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Fraser Coast
REGIONAL COUNCIL

Fraser Coast Regional Council
Sustainable Growth Strategy 2031
Flood Study
Flooding from Local Watercourses
June 2011

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PREFACE

This individual planning study report was commissioned by the Fraser Coast Regional Council (Council) as part its Sustainable Growth Strategy project to assist and inform in the development of a new planning scheme for the entire local government area. It is important to understand that while the study report and its recommendations are a significant input, it does not necessarily represent the final integrated policy position of Council. Rather, the information will be used to assist the drafting of elements of the new planning scheme. The integration and balancing of a range of project inputs, community and State government engagement and other information which becomes available to Council will also influence the final policy content of the new planning scheme. Following an initial review by the State, a statutory public consultation process will occur where formal submissions are considered by Council and the State government before the planning scheme is finally adopted.

1. Introduction

Flood risk mapping is required to assist with the planning of future settlement patterns in the Fraser Coast region. A strategic flood study has been carried out to establish known flood hazards to development within the region and to infill gaps in knowledge.

Phase 1 of the study involved a review of information relevant to the preparation of a flood risk map for the region. Following the identification of specific areas for potential future development (priority areas) Phase 2 goes on to infill missing information regarding the flood risk to the following areas for potential development:

- ▶ Hervey Bay South
- ▶ Maryborough North
- ▶ Maryborough East
- ▶ Maryborough South
- ▶ Tiaro East

Existing studies have been used to provide a detailed assessment of flood risk to priority areas from 'main-river' flooding. Given the currency and accuracy of these studies Phase 2 has focussed on an examination of flood risk from secondary watercourses. The results of localised flood extents from Phase 2 will be compared with those of main-river flooding and any requirement for the adjustment of flood extents in the vicinity of priority areas identified.

The techniques used are based on industry standard methods and the level of detail is commensurate with the strategic nature of the overall study. The results are not intended to replace those required by more detailed stages of design.

The contents of this report include a description of drainage in the vicinity of priority areas followed by a summary of findings from Phase 1 which were used to identify the requirement for further investigations in Phase 2. The main body of the report contains a description of the techniques used in assessing flood risk from local watercourses and the report concludes with a comparison of flood outlines from main-river and more localised sources of flooding. Maps showing flood outlines are reported and represent the report's description of the flood risk to priority areas.

The existence of historic flood levels in Maryborough provides an alternative means of expressing extreme flood risk to that provided by conventional design flood outlines. A brief discussion of issues surrounding these alternative sources is included in Section 3.2.

Storm tide flood hazard has been investigated by a previous study and it is understood that a new study is imminent. The priority areas for development are located away from areas directly affected by storm tide flood hazards. However, an interpretation of the existing knowledge of storm tide effects at the coast has been extrapolated along the Mary River to Maryborough.

2. Priority Areas

The Fraser Coast Regional Strategy has identified five areas for possible future development and their location within the Fraser Coast Region is shown in Figure 1. For the purposes of reporting the areas are referred to as follows:

- ▶ Hervey Bay South
- ▶ Maryborough North
- ▶ Maryborough East
- ▶ Maryborough South
- ▶ Tiaro East

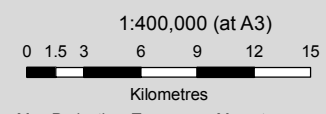
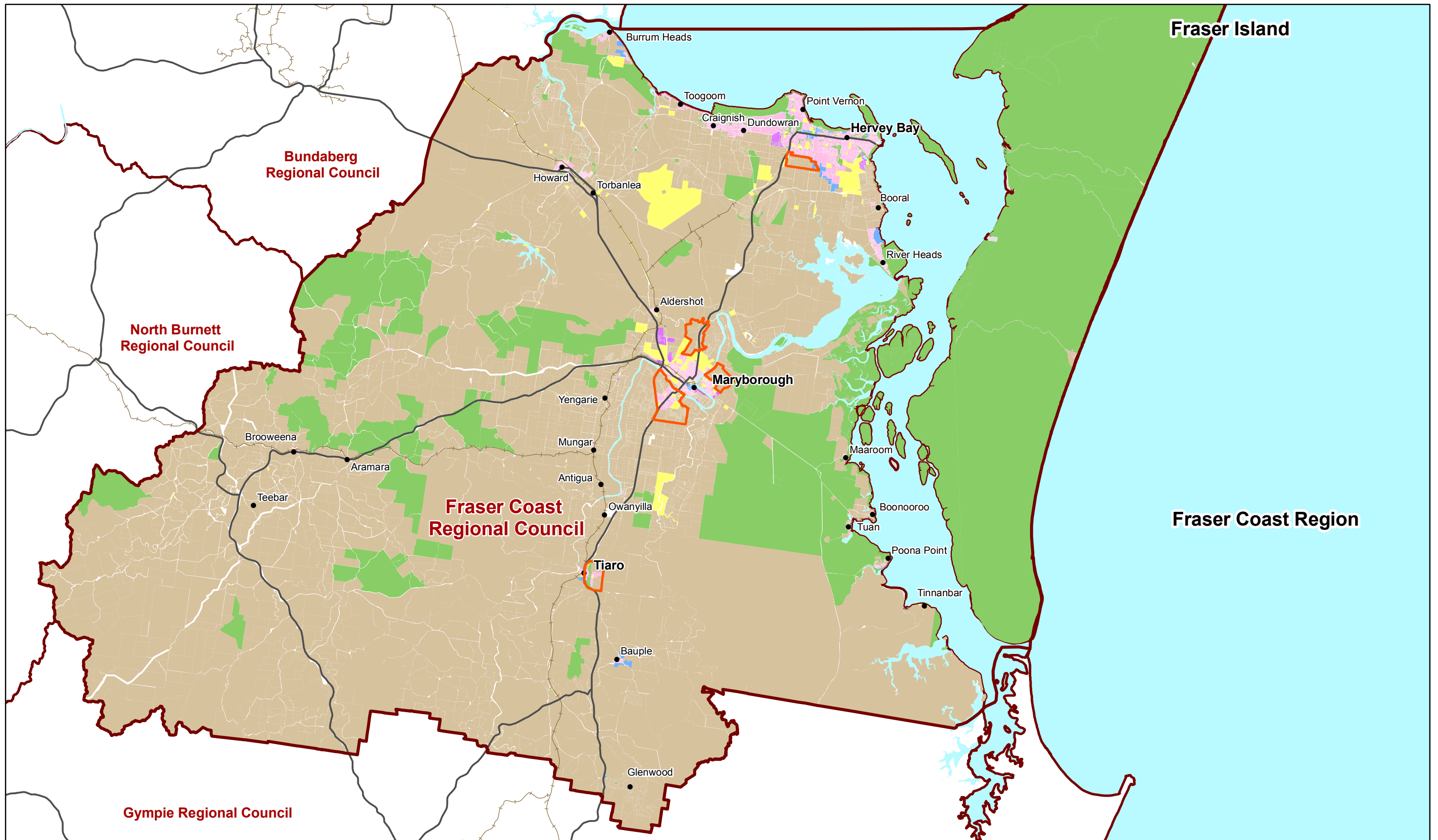
Hervey Bay South comprises an area of about 4 km² located on the southern boundary of existing development within Hervey Bay. Land is currently used for agricultural purposes and is bounded by Chapel Road along its southern edge. Drainage within the priority area of Hervey Bay South consists of a number of minor watercourses flowing from north to south. Two watercourses pass through small farm dams of unknown volume. The depth and width of channels is typically shallow and narrow with relatively steep gradients. The proposed area of development is located just downstream of a catchment divide and therefore the extent of catchment draining into watercourses is relatively small and contained almost completely within the priority area.

Maryborough North extends over an area of about 6 km² and is located in St Helens to the north of Maryborough. Land use is mainly agricultural. The area is bounded by the Saltwater Creek to the north whilst its eastern boundary lies within the Mary River floodplain. A smaller watercourse flows from west to east through the centre of the area. The depth and width of this channel is typically shallow and narrow. The catchment area is 6.5 km² and channel flows will therefore be relatively small. Flow within the Saltwater Creek flows from a catchment of 134 km² and is almost an order of magnitude greater.

Maryborough East has an area of almost 5 km² and is located to the east of Maryborough bounded by Eden Street to the north and Burns Street/Banana Street to the south. Land is agricultural and due to its flatness has no discernable drainage channels. The western edge of the area lies within the Mary River floodplain and its western corner appears to drain westwards away from the area.

Maryborough South is a larger area covering more than 14 km². It is located on the southern side of the Mary River and to the east of the Bruce Highway. Its southern and eastern boundaries coincide with Three Mile Road and Nerada Road, respectively. The northern fringe lies within the Mary River floodplain and its eastern boundary encroaches on the Tinana River floodplain. Two small watercourses cross the priority area flowing from south to north and a third, Bidwell Creek, crosses the south-eastern corner draining a catchment of 12 km².

Tiaro East comprises an area of about 6 km² and is located to the east of Tiaro town. Land use comprises a mixture of pasture and residential small holdings. The area is dissected by Chinaman Creek which flows from south to north draining a catchment of 17 km². The Mary River is located a 1 km to the west.



LEGEND

- Town
- ▭ Fraser Coast Regional Council Area
- Highway
- Railway
- ▭ Water body
- ▭ Priority development areas
- ▭ Rural
- ▭ Residential
- ▭ Industrial
- ▭ Commercial Centre
- ▭ Community Use / Special Purpose
- ▭ Parks / Open Space / Community Use
- ▭ Local Government Boundary



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Sustainable Growth Strategy -
Integrated Transport Study

Job Number	41-22108
Revision	A
Date	15 JUNE 2010

Locality Map

Figure 1

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3. Existing Knowledge of Flood Risk

3.1 Previous Studies

Phase 1 reviewed the contents of flood related studies for the Fraser Coast Region and extracted maps showing the flood extent of the 1 in 100-year ARI event. Studies relevant to the five priority areas are as follows:

- ▶ Hervey Bay South – Bunya Creek (JWP.October, 2006) and Eli Creek (JWP.June, 2005)
- ▶ Maryborough North – Mary River Flood Study (GHD. July, 2005)
- ▶ Maryborough East - Mary River Flood Study (GHD.July, 2005)
- ▶ Maryborough South - Mary River Flood Study (GHD.July, 2005)
- ▶ Tiaro East – Tiaro Flood Risk Study (Contour. February, 2008)

Information within these studies provides the current understanding of flood risk (at a 1 in 100-year ARI event) in the vicinity of the five priority areas (Figure 2).

The accuracy of flood risk mapping in the above mentioned studies was assessed in terms of its year of completion, type of hydrologic and hydraulic models used (eg 1-dimension or 2-dimension), source of topographic information (eg contours or ALS) and model resolution (eg cross-section spacing or grid size), also whether the models were calibrated and the type of flood information reported (eg extent, level, flow and velocity). A summary of this information is given in Table 2.

It is apparent from the review of previous flood studies that all have been carried out within the last six years and that they are based on industry standard modelling techniques. Most models are based on detailed topographic information and all have carried out some kind of model calibration or validation by comparison with alternative model results. Based on this information the accuracy of available flood extents is considered to be consistent and appropriate to the requirements of this study.

The extent and orientation of major waterways within the Fraser Coast region is shown in Figure 2. With the exception of Hervey Bay South each of the priority areas is located partly within or adjacent to the floodplain of the Mary River. By virtue of its catchment size this represents the most prominent flood hazard to these areas.

In addition to main-river flooding from the Mary River priority areas may also be exposed to smaller scale, localised flooding produced by tributaries of the Mary River and other creeks. An assessment of the risk of flooding from these local watercourses is the focus of this report.

Table 1 Summary of Previous Flood Studies

Study	Area km ²	Year	Hydrological Model	Hydraulic Model	Model Calibration	Topographic Data	Flood Risk Mapping
Bunya Creek	1497	2006	RAFTS	Quasi 2D XPSTORM	Using Rational method	0.2-5m contours	10, 20, 50, 100yr ARI

Eli Creek	< 10	2005	RAFTS	MIKE11 & MIKE21	Using 1D model results	Ground Survey	2, 100yr ARI
Mary River	>700000	2004	URBS	2D DELFT	Mary River Gauge at Maryborough	1-5m contours	1 in 100yr ARI
Tiaro	8486	2004	URBS	MIKE11 & HEC-RAS	Mary River Gauge at Tiaro	Surveyed Cross Sections	10, 50, 100, 200, 500yr ARI

3.2 Historic Flood Outlines

Maryborough has experienced flooding on several occasions during the last 140 years, with major floods occurring in 1890, 1893, 1955, and 1974. Other (smaller) flood events occurred in 1898, 1968, 1992 and 1999. It is understood that the interpretation of levels recorded during the largest flood event (1893) for the purposes of defining flood extent has been proposed for the purposes of planning. This would represent an alternative to the 1 in 100-year Average Recurrence Interval (ARI) design flood outline established by previous study (GHD, 2004).

The following issues surround the possible use and interpretation of the historic flood information.

The extent of flooding defined by the historic flood event of 1893 differs from that of the 1 in 100-year ARI design event (Figure 8). Information regarding the depth of flooding will also differ. These differences are caused by discrepancies in what the outlines represent and in their method and accuracy of derivation:

1. Is the ARI of the historic flood equivalent to a 1 in 100-year frequency of occurrence?

The ARI of an historic flood event is normally obtained by reference to a flood frequency diagram developed from gauged flood discharge or flood discharge derived by means of hydraulic models using recorded river stage.

The water level recorded in 1893 exceeded present day gauge limits by a considerable amount and its stage – discharge relationship (rating curve) is unable to provide an estimate of discharge for the 1893 flood event.

Whilst discharge can be determined by hydraulic models using recorded river stage the accuracy of the estimate relies on the model's ability to represent conditions during the extreme flood event. Since 1893, a number of changes to Maryborough and the Mary River have occurred. Those with the potential to exert an impact on flood levels and which are difficult to define for the date of the flood include the extent of siltation within the river (channel capacity) and land-use over the floodplain (flow paths and conveyance). Therefore, inaccuracy in the model's definition of channel capacity and floodplain conveyance will affect the estimation of discharge for the 1893 event.

Whilst previous studies have derived a rating curve estimates of the 1893 flood peak discharge have not been reported. Inspection of a previously defined rating curve (GHD, 2004) shows that the gauge height of 12.27m during the 1893 event could have been caused by a discharge of

about 12,000 m³/s. Referencing this discharge to the flood frequency diagram of a previous study (GHD,2005) indicates that the ARI of the 1893 flood event may not be coincident with a 1 in 100-year ARI.

The comparison of historic and design flood outlines is therefore likely to show discrepancies in water level and flood extent.

2. What is the accuracy of the flood outlines?

It is understood that the historic flood outline has been estimated by interpolation and extrapolation recorded flood levels. The accuracy of extrapolating flood levels is governed by the integrity of the method used to record flood levels; the degree to which the extrapolation has taken into account the impact of localised velocity gradients caused by contraction and expansion of flow paths; and the number of recorded flood levels and thus the distances over which these water levels have been extrapolated. It is further understood that the number of recorded flood levels is limited and therefore the accuracy of the spatial extent of flooding is questionable.

The accuracy of design flood outlines relies on the ability of hydraulic models to adequately represent conditions during a flood event, and this includes a description of topography, land use and flood flows. The verification of this representation is normally by means of model calibration using a comparison of model results with recorded information. A previous study has used recorded information from more recent and smaller extreme flood events (1955 and 1974) which met with mixed success - "close agreement between the modelled and recorded peak flood levels at most locations on the floodplain" and "some relatively larger discrepancies exist{ing} between modelled and recorded 1955 flood levels at some locations along the river and particularly upstream of Henry Palmer Bridge."(GHD, 2005).

Whilst both sources of flood inundation are likely to contain inaccuracies those associated with design flood outlines can be quantified. Those associated with the historic flood outline are largely unknown.

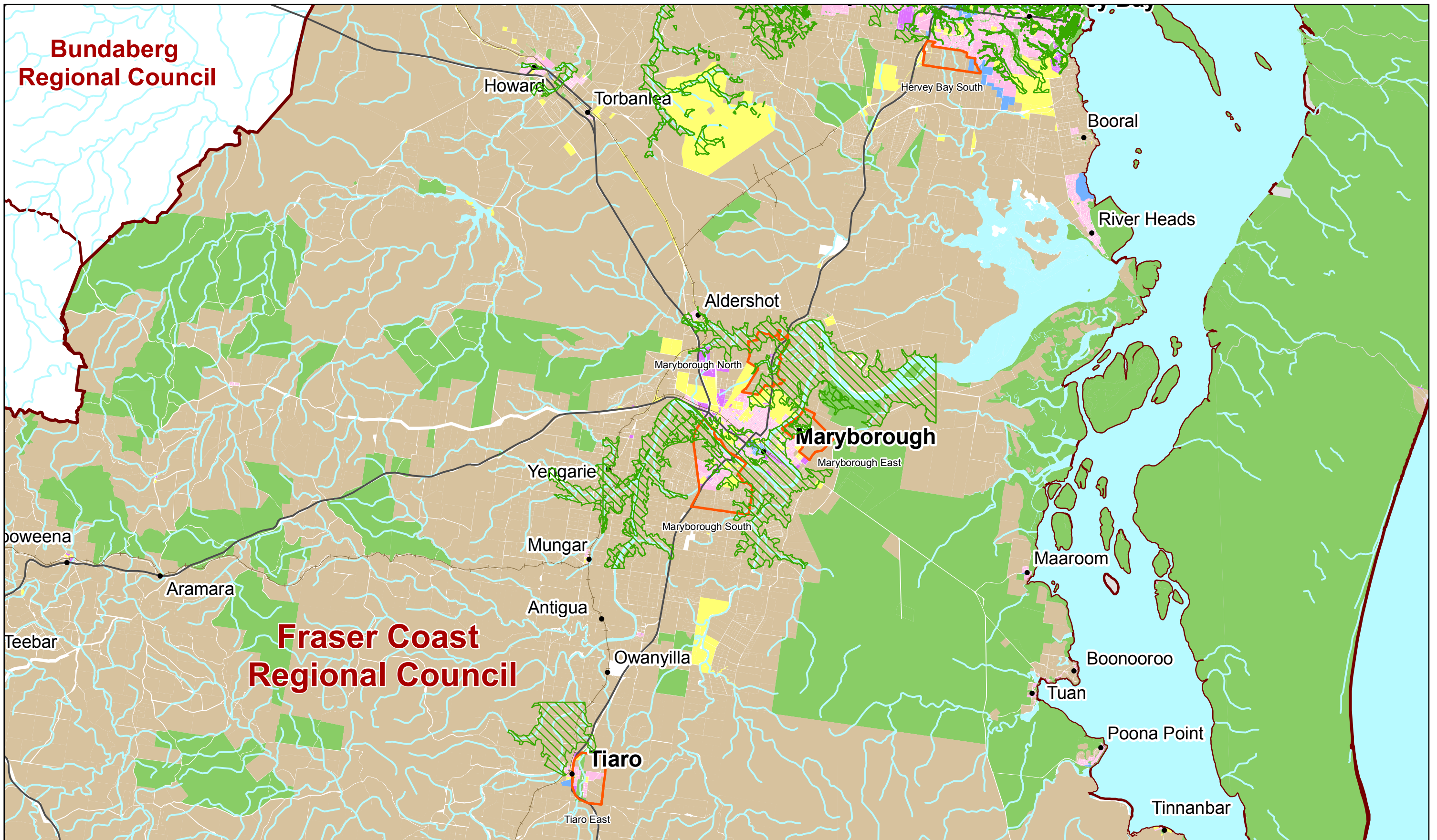
3.3 Climate Change and Storm Tide Hazard

A review of the storm tide threat along the Queensland east coast was carried out in 2004 and included an update and extension of storm tide hazard estimates for the state (DNRM, 2004). It did not investigate the impact of non-cyclonic or remote cyclonic events on medium-term return period (up to 100-year ARI) water levels.

The study reported surge plus tide plus wave set-up levels for the Hervey Bay area of approximately 3.0m AHD, and 3.5m AHD with enhanced Greenhouse effects. The upstream propagation of tide height along the Mary River to Maryborough during normal tide conditions results in an increase in water level of about 0.13m due to the constriction of flow – more detailed studies may establish that such a level would exceed river banks resulting in an expansion of flow and reduced afflux. If this relative change in height can be transposed to more extreme tide conditions then the impact of extreme tide conditions in Maryborough will be less than those caused by fluvial flooding (eg 4.2m AHD during 1893 flood - GHD, 2005).

The level of storm tides is much lower than levels recorded during the 1893 flood event and in isolation of fluvial flood events is unlikely to cause serious flooding. Its impact in combination with fluvial flood events is unlikely to surpass that defined by the previous study 1 in 100-year ARI design flood outline given that the design flood outline assumes a level in the Mary River (downstream boundary condition) of 4.2m AHD.

It is understood that a new study will be undertaken in the near future which may provide more detailed information of storm tide risk in the region.



1:230,000 (at A3)
 0 1 2 4 6 8 10
 Kilometres
 Map Projection: Transverse Mercator
 Horizontal Datum: Geocentric Datum of Australia
 Grid: Map Grid of Australia 1994, Zone XX



LEGEND

- | | | | |
|--|---------------|---------------------------|------------------------------------|
| Previous study 1 in 100-year flood event | Highway | Rural | Commercial Centre |
| Priority development areas | Railway | Residential | Community Use / Special Purpose |
| Fraser Coast Regional Council Area | Water Courses | Industrial | Parks / Open Space / Community Use |
| Town | Water body | Local Government Boundary | |



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Job Number | 41-22108
 Revision | A
 Date | 15 JUNE 2010

Main River 1 in 100-year
 ARI flood event

Figure 2

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4. Modelling Flood Risk from Localised Sources

4.1 Approach

The magnitude and extent of flooding from local watercourses does not appear to have been assessed by previous studies. Therefore, an analysis of the extent of flooding during 1 in 50-year and 1 in 100-year ARI events has been undertaken. The results of this analysis are compared with existing outlines of main-river flooding to identify any requirement for adjustments to accommodate the additional risk of flooding from local watercourses.

Given the smaller scale of watercourses the method to calculate water level is based on 1-D hydraulic flood routing techniques. The absence of significant floodplain storage and river control structures means that model simulations can be restricted to steady state conditions.

The US Army Corps of Engineers HEC-RAS model has been used to calculate water level profiles. The HEC-RAS model requires inputs of:

- ▶ flood peak discharge at the entrance to the river reach;
- ▶ cross-sectional profiles of the channel and floodplain;
- ▶ parameters that help define energy losses due to surface roughness and channel shape;
- ▶ boundary conditions at the extremities of the model.

The HEC-RAS model produces a longitudinal profile of the water surface which can then be used with topographic information to map the spatial extent of flooding by means of Geographical Information System techniques.

Details of HEC-RAS model inputs are presented in the sections below. A comparison of flood outlines from main-river and local sources of flooding is given in Section 5.

4.2 Model Extents

Model extents are commensurate with the length of watercourses that traverse or flow adjacent to each of the five priority areas. Watercourses have been chosen on the basis of their catchment size and their potential to cause flooding within priority areas.

4.3 Flood Hydrology

4.3.1 Methods

The Hydraulic flood routing models is used to calculate flood water levels and requires an estimate of the flood peak discharge at the entrance to the river reach. In this instance 1 in 50-year and 1 in 100-year ARI flood peak discharges are required for each of the watercourses being modelled. Steady state HEC-RAS model simulations are being used and therefore estimates of flood peak discharge are only required.

On the larger catchments (Saltwater Creek in Maryborough North, Bidwell Creek in Maryborough South and Chinaman Creek in Tiaro) differences in the upstream response of sub-catchments could influence the magnitude of flood peaks entering priority areas and therefore recourse to XP-RAFTS modelling has

been made. For the remaining catchments sub-division is not warranted and estimates of flood peak discharge have been obtained from the Rational method.

Data requirements for XP-RAFTS comprise the following for each sub-division of catchment:

- ▶ catchment area;
- ▶ proportion of impervious and pervious areas (based on land use);
- ▶ sub-catchment slopes (derived from topographic data);
- ▶ surface roughness value (Manning's 'n' derived from aerial photographs and standard tables);
- ▶ storm rainfall data for a range of storm durations (obtained from Intensity – Duration – Frequency table on the Bureau of Meteorology website).

Sub-catchment outflows are calculated by Laurenson's (1964) non-linear runoff routing method. Calibration of XP-RAFTS models using streamflow records was not possible due to the lack of gauging stations on the watercourses being modelled. Comparisons were therefore made with the results of the Rational method and an empirical method - Quantile Regression Technique (QRT). Unfortunately, limitations within the database on which the QRT method is based make it less suited to small catchments and therefore no checks were available for the remaining Rational method results.

The Rational method requires a similar set of information to XP-RAFTS:

- ▶ catchment area;
- ▶ 'time of concentration' to establish storm duration (determined from the length and slope of the longest watercourse);
- ▶ runoff coefficient (based on empirical values referenced from slope, land use and rainfall characteristics).

4.3.2 Catchment Characteristics

A summary of catchment characteristics for input to the hydrologic models is given in Table 2 and Table 3. Values of catchment area and slope were determined by GIS using 1m and 5m interval contours. Aerial photographs were used to estimate the percentage urbanisation (representing non-pervious catchment area) and to inform the derivation of representative surface roughness values.

Conservative estimates of initial and continuing rainfall losses of 0.0 mm/hr and 2.5 mm/hr, respectively, were applied to design rainfall event simulations within XP-RAFTS.

Table 2 Input Data for XP-RAFTS

Creek Name	Sub-catchment	Area (km ²)	Slope (%)	Length (km)	Catchment roughness	IFD Rainfall Source
Bidwill Creek, Maryborough South	1	12.2	0.24	4.9	0.035	Maryborough
Chinaman Creek, Tiaro	1	10.0	1.36	6.6	0.045	Tiaro
	2	3.9	0.81	3.8	0.045	

Creek Name	Sub-catchment	Area (km ²)	Slope (%)	Length (km)	Catchment roughness	IFD Rainfall Source
	3	3.4	1.00	3.5	0.045	
Saltwater Creek, Maryborough North	1	33.7	0.25	8.3	0.035	Maryborough
	2	24.4	0.50	3.6	0.035	
	3	34.5	0.25	10.1	0.035	
	4	41.3	0.23	6.9	0.035	

Table 3 Input Data for Rational method

Creek Name	Area (km ²)	Slope (%)	Length (km)	Slope coefficient	Storage coefficient	Land coefficient	IFD Rainfall Source
Bidwill Creek, Maryborough South	12.2	0.24	4.9	0	10	40	Maryborough
Creek 2, Maryborough South	3.2	0.35	2.8	0	10	40	
Creek 1, Maryborough South	2.9	0.58	2.1	0	10	40	
Saltwater Creek, Maryborough North	133.9	0.23	6.9	0	10	30	
Creek 1, Maryborough North	6.5	0.41	4.4	0	10	40	
Chinamen Creek, Tiaro	17.3	1.36	6.7	0	10	40	Tiara
Creek 1 east, Hervey Bay	0.17	2.00	0.8	0	10	35	Hervey Bay
Creek 1 west, Hervey Bay	0.45	4.53	1.1	0	10	35	
Creek 2, Hervey Bay	0.63	1.82	1.4	0	10	35	
Creek 3 east, Hervey Bay	0.82	2.35	0.9	0	10	35	

Creek Name	Area (km ²)	Slope (%)	Length (km)	Slope coefficient	Storage coefficient	Land coefficient	IFD Rainfall Source
Creek 3 west, Hervey Bay	0.72	1.99	1.8	0	10	35	

4.3.3 Design storm rainfall

Design storm rainfall for the 1 in 100-year ARI event has been based on Australian Rainfall and Runoff (AR&R, 2001) methods. Intensity – frequency – duration rainfall values (IFD) have been captured from the Bureau of Meteorology website (Table 4).

Rainfall has been distributed using temporal rainfall patterns for zone 3 in accordance with procedures in AR&R (2001). Critical storm durations have been identified by automated techniques within XPRAFTS and from the ‘time of concentration’ for the Rational method.

No Areal Reduction Factors (ARF) were applied to the rainfall intensities due to the small scale of catchments and this may result in a slightly conservative estimate of flood peak discharge.

Table 4 Rainfall Intensity – Duration – Frequency Data

Storm Duration	Hervey Bay [mm/hr]		Maryborough [mm/hr]		Tiaro [mm/hr]	
	50yr ARI	100yr ARI	50yr ARI	100yr ARI	50yr ARI	100yr ARI
5 mins	281	312	281	313	274	306
6 mins	264	294	263	294	256	286
10 mins	215	240	215	240	209	234
20 mins	156	174	157	176	152	170
30 mins	127	141	128	143	124	138
1 hr	87	96	87	97	84	93
2 hrs	57	64	57	64	54	61
3 hrs	44	50	45	50	42	46
6 hrs	29	32	29	33	26	30
12 hrs	19	22	19	21	17	19
24 hrs	13	15	12	14	11	13

Storm Duration	Hervey Bay [mm/hr]		Maryborough [mm/hr]		Tiaro [mm/hr]	
	50yr ARI	100yr ARI	50yr ARI	100yr ARI	50yr ARI	100yr ARI
48 hrs	9	11	8	9	7	8
72 hrs	7	9.6		7	6	6

4.3.4 Design flood peaks

The calculated design flood peak discharges for watercourses of interest within each priority area are reported in Table 5. Where catchments of similar size show marked differences in discharge this is due to differences in catchment slope which alters the response time to rainfall and differences in the magnitude of IFD rainfall data throughout the region.

Table 5 Design Flood Peak Discharges

Creek Name	1 in 50yr ARI m ³ /s	1 in 100yr ARI m ³ /s	Catchment Area km ²
Bidwill Creek, Maryborough South	63	75	12
Creek 2, Maryborough South	38	44	3.2
Creek 1, Maryborough South	50	57	2.9
Saltwater Creek, Maryborough North	745	880	134
Creek 1, Maryborough North	61	71	6.5
Chinaman Creek, Tiaro	152	176	17
Creek 1 east, Hervey Bay	6	7	0.2
Creek 1 west, Hervey Bay	11	13	0.4
Creek 2, Hervey Bay	14	16	0.6

Creek Name	1 in 50yr ARI m ³ /s	1 in 100yr ARI m ³ /s	Catchment Area km ²
Creek 3 east, Hervey Bay	10	12	0.8
Creek 3 west, Hervey Bay	14	17	0.7

4.3.5 Elevation Data

A description of floodplain topography and channel geometry has been obtained from the following data sources:

- ▶ 1 metre contour data for the Hervey Bay area
- ▶ 20m grid size Digital Elevation Model for Maryborough (GHD Mary River Flood Study, 2004).
- ▶ 5 metre contour data for the Fraser Coast Region.

It is understood that projects are under way to compile Digital Elevation Models from LiDAR data for a large proportion of the Fraser Coast Region. Unfortunately this data was not available at the time of study.

Cross-sections through the channel and floodplain were extracted from available topographic data using 12D software. Cross sectional profiles were obtained at regular intervals along each watercourse over the length of the priority area.

4.3.6 Channel Roughness

Channel and floodplain roughness were described in terms of Manning's 'n' values. Roughness values were based on an interpretation of aerial photography in conjunction industry standard reference values. Roughness values ranged from 0.03 within channels to 0.05 on the floodplain.

4.3.7 Boundary Conditions

The boundary condition at the upstream extent of all HEC-RAS models was defined by the flood peak discharge of upstream catchments as derived by XP-RAFTS modelling or the Rational method.

The modelled reaches within the Hervey Bay South and Tiaro areas occupy the upper catchment of watercourses where downstream boundary conditions can be defined in terms of normal flow depths using local channel gradients.

Watercourses draining the Maryborough North and Maryborough South areas flow directly into the Mary River and boundary conditions are controlled by flow conditions within the Mary River. Given the difference in catchment area between these smaller river systems and that of the Mary River it is unlikely that 1 in 100-year flood peaks would occur simultaneously. Previous modelling studies in Maryborough have used a level coinciding with the 1893 flood event (4.2m AHD) as a boundary condition for the Mary River in Maryborough. An additional boundary condition has been tested which assumes normal flow depths at the outlet of modelled reaches. Given that areas of interest are located some distance upstream of their confluence with the Mary River the difference in modelled water levels and flood extents with alternative boundary conditions was found to be small.

4.4 Model Validation

The lack of observed flood level and gauged discharge data along the watercourses being modelled has prevented the calibration of both the hydrologic and hydraulic models.

However, the results of XP-RAFTS modelling on the larger watercourses have been checked against the results of alternative methods such as the Rational method and QRT empirical method. A good agreement in the results of all three methods is achieved for Tiaro-Chinaman Creek and to a lesser extent for Maryborough North – Saltwater Creek. But there is a significant difference between the results of the three methods for Maryborough South – Bidwell Creek.

Given the discrepancy in flood estimates for Saltwater Creek and Bidwell Creek it was decided to test the sensitivity of their flood extents to the higher flood peak estimates produced by the alternative methods. This was found to have no significant impact on the flood extents.

5. Flood Modelling Results

5.1.1 Design flood events

HEC-RAS modelling results of flood peak water levels in local watercourses within the five priority areas have been used to map the extent of the 1 in 100-year ARI flood events. The flood outlines are shown in Figure 3 to Figure 7 together with outlines of main-river flooding from the Mary River as determined by previous studies. The flood extents of the 1 in 50-year ARI event are not shown as the difference in water surface widths to those of the 1 in 100-year ARI event is typically less than 15m which is less than the accuracy of modelling. This reflects the relatively constrained cross sectional profile of the creeks.

A comparison of the 1 in 100-year ARI event outlines from the two sources of flooding within Maryborough shows that the extent of main-river flooding (Mary River) is likely to exceed that produced by severe flood events on secondary or local watercourses.

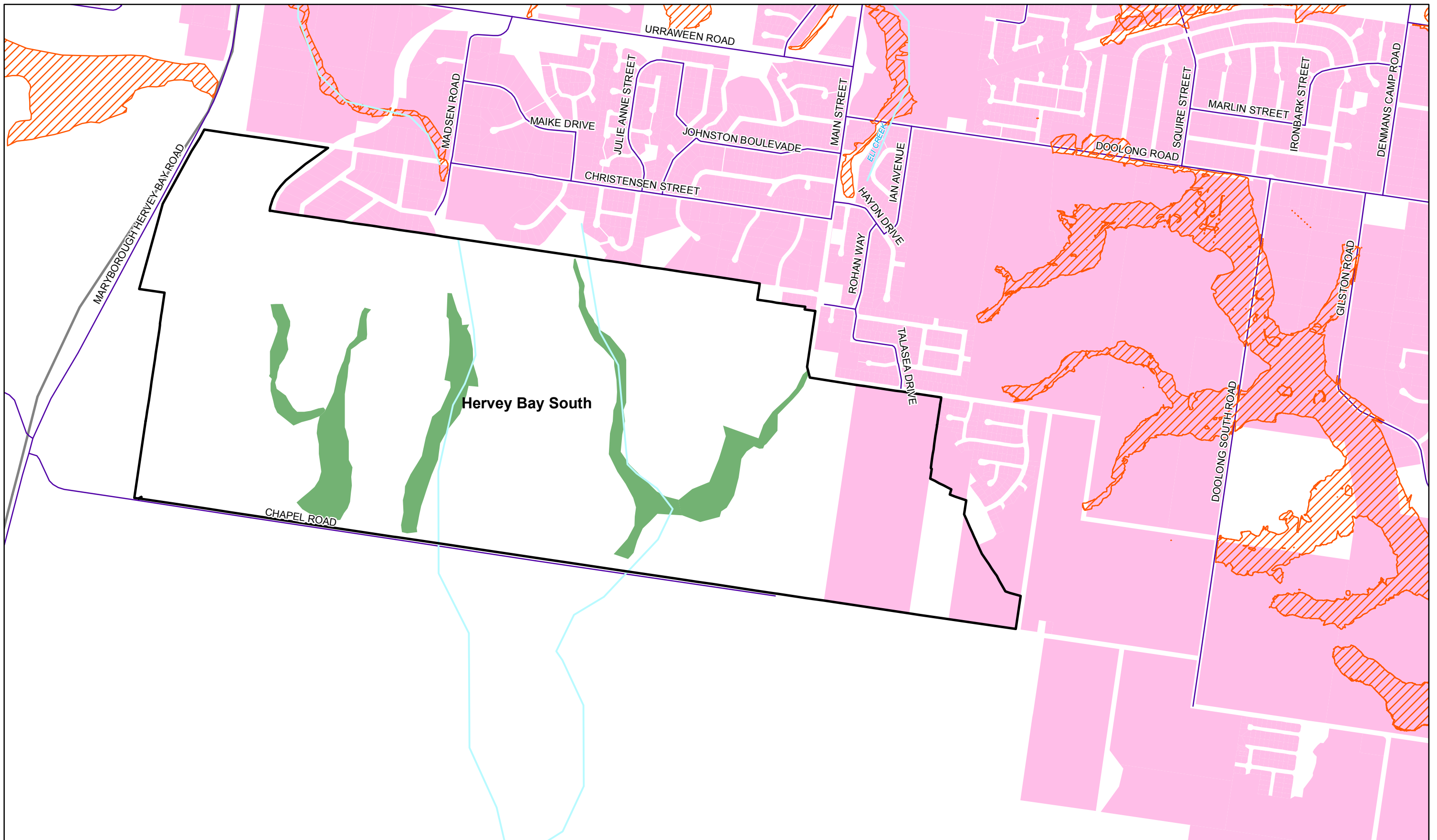
Maryborough East appears to have no significant local drainage features and therefore flood risk is assumed to be limited to main-river flooding from the Mary River.

Flood outlines from existing studies therefore provide an adequate representation of flood risk to priority areas for the purposes of this strategic planning study. The exception is Hervey Bay South and Tiaro where flood risk from main-river flooding is absent due to their location and an indicative map of flood risk from local drainage has been provided. However, it is emphasised that these results are not intended to replace those required by more detailed stages of design.

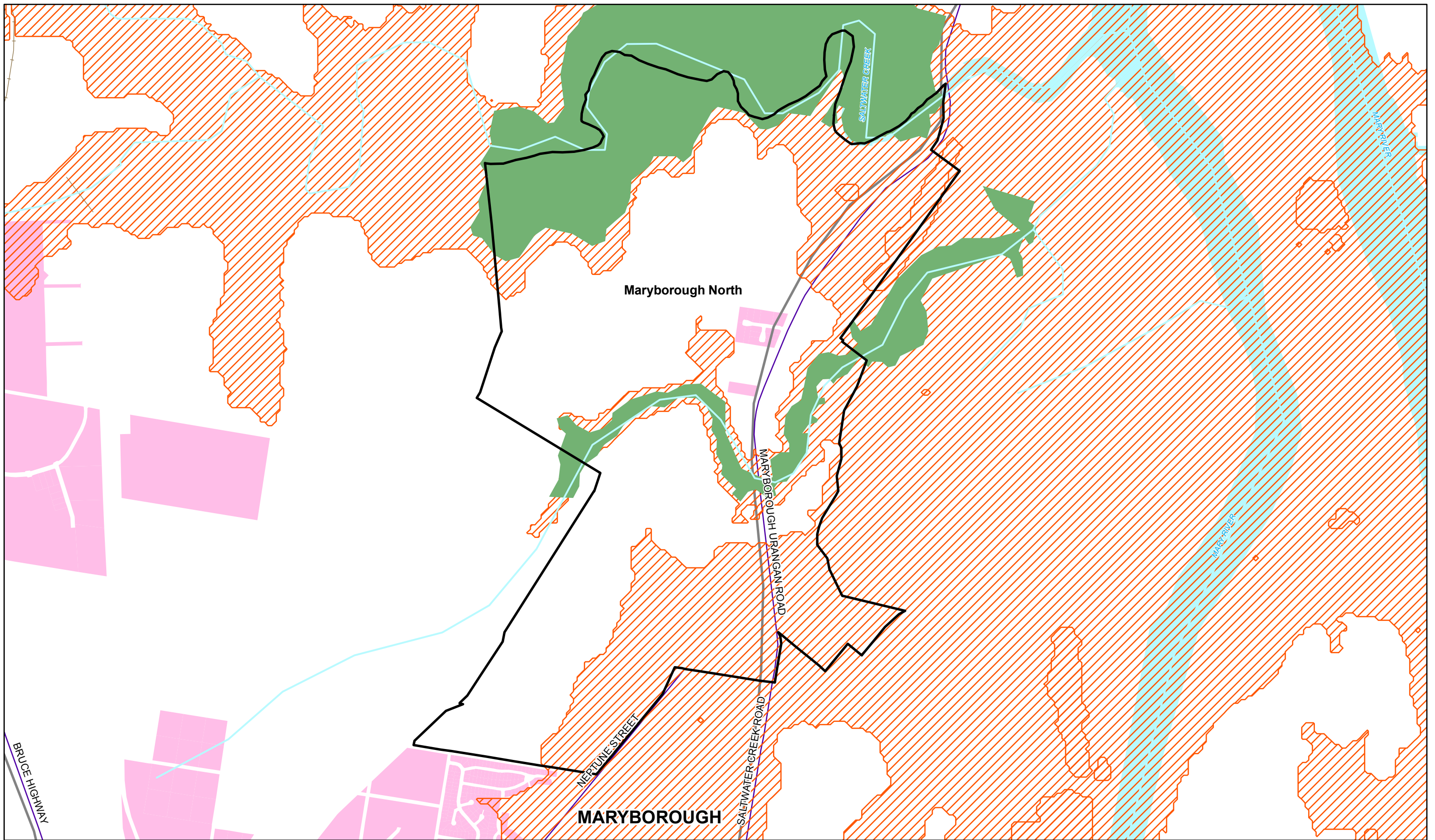
Table 6 summarises typical water depths and velocities within the modelled reaches of the three larger watercourses passing through or adjacent to priority areas. Given the absence of significant floodplain inundation they represent conditions within the channel. Due to the strategic nature of the study and the absence of detailed topographic information these are indicative values, only.

Table 6 Indicative Flood Depth and Velocity within Channels

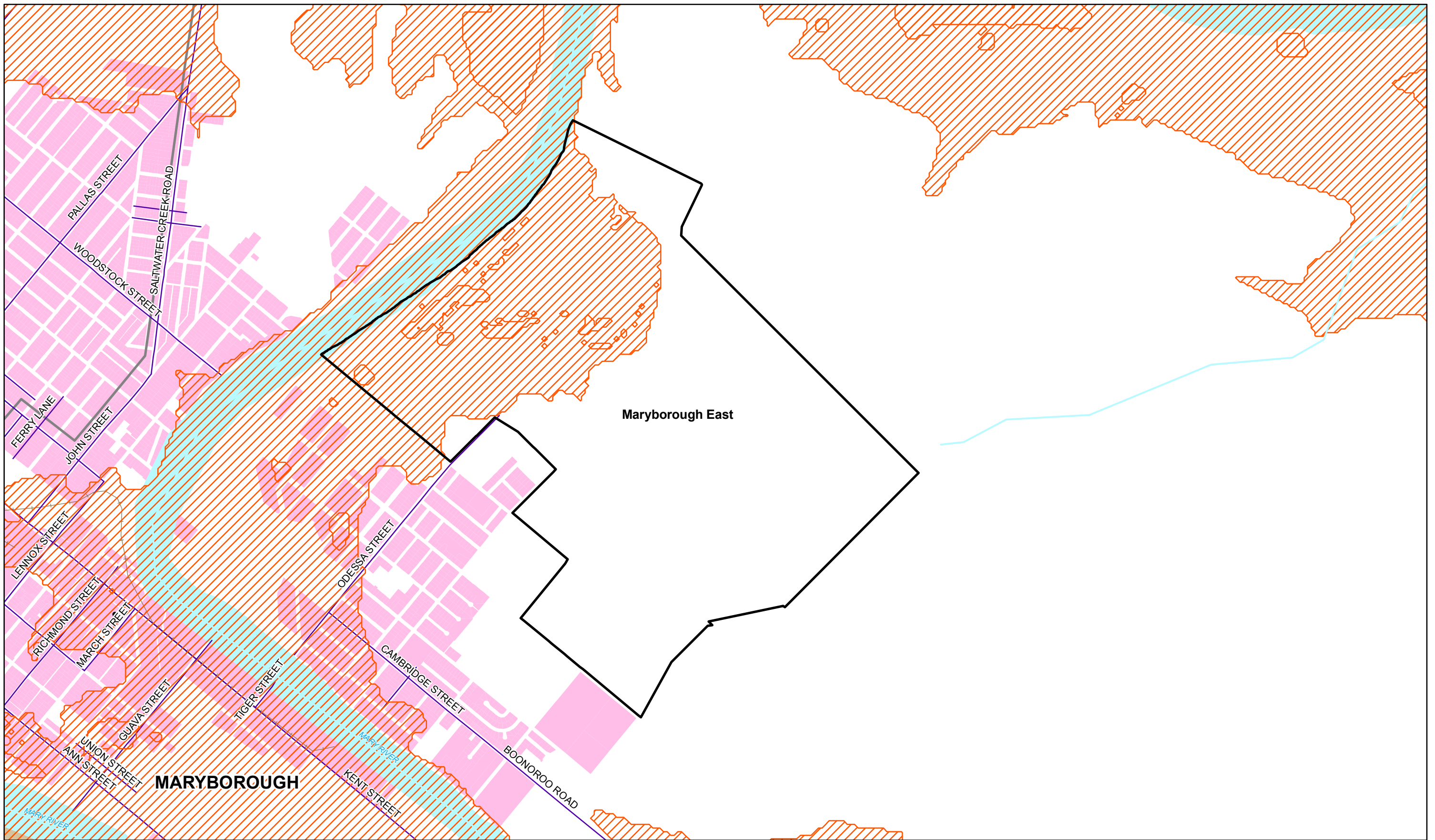
Creek Name	1 in 50yr ARI		1 in 100yr ARI	
	Depth m	Velocity m/s	Depth m	Velocity m/s
Bidwill Creek, Maryborough South	1.0 – 2.2	0.5 – 1.3	1.0 - 2.3	0.6 – 1.4
Saltwater Creek, Maryborough North	3.6 – 4.6	0.6 – 1.5	3.8 – 4.9	0.6 – 1.6
Chinaman Creek, Tiaro	0.6 – 1.0	0.3 – 1.3	0.6 – 1.0	0.3 – 1.4



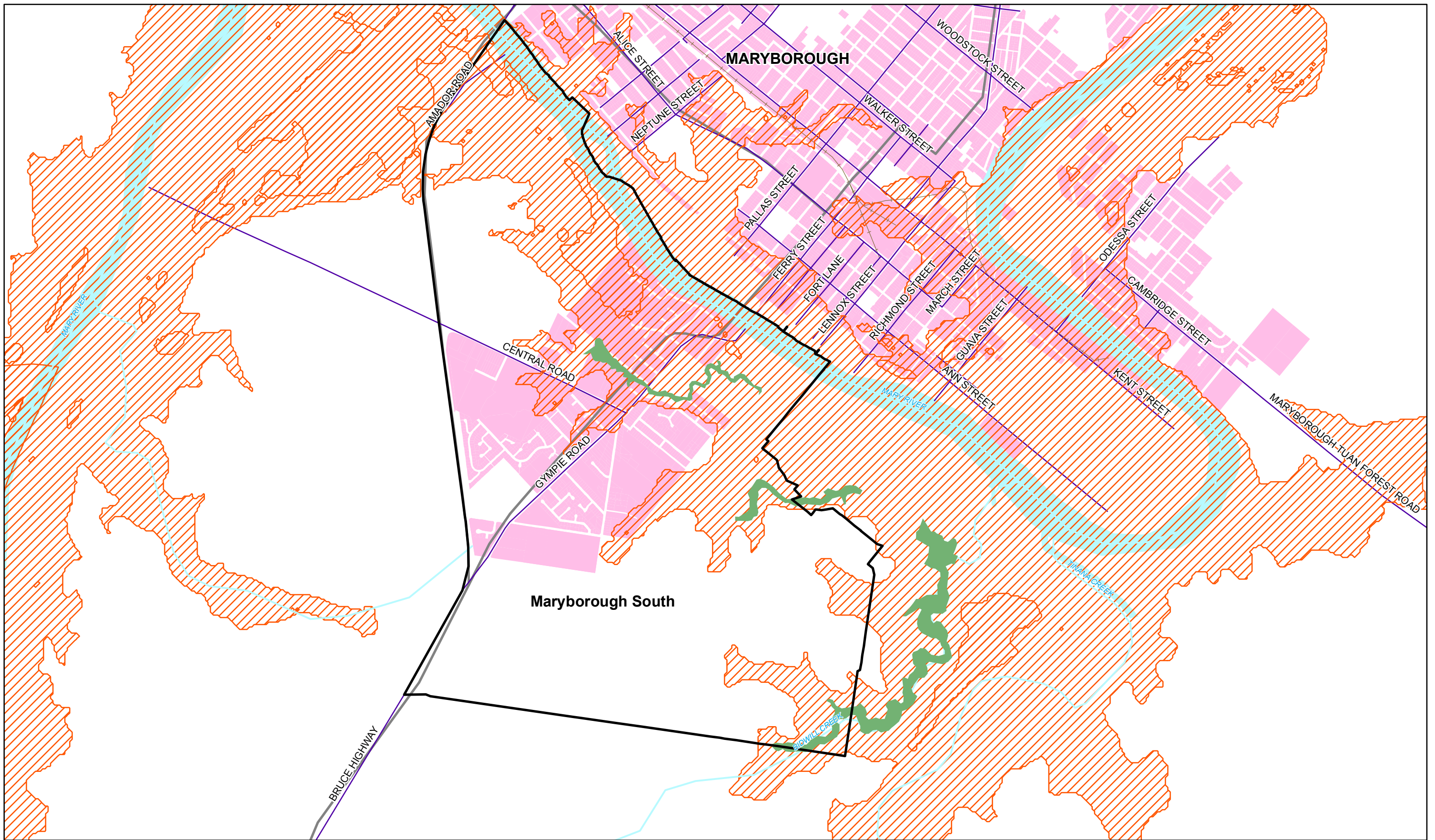
<p>1:15,000 (at A3)</p> <p>0 100 200 400 600 800</p> <p>Meters</p> <p>Map Projection: Transverse Mercator Horizontal Datum: Geocentric Datum of Australia Grid: Map Grid of Australia 1994, Zone XX</p>		<p>LEGEND</p> <ul style="list-style-type: none"> Priority development area Localised 1 in 100-year ARI flood event Previous Study 1 in 100-year ARI flood outline Fraser Coast Regional Council Area Roads Highway Railway Water body Water Courses Built-Up area Local Government Boundary 		<p>Fraser Coast Regional Council Sustainable Growth Strategy</p> <p>Job Number 41-22108 Revision A Date 15 JUNE 2010</p> <p>Hervey Bay South 1 in 100-year ARI flood outlines Figure 3</p>
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<p>1:20,000 (at A3)</p> <p>Meters</p> <p>Map Projection: Transverse Mercator Horizontal Datum: Geocentric Datum of Australia Grid: Map Grid of Australia 1994, Zone XX</p>		<p>LEGEND</p> <table border="0" style="width: 100%;"> <tr> <td> Priority development area</td> <td> Roads</td> <td> Water body</td> </tr> <tr> <td> Localised 1 in 100-year ARI flood event</td> <td> Highway</td> <td> Water Courses</td> </tr> <tr> <td> Main River 1 in 100-year ARI flood event</td> <td> Railway</td> <td> Built-Up area</td> </tr> <tr> <td> Fraser Coast Regional Council Area</td> <td> Local Government Boundary</td> <td></td> </tr> </table>	Priority development area	Roads	Water body	Localised 1 in 100-year ARI flood event	Highway	Water Courses	Main River 1 in 100-year ARI flood event	Railway	Built-Up area	Fraser Coast Regional Council Area	Local Government Boundary		<p>CLIENTS PEOPLE PERFORMANCE</p>		<p>Fraser Coast Regional Council Sustainable Growth Strategy</p> <p>Job Number 41-22108 Revision A Date 15 JUNE 2010</p> <p>Maryborough North 1 in 100-year ARI flood outlines Figure 4</p>
Priority development area	Roads	Water body															
Localised 1 in 100-year ARI flood event	Highway	Water Courses															
Main River 1 in 100-year ARI flood event	Railway	Built-Up area															
Fraser Coast Regional Council Area	Local Government Boundary																



<p>1:20,000 (at A3)</p> <p>0 125 250 500 750 1,000</p> <p>Meters</p> <p>Map Projection: Transverse Mercator Horizontal Datum: Geocentric Datum of Australia Grid: Map Grid of Australia 1994, Zone XX</p>		<p>LEGEND</p> <table border="0"> <tr> <td></td> <td>Priority development area</td> <td></td> <td>Roads</td> <td></td> <td>Water body</td> </tr> <tr> <td></td> <td>Localised 1 in 100-year ARI flood event</td> <td></td> <td>Highway</td> <td></td> <td>Water Courses</td> </tr> <tr> <td></td> <td>Main River 1 in 100-year ARI flood event</td> <td></td> <td>Railway</td> <td></td> <td>Built-Up area</td> </tr> <tr> <td></td> <td>Fraser Coast Regional Council Area</td> <td></td> <td>Local Government Boundary</td> <td></td> <td></td> </tr> </table>		Priority development area		Roads		Water body		Localised 1 in 100-year ARI flood event		Highway		Water Courses		Main River 1 in 100-year ARI flood event		Railway		Built-Up area		Fraser Coast Regional Council Area		Local Government Boundary			<p>CLIENTS PEOPLE PERFORMANCE</p>	<p>Fraser Coast Regional Council Sustainable Growth Strategy</p> <p>Job Number 41-22108 Revision A Date 15 JUNE 2010</p> <p>Maryborough East 1 in 100-year ARI flood outlines Figure 5</p>
	Priority development area		Roads		Water body																							
	Localised 1 in 100-year ARI flood event		Highway		Water Courses																							
	Main River 1 in 100-year ARI flood event		Railway		Built-Up area																							
	Fraser Coast Regional Council Area		Local Government Boundary																									



1:30,000 (at A3)
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 Map Projection: Transverse Mercator
 Horizontal Datum: Geocentric Datum of Australia
 Grid: Map Grid of Australia 1994, Zone XX



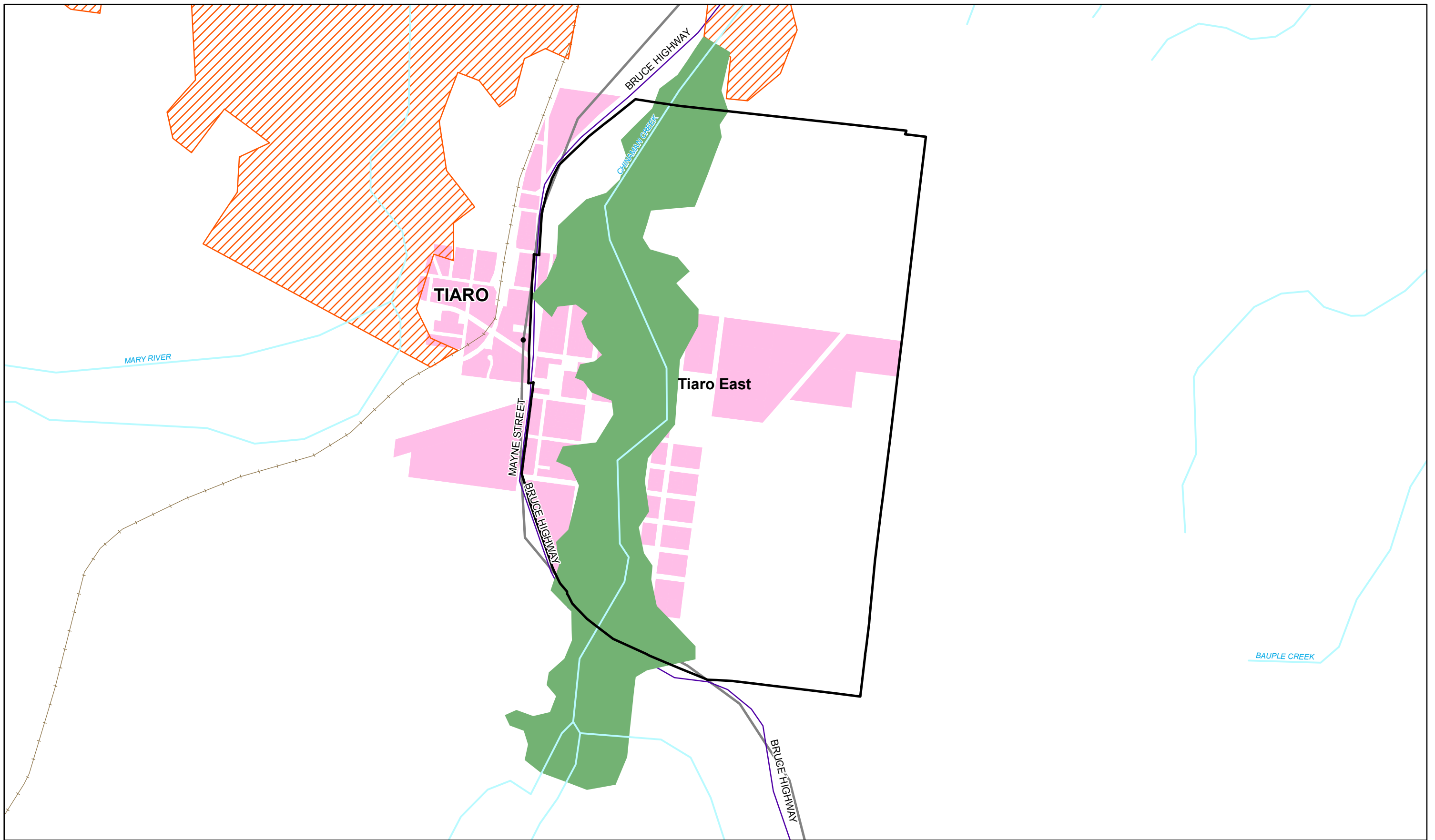
LEGEND			
	Priority development area		Roads
	Localised 1 in 100-year ARI flood event		Highway
	Main River 1 in 100-year ARI flood event		Railway
	Fraser Coast Regional Council Area		Water body
	Local Government Boundary		Water Courses
	Built-Up area		



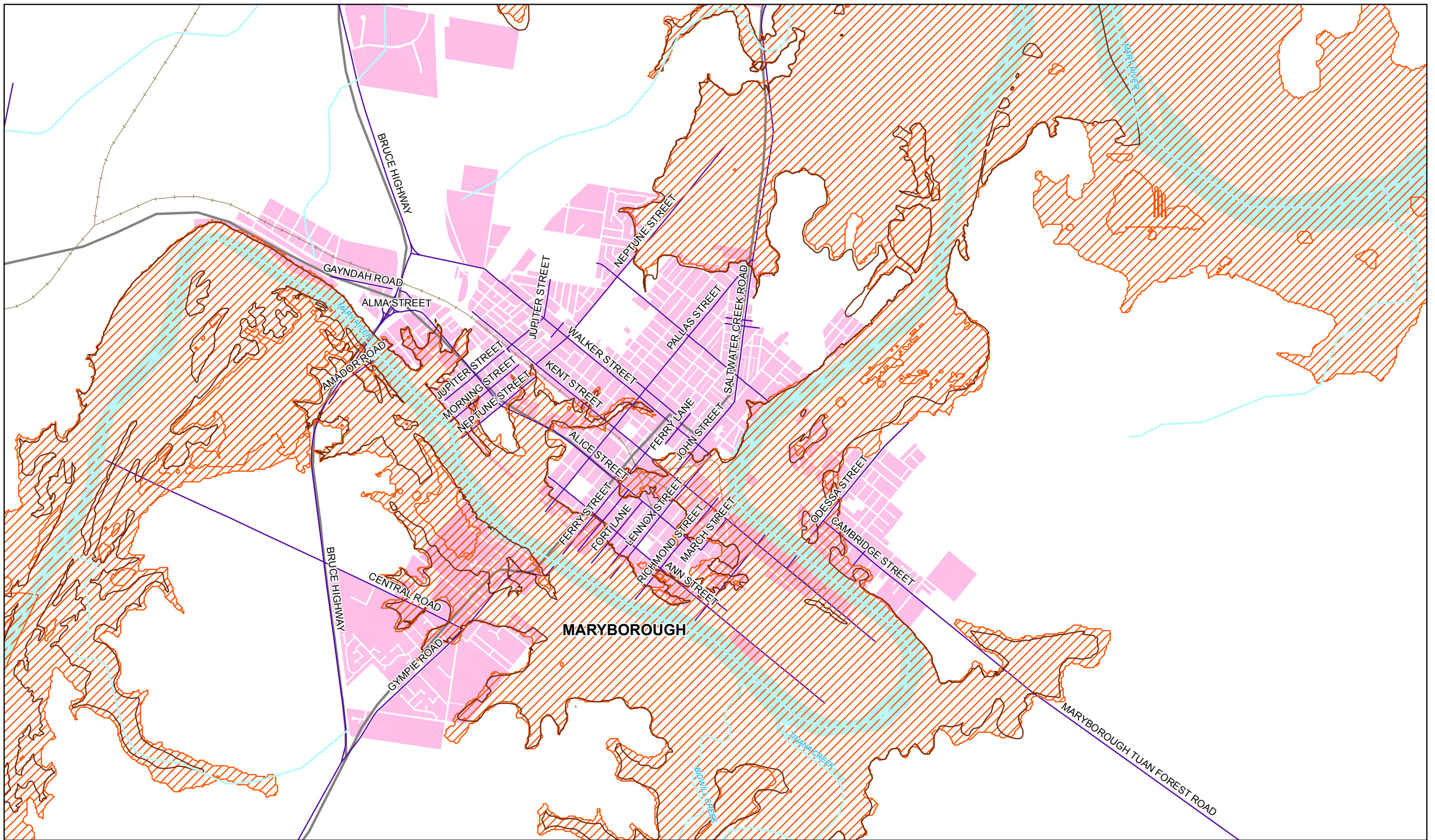
Fraser Coast Regional Council
 Sustainable Growth Strategy
 Job Number | 41-22108
 Revision | A
 Date | 15 JUNE 2010

Maryborough South 1 in 100-year ARI flood outlines **Figure 6**

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<p>1:20,000 (at A3)</p> <p>0 125 250 500 750 1,000</p> <p>Meters</p> <p>Map Projection: Transverse Mercator Horizontal Datum: Geocentric Datum of Australia Grid: Map Grid of Australia 1994, Zone XX</p>		<p>LEGEND</p> <table border="0"> <tr> <td> Priority development area</td> <td> Roads</td> <td> Water body</td> </tr> <tr> <td> Localised 1 in 100-year ARI flood event</td> <td> Highway</td> <td> Water Courses</td> </tr> <tr> <td> Main River 1 in 100-year ARI flood event</td> <td> Railway</td> <td> Built-Up area</td> </tr> <tr> <td> Fraser Coast Regional Council Area</td> <td> Local Government Boundary</td> <td></td> </tr> </table>	Priority development area	Roads	Water body	Localised 1 in 100-year ARI flood event	Highway	Water Courses	Main River 1 in 100-year ARI flood event	Railway	Built-Up area	Fraser Coast Regional Council Area	Local Government Boundary			<p>Fraser Coast Regional Council Sustainable Growth Strategy</p> <p>Job Number 41-22108 Revision A Date 15 JUNE 2010</p> <p>Tiaro East 1 in 100-year ARI flood outlines Figure 7</p>
Priority development area	Roads	Water body														
Localised 1 in 100-year ARI flood event	Highway	Water Courses														
Main River 1 in 100-year ARI flood event	Railway	Built-Up area														
Fraser Coast Regional Council Area	Local Government Boundary															



<p>1:40,000 (at A3)</p> <p>0 250 500 1,000 1,500 2,000</p> <p>Meters</p> <p>Map Projection: Transverse Mercator Horizontal Datum: Geocentric Datum of Australia Grid: Map Grid of Australia 1994, Zone XX</p>		<p>LEGEND</p> <ul style="list-style-type: none"> Historic flood event of 1893 Previous study 1 in 100-year flood outline Fraser Coast Regional Council Area Roads Highway Railway Water body Water Courses Built-Up area Local Government Boundary 		<p>Fraser Coast Regional Council Sustainable Growth Strategy</p> <p>Job Number 41-22108 Revision A Date 15 JUNE 2010</p>
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Maryborough 1 in 100-year ARI flood outlines **Figure 8**

6. Conclusions and Recommendations

Modelling of flood outlines for localised sources of flooding has been carried out with industry standard techniques using the best available information available at the time of study. The analysis has only considered the impacts of flooding from well defined creeks and does not consider impacts from groundwater or dam failure.

The integrity of flood outlines is dependent on the accuracy of model inputs especially flood peak discharge and topographic data describing cross sectional profiles. Where possible flood peak estimates have been compared to the results produced by alternative methods. Such comparisons have highlighted some discrepancies between methods and therefore modelled flood outlines have been assessed with increased estimates of flood peak discharge. This was found to have no significant impact on flood extents.

The absence of up-to-date detailed topographic data is likely to affect the results of modelling especially those of Tiaro where reliance has been made on 5m contours for the description of channel profiles and flood extents.

No calibration of hydraulic models was possible due to the absence of recorded flood levels and flows for the reaches being modelled. However, the resolution and accuracy of modelling is considered to be commensurate with the strategic nature of the study and any shortcomings in the accuracy of input data will be of greater significance to any subsequent detailed design studies.

The comparison of flood outlines from the two sources of flooding shows that flood extents associated with localised sources of flooding are unlikely to exceed those associated with main-river flooding. Therefore, for the purposes of strategic planning no adjustment to existing 1 in 100-year ARI flood outlines was necessary except for the addition of flood extents for Hervey Bay South and Tiaro.

A flood outline based on the highest recorded flood level in 1893 is available for Maryborough. The extent of flooding defined by this historic flood event differs from that defined by the 1 in 100-year ARI design event. These differences are caused by discrepancies in what the outlines represent and in their method and accuracy of derivation. Indications are that the 1893 historic flood event is not equivalent to a 1 in 100-year ARI. Also, the method and quantity of data used to derive the extent of flooding makes the overall accuracy of the flood outline questionable.

Previous studies have reported surge plus tide plus wave setup levels for the Hervey Bay area of approximately 3.0m AHD, and 3.5m AHD with enhanced Greenhouse effects. This level is likely to increase by about 0.13m once it reaches Maryborough. This level is much lower than levels recorded during the 1893 flood event and in isolation of fluvial flood events is unlikely to cause serious flooding. Its impact in combination with fluvial flood events is unlikely to surpass that defined by the previous study 1 in 100-year ARI design flood outline given that it assumes a level in the Mary River (downstream boundary condition) of 4.2m AHD.

The establishment of flood risk within the study area would benefit from the following:

- ▶ A more detailed and up to date digital elevation model covering the priority development areas and the contributing catchments;
- ▶ An appraisal of the ARI for the 1893 Maryborough historic flood outline and thus its severity relative to design flood events.
- ▶ More detailed information regarding storm tide flooding along the Mary River in conjunction with fluvial flood events.

7. References

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Mary River Flood Study Interim Report for Maryborough City Council. (GHD, October 2004).

Mary River Flood Study Draft Final Report for the Maryborough City Council (GHD, July 2005).

Bunya Creek Catchment Flood Risk Reduction Study for the Hervey Bay City Council (JWP, October 2006).

Eli Creek 2D Hydraulic Study for the Hervey Bay City Council (JWP, June 2005).

Tiaro Flood Risk Assessment Study for the Tiaro Shire Council (Contour, February 2008).



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