City Wide Flood Constraints Project
Townsville City Council
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Louisa Creek Flood Study

Base-line Flooding Assessment

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Base-line Flooding Assessment

Client: Townsville City Council

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Prepared by

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Quality Information

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Reviewed by Sally Williams

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			Name/Position	Signature
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Executive Summary

AECOM Australia Pty Ltd (AECOM) was engaged by Townsville City Council (TCC) to develop refined base case hydrologic and hydraulic flood models for the Louisa Creek area as part of the *City Wide Flood Constraints Project*.

For the purposes of this study, the area of interest was identified as the land encompassing the Louisa Creek catchment, including the upper reaches of Louisa Creek to the sea, and the Bohle River to the west.

The *Louisa Creek Flood Study (LCFS)* builds on a number of previous flood assessments carried out in the vicinity. Where needed, existing hydrologic and hydraulic models have been updated and refined in line with the *Preparation of Flood Studies and Reports – Guidelines* (2010) developed by TCC.

A MIKE FLOOD hydraulic model was developed for the Louisa Creek catchment. Upstream boundary conditions were derived using inflow hydrographs from the upstream Middle Bohle hydraulic model. An open ocean boundary was applied as the downstream boundary condition. Base-line flooding conditions were assessed for a range of storm events ranging from the 2 year Average Recurrence Interval (ARI) through to the Probable Maximum Flood (PMF) event. The Rain-on-Grid method was adopted to represent the localised runoff generated within the catchment.

The hydraulic model was calibrated to the February 2014 and April 2014 rainfall events. The modelled results were compared to gauge data and recorded levels within the area of interest. The results of the calibration against these two events showed a good fit with differences between modelled and recorded levels within an acceptable range across the area of interest.

The critical storm durations for the area of interest were the 1 and 12 hour storm durations. These values were determined by assessing the full range of storm durations for the 100 year ARI base case. These critical durations were used to inform the hydraulic modelling for the 2 to 500 year ARI events. The PMF events were assessed using the 3 hour critical duration.

A summary of the flooding results for the Louisa Creek study area are included in Table EX-1. These tables include indicative rainfall for design events to facilitate evaluation against real events.

It is recommended that opportunities to mitigate flood risk across the affected areas are evaluated as part of an overall floodplain management strategy. Furthermore, it is recommended that finished floor level survey for properties in areas deemed to be affected by flooding, is carried out to facilitate the development of suitable flood risk management strategies by Council.

Table Ex-1 Summary of Louisa Creek Flooding Results

Event	Indicative Rainfall	Properties Inundated[1]	Major Evacuation Route Closures	Emergency Management Issues[2]	Flooding Description
2 year ARI	53 mm in 1 hour 70 mm in 2 hours 82 mm in 3 hours 95 mm in 4.5 hours 106 mm in 6 hours 123 mm in 9 hours 138 mm in 12 hours 162 mm in 18 hours 182 mm in 24 hours	0			- Flows contained mainly within the channels. - Floodplain inundation up to 1.5 m across the Town Common floodplain. - No significant impact predicted for residential areas (i.e. water depth generally below 0.3 m).
5 year ARI	70 mm in 1 hour 92 mm in 2 hours 108 mm in 3 hours 125 mm in 4.5 hours 140 mm in 6 hours 163 mm in 9 hours 181 mm in 12 hours 218 mm in 18 hours 247 mm in 24 hours	94			- Floodplain inundation up to 1.5 m across the Town Common floodplain. - No significant impact predicted for residential areas (i.e. water depth generally below 0.3 m).
10 year ARI	81 mm in 1 hour 106 mm in 2 hours 123 mm in 3 hours 144 mm in 4.5 hours 160 mm in 6 hours 186 mm in 9 hours 208 mm in 12 hours 252 mm in 18 hours 286 mm in 24 hours	154			- Floodplain inundation up to 1.5 m across the Town Common floodplain. - Properties south of Dalrymple Road inundated with water depths up to 0.5 m.
20 year ARI	94 mm in 1 hour 123 mm in 2 hours 144 mm in 3 hours	239	Bruce Highway at Bohle River		- Floodplain inundation up to 1.5 m across the Town Common floodplain. - Properties south of Dalrymple Road inundated with water depths up to 0.5 m.

Event	Indicative Rainfall	Properties Inundated[1]	Major Evacuation Route Closures	Emergency Management Issues[2]	Flooding Description
	167 mm in 4.5 hours 187 mm in 6 hours 218 mm in 9 hours 242 mm in 12 hours 295 mm in 18 hours 338 mm in 24 hours				- Localised areas of high velocities (1.5 m/s and higher) predicted in Mount Louisa and Kirwan over roads and in channels.
50 year ARI	112 mm in 1 hour 147 mm in 2 hours 171 mm in 3 hours 199 mm in 4.5 hours 222 mm in 6 hours 259 mm in 9 hours 289 mm in 12 hours 355 mm in 18 hours 408 mm in 24 hours	384	Bruce Highway at Bohle River Bundock Street		- Floodplain inundation up to 2 m across the Town Common floodplain. - Properties south of Dalrymple Road inundated with water depths up to 1 m. - Properties in Bohle and Mount St John (especially near Enterprise Street) inundated with water depths up to 0.75 m. - Properties in Garbutt inundated with water depths of up to 0.5 m. - Localised areas of high velocities (1.5 m/s and higher) predicted in Mount Louisa and Kirwan over roads and in channels, as well as over Bundock Street.
100 year ARI	125 mm in 1 hour 165 mm in 2 hours 192 mm in 3 hours 224 mm in 4.5 hours 250 mm in 6 hours 291 mm in 9 hours 325 mm in 12 hours 400 mm in 18 hours 463 mm in 24 hours	574	Bruce Highway at Bohle River Bundock Street		- Floodplain inundation up to 2 m across the Town Common floodplain. - Properties south of Dalrymple Road inundated with water depths up to 1 m. - Inundation of properties in Kirwan with water depths up to 0.5 m. - Properties in Bohle and Mount St John (especially near Enterprise Street) inundated with water depths up to 1 m. - Properties in Garbutt inundated with water depths of up to 0.5 m. - Localised areas of high velocities (1.5 m/s and higher) predicted in Mount Louisa and Kirwan over roads and in channels, as well as over Bundock Street.
200 year ARI	134 mm in 1 hour 186 mm in 2 hours 225 mm in 3 hours 275 mm in 4.5 hours 312 mm in 6 hours 378 mm in 9 hours 432 mm in 12 hours	901	Bruce Highway at Bohle River		- Floodplain inundation up to 3 m across the Town Common floodplain. - Properties south of Dalrymple Road and in Bohle and Mount St John (especially near Enterprise Street) inundated with water depths up to 1.5 m. - Inundation of properties in Kirwan with water depths up to 2 m. - Properties in Garbutt inundated with water depths of up to 0.75 m. - Localised areas of high velocities (1.5 m/s and higher) predicted in Mount

Event	Indicative Rainfall	Properties Inundated[1]	Major Evacuation Route Closures	Emergency Management Issues[2]	Flooding Description
	522 mm in 18 hours 600 mm in 24 hours				Louisa and Kirwan over roads and in channels, as well as over Bundock Street and Enterprise Street.
500 year ARI	155 mm in 1 hour 214 mm in 2 hours 261 mm in 3 hours 324 mm in 4.5 hours 360 mm in 6 hours 432 mm in 9 hours 504 mm in 12 hours 612 mm in 18 hours 696 mm in 24 hours	1177	Bruce Highway at Bohle River Bayswater Road at Louisa Creek		- Floodplain inundation up to 3 m across the Town Common floodplain. - Properties south of Dalrymple Road and in Bohle and Mount St John (especially near Enterprise Street) inundated with water depths up to 1.5 m. - Inundation of properties in Kirwan with water depths up to 2 m. - Properties in Garbutt inundated with water depths of up to 0.75 m. - Localised areas of high velocities (1.5 m/s and higher) predicted in Mount Louisa and Kirwan over roads and in channels, as well as over Bundock Street and Enterprise Street.
PMF	380 mm in 1 hour 500 mm in 2 hours 570 mm in 3 hours 671 mm in 4.5 hours 738 mm in 6 hours 864 mm in 9 hours 996 mm in 12 hours 1242 mm in 18 hours 1512 mm in 24 hours	1331	Bruce Highway at Bohle River Bayswater Road at Louisa Creek Woolcock Street at Louisa Creek Dalrymple Road at Kern Drain Dalrymple Road (near Nathan Street)	Heatley Secondary College	- Floodplain inundation up to 3 m across the Town Common floodplain. - Properties south of Dalrymple Road and in Bohle, Mount St John (especially near Enterprise Street) and Garbutt inundated with water depths up to 1.5 m. - Inundation of properties in Kirwan with water depths up to 2 m.

Notes:

[1] Number of inundated properties is assessed based on a minimum of 200 mm water depth covering at least 15% of the lot size for urban residential lots. This does not necessarily mean finished floor levels are exceeded and the building flooded as floor level data is not available for this study.

Glossary

AEP	Annual Exceedance Probability
AHD	Australian Height Datum (approximately equivalent to Mean Sea Level)
ARI	Average Recurrence Interval
AR&R	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
DEM	Digital Elevation Model
DERM	Department of Environment and Resource Management
DFE	Defined Flood Event
GSDM	Generalised Short-Duration Method – Methodology for estimating the PMP
GTSMR	Generalised Tropical Storm Method Revised – Methodology for estimating the PMP
HAT	Highest Astronomical Tide – The highest level of water which can be predicted to occur under any combination of astronomical conditions.
HEC-RAS	A steady state 1D hydraulic model
Hydraulic model	A model used for assessing flood levels and velocities from inflows and topography
Hydrologic model	A model used for assessing catchment outflows from rainfall and catchment conditions
IFD	Intensity–Frequency-Duration
LiDAR	Light Detection and Ranging (Aerial Laser Survey)
MHWS	Mean High Water Springs – the average height of spring tide high water
MIKE11	Fully dynamic 1D hydraulic model
MIKE21	Fully dynamic 2D hydraulic model
MIKE FLOOD	Coupled 2D/1D hydraulic model combining MIKE11 and MIKE21
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
XP-RAFTS	An urban and rural runoff-routing hydrologic model

1.0 Introduction

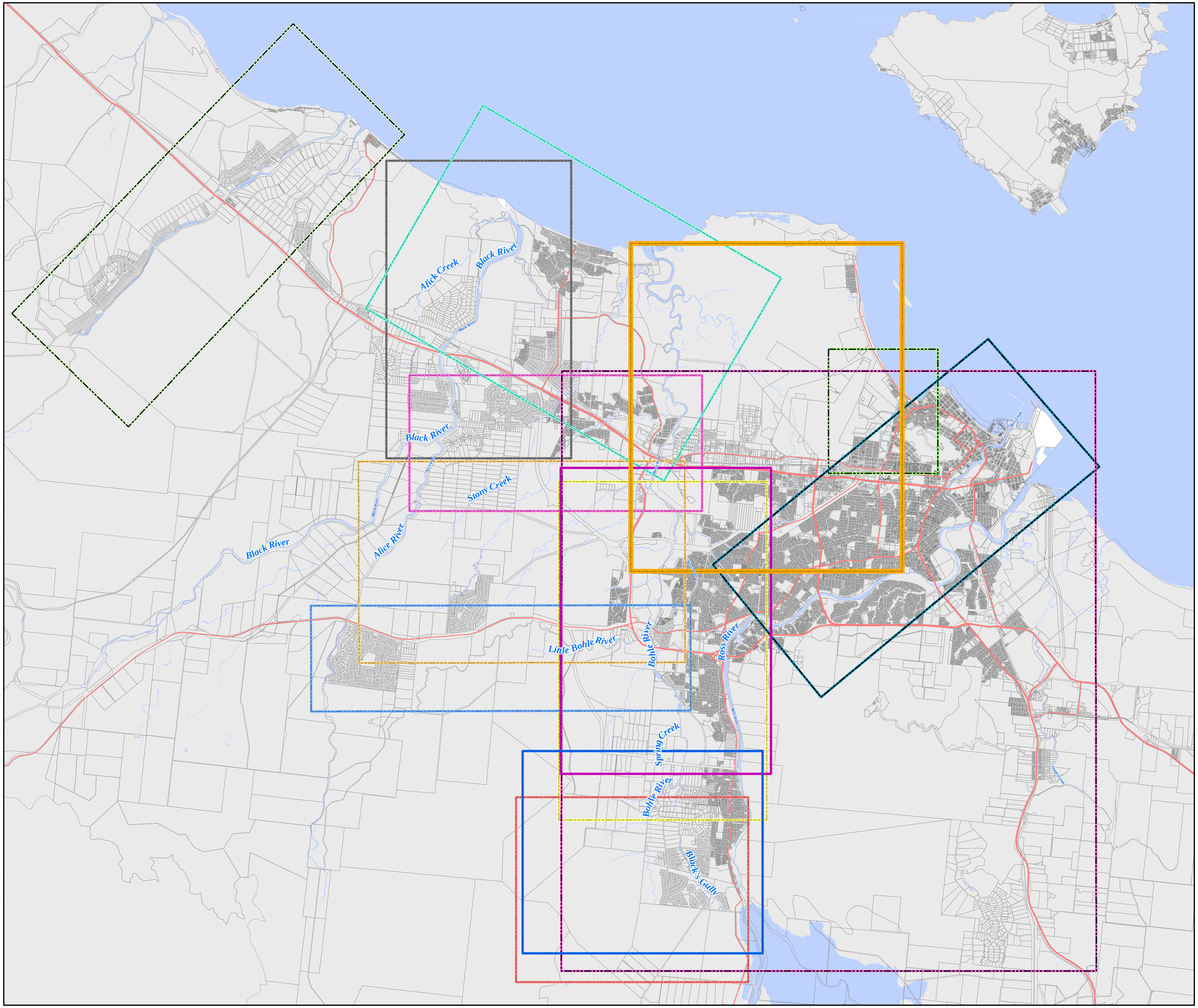
1.1 Overview

AECOM Australia Pty Ltd (AECOM) was engaged by Townsville City Council (TCC) to develop refined base-case hydrologic and hydraulic flood models for the Louisa Creek area as part of the *City Wide Flood Constraints Project*.

The *City Wide Flood Constraints Project* seeks to develop flood models to:

- define flood levels for most urban properties
- identify strategies for trunk stormwater and flood mitigation infrastructure for future capital investment
- provide a means of evaluating the impacts of future flood mitigation and development projects
- assess escape routes and flooding along major arterial roads to assist in disaster management processes.

The model extent for the *Louisa Creek Flood Study* in relation to previous studies is shown in Figure 1-1.



TOWNSVILLE CITY COUNCIL
LOUISA CREEK FLOOD STUDY

Model Extents in relation to previous studies
Figure 1-1

Legend

- Louisa Creek Model Extent (This study)
- Upper Bohle Model Extent (2014)
- Middle Bohle Model Extent (2014)
- Althaus/Deep Creek Model Extent (2013)
- Bluewater Creek Model Extent (2014)
- Ross River Model Extent (2010)
- Ross Creek Model Extent (2013)
- Captains Creek Model Extent (2014)
- Lower Bohle Model Extent (2014)
- Black River Model Extent (2013)
- Deeragun Model Extent (2012)
- Little Bohle River Model Extent (2011)
- BPFPR (Lower Bohle) Model Extent (2010)
- Upper Bohle Plains Model Extent (2011)
- BPFPR (Upper Bohle) Model Extent (2010)

0 1,500 3,000 6,000
Metres

1:130,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
Localities © 2012 (Queensland Govt)

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1.2 Study Area

The study area considered for the assessment, shown in Figure 1-2, extends from the upper reaches of Louisa Creek to the sea. The topography of the area is generally flat and low lying except for the eastern portion that includes Castle Hill and the area around Mount Louisa.

Major watercourses across the study area include the Bohle River and its tributaries (i.e. Kern Drain, Tchooratippa Creek, Kirwan-Bohle Drains A and B, Saunders and Stony Creek), Louisa Creek and Captains Creek.

Major road links across the study area include the Bruce Highway, Woolcock Street, Nathan Street, Dalrymple Road, North Shore Boulevard, Ingham Road and Bundock Street.

The catchments considered for modelling purposes include Louisa Creek, Captains Creek, Bohle River, Kirwan, Saunders Creek and Stony Creek.

1.3 Scope of Works

The scope of works for the *Louisa Creek Flood Study* included:

- collation and review of available data including previous models relevant to the study
- assessment of the study area to confirm catchment parameters as well as gain an understanding of hydraulic controls and flow pathways
- identify and represent new development projects and associated infrastructure from design plans
- establish suitable upstream boundary conditions by examining previous studies
- review of XP-RAFTS hydrologic models within the study area to confirm catchment delineations and derive inflow hydrographs for the 2, 5, 10, 20, 50, 100, 200 and 500 year ARI storm events and the Probable Maximum Precipitation (PMP) event
- develop direct rainfall (Rain-on-Grid) hydrographs to represent localised runoff within urbanised areas
- develop a MIKE FLOOD hydraulic model to determine base-case flood extents, velocity and depth of flow for the 2, 5, 10, 20, 50, 100, 200 and 500 year ARI storm events and Probable Maximum Flood (PMF)
- determine peak flood envelopes for the 50 year and 100 year ARI storm events under existing conditions based on analysis of a range of storm durations, including 1, 2, 3, 4.5, 6, 9, 12, 18 and 24 hour durations
- determine peak flood envelopes for the 2, 5, 10, 20, 200, 500 year ARI storm events and the Probable Maximum Flood (PMF) under existing conditions based on the critical storm durations as determined by the analysis of 50 year and 100 year ARI storm events.

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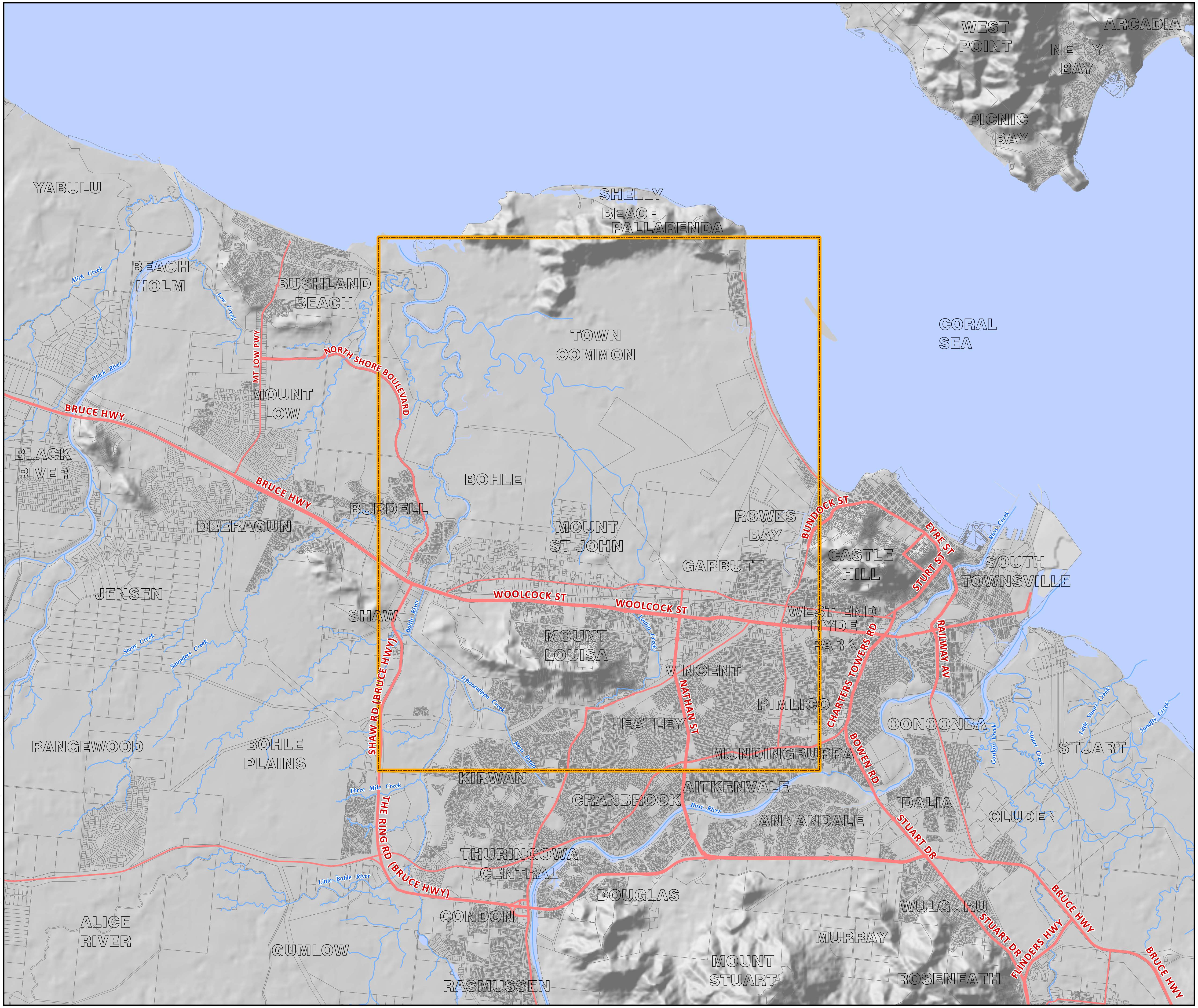
LOUISA CREEK FLOOD STUDY

Locality Plan

Figure 1-2



Legend

- Highways
- Main Roads
- Watercourse
- Property Boundaries
- Model Extent

0 1,000 2,000 4,000
Metres

1:80,000 (when printed at A3)

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Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
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1.4 Study Approach

The assessment of the Louisa Creek study area builds on a number of previous flood studies in the vicinity. Where needed, existing hydrologic and hydraulic models have been updated and refined in accordance with the *Preparation of Flood Studies and Reports - Guidelines* (2010) developed by TCC, to account for significant changes.

The hydraulic model developed includes culverts, bridges and pipes with a capacity greater than or equal to peak discharge from a 2 year ARI storm event (this was taken as structures with a cross sectional area equivalent or greater than that of a 900 mm diameter pipe). Modelling these structures allows for a better representation of flow through the existing drainage infrastructure and a more robust understanding of flooding across the study area.

Inflow boundary conditions were derived using inflow hydrographs from XP-RAFTS hydrologic models for Louisa Creek, Captains Creek, Kirwan, Bohle River, Stony Creek and Saunders Creek catchments. Discharge hydrographs from the Lakes II overflows were taken from the Ross Creek hydraulic model (developed by TCC) and discharge hydrographs for the upstream Bohle River boundary conditions were taken from the Middle Bohle hydraulic model (developed by AECOM). An open ocean boundary was used for the downstream boundary condition to account for tailwater levels associated with Mean High Water Springs tide level and Sea Level Rise conditions. A combination of XP-RAFTS local source points and Rain-on-Grid net precipitation was adopted to represent rainfall runoff.

1.5 Spatial Data

For the purposes of this study a variety of data was available from different sources as summarised below.

AECOM had the following data readily available for use as part of this project:

- MIKE FLOOD model produced as part of a project for Department of Defence in the area (AECOM, 2012)
- flood study report and associated model produced as part of the *Townsville Flood Hazard Assessment (TFHA)* (Maunsell AECOM, 2005)
- flood study report and associated model produced as part of the *Blakey's Crossing Hydraulic Assessment Summary Report* (AECOM, 2013)
- various XP-RAFTS hydraulic models developed by AECOM for previous flood studies in the vicinity of the area of interest.

TCC provided the following data for the study:

- topography data in the form of contours and XYZ tiles at 1 metre (m) spacing based on 2009 LiDAR survey
- topography data in the form of contours and XYZ tiles at 1 metre (m) spacing based on 2012 LiDAR survey
- aerial photography flown in 2011 with pixel sizes of 0.125 m
- digital cadastral database containing property boundaries (TCC, June 2012)
- stormwater Drainage Network Database (TCC, March 2012)
- as-constructed plans for Blakey's Crossing along Ingham Road (TCC, March 2012)
- XP-RAFTS model for Louisa Creek and Captains Creek (TCC, February 2011)
- the report and model files for the *Louisa Creek Flood Study (LCFS)* (GHD, 2000)
- water level recordings from Gauging Station downstream of Bayswater Road (TCC, August 2012)
- surveyed water levels in the area for the January 1998 storm event (TCC, August 2012)
- a copy of *Townsville Northern Approaches Flood Mitigation Funding Submission* (TCC, 2010)
- a copy of *Louisa Creek Hydraulic Upgrade* Report (Sinclair Knight Merz, 2000)
- a copy of *Hydraulic Upgrade Feasibility Assessment* Report (Sinclair Knight Merz, 2001)
- a copy of *Lower Louisa Creek Drainage Scoping* Report (NRA Environmental Consultants, 2004)
- design topography and stormwater as-constructed plans for the Mount Louisa East Domain Central site.

Queensland Transport and Main Roads (TMR) provided the following data:

- bridges and culverts details along Bruce Highway within the model extent (TMR October 2011).

Additionally, AECOM carried out a walkover survey on 14 August 2012, to verify configurations/dimensions of the various structures along Louisa Creek where conflicting information was found in the various datasets.

A topographical survey of Louisa Creek between Bayswater Road and Ingham Road (completed by Brazier Motti in October 2012) was also undertaken as part of the commission. The purpose of this survey was to provide a realistic representation of Louisa Creek and its immediate vicinity.

1.6 Previous Reports

There are a number of previous flood/drainage assessments completed by AECOM and others within and around the study area. A summary of any previous studies referenced throughout this report has been provided below. It also should be noted that some of these studies have been used to inform our assessment.

- **Bohle River Floodplain Management Study (Maunsell McIntyre April 2001)**

The *Bohle River Floodplain Management Study* assessed the hydraulics and mapped the extents of the of the Bohle River floodplain from Kelso Drive to its outlet at Halifax Bay. RORB hydrologic and 1D MIKE 11 hydraulic models were developed to complete the flood extents analysis.

- **Bohle Plains Flood Planning Report (AECOM April 2010)**

The *Bohle Plains Flood Planning Report* consolidated all modelling studies completed in the Bohle Plains area since the *BRFMS*. The assessment included hydrological and hydraulic modelling of the Bohle River, Saunders Creek, Stony Creek and Black River catchments for the 50 year ARI storm event.

- **Ross River Flood Study Report (TCC 2013)**

The *Ross River Flood Study Report* covers the entire Ross River catchment, both upstream and downstream of the dam. The hydraulic model developed provides a broad-scale representation of flows within the lower Ross River and also informs dam outflow management.

- **Blakey's Crossing Hydraulic Assessment Summary Report (AECOM 2013)**

The *Blakey's Crossing Hydraulic Assessment* involved flood modelling to inform the conceptual and detailed design stages of the project. A MIKE FLOOD hydraulic model was built based on TCC's LiDAR topography flown in 2009 with major culverts along Louisa Creek included in the model using 1D MIKE 11 elements. The large scale hydraulic model was calibrated against the January 1998 and February 2008 storm events.

- **Ross Creek Flood Study (TCC 2013)**

The *Ross Creek Flood Study* assessed flooding for the portions of the Townsville Floodplain that drains to Ross Creek, building on a number of previous flood assessment carried out in the vicinity as part of the *City Wide Flood Constraints Project*. A MIKE FLOOD hydraulic model was built based on TCC's LiDAR topography flown in 2009 and major culverts, open channel drains and the underground stormwater system were included in the model using 1 D MIKE 11 and MIKE URBAN elements. The hydraulic model was calibrated to three rainfall events: January 1998, February 2002 and January 2009.

Flows from the hydraulic model were applied to the *Louisa Creek Flood Study* model to represent overflows from the Lakes II.

- **Captains Creek Flood Study (AECOM 2014)**

The *Captains Creek Flood Study* assessed flooding for the Captains Creek catchment as part of *the City Wide Flood Constraints Project*. A MIKE FLOOD hydraulic model was built based on the TCC's LiDAR topography flown in 2009 with major culverts and open channel drains included in the model using the 1D MIKE 11 and MIKE URBAN elements. This hydraulic model was not calibrated as no recent calibration data was available.

- **Lower Bohle/Stony Creek Flood Study (AECOM 2014)**

The *Lower Bohle/Stony Creek Flood Study* assessed base case flooding for the Lower Bohle area building on a number of previous flood assessments carried out in the vicinity as part of the *City Wide Flood Constraints Project*. A MIKE FLOOD hydraulic model was built based on TCC's LiDAR topography flown in 2009 and 2012 and incorporates hydrographic survey of the downstream reaches of the Bohle River. Major culverts and open channel drains were included in the model using the 1D MIKE 11 and MIKE URBAN elements.

- **Upper & Middle Bohle Flood Study (AECOM 2014)**

The *Upper & Middle Bohle Flood Study* assessed flooding for the Upper and Middle Bohle areas building on a number of previous flood assessments carried out in the vicinity as part of the *City Wide Flood Constraints Project*. A MIKE FLOOD hydraulic model was built based on TCC's LiDAR topography flown in 2012 and major culverts and open channel drains were included in the model using the 1D MIKE 11 and MIKE URBAN elements.

2.0 Hydrological Assessment

2.1 Overview

The hydrology for the *Louisa Creek Flood Study* was obtained from the previously completed *Bohle Plains Flood Planning Report* (AECOM, 2010) *Deeragun Flood Study* (AECOM, 2012) and *Lower Bohle Flood Study* (AECOM, 2012). Hydrologic models for Louisa Creek and Captains Creek were developed by TCC and made available to AECOM for the purposes of this study. It must be noted that the results of these models were compared against the rational method but the models were not calibrated or verified. The remaining XP-RAFTS models, which include Bohle River 1, Bohle River 2, Bohle River 3, Bohle River 4, Kirwan, and Saunders Creek, were developed previously by AECOM. No further refinement of hydrologic models was undertaken as part of this study as these models were recently developed using the latest LiDAR data available (2009). Fraction impervious changes were made to various existing XP-RAFTS models to account for significant development in the area. No re-delineation of catchments was undertaken as part of this study.

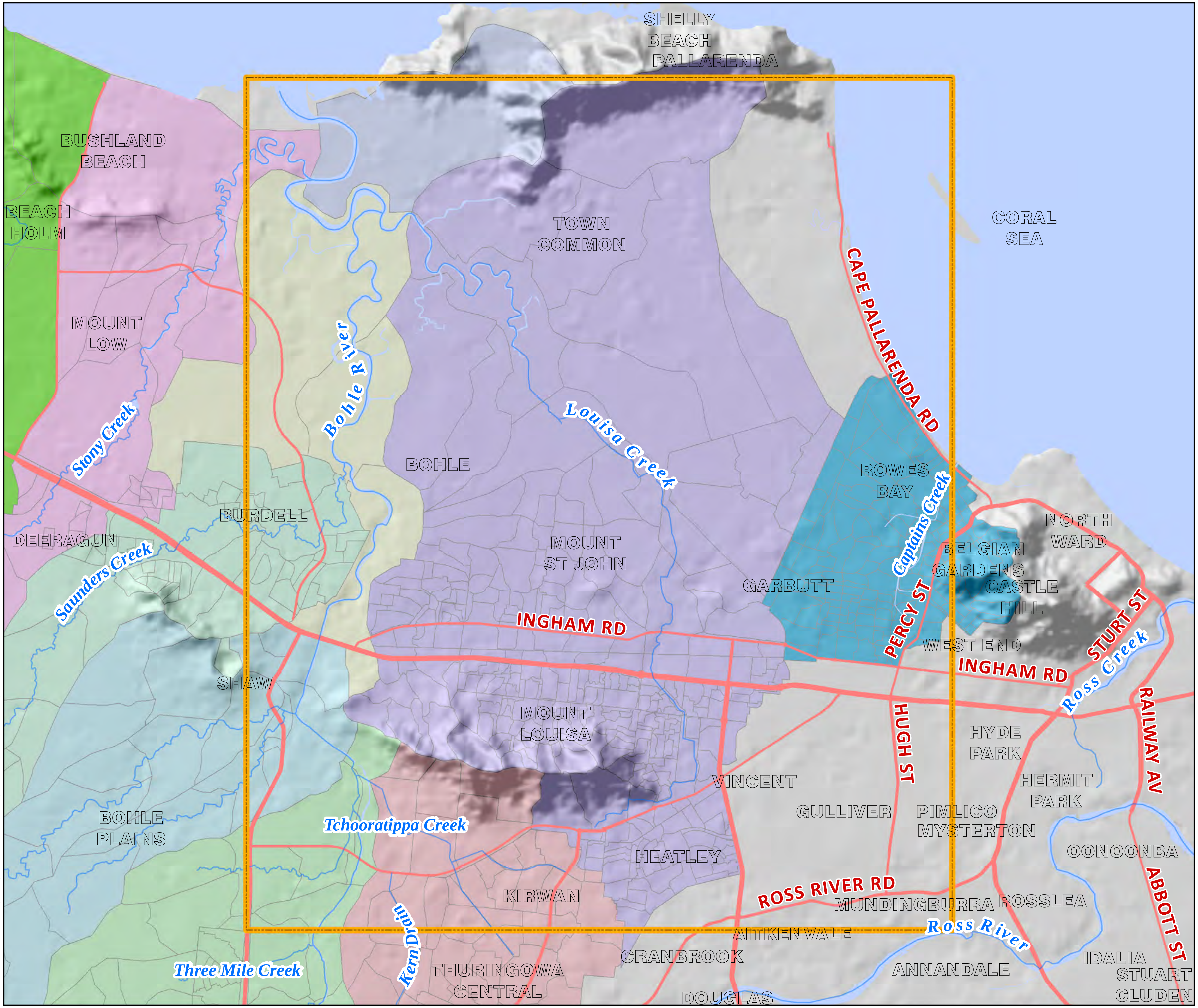
The location and extent of model catchments in relation to the study area is shown in Figure 2-1. For this study the loss factors were adopted based on TCC guidelines *Preparation of Flood Studies and Reports – Guidelines (TCC, 2010).* For the pervious areas within the model the initial loss of 25 mm and continuing loss 2.5 mm/h were used whereas, for the impervious areas within the model the initial loss of 0 mm and continuing loss of 1 mm/h were adopted.

Two methods were used to represent rainfall runoff within the hydraulic models used for this study. They were:

- net precipitation (Rain-on-Grid) which was used across the more urbanised and relatively flat catchments
- the rainfall-runoff hydrological modelling approach (XP-RAFTS) which was generally applied across rural as well as steep sub-catchments.

TOWNSVILLE CITY COUNCIL
LOUISA CREEK FLOOD STUDY

Location and Extents
of Model Catchments
Figure 2-1



Legend

- Model Extent
- Watercourse
- Black River
- Bohle River 1
- Bohle River 2
- Bohle River 3
- Bohle River 4
- Captains Creek
- Condon
- Kirwan
- Little Bohle River
- Louisa Creek
- Saunders Creek
- Stony Creek

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Metres

1:50,000 (when printed at A3)

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Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
Localities © 2012 (Queensland Govt)

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User: mathieu-burrym | Date Saved: 3/06/2014 | FileName: J:\MMPL\60304053\4. Tech Work Area\4.99 GIS\MXD\DRAFT_REPORT_REV0_20140509\60304053_Fig2-1_ModelCatchments.mxd

2.2 Design Rainfall

Intensity Frequency Duration (IFD) input parameters specific for the study area were determined from Volume 2 of *Australian Rainfall and Runoff* (AR&R, 1987). The values are summarised in Table 2-1. Standard techniques from AR&R were used to determine rainfall intensities for the durations assessed, for ARI's up to the 100 year event. For the rainfall events greater than 100 year ARI but less than 1000 year ARI, extrapolation of AR&R has been undertaken and verified against CRC-FORGE rainfall estimation methods. The values obtained for the Louisa Creek catchment are summarised in Table 2-2. The design rainfall intensities developed, correlate with those established in the *Bohle Plains Flood Planning Report* (AECOM, 2010).

Table 2-1 IFD Input Parameters

Parameter	Kirwan	Bohle River 1, 2 and 3	Bohle River 4	Saunders Creek	Louisa Creek
2 year ARI, 1 hour duration (mm/h)	55	55	55	55	53.7
2 year ARI, 12 hour duration (mm/h)	12.3	13	13	13	11.71
2 year ARI, 72 hour duration (mm/h)	5	4	4	4	3.85
50 year ARI, 1 hour duration (mm/h)	110	105	110	105	110.5
50 year ARI, 12 hour duration (mm/h)	25	27.5	27.5	27.5	24.5
50 year ARI, 72 hour duration (mm/h)	9.5	9.5	10	9.5	9.34
G	3.93	3.93	3.93	3.93	3.93
F2	17	17	17	17	17.7
F50	0.05	0.05	0.05	0.05	0.06

Table 2-2 Design Rainfall Intensities for Louisa Creek Catchment in mm/h

Duration (hours)	Average Recurrence Interval (year)							
	2	5	10	20	50	100	200	500
	Rainfall Intensity (mm/h)							
1	53.4	70.3	80.5	93.8	111.5	125.3	134	155
2	35.0	46.1	52.8	61.6	73.3	82.3	93	107
3	27.2	35.9	41.1	47.9	57.0	64.0	75	87
4.5	21.1	27.8	31.9	37.2	44.3	49.7	61	72
6	17.6	23.3	26.7	31.1	37.0	41.6	52	60
9	13.7	18.1	20.7	24.2	28.8	32.3	42	48
12	11.5	15.1	17.3	20.2	24.1	27.1	36	42
18	9.0	12.1	14.0	16.4	19.7	22.2	29	34
24	7.6	10.3	11.9	14.1	17.0	19.3	25	29
36	5.9	8.1	9.5	11.3	13.8	15.7	20	23
48	4.9	6.8	8.1	9.6	11.8	13.5	17	20
72	3.7	5.2	6.3	7.5	9.3	10.8	13	15

2.3 Extreme Rainfall Events

The Generalised Short Duration Method (GSDM) and the Generalised Tropical Storm Method (GTSM) were used to estimate the PMP for this study. The rainfall intensity for the PMP event assessed are summarised in Table 2-3.

The critical duration assessed for the PMP event was 3 hours. The other critical durations were determined following review of the critical duration assessment for the 100 year ARI and agreed with TCC.

PMP rainfall calculations were completed with catchments grouped as follows:

- Kirwan and Condon
- Bohle River 1, Bohle River 2, Bohle River 3 and Bohle River 4, as well as Saunders and Stony Creek
- Louisa Creek.

The sub-catchments were grouped to represent major tributaries within the catchments and to identify the one combination likely to generate the greatest rainfall for the PMP event across the catchment. This approach was based on the generally accepted premise that it is highly unlikely that PMP rainfall would fall across more than one of the main tributaries (all sub-catchments grouped) at the same time.

Table 2-3 Extreme Rainfall Events Intensity (mm/h)

Duration (hours)	Louisa Creek	Captains Creek	Kirwan and Condon	Bohle River 1, 2 and 3, Saunders and Stony Creek
	PMP Rainfall Intensity (mm/h)			
1	380	430	410	350
2	250	285	280	245
3	190	217	217	193
4.5	149	168	170.5	152.5
6	123	138	140	127
9	96	105	107	98
12	83	89	91	84
18	69	73	75	70
24	63	64	67	63
36	51	53	55	52
48	44.9	46.4	47.8	45.3
72	37.6	38.8	40.1	38

2.4 Rain-on-Grid Method – Local Runoff

Rain-on-Grid is a method for applying rainfall to a hydraulic model. It involves applying the rainfall directly on the two-dimensional grid which supplements the rainfall/runoff hydrologic modelling approach using software like XP-RAFTS, RORB, etc. This method is particularly advantageous in ungauged urban areas such as those within the Louisa Creek model extents. For this reason Rain-on-Grid was applied within the hydraulic model extent to simulate the local runoff. It must be noted, however, that this method is not recommended for steep areas and therefore the extent of application across the hydraulic model has been limited to relatively flat areas.

Two-dimensional rainfall excess time series for each ARI and duration were created to represent the local net precipitation for the study area. This rainfall excess is calculated by applying initial and continuing losses to the design rainfall for two extreme scenarios (i.e. pervious and impervious). As outlined in AR&R Volume 1 initial and continuing loss values represent infiltration and storage of runoff in surface depressions. Initial and continuous loss values of 25 mm / 2.5 mm/h and 1 mm / 0 mm/h were applied to the pervious and impervious areas respectively.

For design events between 2 year ARI and 500 year ARI, temporal patterns were applied based on AR&R, Volume 2. For events greater than 500 year ARI with storm durations of less than 6 hours, the GSDM temporal pattern was applied. For longer duration rare events (i.e. greater than 500 year ARI), duration specific temporal patterns were used based on the GTSMR.

An imperviousness map for the existing scenario was created using TCC's property boundary dataset and high resolution aerial imagery (see Figure 2-2). The property boundary dataset contains suitable descriptors that allow the separation between vacant land, vacant land intended for residential use, residential dwelling, parks, commercial and industrial land, etc. To determine the imperviousness percentage, an average house size to land parcel ratio was used. For all other parcels, an imperviousness fraction was applied based on typical values for the type of land in the area from aerial imagery (2011).

A combination of adopting the Rain-on-Grid methodology and not including all minor culverts included in the hydraulic model, results in some localised flooding within the study area. As this project seeks to assess the major flow paths within the study area, this localised flooding may not represent the true localised drainage condition but can be used as a guide to identify potential inundation issues.

2.5 The Lakes

Inflow hydrographs of overflows from the Lakes detention system were directly calculated using two-dimensional MIKE FLOOD models developed as part of the *Ross Creek Flood Study, Base-line Flooding Assessment* (TCC, 2013). The inflow hydrographs were provided to AECOM by TCC, which were incorporated into the hydraulic model as an inflow source points. Further details regarding the locations of inflow source points are provided along with the description of the hydraulic model setup in Section 3.3.2.

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LOUISA CREEK FLOOD STUDY

Imperviousness Map

Figure 2-2

Impervious Fractor (%)

- 0 - 10% Impervious
- 10 - 20% Impervious
- 20 - 30% Impervious
- 30 - 40% Impervious
- 40 - 50% Impervious
- 50 - 60% Impervious
- 60 - 70% Impervious
- 70 - 80% Impervious
- 80 - 90% Impervious
- 90 - 100% Impervious

0 500 1,000 2,000
Metres

1:45,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
Localities © 2012 (Queensland Govt)

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3.0 Hydraulic Assessment

3.1 Overview

MIKE FLOOD was used as the platform to construct a dynamically linked hydraulic model for the Louisa Creek area to assess flooding for the base case. The Louisa Creek model extent is shown in Figure 1-1 along with those for previous overlapping studies undertaken as part of the *Citywide Flood Constraints Project*.

An overview of the model setup and key parameters is provided in Table 3-1.

3.2 MIKE FLOOD Hydraulic Model

MIKE FLOOD is a numerical hydraulic model developed by the Danish Hydraulic Institute (DHI). The model dynamically couples the one-dimensional MIKE URBAN pipe hydraulics and one-dimensional MIKE 11 elements (culverts, bridges and open channels) hydraulics, with the two-dimensional surface water hydraulic model MIKE 21. Outputs from MIKE FLOOD include GIS compatible maps of flood extents, water depth, water level, flow and velocities.

3.2.1 MIKE 11

MIKE 11 is a software package used for one-dimensional simulation of flows, water quality and sediment transport in estuaries, rivers, irrigation systems, channels and other water bodies. The model is typically used to assess one-dimensional flows through structures such as bridges and culverts. It also enables simulation of complex river systems where one-dimensional flow predominates.

3.2.2 MIKE 21

MIKE 21 is a software package used for two-dimensional simulation of flow distribution based on water and ground levels at each time step of a model run. The two-dimensional model provides a more accurate determination of the extent, magnitude and direction of the flood flows than MIKE 11, without the need to pre-determine the flow path.

3.2.3 MIKE URBAN

MIKE URBAN is a software package used for one-dimensional simulation of sanitary or storm drain sewers as well as water distribution systems that couples with MIKE 11 and MIKE 21. This software package can be used to analyse a range of parameters including water quality, rainfall runoff and infiltration.

Table 3-1 Louisa Creek Model Setup Overview

Parameter	Information
Completion Date	2014
Return Periods Assessed (ARI)	2, 5, 10, 20, 50, 100, 200, 500, PMF
Hydrologic Modelling Approach	XP-RAFTS, Rain-on-Grid
IFD Input Parameters	Based on Volume 2 of AR&R 1987 (refer Table 2-1).
Hydraulic Modelling Approach	MIKE 21, MIKE 11, MIKE URBAN
Model Extent	Refer Figure 1-2.
Grid size	10 m
Digital Elevation Model (year flown)	2009 and 2012
Roughness	Spatially varying standard values compliant with AR&R and TCC guidelines (refer to Table 3-2, Figure 3-3).
Eddy Viscosity	Constant, velocity based value of 6 m^2/s.
Model Calibration	February 2014 and April 2014
Model Verification	Verification against Upper and Middle Bohle Flood Study (AECOM, 2014) and Captains Creek Flood Study (AECOM, 2014)
Upstream Model Boundary	Bohle River inflows extracted from Upper and Middle Bohle Flood Study (AECOM, 2014). Lakes overflows extracted from Ross Creek Flood Study (TCC, 2013) hydraulic model. All other inflows obtained from XP-Rafts models.
Downstream Model Boundary	Tidal Boundary (constant MHWS)
Hydraulic Model Time Step	0.5 s
Hydraulic Model Flooding and Drying Depth	0.02 m and 0.003 m respectively
Sensitivity Analysis	Climate Change with Sea Level Rise, Highest Astronomical Tide

3.3 Model Development

The Louisa Creek hydraulic model was constructed using as built or as designed plans of new developments, details of road culverts and information from existing MIKE FLOOD hydraulic models. The previous Middle Bohle, Ross Creek (developed by TCC), Blakey's Crossing and Captains Creek models overlap the study area as shown in Figure 1-1. These models provided relevant information for the construction of the new Louisa Creek model.

3.3.1 Model Geometry

A 10 m by 10 m cartesian grid was developed to represent the topography of the hydraulic model surface. The grid was based on the 2009 and 2012 LiDAR topography supplied by TCC as well as hydrographic survey data covering the lower reaches of the Bohle River.

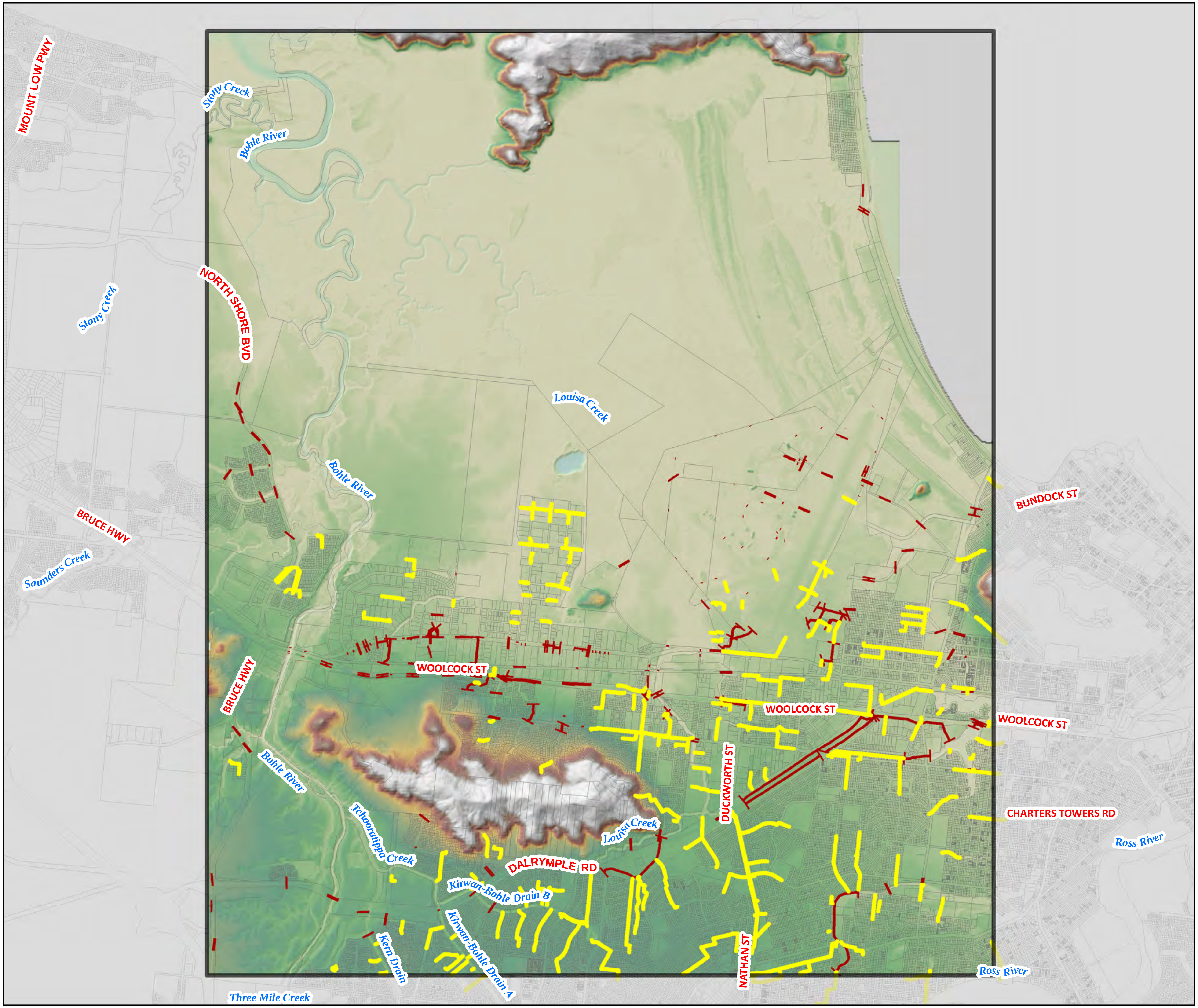
The grid consists of more than one million cells with each cell representing the average elevation over each cell area (10 m x 10 m). To ensure adequate representation and continuity, stream inverts for the major watercourses within the study extents were stamped into the MIKE 21 grid.

Road crown levels of Ingham Road, Railway line, Bruce Highway, Bayswater Road, Dalrymple Road, Mather Street, Banfield Drive, Duckworth Street, Shaw Road and North Shore Boulevard were incorporated into the MIKE 21 grid as they act as major flood control mechanisms within the study area.

Hydraulic structures within the study area were represented using either the 1D MIKE 11 or MIKE URBAN elements that were coupled into the 2D MIKE 21 grid. All major culverts along all roadways were represented in the MIKE 11 model. All other major underground drainage within the model is generally represented using the MIKE URBAN model as shown in Figure 3-1. Note that only structures with a cross-sectional area equivalent, or in excess of, that of a 900 mm diameter pipe were included in the model. Details of the structures modelled using MIKE 11 are summarised in Appendix B.

A major diversion of the Louisa Creek channel has recently been constructed between Dalrymple Road and Bayswater Road in between Davies St and Greg Jabs Drive as is not captured by the 2009 LiDAR survey. The geometry of channel diversion and associated hydraulic structures was added to the model based on as-constructed plans provided by TCC.

The geometry of the Blakeys Crossing upgrade, which is currently under construction, was added to the model based on the AECOM for-construction plans dated February 2014.



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Model Geometry

Figure 3-1

Legend

MIKE URBAN Structures
MIKE 11 Network

0 500 1,000 2,000
Metres

1:45,000 (when printed at A3)

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
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3.3.2 Boundary Conditions

Inflow hydrographs at the upstream boundary of the Bohle River were taken from the Middle Bohle hydraulic models. A single inflow was input into MIKE 21 as a source point to represent surcharge to the study area from The Lakes II drainage system according to the refinement developed by TCC.

Local runoff for the modelled area was represented using inflow hydrographs, obtained from the XP-RAFTS hydrologic model at specific catchments and applied as source points at appropriate locations throughout the hydraulic model. Rain-on-Grid was applied across the more urban and relatively flat areas of the model extent. The locations of all boundary conditions for this model can be seen in Figure 3-2.

An ocean downstream boundary was applied as a fixed water level of 1.254 m AHD which represents the Mean High Water Spring (MHWS) tide for the Townsville area as included in the Queensland Tide Tables (2011).

3.3.3 Roughness

Hydraulic roughness (Manning’s n value) is a measure of the resistance to flow and is primarily dependent on land use. Values selected for each land use are provided in Table 3-2 and the roughness map is shown in Figure 3-3.

These values have been confirmed through calibration to the February 2014 and April 2014 rainfall events as part of this study. The high roughness associated with the upper reaches of the Louisa Creek Channel is supported by observations of existing vegetated condition of the channel, as can be observed from the photos provided in Appendix D.

Table 3-2 Hydraulic Roughness Values

Land Use	Manning's n Value
Roads/Rail	0.020
Drainage Easements	0.025
River Channel	0.030
Open Space/Sandy area	0.050
Urban Areas	0.060
Louisa Creek	0.067
Open Grassland	0.070
Bushland	0.080
Riparian Zone	0.100

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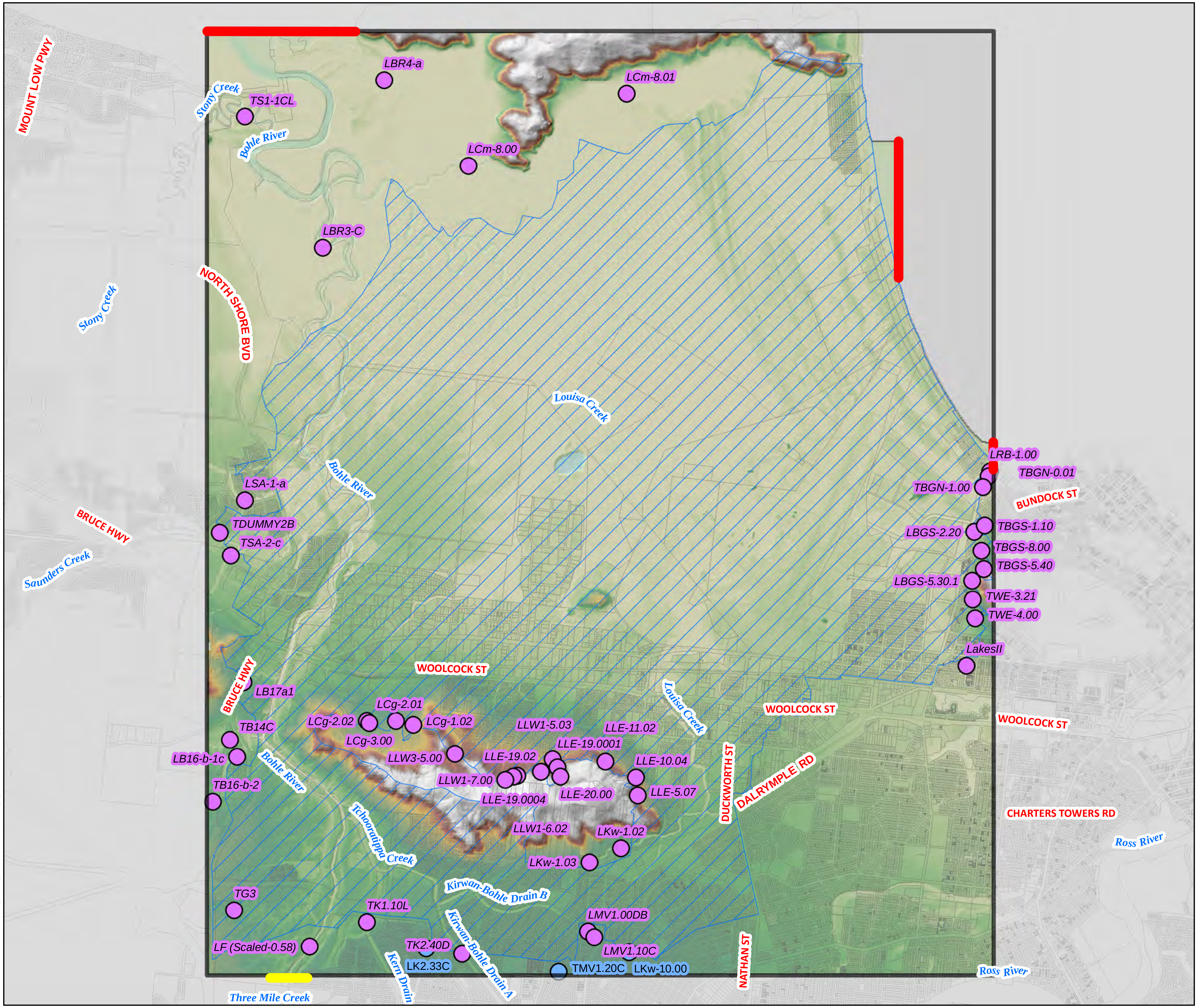
LOUISA CREEK FLOOD STUDY

Boundary Conditions

Figure 3-2



Legend

- Mike 21 Source Locations
- Mike URBAN Source Locations
- Inflow Boundaries
- Outflow Boundaries
- Rain on Grid Area Net Precipitation

0 500 1,000 2,000

Metres

1:45,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
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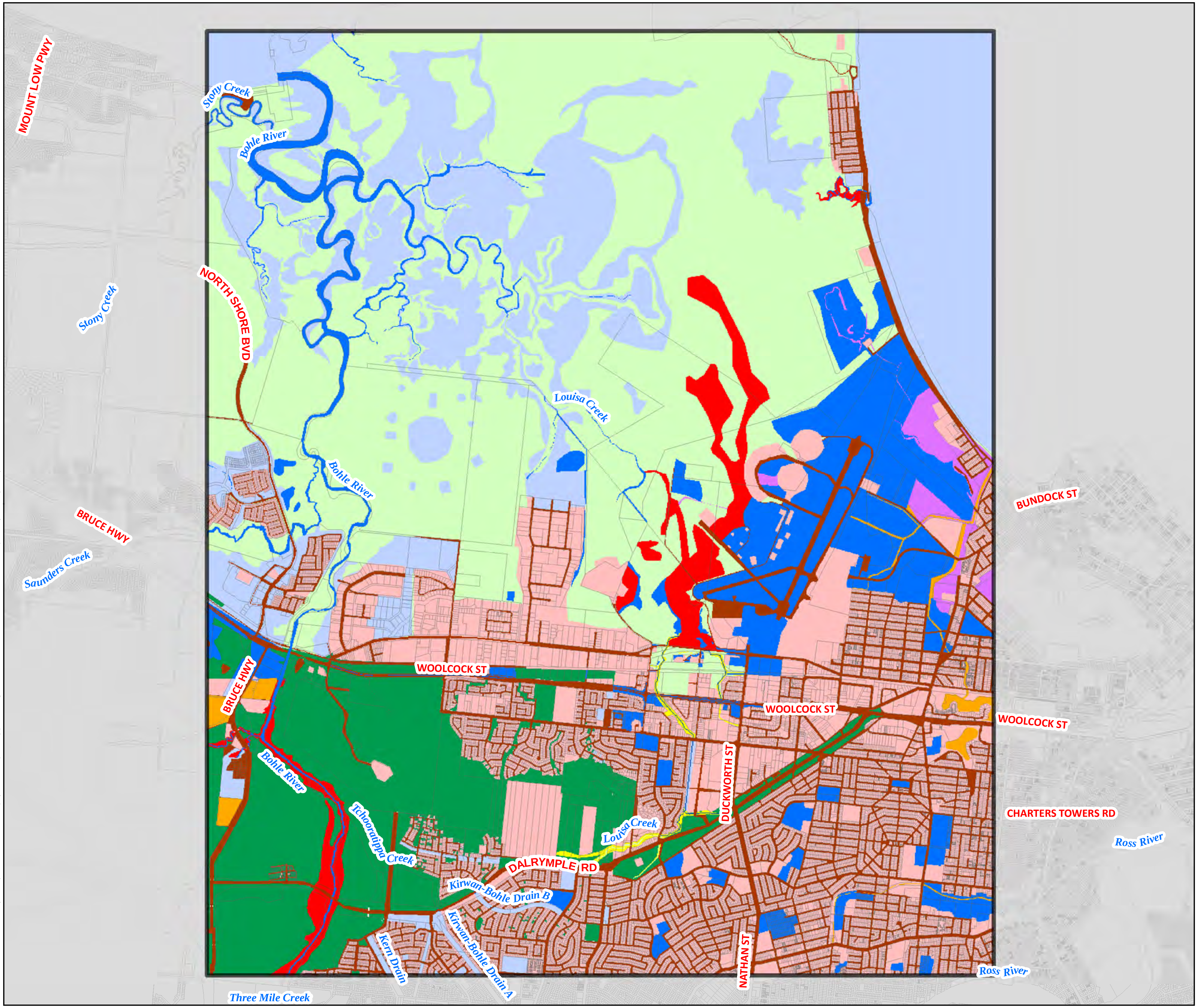
Roughness Map

Figure 3-3



Manning's (n)

- 0.020
- 0.025
- 0.030
- 0.040
- 0.050
- 0.060
- 0.067
- 0.070
- 0.080
- 0.100

0 500 1,000 2,000
Metres

1:45,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
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User: mathieu-burrym | Date Saved: 3/06/2014 | FileName: \\autsv1fp001\jobs\MMPL\60304053\4. Tech Work Area\4.99 GIS\MXD\DRAFT_REPORT_REV0_20140509\60304053_Fig3-3_RoughnessMap.mxd

3.4 Model Checking and Verification

Calibration of the Louisa Creek hydraulic model was undertaken to facilitate comparison against the available records for the Louisa Creek catchment.

3.4.1 Calibration Event Data

3.4.1.1 Historical Rainfall Data

A comparison of the IFD relationships for several significant rainfall events in the Louisa Creek catchment is shown in Figure 3-4. The events plotted are based on the following data:

- TCC Louisa Creek ALERT gauge for the February 2014, April 2014 and February 2008 events.
- Townsville Airport Bureau of Meteorology rainfall gauge for the January 1998 event.

From Figure 3-4, the following observations are made:

- The January 1998 rainfall event was greater than 100 year ARI for all durations.
- The February 2008 rainfall event represented rainfall around a 5 year ARI for durations between 6 hours and 9 hours.
- The February 2014 was generally greater than the 2 year ARI event for all durations and around a 5 year ARI for durations between 6 hours and 12 hours.
- The April 2014 rainfall event was less than a 2 year ARI event for durations less than 3 hours but higher than a 2 year ARI for longer durations.

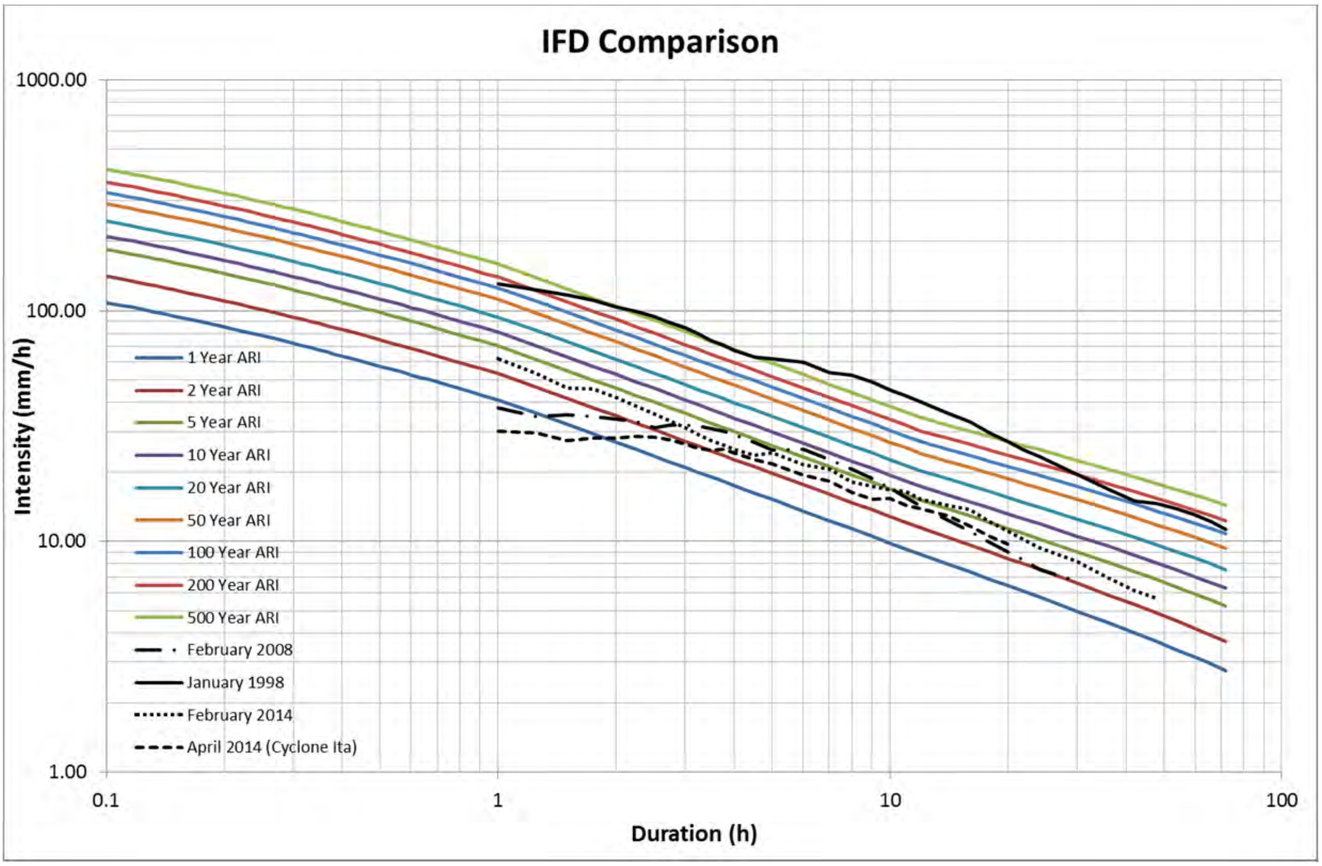

Figure 3-4 IFD comparison

3.4.1.2 Historical Gauge Data

A flood ALERT gauge was installed at the Bayswater Road crossing of Louisa Creek in 2000. The peak water levels recorded at the gauge corresponding to the events shown in Figure 3-4 are given in Table 3.3.

The highest water level recorded at the Louisa Creek gauge between 2000 and 2014 was 5.93 m AHD (recorded on 3rd February 2009 at 4.30 am).

Table 3-3 Recorded peak water levels at Louisa Creek flood ALERT

Date	Time	Peak Water Level (m AHD)
3rd February 2009	04.30 AM	5.93
15th February 2008	10:40 PM	5.73
18th February 2014	03:55 AM	5.68
13th April 2014	08:15 AM	5.68

3.4.1.3 Calibration Event Selection

Following the review of the available calibration data and of recent changes across the Louisa Creek catchment, the 2014 flood events were selected for model calibration.

Whilst the most recent events do not represent the highest recorded floods in recent times, the older recorded data was not considered as representative of current catchment conditions given that several significant developments have occurred in recent years, these include:

- urbanisation of the catchment, including filling of land in the Bohle industrial area and levee construction
- construction of the Louisa Creek channel diversion adjacent Greg Jabs Drive
- Kern Drain diversion
- construction of the Blakey's Crossing upgrade.

3.4.2 Model Calibration

The calibration process was undertaken by adjusting roughness values in order to obtain results similar to the recorded levels for the February and April 2014 events. The 1998 event was also simulated for model verification.

3.4.2.1 February 2014 Rainfall Event

The rainfall data at the Louisa Creek ALERT station for the rainfall event which occurred between the 17th and 18th February 2014 is shown in Figure 3-5. The rainfall event represented close to a 5 year ARI event at both the Louisa Creek ALERT and at the Townsville Airport pluviograph.

A comparison of the modelled and gauged flood levels at the Louisa Creek gauge is shown in Figure 3-6. The comparison shows reasonable agreement in terms of peak flood levels (modelled peak is approximately 100 mm lower than the recorded peak at the gauge) and timing between the recorded levels and those predicted by the MIKE FLOOD model.

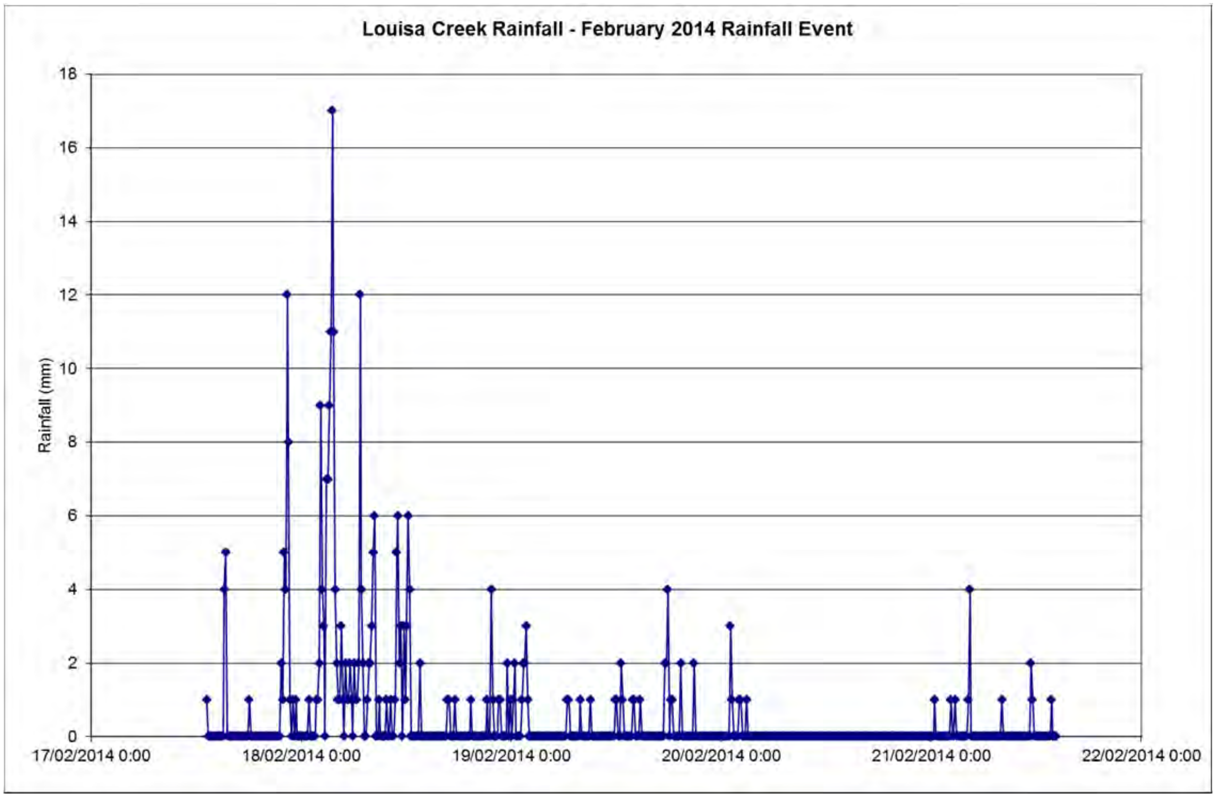

Figure 3-5 Louisa Creek Rainfall – February 2014 Rainfall Event

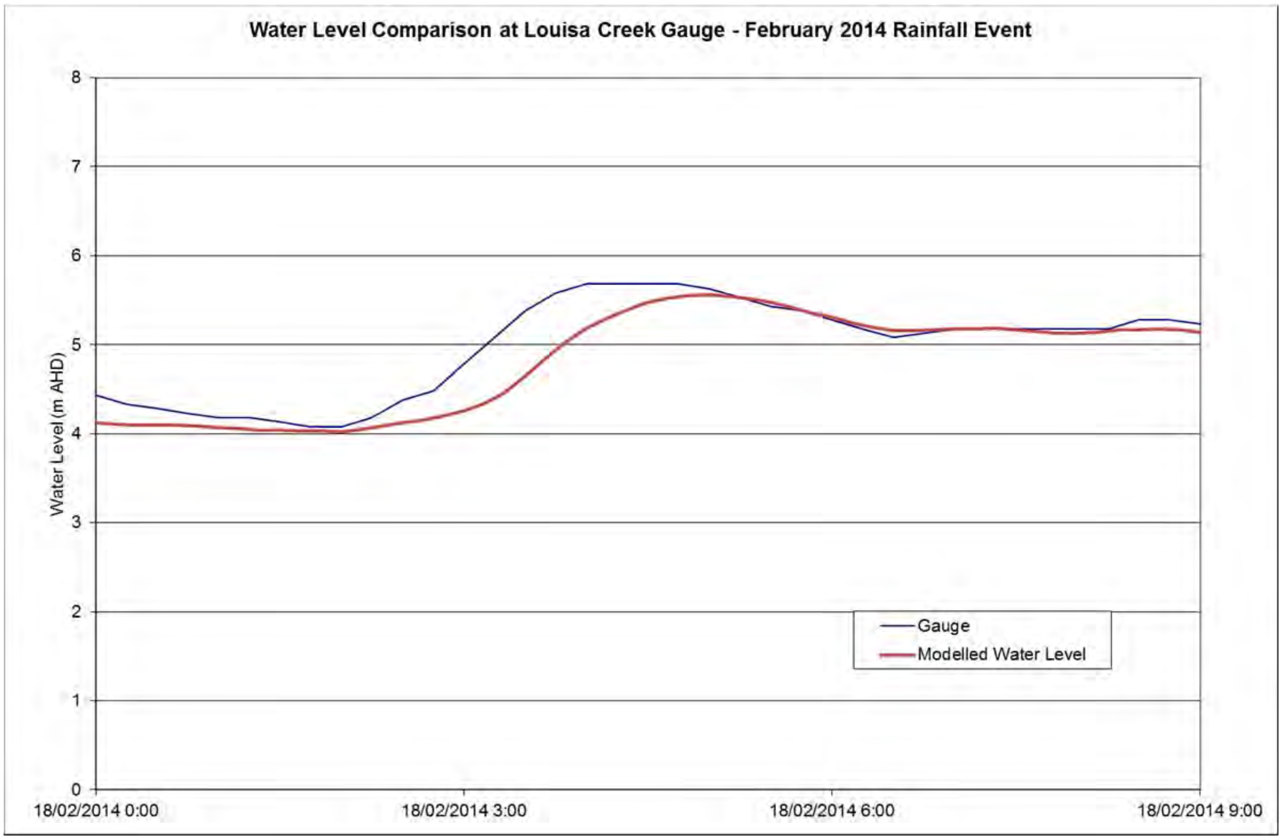

Figure 3-6 Water Level Comparison at Louisa Creek Gauge – February 2014 Rainfall Event

Post flood debris levels were surveyed on the afternoon of 18th February 2014 at Blakey's Crossing, which is located on Ingham Road between Mathers Street and Duckworth Street. Photographs taken in the vicinity of the crossing shortly after the peak of the flood event are provided in Appendix E.

An upgrade to the crossing had partially been constructed at the time of the flood event, with some road embankment being in place however no bridge or culvert structures were in place. As far as possible the model bathymetry was modified to reflect as-constructed conditions following observations made during an AECOM site visit following the flood, however detailed survey of the exact length of embankment in place was not taken for this purpose.

The planned raising of Blakey St had not been constructed at the time of the flood and a gap in the embankment was present to allow access to Blakey St from the existing Ingham Road crossing. All culverts on the existing Blakeys Crossing causeway, which is downstream of the partially constructed crossing, were observed to be blocked by siltation.

Debris levels and flood marks were recorded both upstream and downstream of the road embankment. Table 3-4 provides a comparison between the model results and surveyed debris levels during the February 2014 flood event.

As with the upstream gauge data, the average modelled results upstream of both Louisa Creek and Pee Wee Creek were approximately 150 mm lower than the average recorded flood level. Average downstream water levels were in the order of 230 mm and 300 mm lower in the model than as recorded at Pee Wee Creek and Louisa Creek, respectively. This indicates that the model may be slightly overpredicting the head loss across the embankment.

Modelled flood extents were generally found to match observations made around the catchment shortly after the peak of the flood event as well as anecdotal evidence from residents and photographs taken in the vicinity of Blakeys Crossing (some photographs are provided in Appendix E).

These results were considered as acceptable given the uncertainty in surveyed debris levels, the small difference between modelled and measured results and also the partially constructed condition of the embankment at the time of the flood event.

Table 3-4 Water Level Recorded at Blakeys Crossing on the 18th February 2014

Point	Description	Survey Elevation (m AHD)	Model Elevation (m AHD)	Difference (m)
1	Louisa Creek US WL	4.08	4.15	0.07
9	Louisa Creek US WL	3.94	4.01	0.07
3	Louisa Creek US WL	3.96	3.70	-0.26
8	Louisa Creek US WL	4.00	3.70	-0.30
7	Louisa Creek US WL	3.97	3.73	-0.24
	Average	*3.99*	*3.86*	*-0.13*
2	Louisa Creek DS WL	3.83	3.62	-0.21
4	Louisa Creek DS WL	3.94	3.59	-0.35
5	Louisa Creek DS WL	3.94	3.57	-0.37
	Average	*3.90*	*3.59*	*-0.31*
12	Blakey St US	3.86	3.91	0.05
10	Blakey St US	3.87	3.96	0.09
11	Blakey St US	3.88	3.91	0.03
6	Blakey St	3.82	3.71	-0.11
	Average	*3.87*	*3.93*	*0.06*

Point	Description	Survey Elevation (m AHD)	Model Elevation (m AHD)	Difference (m)
15	Pee Wee Creek US WL	4.06	3.96	-0.09
18	Pee Wee Creek US WL	4.04	3.83	-0.21
19	Pee Wee Creek US WL	4.01	3.86	-0.15
20	Pee Wee Creek US WL	3.98	3.85	-0.13
	Average	*4.02*	*3.88*	*-0.15*
14	Pee Wee Creek DS WL	3.87	3.63	-0.24
16	Pee Wee Creek DS WL	3.88	3.53	-0.35
23	Pee Wee Creek DS WL	3.90	3.58	-0.32
21	Pee Wee Creek DS WL	3.80	3.65	-0.15
22	Pee Wee Creek DS WL	3.79	3.69	-0.10
	Average	*3.85*	*3.62*	*-0.23*

3.4.2.2 April 2014 (Cyclone Ita) Rainfall Event

The rainfall data at the Louisa Creek gauge for the rainfall event which occurred due to the passage of Cyclone Ita between the 12th and 14th April 2014 is shown in Figure 3-7 along with the modelled flood level at the Louisa Creek gauge.

The rainfall event generally represented rainfall less than a 5 year ARI for the Louisa Creek catchment. Photos of flooding within the Louisa Creek catchment taken shortly after the peak of the April 2014 flood event are provided in Appendix F.

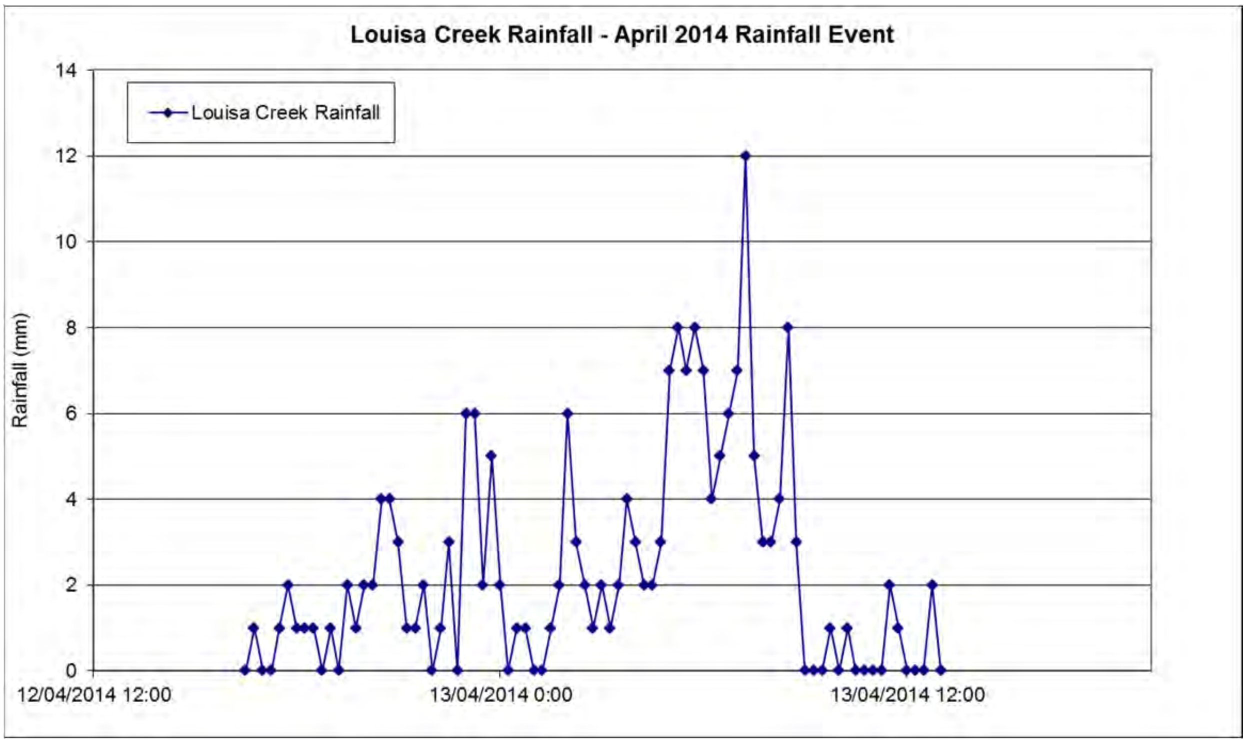

Figure 3-7 Louisa Creek Rainfall – April 2014 Rainfall Event

A comparison of modelled and gauged flood levels at the Louisa Creek gauge is shown in Figure 3-8. The comparison shows reasonable agreement in terms of peak flood levels and timing between the recorded levels and those predicted by the MIKE FLOOD model.

The modelled flood peak is approximately 150 mm lower than the recorded peak at the gauge.

In general the predicted flood extents were broadly consistent with observations made on site shortly after the peak of the event (photographs are provided in Appendix F). Observations made at the Hastings Street causeway flood level marker at the peak of the event were also consistent with the model predicted depth of water over the crossing.

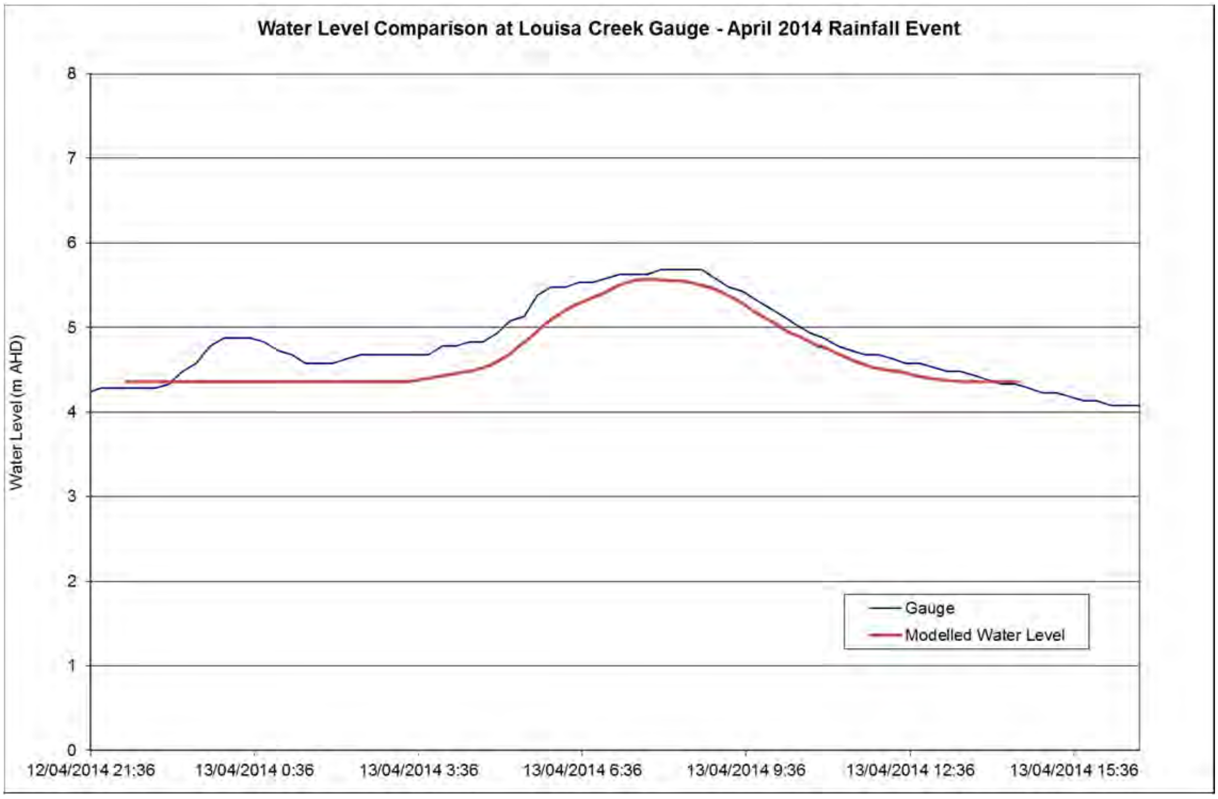

Figure 3-8 Water Level Comparison at Louisa Creek Gauge – April 2014 Rainfall Event

Post flood debris levels were again recorded at the partially constructed upgrade to Blakey's Crossing. Levels were recorded in the vicinity of Blakey St only. Table 3-5 summarises the model and surveyed flood elevations for the April 2014 flood event. The average modelled results were approximately 240 mm lower than the average surveyed flood level in the vicinity of Blakey Street.

Table 3-5 Water Level Recorded on the 14th April 2014

Surveyed Location	Surveyed Flood Level (m AHD)	MIKE FLOOD Flood Level (m AHD)	Difference in Flood Levels (m)
1	3.89	3.91	0.02
2	4.12	3.96	-0.16
3	4.12	3.96	-0.16
4	4.1	3.71	-0.39
5	4.1	3.65	-0.45
6	4.02	3.86	-0.16
7	4.03	3.66	-0.37
Average			-0.24

3.4.2.3 January 1998 Event

Given the relatively low ARI of the two 2014 flood events, the January 1998 flood event was also modelled for model verification. As shown in Figure 3-4, the January 1998 rainfall event was greater than 100 year ARI for all durations.

The model bathymetry used for the January 1998 event did not include the recently constructed Louisa Creek channel diversion or the Blakeys Crossing upgrade, however no further efforts were made to reflect catchment conditions as at January 1998.

The results of the January 1998 verification are provided in Appendix G. Overall the model provided adequate results across the floodplain. The significant difference at the Lotus Glen survey point is thought to be due to the amount of recent development in the vicinity of the Bohle industrial estate, which would not have been present in 1998.

3.4.2.4 Summary

Overall the final calibration results obtained from the two calibration runs and the verification run suggests that the model produces results within acceptable limits in modelling terms to those recorded during historical flood events assessed.

The results show that the model may be slightly underpredicting levels in the Louisa Creek channel for low ARI flood events such as the 2014 flood events, however the 1998 verification event provided confidence that the model is also able to capture larger events. Therefore, it was concluded that the Louisa Creek model has been successfully calibrated and is suitable for determining flood levels for the study area.

It is thought that improved confidence can be obtained for lower ARI events which would require more detailed survey and improved model resolution to more accurately capture the upper reaches of the Louisa Creek channel. A number of major developments are currently underway in the upper reaches of the Louisa Creek catchment along Dalrymple Road and it is therefore recommended that revised LiDAR survey and detailed channel survey should be taken following these changes to update the flood model. A flood ALERT gauge in the vicinity of the Banfield Drive crossing may also assist in improving future flood level predictions for residential areas in this vicinity.

3.4.3 Verification Against Previous and Overlapping Studies

Results of the model for this study were compared along the Bohle River to the MIKE FLOOD results from the *Deeragun Flood Study* (AECOM, 2012) *Bohle Plains Flood Planning Report* (AECOM, 2010), the *Lower Bohle/Stony Creek Flood Study* (AECOM, 2014), and the *Upper and Middle Bohle Flood Study* (AECOM, 2014) to verify model topography and other input parameters. The results along Captains Creek were compared to the *Captains Creek Flood Study* (AECOM, 2014) and the *Blakey's Crossing Hydraulic Assessment Summary Report* (AECOM, 2013).

Locations of the chainages for these long sections are shown in Figure 3-9.

Figure C-1 shows a comparison of the hydraulic grade lines along the Bohle River for the 100 year ARI 12 hour event. The Louisa Creek model is slightly higher than the Upper and Middle Bohle model for the section of the Bohle River upstream of Bruce Highway. In the *Upper and Middle Bohle River Flood Study* (AECOM, 2014), the overlapping section of the Bohle River downstream of the Bruce Highway is outside the model extent and is represented as a Mike 11 branch acting as a downstream boundary. Flood levels along Bohle River are slightly lower in the current study than the predicted flood levels in the *Lower Bohle/Stony Creek Flood Study*.

Figure C-2 and Figure C-3 show the comparison of the hydraulic grade lines along Captains Creek for the 100 year ARI 3 hour duration and 50 year ARI 3 hour duration events respectively.

Flood levels predicted in the current study for the 100 year ARI 3 hour duration design event compare well to the results of previous studies. The Blakey's Crossing model is lower than the Louisa Creek and Captains Creek models at the upstream end of Captains Creek which can be explained by the inclusion of the Lakes II inflows. The Blakeys Crossing Flood Study flood levels in the lower reaches of Captains Creek are higher than the *Louisa Creek Flood Study* results which can be explained by the inclusion of the creek invert levels in the Louisa Creek model. Flood levels predicted for the 50 year ARI 3 hour duration design event are higher in the current study than the predicted flood levels in the Captains Creek and Blakey's Crossing flood studies by approximately 300 mm.

Figure C-4 and Figure C-5 show the comparison of the hydraulic grade lines along Captains Creek for the 100 year ARI 24 hour duration and 50 year ARI 24 hour duration respectively. Flood levels are lower in the *Louisa Creek Flood Study* than the *Captains Creek Flood Study* by over 200 mm in the 50 and 100 year ARI 24 hour duration events.

It can be concluded that the *Louisa Creek Flood Study* predicted levels lower than the *Captains Creek Flood Study* for longer duration events and higher than the *Captains Creek Flood Study* for shorter duration events. It is noted that the critical duration through Captains Creek is shorter in the Louisa Creek model than the Captains Creek model. The differences between the flood levels predicted by the Louisa Creek and Captains Creek models may also be attributed to the difference in boundary conditions, i.e. the Louisa Creek model extent ends upstream of the mouth of Captains Creek.

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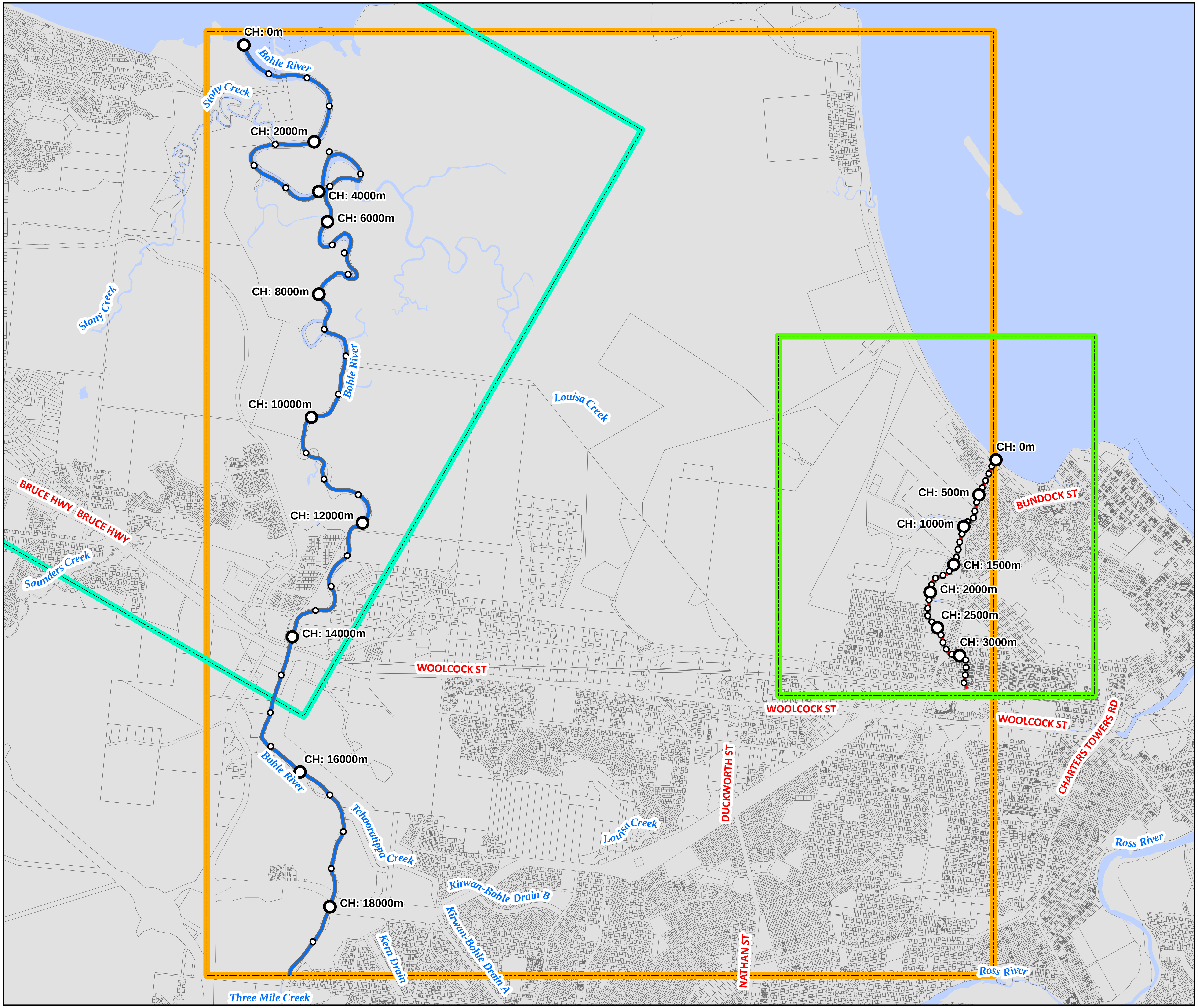
Longitudinal Profile
Plan View
Figure 3-9



Legend

- Major Chainage
- Minor Chainage
- Bohle River
- Captains Creek
- Louisa Creek Model Extent
- Lower Bohle Model Extent
- Middle Bohle Model Extent
- Captains Creek Model Extent
- Highways
- Main Roads
- Watercourse

0 500 1,000 2,000
Metres

1:45,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
Localities © 2012 (Queensland Govt)

AECOM
www.aecom.com

User: mathieu-burrym | Date Saved: 25/06/2014 | FileName: J:\MMPL\60304053\4. Tech Work Area\4.99 GIS\MXD\DRAFT_REPORT_REV1_20140625\60304053_Fig3-9_LongProfilePlanView.mxd

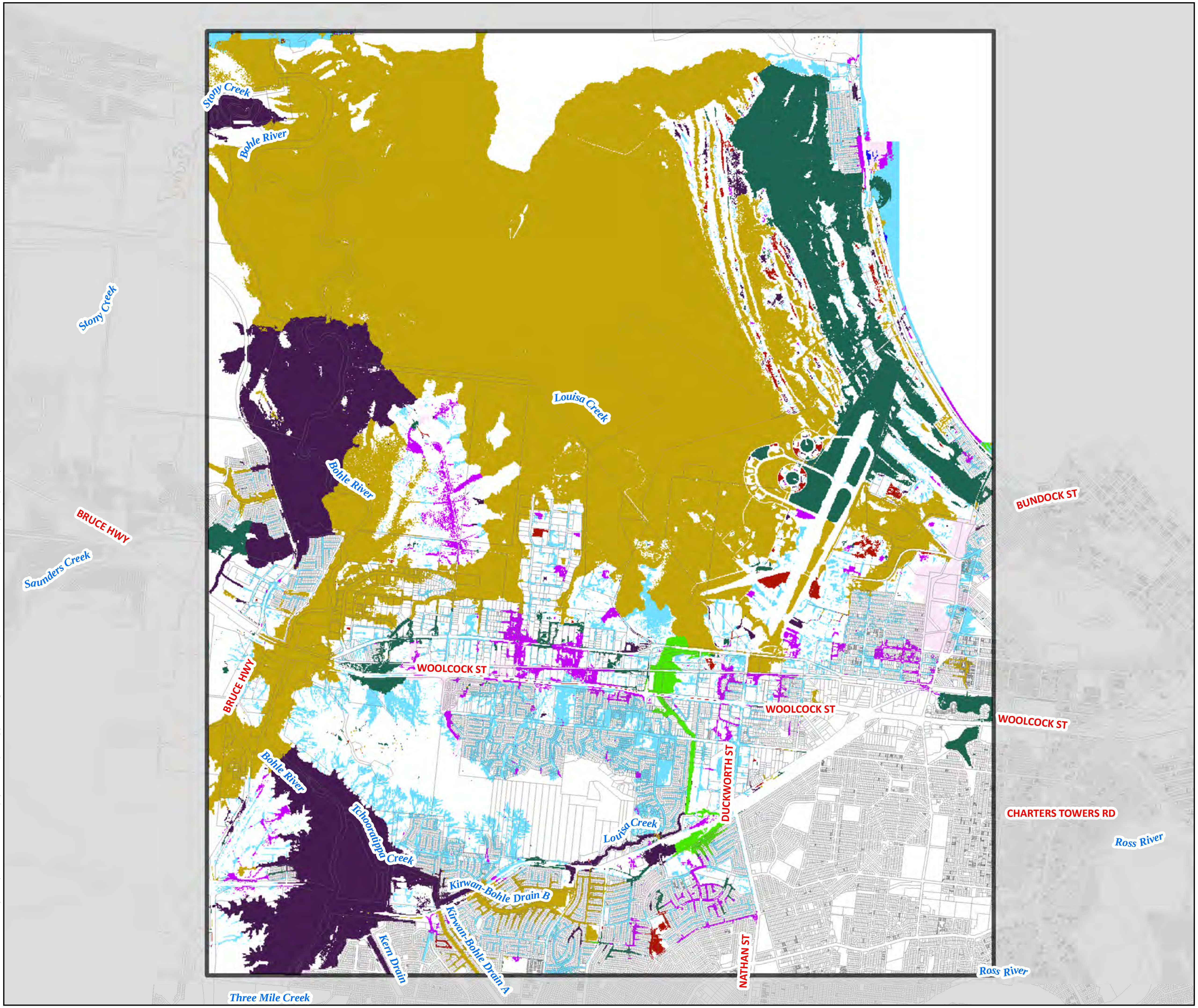
3.6 Design Flood Critical Duration Assessment

The critical duration for the 2, 5, 10, 20, 200, and 500 year ARI events were assessed by simulating the 1, 2, 3, 4.5, 6, 9, 12, 18 and 24 hour durations for the 50 year and 100 year ARI events. Figure 3-10 and Figure 3-11 show the 50 year and 100 year ARI critical duration respectively for areas within the Louisa Creek flood model. The critical durations adopted were the 1 and 12 hour durations.

Graphical displays of maximum water depth, surface elevation and flow velocity magnitude for each event modelled are provided in Appendix A.

TOWNSVILLE CITY COUNCIL
LOUISA CREEK FLOOD STUDY

Critical Duration Assessment
50 year ARI
Figure 3-10



Duration (hours)

- 1
- 2
- 3
- 4.5
- 6
- 9
- 12
- 18
- 24

0 500 1,000 2,000
Metres

1:45,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
Localities © 2012 (Queensland Govt)

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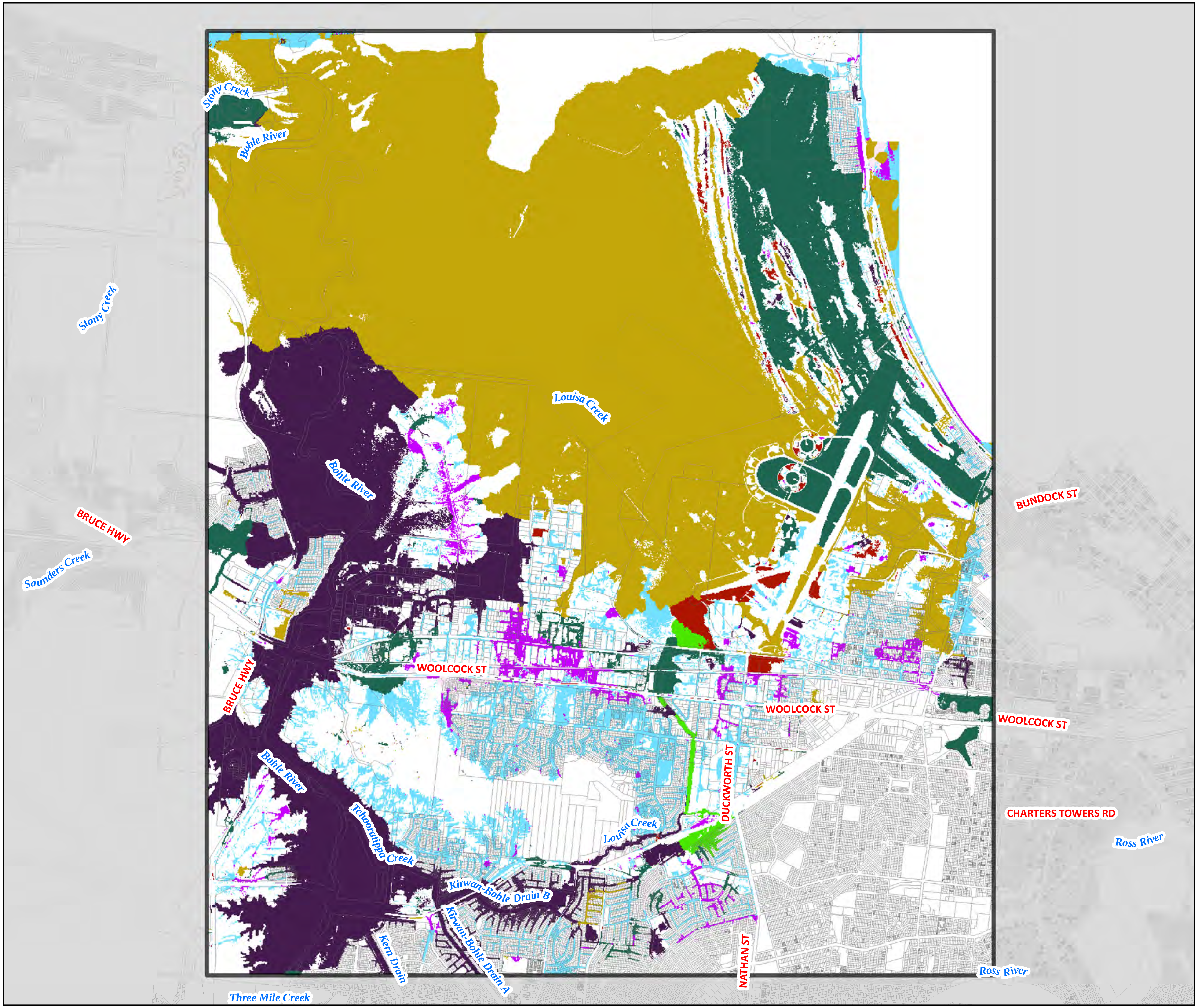
User: mathieu-burrym | Date Saved: 25/06/2014 | FileName: J:\MMPL\60304053\4. Tech Work Area\4.99 GIS\MXD\DRAFT_REPORT_REV1_20140625\60304053_Fig3-10_CriticalDuration_50y.mxd

TOWNSVILLE CITY COUNCIL
LOUISA CREEK FLOOD STUDY

Critical Duration Assessment
100 year ARI
Figure 3-11



Duration (hours)

- 1
- 2
- 3
- 4.5
- 6
- 9
- 12
- 18
- 24

0 500 1,000 2,000
Metres

1:45,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
Localities © 2012 (Queensland Govt)

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4.0 Flood Assessment

4.1 Flooding Across the Study Areas – Summary

Base case flood maps for design ARI storms are provided in Appendix A. The maps show maximum water depth, water surface level and flow velocity magnitude for the following storms:

- 2 year ARI
- 5 year ARI
- 10 year ARI
- 20 year ARI
- 50 year ARI
- 100 year ARI
- 200 year ARI
- 500 year ARI
- Probable Maximum Flood.

For mapping purposes the criteria adopted involves:

- including water depths greater than or equal to 0.1 m, or
- including water velocities greater than or equal to 0.3 m/s.

Therefore, only areas predicted to experience water depths lower than 0.1 m and water velocities lower than 0.3 m/s are shown as free from flooding in the mapping undertaken. This is in line with TCC's Flood Hazard Mapping Criteria.

To facilitate reading of flood modelling results, the majority of labels have been left out of the flood maps. The key areas mentioned in the assessment included in this section are shown in the locality map Figure 1-2 and therefore it is recommended that this is used as a reference when reviewing the flood maps.

Description of the flooding for the various design events is provided in Table 4-1. Assessment for out of bank flow, ponding across developed areas and high velocities within channels has been undertaken for each ARI assessed.

Table 4-1 Louisa Creek – Flooding Assessment Summary

Event	Description	Map Ref
2 year ARI	- Flows contained mainly within the channels. - Floodplain inundation up to 1.5 m across the Town Common floodplain. - No significant impact predicted for residential areas (i.e. water depth generally below 0.3 m).	A1, A10 and A19
5 year ARI	- Floodplain inundation up to 1.5 m across the Town Common floodplain. - No significant impact predicted for residential areas (i.e. water depth generally below 0.3 m).	A2, A11 and A20
10 year ARI	- Floodplain inundation up to 1.5 m across the Town Common floodplain. - No significant impact predicted for residential areas (i.e. water depth generally below 0.3 m). - Properties south of Dalrymple Road inundated with water depths up to 0.5 m.	A3, A12 and A21
20 year ARI	- Floodplain inundation up to 1.5 m across the Town Common floodplain. - Properties south of Dalrymple Road inundated with water depths up to 0.5 m. - Localised areas of high velocities (1.5 m/s and higher) predicted in Mount Louisa and Kirwan over roads and in channels.	A4, A13 and A22
50 year ARI	- Floodplain inundation up to 2 m across the Town Common floodplain. - Properties south of Dalrymple Road inundated with water depths up to 1 m. - Properties in Bohle and Mount St John (especially near Enterprise Street) inundated with water depths up to 0.75 m. - Properties in Garbutt inundated with water depths of up to 0.5 m. - Localised areas of high velocities (1.5 m/s and higher) predicted in Mount Louisa and Kirwan over roads and in channels, as well as over Bundock Street.	A5, A14 and A23
100 year ARI	- Floodplain inundation up to 2 m across the Town Common floodplain. - Properties south of Dalrymple Road inundated with water depths up to 1 m. - Inundation of properties in Kirwan with water depths up to 0.5 m. - Properties in Bohle and Mount St John (especially near Enterprise Street) inundated with water depths up to 1 m. - Properties in Garbutt inundated with water depths of up to 0.5 m. - Localised areas of high velocities (1.5 m/s and higher) predicted in Mount Louisa and Kirwan over roads and in channels, as well as over Bundock Street.	A6, A15 and A24
200 year ARI	- Floodplain inundation up to 3 m across the Town Common floodplain. - Properties south of Dalrymple Road and in Bohle and Mount St John (especially near Enterprise Street) inundated with water depths up to 1.5 m. - Inundation of properties in Kirwan with water depths up to 2 m. - Properties in Garbutt inundated with water depths of up to 0.75 m. - Localised areas of high velocities (1.5 m/s and higher) predicted in Mount Louisa and Kirwan over roads and in channels, as well as over Bundock Street.	A7, A16 and A25
500 year ARI	- Floodplain inundation up to 3 m across the Town Common floodplain. - Properties south of Dalrymple Road and in Bohle and Mount St John (especially near Enterprise Street) inundated with water depths up to 1.5 m. - Inundation of properties in Kirwan with water depths up to 2 m. - Properties in Garbutt inundated with water depths of up to 0.75 m. - Localised areas of high velocities (1.5 m/s and higher) predicted in Mount Louisa and Kirwan over roads and in channels, as well as over Bundock Street and Enterprise Street.	A8, A17 and A26
PMF	- Floodplain inundation up to 3 m across the Town Common floodplain. - Properties south of Dalrymple Road and in Bohle, Mount St John (especially near Enterprise Street) and Garbutt inundated with water depths up to 1.5 m. - Inundation of properties in Kirwan with water depths up to 2 m.	A9, A18 and A27

4.2 Major Arterial Roads

There are various main roads and highways across the extent of the Louisa Creek model which if flooded would have an impact on the local residents of these communities. An indication of the maximum estimated level of flooding over main roads across the Louisa Creek model extent is provided in Table 4-2. The location of the road crossing assessed is included in Figure 4-1.

Table 4-2 Flooding Affecting Main Roads within the Louisa Creek Model Extent

Location	Description	Event (Year ARI)								PMF
		2	5	10	20	50	100	200	500	
		Water Depth (m)								
1	Bruce Highway at Bohle River breakout	-	0.11	0.23	0.42	0.58	0.65	0.66	0.73	0.89
2	Bruce Highway at Bohle River	-	-	-	0.27	0.63	0.80	0.95	1.10	1.45
3	Woolcock Street at Louisa Creek	-	-	-	-	-	-	-	-	0.70
4	Percy Street	-	-	-	0.10	0.13	0.16	0.21	0.24	0.25
5	Dalrymple Road (Kern Drain)	-	-	-	-	-	-	-	-	0.68
6	Dalrymple Road (near Nathan Street)	-	-	-	-	-	-	0.11	0.24	0.58
7	Bayswater Road at Louisa Creek	-	-	-	-	-	0.06	0.26	0.38	0.65

Note: For the purposes of the above table, only water depths in excess of 0.1 m have been considered.