Townsville City Council
07-Dec-2018
Doc No. 60571541

Base-line Flooding Assessment

Lansdown Station Flood Study

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Lansdown Station Flood Study

Client: Townsville City Council

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07-Dec-2018

Job No.: 60571541

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Quality Information

Document Lansdown Station Base-line Flooding Assessment

Ref 60571541
P:\605x\60571541\8. issued docs\8.1 reports\report_final.docx

Date 07-Dec-2018

Prepared by [redacted]

Reviewed by [redacted]

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
0	20-Nov-2018	Draft Issue	[redacted]	Original Signed
1	07-Dec-2018	Final Issue	[redacted]	[redacted]

Table of Contents

1.0 Introduction 2
- 1.1 Overview 2
- 1.2 Study Area 2
- 1.3 Scope 2
- 1.4 Study Approach 4
- 1.5 Available Data 4
  - 1.5.1 Spatial Data 4
  - 1.5.2 Historical Rainfall and Stream Gauging Records 4
  - 1.5.3 Related Flood Studies 4
  - 1.5.4 Site Investigation 5

2.0 Hydrological Assessment 6
- 2.1 Overview 6
- 2.2 Catchment Delineation 6
- 2.3 Design Rainfall Inputs 8
  - 2.3.1 Intensity-Frequency-Duration Values (IFDs) 8
  - 2.3.2 Temporal Patterns 9
  - 2.3.3 Preburst Rainfall 9
  - 2.3.4 Areal Reduction Factors (ARF) 9
- 2.4 Hydrologic Model Setup 9
  - 2.4.1 Roughness 9
  - 2.4.2 Catchment Slope 10
  - 2.4.3 Fraction Impervious 10
  - 2.4.4 Routing 10
  - 2.4.5 Loss Model 10
- 2.5 Hydrologic Model Calibration 10
- 2.6 Loss Model Verification 11
- 2.7 Critical Duration Assessment 12

3.0 Hydraulic Assessment 16
- 3.1 Overview 16
- 3.2 MIKE FLOOD Hydraulic Model 16
  - 3.2.1 MIKE 11 16
  - 3.2.2 MIKE 21 16
- 3.3 Model Development 16
  - 3.3.1 2D Model Geometry 16
  - 3.3.2 1D Structures 16
  - 3.3.3 Boundary Conditions 19
  - 3.3.4 Roughness 19
  - 3.3.5 Rain-on-Grid Method for Local Runoff 19
- 3.4 Model Validation 20
  - 3.4.1 Structure loss verification 20

4.0 Baseline Flooding Results 24
- 4.1 Flooding across the Study Area – Summary 24
- 4.2 Flooding at Potential Industrial Development Site 25
- 4.3 Climate Change Sensitivity 26
  - 4.3.1 Approach 26

5.0 Conclusion 29
- 5.1 Summary 29
- 5.2 Recommendations 29

6.0 References 30

Appendix A
Photos from Site Inspection A

Appendix B
Martin Ryan Bridge Survey B

Appendix C
Catchment Parameters C

Appendix D
Structure Details D

Appendix E
Flood Mapping Results E

List of Figures

Figure 1-1	Model Extents in Relation to Previous Studies	3
Figure 2-1	Location and Extents of Model Catchments	7
Figure 2-2	XPRAFTS Model Calibration at Major Creek Flow Gauge – March 2012 Event	11
Figure 2-3	Flood Frequency Analysis at Major Creek Gauge	12
Figure 2-4	Comparison of storm ensembles for 1% AEP event at Lansdown Station.	14
Figure 2-5	Hydrographs for the 1% AEP 6 hour duration storm ensemble close to the outlet of the Lansdown Station project focus area.	15
Figure 3-1	Model Geometry	18
Figure 3-2	Boundary Conditions	21
Figure 3-3	Roughness	22
Figure 3-4	Fraction Impervious	23
Figure 4-1	Climate Change Sensitivity Analysis – 1% AEP	28

List of Tables

Table 2-1	Lansdown Station IFD Parameters	8
Table 2-2	Rainfall IDF data (mm/h) For Rare to Extreme Events	8
Table 2-3	Median Pre-burst Rainfall Values for Lansdown Station	9
Table 2-4	Design Flow Comparison at Major Creek Gauge	12
Table 3-1	Roughness Values and Associated Land Uses	19
Table 3-2	Comparison of head losses between HEC-RAS and MIKE	20
Table 4-1	Lansdown Station Flooding Summary	24
Table 4-2	Climate Futures Outlook for 2070 for the Monsoonal North (East) NRM Cluster	26

Executive Summary

The Lansdown Station comprises approximately 2,300 ha land area located 45 km southeast of Townsville. The Station is currently used for grazing via a lease arrangement however Townsville City Council (TCC) is considering a change in the formal planning zoning for the area. AECOM Australia Pty Ltd (AECOM) was engaged by TCC to develop baseline hydrologic and hydraulic models for the Lansdown Station catchment to support a planning scheme amendment for the Lansdown Station.

Lansdown Station is situated in the upper reaches of the Haughton River and Ross Dam catchments immediately upstream of the Great Northern rail line and the Flinders Highway. The site is bordered to the north-east by the Lansdown Creek and to the south by Double Barrel Creek, a tributary of Major Creek which ultimately flows to the Haughton River.

An XP-RAFTS 2018 hydrologic model was developed for the area to determine design discharges for a range of flood events. The model was verified against flows at the Major Creek gauge. Hydrologic inputs were guided by the latest Australian Rainfall and Runoff Guidelines (ARR, 2016).

Design event discharges from the hydrologic model were inputs to a two-dimensional DHI MIKE FLOOD model. Key hydraulic structures along the Flinders Highway and Great Northern Rail line were included within the model and design flood levels were estimated for the 0.2%, 0.5%, 1%, 2%, 5%, 10%, 20% and 50% Annual Exceedance Probability (AEP) flood events as well as the Probable Maximum Flood.

From a planning scheme perspective the 1% AEP and the Probable Maximum Flood (PMF) flood events are of most interest as these events inform the Flood Hazard Overlay mapping. The 1% AEP flood event is also the Defined Flood Event (DFE) within the TCC City Plan (2014).

Much of the Lansdown Station is inundated by up to 1 m in the 1% AEP. Velocities are generally low across the floodplain, with ponding occurring adjacent to key hydraulic controls such as the Flinders Highway and Great Northern Rail line downstream of the site. In the 1% AEP flood event Flinders Highway is inundated at several watercourse crossings between Woodstock and Calcium. Double Barrel Creek breaks out to the north towards Manton Quarry Road.

In the PMF event extensive floodplain inundation up to 3 m across is predicted across the Lansdown Station. Overtopping of Flinders Highway and Great Northern Rail line occurs at several locations between Woodstock and Calcium.

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
GTSMR	Generalised Tropical Storm Method Revised – Methodology for estimating the PMP
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 flows from rainfall and catchment characteristics
IFD	Intensity–Frequency-Duration
LiDAR	Light Detection and Ranging (Aerial Laser Survey)
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 to develop baseline hydrologic and hydraulic models for the Lansdown Station catchment. The site is currently used for grazing via a lease arrangement however council is considering a change in the formal planning zoning from rural to medium/high impact industrial for the area.

The key objective of this Project is to provide flood mapping to inform a statutory amendment (under the Planning Act, 2016) to council's current planning scheme. This amendment would change zoning of some land parcels within the study area from rural to industrial as well as define flood hazard overlay planning constraints within the Project area.

1.2 Study Area

The Lansdown Station is situated 45 km southeast of Townsville (Figure 1-1) on land that is currently designated as a 'rural' zone for planning purposes. Lansdown Station comprises approximately 2,300 ha land area. Much of the land area is situated in the upper reaches of the Major Creek catchment, upstream of the Queensland Department of Transport and Main Roads (DTMR) controlled Flinders Highway and the Queensland Rail Great Northern rail line.

The vast majority of the Project area drains eastwards towards Major Creek, and ultimately to the Haughton River. To the north-west, the station is bordered by Lansdown Creek, which flows north towards the Ross River dam reservoir and also has the potential to inundate the north portion of the Lansdown Station during large flood events. Flows in both the Major Creek and the Lansdown Creek catchments were considered in this study.

1.3 Scope

The scope of *Lansdown Station Flood Study* included:

- Collation and review of available data including previous models relevant to the study and a site visit to verify the existing catchment conditions.
- Catchment delineation for the Project area and upstream.
- Determination of the critical catchment storm for the 50%, 20%, 10% 5%, 2%, 1% 0.5%, and 0.2% Annual Exceedance Probability (AEP) design floods and the Probable Maximum Flood (PMF) using a hydrological model, XPRAFTS 2018, and apply this storm to the hydraulic model for each AEP.
- Derive inflow hydrographs for the 50%, 20% and 10% 5%, 2%, 1% 0.5%, 0.2% AEP design floods and the PMF using the hydrological model based on methods from AR&R 2016.
- Develop a MIKE FLOOD hydraulic model within the study area to determine base-case flood extents, velocity and depth of flow for 50%, 20% and 10% 5%, 2%, 1% 0.5%, 0.2% AEP design floods and the PMF.
- Assess the sensitivity of the study area to the projected impacts of climate change.

LANSDOWN STATION FLOOD STUDY

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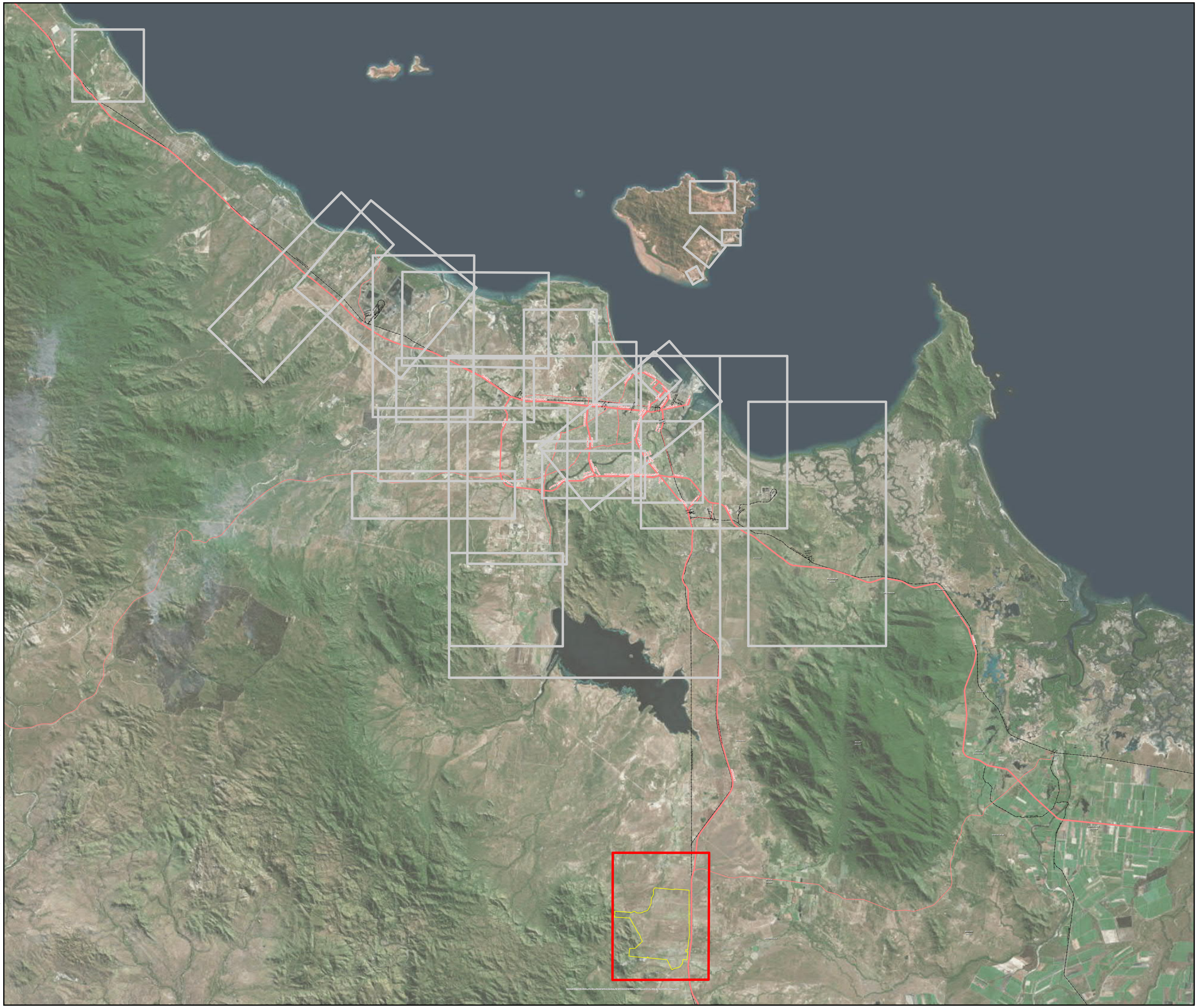
Locality Plan

Figure 1-1



Metres

1:275,000 (when printed at A3)

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
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Localities © 2012 (Queensland Govt)

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1.4 Study Approach

The hydraulic model developed includes culverts and two bridges. Modelling these structures facilitates the representation of flow through the existing drainage infrastructure and results in a robust understanding of flooding across the study area.

Inflow boundary conditions were derived using inflow hydrographs from XP-RAFTS 2018 hydrologic models for Lansdown Station catchment. A combination of XP-RAFTS local source points and Rain-on-Grid net precipitation was adopted to represent runoff. The 2016 Australian Rainfall-Runoff Guidelines (ARR2016) were followed in order to derive appropriate hydrologic inputs.

1.5 Available Data

1.5.1 Spatial Data

TCC provided the following spatial data for use in the study:

- Aerial photography flown in 2011/2012
- 2011 and 2012 LiDAR Survey
- Digital cadastral database containing property boundaries (TCC, October 2014).
- Complete Planning Scheme for land use overlays
- Stormwater asset network data
- Rainfall records from council flood alert network (TARDIS).

Relevant infrastructure data (such as structure details) for the Flinders Highway and Great Northern Rail line adjacent to the Lansdown Station was provided by DTMR Northern Region and Queensland Rail respectively. A site inspection was performed to confirm existing structure details.

1.5.2 Historical Rainfall and Stream Gauging Records

Historical rainfall gauges in the vicinity of the Lansdown Station study area include the Calcium Rainfall Gauge (operated by TCC, station number 533070).

AECOM sourced historical data for the Great Northern Rail “Calcium Culvert at Woodstock” water level gauge from Queensland Rail. The available data dates back to 2014.

1.5.3 Related Flood Studies

There are a number of previous flood studies undertaken within and around the study area which relate to the current study.

- **Townsville Citywide Flood Hazard Constraints Project (2014)**

TCC undertook the City Wide Flood Constraints Project during 2012-2014 to develop flood constraints mapping for the Townsville City Plan (2014). The City Wide Flood Constraints project developed flood mapping across the city from several flood modelling studies. The flood mapping identified areas likely to be inundated during river and rainfall flood events. The flood mapping also identified important information about flooding, such as frequency, water depth, flow velocity and flood levels.

The current *Lansdown Station Flood Study* will extend the coverage of City Wide Flood Constraints Mapping to include the Lansdown and Woodstock areas. This study adopts a similar methodology as the existing City Wide Flood constraint models and aims to be consistent with those studies in terms of overall methodology and outcomes, other than the adoption of AR&R 2016 methods. It is understood that other flood modelling studies within the Townsville LGA will be updated to AR&R 2016 methods in the near future.

- **Haughton River Floodplain and Road Planning Study (2014)**

AECOM were engaged by TMR in 2014 to undertake the Haughton River Floodplain and Road Planning Study which investigated long-term solutions for Bruce Highway in and around the city of Giru. The planning study included extensive hydrologic and hydraulic modelling in order to identify and evaluate options to address the issues of flood immunity, capacity, freight movement and amenity of the Bruce Highway and North Coast Rail Line across the Haughton Floodplain.

The current *Lansdown Station Flood Study* in contained within the upper reaches of the Haughton River catchment. Due to the lack of available calibration data for the Lansdown Station study area, some of the previously adopted model parameters (e.g. Manning's hydraulic roughness) which were formed part of the calibrated Haughton River Flood Model were adopted within the current study.

1.5.4 Site Investigation

On the 4th June 2018, a site investigation was conducted to confirm the location and sizing of drainage structures along the highway and railway within the hydraulic study area. Photos of key hydraulic structures taken during the site visit in the model are provided in Appendix A.

During the site inspection, it was observed that the remains of the old Double Barrel Creek Bridge are still located under the current TMR Double Barrel Creek Bridge. Survey of TMR Double Barrel Creek Bridge, including the old bridge, was requested and this data was incorporated into the hydraulic model (Appendix B).

Several additional structures were identified during the site visit and were incorporated into the hydraulic model. These were structures located along minor roads such as Sky Diver Road and the Manton Quarry Road. Dimensions of the structures were measured on-site during the site visit and the invert levels were later estimated from aerial LiDAR. It was observed during the site visit that culvert structures on Sky Diver Road were up to 50% blocked with debris (Appendix A, Figure 2).

2.0 Hydrological Assessment

2.1 Overview

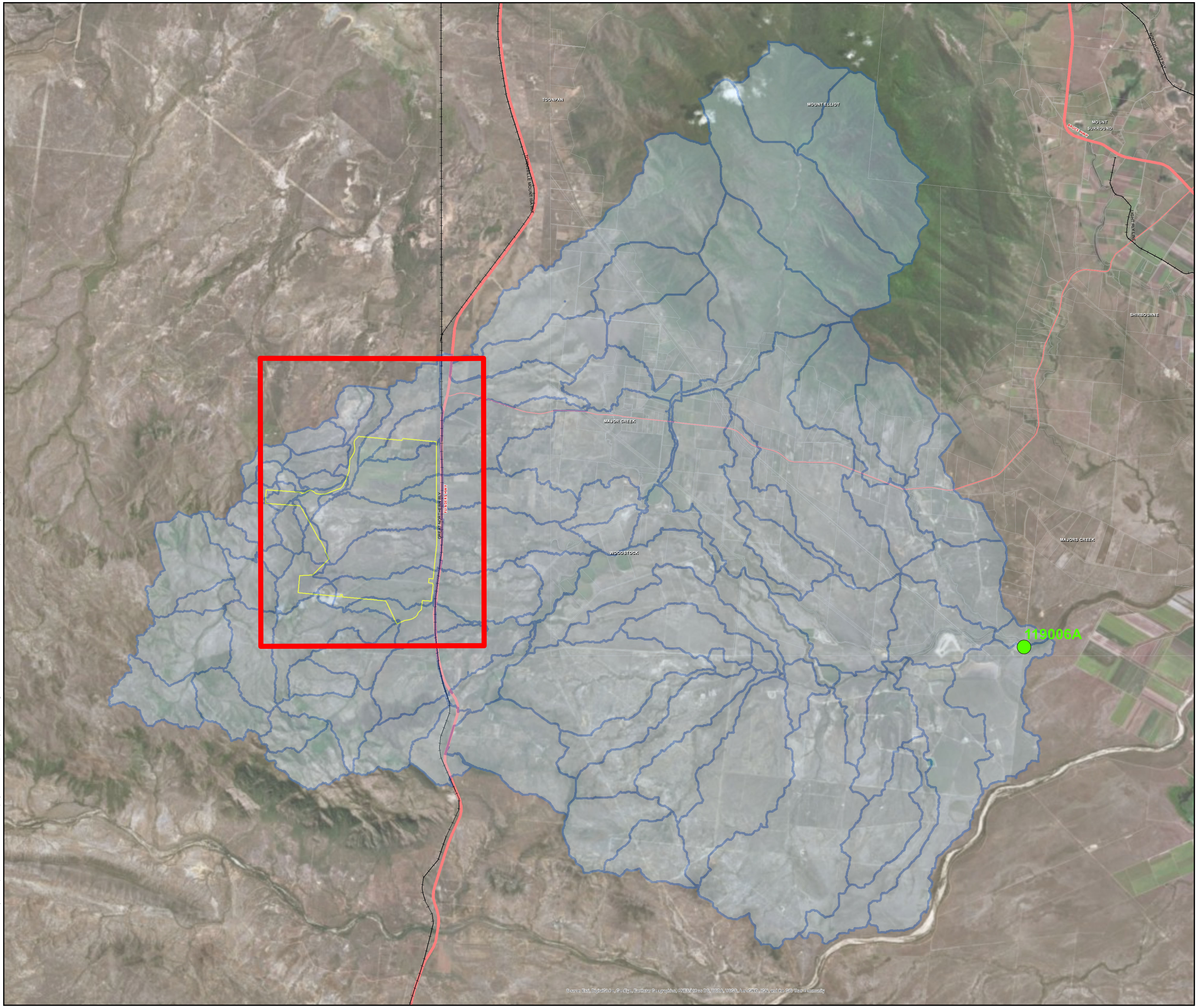
ARR 2016 methods were used to guide the hydrological inputs into the Lansdown Station Flood Study. Two methods were used to represent rainfall-runoff:

- A rainfall-runoff hydrological modelling approach (XPRAFTS 2018) which was generally applied across steep sub-catchments and also used to determine critical duration events.
- Direct precipitation (Rain-on-Grid) which was used across the relatively flat catchments within the MIKE FLOOD hydraulic model.

The XPRAFTS model was calibrated to flows at the Major Creek gauge and verification to the ARR2016 Regional Flood Frequency Estimation (RFFE) as well as an at-site Flood Frequency Analysis at the Major Creek gauge to verify our predicted design flows for the project.

2.2 Catchment Delineation

The Lansdown Station catchment and sub-catchments were delineated, ensuring consistency in sub-catchment size. The location and extent of the local model catchments in relation to the study area and the Major Creek Gauge site is shown in Figure 2-1 and a table of the local catchment parameters is provided in Appendix C.



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Location and Extents of Model Catchments

Figure 2-1

Legend	
Study Area	
Main Roads	
Highways	
Qld_Railway_Lines	
Lansdown Station Focus Area	
Local Catchments	
DNRM Open Gaging Stations	

0 500 1,000 2,000
Metres

1:120,000 (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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2.3 Design Rainfall Inputs

Design rainfall inputs were obtained from the ARR 2016 online Data Hub for a range of durations and frequencies (http://data.arr-software.org/).

2.3.1 Intensity-Frequency-Duration Values (IFDs)

IFD data were downloaded from the ARR2016 data hub and loaded within XPRAFTS 2018 and are as shown in Table 2-1.

The Generalised Short Duration Method (GSDM) was used to estimate PMP depths for storm events up to 6 hours. It was found that the 4.5 hour duration storm was critical for the project focus area. Rainfall estimates for the 1 in 200 and 1 in 500 AEP obtained from CRC-FORGE rainfall estimation methods and checked for consistency with the more frequent event IFD data outlined in **Section 2.3.1** Rainfall intensities for these events are listed below in Table 2-2**.**

Table 2-1 Lansdown Station IFD Parameters

	Annual Exceedance Probability (AEP)					
Duration	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 hour	43.2	59.3	69.6	79.2	91.4	100
2 hour	56.1	78.3	92.9	107	125	138
3 hour	64.3	91	109	126	149	166
4.5 hour	73.5	106	127	149	177	199
6 hour	80.6	117	142	167	200	226
12 hour	101	151	186	221	268	305
24 hour	129	197	245	293	356	404
48 hour	164	254	317	382	459	517
72 hour	187	290	362	436	520	582
96 hour	203	314	392	472	560	625
120 hour	214	331	413	495	588	656
144 hour	222	341	426	510	607	678
168 hour	227	348	434	519	620	695

Table 2-2 Rainfall IDF data (mm/h) For Rare to Extreme Events

	Rainfall intensity (mm) for given AEP (1 in Y)		
Duration	**0.5% (200)**	**0.2% (500)**	**PMP**
6 hour	312	373	540

2.3.2 Temporal Patterns

The study adopted the ensemble approach outlined in ARR2016. Temporal patterns for the Wet Tropics sub-region were sourced from the ARR 2016 data hub to inform the study.

2.3.3 Preburst Rainfall

The design rainfall IFDs from the Bureau of Meteorology as shown in Table 2-1 are rainfall bursts for the given duration and not complete storms. However, the guideline initial loss values from Australian Rainfall and Runoff are for complete storms not bursts.

Studies undertaken to inform the new ARR guidelines indicated that pre-burst rainfall may be as important as the varying temporal patterns in an ensemble for flood study outcomes. ARR recommends that pre-burst rainfalls are used to scale up design rainfalls to complete storms.

Pre-burst rainfall is negligible for most of Australia, however, the Townsville region is an exception. Table 2-3 shows the median pre-burst rainfalls for the Lansdown Station. The pre-burst rainfall is generally large compared to the storm initial loss which means the burst initial loss will be very low or even negative. Negative Initial Losses are assumed as zero.

Table 2-3 Median Pre-burst Rainfall Values for Lansdown Station

Duration min (h)	Preburst depth for given AEP (mm)					
	50	20	10	5	2	1
60 (1.0)	24.5	27.8	29.9	32	31.3	30.8
90 (1.5)	17.7	32.6	42.5	51.9	54.5	56.5
120 (2.0)	16.5	28.5	36.4	44	44.4	44.8
180 (3.0)	6.4	27.3	41.1	54.3	77.5	94.9
360 (6.0)	12.5	32.5	45.7	58.4	68.8	76.5
720 (12.0)	15.9	28.1	36.3	44.1	53.8	61.1
1080 (18.0)	13.6	30.8	42.2	53.1	61.9	68.5
1440 (24.0)	6.5	20	28.9	37.5	55.3	68.7
2160 (36.0)	2.6	11.6	17.6	23.4	46.5	63.8
2880 (48.0)	0.1	8.6	14.2	19.5	24.7	28.5
4320 (72.0)	0	3.8	6.3	8.7	12.2	14.8

2.3.4 Areal Reduction Factors (ARF)

Areal reduction factors were applied to rainfall depths following guidance in Table 2.4.1 of AR&R2016 Book 2, Chapter 4. The duration dependant areal reduction factors were automatically applied within XPRAFT based on ARR data hub coefficients for the total catchment area of 257 km^2. .

2.4 Hydrologic Model Setup

Sub-catchment characteristics were determined using the topographic data and aerial imagery provided by TCC. A summary of the sub-catchment parameters for the project focus area are provided in Appendix C.

Details of the determination of the sub-catchment parameters and hydrologic model setup assumptions are provided below.

2.4.1 Roughness

Aerial imagery was used for the purposes of defining hydraulic roughness for the study area. Overland flow roughness coefficients from the calibrated Haughton River model (AECOM, 2016) were adopted.

The majority of the site has medium to heavy vegetation cover with Manning's 'n' values varying from 0.06 to 0.07, and up to 0.09 for some upper reaches around the Mingela State Forest.

2.4.2 Catchment Slope

Catchment slope was determined through analysis of the LiDAR topographic data. In some parts of the catchment (outside of the focus area), Shuttle Radar Topographic Mission survey was the only available topographic data available. Catchment slopes vary from almost flat up to 15% in areas of the Mingela State Forest.

2.4.3 Fraction Impervious

Impervious area was set to zero for all sub-catchments, given the rural nature of the entire catchment upstream of the Major Creek gauge.

2.4.4 Routing

A recent AR&R 2016 review indicated that either a lagging or a kinematic wave model approach are suitable for most Australian catchments. A simple lagging model was adopted for this study based on the catchment flowpath length and an approximate velocity of 0.5 m/s in flat catchments.

A recent review of hydrologic model approaches showed that the time-step adopted within hydrologic models can be important for the calibration of continuing loss parameters. It was recommended that loss adjustment factors be used if different time-steps were adopted for different duration storms (ARR, 2016). A uniform routing increment of 10 minutes was adopted for all simulations in this study.

2.4.5 Loss Model

An initial-continuing loss model was adopted for this study. This is the most common loss model used for Australian catchments (ARR, 2016). Calibration and verification of the loss parameters is discussed in Section 2.5 below.

2.5 Hydrologic Model Calibration

A key focus of the AR&R 2016 is also the use of at-site gauging data to inform, calibrate and verify flood estimation. Whilst there is no flow gauging available for the Lansdown Station Flood Study there is a gauge downstream of the site at Major Creek (119006A) with data available for a long period (1976-2018).

The XP-RAFTS hydrological model was calibrated against the recorded flows at the Major Creek (119006A) stream gauge data during the March 2012 rainfall event. Comparison to the at-site Flood Frequency Assessment indicated that this event was in the order of a 15-20% AEP.

Overland flow roughness coefficients from the calibrated Haughton River model (AECOM, 2016) were initially adopted for the Lansdown Station hydrological model and these were not changed during the model calibration.

Recorded data at the Calcium pluviograph was applied to the catchments closet to this gauge and the hyetograph from the Major Creek rain gauge was applied to catchments located further downstream. Generally, the catchment Manning's roughness parameter was in the order of 0.06-0.08 for the flatter agricultural land. Manning roughness values between 0.08 - 0.1 were applied to the very heavily vegetated upper catchment areas in the Mingela State Forest.

A storm initial loss of 30 mm and continuing loss of 1.25 mm/hr provided the best match to the gauged data in terms of the peak flow timing and magnitude however as the receding limb of the modelled hydrograph dropped faster than the gauged hydrograph the overall volume was not matched as well. Increasing the BX storage factor provided a smoother hydrograph shape matching the gauge data, however a further reduction in continuing loss less than 1 mm/hr was required for an overall volume match.

A storm initial loss of 30 mm and continuing loss of 1.75 mm/hr matched both the peak flow and volume within 5% with a peak flow of 1094 m^3/s recorded peak at the gauge and a model predicted peak flow of 1142 m^3/s in (Figure 2-2). A storm initial loss of 30 mm and continuing loss of 1.75 mm/hr with a default storage factor of 1 was confirmed as the best overall match to the gauge hydrograph.

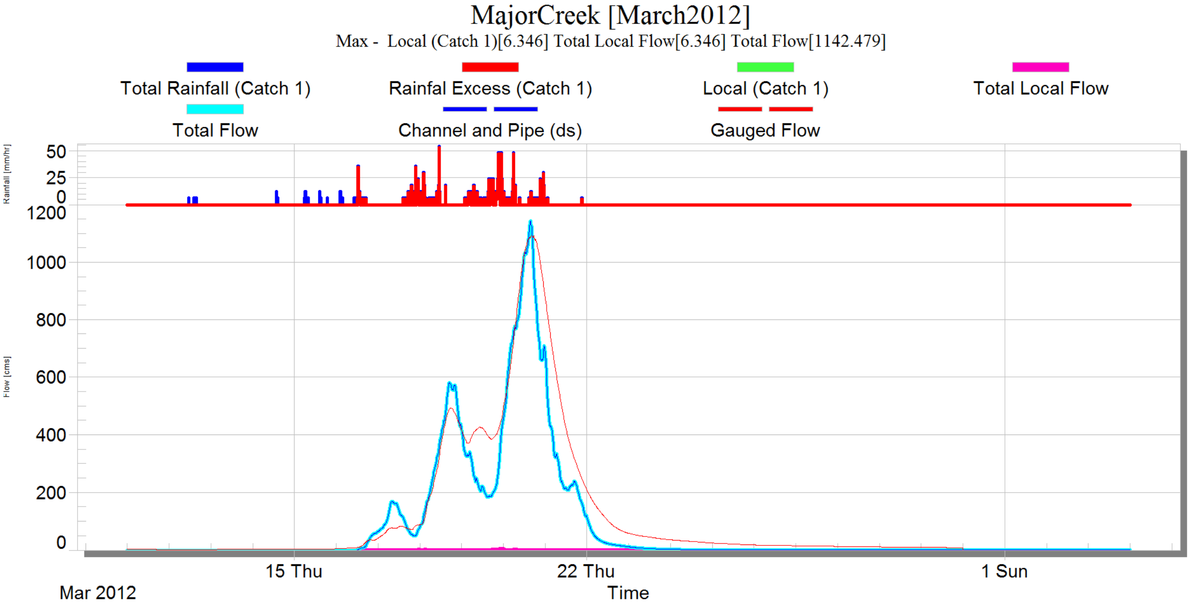

Figure 2-2 XPRAFTS Model Calibration at Major Creek Flow Gauge – March 2012 Event

2.6 Loss Model Verification

At site gauging data was also used to verify design flood estimation. Whilst there is no flow gauging available for the Lansdown Station Flood Study there is a gauge downstream of the site at Major Creek (119006A) with data available for a long period (1976-2018).

Regional loss values for the site from the ARR data hub indicate an initial loss varying between 52.5 and 62 mm and a continuing loss in the order of 3.5 - 4 mm/hr.

A flood frequency analysis was undertaken using TUFLOW-FLIKE software which has the ability to fit a range of statistical distributions using either Bayesian or L-Moments Inference. A number of distributions were tested and it was found that the Log Pearson III statistical distribution provided the best fit to the gauge data. The probability plot is shown below in Figure 2-3. The Annual Exceedance Probability (AEP) in terms of 1 in Y AEP is displayed along the x-axis and the information on log discharge is shown along the y-axis.

Anecdotal evidence from local residents indicated that a breakout occurred from Major Creek to the Barrattas catchment upstream of the Major Creek gauge during the 2008 flood event (which had a peak flow of 1,260 m^3/s) but the breakout was not known to have occurred during the March 2012 flood event (peak flow of 1,095 m^3/s). Uncontrolled farm levees in the area are known to exist and can change with time, which makes matching of the gauge data for large flood events problematic. Overestimation of the design flows at the gauge location for AEPs greater than 5% was deemed acceptable due to the likelihood of breakouts upstream of the gauge.

Figure 2-3 and Table 2-4 provide a comparison of the XP-RAFTS model results and flood quantiles estimated through FFA assuming initial storm loss and continuing loss values of 30 mm and 1.25 mm/hr. Despite being lower than ARR2016 regional loss values, an initial storm loss of 30 mm and a continuing loss values and 1.25 mm/hr provided a good fit to the FFA.

Comparison with previous studies for the area, such as the *Ross River Upstream Catchment Flood Study* showed that previous models were calibrated to continuing loss values in the range 0.75-1.75 mm/hr for events 1998-2010. The storm initial losses for events were 20 - 40mm.

Based on Table 2-2 and Table 2-3 it is noted that for initial storm loss of 30 mm, the burst initial loss for the Lansdown Station is generally close to zero for flood events greater than 20% AEP.

Table 2-4 Design Flow Comparison at Major Creek Gauge

AEP (%)	XP-RAFTS Peak Flows (m^3/s)	FFA Peak Flows (m^3/s)	Difference (%)
1	1,943	1,617	20%
2	1,682	1,527	10%
5	1,388	1,348	3%
10	1,114	1,147	-3%
20	852	875	-3%
50	426	389	10%

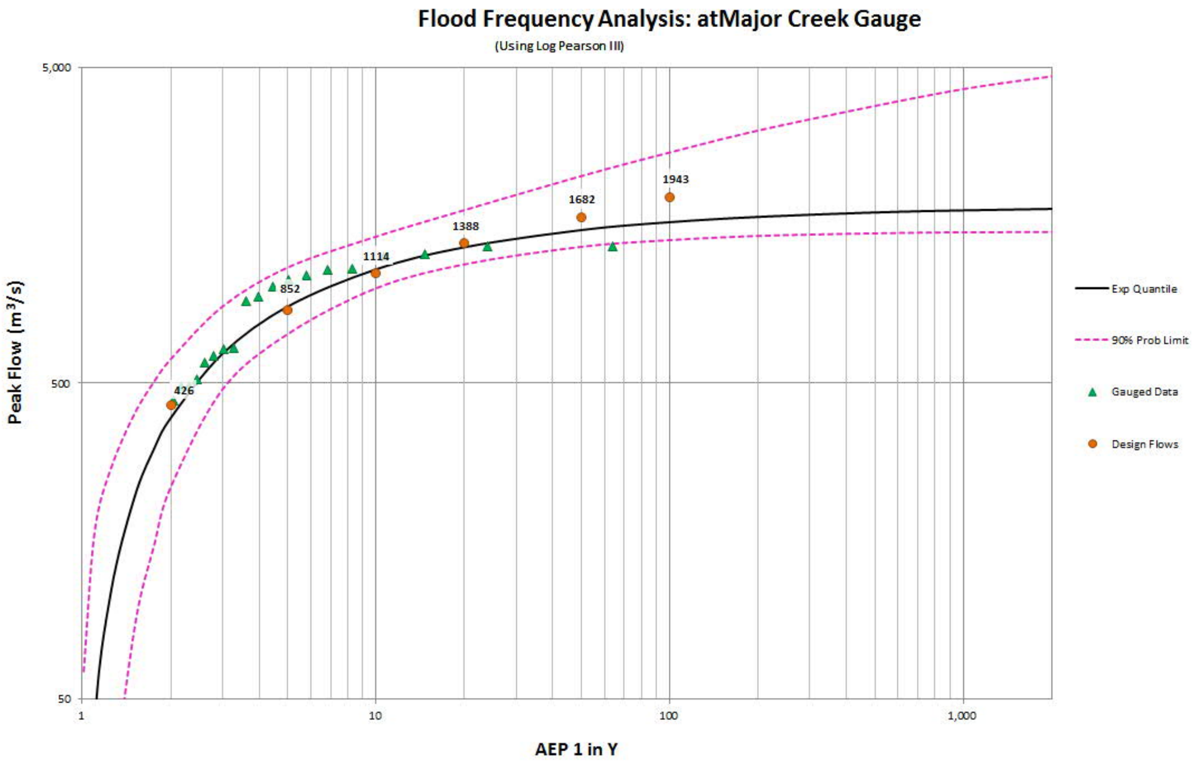

Figure 2-3 Flood Frequency Analysis at Major Creek Gauge

2.7 Critical Duration Assessment

Given the rural nature of the project focus area and the upstream catchments, with no hydraulic structures or major catchment storages located upstream of Lansdown Station, it was appropriate to determine the critical duration of the focus area solely with the hydrologic model.

Peak flood level ensemble analysis at key locations across the project focus area. Output hydrographs for durations between 0.5 hours and 48 hours with 10 temporal patterns applied for each duration. The critical duration at XPRAFTS node LS27 (Double Barrel Creek) and RD7 (Lansdown Creek) were analysed and then compared to other nodes within the project focus area.

Figure 2-4 shows the result of the critical duration assessment for the 1% AEP flood event. From review of the hydrographs across several locations within the project focus area the 6 hour duration storm event with temporal pattern 2 was identified as being the most suitable for application to the hydraulic model. This temporal pattern provided the median peak flow, which was also just above the mean peak flow for all ensembles at most locations of interest.

The critical duration was confirmed as the 6 hour duration event for other AEPs, except for the Probable Maximum Precipitation which had a critical duration of 4.5 hours. For a small number of catchments in the north-west area of the focus area, the 4.5 hour duration was close to the critical duration but the 6 hour remained critical for all key waterways and the 6 hour duration volume was also higher.

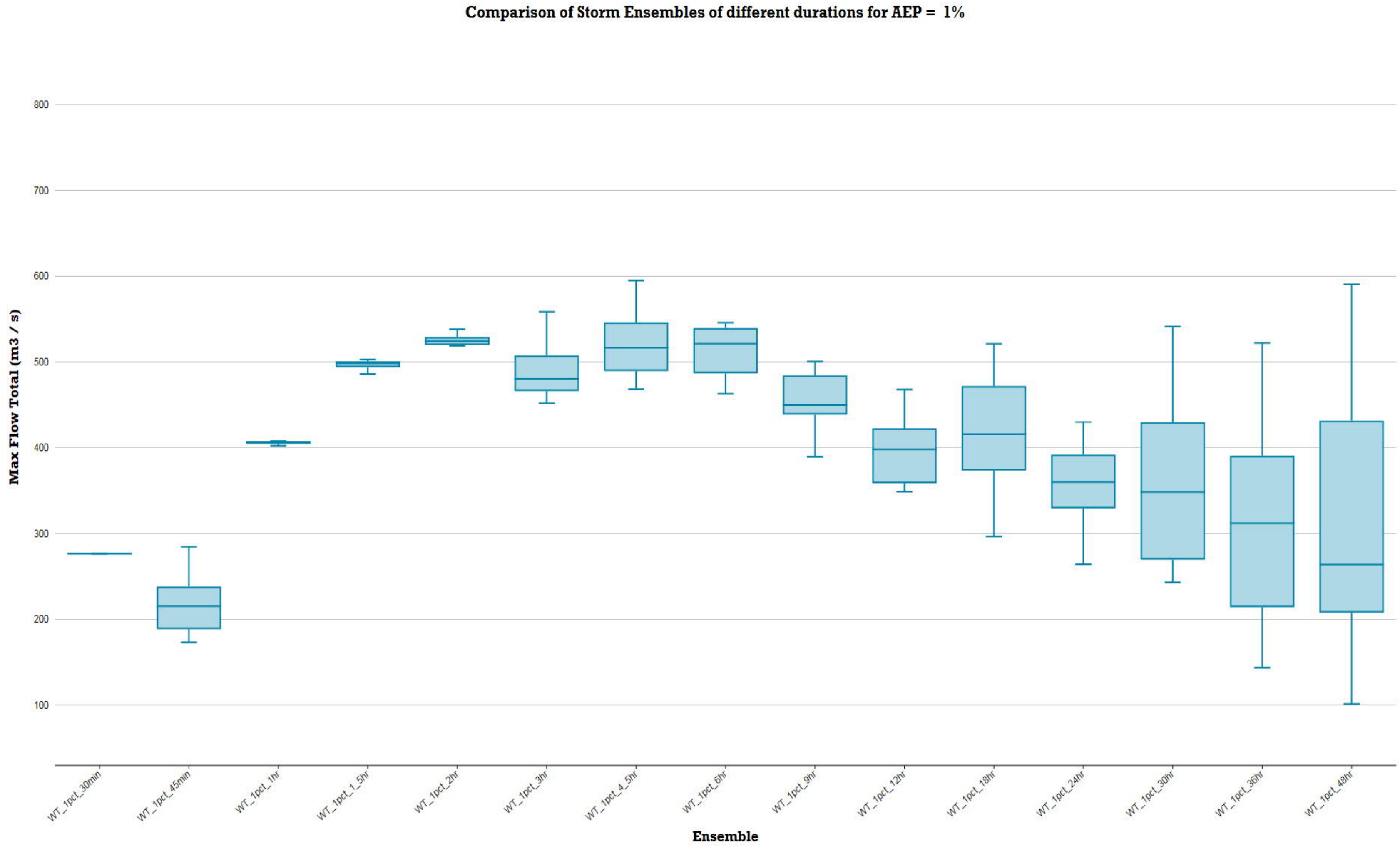

Figure 2-4 Comparison of storm ensembles for 1% AEP event at Lansdown Station.

Figure 2-5 shows the hydrographs for the 6 hour duration ensemble at the project focus area. Temporal pattern 2 results in a hydrograph which has a peak flow of 59 m^3/s which is just above the mean peak flow and had a high volume relative to some of the other temporal pattern hydrographs. The temporal pattern select was ensured to be not ‘peaky’ (e.g. Pattern 9) as hydraulic model would attenuate the peaks and this pattern would not be representative of the overall ensemble.

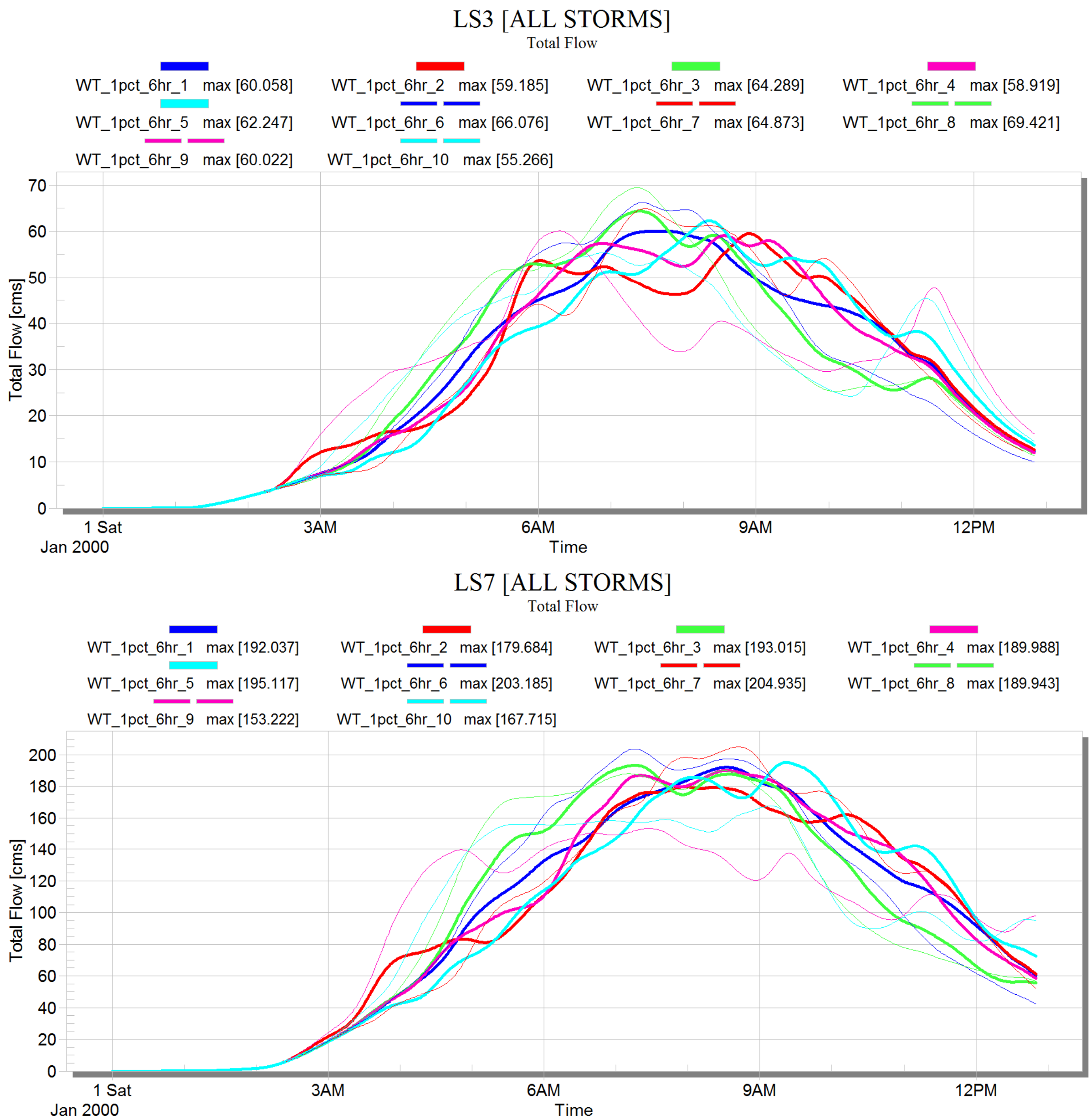

Figure 2-5 Hydrographs for the 1% AEP 6 hour duration storm ensemble close to the outlet of the Lansdown Station project focus area.

3.0 Hydraulic Assessment

3.1 Overview

MIKE FLOOD was used as the platform to construct a dynamically linked two-dimensional and one-dimensional hydraulic model for the Lansdown Station area. The Lansdown Station model extent is shown in Figure 1-1.

An overview of the model setup and key parameters is provided in Figure 3-1. The hydraulic model includes 34 culverts and two bridge structures. Modelling these structures facilitates the representation of flow through the existing drainage infrastructure and results in a robust understanding of flooding across the study area.

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 11 elements (culverts, bridges and open channels) with the two-dimensional overland flow model MIKE 21. Outputs from MIKE FLOOD include georeferenced 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 when applied in MIKE FLODD. It also enables simulation of 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 distributions 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 11for complex two-dimensional flow paths.

3.3 Model Development

3.3.1 2D Model Geometry

A 5 metre grid Digital Elevation Model (DEM) was developed to represent the topography of the Lansdown Station catchment. Figure 3-1 shows the full extent of the model as well as the project focus area as designated by Townsville City Council.

The DEM was derived from 1 m resolution aerial Light Detection and Ranging (LiDAR) survey captured in 2011 and 2012. The vast majority of the model extent was covered by the LiDAR captured in 2011, with a very small portion of the model domain covered by the 2012 survey.

The 5 m DEM represents the average elevation over each 5 m grid cell area (Figure 3-1), however key hydraulic controls such as road crown levels, rail levels and creek invert levels may be lost in the DEM gridding process. These controls were refined within the MIKE 21 topographic grid to ensure that the overland flow regime was appropriately represented.

Rating curve downstream boundary conditions were applied within MIKE 21 at the outflow of defined waterways along the northern and eastern boundaries of the model domain. The outflow rating curves were derived based on the LiDAR extracted cross section of the stream and a Manning's equation calculation assuming a slope of 0.01 and a Manning's 'n' roughness of 0.04.

3.3.2 1D Structures

Existing bridge and culvert structures within the project focus area having over 900 mm diameter equivalent were represented in the MIKE 11 model based on the supplied data.

The MIKE 11 model included two bridge structures and 34 culvert crossings. The modelled structures are predominately located along the Great Northern Rail line and the Flinders Highway. Structures along the Flinders Highway and Great Northern Rail line between Woodstock-Giru Road and Orme Road intersections were included.

Where available, the structure inverts and dimensions of the existing highway and rail cross drainage structures were derived from the latest plans provided TMR and Queensland Rail. The dimensions of key structures were confirmed during a site visit. Some additional structures were also identified during the initial site visit and were included in the model, these were generally located on local roads, Sky Diver Road and the Manton Quarry Road.

Full details of the structures modelled using MIKE 11 are summarised in Appendix D and their locations are illustrated in Figure 3-1. As noted in Section 1.5.4, it was observed during the site visit that culvert structures on Sky Diver Road were up to 50% blocked with debris. This impact was modelled as a structure of only 1 barrel rather than 2 barrels.

The structure drawings supplied by TMR for the Flinders Highway Double Barrel Creek bridge crossing (Martin Ryan Bridge) were identified as inaccurate during a site visit. In particular, an old bridge was noted to still be in place following the construction of the existing bridge for the Flinders Highway. Given the importance of this structure to model outcomes within the focus area, detailed survey of this structure was obtained for the purpose of this study (Appendix B).

LANSDOWN STATION FLOOD STUDY
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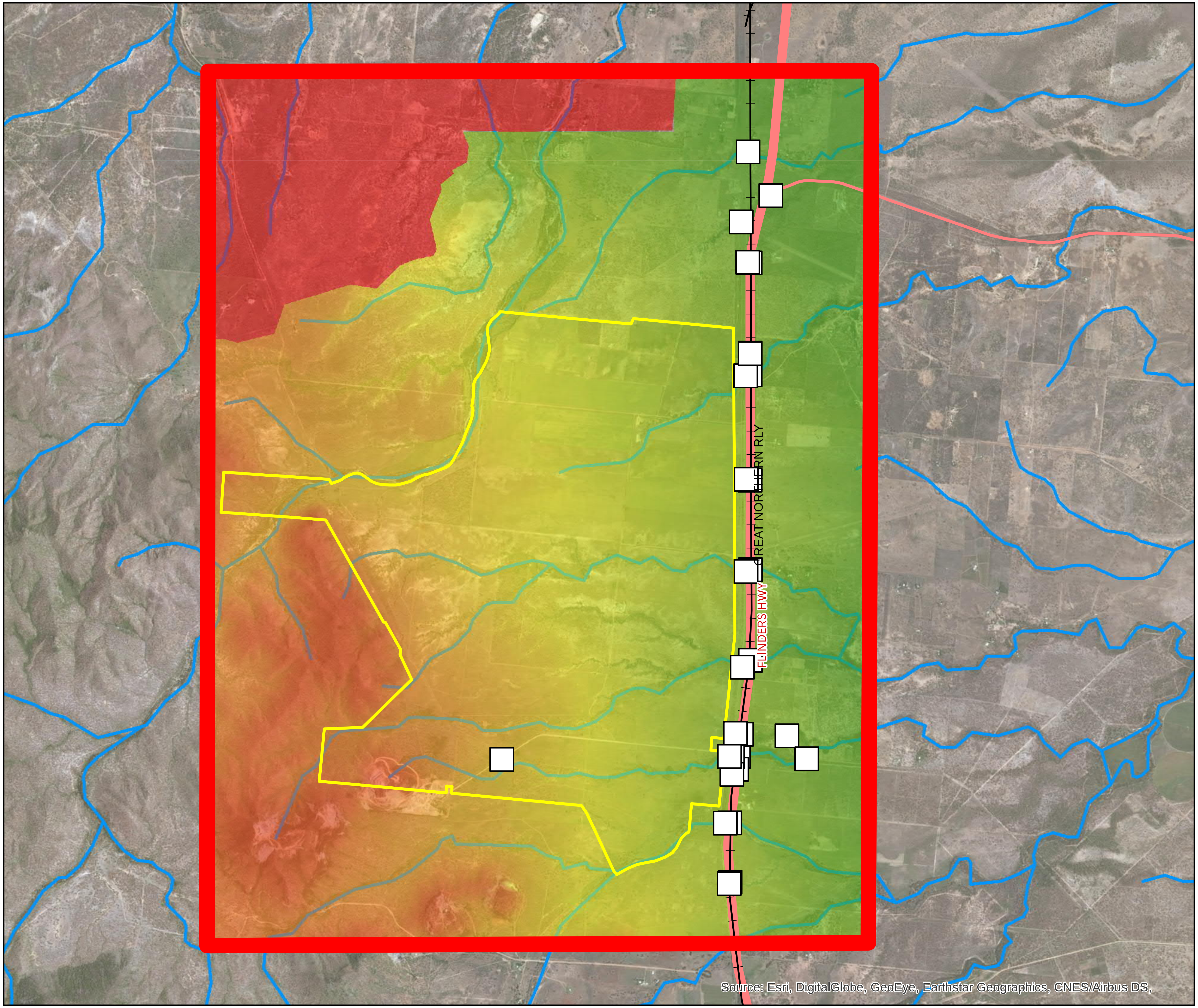
Model Geometry

Figure 3-1



Study Area
Lansdown Station Focus
Structures
DEM
(m) AHD
High : 1000
Low : 54.74

0 500 1,000 2,000
Metres
1:40,000 (when printed at A3)

Coordinate System: GDA 1994 MGA Zone 55

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

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3.3.3 Boundary Conditions

Level-flow boundary conditions were derived for all model outflows along the northern and eastern model boundaries based on the LiDAR terrain, channel slope and an assumed Manning roughness value matching the 2D domain. Outflow boundaries were applied in the 2D domain as rating curve boundaries at the locations shown on Figure 3-2.

Inflow source points were derived from the XPRAFTS hydrologic model for the steep catchments (above 15% slope) to the west of Lansdown station (, inflows for the remainder of the flatter model catchments were based on two-dimensional direct-rainfall (rain-on-grid) inflow time-series. The adopted

3.3.4 Roughness

A spatially varying hydraulic roughness map was developed based on 2016 aerial photography of the study area (Figure 3-3). A summary of the roughness values adopted for varying land uses is shown in Table 3-1. The roughness values were broadly consistent with those derived during hydraulic model calibration for the nearby Haughton River Floodplain Road (AECOM, 2014).

Table 3-1 Roughness Values and Associated Land Uses

Land Use / Zoning	Manning's M	Manning's 'n'
Riparian Areas/Dense Natural Vegetation	12.5	0.08
Creeks	30.3	0.033
Hillside/Floodplain/Wetlands/Lagoon surrounds	16.67	0.06
Local Roads/Manton Quarry	40	0.025
Main Highway/Railway	50	0.02

3.3.5 Rain-on-Grid Method for Local Runoff

Rain-on-Grid is a method for directly applying net precipitation to a hydraulic model. It involves applying the rainfall directly on the two-dimensional grid at every grid-cell within the application area.. 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. For steep areas, inflows were applied to the model based on the XP-RAFTS model. Further details regarding the extents of the application of the rain-on-grid method are provided along with the description of the hydraulic model setup in Section 3.3.5.

Two-dimensional rainfall excess time series for each AEP and duration were created to represent the local net precipitation for the study area. This rainfall excess was calculated by applying specific initial and continuing losses for pervious and impervious areas. Pervious initial and continuous loss values of 30 mm and 1.25 mm/h were applied, while impervious area losses of 1 mm and 0 mm/h were applied. As in the XPRAFTS model, pre-burst values were averaged over 10 time-steps and included in the rainfall time-series.

A fraction imperviousness map for the base case scenario was created using TCC's land use dataset (see Figure 3-4). This dataset contains suitable descriptors that allow the separation between vacant land, vacant land intended for residential use, residential dwelling, parks, commercial and industrial lands, etc. To determine the imperviousness percentage an average house size to land parcel ratio was used. For all other parcels such as parks, crown land, etc., an imperviousness value was applied based on typical values for the type of land in the area identified from aerial imagery (2011).

Values of 50% impervious were assumed for major and minor road corridors as well as the rail line and the developed area of the Manton Quarry site. Much of the project area is rural and is pervious. Major creek alignments were represented as 100% impervious due to the presence of water within the creeks during the event. .

3.4 Model Validation

Historical data was sourced for the “Calcium Culvert at Woodstock” water level gauge on the Great Northern Rail line from Queensland Rail. The available data dated back to 2014. Following inspection of the available data it was identified that the data was not suitable for calibration. The recorded levels generally did not rise above 100 mm with the exception of what appeared to be an anomaly in the gauge data with a prolonged large spike during the dry season. Over this time, the Calcium pluviograph did not record any rainfall.

3.4.1 Structure loss verification

A separate one-dimensional HEC-RAS model was developed to independently calculate head losses across bridge structures within Double Barrel Creek for comparison to MIKE FLOOD. The HEC-RAS model stretches across both the bridges and was run as a steady-state model using the flow and downstream water level extracted from the MIKE FLOOD model.

Verification of predicted hydraulic losses at the Double Barrel Creek road and rail bridges was undertaken for the 1% and 2% AEP flood events. The losses calculated between the two models are shown below in Table 3-2.

Table 3-2 Comparison of head losses between HEC-RAS and MIKE

Model	2% AEP Head Loss (mm)	1% AEP Head Loss (mm)
HEC-RAS	320	240
MIKE FLOOD	333	335
Difference	**13 mm**	**95 mm**

The HEC-RAS model predicts a head loss of 240 mm across the multiple bridges for the 1% AEP flood event while MIKE FLOOD shows a higher value of 335 mm. Overall the difference between models for both events was less than 100 mm and therefore within reasonable tolerance.

LANSDOWN STATION FLOOD STUDY
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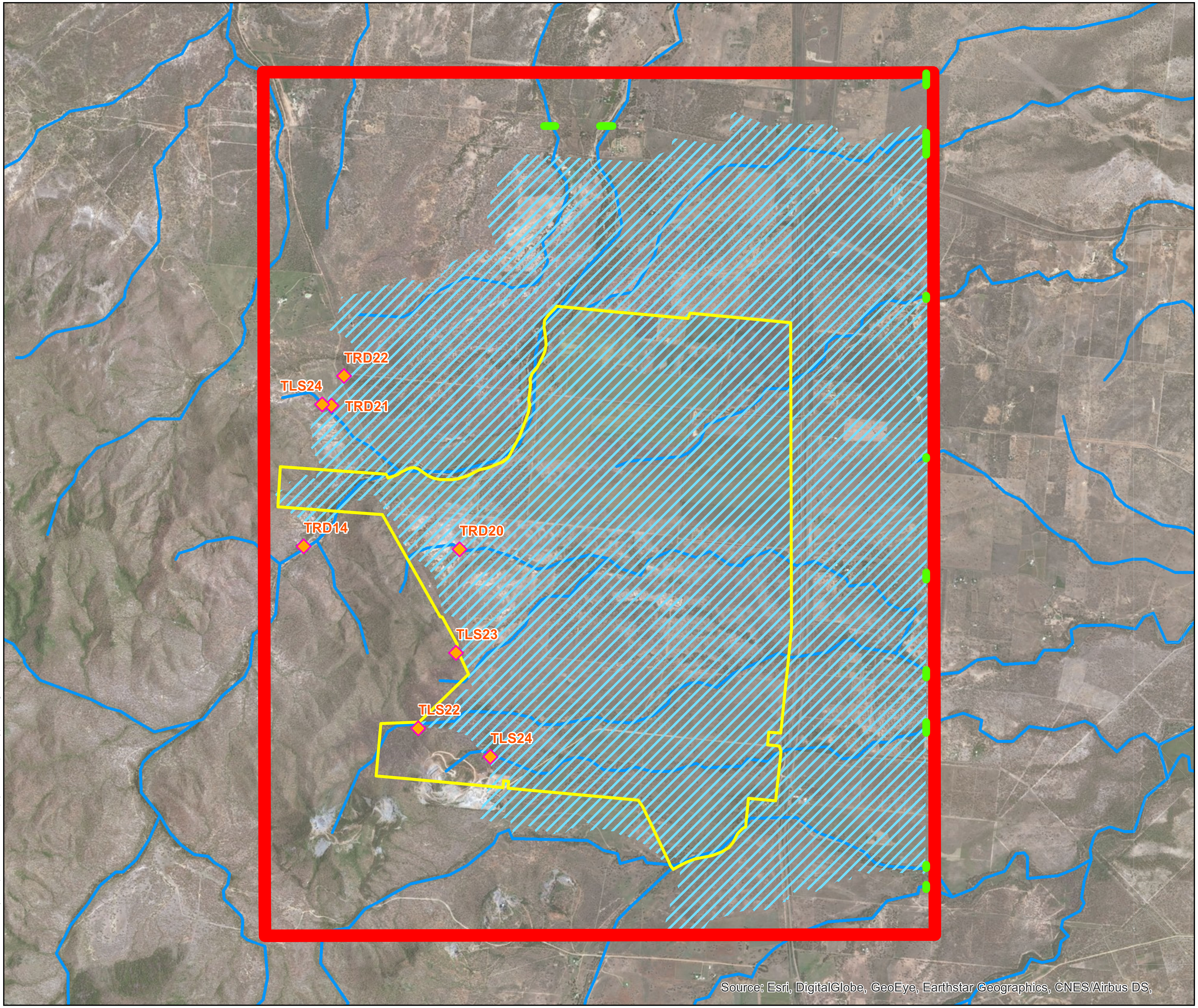
Boundary Conditions

Figure 3-2



Legend:
- Study Area
- Lansdown Station Focus Area
- Rain On Grid
- Highways
- Q-h Boundariesbondaries
- RAFTS Inflows
- Main Roads

0 500 1,000 2,000
Metres

1:40,000 (when printed at A3)

Coordinate System: GDA 1994 MGA Zone 55

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

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LANSDOWN STATION FLOOD STUDY
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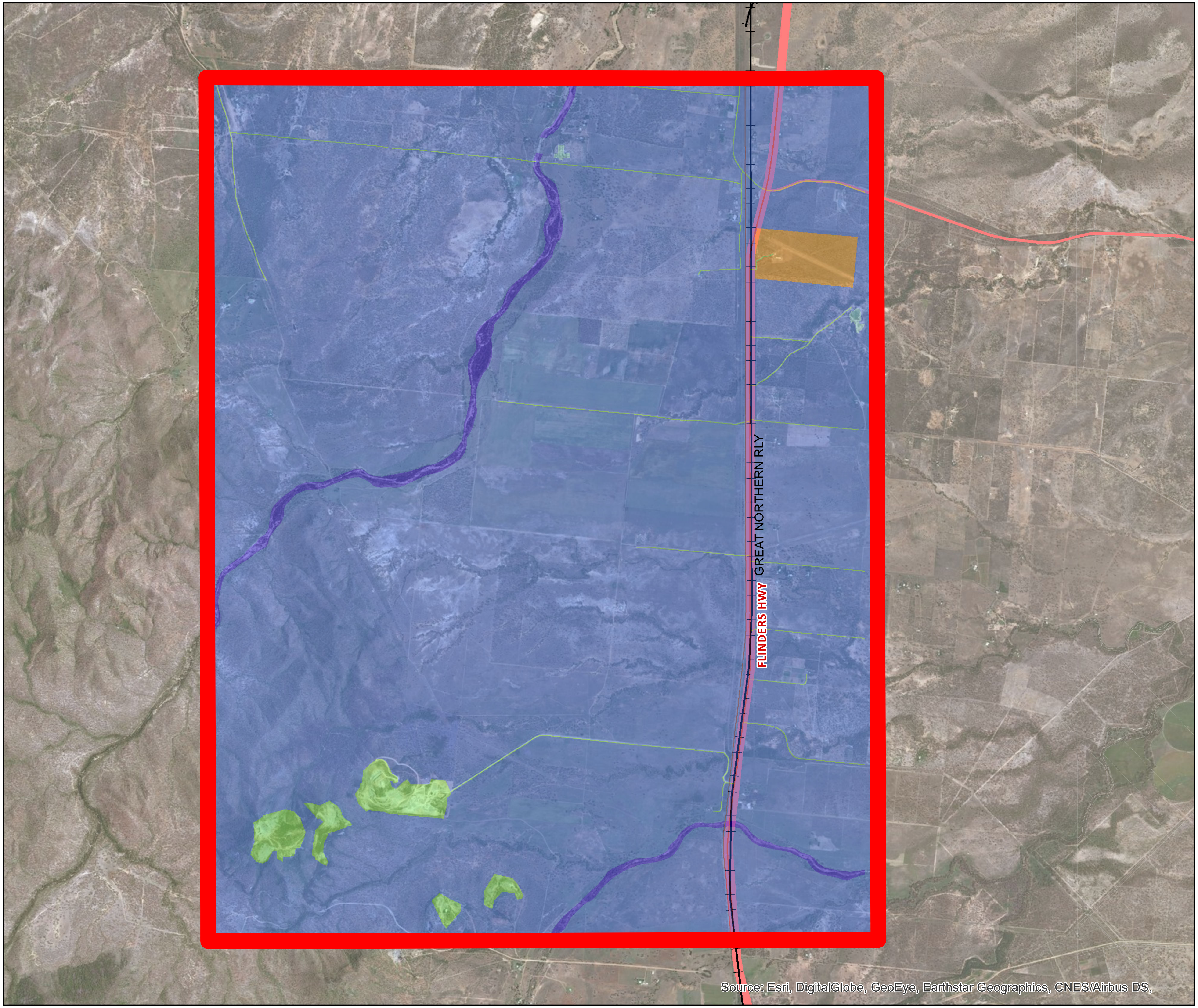
Model Roughness

Figure 3-3



Lansdown Station Focus Area

Roughness(old version)

Manning M

- 50
- 40
- 30.3
- 25
- 20
- 16.67
- 10
- 7
- 5

0 500 1,000 2,000

Metres

1:40,000 (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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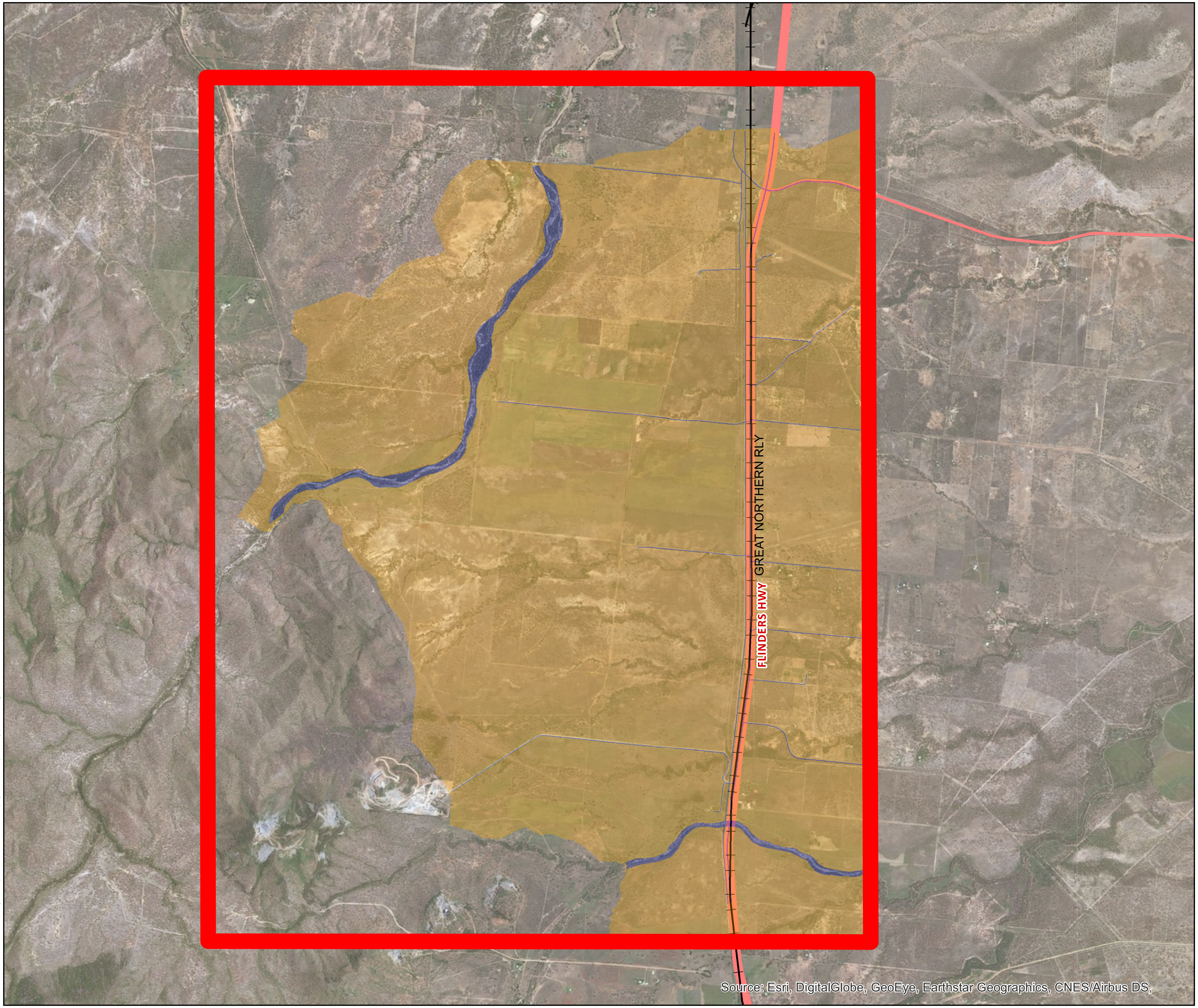

LANSDOWN STATION FLOOD STUDY
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Model Fraction Impervious

Figure 3-4

Lansdown Station Focus Area

Surface type

Pervious

Impervious

0 500 1,000 2,000

Metres

1:40,000 (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 Baseline Flooding Results

4.1 Flooding across the Study Area – Summary

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

- 50% AEP
- 20% AEP
- 10% AEP
- 5% AEP
- 2% AEP
- 1% AEP
- 0.5% AEP
- 0.2% AEP
- Probable Maximum Flood.

Direct rainfall hydraulic modelling, will display all areas within the model as wet unless a filtering criteria is applied For mapping purposes the flowing filter criteria were adopted to ensure appropriate display:

- including water depths greater than or equal to 0.1 m; and
- including water velocities greater than or equal to 0.8 m/s.

Therefore, only areas predicted to experience water depths lower than 0.1 m and water velocities lower than 0.8 m/s are shown as free from flooding in the mapping undertaken. This is in line with TCC's Flood Hazard Mapping Criteria.

A description of the flooding characteristics 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 AEP simulated.

Table 4-1 Lansdown Station Flooding Summary

Event	Description	Map Ref
50% AEP	• Isolated ponding across of up to 0.25 m across the Lansdown Station floodplain and in localised areas adjacent to main overland flowpaths and the Great Northern Rail line. • No inundation of the Flinders Highway or Great Northern Rail line.	E1A, E1B, E1C
20% AEP	• Isolated ponding across of up to 0.25 m across the Lansdown Station floodplain and in localised areas adjacent to main overland flowpaths and the Great Northern Rail line. • Overflow from Double Barrel Creek north towards Manton Quarry Road. Some water on the Great Northern Rail line north of Double Barrel Creek.	E2A, E2B, E2C
10% AEP	• Floodplain inundation up to 0.5 m across the Lansdown Station in localised areas adjacent to main overland flowpaths and culvert crossing of the Great Northern Rail line. • Inundation of the Great Northern Rail line north of Double Barrel Creek.	E3A, E3B, E3C
5% AEP	• Floodplain inundation up to 0.75 m across the Lansdown Station adjacent to main overland flowpaths. • Overtopping of 200 mm on Flinders Highway at Double Barrel Creek.	E4A, E4B, E4C

Event	Description	Map Ref
	• Inundation of the Great Northern Rail line north of Double Barrel Creek.	
2% AEP	• Floodplain inundation up to 1 m across the Lansdown Station adjacent to main overland flowpaths and up to 0.35 m in isolated areas. • Significant ponding adjacent to the Great Northern Rail line and Flinders Highway road alignment. • Overtopping of Flinders Highway and the Great Northern Rail line at the northern side of Double Barrel Creek.	E5A, E5B, E5C
1% AEP	• Floodplain inundation up to 1.25 m across the Lansdown Station adjacent to main overland flowpaths and up to 0.5 m in isolated areas adjacent to the Great Northern Rail line. • Overtopping of Flinders Highway at several major flowpath locations between Woodstock and Double Barrel Creek. • Overtopping of North Coast Rail line at several major flowpath locations between Woodstock and Double Barrel Creek.	E6A, E6B, E6C
0.5% AEP	• Floodplain inundation up to 1.5 m across the Lansdown Station adjacent to main overland flowpaths and up to 0.5 m in isolated areas adjacent to the Great Northern Rail line. • Overtopping of Flinders Highway at several major flowpath locations between Woodstock and Double Barrel Creek. • Overtopping of North Coast Rail line at several major flowpath locations between Woodstock and Double Barrel Creek.	E7A, E7B, E7C
0.2% AEP	• Floodplain inundation up to 1.75 m across the Lansdown Station adjacent to main overland flowpaths and up to 0.5 m in isolated areas adjacent to the Great Northern Rail line. • Overtopping of Flinders Highway at several major flowpath locations between Woodstock and Double Barrel Creek. • Overtopping of North Coast Rail line at several major flowpath locations between Woodstock and Double Barrel Creek.	E8A, E8B, E8C
PMF	• Extensive floodplain inundation up to 3 m across the Lansdown Station. • Overtopping of Flinders Highway and Great Northern Rail line at Woodstock, Double Barrel Creek and Calcium culverts.	E9A, E9B,E9C

4.2 Flooding at Potential Industrial Development Site

TCC has identified a site for potential development as a battery processing plant. The site is comprised of several lots located on Bidwilli Road, upstream of the Flinders Highway. The site is highlighted on each of the base case flood maps provided in Appendix E.

The proposed battery plant site is traversed by a small creek to the north west of the site. Water depths of up to 2 m are predicted within this creek up to the 1% AEP, however flows are broadly contained within the channel banks.

The proposed industrial site is not predicted to be impacted by significant breakouts of the unnamed creek immediately south of Bidwilli Road in flood events up to the 1% AEP, however up to 300 mm is predicted at Bidwill Road, which is a potential access point for the site. Access to the north of the lot is more likely to be flood immune.

Widespread overland flow of up to 300 mm is predicted at the proposed battery plant site in the Probable Maximum Flood. Corresponding flow velocities are predicted to be up to 0.75 m/s.

4.3 Climate Change Sensitivity

4.3.1 Approach

Climate change projections indicate that there is a high likelihood of a future increase in rainfall intensity due to the impacts of global warming. An assessment of the impact of the projected changes to rainfall intensity was undertaken to understand the sensitivity of the predicted flood impacts to the likely effects of climate change. The study area is sufficiently away from the coast that sea-level rise is will not influence flood levels.

AR&R2016 recommends scaling of design IFD's based on temperature (rather than rainfall), since climate models are much more reliable at producing temperature estimates than individual storm events.

For this study, climate change projections of increases to temperature were using the Climate Futures Tool developed by the CSIRO (https://www.climatechangeinaustralia.gov.au/en/climate-projections/climate-futures-tool/projections) as recommended by ARR 2016. Revised inflows were calculated for the 1% and 2% AEP flood events as these events are generally of most interest in relation to future floodplain planning constraints.

The CSIRO Climate Futures Tool analyses a series of climate models and provides temperature outputs for differing Representative Concentration Pathways (RCPs), which are future greenhouse gas emissions scenarios. Guidance from AR&R (2016) recommends using RCP4.5 and RCP8.5 for impact assessments and these were considered. Projections are given at future times, relative to a 1986 - 2005 baseline.

The Lansdown Station catchment is in the Monsoonal North (East) Natural Resource Management (NRM) cluster. The projections from the CSIRO Climate Futures Tool for the Monsoonal North (East) NRM cluster for 2070 are provided in Table 4-2, projections to 2050 and 2090 (the most future date available) were found to have similar consensus.

The majority of climate projection models agree that that warming between 1.5-3.0 degrees (the "Hotter" scenario) is more likely than warming greater than 3.0 degrees (the "Much Hotter" scenario). Among the models forecasting warming between 1.5 and 3.0 degrees there is no consensus on the associated increase or decrease of rainfall.

Approximately 19% of all models agree that 1.5 to 3.0 degrees of warming will result in little change (-5% to +5%) in annual rainfall; 15% of all models provide a consensus of 5 to 15% increase in rainfall for 1.5 to 3.0 degrees of warming and 12% of models provide a consensus of >15% increase in rainfall.

Table 4-2 Climate Futures Outlook for 2070 for the Monsoonal North (East) NRM Cluster

		Annual Mean Surface Temperature Increase (^{o}C)	
		Hotter (1.5 – 3.0)	Much Hotter (>3.0)
Annual Rainfall Increase (%)	Much Wetter (>15%)	6 of 48	1 of 48
	Wetter (5 to 15%)	7 of 48	4 of 48
	Little Change (-5% to 5%)	9 of 48	3 of 48
	Drier (-15% to 5%)	5 of 48	3 of 48
	Much Drier (<-15%)	2 of 48	8 of 48

Since there is no overwhelming consensus an alternative approach of assuming warming by 1.5 to 3.0 degrees Celsius will be used as recommended in AR&R (2016).

Since there is a majority consensus of models for a "Hotter" climate scenario the range of 1.5 and 3.0 is used to determine the median between these values (2.25) and used to estimate adjustments to design rainfalls. The median of the temperature class interval with the highest consensus in the

Climate Futures Tool (i.e. the “Hotter” scenario of between 1.5 to 3.0 degrees warming) is used in Equation 1 to estimate the potential impacts of climate change on rainfall.

Equation 1: Projected rainfall intensity equation for climate change based on temperature (AR&R, 2016)

$$I_p = I_{ARR} \, x \, 1.05^{T_m}$$

I_p = Projected Rainfall Intensity or Depth

I_{ARR} = Design rainfall intensity or depth for current climate conditions

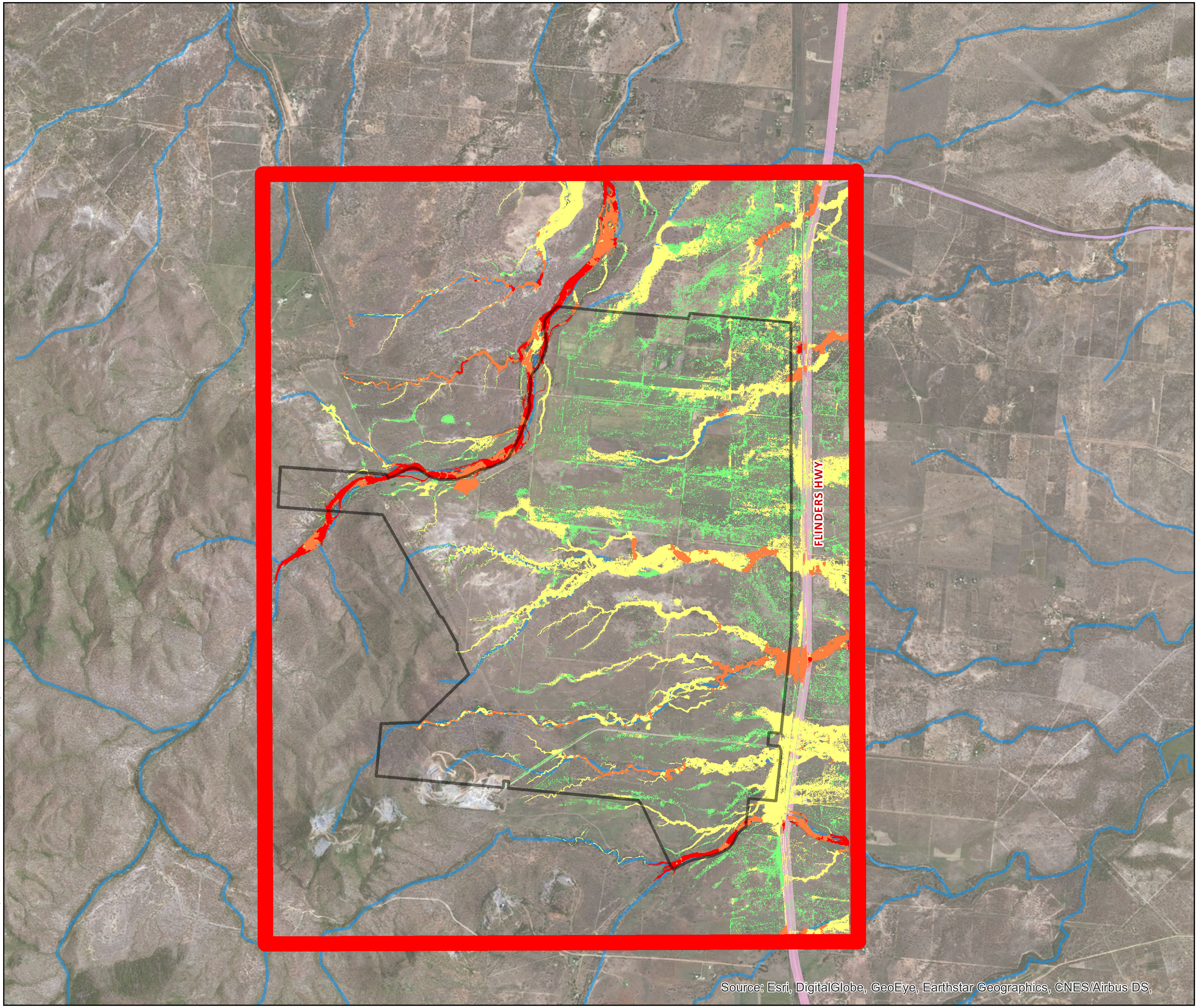
1.05 = assumed temperature scaling constant

Tm = temperature median of the selected Climate Futures Temperature Class Interval = (1.5 + 3) / 2 = 2.25

Equation 1 suggests that climate change will have an impact of a 12% increase in rainfall, therefore the BoM 2016 design rainfall IFDs used in the local catchment hydrological model for the Lansdown Station were increased by 12% and the resultant design hydrographs and direct rainfall time series were input into the hydraulic model.

The resulting assumptions adopted for the Lansdown Flood Study climate change sensitivity analysis are similar to the previous flood studies which underpinned the Townsville Citywide Flood Constraints projects; many of the previous studies adopted an approach to climate change based on a 15% increase in rainfall intensities by the year 2100 (which was based on previous Local Government of Queensland advice).

Figure 4-1 shows the difference in the maximum water depths between the 1% AEP climate change scenario and the 1% AEP flood event respectively. The results of the climate change sensitivity analysis showed that the Lansdown Station area experiences an increase in flood depths of generally in the range of 100 mm to 250 mm for both the 1% and 2% AEP flood events.



LANSDOWN STATION FLOOD STUDY
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Sensitivity Analysis
Climate Change 1% AEP

Figure 4-1

Study Area
Lansdown Station Focus Area
Highways
Main Roads

1% AEP Climate Change

Below -1
-1 - -0.5
-0.5 - -0.25
-0.25 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 1
Above 1

0 500 1,000 2,000
Metres

1:40,000 (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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5.0 Conclusion

5.1 Summary

The following summarises the work undertaken and outcomes for this study:

- A hydrologic model that covers the Lansdown Station area was developed by applying AR&R 2016 hydrological methods to an XP-RAFTS 2018 hydrologic model of the Major Creek catchment upstream of the Major Creek gauge
- The Rain-on-Grid method was used across the majority of the project area with only the steep upper catchment areas of the Mingela State Forest assessed with the more traditional hydrologic model output method applied through rural and relatively steep areas across the model.
- The model parameters adopted for roughness as well as initial and continuing losses are in line with those used in previous studies undertaken as part of the *City Wide Flood Constraints Project*.
- The critical durations adopted for flood events up to 0.2% AEP was 6 hours and a critical duration of 4.5 hours applied to the PMF event.
- A hydraulic model was developed using TCC 2011 LiDAR topography to support the assessment of overland flow and key structures along the Flinders Highway and Great Northern Rail line represented as one-dimensional elements.
- No suitable data was available to calibrate the hydraulic model.
- Areas of the Lansdown Station site are impacted by flooding from Double Barrel Creek and smaller unnamed flowpaths upstream of the Great Northern Rail line in flood events as illustrated in Table 4-1 and Appendix E.
- Based on the current forecast of future temperature increases to 2100, the likely impacts of future climate change will be a 100 – 250 mm increase in flood levels across the Lansdown Station in events up to the 1% AEP.

5.2 Recommendations

The following recommendations are made as part of this study:

- That the model is revisited when revised LiDAR data is available in order to provide a better representation of the topography across the study area.
- A stream gauge is installed within Double Barrel Creek and Lansdown Creek to facilitate calibration of any future revisions/updates of the model and real time observations of flooding for any future development.
- Local refinement of the model is undertaken if a site specific assessment of flood risk is needed, within the bounds of the Lansdown Station site.
- opportunities or options to mitigate flood risk across the affected areas of the site through the implementation of strategic large scale measures, may be investigated in future. Any flood mitigation measures should be explored as part of an overall floodplain management strategy for the area..

6.0 References

AECOM (2014), Haughton River Floodplain Updrage for Queenlsnad Department of Transport and Main Roads.

AECOM (2014), Haughton River Floodplain Updrage for Queenlsnad Department of Transport and Main Roads.

ARR (1987), Australian Rainfall and Runoff Guidelines, Engineers Australia.

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TCC (2013), Ross River Flood Study Base-line Flooding Assessment, Volume 1, Townsville City Council.

Appendix A

Photos from Site Inspection

Appendix A Photos from Site Inspection

Photo 1 Sky Diver Road Culvert – 50% Blocked

Photo 2 – Flinders Highway at Double Barrel Creek (looking upstream)

Appendix B

Martin Ryan Bridge Survey

LEGEND

- Lot Boundary
- Edge of Bitumen
- Edge of Conc
- Stressing Bars
- Bridge Deck Top
- Bridge Deck Underside
- Top of Bank
- Bottom of Bank
- Change of Grade
- Major Contour (1.0m)
- Minor Contour (0.2m)
- Change of Grade
- Top of Bank
- Bottom of Bank
- Fence Line
- Wall
- Edge of Bitumen
- Concrete
- Electricity Pit
- Telstra Pit
- Electricity Manhole
- Telstra Manhole
- Electricity Pillar
- Telstra Pillar
- Power Pole
- D.O.T. Pit
- Light Pole
- Traffic Light
- Optus Pit
- Stormwater Manhole
- Gas Valve
- Gully Trap
- Fuel Filler-Cap
- Field Inlet
- Sewer Manhole
- Traffic Sign
- Inspection Opening
- Sign
- Water Meter
- Bench Mark
- Tap
- Tree
- Water Valve
- Shrub
- Fire Hydrant
- Palm Tree
- Fence Post
- Approx Column Location

IMPORTANT NOTE

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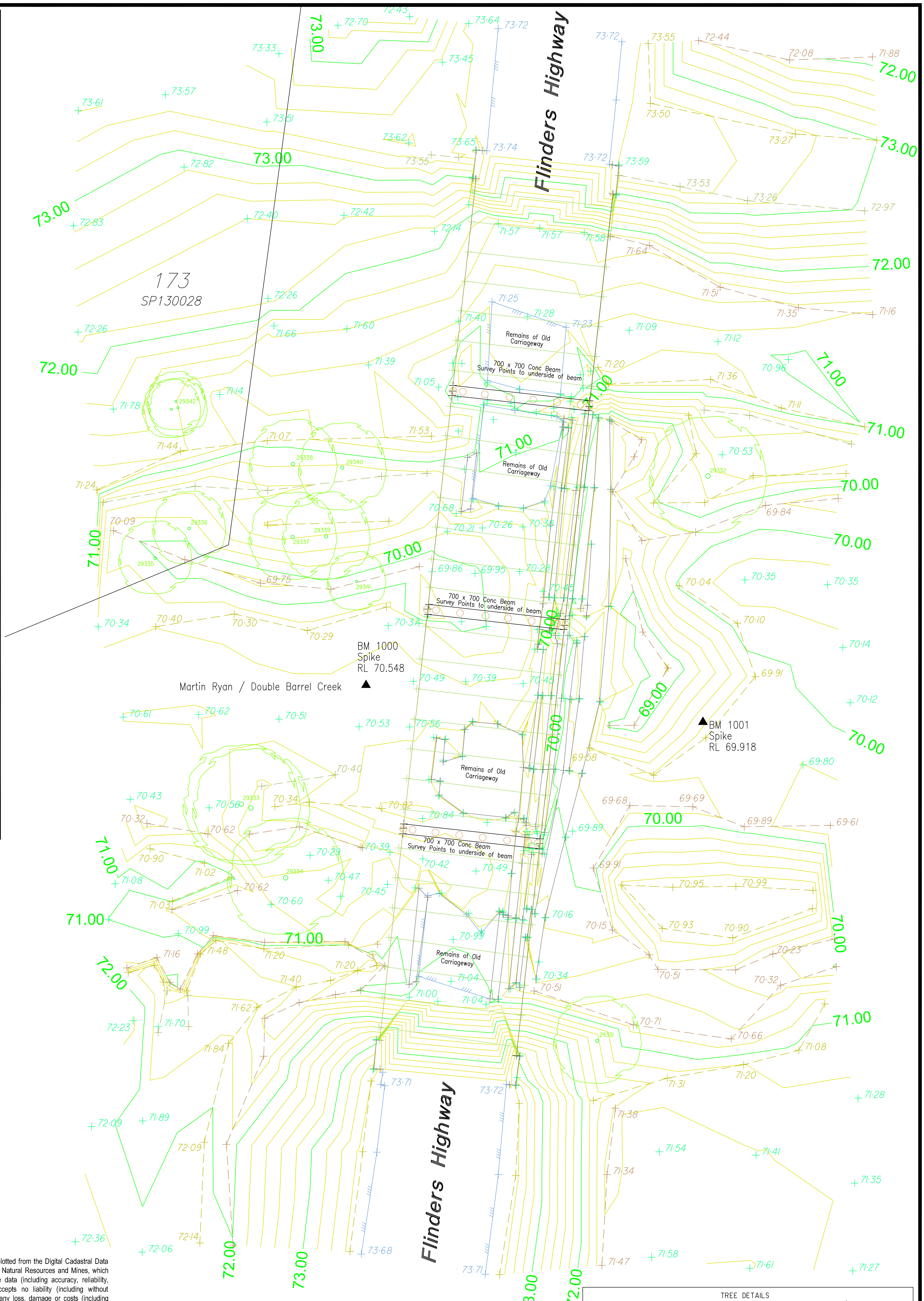

PROPERTY BOUNDARIES

Boundaries shown on this plan are plotted from the Digital Cadastral Data Base provided by the Department of Natural Resources and Mines, which gives no warranty in relation to the data (including accuracy, reliability, completeness or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data.

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Boundary corners were not marked at the time of survey.

CONTOURS

The contours shown represent the site as it was at the time of survey. Major Contour Interval: 1.0m, Minor Contour Interval: 0.2m

VEGETATION

Only trees greater than or equal to 100mm breast height diameter have been located. Tree heights are approximate only. Whilst all care has been taken by the field surveyor to correctly identify the species and type of trees located during this survey, they are only estimates to assist with identification on site. If accurate identification of tree types is to be relied upon for any purpose, then all trees listed will require on site verification by a suitably qualified expert.

TREE DETAILS

ID	SPECIES	DIAMETER	SPREAD	HEIGHT
29331	Paperbark	0·50	6·0	10·0
29332	Paperbark	0·50	8·0	10·0
29333	Paperbark - 2x Trunks	0·50	8·0	8·0
29334	Paperbark - 2x Trunks	0·50	8·0	8·0
29335	Acacia	0·30	5·0	6·0
29336	Acacia	0·40	5·0	10·0
29337	Paperbark	0·50	6·0	10·0
29338	Paperbark	0·50	6·0	10·0
29339	Paperbark	0·50	6·0	10·0
29340	Paperbark	0·50	6·0	10·0
29341	Acacia	0·20	4·0	6·0
29342	Paperbark - Cluster of 3	0·20	4·0	8·0

Scale 1:250

0 2.5m 5m 7.5m 10m 12.5m

Horizontal Datum	MGA Zone 55
Azimuth	MGA Zone 55
Origin	MGA Zone 55
Vertical Datum	AHD
Origin	PSM 156630
RL	RL: 70.208
Locality	CALCIUM
Local Authority	TOWNSVILLE CITY COUNCIL
Lat Long	N/A
DWG:	141043-001.dwg
12D:	141043 001.12d

CLIENT: AECOM Australia Holdings Pty Ltd

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370 Flinders Street Mall
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Townsville QLD 4810
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ISO 9001 Quality Management FS520623

PROJECT: Lansdown Flood Study

Detail & Contour Survey

Martin Ryan/Double Barrel Creek Bridge & Adjoining Creek Detail

Flinders Highway, QLD

Scale 1:250 | Sheet 1 of 1 | Sheet A3 | 141043-001 | Rev -

Appendix C

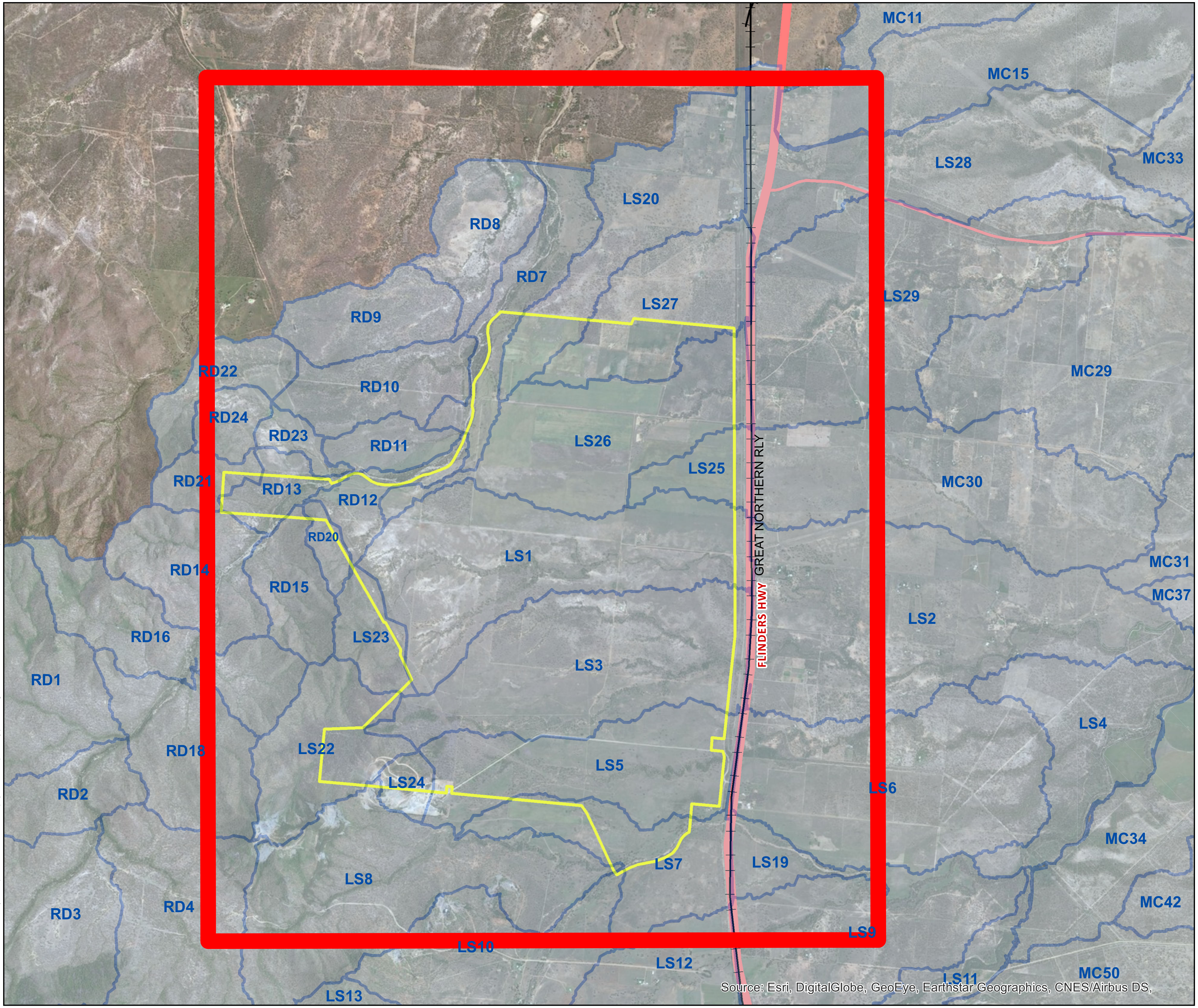
Catchment Parameters

Appendix C Catchment Parameters

Catchment	Slope [%]	Mannings 'n'	Percentage Impervious [%]	Init/Cont Rainfall Loss	Total Area [ha]
LS1	1.1	0.07	0.001	I30C1p25	532
LS10	3.8	0.08	0.001	I30C1p25	340
LS11	2.8	0.07	0.001	I30C1p25	271
LS12	3.6	0.08	0.001	I30C1p25	482
LS13	6.9	0.08	0.001	I30C1p25	213
LS14	8.3	0.08	0.001	I30C1p25	412
LS15	9.8	0.07	0.001	I30C1p25	393
LS16	5.5	0.08	0.001	I30C1p25	287
LS17	11.3	0.08	0.001	I30C1p25	211
LS18	10.3	0.08	0.001	I30C1p25	321
LS19	1.7	0.07	0.001	I30C1p25	69
LS2	1.1	0.07	0.001	I30C1p25	777
LS20	0.7	0.06	0.001	I30C1p25	321
LS22	10.4	0.08	0.001	I30C1p25	219
LS23	10.3	0.08	0.001	I30C1p25	82
LS24	9.3	0.08	0.001	I30C1p25	37
LS25	1.3	0.07	0.001	I30C1p25	82
LS26	1.0	0.06	0.001	I30C1p25	387
LS27	0.9	0.06	0.001	I30C1p25	257
LS28	1.1	0.06	0.001	I30C1p25	507
LS29	1.2	0.07	0.001	I30C1p25	687
LS3	1.1	0.07	0.001	I30C1p25	506
LS4	1.4	0.07	0.001	I30C1p25	296
LS5	1.1	0.07	0.001	I30C1p25	339
LS6	1.1	0.07	0.001	I30C1p25	569
LS7	0.9	0.06	0.001	I30C1p25	234
LS8	7.4	0.08	0.001	I30C1p25	572
LS9	1.5	0.07	0.001	I30C1p25	444
MC1	9.2	0.08	0.001	I30C1p25	841
MC11	5.5	0.08	0.001	I30C1p25	2009
MC14	5.5	0.07	0.001	I30C1p25	642
MC15	0.1	0.06	0.001	I30C1p25	687

Catchment	Slope [%]	Mannings 'n'	Percentage Impervious [%]	Init/Cont Rainfall Loss	Total Area [ha]
MC17	3.3	0.06	0.001	I30C1p25	958
MC20	4.5	0.07	0.001	I30C1p25	845
MC21	0.8	0.06	0.001	I30C1p25	2008
MC22	4.4	0.07	0.001	I30C1p25	715
MC23	0.2	0.06	0.001	I30C1p25	1115
MC24	1.6	0.07	0.001	I30C1p25	662
MC28	0.6	0.06	0.001	I30C1p25	469
MC29	1.1	0.07	0.001	I30C1p25	1365
MC30	1.1	0.07	0.001	I30C1p25	555
MC31	1.0	0.07	0.001	I30C1p25	270
MC32	1.2	0.06	0.001	I30C1p25	687
MC33	0.9	0.07	0.001	I30C1p25	436
MC34	1.0	0.06	0.001	I30C1p25	883
MC35	0.2	0.06	0.001	I30C1p25	444
MC36	0.2	0.07	0.001	I30C1p25	482
MC37	0.9	0.06	0.001	I30C1p25	208
MC39	0.3	0.06	0.001	I30C1p25	935
MC4	9.2	0.08	0.001	I30C1p25	1489
MC40	0.2	0.06	0.001	I30C1p25	1115
MC42	0.2	0.07	0.001	I30C1p25	667
MC43	0.6	0.08	0.001	I30C1p25	679
MC45	0.3	0.06	0.001	I30C1p25	962
MC48	0.3	0.06	0.001	I30C1p25	31
MC49	0.1	0.07	0.001	I30C1p25	1364
MC5	9.0	0.08	0.001	I30C1p25	2052
MC50	0.7	0.07	0.001	I30C1p25	1424
MC51	0.1	0.06	0.001	I30C1p25	68
MC52	0.1	0.07	0.001	I30C1p25	66
MC54	4.3	0.06	0.001	I30C1p25	962
MC55	0.9	0.06	0.001	I30C1p25	763
MC56	1.1	0.06	0.001	I30C1p25	493
MC58	0.4	0.07	0.001	I30C1p25	611
MC62	0.2	0.06	0.001	I30C1p25	274

Catchment	Slope [%]	Mannings 'n'	Percentage Impervious [%]	Init/Cont Rainfall Loss	Total Area [ha]
MC63	0.2	0.06	0.001	I30C1p25	538
MC67	0.1	0.06	0.001	I30C1p25	189
MC68	0.3	0.07	0.001	I30C1p25	1388
MC69	0.7	0.07	0.001	I30C1p25	2430
MC7	2.0	0.06	0.001	I30C1p25	1551
MC71	0.2	0.06	0.001	I30C1p25	578
MC72	0.2	0.06	0.001	I30C1p25	667
MC73	2.3	0.08	0.001	I30C1p25	571
MC74	1.3	0.07	0.001	I30C1p25	434
MC80	1.7	0.06	0.001	I30C1p25	284
Outlet	2.2	0.06	0.001	I30C1p25	106
RD1	11.3	0.08	0.001	I30C1p25	607
RD10	1.4	0.06	0.001	I30C1p25	159
RD12	1.3	0.07	0.001	I30C1p25	74
RD13	1.7	0.07	0.001	I30C1p25	67
RD14	8.7	0.08	0.001	I30C1p25	198
RD15	9.8	0.08	0.001	I30C1p25	113
RD16	9.3	0.08	0.001	I30C1p25	244
RD18	7.1	0.08	0.001	I30C1p25	235
RD2	7.3	0.08	0.001	I30C1p25	145
RD20	11.2	0.08	0.001	I30C1p25	31
RD21	10.6	0.08	0.001	I30C1p25	59
RD22	4.8	0.08	0.001	I30C1p25	103
RD23	1.2	0.07	0.001	I30C1p25	36
RD24	6.1	0.08	0.001	I30C1p25	58
RD3	9.2	0.08	0.001	I30C1p25	606
RD4	6.3	0.08	0.001	I30C1p25	490
RD5	10.4	0.08	0.001	I30C1p25	432
RD6	11.2	0.08	0.001	I30C1p25	372
RD7	1.3	0.07	0.001	I30C1p25	181
RD8	0.8	0.06	0.001	I30C1p25	160
RD9	1.2	0.06	0.001	I30C1p25	153



LANSDOWN STATION FLOOD STUDY
TOWNSVILLE CITY COUNCIL

Local Catchments
Figure C1

Study Area
Main Roads
Highways
Qld_Railway_Lines
Lansdown Station Focus Area
Local Catchments

0 500 1,000 2,000
Metres

1:40,000 (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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Appendix D

Structure Details

Appendix D Structure Details

Table D-1 Details of culvert and bridge structures modelled using MIKE 11 in the Lansdown Station model

Name	USIL	DSIL	Type	Height	Width	No. Barrels
FH_Ch31.606_ID39579	61.4	60.9	Rectangular	2.1	1.5	3
FH_Ch33.825_ID25908	66.31	66.3	Rectangular	3.6	1.8	1
FH_Ch34.069_ID25905	65.45	65.4	Rectangular	3.6	1.8	2
FH_Ch35.267_ID39580	68.9	68.85	Rectangular	1.2	0.9	6
FH_Ch36.275_ID43546	66.4	66.35	Circular	1.8		5
FH_Ch38.430_ID38822	67.1	67	Circular	1.8		4
FH_Ch39.850_ID43548	71.05	70.81	Circular	0.6		5
FH_Ch37.300_ID38796	65.31	65.21	Circular	1.8		5
FH_Ch38.168_ID39581	67.14	67.12	Circular	0.75		4
FH_Ch32.809_ID43545	63.55	63.5	Circular	0.75		2
FH_Ch38.570_ID43547	68.25	68.15	Circular	0.75		1
GNRL_Ch27.26	60.24	60.24	Rectangular	3	2.1	2
GNRL_Ch29.8	66.33	66.33	Rectangular	2.7	1.5	2
GNRL_Ch29.8	66.33	66.33	Rectangular	1.8	1.5	2
GNRL_Ch32.02	67.86	67.53	Rectangular	2.7	2.1	2
GNRL_Ch32.02	67.86	67.53	Rectangular	2.1	2.1	2
GNRL_Ch33.11	66.05	66.05	Rectangular	3	3	3
GNRL_Ch34.12	69.17	69.55	Rectangular	2.7	2.1	2
GNRL_Ch27.99	61.51	61.35	Circular	1.5		3
GNRL_Ch28.45	64.83	64.59	Circular	0.75		2
GNRL_Ch29.56	66.08	66.06	Rectangular	1.5	1.8	2
GNRL_Ch30.973	69.7	69.7	Rectangular	1.8	1.2	2
GNRL_Ch30.973	69.7	69.7	Rectangular	1.2	1.2	1
GNRL_Ch33.86	68.54	68.53	Rectangular	1.2	1.2	1
GNRL_Ch34.34	69.85	69.75	Rectangular	1.2	1.2	1
MantonQuarryRd	92.82	91.81	Circular	0.8		1
GNRL_Ch35.56	73.01	72.89	Rectangular	1.2	1.2	1
SkyDiverRd1	65.19	64.96	Circular	0.9		1
SkyDiverRd2	63.53	63.47	Circular	0.9		1