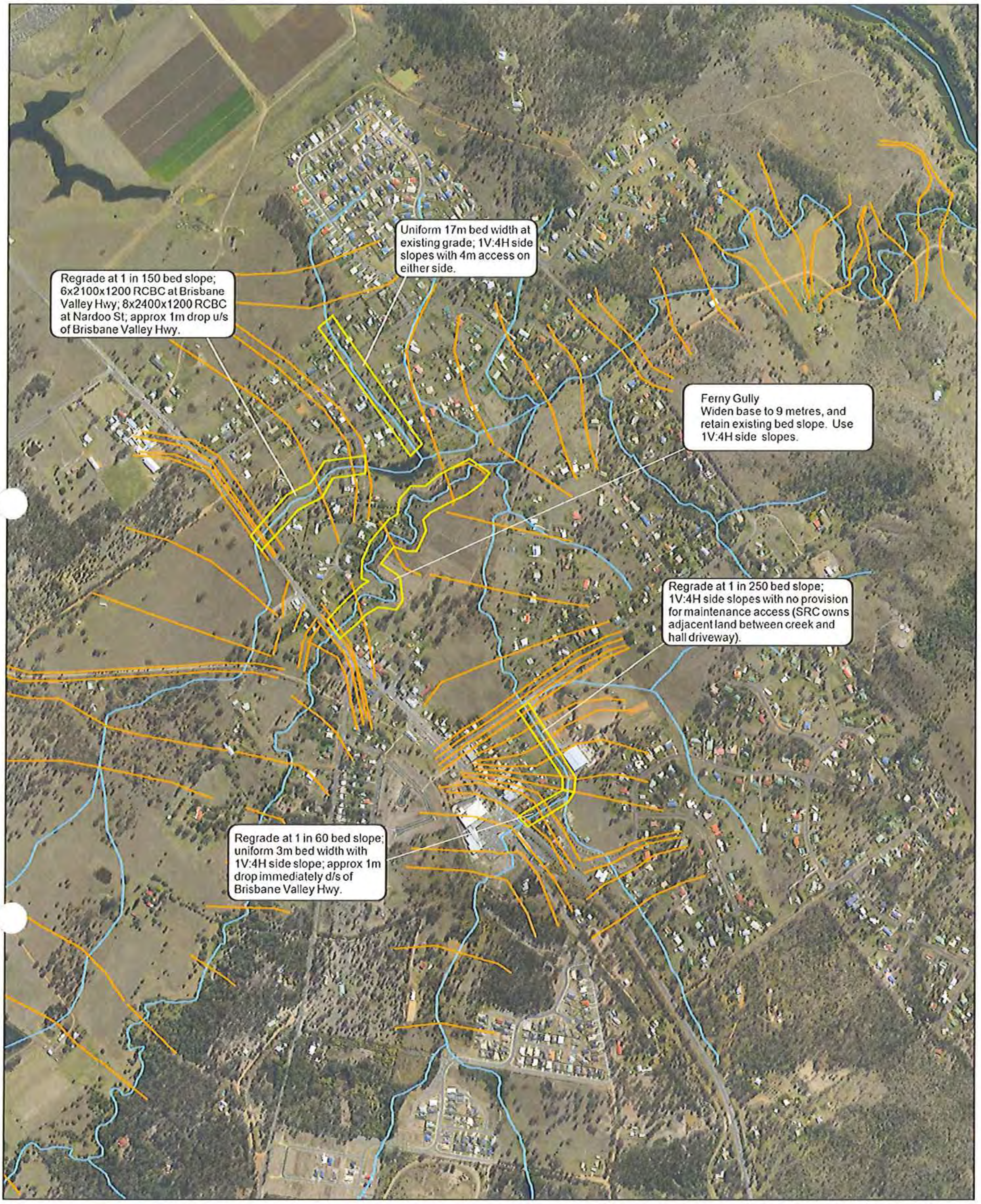
6.4 Further Investigations for Detailed Design

While this investigation has focussed on increasing drainage channel capacity as a way of reducing the flood risk, particularly for the DFE, it is recommended that a cost-benefit analysis be undertaken to quantify the benefit of increasing channel capacity against other floodplain management strategies such as voluntary property acquisition, house-raising, levees, or the benefit of upstream regional detention basins. In order to conduct a cost-benefit analysis of options, it will be necessary to perform an additional study to assess the flood risk for a range of floods from the 200 year ARI to the Probable Maximum Flood (PMF).

A Natural Channel Design (NCD) should be considered during any detailed design of any open drainage channels. NCD is a waterway design concept based on the planning, design, construction and maintenance of a waterway channel that is compatible with current and future hydrologic, ecological and social requirements for the catchment. Fish passageways are an example of such requirements. Urban drainage channels that are designed using the principles of NCD may also be referred to as vegetated channels. The adoption of NCD features into an urban drainage channel must be preceded by the adoption and appropriate enforcement of Erosion & Sediment Control (ESC) principles throughout the catchment. Without effective sediment control measures, the on-going maintenance requirements (i.e. desilting) of the drainage channel will be incompatible with the vegetative features of a natural channel design (DNRW, 2007).

It is impractical to expect a pristine natural channel to remain unchanged once the catchment has been urbanised. The degree of physical change experienced by a pristine waterway is dependent on a number of factors including the degree of change to the natural water cycle. In circumstances where the existing channel is either heavily modified or degraded, then consideration should be given to the rehabilitation of the channel to a condition consistent with the proposed hydrologic and ecological conditions of the catchment (DNRW, 2007).

The effects of climate change should be assessed during any detailed design.



NOTE: Mapping scale displays full extent of aerial imagery.

LEGEND

- Hydraulic Model Cross Section
- Watercourse

The proposed works are preliminary only, subject to a detailed design assessment, and also subject to obtaining the necessary government approvals for the legistlative acts that will apply.

1:10,000

0 100 200 metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Somerset Regional Council
Fernvale Flooding Investigation

Job Number | 41-23656-01
Revision | 0
Date | 25 May 2011

Preliminary Sizing
Proposed Drainage Improvement Works

Figure 6.1

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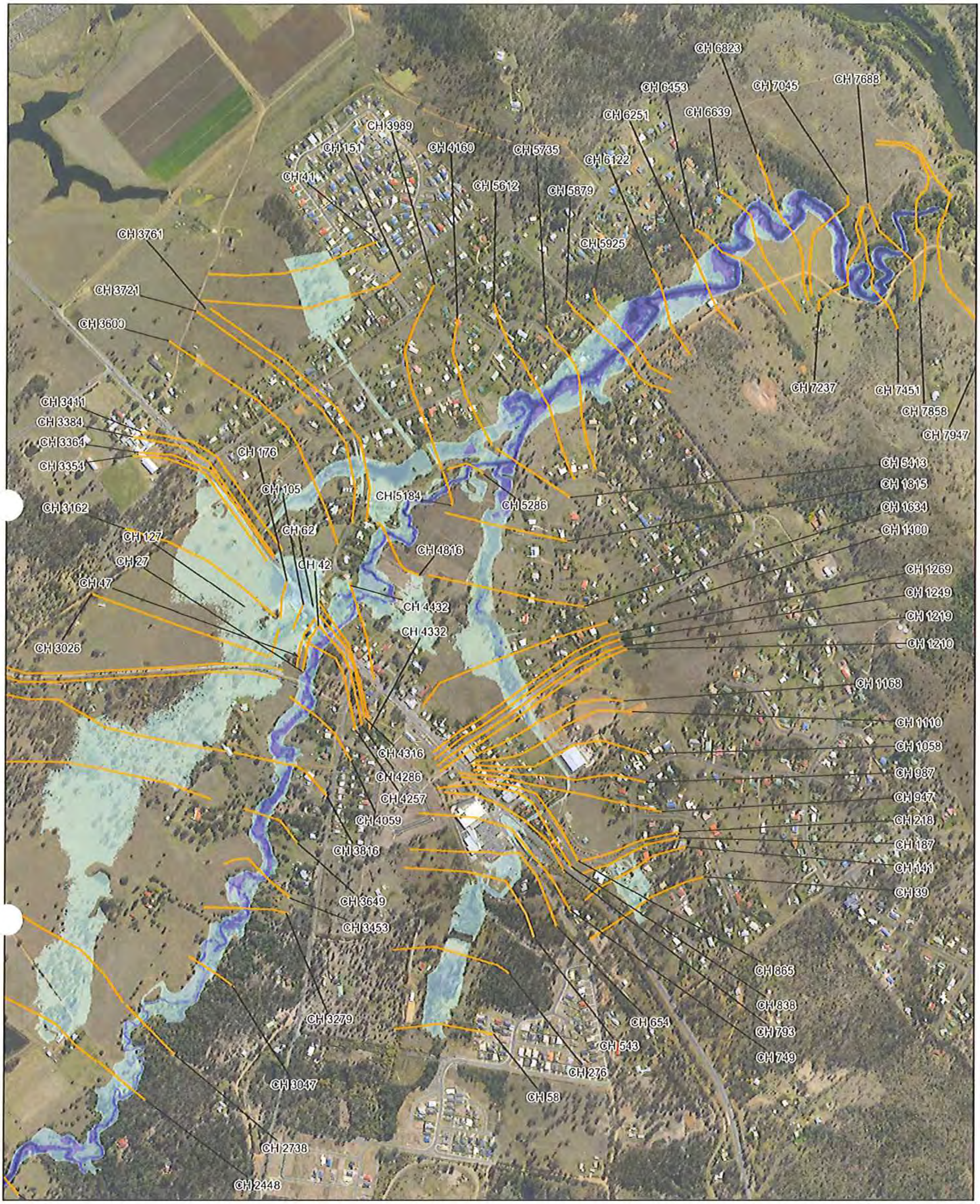
Suite 4, 1-3 Annand Street Toowoomba QLD 4350 Australia T 61 7 4633 8000 F 61 7 4613 1687 E tbamail@ghd.com.au W www.ghd.com.au

Data source: GHD: Flood Extent & Cross Sections; SRC: Aerial Image undated. Created by: PJM



LEGEND

Water Depth

0 - 0.5 m
0.5 - 1.5 m
1.5 - 3 m
>3 m

Hydraulic Model Cross Section

The proposed works are preliminary only, subject to a detailed design assessment, and also subject to obtaining the necessary government approvals for the legistlative acts that will apply.

NOTE: Mapping scale displays full extent of aerial imagery. Drainage improvement work outcome for Ferny Gully is not shown on this figure, not any works upstream of the Brisbane Valley Highway.

1:10,000

0 100 200
metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Somerset Regional Council
Fernvale Flooding Investigation

Job Number | 41-23656-01
Revision | 0
Date | 25 May 2011

Estimated 100 Year ARI Flood Extents with Proposed Preliminary Drainage Works

Figure 6.2

G:\41\23656\GIS\23656-22.WOR

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7. Floodplain Management Policy

This section discusses the SRC's current floodplain management policy regarding development in the Fernvale area. An overview of the State Planning Policy 1/03 (SPP) is provided which is a statutory instrument expressing the State's interest in minimising the adverse impact of floods, bushfire, and landslip. Brisbane City Council has established an interim policy for development in the wake of the January 2011 flood, and their policy is reviewed to determine if a similar approach should be adopted for the Fernvale area.

7.1 Current Policy

SRC's Planning Scheme has some guidance on the development of floodprone land and floodplain management. Scheme Policy 12 (Flood Mitigation in the Lowood & Fernvale Locality) is the relevant policy document to consider and a copy of the policy is provided in Appendix E.

The purpose of the current policy is to identify and implement the standards Council will rely on when determining the level of flood immunity of all future development in the Lowood & Fernvale locality. When considering and determining the merits of all development applications in the Lowood & Fernvale locality, use is made of the "SRC Q100 Flood Level 091010" as the basis of assessment in determining a suitable level of flood risk. This map is 100 year ARI flood inundation map from the Fernvale and Lowood Flood Study (BCC, 2009) and a copy of this map is provided in Appendix E. This means Council has adopted the Defined Flood Event (DFE) as the 100 year ARI event, which is the default ARI nominated by the State Planning Policy 1/03 (SPP) (see Section 7.2).

The basis for SRC's policy approach is as follows. As the Lowood and Fernvale locality is becoming an increasingly desirable place to live the Somerset Regional Council has recognized the need to adopt a range of contemporary development standards to provide confidence in the market and to achieve an appropriate standard of development.

While this policy provides some guidance on flood inundation areas for the 100 year ARI event, the information is based on flooding along Brisbane River floodplain and does not consider localised creek flooding. This means the true extent of the 100 year ARI flood extent is not entirely defined, though Council does consider hydraulic modelling studies of local drainage areas as suitable estimates. In the absence of design flood level information, the SPP essentially recommends the adoption of historical flood levels for the DFE and this is SRC's current approach.

Another SRC document of relevance to floodplain management is "The Regulations Checklist and Information, New Dwellings and Enclosed Additions." This document states that all design works are to comply with the Sustainable Planning Act, the Queensland Building Act, Building Regulation, Housing Provisions of the Building Code of Australia, and the Queensland Development Code and all other relevant standards and manufacturer's literature. A council requirement in relation to floor heights is that height for an inhabitable space is to be a minimum of 300 mm above any previous flood levels.

The issue, therefore, for SRC is in applying levels from two recent large historical floods where the flood extent is known (January 1974 and January 2001). The 1974 flood occurred before the construction of Wivenhoe Dam, and the January 2011 event has an ARI (approximately 2,000 years) much greater than the 100 year ARI probability for the DFE. Adopting the January 2011 flood extent for local watercourse flooding may unnecessarily preclude land from future development. That is, a flood risk standard may be enforced which is inconsistent with the river flooding inundation ARI adopted under Scheme Policy 12, and with the SPP.

7.2 State Planning Policy

The State Planning Policy 1/03: "Mitigating the Adverse Impacts of Flood, Bushfire and Landslide" is a statutory instrument expressing the State's interest in minimising the adverse impacts of these three natural hazards on people, property, economic activity, and the environment when making decisions about development (DLGP and DES, 2003). The following information is drawn directly from the SPP.

A flood is defined as the temporary inundation of land by expanses of water that overtop the natural or artificial banks of a watercourse (i.e. a stream, creek, river, estuary, lake or dam). The behaviour of floodwaters varies across the floodplain and over the duration of a flood event, as well as between different flood events. Therefore, there is a need to understand the full range of floods, up to and including the Probable Maximum Flood (PMF).

A floodplain is determined as the extent of land inundated by the PMF. However, it is generally impractical (and probably overly cautious) to adopt the PMF for the purposes of managing floodplain land use and development. Generally, a much more likely flood is used for this purpose and is referred to as the 'Defined Flood Event' (DFE).

The SPP defines a DFE as 'the flood event adopted by a local government for the management of development in a particular locality'. The determination of the DFE should be based on a rational appraisal of the impacts of a range of floods and the social and economic benefits of development. Historically, the 1% Annual Exceedance Probability (AEP) flood – essentially equivalent to the 100 year ARI – has been accepted as the preferred DFE, with little assessment of the consequences of larger, less frequent floods or the potential for allowing residential development based on a lesser flood.

The SPP Guideline also provides some recommendations on appropriate design flood levels for community infrastructure such as emergency services, emergency shelters, police facilities, hospitals, power stations for example. Typically these facilities should be situated in areas free of flooding from larger magnitude floods, usually a 200 to 500 year ARI event.

Typically a flood study is conducted to estimate the flood levels for various probability events up to and including the PMF. These studies usually rely on calibrating hydrology and hydraulic models to gauged information where it exists. A flood study is not essential, and it is possible for a local government area to adopt a DFE based on historical flood levels. However, where a historical flood level is chosen as the DFE, some assessment of its AEP is necessary to give an indication of the level of flood risk that is accepted (DLGP & DES, 2003).

Climate change should also be considered for future development. Predicted changes are likely to include reductions in annual rainfall but increases in rainfall intensity, and flood risk and damage to transport infrastructure and low-lying human settlements. These changes would have significant impacts on the nature and extent of natural hazards and, where practicable, should be considered when developing hazard mitigation strategies.

7.3 Interim Policy Adopted by Brisbane City Council

The January 2011 flood in the Brisbane City Council (BCC) area resulted in flood levels higher than their DFE. A Joint Flood Taskforce (JFT) was established and the following is extracts from their report.

The JFT sought to try and answer the following three questions:

- How does the January 2011 flood event compare to the Q100 as presently defined and Brisbane City Council's Defined Flood Event?
- Does Q100, as it is currently described, remain the best estimate of a 1 in 100 year event?
- Accordingly, what standard should be used to enable new development and redevelopment to proceed with confidence and certainty?

In answering these questions the JFT focussed on river flooding only. Flooding in tributaries to the Brisbane River and the impact of Storm Surge were considered to be outside the scope for this review.

Based on examination of the rainfall patterns of a number of previous Brisbane River floods, it is concluded that the Brisbane catchment experienced a significant rainfall event with a rain pattern that was different from that experienced in 1974. The level recorded at Savages Crossing was higher than in 1974. On balance the JFT considers that the flood runoff resulting from the major rainfall event of January 2011 was greater than the 1974 event but not as great as the 1893 event.

All of the peak flood levels recorded in January 2011 by the gauges along the Brisbane River were higher than the existing Defined Flood Level (DFL). That is, the level previously calculated for the 1974 flood event mitigated by Wivenhoe Dam, and for areas where river flooding causes the highest level of flooding. Therefore, taking into account this fact together with its assessment of the rainfall event, the JFT considers that the January 2011 flood event was larger than the Brisbane City Council's DFE. BCC's DFE is higher than the 100 year ARI flood level and is based on flooding associated with the 1974 flood.

The DFL is the level above Australian Height Datum (AHD) that Council requires habitable floors to be built above to provide protection against floods up to the magnitude of the DFE. DFL is based on the flood levels that are estimated in the DFE. It is a planning control to avoid people building habitable floor levels in locations or at heights that carry greater risk of flooding than that protected against by the DFL. The Brisbane City Plan also requires an additional 500mm of "freeboard" to be added to allow for a factor of safety, uncertainties and localised effects.

On balance, the JFT believes that, in the absence of results of a detailed flood study review, a precautionary approach should be adopted. Therefore, it considers that the actual January 2011 flood event, as observed during the event, should be used as the interim standard on which Brisbane City Council bases its decisions concerning habitable floor levels for new development and should be a consideration for habitable floor levels for redevelopment of existing properties. Wherever the existing DFL is higher than the January 2011 flood event, the existing higher flood level should prevail.

The JFT recommended that this interim standard apply until the conclusion of the Commission of Inquiry and a comprehensive flood study is completed. Such a study would be a complete Flood Risk Management analysis for the area of Brisbane affected by flooding by Brisbane River and its tributaries. Flood risk management requires that the consequences of floods be investigated for a range of flood events up to and including the PMF. For land use planning, flood levels as well as flood flows corresponding to specific probabilities must be considered. This approach must include identification of the benefits of the management of risk, rather than seeing it as all cost.

7.4 Discussion

The January 2011 flood event in Fernvale is considered to be significantly larger than the 100 year ARI design flood. The estimated probability of the January 2011 event is likely to be at least a 500 year ARI event, and possibly as rare as a 2,000 year ARI event.

As a result of the flooding through the Brisbane local government area, BCC has adopted the peak flood levels from the January 2011 event as an interim measure for development assessment until the conclusion of the Commission of Inquiry and the recommended comprehensive flood study is completed. This approach has been chosen as the January 2011 flood was higher than their DFE and has resulted in uncertainty for development applications.

It is considered prudent that SRC also adopt an interim approach for development applications in the Fernvale area, though not in exactly the same manner as BCC due to the different flooding behaviour experienced in January 2011. The Brisbane area did not receive any heavy rainfall nor experience significant creek flooding to the same degree as Fernvale. Also, the flood levels fluctuated far more in the Fernvale area than in Brisbane City. Therefore, it is recommended that Council continue with their policy that the DFE for residential areas is the 100 year ARI event which the SPP which considers an appropriate level of flood risk for residential areas.

Traditionally, when considering the extents of flooding to adopt for the DFE, the combination of regional and local flooding is often considered as being independent. That is, when a large flood event is happening across a region (e.g. the Brisbane River), then it is highly like that the smaller catchment (e.g. Ferny Gully) may only experience a smaller event. However, the January 2011 event demonstrated the large floods can occur simultaneously on a regional scale and a local scale.

It is therefore recommended that Council give consideration to adopting the largest of the river and local flooding extents at all locations across the Ferny Gully catchment floodplain as the minimum lot level for residential developments with a freeboard of at least 500 mm to define the minimum habitable floor level. The 500 mm freeboard reflects the anticipated accuracy of the flood modelling in the Ferny Gully catchment, providing an increased factor of safety, and allowing from uncertainties and localised effects. This is the freeboard adopted by BCC, and by local governments in New South Wales.

Emergency community facilities should be located above flood levels for events larger than the 100 year ARI event. It is recommended that Council adopt the January 2011 peak flood extent until the results from additional flood studies are compiled for larger to rare flood events (i.e. the 200, 500, 1,000, and 2,000 year ARI events).

Although new dwellings are to have habitable floor levels above the DFE, there is not a perceived need to construct the dwellings with materials that are not adversely affected by flood water. However, as the January 2011 event showed, there are some areas with a small flood risk. It is recommended that Council give consideration to any materials of existing houses damaged by flood inundation during the January 2011 event to be placed with materials that are not adversely affected by flooding. This flood risk standard should also be considered by Council for those parts of any new buildings potentially flooded by the January 2011 flood inundation extent.

The hydraulic modelling performed for this investigation has found that the capabilities of the one-dimensional unsteady flow hydraulic model are tested due to the broad shallow sheet flow that can occur with overflows from one watercourse to another. Therefore, some uncertainty exists for the estimated

100 year ARI flood extent, which is Council's DFE. Also, Council is yet assessed the risk profile of larger floods, such as the 200 year or 500 year ARI events.

Since the development of the Fernvale Master Drainage Plan in 2000, there have been significant advancements in hydraulic modelling techniques for two-dimensional unsteady flow hydraulic models. The data availability for two-dimensional models has improved immensely, and these types of model can be readily integrated with one-dimensional unsteady flow models to adequately simulate channel flow and overland sheet flow, as well as hydraulic structures. It is recommended that Council undertake a detailed flood study using a linked one-dimensional/two-dimensional model when assessing the DFE and the flood extents for larger to rarer flood events.

8. Conclusions & Recommendations

8.1 Conclusions

8.1.1 Behaviour of the January 2011 Flood Event

At the end of 2010, it was the wettest December on record for Queensland and for eastern Australia as a whole. An upper-level low combined with a humid easterly flow to bring very heavy rain to southeast Queensland and northeast New South Wales. There was major flooding through most of the Brisbane River catchment, most severely in the Lockyer and Bremer catchments where numerous flood height records were set (BOM, 2011). For the January 2011 flood event as the catchment was already close to full saturation at the beginning of the Event (Seqwater, 2011).

The January 2011 rainfall was significantly larger than any rainfall previously recorded in the vicinity of Fernvale. While the January 2011 rainfall was only 10% larger for the previous highest one day total (1965), it was 30 to 43% higher for the two and three day totals (from January 1974). An analysis of the peak rainfall bursts at the Savages Crossing gauge indicated that the ARI of the January 2011 rainfall over the Ferny Gully catchment was very large; at least 500 year ARI based on the ARR IFD data, and exceeding 2,000 years using the CRC-Forge data for Queensland. Either way, it appears that the rainfall ARI was well in excess of the State Planning Policy 1/03 default DFE ARI of 100 years for floodplain management. Hydrological modelling of this event demonstrated the event generally appears to have an ARI of around 2,000 years.

When compared with historical events, flood volumes indicate the volume of the January 2011 Event was almost double that of the January 1974 flood, and rivals the February 1893 flood (Seqwater, 2011). The closest water level gauge to Fernvale is Savages Crossing on the Brisbane River, just upstream of the Ferny Gully confluence. The peak water level at Savages Crossing was 42.48 m AHD occurred at 2:12 am on 12 January 2011. This is slightly higher than the peak level of 42.22 m AHD in the January 1974 flood (Seqwater, 2011). Seqwater (2011) concluded that below Wivenhoe Dam, the flood had an ARI similar to that of the post-Wivenhoe 1974 flood and may be as high as 1,000 years.

At the beginning of January 11 the peak water level at Savages Crossing was around 34 m AHD, and after about 7 am, the water level starts to increase sharply. This was due to the heavy rainfall over the Lockyer Creek catchment. The intense rainfall over the Ferny Gully catchment commenced around 6 am and essentially concluded by 3 pm at which time the river level had risen to approximately 39 m AHD. For the remainder of the day the water level continued to rise in the absence of any local rainfall. The peak water level recorded at Savages Crossing was in the early hours of January 12. Therefore, Fernvale experienced two flood peaks, one due to rainfall during the day, and a second peak during the night due to backwater flooding from the Brisbane River.

8.1.2 Hydraulic Modelling of January 2011 Event

Hydraulic modelling of the January 2011 event resulted in a reasonably good fit to the inundation extent mapped by SRC. There were some small discrepancies. The largest of these was the simulated flood in the vicinity of Titmarsh Gully where there is a natural saddle. During the January 2011 event, floodwaters from the Brisbane River broke out across this saddle to flow into Titmarsh Gully to then reach Ferny Gully before re-joining the Brisbane River. Therefore, additional flow volume entered the system which is considered the reason for the not matching the recorded inundation extent in this area. Accounting for this breakout was beyond the scope of this study as it requires modelling of the Brisbane River in conjunction with the Ferny Gully Catchment. Other smaller discrepancies are associated with breakouts of shallow broad sheet flow, and some uncertainty with identifying the flood peak from debris marks. Overall, it was considered that the hydrology model and hydraulic models provide a reasonable estimation of surface runoff and peak water levels for the Ferny Gully catchment.

Flooding due to the intense rainfall was the major cause of any inundation in Banks Creek upstream of Burns Road and backwater flooding from the Brisbane River did not encroach on this area. A similar situation existed for the Lagoon tributary in the vicinity of the Brisbane Valley Highway, though in this instance there were minor increases due to backwater flooding from the Brisbane River during the recession.

The Brisbane River backwater flooding resulted in higher flood levels than the rainfall-induced flooding in the vicinity of Banks Creek Road, and the areas near Poole Road. At Banks Creek Road it appears the rainfall-induced flood peak is similar to the backwater river flood peak. However, along the Lagoon Tributary and Ferny Gully near Poole Road, it appears that the backwater flooding from the Brisbane River resulted in a flood peak that is approximately two metres higher at chainage 3988 (to the south of the Titmarsh Gully), and nearly 5 metres higher further to the north along Poole Road at chainage 5878 (in the vicinity of Powells Road) than their respective peak rainfall-induced peak water levels.

8.1.3 Hydraulic Modelling of the Design Flood Events

The 100 year ARI peak water levels using the updated and extended hydraulic model are very similar to those estimated for the earlier Fernvale Master Drainage study (GHD, 2000). Both models indicated there is very little difference in peak water levels between the existing and ultimate development scenarios for the respective models. There are some minor changes in the estimated peak water levels estimated in the earlier Fernvale Master Drainage study and those from extended model from this study. These differences are attributed to the higher quality of topographic information available now that was not available previously, and the additional resolution provided by the hydrology model.

The estimated capacity of the existing drainage paths in the Ferny Gully catchment downstream of the Brisbane Valley Highway varies from location to location. Based on the preliminary assessment undertaken for this study, the Banks Creek (upstream of Banks Creek Road), Ferny Gully, and Titmarsh Gully watercourses all have an estimated 5 year ARI capacity. The ARI capacity of the Lagoon Tributary is approximately 10 years, while in Banks Creek downstream of Banks Creek Road, the estimated capacity is around 50 years.

8.1.4 Floodplain Management Policy Considerations

SRC's Planning Scheme has some guidance on the development of floodprone land and floodplain management. Scheme Policy 12 (Flood Mitigation in the Lowood & Fernvale Locality) is the relevant policy document to consider, and indicates Council has adopted the Defined Flood Event (DFE) as the 100 year ARI event.

While this policy provides some guidance on flood inundation areas for the 100 year ARI event, the information is based on flooding along Brisbane River floodplain and does not consider localised creek flooding. This means the true extent of the 100 year ARI flood extent is not entirely defined, though Council does consider hydraulic modelling studies of local drainage areas as suitable estimates. In the absence of design flood level information, the SPP essentially recommends the adoption of historical flood levels for the DFE and this is SRC's current approach.

The issue for SRC is, therefore, applying the levels from two recent large historical floods where the flood extent is known (January 1974 and January 2001). The 1974 flood occurred before the construction of Wivenhoe Dam, and the January 2011 event has an ARI (approximately 2,000 years) much greater than the 100 year ARI probability for the DFE. Adopting the January 2011 flood extent for local watercourse flooding may unnecessarily preclude land from future development. That is, a flood risk standard may be enforced which is inconsistent with the river flooding inundation ARI adopted under Scheme Policy 12, and with the SPP.

BCC has initiated an interim floodplain management policy following the January 2011 flood as flood levels higher than their DFE were recorded in their area. On balance, in the absence of results of a detailed flood study review, a precautionary approach was recommended to be adopted. However, the nature of flooding behaviour experienced in January 2011 in Brisbane City was quite different to that experienced in Fernvale. The Brisbane area did not receive any heavy rainfall, nor experience significant creek flooding to the same degree as Fernvale. Also, the flood levels fluctuated far more in the Fernvale area than in Brisbane City.

As the January 2011 flood event in Fernvale is considered to be significantly larger than the 100 year ARI design flood, and the estimated probability of the January 2011 event is likely to be at least a 500 year ARI event, and possibly as rare as a 2,000 year ARI event, it is considered appropriate for SRC to retain the 100 year ARI event as the DFE as this is considered an appropriate level of risk for residential areas by the SPP.

The SPP recommends that emergency community facilities be established above larger flood events such as the 200 year or 500 year ARI event. Council does not have any design flood level estimates for these types of floods, and it is considered appropriate that Council give consideration to adopting the January 2011 flood level for any new facilities of this nature, and for materials used in all buildings, until the level is refined as a result of further flood studies to define the flood risk profile for the Ferny Gully catchment.

8.2 Recommendations

To reduce the flood risk in Fernvale, it recommended that Council give consideration to:

- Undertaking a detailed design of the preliminary drainage improvement options discussed in Section 6.2 of this report and shown in Figure 6.1.
- Adopting the design criteria listed in Section 6.1 of this report when undertaking the detailed design.
- Maintaining the existing drainage paths and keeping them free from debris or anything that will impede flow.
- Establishing low-flow concrete drains to allow quick drainage, minimise ponding of water so that drains dry out more efficiently in order to facilitate access by maintenance vehicles without damaging the drainage channel.

It is further recommended that Council give consideration to adopting the following floodplain management measures:

- the 100 year ARI local flooding extent based on a 100 year ARI tailwater flood level in the Brisbane River.
- the largest of the 100 year ARI river and local flooding extents at all locations across the Ferny Gully catchment floodplain as the minimum lot level for residential developments, with a freeboard of at least 500 mm for defining the minimum habitable floor level.
- the January 2011 peak flood extent for any emergency community facilities until the results from additional flood studies are compiled for larger to rare flood events (i.e. the 200, 500, 1,000, and 2,000 year ARI events).
- Material belonging to habitable structures damaged by flood waters from the January 2011 flood be replaced by materials not adversely affected by flood water.
- New dwellings located within the January 2011 flood extent have all material of any habitable dwelling up to that level to be of a type that is not adversely affected by flood water.

It is recommended that Council give consideration for the following additional studies to be undertaken to provide clarification to Council's floodplain management policy:

- a detailed flood study using a linked one-dimensional/two-dimensional model be established to assess the DFE and the flood extents for larger to rarer flood events for quantifying the flood risk in Fernvale and facilitating future planning of residential and emergency community facilities, and climate change impacts should be assessed as part of this study.
- a cost-benefit analysis of the preliminary drainage improvement options, where other floodplain management practices such as voluntary property acquisition, house raising are assessed.

9. References

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Palmen, L. B. and Weeks, W. D. Regional Flood Frequency for Queensland using the Quantile Regression Technique, 32nd Hydrology and Water Resources Symposium, 2009.

Seqwater, January 2011 Flood Event, Report on the Operation of Somerset Dam and Wivenhoe Dam, 2 March 2011.

SKM, Fernvale and Lowood Local Area Plan, report prepared for Esk Shire Council by Sinclair Knight Merz Pty Ltd, 26 May 2006.

UWS, Project 5, Regional Flood Methods, report prepared for the Institution of Engineers Australia, Water Engineering by The University of Western Sydney, School of Engineering, Building XB, Kingswood, November 2009.

XP Software, XP-Rafts 2000, Version 6 released in 2001.

Appendix A

Site Visit Photographs

Photograph A1 - Upstream face low-flow outlet structure of the damaged basin

Photograph A2 – Right abutment of damaged basin, showing remains of the embankment

Photograph A3 – Looking at the damaged left abutment of the detention basin, damaged car park pavement is evident in the background.

Photograph A4 – Looking upstream across damaged car park pavement towards the damaged detention basin

Photograph A5 – Damaged fence on Titmarsh Circuit in stormwater drainage easement.

Photograph A6 – Looking downstream from Poole Road along drainage corridor. Note debris caught in the lower limb of the tree shown in the right foreground.

Photograph A7 – Looking from upstream side of Banks Creek Road crossing from the left bank.

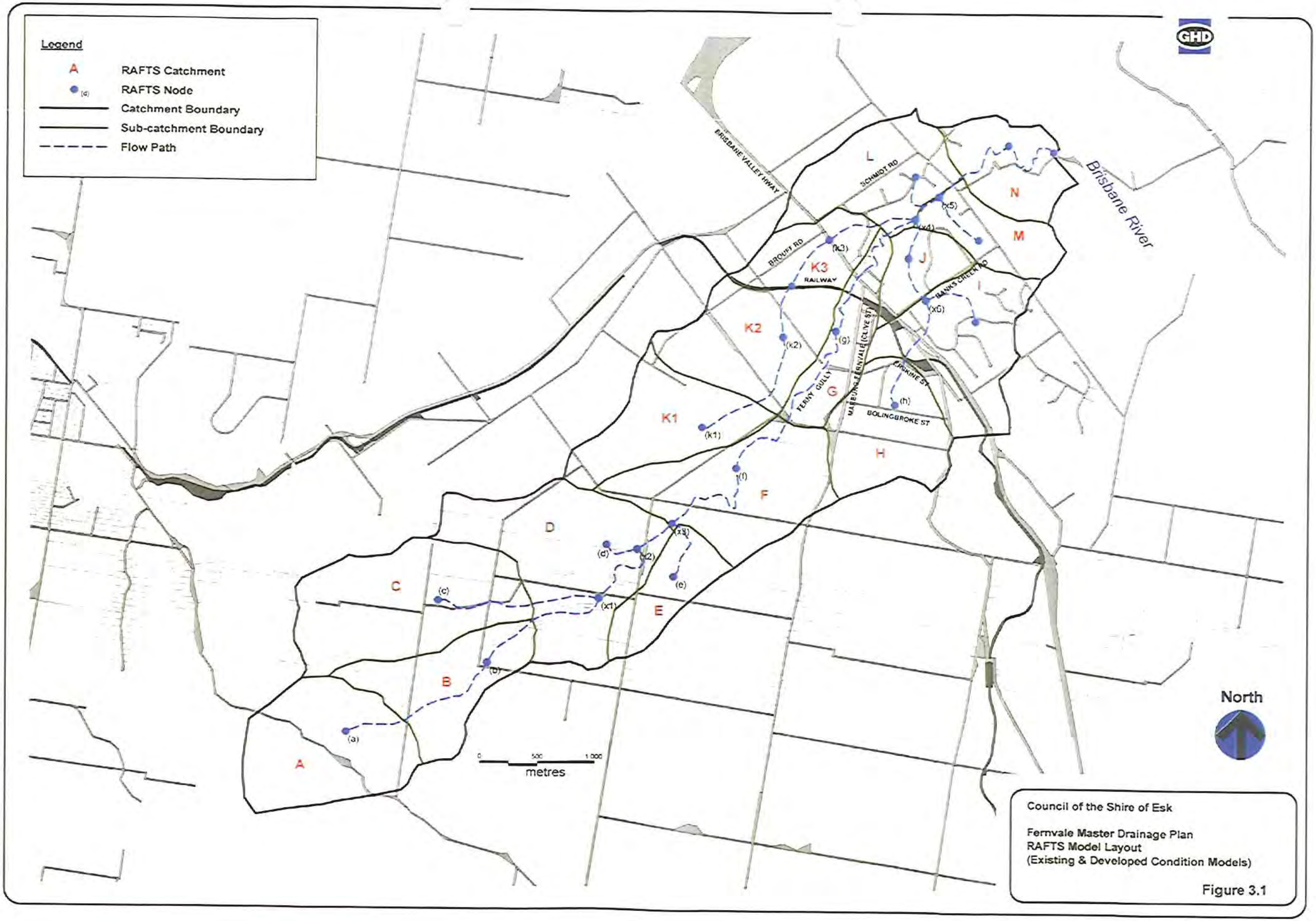
Photograph A8 – Old rail bridge crossing wash-out on the Old Brisbane Valley Rail Line.

Photograph A9 – Looking downstream from location shown in Photograph A9. Freedom Fuels Service Station on the Brisbane Valley Highway is at the centre of the background.

Photograph A10 – Another example of severe erosion of the Old Brisbane Valley Rail Line (further to the west).

Appendix B

Plans of Relevance from Earlier Studies

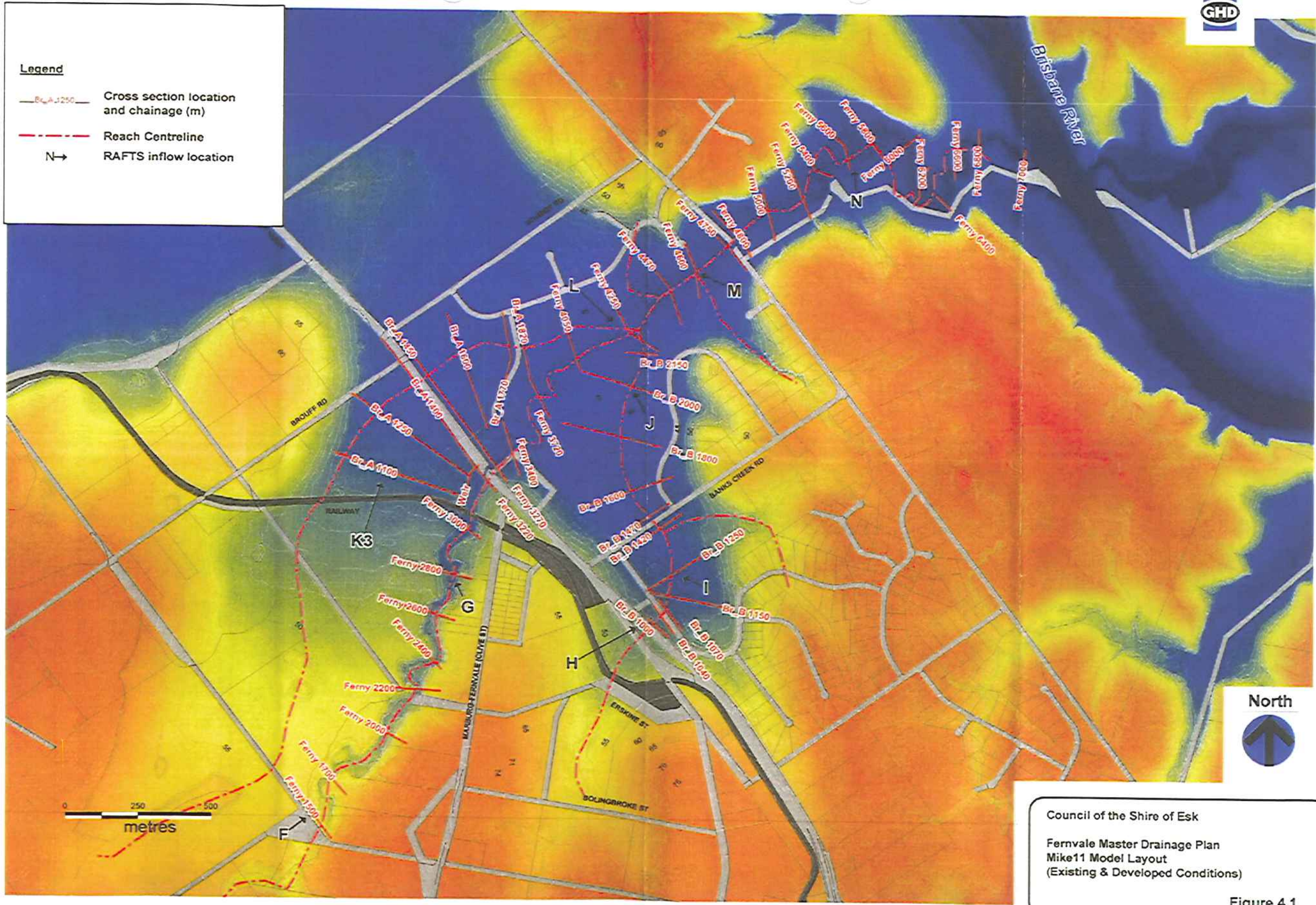


Council of the Shire of Esk

Fernvale Master Drainage Plan
RAFTS Model Layout
(Existing & Developed Condition Models)

Figure 3.1

g/411/15900/map nfo/Fernvale_Rafts wor

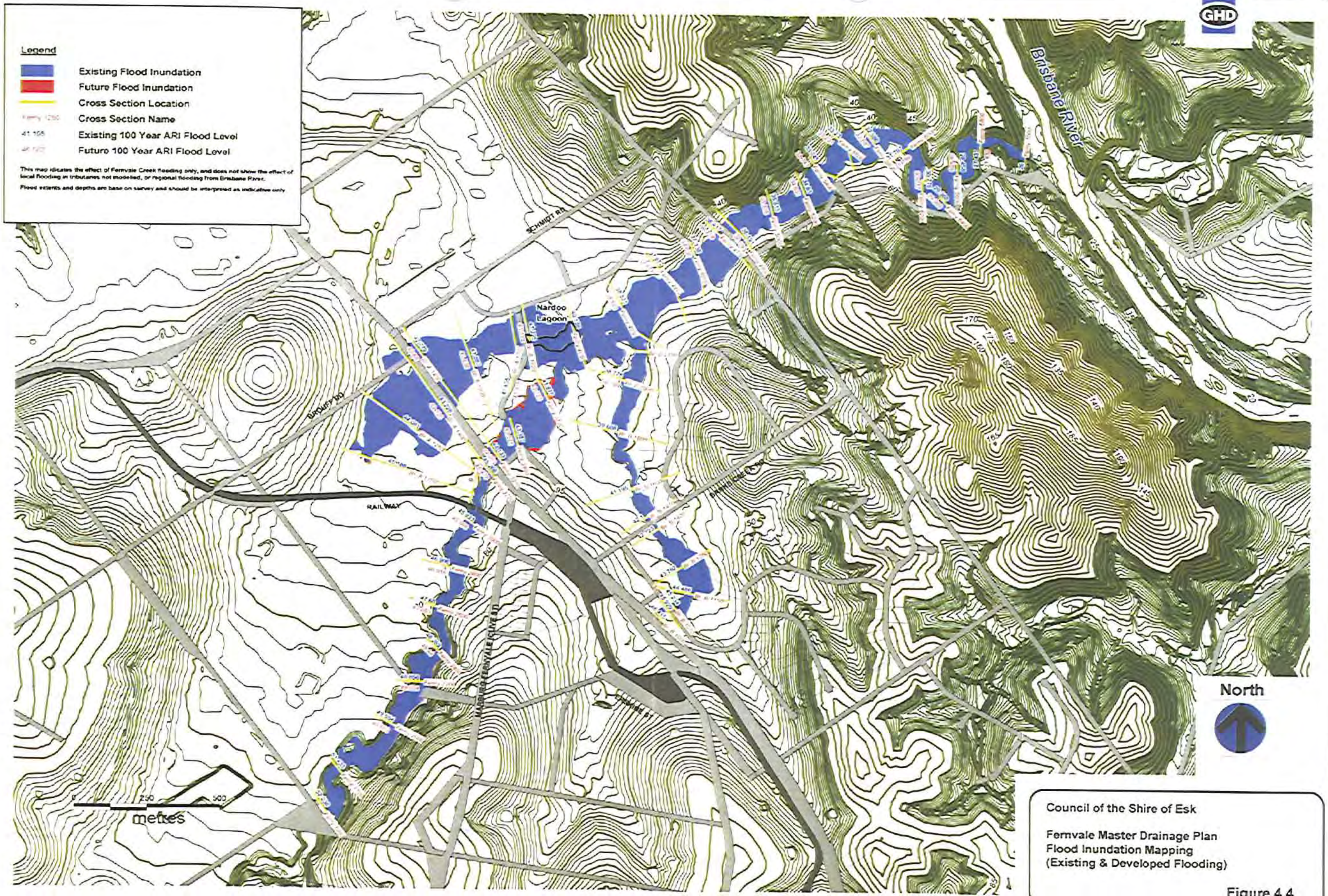


Council of the Shire of Esk

Fernvale Master Drainage Plan
Mike11 Model Layout
(Existing & Developed Conditions)

Figure 4.1

g:/411/15900/mapinfo/Fernvale.wor



Council of the Shire of Esk

Fernvale Master Drainage Plan
Flood Inundation Mapping
(Existing & Developed Flooding)

Figure 4.4

g:/411/15900/mapinfo/FernFloodMap wor

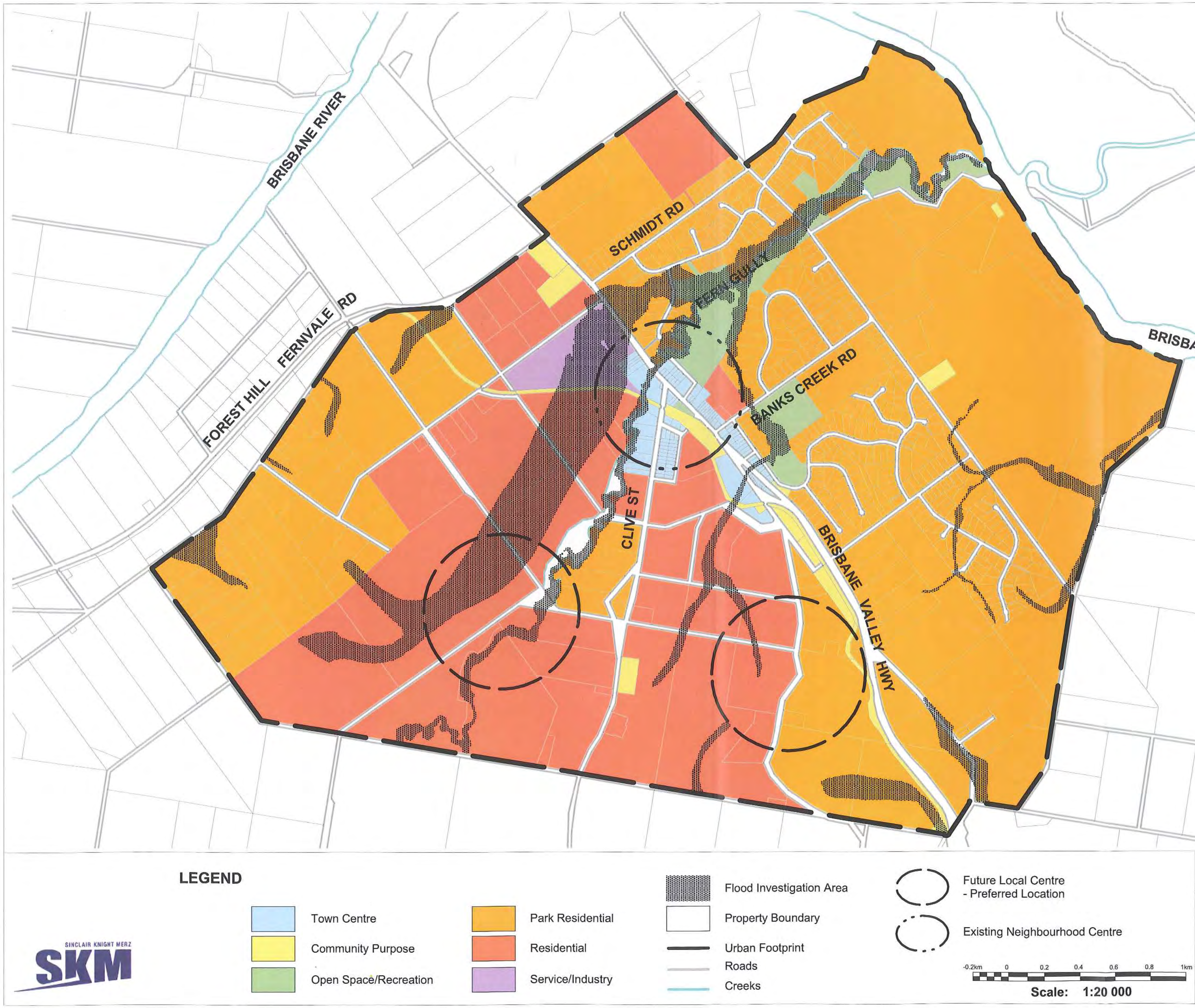
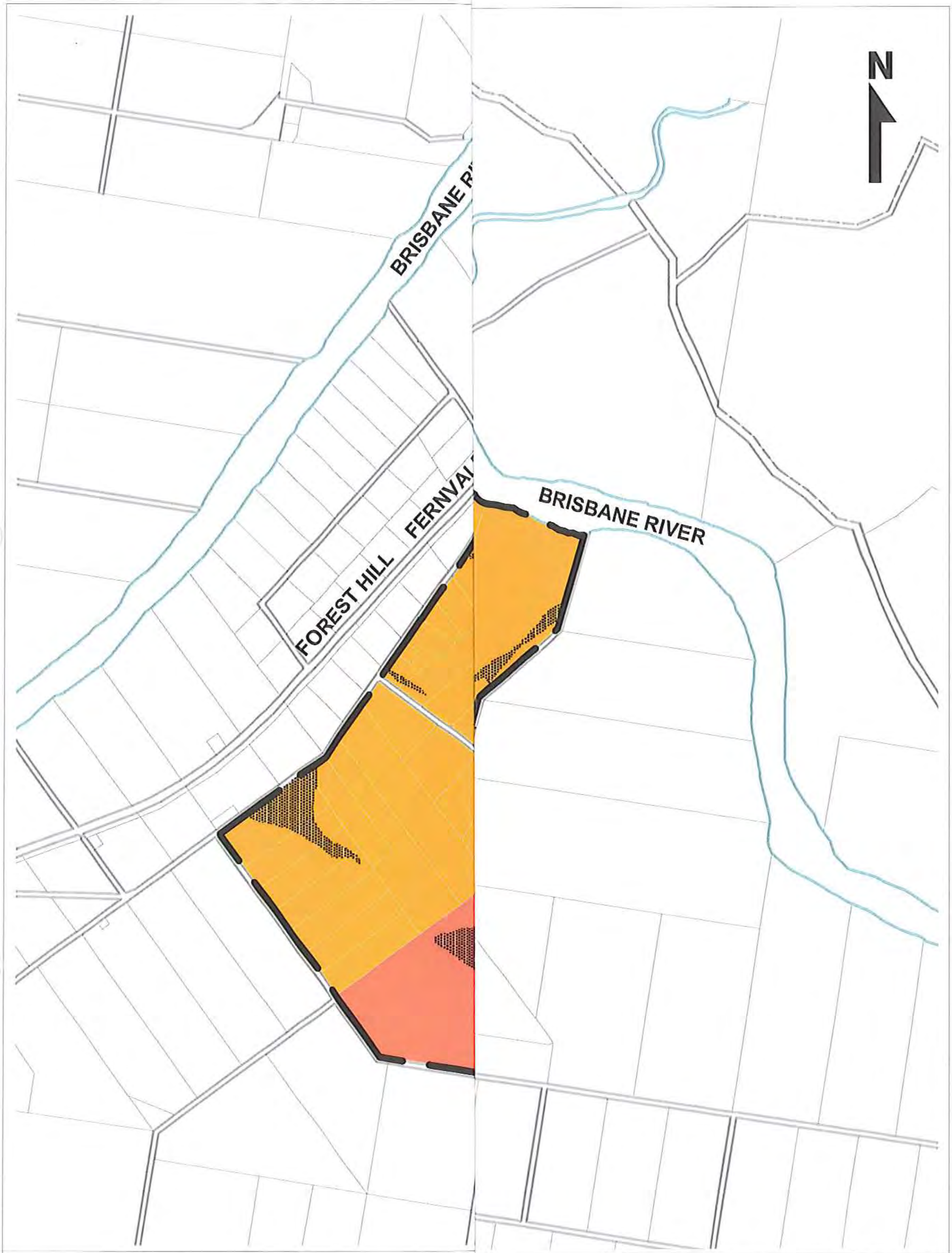


FIGURE 10a

TITLE

Fernvale Local Area Plan

DATE	REVISION
18/11/05	Rev_2



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SKM

FIGURE 10a

TITLE

Fernvale

Local Area Plan

DATE	REVISION
18/11/05	Rev_2

Appendix C
Hydrological Information

Bureau of Meteorology Climate Maps

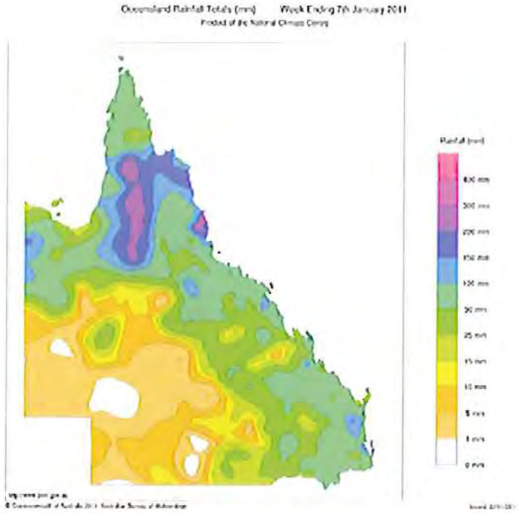

Figure C1 – Rainfall for the Week Ending January 7, 2011

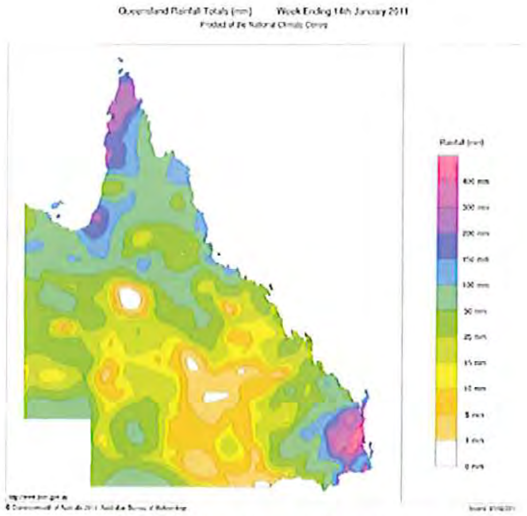

Figure C2 – Rainfall for the Week Ending January 14, 2011

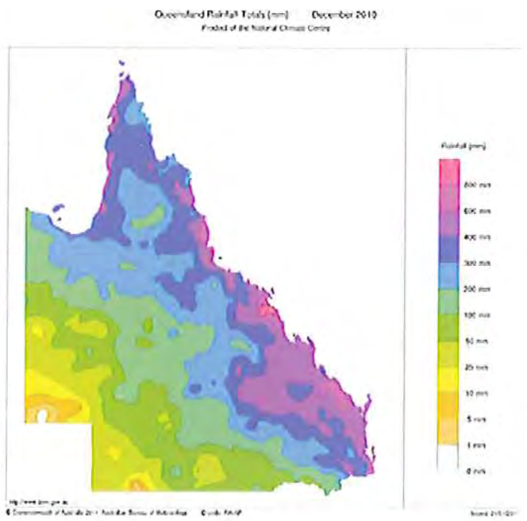

Figure C3 – December 2010 Rainfall Totals

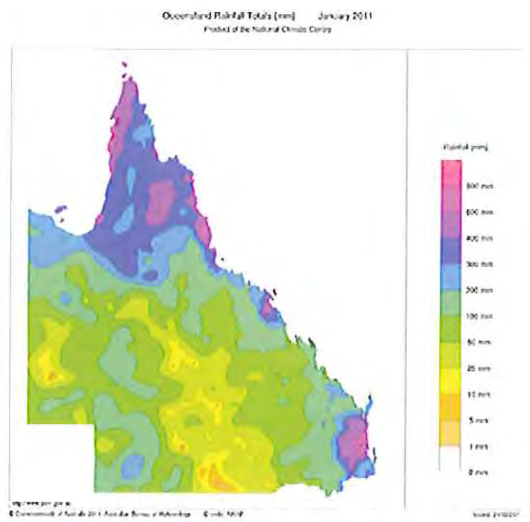

Figure C4 – January 2011 Rainfall Totals

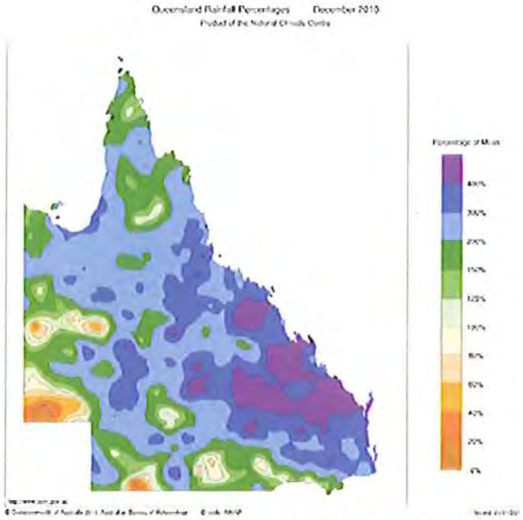

Figure C5 - December 2010 Rainfall Percentages

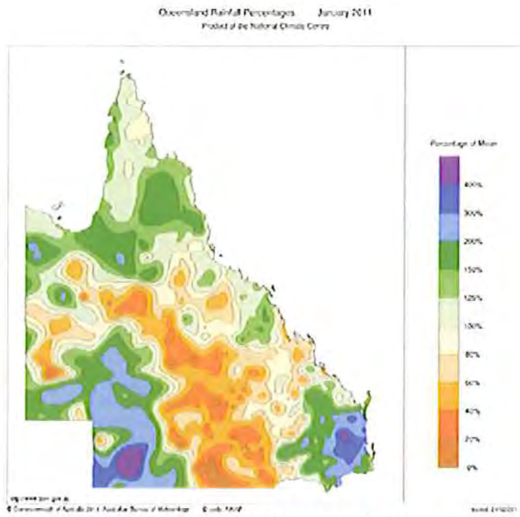

Figure C6 - January 2011 Rainfall Percentages

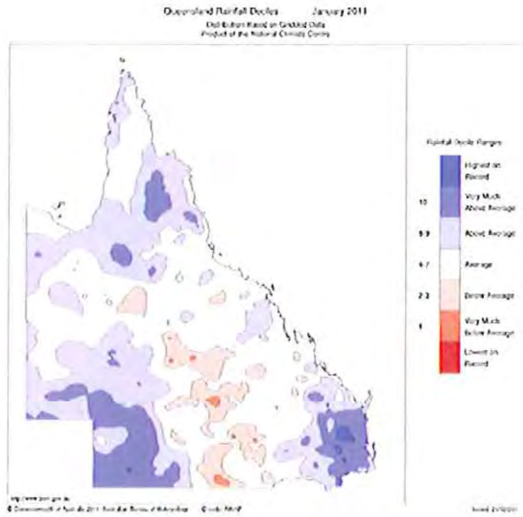

Figure C7 - December 2010 Rainfall Deciles

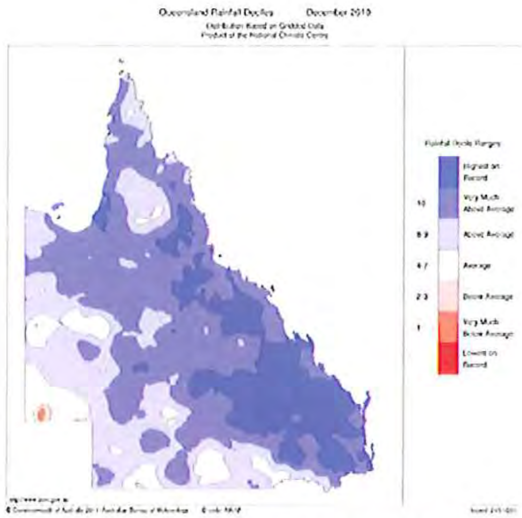

Figure C8 - January 2011 Rainfall Deciles

Rainfall Intensity-Frequency-Duration Calculation to AR&R

Program : IFD.xls
Version : 3.0

Data

Location : **Fernvale**

1 HR DUR 2 ARI	45.50	mm/hr
12 HR DUR 2 ARI	7.80	mm/hr
72 HR DUR 2 ARI	2.00	mm/hr
1 HR DUR 50 ARI	88.00	mm/hr
12 HR DUR 50 ARI	14.80	mm/hr
72 HR DUR 50 ARI	4.20	mm/hr
G (skewness)	0.25	mm/hr
F2 Geo factor 2 ARI	4.37	
F50 Geo factor 50 ARI	17.20	

Duration		**Design Rainfalls for Average Recurrance Intervals**								
(min)	(hr)	**1 Year** (mm/hr)	**2 Years** (mm/hr)	**5 Years** (mm/hr)	**10 Years** (mm/hr)	**20 Years** (mm/hr)	**50 Years** (mm/hr)	**100 Years** (mm/hr)	**200 Years** (mm/hr)	**500 Years** (mm/hr)
		1 yr ARI	2 yr ARI	5 yr ARI	10 yr ARI	20 yr ARI	50 yr ARI	100 yr ARI	200 yr ARI	500 yr ARI
5	0.083	110.5	142.5	181.1	204.9	237.3	281.5	316.2	352.7	403.5
6	0.100	103.7	133.7	170.1	192.6	223.2	264.8	297.6	332.1	380.1
7	0.117	97.9	126.3	160.9	182.2	211.2	250.7	281.9	314.6	360.2
8	0.133	93.0	120.0	152.9	173.3	201.0	238.7	268.4	299.7	343.2
9	0.150	88.7	114.5	146.1	165.6	192.1	228.2	256.7	286.6	328.4
10	0.167	84.9	109.7	140.0	158.8	184.2	218.9	246.3	275.1	315.3
11	0.183	81.6	105.4	134.6	152.7	177.2	210.7	237.1	264.9	303.6
12	0.200	78.6	101.5	129.7	147.2	170.9	203.2	228.8	255.6	293.1
13	0.217	75.9	98.0	125.3	142.2	165.2	196.5	221.2	247.2	283.5
14	0.233	73.4	94.8	121.3	137.7	160.0	190.4	214.3	239.6	274.8
15	0.250	71.1	91.9	117.6	133.6	155.2	184.7	208.0	232.6	266.8
16	0.267	69.0	89.2	114.2	129.8	150.8	179.5	202.2	226.1	259.4
17	0.283	67.1	86.7	111.1	126.2	146.7	174.7	196.8	220.1	252.6
18	0.300	65.3	84.4	108.2	122.9	142.9	170.2	191.8	214.5	246.2
20	0.333	62.0	80.2	102.9	117.0	136.1	162.1	182.7	204.4	234.7
25	0.417	55.5	71.8	92.3	105.0	122.2	145.7	164.4	184.0	211.4
30	0.500	50.5	65.4	84.1	95.8	111.6	133.2	150.3	168.3	193.5
35	0.583	46.5	60.3	77.6	88.5	103.1	123.2	139.0	155.8	179.2
40	0.667	43.3	56.1	72.3	82.5	96.2	114.9	129.8	145.5	167.5
45	0.750	40.6	52.6	67.9	77.5	90.3	108.0	122.0	136.8	157.6
50	0.833	38.2	49.6	64.1	73.2	85.4	102.1	115.4	129.4	149.1
55	0.917	36.2	47.0	60.8	69.4	81.1	97.0	109.7	123.0	141.8
60	1.00	34.5	44.8	57.9	66.2	77.3	92.5	104.6	117.4	135.3
75	1.25	29.6	38.4	49.7	56.7	66.2	79.2	89.6	100.5	115.8
90	1.5	26.1	33.8	43.7	49.9	58.2	69.7	78.8	88.3	101.8
120	2	21.3	27.6	35.7	40.7	47.5	56.8	64.1	71.9	82.8
180	3	16.0	20.7	26.7	30.4	35.4	42.4	47.8	53.6	61.7
240	4	13.0	16.8	21.7	24.7	28.8	34.4	38.8	43.5	50.0
300	5	11.1	14.3	18.5	21.0	24.5	29.2	33.0	37.0	42.5
360	6	9.7	12.6	16.2	18.4	21.5	25.6	28.9	32.4	37.2
480	8	7.9	10.3	13.2	15.0	17.5	20.8	23.5	26.3	30.2
540	9	7.3	9.4	12.1	13.8	16.0	19.1	21.6	24.1	27.7
600	10	6.8	8.7	11.2	12.8	14.9	17.7	20.0	22.4	25.7
720	12	5.9	7.7	9.9	11.2	13.0	15.5	17.5	19.6	22.5
810	13.5	5.5	7.1	9.1	10.3	12.1	14.4	16.2	18.2	20.9
900	15	5.1	6.6	8.4	9.6	11.2	13.4	15.2	17.0	19.6
1,080	18	4.4	5.7	7.4	8.5	9.9	11.9	13.5	15.1	17.4
1,440	24	3.6	4.7	6.1	7.0	8.2	9.8	11.2	12.5	14.5
2,160	36	2.6	3.5	4.5	5.2	6.2	7.5	8.5	9.6	11.1
2,880	48	2.1	2.8	3.7	4.2	5.0	6.1	6.9	7.8	9.1
4,320	72	1.5	2.0	2.6	3.1	3.6	4.4	5.1	5.8	6.8

Note: Values for 200 and 500 yearARI are approximate only and does not conform to Book 6 of AR&R (1999)

CRC Forge Design Rainfall Totals (mm)

Storm Duration (Hours)	AEP (1 in Y)					
	50	100	200	500	1,000	2,000
0.25	44	49	55	63	69	76
0.50	63	71	79	91	100	110
0.75	75	85	95	109	120	132
1.00	88	99	111	127	140	153
1.5	97	110	123	141	156	171
2	107	121	136	155	171	188
3	117	133	148	170	187	205
4.5	129	145	162	186	205	225
6	140	158	177	203	223	245
9	154	174	194	222	245	269
12	167	189	211	242	267	293
18	194	219	244	280	309	339
24	214	242	270	310	342	375
36	245	278	313	362	403	446
48	276	314	355	415	465	517
72	308	352	400	469	526	589
96	333	382	434	510	572	641
120	348	399	453	532	597	667

PMP Estimates - For small areas and short durations

GSDM Calculation Sheet

Location Information		
Catchment	Ferny Gully	
Area (km^2)	16.70	
State	Queensland	
Latitude		
Longitude		
Refer to Figure 2 to determine which zone the catchment lies in and the maximum duration		
Duration Limit (hours)	6.00	
Portion of area Considered		
*Refer to a suitably contoured map of the area to determine the per cent 'smooth' & the per cent 'rough'**		
Smooth, **S =**	1	(0.0 to 1.0)
Rough, **R =**	0	(0.0 to 1.0)
Elevation adjustment factor (EAF)		
Mean elevation (m)	70	
Adjustment for elevation	0.00	
(-0.05 per 300m above 1500m)		
EAF =	1.00	(0.86 to 1.00)
Moisture adjustment factor		
Refer to Figure 3		
MAF =	0.83	(0.4 to 1.00)

*NB: 'Rough' terrain is that in which elevation changes of 50m or more within horizontal distances of 400m are common. Terrain which is within 20km of generally rough terrain should be classified as 'rough'.

PMP values (mm)

Refer to Figure 4 for D_s and D_R

Duration (hours)	Initial Depth - smooth (D_s)	Initial Depth - rough (D_R)	PMP estimate (D_s*S+D_R*R) *MAF*EAF	Rounded PMP estimate (nearest 10mm)
0.25	205		170	170
0.50	300		249	250
0.75	380		315	320
1.00	450		374	370
1.50	510		423	420
2.00	575		477	480
3.00	640		531	530
4.00	710		589	590
5.00	760		631	630
6.00	810		672	670

Table C1 Sub-Catchment Parameters

Sub-Catchment	Total Area (ha)	Fraction Impervious		Slope (%)	Manning's n	
		Existing	Developed		Impervious	Pervious
SC1	138.6	0.03	0.03	2.39	0.06	0.015
SC2	137.4	0.02	0.02	1.31	0.045	0.015
SC3	176.4	0.04	0.04	1.64	0.06	0.015
SC4	218.8	0.04	0.05	0.66	0.045	0.015
SC5	87.6	0.03	0.38	0.54	0.045	0.015
SC6	37.8	0.06	0.52	3.27	0.1	0.015
SC7	45.1	0.11	0.43	0.46	0.09	0.015
SC8	33.2	0.20	0.43	0.63	0.12	0.015
SC9	26.0	0.30	0.51	2.50	0.05	0.015
SC10	18.1	0.26	0.57	1.68	0.1	0.015
SC11	11.5	0.07	0.53	3.24	0.08	0.015
SC12	16.0	0.20	0.56	2.54	0.05	0.015
SC13	30.5	0.18	0.55	1.13	0.1	0.015
SC14	3.8	0.40	0.66	0.72	0.08	0.015
SC15	8.7	0.46	0.65	1.57	0.05	0.015
SC16	30.4	0.19	0.33	2.04	0.08	0.015
SC17	20.2	0.35	0.42	1.78	0.06	0.015
SC18	17.6	0.27	0.29	0.76	0.06	0.015
SC19	23.0	0.24	0.29	2.58	0.05	0.015
SC20	16.7	0.14	0.25	3.29	0.045	0.015
SC21	5.7	0.29	0.11	1.87	0.045	0.015
SC22	28.1	0.10	0.28	0.70	0.045	0.015
SC23	10.2	0.21	0.28	3.47	0.05	0.015
SC24	1.8	0.09	0.13	0.86	0.045	0.015
SC25	2.2	0.02	0.07	1.66	0.045	0.015
SC26	45.9	0.02	0.40	1.99	0.045	0.015
SC27	28.9	0.03	0.33	2.74	0.06	0.015
SC28	71.2	0.04	0.50	0.82	0.06	0.015
SC29	35.7	0.06	0.49	1.82	0.07	0.015

Sub-	Total Area (ha)	Fraction Impervious		Slope (%)	Manning's n	
SC30	46.8	0.09	0.49	0.51	0.08	0.015
SC31	44.6	0.06	0.60	0.51	0.045	0.015
SC32	25.1	0.22	0.31	0.23	0.06	0.015
SC33	12.7	0.30	0.43	1.10	0.14	0.015
SC34	11.9	0.10	0.25	0.15	0.05	0.015
SC35	16.4	0.13	0.25	0.23	0.05	0.015
SC36	1.3	0.25	0.25	0.97	0.05	0.015
SC37	1.7	0.04	0.04	1.52	0.045	0.015
SC38	18.0	0.31	0.34	2.10	0.06	0.015
SC39	1.3	0.03	0.20	2.90	0.045	0.015
SC40	11.8	0.20	0.22	4.64	0.07	0.015
SC41	10.2	0.22	0.29	3.23	0.06	0.015
SC42	7.8	0.14	0.20	0.87	0.045	0.015
SC43	23.4	0.06	0.23	5.25	0.05	0.015
SC44	9.4	0.07	0.24	9.00	0.055	0.015
SC45	16.8	0.16	0.25	2.72	0.08	0.015
SC46	22.2	0.10	0.19	0.38	0.07	0.015
SC47	35.2	0.09	0.20	0.43	0.045	0.015
SC48	25.4	0.03	0.18	0.39	0.06	0.015
Total	**1669**	**0.09**	**0.25**	-	-	-

Table C2 RAFTS Hydrology Model Results

Sub-Catchment	January 2011 Event	Existing Catchment - 100 year ARI		Developed Catchment - 100 year ARI	
	Peak Discharge (Total) (m³/s)	Peak Discharge (Total) (m³/s)	Critical Duration (min)	Peak Discharge (Total) (m³/s)	Critical Duration (min)
J1	108.5	63.8	120	63.8	120
J10	79.7	46.3	90	83.8	60
J11	247.7	142.1	180	186	60
J12	254.9	145.3	180	200.3	60
J13	10	12.9	60	14.4	60
J2	20.7	18.9	60	30.8	20
J3	44.7	35	60	51.4	60
J4	12.1	12.7	60	14.3	60
J5	62.8	52	60	68.4	60
J6	73.3	58.6	60	76.5	60
J6a	203.1	110.6	180	107.1	180
J7	21.7	18	60	26.8	25
J8	46.5	30.2	90	47.9	60
J9	75.5	44.1	90	79.2	60
N01	36.6	22.6	90	22.6	90
N02	67.7	41.4	90	41.4	90
N03	42	22.5	120	22.5	120
N04	147.8	84.6	120	84.5	120
N05	162.7	93.1	120	90.6	120
N06	167.6	96.3	120	92.1	120
N07	173	98.7	120	94	120
N08	177.2	100.2	120	95.2	120
N09	7.9	8.8	60	12.4	25
N10	12.7	12.4	60	18.9	20
N11	3.3	2.9	60	5.4	25
N12	8	7.4	60	12.1	25
N13	27.3	22.5	60	39.4	20
N14	28.4	23.3	60	40.2	20

Sub-Catchment	January 2011 Event	Existing Catchment - 100 year ARI		Developed Catchment - 100 year ARI	
N15	30.8	25.7	60	41.3	20
N16	8.3	6	60	8.7	25
N17	14.1	11.1	60	14.1	20
N18	49.4	37.7	60	54.5	60
N19	7	7.2	60	7.8	60
N20	5.1	6	60	6.4	60
N21	13.7	14.5	60	16	60
N22	70.3	56.1	60	73.1	60
N23	3.1	3.9	60	4.4	60
N24	73.8	59.1	60	77	60
N25	203.3	110.6	180	107.1	180
N26	13.4	10.9	60	17.1	25
N27	8.3	7	60	9.6	25
N28	37.1	24.5	60	39.5	60
N29	9.6	6	90	14.1	25
N30	53.7	33.3	90	60	60
N31	63.7	38.6	90	70.3	60
N32	67.7	40.4	90	73.2	60
N33	2.8	2.7	25	3.6	25
N34	4.8	3.6	20	5.4	25
N35	8.1	5.3	60	8	60
N36	8.4	5.7	60	8.4	60
N37	75.9	44.2	90	79.7	60
N38	5.4	5.6	60	6	25
N39	79.9	46.4	90	84.1	60
N40	3.6	4	60	4.1	60
N41	6.6	7.1	60	7.3	60
N42	248.3	142.5	180	187.6	60
N43	7	8.8	60	9.5	60
N44	2.9	4.5	60	4.9	60
N45	14.7	16.4	60	18	60

Sub-Catchment	January 2011 Event	Existing Catchment - 100 year ARI		Developed Catchment - 100 year ARI	
N46	258.6	147.1	180	202.1	60
N47	265.3	149.7	180	205.5	60
N48	269.6	151.7	180	207.3	60

Appendix D

Hydraulic Modelling Information

Table D1 Inflow Locations for Extended Hydraulic Model

Sub-catchment	Total/Local	Inflow to branch	Chainage
26	Local	Branch A	1000
27	Local	Branch A	1000
28	Local	Branch A	2400
29	Local	Branch A	2400
30	Local	Branch A	2680
32	Local	Branch A	3320
31	Local	Branch A	3370
37	Local	Branch A	4140
38	Local	Branch A	4140
9-12	Total	Branch B	57.75
13	Local	Branch B	490
14	Local	Branch B	660
15	Local	Branch B	900
17	Local	Branch B	900
18	Local	Branch B	1240
19-21	Total	Branch B	1240
22	Local	Branch B	1815.39
23	Local	Branch B	1815.39
1-4	Total	Ferny	162.6
5	Local	Ferny	2100
6	Local	Ferny	2100
7	Local	Ferny	3850
33	Local	Ferny	3900
34	Local	Ferny	3900
35	Local	Ferny	3900
36	Local	Ferny	3900
8	Local	Ferny	5286.35
24	Local	Ferny	5286.35
25	Local	Ferny	5550

Sub-catchment	Total/Local	Inflow to branch	Chainage
39	Local	Ferny	5550
40-41	Total	Ferny	5620
42	Local	Ferny	5790
43-45	Total	Ferny	5800
46	Local	Ferny	6350
47	Local	Ferny	6940
48	Local	Ferny	7940
16	Local	Tributary B	39.1

Estimated Peak Discharges (m^3/s) - Existing Channel Geometries; Existing and Developed Catchments; 100 yr ARI and January 2011 Events

Location	Chainage (m)	Invert (m)	January 2011	Peak 100yr Existing	Peak100yr Developed	+/-
FERNY	162.6	63.9	147.8	84.5	84.5	0.0
FERNY	648.9	60.6	147.7	84.5	84.5	0.0
FERNY	1532.2	53.6	147.6	84.3	84.7	0.4
FERNY	1763.6	52.3	171.6	97.6	95.4	-2.2
FERNY	2448.1	50.2	171.2	97.3	95.1	-2.2
FERNY	2738.3	48.7	171.2	97.3	95.1	-2.3
FERNY	3047.0	47.4	171.1	97.2	95.0	-2.3
FERNY	3279.3	46.0	171.1	97.2	94.9	-2.3
FERNY	3452.9	45.7	171.0	97.1	94.9	-2.3
FERNY	3648.8	45.1	171.0	97.1	94.8	-2.3
FERNY	3816.3	45.3	182.5	102.6	100.2	-2.4
FERNY	4020.2	43.9	185.1	103.5	101.2	-2.3
FERNY	4020.2	43.9	185.1	103.4	101.1	-2.3
FERNY	4059.0	43.6	183.3	102.6	100.3	-2.3
FERNY	4200.0	42.6	181.2	102.5	101.3	-1.2
FERNY	4200.0	42.6	163.5	102.0	100.5	-1.5
FERNY	4257.0	42.2	160.7	102.0	102.1	0.1
FERNY	4271.2	42.2	159.3	102.0	103.0	1.0
FERNY	4271.2	42.2	137.6	97.1	96.4	-0.7
FERNY	4286.4	42.1	135.0	97.1	98.0	0.9
FERNY	4316.4	42.1	136.0	97.1	97.2	0.1
FERNY	4332.3	41.7	139.0	97.1	95.5	-1.6
FERNY	4393.0	41.1	146.3	97.1	93.9	-3.2
FERNY	4393.0	41.1	125.3	89.7	87.5	-2.2
FERNY	4431.8	40.7	126.0	89.6	87.4	-2.2
FERNY	4815.8	39.0	126.4	89.0	86.3	-2.7
FERNY	5183.6	35.4	126.6	89.1	86.3	-2.8
FERNY	5286.4	35.4	130.4	90.7	88.4	-2.3
FERNY	5369.9	34.9	134.4	92.6	90.7	-1.9
FERNY	5369.9	34.9	180.8	112.8	112.3	-0.4
FERNY	5412.6	34.7	181.0	113.0	112.4	-0.6
FERNY	5585.8	34.2	182.3	113.8	113.4	-0.3
FERNY	5585.8	34.2	298.3	168.3	171.0	2.8
FERNY	5611.7	34.2	301.2	169.9	172.8	2.9
FERNY	5734.6	33.1	309.2	174.1	177.7	3.6
FERNY	5878.6	33.2	307.9	174.0	177.7	3.6
FERNY	5924.5	32.7	307.4	174.0	177.6	3.6
FERNY	6122.0	31.7	304.4	173.9	177.6	3.7
FERNY	6251.3	32.1	304.9	175.7	179.3	3.5
FERNY	6453.3	29.9	300.3	175.6	179.2	3.6
FERNY	6639.3	29.4	300.7	175.5	179.1	3.6
FERNY	6822.8	28.7	300.6	175.4	179.0	3.6
FERNY	7045.1	27.9	305.2	178.7	182.4	3.7
FERNY	7237.0	26.0	303.9	178.6	182.3	3.7
FERNY	7451.0	24.9	301.7	178.6	182.3	3.7
FERNY	7687.6	22.4	298.7	178.6	182.3	3.7
FERNY	7857.8	21.3	296.2	178.6	182.3	3.7
FERNY	7947.3	20.9	294.2	178.6	182.3	3.7
BRANCH_A	191.6	77.3	0.0	0.0	0.0	0.0
BRANCH_A	529.8	68.3	0.2	0.2	0.2	0.0
BRANCH_A	869.7	62.2	0.9	0.9	0.9	0.0
BRANCH_A	1087.6	59.1	21.6	17.8	24.2	6.4
BRANCH_A	1580.2	54.0	21.2	16.8	18.8	2.0
BRANCH_A	1801.0	52.2	21.1	16.2	18.1	1.9
BRANCH_A	2384.2	48.0	45.0	28.0	33.1	5.1
BRANCH_A	2505.3	47.0	52.0	30.7	41.3	10.7
BRANCH_A	2921.9	45.1	52.3	30.0	38.2	8.2
BRANCH_A	2921.9	45.1	50.8	30.0	38.2	8.2
BRANCH_A	2957.0	45.0	50.2	29.7	37.7	8.0
BRANCH_A	2985.0	44.8	50.2	29.7	37.7	8.0
BRANCH_A	3025.6	44.6	50.2	29.7	37.7	8.0
BRANCH_A	3073.9	44.2	50.1	29.7	37.7	8.0
BRANCH_A	3073.9	44.2	65.5	29.8	37.7	7.9

Estimated Peak Discharges (m³/s) - Existing Channel Geometries; Existing and Developed Catchments; 100 yr ARI and January 2011 Events

Location	Chainage (m)	Invert (m)	January 2011	Peak 100yr Existing	Peak100yr Developed	+/-
BRANCH_A	3162.0	43.4	65.5	29.7	37.6	7.9
BRANCH_A	3272.2	42.7	65.5	29.5	37.5	8.1
BRANCH_A	3272.2	42.7	84.1	38.6	40.7	2.1
BRANCH_A	3354.2	42.2	87.5	39.6	42.5	2.9
BRANCH_A	3384.2	42.1	95.7	43.2	46.8	3.6
BRANCH_A	3411.4	41.9	95.7	43.2	46.8	3.6
BRANCH_A	3505.3	41.0	95.5	42.9	46.5	3.6
BRANCH_A	3505.3	41.0	118.2	52.1	53.2	1.1
BRANCH_A	3600.5	40.1	118.1	52.0	53.1	1.1
BRANCH_A	3721.2	39.094	118.0	52.0	53.1	1.1
BRANCH_A	3761.2	39.094	118.0	52.0	53.1	1.1
BRANCH_A	3941.05	38.798	117.9	51.9	53.0	1.1
BRANCH_A	3941.05	38.798	120.1	57.8	58.8	1.0
BRANCH_A	3988.55	38.721	120.1	57.8	58.8	1.0
BRANCH_A	4160	36.98	120.8	58.0	59.2	1.2
BRANCH_B	57.75	53.85	20.7	18.9	30.7	11.8
BRANCH_B	275.58	51.294	20.5	17.4	26.5	9.1
BRANCH_B	542.91	48.279	27.0	20.5	33.6	13.2
BRANCH_B	654	47	28.0	21.1	34.3	13.2
BRANCH_B	749	46.6	28.0	21.1	34.1	13.0
BRANCH_B	793.28	45.829	28.0	21.1	34.0	13.0
BRANCH_B	837.68	44.651	28.0	21.1	34.4	13.4
BRANCH_B	864.71	44.551	28.0	21.1	33.8	12.8
BRANCH_B	929.05	43.864	34.0	26.1	39.4	13.4
BRANCH_B	929.05	43.864	42.5	31.1	45.6	14.5
BRANCH_B	946.53	43.678	44.2	32.5	47.1	14.7
BRANCH_B	987	43.495	44.1	32.5	47.1	14.7
BRANCH_B	1058.04	42.913	44.2	32.4	47.1	14.7
BRANCH_B	1110	42.502	44.2	32.5	47.1	14.7
BRANCH_B	1168	42.108	44.5	32.7	47.4	14.7
BRANCH_B	1209.96	41.179	45.4	33.5	48.3	14.8
BRANCH_B	1219	41.191	46.0	34.7	48.8	14.1
BRANCH_B	1249	40.997	63.5	49.5	65.7	16.2
BRANCH_B	1268.82	41.1	62.7	49.0	64.9	15.9
BRANCH_B	1400.18	39.754	61.9	48.1	63.7	15.6
BRANCH_B	1634.19	38.477	61.6	47.6	62.8	15.2
BRANCH_B	1815.39	37.555	63.9	49.1	62.3	13.2
TRIBUTARY_B	39.1	50.897	8.3	5.9	8.7	2.7
TRIBUTARY_B	140.76	48.947	8.3	5.7	8.2	2.5
TRIBUTARY_B	186.92	48.491	8.3	13.1	21.8	8.6
TRIBUTARY_B	218.48	47.014	8.5	21.0	34.3	13.3
TRIBUTARY_A	41.29	41.078	0.0	0.0	0.0	0.0
TRIBUTARY_A	151.48	41.215	11.6	11.6	11.6	0.0
WEIR_A	0	44.869	17.7	0.8	0.8	0.0
WEIR_A	27	44.869	17.2	0.9	1.0	0.1
WEIR_A	47	44.869	17.1	0.9	1.0	0.1
WEIR_A	189	44.869	17.0	0.9	1.1	0.1
WEIR_B	0	42.839	21.0	7.4	6.5	-0.9
WEIR_B	79	42.839	22.0	7.4	6.5	-0.9
WEIR_B	99	42.839	22.0	7.4	6.5	-0.9
WEIR_B	372	42.839	23.0	11.4	10.9	-0.5
WEIR_C	0	45.903	0.1	0.1	0.1	0.0
WEIR_C	90	45.903	0.0	0.0	0.0	0.0
WEIR_C	110	45.903	0.0	0.0	0.0	0.0
WEIR_C	161.25	45.903	0.2	0.2	0.2	0.0
WEIR_D	0	44.25	21.7	6.8	6.7	-0.2
WEIR_D	42	44.25	21.8	9.9	8.3	-1.6
WEIR_D	62	44.25	22.3	10.2	8.4	-1.8
WEIR_D	256.12	44.25	24.2	12.0	10.2	-1.8

Estimated Peak Water Levels (m) - Existing Channel Geometries; Existing and Developed Catchments; 100 yr ARI and January 2011 Events

Location	Chainage (m)	Invert (m)	January 2011	Peak 100yr Existing	Peak100yr Developed	+/-	100 yr Existing - Tailwater @ 40.32m	100 yr Developed - Tailwater @ 40.32m	January 2011 - Localised Flooding	January 2011 - Wivenhoe Flooding
FERNY	162.6	63.9	65.6	65.3	65.3	0.0	65.3	65.3	65.6	64.3
FERNY	648.9	60.6	62.4	62.0	62.0	0.0	62.0	62.0	62.4	60.9
FERNY	1632.2	63.6	59.1	58.0	58.0	0.0	58.0	58.0	59.1	54.9
FERNY	1763.6	62.3	59.1	58.0	57.9	0.0	58.0	57.9	59.1	54.9
FERNY	2448.1	50.2	52.8	52.5	52.5	0.0	52.5	52.5	52.8	51.8
FERNY	2738.3	48.7	51.2	50.9	50.9	0.0	50.9	50.9	51.2	49.6
FERNY	3047.0	47.4	50.0	49.6	49.6	0.0	49.6	49.6	50.0	48.5
FERNY	3279.3	46.0	49.3	48.7	48.7	0.0	48.7	48.7	49.3	47.4
FERNY	3452.9	45.7	48.4	48.0	48.0	0.0	48.0	48.0	48.4	46.5
FERNY	3648.8	45.1	48.4	47.9	47.9	0.0	47.9	47.9	48.4	46.3
FERNY	3816.3	45.3	47.0	46.6	46.6	0.0	46.6	46.6	47.0	45.7
FERNY	4020.2	43.9	46.2	45.7	45.7	0.0	45.7	45.7	46.2	44.6
FERNY	4020.2	43.9	46.2	45.7	45.7	0.0	45.7	45.7	46.2	44.6
FERNY	4059.0	43.6	46.1	45.6	45.6	0.0	45.6	45.6	46.1	44.4
FERNY	4200.0	42.6	45.7	45.3	45.3	-0.1	45.3	45.3	45.7	43.7
FERNY	4200.0	42.6	45.7	45.3	45.3	-0.1	45.3	45.3	45.7	43.7
FERNY	4257.0	42.2	45.5	45.2	45.0	-0.2	45.2	45.0	45.5	43.3
FERNY	4271.2	42.2	45.4	45.1	44.9	-0.2	45.1	44.9	45.4	42.8
FERNY	4271.2	42.2	45.4	45.1	44.9	-0.2	45.1	44.9	45.4	42.8
FERNY	4286.4	42.1	45.5	45.1	44.9	-0.2	45.1	44.9	45.5	42.7
FERNY	4316.4	42.1	44.4	44.0	44.0	0.0	44.0	44.0	44.4	42.5
FERNY	4332.3	41.7	44.4	44.0	44.0	0.0	44.0	44.0	44.4	42.5
FERNY	4393.0	41.1	43.8	43.5	43.5	0.0	43.5	43.5	43.8	42.5
FERNY	4393.0	41.1	43.8	43.5	43.5	0.0	43.5	43.5	43.8	42.5
FERNY	4431.8	40.7	43.6	43.3	43.3	0.0	43.3	43.3	43.6	42.5
FERNY	4815.8	39.0	42.5	41.7	41.7	0.0	41.9	41.9	42.0	42.5
FERNY	5183.6	35.4	42.5	39.0	39.0	0.0	40.6	40.6	40.2	42.5
FERNY	5286.4	35.4	42.5	38.9	38.8	0.0	40.6	40.6	40.2	42.5
FERNY	5369.9	34.9	42.5	38.6	38.7	0.0	40.6	40.6	40.2	42.5
FERNY	5369.9	34.9	42.5	38.6	38.7	0.0	40.6	40.6	40.2	42.5
FERNY	5412.6	34.7	42.5	38.6	38.6	0.0	40.6	40.6	40.2	42.5
FERNY	5585.8	34.2	42.5	38.1	38.1	0.0	40.5	40.6	40.2	42.5
FERNY	5585.8	34.2	42.5	38.1	38.1	0.0	40.5	40.6	40.2	42.5
FERNY	5611.7	34.2	42.5	37.9	37.9	0.0	40.5	40.6	40.2	42.5
FERNY	5734.6	33.1	42.5	37.3	37.3	0.0	40.5	40.5	40.2	42.5
FERNY	5878.6	33.2	42.5	36.9	36.9	0.0	40.5	40.5	40.2	42.5
FERNY	5924.5	32.7	42.5	36.7	36.7	0.0	40.5	40.5	40.2	42.5
FERNY	6122.0	31.7	42.5	36.0	36.0	0.0	40.5	40.5	40.2	42.5
FERNY	6251.3	32.1	42.5	35.3	35.3	0.0	40.5	40.5	40.2	42.5
FERNY	6453.3	29.9	42.5	34.2	34.2	0.0	40.5	40.5	40.2	42.5
FERNY	6639.3	29.4	42.5	33.7	33.7	0.0	40.4	40.4	40.2	42.5
FERNY	6822.8	28.7	42.5	33.0	33.0	0.0	40.4	40.4	40.2	42.5
FERNY	7045.1	27.9	42.5	32.0	32.1	0.0	40.4	40.4	40.2	42.5
FERNY	7237.0	26.0	42.5	30.9	30.9	0.0	40.4	40.4	40.2	42.5
FERNY	7451.0	24.9	42.5	29.8	29.8	0.0	40.4	40.4	40.2	42.5
FERNY	7687.6	22.4	42.5	27.2	27.2	0.0	40.3	40.3	40.2	42.5
FERNY	7857.8	21.3	42.5	26.4	26.4	0.0	40.3	40.3	40.2	42.5
FERNY	7947.3	20.9	42.5	26.0	26.0	0.0	40.3	40.3	40.2	42.5
BRANCH_A	191.6	77.3	77.4	77.4	77.4	0.0	77.3	77.3	77.4	77.3
BRANCH_A	529.8	68.3	68.4	68.4	68.4	0.0	68.4	68.4	68.4	68.3
BRANCH_A	869.7	62.2	62.3	62.3	62.3	0.0	62.2	62.2	62.3	62.2
BRANCH_A	1087.6	69.1	59.7	59.7	59.7	0.0	59.7	59.7	59.7	59.1
BRANCH_A	1580.2	64.0	54.9	54.8	54.8	0.0	54.8	54.8	54.9	54.2
BRANCH_A	1801.0	62.2	52.7	52.7	52.7	0.0	52.7	52.7	52.7	52.3
BRANCH_A	2384.2	48.0	48.5	48.4	48.4	0.0	48.4	48.4	48.5	48.1
BRANCH_A	2505.3	47.0	47.6	47.5	47.6	0.0	47.5	47.6	47.6	47.3
BRANCH_A	2921.9	45.1	46.5	46.4	46.4	0.0	46.4	46.4	46.5	45.8
BRANCH_A	2921.9	45.1	46.5	46.4	46.4	0.0	46.4	46.4	46.5	45.8
BRANCH_A	2957.0	45.0	46.5	46.4	46.4	0.0	46.4	46.4	46.5	45.8
BRANCH_A	2985.0	44.8	45.3	45.2	45.2	0.0	45.2	45.2	45.3	45.0
BRANCH_A	3025.6	44.6	45.0	44.9	45.0	0.0	44.9	45.0	45.0	44.8
BRANCH_A	3073.9	44.2	44.6	44.5	44.5	0.0	44.5	44.5	44.6	44.3
BRANCH_A	3073.9	44.2	44.6	44.5	44.5	0.0	44.5	44.5	44.6	44.3
BRANCH_A	3162.0	43.4	43.9	43.7	43.8	0.0	43.7	43.8	43.9	43.6
BRANCH_A	3272.2	42.7	43.5	43.3	43.3	0.0	43.3	43.3	43.5	43.1
BRANCH_A	3272.2	42.7	43.5	43.3	43.3	0.0	43.3	43.3	43.5	43.1
BRANCH_A	3354.2	42.2	43.5	43.3	43.3	0.0	43.3	43.3	43.5	43.1
BRANCH_A	3384.2	42.1	42.8	42.6	42.6	0.0	42.6	42.6	42.8	42.5
BRANCH_A	3411.4	41.9	42.7	42.5	42.5	0.0	42.5	42.5	42.7	42.5
BRANCH_A	3505.3	41.0	42.5	41.9	41.9	0.0	41.9	41.9	42.2	42.5
BRANCH_A	3505.3	41.0	42.5	41.9	41.9	0.0	41.9	41.9	42.2	42.5
BRANCH_A	3600.5	40.1	42.5	41.7	41.7	0.0	41.7	41.7	42.1	42.5
BRANCH_A	3721.2	39.094	42.5	41.5	41.5	0.0	41.5	41.5	41.7	42.5
BRANCH_A	3761.2	39.094	42.5	40.9	40.9	0.0	41.1	41.1	41.5	42.5
BRANCH_A	3941.05	38.798	42.5	40.0	40.0	0.0	40.6	40.6	40.4	42.5
BRANCH_A	3941.05	38.798	42.5	40.0	40.0	0.0	40.6	40.6	40.4	42.5
BRANCH_A	3988.55	38.721	42.5	39.7	39.7	0.0	40.5	40.5	40.2	42.5
BRANCH_A	4160	36.98	42.5	38.1	38.1	0.0	40.5	40.6	40.2	42.5
BRANCH_B	57.76	53.85	54.6	54.6	54.7	0.2	54.6	54.7	54.6	53.9
BRANCH_B	275.58	51.294	51.9	51.8	51.9	0.1	51.8	51.9	51.9	51.3
BRANCH_B	542.91	48.279	49.5	49.4	49.5	0.2	49.4	49.5	49.5	48.8
BRANCH_B	654	47	48.2	48.1	48.3	0.2	48.1	48.3	48.2	47.2
BRANCH_B	749	46.6	47.7	47.6	47.8	0.2	47.6	47.8	47.7	46.8
BRANCH_B	793.28	45.829	46.7	46.6	46.8	0.1	46.6	46.8	46.7	46.1
BRANCH_B	837.68	44.651	45.9	45.8	46.0	0.1	45.8	46.0	45.9	44.9
BRANCH_B	864.71	44.651	45.9	45.8	46.0	0.1	45.8	46.0	45.9	44.8
BRANCH_B	929.05	43.864	45.0	45.0	45.0	0.1	45.0	45.0	45.0	44.1

Estimated Peak Water Levels (m) - Existing Channel Geometries; Existing and Developed Catchments; 100 yr ARI and January 2011 Events

Location	Chainage (m)	Invert (m)	January 2011	Peak 100yr Existing	Peak100yr Developed	+/-	100 yr Existing - Tailwater @ 40.32m	100 yr Developed - Tailwater @ 40.32m	January 2011 - Localised Flooding	January 2011 - Wivenhoe Flooding
BRANCH_B	929.05	43.864	45.0	45.0	45.0	0.1	45.0	45.0	45.0	44.1
BRANCH_B	946.53	43.678	44.9	44.9	45.0	0.1	44.9	45.0	44.9	44.0
BRANCH_B	987	43.495	44.3	44.2	44.3	0.1	44.2	44.3	44.3	43.6
BRANCH_B	1058.04	42.913	44.0	43.9	44.0	0.1	43.9	44.0	44.0	43.2
BRANCH_B	1110	42.602	43.5	43.5	43.6	0.1	43.5	43.6	43.5	42.7
BRANCH_B	1168	42.108	43.1	43.0	43.1	0.1	43.0	43.1	43.1	42.5
BRANCH_B	1209.96	41.179	42.8	42.7	42.8	0.2	42.7	42.8	42.8	42.5
BRANCH_B	1219	41.191	42.8	42.6	42.8	0.2	42.6	42.7	42.8	42.5
BRANCH_B	1249	40.997	42.6	42.5	42.6	0.1	42.5	42.6	42.6	42.5
BRANCH_B	1268.82	41.1	42.5	42.3	42.5	0.1	42.3	42.5	42.4	42.5
BRANCH_B	1400.18	39.764	42.5	41.3	41.4	0.1	41.4	41.5	41.4	42.5
BRANCH_B	1634.19	38.477	42.5	40.0	40.1	0.1	40.6	40.7	40.2	42.5
BRANCH_B	1815.39	37.555	42.5	38.6	38.7	0.0	40.6	40.6	40.2	42.5
TRIBUTARY_B	39.1	60.897	51.3	51.3	51.3	0.0	51.3	51.3	51.3	50.9
TRIBUTARY_B	140.76	48.947	49.5	49.5	49.5	0.0	49.5	49.5	49.5	49.0
TRIBUTARY_B	186.92	48.491	48.7	48.7	48.7	0.0	48.7	48.7	48.7	48.5
TRIBUTARY_B	218.48	47.014	47.1	47.1	47.1	0.0	45.0	45.0	47.1	44.1
TRIBUTARY_A	41.29	41.078	42.5	41.2	41.2	0.0	41.1	41.1	41.2	42.5
TRIBUTARY_A	151.48	41.215	42.5	41.3	41.3	0.0	40.6	40.6	41.3	42.5
WEIR_A	0	44.869	45.7	45.3	45.3	-0.1	45.3	45.3	45.7	43.7
WEIR_A	27	44.869	45.7	45.3	45.3	-0.1	45.3	45.3	45.7	44.9
WEIR_A	47	44.869	45.4	45.1	45.0	-0.1	45.1	45.0	45.4	44.9
WEIR_A	189	44.869	45.0	45.0	45.0	0.0	44.5	44.5	45.0	44.3
WEIR_B	0	42.839	43.8	43.5	43.5	0.0	43.5	43.5	43.8	42.5
WEIR_B	79	42.839	43.7	43.5	43.4	0.0	43.5	43.5	43.7	42.8
WEIR_B	99	42.839	43.6	43.3	43.3	0.0	43.3	43.3	43.6	42.8
WEIR_B	372	42.839	42.9	42.9	42.9	0.0	41.9	41.9	42.9	42.5
WEIR_C	0	45.903	46.2	46.0	46.0	0.0	45.7	45.7	46.2	44.6
WEIR_C	90	45.903	46.3	46.2	46.2	0.0	46.2	46.2	46.3	45.9
WEIR_C	110	45.903	46.5	46.4	46.4	0.0	46.4	46.4	46.5	45.9
WEIR_C	161.25	45.903	46.5	46.4	46.4	0.0	46.4	46.4	46.5	45.8
WEIR_D	0	44.25	45.4	45.1	44.9	-0.2	45.1	44.9	45.4	42.8
WEIR_D	42	44.25	45.3	45.1	44.9	-0.2	45.0	44.9	45.3	44.3
WEIR_D	62	44.25	45.0	44.9	44.7	-0.2	44.9	44.7	45.0	44.3
WEIR_D	256.12	44.25	44.4	44.4	44.4	0.0	43.3	43.3	44.4	43.1

Estimated Peak Water Levels (m) - Channel Geometries w/ Drainage Solutions; Existing and Developed Catchments; 100 yr ARI Event

Location	Chainage	Invert (m)	Peak 100yr Existing w/ Drainage Solutions	Peak 100yr Developed w/ Drainage Solutions	+/-
FERNY	162.60	63.9	65.3	65.3	0.0
FERNY	648.86	60.6	62.0	62.0	0.0
FERNY	1532.21	53.6	58.0	58.0	0.0
FERNY	1763.58	52.3	58.0	57.9	0.0
FERNY	2448.13	50.2	52.5	52.5	0.0
FERNY	2738.34	48.7	50.9	50.9	0.0
FERNY	3046.98	47.4	49.6	49.6	0.0
FERNY	3279.33	46.0	48.7	48.7	0.0
FERNY	3452.88	45.7	48.0	48.0	0.0
FERNY	3648.80	45.1	47.9	47.9	0.0
FERNY	3816.25	45.3	46.6	46.6	0.0
FERNY	4020.18	43.9	45.7	45.7	0.0
FERNY	4020.18	43.9	45.7	45.7	0.0
FERNY	4058.96	43.7	45.6	45.6	0.0
FERNY	4200.00	42.6	45.3	45.3	0.1
FERNY	4200.00	42.6	45.3	45.3	0.1
FERNY	4257.00	42.2	45.1	45.2	0.1
FERNY	4271.17	42.2	45.0	45.1	0.1
FERNY	4271.17	42.2	45.0	45.1	0.1
FERNY	4286.37	42.1	45.0	45.1	0.1
FERNY	4316.37	42.1	44.0	43.9	-0.1
FERNY	4332.29	41.7	44.0	43.9	-0.1
FERNY	4393.00	41.1	43.6	43.5	-0.1
FERNY	4393.00	41.1	43.6	43.5	-0.1
FERNY	4431.79	40.7	43.4	43.3	-0.1
FERNY	4815.76	39.0	41.8	41.7	0.0
FERNY	5183.64	35.4	39.1	39.0	-0.1
FERNY	5286.35	35.4	38.9	38.9	-0.1
FERNY	5369.85	34.9	38.7	38.7	0.0
FERNY	5369.85	34.9	38.7	38.7	0.0
FERNY	5412.57	34.7	38.6	38.6	0.0
FERNY	5585.76	34.2	38.1	38.1	0.0
FERNY	5585.76	34.2	38.1	38.1	0.0
FERNY	5611.65	34.2	38.0	38.0	0.0
FERNY	5734.55	33.1	37.3	37.3	0.0
FERNY	5878.55	33.2	36.9	36.9	0.0
FERNY	5924.54	32.7	36.7	36.7	0.0
FERNY	6121.95	31.7	36.0	36.0	0.0
FERNY	6251.25	32.1	35.4	35.4	0.0
FERNY	6453.33	29.9	34.3	34.3	0.0
FERNY	6639.32	29.4	33.7	33.7	0.0
FERNY	6822.80	28.7	33.0	33.1	0.0
FERNY	7045.07	27.9	32.1	32.1	0.0
FERNY	7237.00	26.0	30.9	31.0	0.0
FERNY	7451.02	24.9	29.8	29.8	0.0
FERNY	7687.64	22.4	26.1	26.1	0.0
FERNY	7857.80	21.3	26.0	26.1	0.0
FERNY	7947.31	20.9	26.0	26.0	0.0
BRANCH_A	191.55	77.3	77.3	77.3	0.0
BRANCH_A	529.81	68.3	68.4	68.4	0.0
BRANCH_A	869.69	62.2	62.2	62.2	0.0
BRANCH_A	1087.62	59.1	59.7	59.7	0.0
BRANCH_A	1580.17	54.0	54.8	54.8	0.0
BRANCH_A	1800.95	52.2	52.7	52.7	0.0
BRANCH_A	2384.19	48.0	48.4	48.4	0.0
BRANCH_A	2505.25	47.0	47.5	47.6	0.0
BRANCH_A	2921.92	45.1	45.6	45.7	0.1
BRANCH_A	2921.92	45.1	45.6	45.7	0.1
BRANCH_A	2957.00	45.0	45.6	45.7	0.1
BRANCH_A	2985.00	44.8	45.2	45.2	0.0
BRANCH_A	3025.58	44.6	44.9	45.0	0.0
BRANCH_A	3073.93	44.2	44.5	44.5	0.0
BRANCH_A	3073.93	44.2	44.5	44.5	0.0
BRANCH_A	3161.95	43.4	43.7	43.8	0.0
BRANCH_A	3272.20	42.7	43.2	43.3	0.0
BRANCH_A	3272.20	42.7	43.2	43.3	0.0
BRANCH_A	3344.19	42.2	43.0	43.1	0.1

Estimated Peak Water Levels (m) - Channel Geometries w/ Drainage Solutions; Existing and Developed Catchments; 100 yr ARI Event

Location	Chainage	Invert (m)	Peak 100yr Existing w/ Drainage Solutions	Peak 100yr Developed w/ Drainage Solutions	+/-
BRANCH_A	3354.19	41.3	43.0	43.1	0.1
BRANCH_A	3384.19	41.3	42.1	42.2	0.1
BRANCH_A	3411.35	41.2	42.0	42.1	0.1
BRANCH_A	3505.30	40.5	41.6	41.6	0.1
BRANCH_A	3505.30	40.5	41.6	41.6	0.1
BRANCH_A	3600.49	39.9	41.2	41.3	0.1
BRANCH_A	3721.20	39.1	41.1	41.1	0.1
BRANCH_A	3761.20	39.1	40.8	40.9	0.1
BRANCH_A	3941.05	38.8	40.0	40.0	0.0
BRANCH_A	3941.05	38.8	40.0	40.0	0.0
BRANCH_A	3988.55	38.7	39.7	39.7	0.0
BRANCH_A	4160.00	37.0	38.1	38.1	0.0
BRANCH_B	57.75	53.9	54.6	54.7	0.2
BRANCH_B	275.58	51.3	51.8	51.9	0.1
BRANCH_B	542.91	48.3	49.4	49.5	0.2
BRANCH_B	654.00	47.0	48.1	48.3	0.2
BRANCH_B	749.00	46.6	47.6	47.8	0.2
BRANCH_B	755.00	46.1	47.5	47.7	0.1
BRANCH_B	783.28	45.8	46.5	46.6	0.1
BRANCH_B	793.28	44.8	45.8	46.1	0.3
BRANCH_B	837.68	43.6	45.6	45.9	0.3
BRANCH_B	864.71	43.6	44.5	44.8	0.3
BRANCH_B	900.00	43.0	44.1	44.4	0.3
BRANCH_B	929.05	42.5	43.9	44.3	0.4
BRANCH_B	929.05	42.5	43.9	44.3	0.4
BRANCH_B	946.53	42.2	43.8	44.2	0.4
BRANCH_B	987.00	42.1	43.6	44.0	0.4
BRANCH_B	1058.04	41.8	43.4	43.7	0.4
BRANCH_B	1110.00	41.6	43.0	43.2	0.2
BRANCH_B	1168.00	41.4	42.8	43.0	0.2
BRANCH_B	1209.96	41.2	42.6	42.8	0.1
BRANCH_B	1219.00	41.2	42.6	42.7	0.1
BRANCH_B	1249.00	41.0	42.5	42.6	0.1
BRANCH_B	1268.82	41.1	42.3	42.5	0.1
BRANCH_B	1400.18	39.8	41.4	41.4	0.1
BRANCH_B	1634.19	38.5	40.0	40.1	0.1
BRANCH_B	1815.39	37.6	38.7	38.7	0.0
TRIBUTARY_B	39.10	50.9	51.3	51.3	0.0
TRIBUTARY_B	140.76	49.0	49.5	49.5	0.0
TRIBUTARY_B	186.92	48.5	48.7	49.1	0.4
TRIBUTARY_B	218.48	47.0	43.9	44.3	0.4
TRIBUTARY_A	41.29	41.1	41.1	41.1	0.0
TRIBUTARY_A	151.48	41.2	40.0	40.0	0.0
WEIR_A	0.00	44.9	45.3	45.3	0.1
WEIR_A	27.00	44.9	45.3	45.3	0.1
WEIR_A	47.00	44.9	45.0	45.1	0.1
WEIR_A	189.00	44.9	44.5	44.5	0.0
WEIR_B	0.00	42.8	43.6	43.5	-0.1
WEIR_B	79.00	42.8	43.6	43.5	-0.1
WEIR_B	99.00	42.8	42.8	42.8	0.0
WEIR_B	372.00	42.8	41.6	41.6	0.1
WEIR_C	0.00	45.9	45.7	45.7	0.0
WEIR_C	90.00	45.9	45.8	45.8	0.0
WEIR_C	110.00	45.9	45.9	45.9	0.0
WEIR_C	161.25	45.9	45.6	45.7	0.1
WEIR_D	0.00	44.3	45.0	45.1	0.1
WEIR_D	42.00	44.3	44.9	45.0	0.1
WEIR_D	62.00	44.3	44.7	44.9	0.1
WEIR_D	256.12	44.3	43.2	43.3	0.0

Appendix E

Policy Information

Planning Scheme Policy 12-Flood Mitigation in the Lowood & Fernvale Locality

1.0 Purpose
To identify and implement the standards Council will rely on when determining the level of flood immunity of all future development in the Lowood & Fernvale locality.

2.0 Contents
Council when considering and determining the merits of all development applications in the Lowood & Fernvale locality will use the Fernvale & Lowood Flood Study including map "SRC Q100Flood Level 091010" as the basis of assessment in determining a suitable level of flood immunity.

Explanatory Statement
As the Lowood and Fernvale locality is becoming an increasingly desirable place to live the Somerset Regional Council has recognized the need to adopt a range of contemporary development standards to provide confidence in the market and to achieve an appropriate standard of development.
Brisbane City Works has recently completed a flood study for the Lowood and Fernvale locality as part of their Flood Mitigation Strategy for the Brisbane River. Accordingly Somerset Regional Council has adopted this study including map "SRC Q100Flood Level 091010" as the basis of assessment in determining a suitable level of flood immunity for all new development in the Lowood & Fernvale locality.

Requirement Checklist and Information

New Dwellings & Enclosed Additions

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15/6/10

- ☐ Completed Development Application – IDAS Forms 1 & 2 for building work.(original only)
- ☐ An appropriately qualified person will be required to provide the site investigation details and certify the design wind classification in accordance with AS 4055 for the site.
- ☐ All housing building applications will require a certified soil test and footing / slab design. Extensions to dwellings will require the engineer to reassess the original design and provide a detail and certification covering the extension. Restumping of a dwelling requires this process to be followed also.
- ☐ Three (3) copies of professionally drafted plans showing author, BSA licence number, plan reference and page numbers, are required with <u>all</u> applications.
- ☐ All steel frame construction requires engineer's certification as well as buildings of unusual design or that exceed the parameters of standard tables or codes.
- ☐ A Truss layout, uplift values and tie-down recommendations from Truss Manufacturer together with details of significant tie down points.
- ☐ Documentation will be required that the owner is aware of the anti-termite measures used, their life and maintenance requirements.
- ☐ Certification by an accredited person that the design of the energy efficiency provisions complies with the BCA provisions.
- ☐ Certification by an appropriately experienced person in respect to design of buildings in bushfire prone areas.
- ☐ QBSA: Queensland Building Services Authority Requirements of:
  - ☐ Owner Builders Number or
  - ☐ Evidence of Cover by the builder.
- ☐ QLeave: (Portable Long Service Leave Levy Authority / Division of Workplace Health and Safety) Payment Form.
- ☐ Required fees must be paid when application is made.
- ☐ A properly made plumbing and drainage application must be made and approved prior to the building approval being issued in non-sewered areas. (Refer to P/D Info sheet.)
- ☐ Where a Material Change of Use (MCU), Building Work under the Planning Scheme planning approval or an SP Reg siting referral advice is required for the development; the MCU, BWAPS or siting approval must precede the approval of the building work.

Plans to show the following:- (where applicable)

- ☐ Site Plan - adequate size to clearly dimension location of building in relation to other structures and property boundaries.
- ☐ Floor Plans and Elevations.
- ☐ Contour Plan - to a suitable scale.
- ☐ Sewer - Drainage Plan to a suitable scale.
- ☐ Bracing plan and calculations or be Engineer Certified. Illustrations to include details of fixing to roof frame or external wall, and connection to floor.
- ☐ Tie-down specification including drawn details, including species/stress grade. Specific detail of the job is required rather than general selection tables.
- ☐ Proposed termite prevention measures to be defined.
- ☐ Smoke detectors location and specification.
- ☐ BCA Energy Efficiency provisions are to be detailed.
- ☐ QDC MP4.1 - Sustainable Buildings provisions are specified.
- ☐ QDC MP4.2 – Water Savings Targets are specified.
- ☐ Bush Fire provisions are to be detailed.
- ☐ Retaining walls and other site structures.
- ☐ Detail of stormwater disposal suitable for the proposed site and should also detail run off management from the site prior to site stabilisation.
- ☐ Detail of design compliance with the QDC NMP 1.4 for Excavation and Piling near Sewers, Storm Water Drains and Water Mains as adopted by Somerset Regional Council.

Building Permit Fees: (includes Approval and Inspection) (Current to 1/7/11)
(*includes GST if applicable)

• **Dwellings - New & Additions** (including Relatives Accom and Caretakers Dwelling)		
• New Dwelling (up to 200 sq metres)(incl. 4 insp.)	$	830.00*
(exceeding 200 sq metres)(incl. 4 insp.)	$	894.00*
• Enclosed – Alterations, Additions & Restumping (incl. 2 insp.)	$	397.00*
• Minor alt and add incl. new toilet addit, structural beam placement etc (incl 1 insp.)	$	233.00*
• **Archive / Lodgement Fee**	$	108.00
• Re-Inspection Fee	$	125.00*
• Written Report on Inspection	$	87.00*
• Multiple Dwellings (per unit)	$	592.00*
• New prefabricated transportable dwelling assessment / approval (per design) and building inspections (per inspection, per unit)	$ $	291.00* 125.00*
• Change of use of building – # same fee as for Class being sought as if it were new works.		#*
• Referral Agency performance siting assessment under the Bld Reg.	$	209.00
• Amendment to existing approved plans (% of applicable original charge)		20%

__Design__

- All works are to comply with the ***Sustainable Planning Act, Queensland Building Act*****, Building Regulation, Housing Provisions of the Building Code of Australia Vol 2, the Queensland Development Code (QDC)** and all other relevant Standards and Manufacturers literature.

- __Siting__ requirements are set within the above legislation and require to be interpreted by the designer or building certifier in conjunction with the landowner.

  The proposed buildings should be designed to ensure compliance with all siting requirements contained in the Planning Schemes, the Building Regulation, the Building Code of Australia and the QDC in all respects.

  This includes considerations of issues such as:
    - distances from road frontages in the Planning Schemes and the Bldg Reg,
    - distances from side and rear boundaries,
    - exceeding the 9.0 maximum length of elevation when within the 1.5 meter side and rear boundary setback,
    - fire separation requirements between dwellings and boundaries where an outbuilding is between,
    - percentage of site coverage,
    - discharge of storm water from the building and the direction of overland water flow due to the building placement,
    - requirements for the maintenance of the building,
    - support or retaining of building platform where cut or fill occurs,
    - checking that buildings are not over easements, storm water, septic or sewerage infrastructure.

- Construction in designated bush fire prone areas as defined on Planning Scheme Maps - Bushfire Hazard Areas, may trigger assessment & design under the Australian Standard 3959 - Construction of buildings in bushfire prone areas.

- Issues such as termite management proposals; minimum ceiling heights; facilities to be provided e.g. kitchen, vanity, bath/shower, laundry and toilet; light and ventilation requirements; stormwater design calculations details; damp proofing and weep holes; location of hardwired smoke alarms; bushfire protection measures; fire separation; sound transmission; energy efficiency provisions etc are set out in the **Housing Provisions of the Building Code of Australia**. These details need to be documented in the design presentation.

- Council specific requirements in relation to __floor heights__ include:-
  - The minimum stump height for a dwelling shall be 450mm above ground level.
  - Minimum slab height for a dwelling slab be 225mm above ground level to allow for in-slab drainage.
  - Floor height for habitable space is to be minimum of 300mm above any previous flood levels. It is the responsibility of the applicant to ensure compliance and to provide documentation for any proposed floor level which is in doubt.

- **A Material Change of Use (MCU) application (IDAS Forms 1 & 5) under the planning schemes may be required in the following circumstances:** (Caution: The old Esk and old Kilcoy schemes are still in force and have some similarities but also some differences as noted.)
  - Housing affected by the catchment management stream hierarchy overlay mapping, declared catchments or water supply protection buffer (both);
  - Housing on flood prone land (both);
  - Housing on land of gradient 1:8 or greater for 50% or more of the site (Kilcoy);
  - Proposed house sites in the Declared Bush Fire Prone areas (Kilcoy) (Esk - Advisory only).
  - Housing in an area of biodiversity significance as referenced in the overlay mapping (both).
  - Second dwellings or relatives apartments (both);
  - Housing on allotments serviced by an unformed road (Esk);
  - Housing on allotments of 4,000 sq metres or less in the Rural zone without a sealed road and not connected to approved reticulated sewerage and water (Esk);
  - Proposed house sites with separation distances which compromise a continued operation of an existing or approved intensive animal husbandry or rural use (both).
  - Where the site frontage is to a main road and is less than the 65 metre siting setback as required by the planning scheme overlay for Major Transport Infrastructure (Esk).
  - The lot has an electricity transmission line easement, substation or power generating station located in the proximity and therefore is subject to a 40 metre siting setback as required by the planning scheme overlay for the Energy Corridor and Infrastructure overlay (Esk).
  - The lot has a gas pipeline located in the proximity and therefore is subject to a 100 metre siting setback as required by the planning scheme overlay for the Energy Corridor and Infrastructure overlay (Esk).

- **A Building Works against Planning Scheme application (IDAS Forms 1 & 6) may be required in the following circumstances:** (Caution: The old Esk and old Kilcoy schemes are still in force and have some similarities but also some differences as noted.)
  - The erection of a Class 10 building that is not an ancillary structure to an existing domestic use is code assessable (both).
  - Second sheds – rural exempt (Kilcoy).
  - Sheds greater than 72 sq met in Town and Village Zones (Esk)
  - Sheds greater than 120 sq met and exceeding 3.6 met in height any zone (Kilcoy).
  - Development within the Cultural Heritage Overlay incl Schedule 1 (Kilcoy).

- **Application for Local Govt Referral under SP Reg Sched 7** (Council form) is triggered by:
  (a) siting of a proposed building which is less than that specified in either of the planning schemes, or
  (b) less than that specified in the Queensland Development Code (QDC).

  Examples of the triggers in the Esk scheme include:
  - Any building less than 6.0 metres from a road frontage in Town and Village zone.
  - Any building less than 15.0 meters from a road frontage in the Rural Zone, except where it is within the Urban Footprint.

  Examples of triggers in the Kilcoy scheme include:
  An outbuilding -
  - less than 3.0 metres from a side boundary.
  - less than 6.0 metres to a front or rear boundary.
  - less than 6.0 metres from an existing dwelling.

<u>Required Documents for Dwelling Finals</u>:- (where applicable)

(a) Engineer's Certificates (Form 16) e.g. Inspection of Footings, Slabs and Frame.
(b) Termite Treatment Documentation - Underslab and Perimeter Poison Certificate.
- Installation Certificates.
(c) Glazing Supplier's Certification.
(d) Wet Area Installation Certification.
(e) Truss Supplier's Certification.
(f) Electrical & Smoke Alarm Installation Certificate.
(g) As-constructed drawings.
(h) Survey Certificates.
(i) Evidence of Insulation Installation.

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www.somerset.qld.gov.au
mail@somerset.qld.gov.au

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Crn Main & Michel Street
Lowood Qld 4311
Telephone: 5426 1451

Kilcoy Office
15 Kennedy Street
Kilcoy Qld 4515
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Address all correspondence to:

Chief Executive Officer
Somerset Regional Council
PO Box 117
Esk Qld 4312

<u>Building</u>
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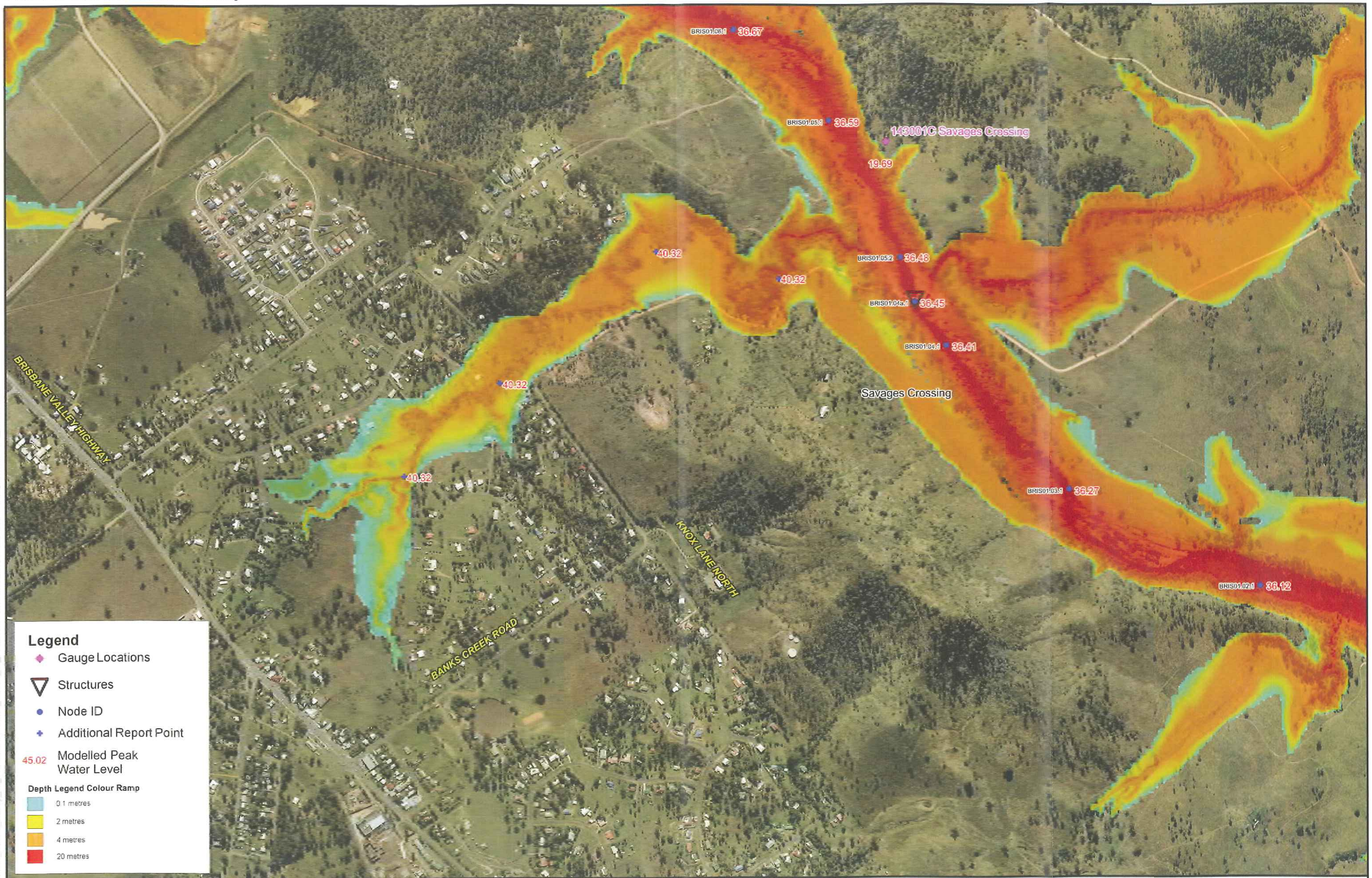
Craig Stevens, Matthew Simpson &
Scott McGovern (Cadet Building Surveyors)
<u>Plumbing/Drainage</u>
Pete Hoar & Tom Longshaw (Plumbing Inspectors)
<u>Planning</u>
Linda Cannon (PA/Administration)
Robert Gardiner (Cadet Town Planner)
Madeline Dye (Planning Officer)
Julie Bertsos (Senior Planner)
Brad Sully (Manager Planning and Development)
<u>Engineering</u>
George Winter & Denis Misso (Drafting)
Craig Harris (Design Development Engineer)
Andrew Johnson (Works Engineer)
Tony Jacobs (Engineer/MOPER)



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Flood Extent for 1 in 100 yr Annual Probability Event - Area 5

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