aurecon

Project: Rockhampton Local Catchments Flood Study

Ramsay Creek Hydrologic and Hydraulic Modelling Report

Reference: 231721

Prepared for: Rockhampton Regional Council

Revision: 2

30 May 2014

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Leading. Vibrant. Global.
www.aurecongroup.com

Document Control Record

Document prepared by:

Aurecon Australia Pty Ltd
ABN 54 005 139 873
Level 14, 32 Turbot Street
Brisbane QLD 4000
Locked Bag 331
Brisbane QLD 4001
Australia

T +61 7 3173 8000
F +61 7 3173 8001
E brisbane@aurecongroup.com
W aurecongroup.com

Document control						aurecon
Report Title		Ramsay Creek Hydrologic and Hydraulic Modelling Report				
Document ID			**Project Number**		231721	
File Path		Content Server: 231721\Service Delivery\Reports\RAM\Draft				
Client		Rockhampton Regional Council	**Client Contact**		Bruce Russell	
Rev	**Date**	**Revision Details/Status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	21 January 2013	Draft Report	C Smyth	T Campbell	M Gould	C Russell
1	17 March 2014	Draft Report incorporating calibration	C Smyth	T Campbell	T Graham	C Russell
2	30 May 2014	Final	C Smyth	T Campbell	T Graham	C Russell
Current Revision		**2**				

Approval			
Author Signature		Approver Signature	
Name	Talia Campbell	Name	Chris Russell
Title	Associate, Water Services	Title	Technical Director, Water Services

Rockhampton Local Catchments Flood Study

Date | 30 May 2014
Reference | 231721
Revision | 2

Aurecon Australia Pty Ltd
ABN 54 005 139 873
Level 14, 32 Turbot Street
Brisbane QLD 4000
Locked Bag 331
Brisbane QLD 4001
Australia

T +61 7 3173 8000
F +61 7 3173 8001
E brisbane@aurecongroup.com
W aurecongroup.com

Contents

Appendices

Index of Figures

Index of Tables

1 Introduction

1.1 Study background

The Fitzroy River Flood Study provided Rockhampton Regional Council with a suite of Fitzroy River related flood information for use in development and emergency planning. The flood study report also recommended that Council's flood database should be further developed to include local catchment flood information. The Local Creeks Catchment Flood Study was undertaken to address this recommendation and provide flood information for many of Rockhampton's developed areas on the north-eastern side of the Fitzroy River.

The Local Creeks Catchment Flood Study also addresses recommendation 2.4 of the Queensland Floods Commission of Inquiry Final Report which states that *"a recent flood study should be available for use in floodplain management for every urban area in Queensland. Where no recent study exists, one should be initiated."* It is also the first step in addressing recommendation 2.12, that *"Councils in floodplain areas should, resources allowing, develop comprehensive floodplain management plans that accord as closely as practicable with best practice principles."*

The outputs from the Local Creek Catchments Flood Study provide input to Council's new planning scheme and will assist with development planning. The outputs will also be used to assist with Council's emergency planning and provide an understanding of flood affected areas under a range of flood events.

1.2 Study area

The six local catchments identified for this study are located on the north-eastern side of the Fitzroy River and all discharge directly to the river. The location of the Local Creek Catchments study area and the extents of the catchments contributing to flows in this area are presented in Figure 2 and Figure 3. These catchments all contain existing development or are earmarked for future development. This includes:

- Ramsay Creek
- Limestone Creek
- Splitters Creek
- Moores Creek
- Frenchmans Creek
- Thozets Creek

This report focuses upon the Ramsay Creek catchment.

1.3 Ramsay Creek model area

The Ramsay Creek catchment is largely rural, with areas such as Paramount Park currently under development. The Ramsay Creek RAFTS hydrologic model covers the entire catchment extents, from Grigg Road in Rockyview at the upper end, to the Fitzroy River at the downstream end.

There are residential development pressures for significant areas within this catchment. The TUFLOW hydraulic model covers the developing portion of the catchment, from upstream of Paramount Park (upstream of the junction of Angela Road and Stirling Drive) to Belmont Road at the downstream end. The downstream reaches of this creek are low-lying and swampy and are inundated under minor Fitzroy River flood events, therefore it was not considered necessary to include them in the hydraulic model.

1.4 Study objectives

The key objectives of the study are:

- Development of comprehensive computer-based hydrologic and hydraulic models of the study area and its contributing catchments
- Calibration of the models to available data from the 2013 Australia Day Long Weekend flood event
- Determination and documentation of flood levels, inundation extents, velocities, depths and hazards across the study area for the nominated design events
- Identification of critical infrastructure and emergency facilities for which safe operation may be disrupted by flood events
- Identification of flood events that may isolate parts of the community and assessment of periods of isolation and emergency evacuation routes consistent with the Queensland Evacuation Guidelines (August 2011)
- Preparation of detailed maps and GIS layers for inclusion in Council's databases
- Detailed reporting of all elements of the project and its outcomes
- Input to Council's emergency and development planning information databases

The work undertaken to achieve the above objectives is documented in the following report.

2 Study data

The data collected for use in this study is detailed in the following sections.

2.1 Previous studies

No previous study data was available.

2.2 Topographic data

Rockhampton Regional Council (RRC) and the Department of Environment and Resource Management (DERM) commissioned LiDAR survey of a large part of the Gladstone and Rockhampton region which was flown in June 2009. This data was provided to Aurecon as 1 m grid Digital Elevation Model (DEM) (xyz) tiles over the eastern part of the Mt Archer National Park area. This data has a vertical accuracy of ± 0.15 m and a horizontal accuracy of ± 0.30 m.

SunWater commissioned LiDAR survey of a large portion of the lower Fitzroy River catchment in 2010. This data was provided to Aurecon as 1 m grid DEM (xyz) tiles over almost the entire study area.

The extent of each dataset and the areas over which each dataset was adopted is presented in Figure 4. The Sunwater data was adopted where it was available, with the RRC/DERM data used in all other areas.

The raw LiDAR data was converted into a GIS-based DEM using the following process:

- Both raw data sets were triangulated using the 12D civil design software and exported in a GIS compatible format
- The 12D exports were then imported into the GIS MapInfo package as DEMs
- Both DEMs were then spliced together to create an overall DEM of the local creek catchments

2.3 Aerial photography

Two aerial images were provided to cover the catchments and study area. A detailed 10 cm aerial image (captured in June 2010) was provided covering almost the entire hydraulic modelling area and a 50 cm aerial image (captured in July/September 2010) was provided covering the entire catchment area. This aerial photography was used to identify and confirm topographic and vegetative characteristics of the study area.

2.4 Historical flood data

Historical data from the Australia Day Long Weekend 2013 flood event was collected for use in the model calibration process. This data included:

- Pluviograph (1 minute interval) rainfall data from the Rockhampton Aero rainfall gauge
- Pluviograph (30 minute interval) rainfall data recorded by a property owner on Serocold Street in the Moores Creek catchment
- Daily rainfall totals for a number of other rainfall gauges in the region
- Three GIS survey datasets of flood observations during the event
  - Doorknock survey information – Information gathered after the event via a doorknock survey of residents with some level of exposure to the flood event. The information consists primarily of residents observations, most of which give a description of where the flood waters reached on either the residents own property or at a nearby location
  - Extra survey points – Additional information provided by residents either from memory or photographs
  - Event pickups – Points surveyed at either debris edges or debris top elevations
- Photographs showing flood levels and extents during the event

2.5 Hydraulic structure data

Available Design or As-Constructed data for hydraulic structures beneath the Central Railway Line and state controlled roads was sourced from Queensland Rail/QR National and the Department of Transport and Main Roads (TMR). Information for Council owned structures was sourced from Council in the form of GIS information from Council's GIS database.

The structure data was supplemented with measurements collected during the site visit, as discussed in Section 2.7.

2.6 GIS data

Council provided digital cadastral boundary data in GIS format for use in the study. GIS information for major roadways, emergency facilities and other critical infrastructure was not provided for this study; therefore the information provided for the Fitzroy River Flood study was used. This information was previously provided to Aurecon on 17 May 2010.

These datasets were used to help interrogate model outputs and were also used in the flood mapping phase of the project.

2.7 Site inspection

A site inspection was carried out on 28 and 29 August 2012 and was used to capture and check structure details, hydraulic roughness parameters and catchment details for input to the modelling. Structure details for many of the hydraulic structures were measured during this site visit.

3 Hydrologic model development

A RAFTS hydrologic model was developed for the Ramsay Creek catchment. This software is a runoff-routing model which is used to simulate catchment and channel routing behaviour in response to rainfall. It has been developed for use and application in both urban and rural catchments and includes the ability to model natural and artificial storages as well as channel and river storage throughout the catchment. The model accounts for catchment and channel characteristics including slopes, impervious areas and roughnesses.

The following section discusses the model development process, rainfall inputs and parameters. Figure 5 presents the hydrologic model layout. The adopted model parameters are provided in Appendix B.

3.1 Model layout

3.1.1 Sub-catchment delineation and slope

Sub-catchments were defined using a GIS interface based on the available topographic data discussed in Section 2.2. Nineteen sub-catchments were delineated within the Ramsay Creek catchment, with the areas of each sub-catchment being derived from interrogation of the GIS discretisation.

Catchment slopes were also determined based on the available topographic data with the equal area slope method being used to calculate the adopted values.

3.1.2 Impervious area and PerN

The land use within the catchment is a mixture of rural and various types of development (eg residential, industrial). Areas were assigned a percentage impervious related to their land use type. The overall percentage impervious for each sub-catchment was calculated based upon the proportional contribution of rural, residential, industrial and vegetated areas.

Similar to the impervious percentages, the RAFTS roughness parameters (PerN) were assigned a value relating to their land use. Rural areas were assigned a lower PerN coefficient than residential areas to reflect smoother ground conditions in line with industry standard values. The overall value for each sub-catchment was calculated based on the proportional contribution of both developed and undeveloped areas.

3.1.3 Catchment links

The catchment flowpath links were defined using lag links. Lag times were calculated using the slope and length of the flowpath, with adopted average stream velocities of 2.5 m/s, 1.7 m/s and 1.0 m/s chosen for the upper, mid and lower catchments respectively. A coarse hydraulic model was setup to cross-check these velocities which were also confirmed with additional Manning's calculations.

The selected values were further verified by calculating 'peak-to-peak' travel times looking at the propagation of the discharge hydrographs through the hydraulic model. The celerity (speed) of the flood wave was established for varying topographic conditions and was observed to correlate well to the adopted stream velocities.

3.2 Rainfall data

A summary of the rainfall data used for the different events is provided in Sections 3.2.1 to 3.2.5.

3.2.1 Calibration event

Initially, a comparison of the daily rainfall totals across a number of rainfall gauges in the region was carried out. These totals are presented in Table 1 and show that in all locations the heaviest rain fell on the 25 January 2013; however the amount of rainfall varied across the region.

Table 1 | Daily rainfall totals across the region (mm)

Date	Rocky Aero	Broadmeadows	Hedlow Airfield	Belmont CSIRO	Serocold St
24/1/13	118	161	108	40	183
25/1/13	349	478	205	252	449
26/1/13	23.2	130	No Data	101	68

From the above analysis it was decided that the Serocold Street rainfall data would be the most representative data for use in the calibration process. It is the most central to the calibration area and shows similar rainfall patterns to the nearby gauges, therefore it is considered reliable. This data was applied to the RAFTS model to produce calibration event hydrographs for input to the hydraulic model.

No initial rainfall losses were applied in the calibration event, as there was rainfall which occurred prior to the event timing which has been analysed above. Continuing losses were applied as discussed in Section 3.2.5.

3.2.2 Design events

The RAFTS model was run for the 2, 5, 10, 20, 50, and 100 year ARI events using standard Australian Rainfall and Runoff temporal patterns and IFD parameters. The 15, 30, 45, 60, 90, 120, 180, 270 and 360 minute events were simulated. Rainfall intensities for the modelled events are presented in Table 2. These intensities are based upon a mid-catchment IFD curve which averages the higher upper catchment intensities with the lower intensities from the downstream end of the catchment.

Table 2 | Design event rainfall intensities

Event Duration (mins)	Rainfall Intensities (mm/h)					
	2yr ARI	5yr ARI	10yr ARI	20yr ARI	50yr ARI	100yr ARI
15	89.8	117.3	133.4	155.9	186.5	210.7
30	64.6	84.1	95.4	111.3	132.9	150.0
45	52.3	68.0	77.0	89.7	107.0	120.6
60	44.8	58.0	65.7	76.5	91.1	102.7
90	34.8	45.2	51.3	59.8	71.3	80.4
120	29.0	37.8	42.9	50.0	59.7	67.4
180	22.4	29.0	33.2	38.8	46.4	52.4
270	17.2	22.5	25.7	30.0	36.0	40.7
360	14.3	18.8	21.4	25.0	30.0	34.0

3.2.3 Extreme events

The hydrologic analysis considered three extreme events, being the 200 and 500 year ARI events and the Probable Maximum Precipitation (PMP) event. The 15, 30, 45, 60, 90, 120, 180, 270 and 360 minute storms were simulated for the 200 and 500 year ARI events and the PMP analysis also included the 150, 240 and 300 minute storms (as per standard PMP methodology).

The 200 and 500 year ARI design rainfall intensities were calculated using both the AR&R and CRC-FORGE approaches. It was found that the rainfall intensities calculated using the CRC-FORGE approach were marginally higher than those determined using the AR&R guidelines (approximately +9% to +13%). Accordingly the CRC_FORGE rainfall intensities were adopted for use in the RAFTS hydrologic model. Table 3 summarises the rainfall intensities for the 200 and 500 year ARI storm events.

The Probable Maximum Precipitation was determined using the Generalised Short Duration Method (GSDM). This approach is outlined in *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method* (Bureau of Meteorology, 2003). This approach is suitable for the Ramsay Creek catchment as it is less than 1,000 km^2 in total area and its critical storm duration is less than six hours. Table 3 shows the PMP rainfall intensities for the Ramsay Creek catchment. These intensities are specific to this catchment as they are directly related to the catchment area.

Table 3 | Extreme event rainfall intensities

Event Duration (mins)	Rainfall Intensities (mm/h)		
	200yr ARI	500yr ARI	PMP
15	271.5	317.5	720
30	193.4	226.1	540
45	155.1	180.7	453
60	132.5	154.9	400
90	103.2	120.4	347
120	86.1	100.7	300
150	-	-	268
180	67.2	78.6	243

Event Duration (mins)	Rainfall Intensities (mm/h)		
	200yr ARI	500yr ARI	PMP
240	-	-	208
270	52.0	60.8	-
300	-	-	182
360	43.5	50.8	162

3.2.4 Climate change events

Climate change scenarios were tested within the Ramsay Creek hydrologic model as per the recommendations outlined in:

- *Increasing Queensland's resilience to inland flooding in a changing climate: Final report on the Inland Flooding Study* (Office of Climate Change – Queensland Department of Environment and Resource Management, Queensland Department of Infrastructure and Planning and Local Government Association of Queensland, 2010) which predicts a 5% increase in rainfall intensity for each degree of global warming and an increase in temperatures of 4 degrees Celsius by 2100 (hence an increase in rainfall intensities of +20% by 2100)
- *Guidelines for Preparing a Climate Change Impact Statement (CCIS)* (Queensland Office of Climate Change, Environmental Protection Agency, 2008) which predict an increase in cyclonic rainfall intensity of +20 to +30% by 2050

Accordingly, the effects of climate change were assessed by increasing the 100, 200 and 500 year ARI rainfall intensities (as shown in Table 2 and Table 3) in the hydrologic model by +20% and +30%. The discharge hydrographs for both scenarios were then incorporated into the hydraulic model.

3.2.5 Rainfall losses

The initial and continuing loss method was used to represent rainfall losses in the design, extreme and climate change events. The adopted loss values for pervious and impervious areas are presented in Table 4. Based on the impervious percentage of each sub-catchment, a weighted average was calculated to provide a continuing loss specific to each sub-catchment.

Table 4 | Adopted loss values for 2 year and 5 year ARI events

	Initial Loss* (mm)	Continuing Loss (mm/hr)
2 and 5 year ARI – Pervious Areas	15	2.5
10 year ARI – Pervious Areas	10	2.5
20 year ARI – Pervious Areas	5	2.5
>20 year ARI – Pervious Areas	0	2.5
All events – Impervious Areas	0	0

3.3 Verification

As no calibration data was available to confirm the results of the hydrologic model separately to those of the hydraulic model, the Rational Method was used to cross-check the outputs of the RAFTS hydrologic model and ensure the design discharges were of the correct order of magnitude for the 5 and 100 year ARI events. It is acknowledged that the Rational Method offers a less robust estimate of the design discharge and should not be relied upon as a definitive approach. The Rational Method is only recommended for use in catchments with areas of up to 500 ha for urban catchments and 2500 ha for rural catchments. It is empirical in nature and has been found to be unreliable in some catchment shapes, such as long thin catchments.

In the upcoming release of Australian Rainfall and Runoff the Rational Method will no longer be the recommended approach for determining discharges in ungauged catchments; therefore it was only used to provide an order of magnitude comparison.

In addition to Rational Method checks, verification of the assumed flood velocities used to calculate the RAFTS lag times was carried out using a coarse hydraulic model.

3.4 Sensitivity analysis

A sensitivity analysis of three key hydrologic parameters/coefficients was conducted to establish the effect that these parameters/coefficients have on the predicted peak discharge for the 5 and 100 year ARI events. This involved varying:

- Bx, the storage coefficient multiplication factor by ±10%
- PerN, the subcatchment roughness coefficient by ±20%
- The adopted channel link velocities by ±20%

4 Hydraulic model development

In order to compute and predict the hydraulic behaviour of Ramsay Creek a hydraulic model was developed as part of the flood study. The TUFLOW two-dimensional hydraulic modelling package was used for this assessment. TUFLOW models free surface flow situations in which stratification can be neglected. TUFLOW simulates water level variations and flows in response to a variety of forcing functions in floodplains, lakes, estuaries, bays and coastal areas. The water levels and flows are resolved on a rectangular grid covering the area of interest when provided with bathymetry (topography), bed resistance coefficients, wind field, hydrographic boundary conditions etc.

TUFLOW also includes the capacity to incorporate one-dimensional elements which are hydraulically linked to the two-dimensional floodplain, such as culverts. The one-dimensional modelling package within TUFLOW is called ESTRY.

The following sections discuss the model development process and parameterisation. The model layout is presented in Figure 6.

4.1 Model grid

A 5 m grid spacing was adopted for the following reasons:

- A 5 m grid provided detailed resolution throughout the study area and sufficient detail to represent key features such as roadways and drainage channels
- A 5 m grid provided a reasonable balance between resolution and model run times
- A 5 m grid was consistent with modelling undertaken for other local catchments within the Rockhampton Region
- Smaller grid sizes would have compromised the accuracy of the models as the shallow water equations on which the hydraulic model is based are no longer valid once the depth of the water is greater than the cell size

4.2 Topography

A 2 m grid Digital Terrain Model (DTM) was developed from the LiDAR data described in Section 2.2. The model topographies were based upon this DTM. Topographic modifiers were included where necessary to ensure a continuous drainage path occurred and LiDAR triangulations across the channel were removed. The accuracy with which this DTM represents the developed case topography of the most recent stage of development in Paramount Park is unknown.

4.3 Land use type

The aerial photography was used to define the land use type across the model, as presented in Figure 7. The Manning's roughness values presented in Table 5 were applied for the specified land use types.

Table 5 | Manning's n roughness values

Land Use Type	Manning's n
High Density Residential	0.150
Medium Density Residential	0.120
Low Density Residential	0.090
Industrial	0.150
Medium Density Vegetation	0.070
Low Density Vegetation	0.045
Channel	0.050
Riparian Corridor	0.060
Long Grass	0.040
Road Reserve	0.030

4.4 Hydraulic structures

The hydraulic structure details were sourced from available data. The modelled culverts and their details are presented in Table 6 and the modelled bridges and their associated details are presented in Table 7. The structure locations are presented on the model layout plan (Figure 6).

Table 6 | Modelled culvert structures

Culvert ID	Culvert Location	Dimensions (mm)	Upstream Invert Level (m AHD)	Downstream Invert Level (m AHD)
RAM_STI_01	Stirling Drive	4/3000*2700 RCBC	28.00	27.80
RAM_XXX_01	Paramount Park	3/3000*2100 RCBC	29.48	29.29
RAM_YAA_02	Yaamba Road	2/1650 RCP	26.87	26.55
RAM_YAA_03	Yaamba Road	5/2150*1250 RCBC	25.93	25.86
RAM_NOR_01	North Coast Railway	1/2400 RCP	23.10	22.85

Table 7 | Modelled bridge structures

Bridge ID	Bridge Location	Dimensions (m)
RAM_YAM_01	Yaamba Road	3/12.5m span bridge
RAM_NCR_02	North Coast Railway	3/10m span bridge

4.5 Boundary conditions

The RAFTS model outputs were applied as inflows into the TUFLOW model. Total inflows from catchments upstream of the hydraulic model extents were applied at the upstream model boundary and local inflows from areas within the TUFLOW model were applied throughout the model.

The Mean High Water Spring level (2.66 m AHD) was applied as the downstream boundary condition for the design event simulations of 2 through 20 year ARI events.

The Highest Astronomical Tide level (3.9 m AHD) was applied as the downstream boundary condition for the design event simulations greater than 20 year ARI event.

The Highest Astronomical Tide level plus 0.8 m (4.7 m AHD) was applied as the downstream boundary condition for the climate change design event simulations.

4.6 Calibration, design and extreme event modelling

The same model was used for the calibration, design and extreme events.

4.7 Sensitivity analysis

Sensitivity analysis was undertaken to assess the effect that the following key parameters have on the 5 and 100 year ARI model predictions:

- Manning's roughness (±10%)
- Structure blockage (50 & 100%)
- Tailwater level (Fitzroy River 5yr ARI level)

5 Calibration and verification results

5.1 Hydrologic model verification

5.1.1 Rational Method comparisons

The Rational Method was used to check the predicted peak discharges from the RAFTS model at a number of key locations (typically upstream boundary locations). This was carried out for the 5 and 100 year ARI events only.

For each catchment the time of concentration was modelled using the Bransby Williams equation, the Modified Friends equation or Urban catchment methods. An appropriate method was selected based upon the predominant land use type in the catchment. Bransby Williams and Modified Friends equation are both used in rural catchments, with the Modified Friends equation taking better account of the channel characteristics.

Rational Method comparisons were carried out at three locations within the Ramsay Creek catchment. These catchment locations can be found on Figure 5. DUM-1 is located at the confluence of catchments RAM-2 and RAM-3. DUM-1 represents a large rural catchment in the upper reaches of the model. The RAM-17 location represents almost the entire Ramsay Creek catchment. Location RAM-18 represents a local catchment within the Ramsay Creek model. Table 8 presents the Rational Method parameters and Table 9 presents the results.

The peak discharge comparisons in Table 8 shows that, in comparison to RAFTS, the Rational Method is overestimating the peak flows from the smaller catchments and is predicting a similar peak discharge for catchment RAM-17. Given the known limitations with the Rational Method, this was considered an acceptable verification of the hydrologic model predictions.

Table 8 | Rational Method parameters

Location	Catchment Area (ha)	Stream Length (km)	Stream Slope (%)	Adopted Method	Time of Concentration (mins)	Equivalent Velocity (m/s)
DUM-1 (RAM-2+RAM-3)	341	3.1	1.8	Bransby Williams	54	0.6
RAM-17	1732	10.9	0.6	Modified Friends	235	0.8
RAM-18	154	1.9	1.1	Bransby Williams	57	0.5

Table 9 | Rational Method results

Location	5yr ARI Modelled Peak Discharge (m^3/s)	5yr ARI Rational Method Peak Discharge (m^3/s)	5yr ARI Difference (%)	100yr ARI Modelled Peak Discharge (m^3/s)	100yr ARI Rational Method Peak Discharge (m^3/s)	100yr ARI Difference (%)
DUM-1 (RAM-2+RAM-3)	18	29	53	49	65	24
RAM-17	83	78	-6	211	179	-18
RAM-18	6	16	64	17	35	52

5.1.2 Stream velocity checks

The RAFTS model catchment flowpath links were defined using lag links. Lag times were calculated using the slope and length of the flowpath, with adopted average stream velocities of 2.5 m/s, 1.7 m/s and 1.0 m/s chosen for the upper, mid and lower catchments respectively.

A coarse hydraulic model was setup to cross-check these velocities. The selected values were verified by calculating travel times of the discharge hydrographs through the hydraulic model. The speed of the flood wave propagation was established for varying topographic conditions and was observed to correlate well to the adopted stream velocities.

5.2 Calibration dataset

No calibration dataset points were available within the Ramsay Creek catchment.

5.3 Hydraulic model review

As no calibration data was available in the Ramsay Creek catchment, calibration of the hydraulic model to known water levels was not possible. Ramsay Creek is considered a similar type of catchment to Limestone Creek, therefore a model review was undertaken to keep the Ramsay Creek model setup consistent with the Limestone Creek model setup. This review included:

- An enhanced delineation of roughness polygons
- Modification of Manning's roughness values to better match localised ground cover types evident in site photos
- A review of Manning's n values to ensure different land use types were adequately represented
- The final adopted land use types are those presented in Table 5

5.4 Peer review

A peer review of the hydrologic and hydraulic assessment was carried out by BMT WBM to provide further verification of the adopted methodology and processes which are documented in this report.

6 Design and extreme event results

This section of the report presents the hydraulic modelling results. It provides information relating to the flood mapping, design discharges, critical durations and flood depths for the complete range of design and extreme event magnitudes. It also presents the results of the critical infrastructure assessment and the climate change analyses.

6.1 Mapping

The TUFLOW model results were analysed and a series of maps (Figure 8 to Figure 25) were developed to present the results for each modelled return period. Three sets of maps were produced to display:

- Inundation extents with peak water surface levels and velocity vectors – these maps present 0.5 m contours of the peak water surface levels, as well as peak velocities displayed as arrows. The velocity arrows show the direction of the flow and are scaled to represent the magnitude of the flow (ie larger arrows mean faster flow)
- Peak depths – the maps present peak depth contours in 0.5 m bands up to a depth of 5 m, with the lower band separated into two bands covering 0 to 0.3 m and 0.3 to 0.5 m
- Hazard maps – hazard is a function of flood depth and flood velocity and is related to safety of the flood waters. The peak low, medium, high and extreme hazard contours presented in these maps are based upon the recommendations in *Floodplain Management in Australia Best Practice Principles and Guidelines* produced by the Standing Committee on Agriculture and Resource Management (SCARM) (2000). Image 1 is an extract from the guidelines and presents the adopted hazard category relationship

Further to these three sets of maps, a single map showing a comparison of the inundation extents for the 2, 5, 10, 20, 50 and 100 year ARI design events has also been produced (Figure 35).

The mapping information has all been provided to Council in GIS format.

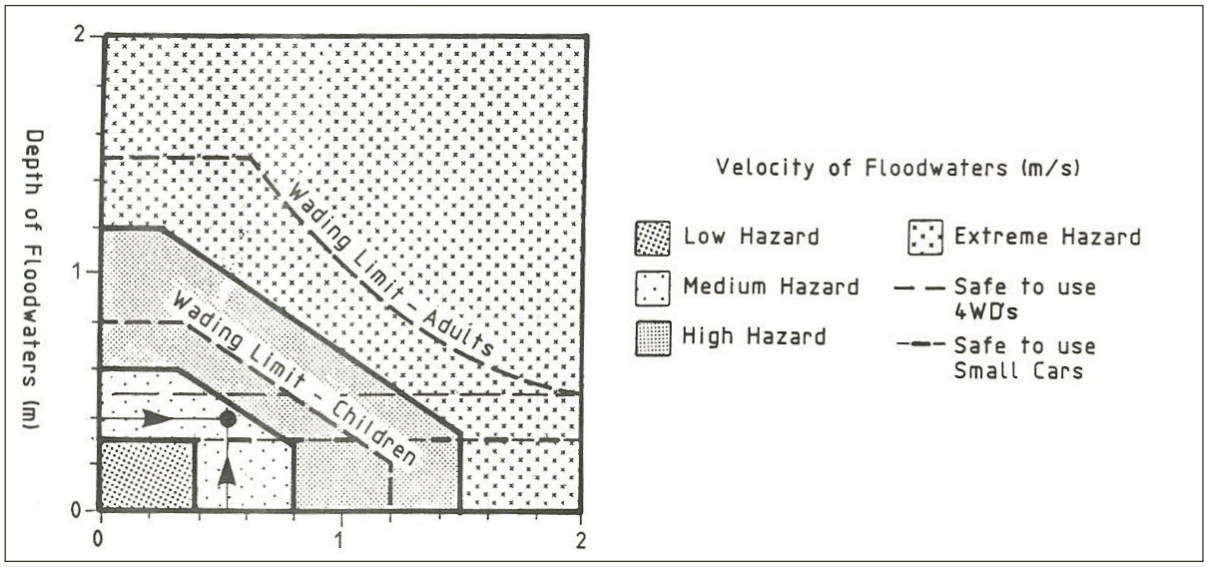


Image 1 | Hazard categories

6.2 Design event discharges

Peak modelled discharges (from the TUFLOW model) at locations of major road and rail crossings and other key locations are presented in Table 10 and the associated critical durations are presented in Table 11. These results show that the main channel peak discharges are similar throughout the entire model area. This is because the catchment area that contributes most of the discharge to the creek occurs upstream of the hydraulic model area.

Appendix C contains information regarding peak discharges and critical durations at additional locations throughout the model area and Appendix D contains flow hydrographs for the critical duration event at each location.

Peak modelled discharges are not presented for the extreme events. Breakouts between tributaries and channels become more common in the extreme events and the reporting of flows for individual crossings becomes difficult.

Table 10 | Design event peak discharges at key locations

Location	Peak Discharge (m^3/s)					
	2yr	5yr	10yr	20yr	50yr	100yr
RAM_YAM_01 (Bridge)	25.8	39.9	52.2	70.0	91.0	105.0
RAM_YAA_02 (Culvert)	5.4	8.0	9.6	11.3	12.2	12.8
RAM_YAA_03 (Culvert)	3.3	5.2*	6.8*	9.0*	11.4*	13.7*
RAM_NOR_01 (Culvert)	3.1	4.7	6.1	7.9	12.0	15.3
RAM_NCR_02 (Bridge)	31.7	48.8	63.7	83.6	105.6	121.5

** Indicates that road is inundated*

Table 11 | Design event critical durations at key locations

Location	Critical Duration (mins)					
	2yr	5yr	10yr	20yr	50yr	100yr
RAM_YAM_01 (Bridge)	180	180	180	120	120	120
RAM_YAA_02 (Culvert)	360	180	180	180	120	120
RAM_YAA_03 (Culvert)	180	180	120	120	120	120
RAM_NOR_01 (Culvert)	180	180	120	120	120	120
RAM_NCR_01 (Bridge)	270	180	180	180	120	120

6.3 Design event results

The results presented in Figure 8 to Figure 25 show that Ramsay Creek catchment is largely rural and that few properties are affected by inundation. Exceptions to this generalisation are:

- The property on McLauglin Street becomes isolated by flood waters during the 2 year ARI event
- A property off Yaamba Road to the East becomes isolated by flood waters during the 2 year ARI event
- True Blue Motor Inn is inundated for the 2 year ARI event. This is based upon a comparison of flood extents to the aerial image and does not take into account the building floor level
- In the 50 year ARI event, inundation may reach the property at the end of Sondra Lena Drive. Two additional properties are inundation in the 100 year ARI event. This is based upon a comparison of flood extents to the aerial image and does not take into account the building floor level
- Westco Truck Sales starts to become inundated in the 100 year ARI event
- A property within the Paramount Park development may be inundated by events greater than the 2 year ARI event. The analysis of this area is based upon the topography provided to Aurecon and may not accurately represent areas currently under development

Some key points to note are:

- For the inundation identified above:
  - The areas identified as being inundated for each ARI include those areas identified for smaller events
  - The discussion has focussed on areas where buildings are shown in the aerial image
  - Properties identified as being inundated may only be partially inundated and may not be inundated at the location of building
  - The discussion does not take into account building floor levels, which may be above the inundation levels
- Critical durations in this catchment are relatively short in duration when compared with a Fitzroy River flood event. Along the main creek channel the critical durations range between:
  - Three and six hours in the downstream reaches
  - Two and six hours in the middle reaches
  - Two and three hours in the upper reaches, which are the primary areas of interest
  - The critical duration varies on the side tributaries as these are much smaller and therefore runoff is more rapid.

6.4 Extreme event results

Extreme events are assessed as a requirement of State Planning Policy 1/03 and also Council's Planning Policy. These policies require community infrastructure such as emergency facilities, hospitals and key services (eg power) to be located above extreme flood levels. The PMF is assessed to define the extent of the floodplain.

The results for the 200 and 500 year ARI and the PMF events are presented in Figure 26 to Figure 34. These results are presented in the same format (three sets of maps) as the design event results. A comparison of the 100, 200 and 500 year ARI and PMF inundation extents is shown in Figure 36.

These maps show that in the 200 and 500 year ARI events inundation occurs in the following additional areas:

- Additional properties in the Paramount Park development
- Additional properties along Sondra Lena Drive
- Westco Truck Sales
- The property at the southern end of Leichardt Street

The results presented in Figure 32 to Figure 34 show that much of the area in the vicinity of the creek becomes inundated in the PMF event. The flood extents through much of the catchment are approximately 500 m wide.

6.5 Hydraulic category mapping

Hydraulic category mapping has been carried out in accordance with the Planning Scheme requirements. This mapping defines the areas of floodway, flood storage and flood fringe and is consistent with that carried out for the Fitzroy River. The hydraulic category map is based upon the 100 year ARI event and is presented in Figure 37.

Floodways are areas which convey a significant portion of flood flows and which would cause significant adverse impacts if they were to be blocked. Flood storage areas are those in which temporary storage of floodwaters occurs during a flood event and which could potentially cause increases in flood levels/discharges in other areas of the floodplain if filled. All other areas are considered flood fringe.

The following criteria were used to define the hydraulic categories:

- Floodway
  - Velocity-depth product ≥ 0.5 m^2/s or
  - Velocity ≥ 1 m/s
- Flood storage
  - Velocity-depth product ≤ 0.5 m^2/s and
  - Depth ≥ 0.5 m
- Flood fringe
  - Velocity-depth product ≤ 0.5 m^2/s and
  - Depth ≤ 0.5 m

A number of manual overrides to the above definitions were also required across the floodplain, including:

- Removal of isolated zones/areas within categories – eg if a small area of flood storage was completely surrounded by a large area of floodway the flood storage was redefined as floodway and vice versa
- Removal of small sections of categories – any location in which the category area was less than 0.1 Ha was integrated into the nearby category

6.6 Climate change

Two Climate Change scenarios were assessed:

- Climate Change Scenario 1: 20% increase in rainfall intensity and 0.8 m increase in tailwater level for the 100, 200 & 500 year ARI events
- Climate Change Scenario 2: 30% increase in rainfall intensity and 0.8 m increase in tailwater level for the 100, 200 & 500 year ARI events

The results of this assessment are presented in the following sections.

6.6.1 Scenario 1

The impacts of Climate Change Scenario 1 are presented in Figure 38 to Figure 40. These figures show impacts from the Fitzroy River to 650 m upstream of Belmont Road of +0.25 m to +0.45 m. From this location to the North Coast Railway the water elevation increases in the range of +0.05 m to +0.30 m. From the North Coast Railway to the upstream end of the hydraulic model the flow is mainly contained within the channel and the water elevations increase between +0.1 m to +0.4 m. These impacts are similar for the 100, 200 and 500 year ARI events.

For the 100 year ARI Scenario 1 case, the inundation extents are similar to but slightly less than the Existing Case 200 year ARI event throughout much of the model area. A similar comparison is evident between the 200 year ARI Scenario 1 and the Existing Case 500 year ARI extents.

For the 100 year ARI Scenario 1 case, the greatest increase in inundation extents occurs downstream of the North Coast Railway. The greatest increase in inundation extent for the 200 Year ARI Scenario 1 case occurs between the North Coast Railway and Yaamba Road.

6.6.2 Scenario 2

The increases in peak water levels and inundation extents resulting from Climate Change Scenario 2 are presented in Figure 42 to Figure 44. These figures show that the increase in peak water level is typically +0.10 to +0.55 m throughout much of the model area. Peak water levels in Scenario 2 are approximately +0.1 m higher than those for Scenario 1. Similar to Scenario 1, the greatest increases in inundation extents extend from Yaamba Road 750 m downstream of the North Coast Railway.

The 100 year ARI Scenario 2 results show that inundation extents are similar to the Existing Case 200 year ARI extents. A similar comparison can be made between the 200 year ARI Scenario 2 inundation extents and the Existing Case 500 year ARI extents.

Similar to the Scenario 1 results, the greatest increase in inundation extent for the 500 year ARI Scenario 2 case occurs between the North Coast Railway and Yaamba Road.

6.6.3 Inundation extent comparisons

Comparisons of the 100, 200 and 500 year inundation extents for Climate Change Scenario 1 and Climate Change Scenario 2 are presented in Figure 41 and Figure 45 respectively.

Comparisons of the inundation extents for the Existing Case, Climate Change Scenario 1 and Climate Change Scenario 2 are presented for the 100, 200 and 500 year ARI events respectively in Figure 46, Figure 47 and Figure 48.

6.7 Critical infrastructure assessment

A list of critical infrastructure and the design event at which it is likely to be inundated has been prepared and included in Appendix E. This includes the following infrastructure:

- Emergency services facilities (eg ambulance, police, fire, coast guard, airstrip, hospital)
- Significant facilities for evacuation (eg child care, education, retirement, nursing care, media)
- Key water and sewerage infrastructure
- Roads/bridges

7 Sensitivity testing

This section presents the results of the hydrologic and hydraulic model sensitivity testing.

7.1 Hydrologic model sensitivity testing

A sensitivity analysis of key RAFTS parameters (Bx, PerN and the adopted channel velocities) was conducted to establish the effect that these parameters/coefficients have on the predicted peak discharge for the 5 and 100yr ARI events. This was done to provide an understanding of the primary influences to model and catchment behaviour, the findings of which are discussed in the following sections. The three locations at which sensitivity checks were undertaken were chosen to match those used for the Rational Method checks.

7.1.1 Storage coefficient, Bx

Bx is the storage coefficient multiplication factor and is used to modify the calculated storage time delay coefficient. This value was both increased and decreased by 10%.

Table 12 summarises the results of this sensitivity analysis and shows that flow increases with a decrease in Bx and vice versa. The maximum change in discharge was +10% and the average change was 7% (absolute). This indicates that the model response is not linear in comparison to the change in Bx value and the sensitivity is less than the absolute change in Bx value.

Table 12 | Hydrologic model sensitivity results – Bx sensitivity

ARI (yrs)	Modified Parameter	Location	Sensitivity Model Peak Discharge (m^3/s)	Base Model Peak Discharge (m^3/s)	Difference (%)
5yr	Bx + 10%	1 (DUM2)	28	30	-7%
		2 (RAM15)	70	73	-4%
		3 (CON3)	11	12	-8%
	Bx - 10%	1 (DUM2)	33	30	10%
		2 (RAM15)	76	73	4%
		3 (CON3)	13	12	8%

ARI (yrs)	Modified Parameter	Location	Sensitivity Model Peak Discharge (m^3/s)	Base Model Peak Discharge (m^3/s)	Difference (%)
100yr	Bx + 10%	1 (DUM2)	74	81	-9%
		2 (RAM15)	163	175	-7%
		3 (CON3)	29	31	-6%
	Bx - 10%	1 (DUM2)	88	81	9%
		2 (RAM15)	188	175	7%
		3 (CON3)	34	31	10%

7.1.2 Sub-catchment roughness coefficient, PerN

PerN is an empirical parameter that is used to take pervious and impervious sub-catchment roughness into account. It is incorporated as an average Manning's n representation of sub-catchment roughness. This parameter was increased and decreased by 20% and the results are tabulated in Table 13.

The effects of the PerN coefficients were not of a linear nature, with reduced PerN values having an average impact of +15% and the increased PerN values having an average impact of -11%. The maximum change in discharge was +17% and the average change was +13% (absolute).

Table 13 | Hydrologic model sensitivity results – PerN sensitivity

ARI (yrs)	Modified Parameter	Location	Sensitivity Model Peak Discharge (m^3/s)	Base Model Peak Discharge (m^3/s)	Difference (%)
5yr	PerN + 20%	1 (DUM2)	27	30	-10%
		2 (RAM15)	68	73	-7%
		3 (CON3)	11	12	-8%
	PerN - 20%	1 (DUM2)	35	30	17%
		2 (RAM15)	79	73	8%
		3 (CON3)	14	12	17%
100yr	PerN + 20%	1 (DUM2)	70	81	-14%
		2 (RAM15)	156	175	-11%
		3 (CON3)	27	31	-13%
	PerN - 20%	1 (DUM2)	94	81	16%
		2 (RAM15)	200	175	14%
		3 (CON3)	36	31	16%

7.1.3 Channel link velocities

Adopted channel link velocities were also tested for sensitivity. The chosen velocity is used in conjunction with the length of the channel to estimate the lag time from one node to the next. The channel velocity was increased and decreased by 20% and the results are shown in Table 14.

The average change in discharge observed due to a 20% variation in channel velocity was 1% (absolute). An increase in velocity was observed to correspond with an increase in discharge and vice versa.

Table 14 | Hydrologic model sensitivity results – link velocity sensitivity

ARI (yrs)	Modified Parameter	Location	Sensitivity Model Peak Discharge (m^3/s)	Base Model Peak Discharge (m^3/s)	Difference (%)
5yr	Lag Link Velocity + 20%	1 (DUM2)	30	30	0%
		2 (RAM15)	76	73	4%
		3 (CON3)	12	12	0%
	Lag Link Velocity - 20%	1 (DUM2)	30	30	0%
		2 (RAM15)	70	73	-4%
		3 (CON3)	12	12	0%
100yr	Lag Link Velocity + 20%	1 (DUM2)	81	81	0%
		2 (RAM15)	179	175	2%
		3 (CON3)	31	31	0%
	Lag Link Velocity - 20%	1 (DUM2)	81	81	0%
		2 (RAM15)	170	175	-3%
		3 (CON3)	31	31	0%

7.1.4 Summary of sensitivity analysis results

Overall, the sensitivity testing of the hydrologic models shows that changing the lag link velocity has a minimal effect on the predicted peak discharge. The impacts of PerN and Bx are of a smaller magnitude than the corresponding parameter change. These tests show that the model is not particularly sensitive to any of the adopted model parameters which provides confidence that the predicted peak discharge hydrographs are suitable for use in the Ramsay Creek flood study.

7.2 Hydraulic model sensitivity testing

A number of sensitivity tests were conducted using the Ramsay Creek TUFLOW model to assess the effects these parameters/coefficients have on the predicted model results. This was undertaken to provide an understanding of the primary influences on model and catchment behaviour. These sensitivity checks were carried out for the 5 and 100 year ARI events and are summarised in the following bullet points:

- Varied Manning's n roughness coefficients (± 10%)
- 50% structure blockage
- 100% structure blockage
- Tailwater level set to 5 year ARI Fitzroy River flood level

The structure blockage values were applied to culverts and to bridge handrails. No blockage was applied to the waterway areas beneath the bridge decks as it was assumed that bridge openings are large enough to pass most debris and are not likely to become blocked.

A discussion of the sensitivity test results is provided below. No mapping of the sensitivity testing has been included in this report.

7.2.1 Manning's n roughness coefficient

The results of the Manning's n roughness coefficient sensitivity testing show that the impacts are similar for the 5 and the 100 year ARI events. When Manning's n value is reduced by 10% the predicted peak water levels are reduced by -0.20 m to -0.02 m (typically). When the Manning's n value is increased by +10% the peak water levels are predicted to increase by +0.01 m to +0.20 m. The sensitivity of the model to the Manning's roughness value is not considered significant and these potential impacts to peak water levels are within typical freeboard allowances.

7.2.2 Structure blockage

In the 50% blockage case, impacts occur on the upstream side of the North Coast Railway and Yaamba where peak water levels increase in the range of +0.15 m to +0.45 m. Impacts also occur throughout the Paramount Park development.

In the 100% blockage case flood waters upstream of the North Coast Railway and Yaamba Road and throughout the Paramount Park development are not able to drain beneath the road and pooling of water occurs. Peak water levels are increased by up to +1.65 m in these areas.

The increases in peak water levels throughout the Paramount Park development have the potential to impact upon a number of properties. Regular cleaning and maintenance of these culverts may reduce potential blockage impacts.

7.2.3 Tailwater level

The tailwater sensitivity analysis was undertaken for the 100 year ARI local catchment event with a coincident 5 year ARI Fitzroy River tailwater level. The model results were compared to the results using MHWS as the tailwater level. These results showed that using the 5 year ARI tailwater raises peak water levels within the downstream reach of the model; however the areas in which this change occurs are wholly contained within the flood extent created by 100 year ARI Fitzroy River flooding. This means that the selection of model tailwater will have no impact upon the planning conditions which are applied in the downstream reaches of the creek.

8 Conclusions

Detailed RAFTS hydrologic and TUFLOW hydraulic models of Ramsay Creek were developed. Mapping and GIS layers of existing flood conditions were prepared as key outputs from the study. These maps include flood levels, inundation extents, velocities, depths and hazard across the study area for the 2, 5, 10, 20, 50 and 100 year ARI design events and the 200 and 500 year ARI and PMF extreme events. These uncalibrated models were verified using alternate methods and the key model parameters were tested to confirm that the models were providing a good representation of flood behaviour.

The results presented in this report show that flooding may regularly isolate one property on McLauglin Street, inundate the area around the True Blue Motor Inn and regularly inundate parts of the Paramount Park development. Analysis of the extreme events showed that flow patterns are similar to the 100 year ARI event, with wider inundation extents resulting from the increased flows.

For extreme events floodwaters are predicted to break out from the main channel in a number of locations. Under the PMF event much of the area in the vicinity of the creek is subject to flood inundation.

Climate change analysis showed that, with increased rainfall intensities, the 100 year ARI event magnitude increases and becomes similar to the Existing Case 200 year ARI event.

Hydraulic category mapping of the catchment was prepared for input to Council's Planning Scheme, with areas prone to flooding in the 100 year ARI event being categorised into floodway, flood storage or flood fringe areas. An assessment of critical infrastructure at risk of flooding was also undertaken to provide information for emergency planning and response.

9 Explanatory notes and disclaimers

9.1 General notes

- This report and the associated mapping were developed to represent creek flooding in the developed/developable areas in Ramsay Creek. Flooding continues beyond the upstream extents. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made
- The levels of flood risk presented in this report and on the associated mapping are based upon ground surface elevations. The level of risk of above floor flooding has not been assessed as part of this study. The risk of above floor flooding will be reduced from that shown on the mapping, depending upon how high each individual property is above the ground level
- The topographic data used in preparation of the hydraulic model and this report was based upon the best information available as at September 2012 and relied upon LiDAR survey captured in 2009 and 2010. No bathymetric data was included
- The results presented in this report are based upon model results from the Ramsay Creek RAFTS and TUFLOW models as at March 2014
- Information presented in this report is indicative only and may vary, depending upon the level of catchment and floodplain development. Filling of land or excavation and levelling may alter the ground levels locally at any time, whilst errors may also occur from place to place in the local ground elevation data from which the models have been developed
- The hydraulic modelling presented in this report was based upon a 5 m grid hydraulic model. This model resolution may not be representative of features such as small, local drainage channels
- Flood hazard assessments have been based upon consideration of flood depths and velocities only. No consideration of evacuation times has been included

9.2 Important things you should know about this report

9.2.1 Exclusive use

- This report has been prepared by Aurecon at the request of Rockhampton Regional Council ("Client") exclusively for the use of its Client
- The basis of Aurecon's engagement by the Client is that Aurecon's liability, whether under the law of contract, tort, statute, equity or otherwise, is limited as set out in the terms of the engagement

9.2.2 Third parties

- It is not possible to make a proper assessment of this report without a clear understanding of the terms of engagement under which the report has been prepared, including the scope of the instructions and directions given to and the assumptions made by the consultant who has prepared the report
- The report is a report scoped in accordance with instructions given by or on behalf of Client. The report may not address issues which would need to be addressed with a third party if that party's particular circumstances, requirements and experience with such reports were known and may make assumptions about matters of which a third party is not aware
- Aurecon therefore does not assume responsibility for the use of, or reliance on, the report by any third party and the use of, or reliance on, the report by any third party is at the risk of that party

9.2.3 Limited scope

- The limited scope of Aurecon's brief in this matter, including the limited scope of investigation requested by Client, means that the report necessarily concentrates on readily apparent major items
- Amongst other things, Aurecon's brief expressly excludes investigation or advice in relation to the actual or potential presence of pollution, contamination or asbestos, or the actual or potential risk of any incident affecting the safety of operation

9.2.4 Limits on investigation and information

- Where site inspections have been made, they have been limited in their scope to external visual inspections
- The report is also based on information provided to Aurecon by other parties. Although the providers of the information have not warranted the accuracy of the data and have waived liability in respect of its use, Aurecon's report is provided strictly on the basis that the information that has been provided is accurate, complete and adequate
- Aurecon takes no responsibility and disclaims all liability whatsoever for any loss or damage that the Client or any other party may suffer resulting from any conclusions based on information provided to Aurecon, except to the extent that Aurecon expressly indicates in the report that it has verified the information to its satisfaction

9.2.5 Legal documents etc

- The report may contain various remarks about and observations on legal documents and arrangements such as contracts, supply arrangements, leases, licences, permits and authorities. A consulting engineer can make remarks and observations about the technical aspects and implications of those documents and general remarks and observations of a non-legal nature about the contents of those documents. However, as a Consulting Engineer, Aurecon is not qualified, cannot express and should not be taken as in any way expressing any opinion or conclusion about the legal status, validity, enforceability, effect, completeness or effectiveness of those arrangements or documents or whether what is provided for is effectively provided for. They are matters for legal advice

If the reader should become aware of any inaccuracy in or change to any of the facts, findings or assumptions made either in Aurecon's report or elsewhere, the reader should inform Aurecon so that it can assess its significance and review its comments and recommendations.

Nothing in this report shall be read or applied so as to purport to exclude, restrict or modify, or have the effect of excluding, restricting or modifying the application of all or any of the provisions of the Trade Practices Act 1974 or any other legislation which by law cannot be excluded, restricted or modified.

Appendices

Appendix A
List of figures

This mapping was developed to represent flooding in the Ramsay Creek catchment. Flooding extends upstream of the limits shown but has not been mapped as part of this study. No consideration of flooding in areas of piped urban stormwater drainage has been made.

The levels of flood risk presented on this mapping are based upon ground surface elevations. The level of risk of above floor flooding has not been assessed as part of this study. The risk of above floor flooding will be reduced from that shown on the mapping, depending upon how high each individual property is above the ground level.

The topographic data used in preparation of the hydraulic model and this mapping was based upon the best information available as at September 2012 and relied upon LiDAR survey captured in 2009 and 2010. No bathymetric data was included.

The results presented in this mapping are based upon model results from the Local Creek Catchments - Ramsay Creek Flood Study RAFTS and TUFLOW models.

Information presented in this mapping is indicative only and may vary depending upon the level of catchment and floodplain development. Cutting, filling and levelling of land associated with new or upgraded developments may alter the ground levels locally at any time, and depending on the time that such works have been carried out, they may not have been captured in original LiDAR survey. Errors may also occur from place to place in the local ground elevation data from which the models have been developed.

The hydraulic model results presented in this mapping are based upon 5m grid hydraulic models. This model resolution may not be representative of features such as small, local drainage channels.

All level information presented in this mapping is expressed in metres AHD.

Flood hazard assessments have been based upon consideration of flood depths and velocities only. No consideration of evacuation times has been included.

These maps were produced to accompany the Ramsay Creek Flood Study Report. Detailed information regarding the model setup and modelling methodology is available in this report.

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

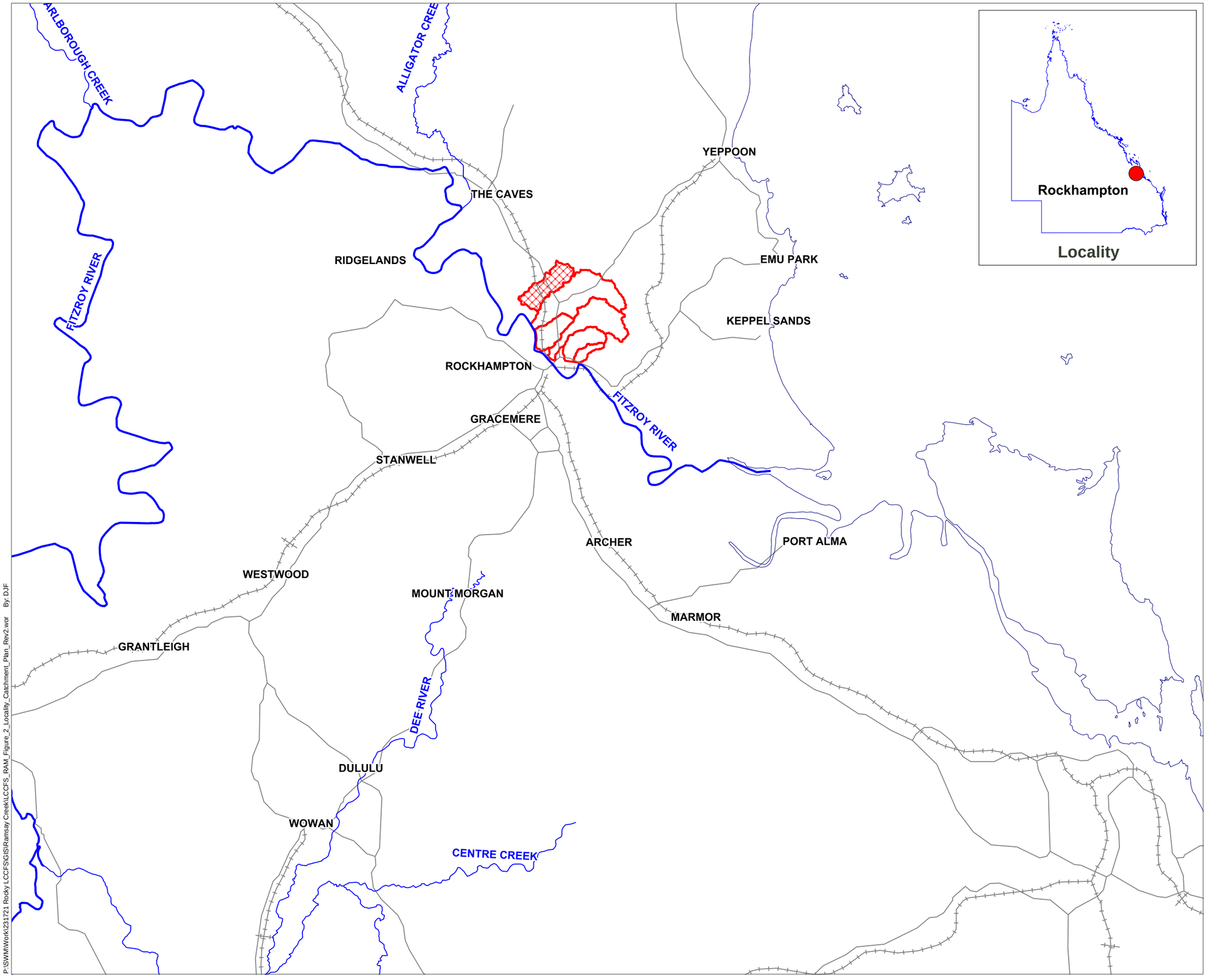
Notes:

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_1_Explanatory_Notes_Rev2.wor By: DJF

Local Creek Catchments Flood Study: Ramsay Creek

Figure 1: Explanatory Notes and Disclaimers



P:\SWMWork\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_2_Locality_Catchment_Plan_Rev2.wor By: DJF

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Local Creek Catchments
- Ramsay Creek Catchment
- Coastline
- Fitzroy River
- Major Waterways
- Railways
- Main Roads

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.

Date: 29/05/2014 **Version: 2**

0 25000 (m)

Scale 1:500 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

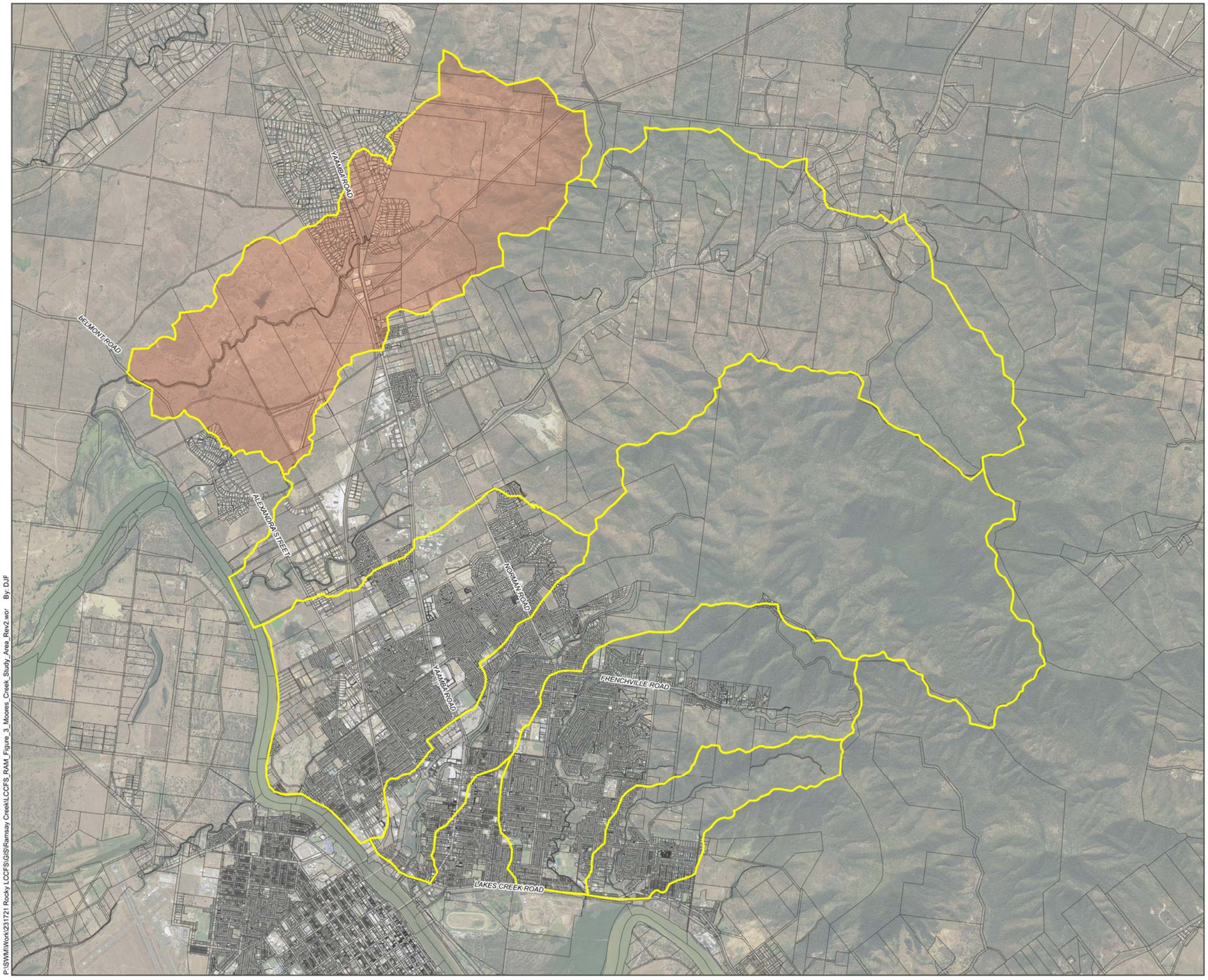
Figure 2: Locality and Catchment Plan

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- Cadastre
- Ramsay Creek Catchment
- Local Creek Catchments

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_3_Moores_Creek_Study_Area_Rev2.wor By: DJF

0 3000 (m)

Scale 1:60 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 3: Study Area

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Rafts Model Extents
- SunWater 2010 LiDAR Data Extents
- Rockhampton Regional Council 2009 LiDAR Data Extents

NORMAN ROAD

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_4_Moores_Creek_Survey_Dataset_Extents_Rev2.wor By: DJF

0 2000 (m)

Scale 1:40 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

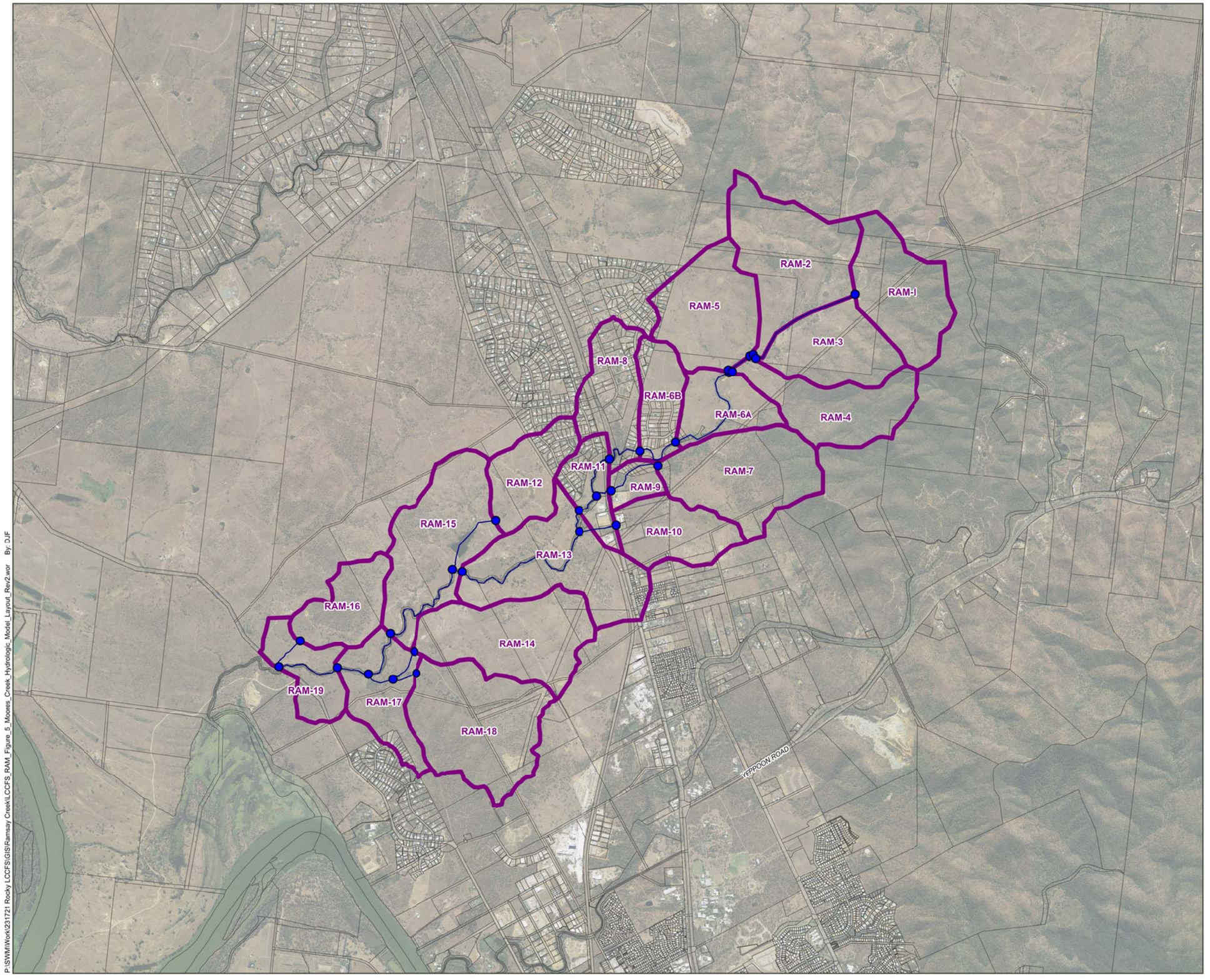
Figure 4: Survey Data Extents

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- Sub-Catchments
- Node
- Link
- Cadastre

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.

Date: 29/05/2014 **Version:** 2

0 2000 (m)

Scale 1:40 000 (m) (@ A3 size)

Projection: MGA Zone 56

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_5_Moores_Creek_Hydrologic_Model_Layout_Rev2.wor By: DJF

Local Creek Catchments Flood Study: Ramsay Creek

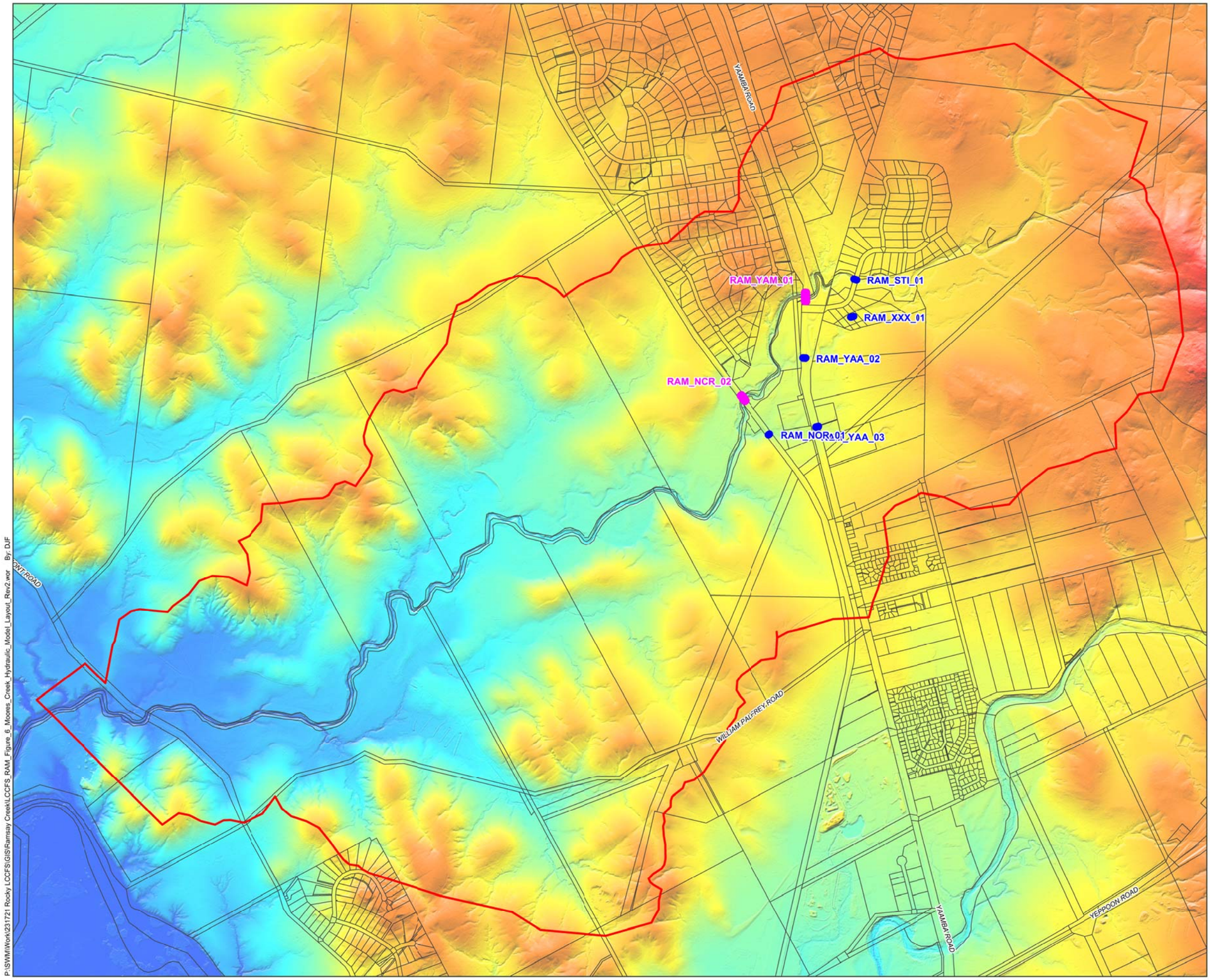
Figure 5: Hydrologic Model Layout

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- TUFLOW Model Boundary
- Culvert
- Bridge
- Cadastre

Elevation (m AHD)

200.0
50.0
30.0
15.0
0.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_6_Moores_Creek_Hydraulic_Model_Layout_Rev2.wor By: DJF

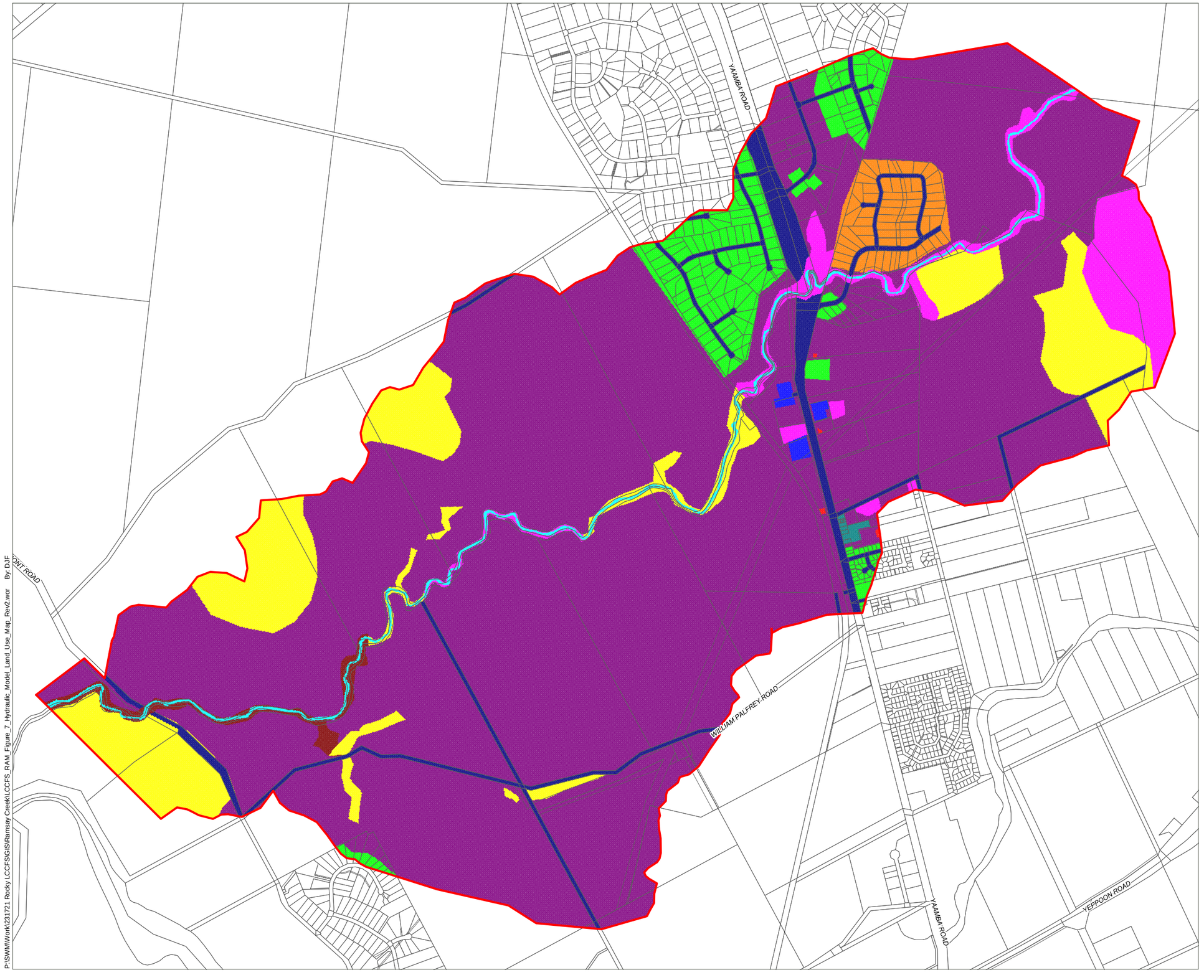
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 6: Hydraulic Model Layout



aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- 0.150 (High Density Residential)
- 0.090 (Low Density Residential)
- 0.150 (Industrial)
- 0.070 (Medium Dense Vegetation)
- 0.045 (Low Density Vegetation)
- 0.050 (Channel)
- 0.060 (Riparian Corridor)
- 0.030 (Road Reserve)
- 0.040 (Long Grass)
- 0.120 (Medium Density Residential)
- 0.055 (Low Density Residential)

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.

Date: 29/05/2014 **Version: 2**

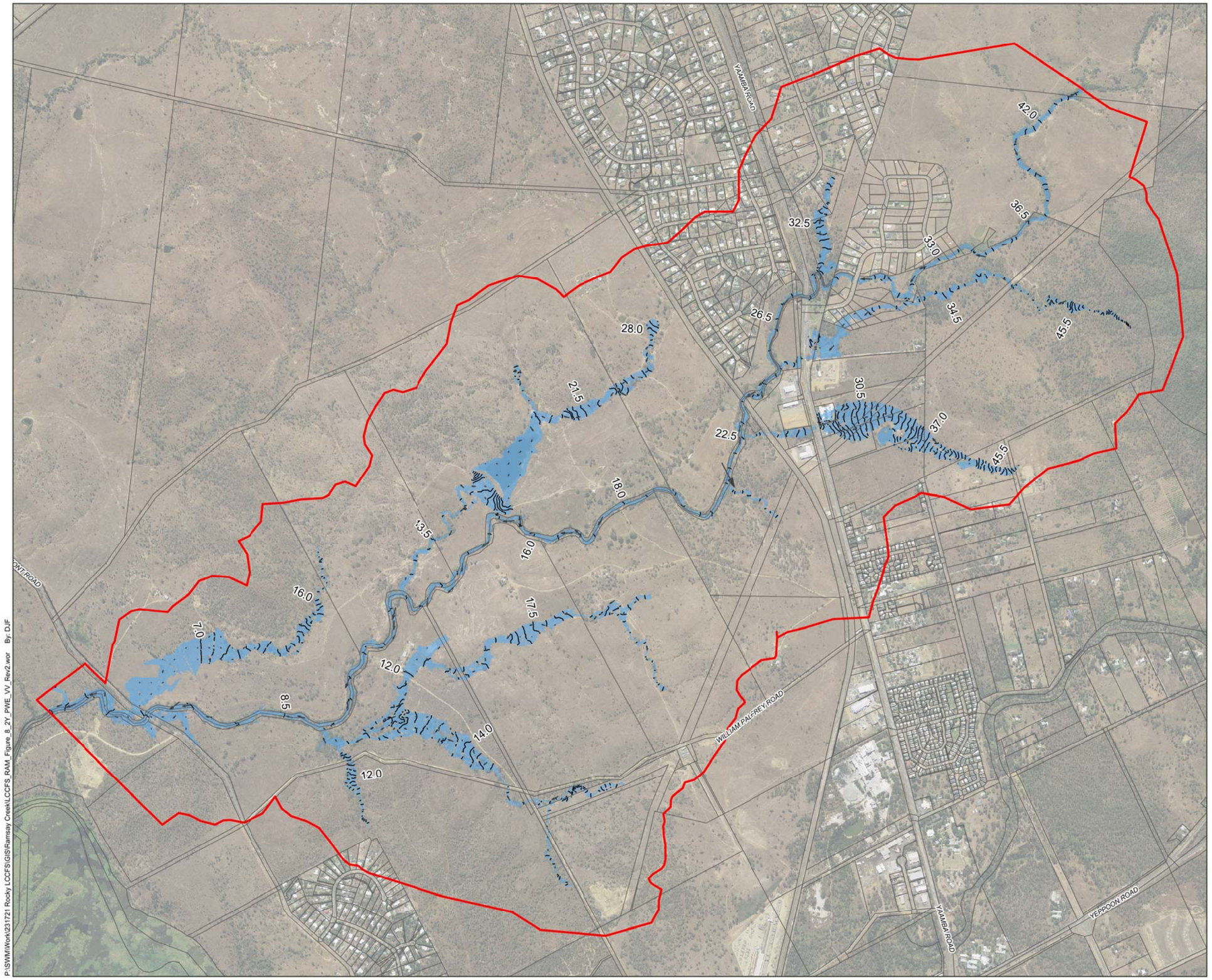
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 7: Hydraulic Model Land Use Map



P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_8_2Y_PWE_VV_Rev2.wor By: DJF

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

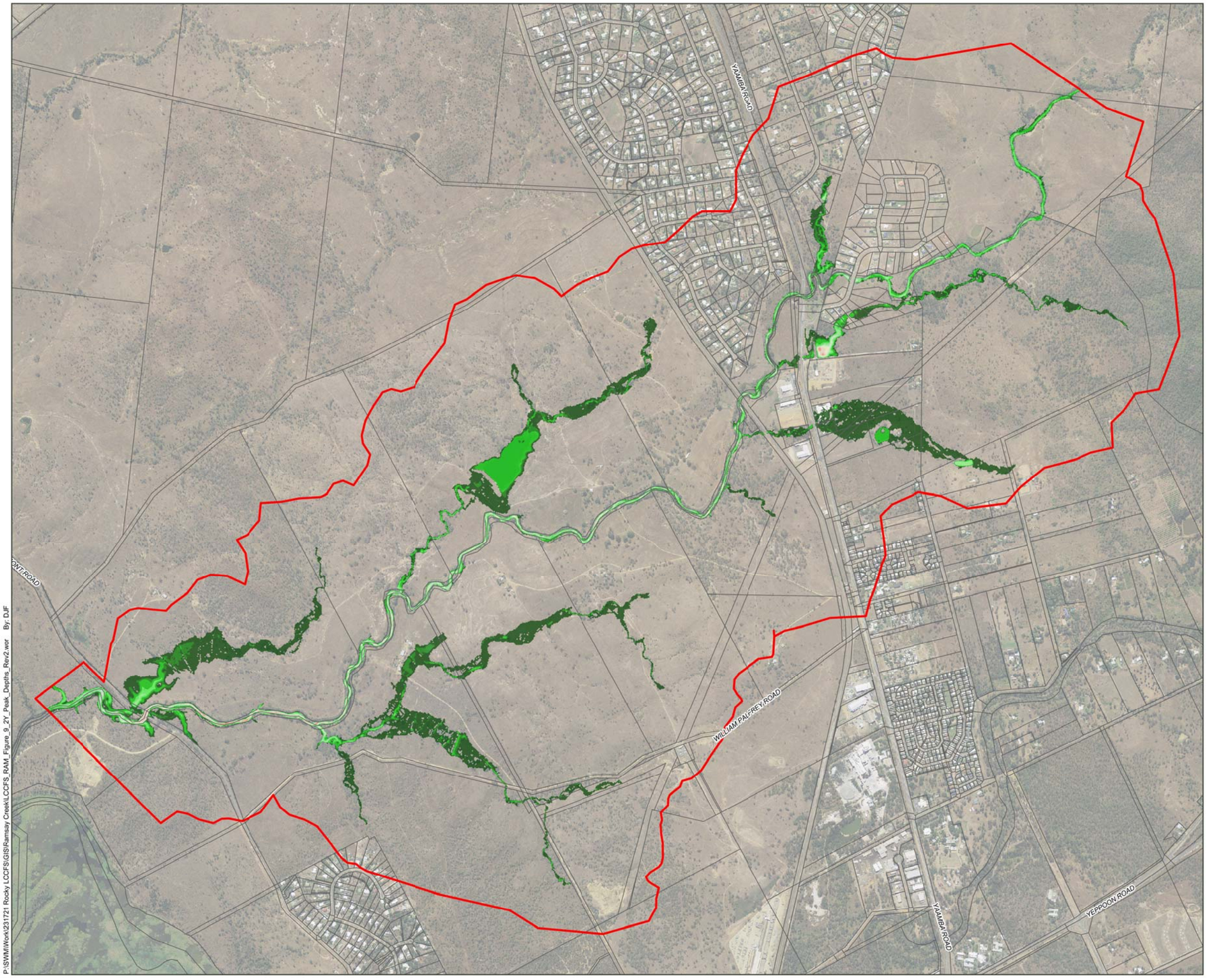
Figure 8: Existing Conditions - 2 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- Cadastre
- TUFLOW Model Extents

Depth (m)

- 0.0 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_9_2Y_Peak_Depths_Rev2.wor By: DJF

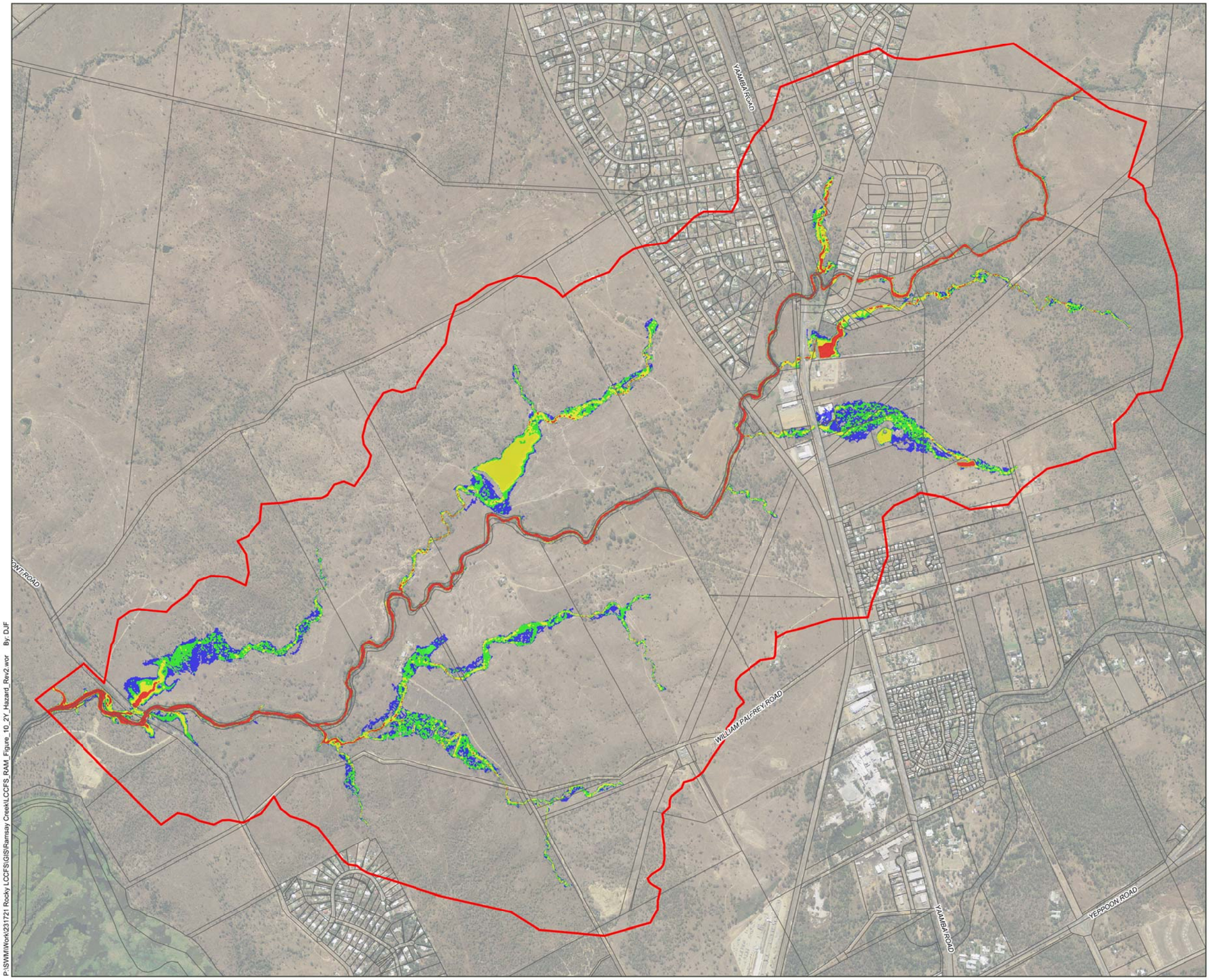
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 9: Existing Conditions - 2 Year ARI Peak Depths



aurecon

Rockhampton Regional Council

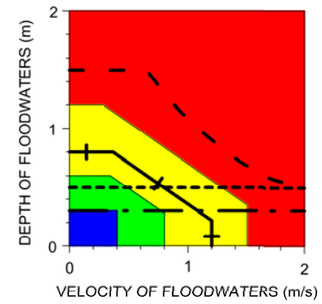
Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

- Low
- Medium
- High
- Extreme

Hazard Thresholds

- Wading Limit - Children
- Wading Limit - Adults
- Safe to Use Small Cars
- Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_10_2Y_Hazard_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 10: Existing Conditions - 2 Year ARI Peak Hazard

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 11: Existing Conditions - 5 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities

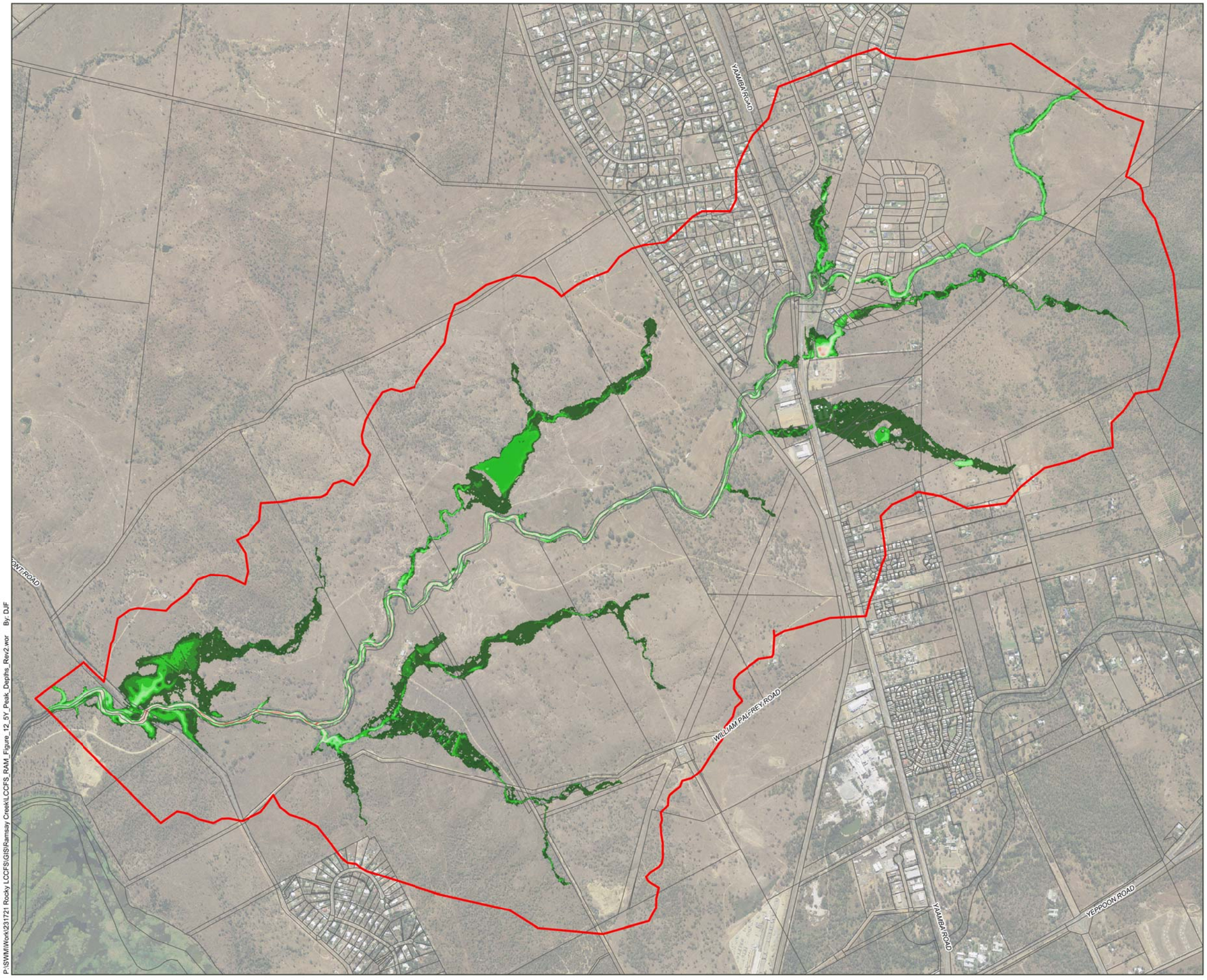
P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_11_5Y_PWE_VV_Rev2.wor By: DJF

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- Cadastre
- TUFLOW Model Extents

Depth (m)

0.0 to 0.3	2.5 to 3.0
0.3 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_12_5Y_Peak_Depths_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 12: Existing Conditions - 5 Year ARI Peak Depths

aurecon

Rockhampton Regional Council

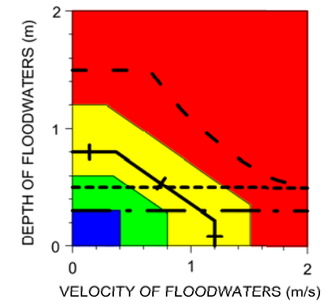
Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

- Low
- Medium
- High
- Extreme

Hazard Thresholds

- Wading Limit - Children
- Safe to Use Small Cars
- Wading Limit - Adults
- Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

YAMBA ROAD
WILLIAM PALFREY ROAD
YAMBA ROAD
YEPPOON ROAD

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_13_5Y_Hazard_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

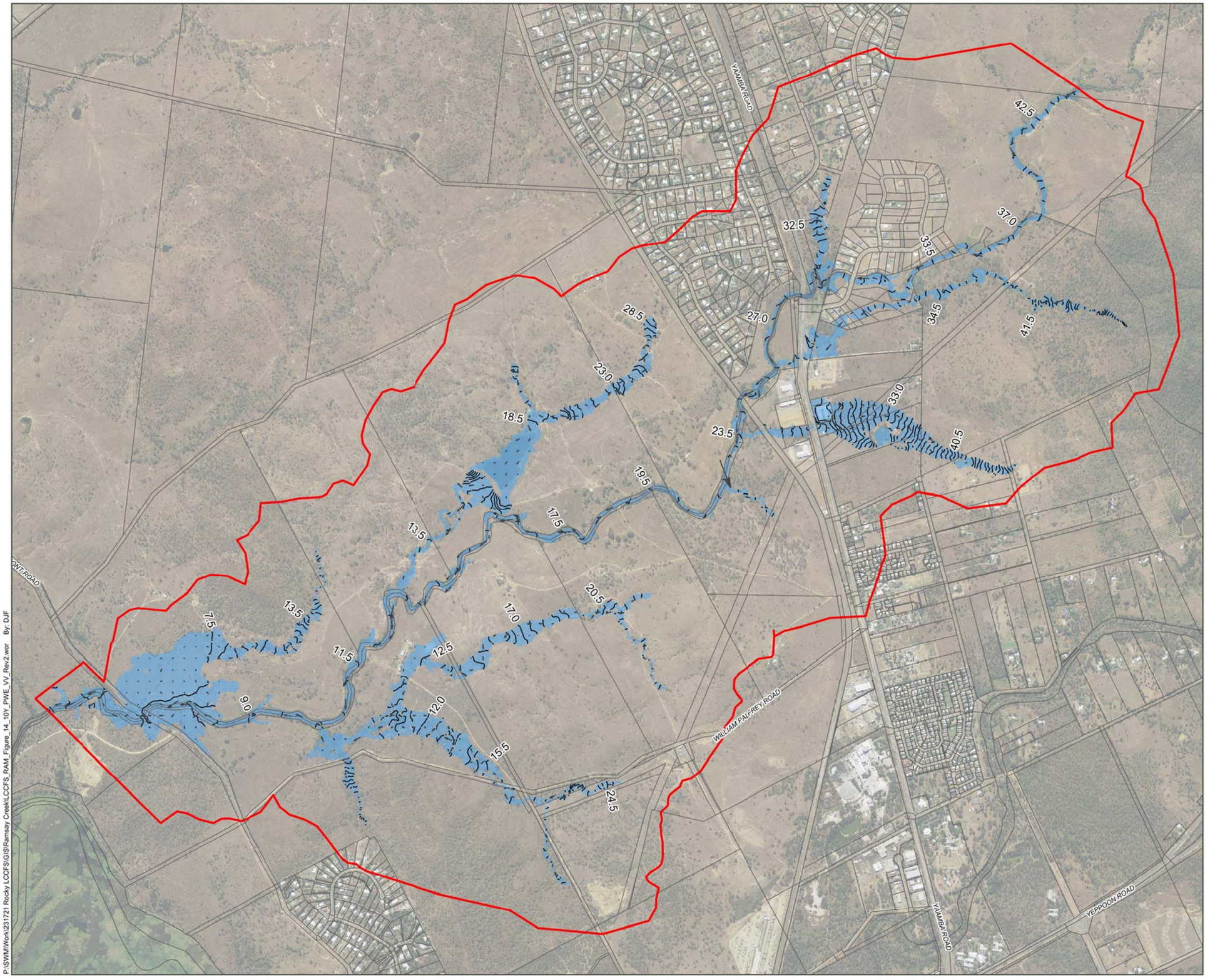
Figure 13: Existing Conditions - 5 Year ARI Peak Hazard

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_14_10Y_PWE_VV_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

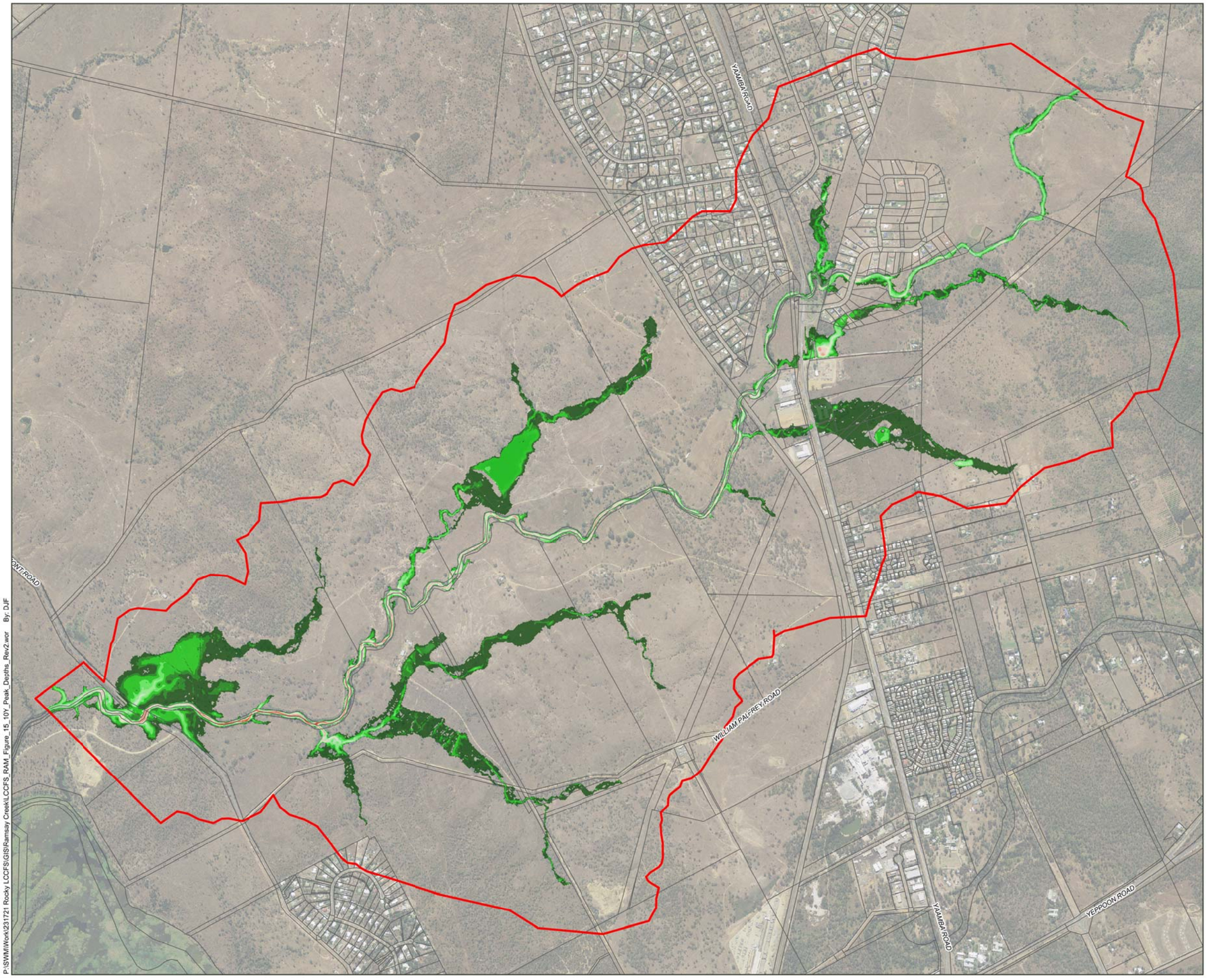
Figure 14: Existing Conditions - 10 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- Cadastre
- TUFLOW Model Extents

Depth (m)

- 0.0 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_15_10Y_Peak_Depths_Rev2.wor By: DJF

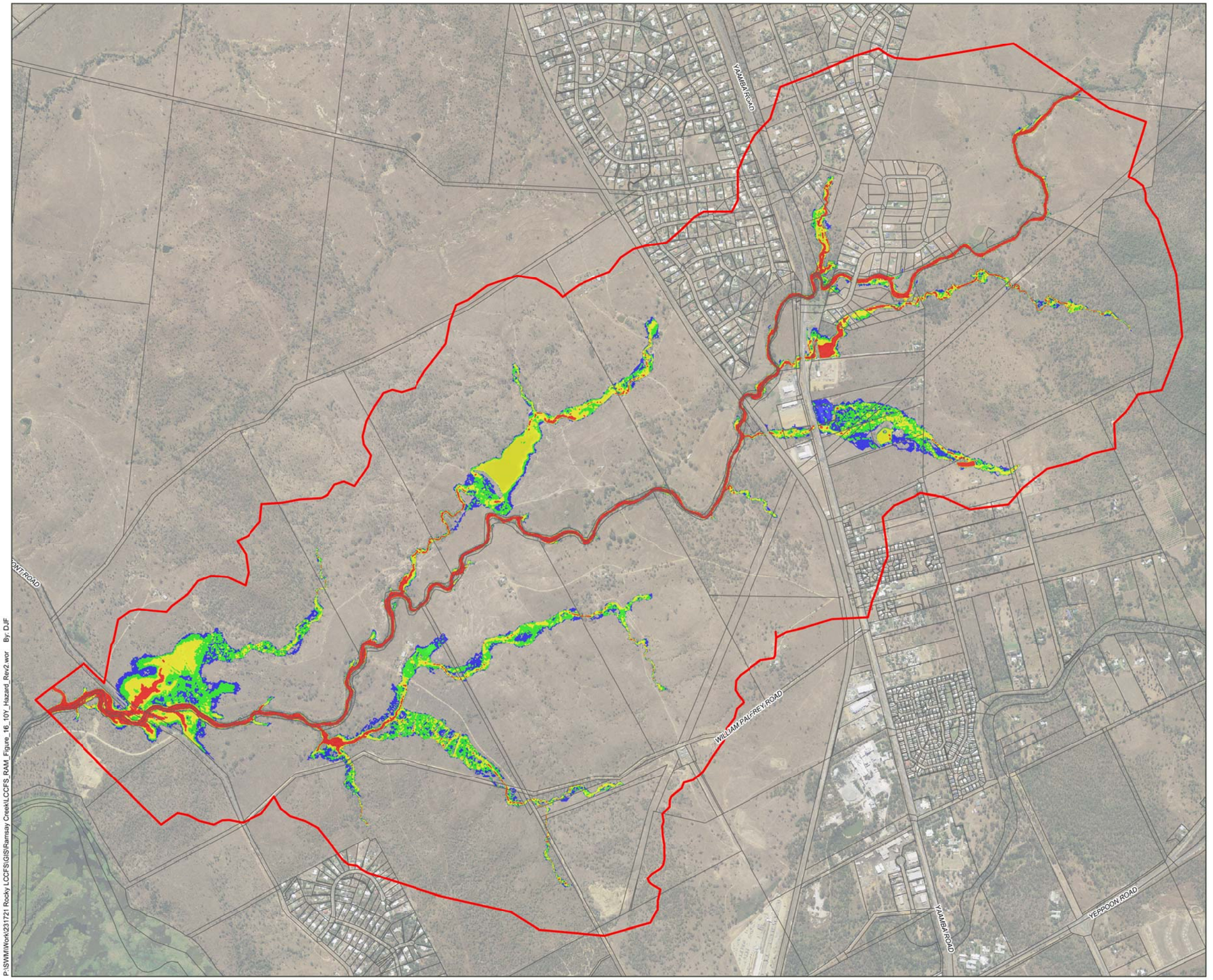
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 15: Existing Conditions - 10 Year ARI Peak Depths



P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_16_10Y_Hazard_Rev2.wor By: DJF

aurecon

Rockhampton Regional Council

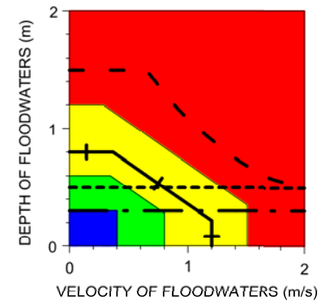
Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

- Low
- Medium
- High
- Extreme

Hazard Thresholds

- Wading Limit - Children
- Safe to Use Small Cars
- Wading Limit - Adults
- Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

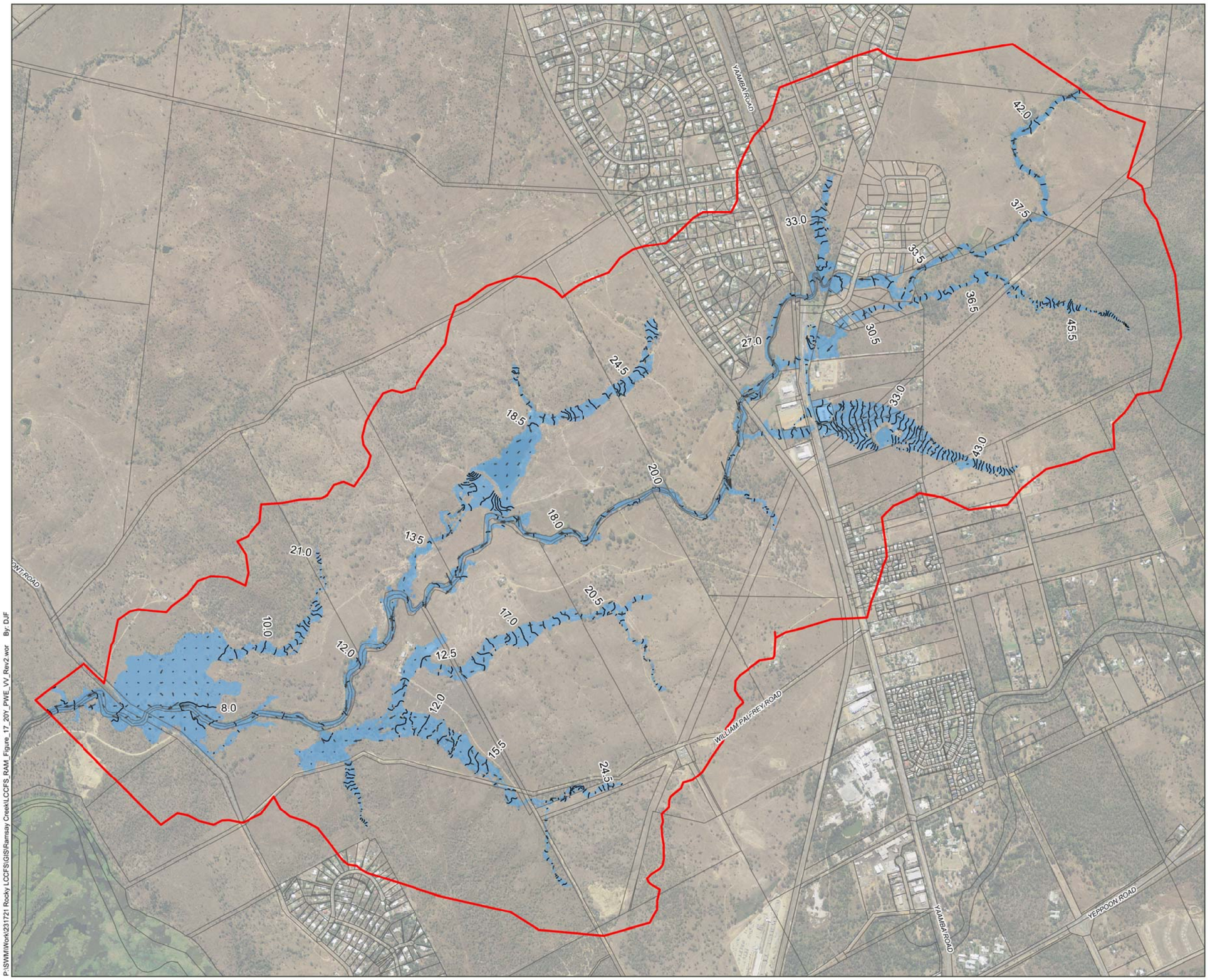
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 16: Existing Conditions - 10 Year ARI Peak Hazard



aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_17_20Y_PWE_VV_Rev2.wor By: DJF

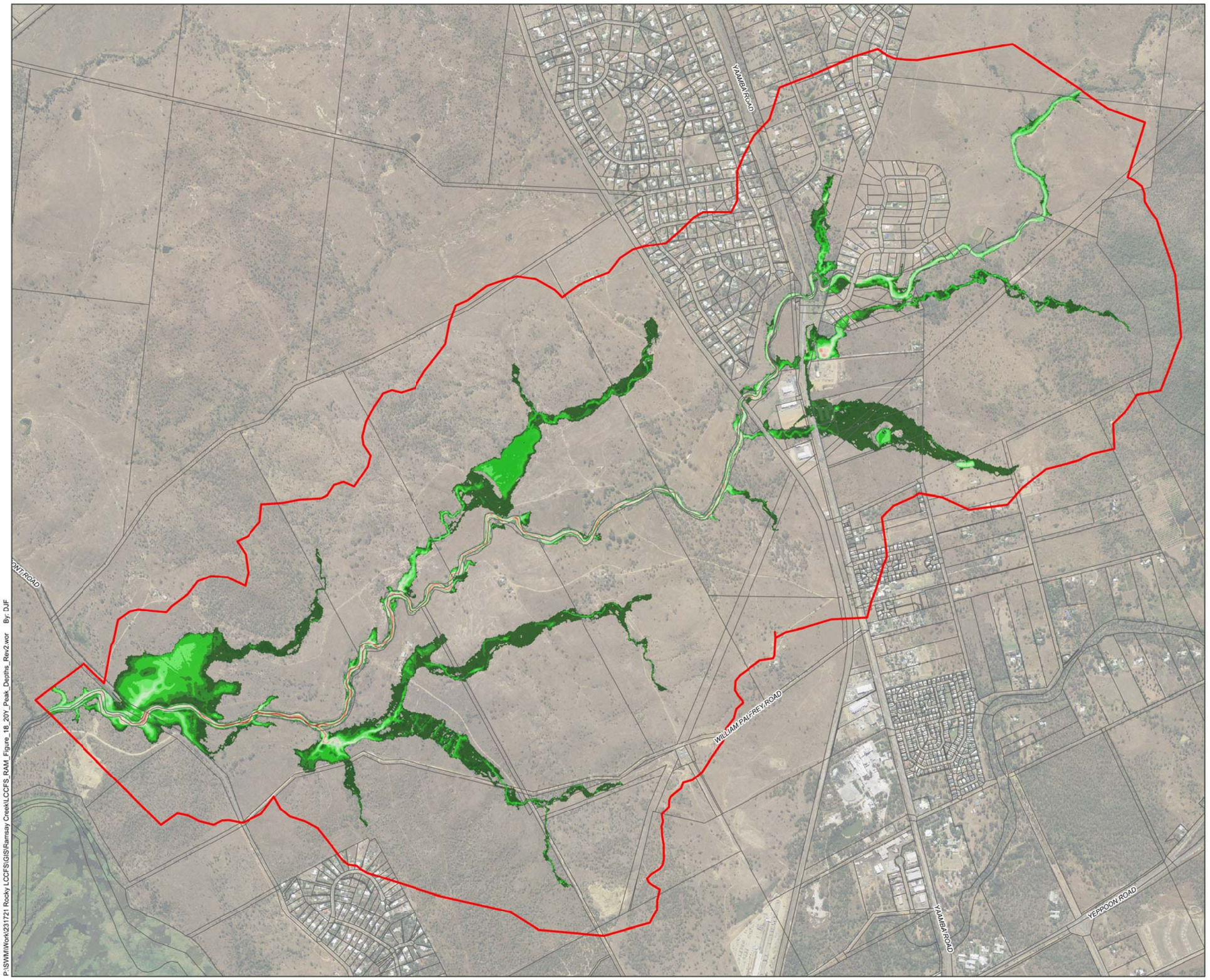
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 17: Existing Conditions - 20 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities



aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents

Depth (m)

- 0.0 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_18_20Y_Peak_Depths_Rev2.wor By: DJF

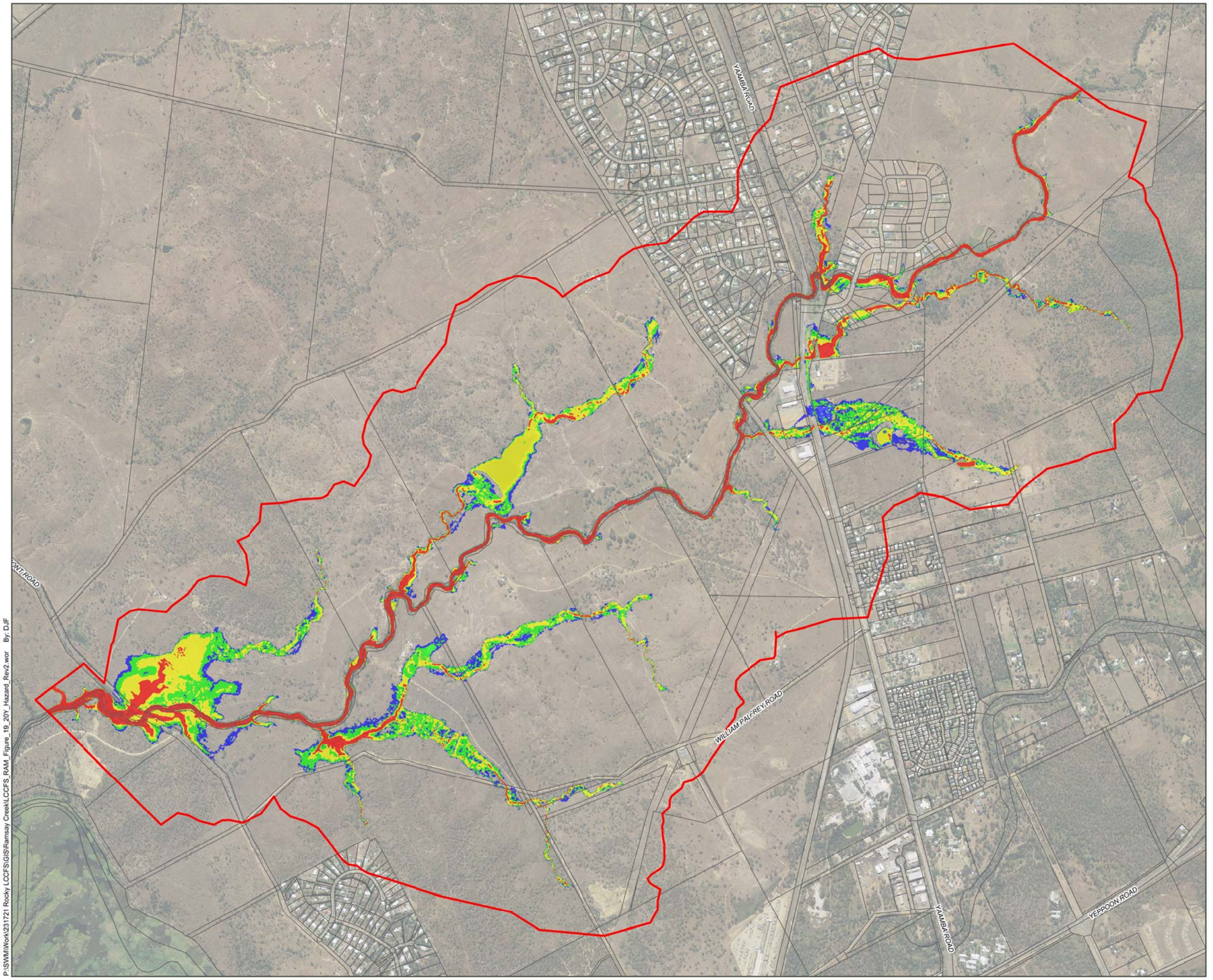
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 18: Existing Conditions - 20 Year ARI Peak Depths



aurecon

Rockhampton Regional Council

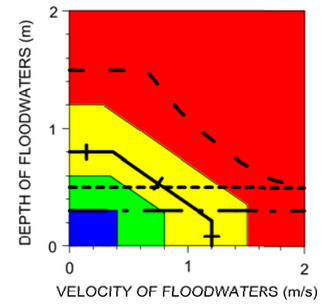
Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

- Low
- Medium
- High
- Extreme

Hazard Thresholds

- Wading Limit - Children
- Safe to Use Small Cars
- Wading Limit - Adults
- Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Mean High Water Springs tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_19_20Y_Hazard_Rev2.wor By: DJF

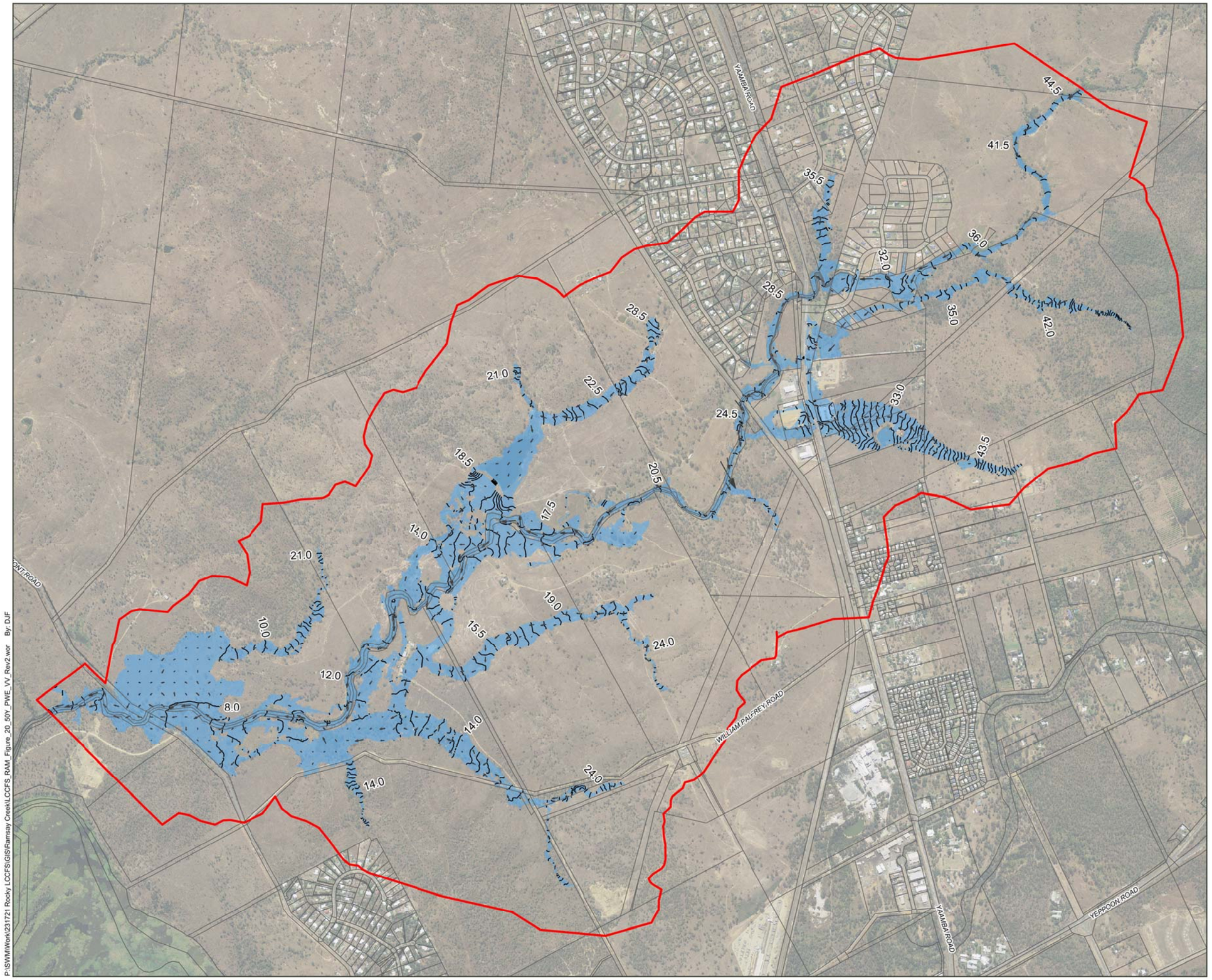
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 19: Existing Conditions - 20 Year ARI Peak Hazard



P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_20_50Y_PWE_VV_Rev2.wor By: DJF

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 20: Existing Conditions - 50 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents

Depth (m)

0.0 to 0.3	2.5 to 3.0
0.3 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_21_50Y_Peak_Depths_Rev2.wor By: DJF

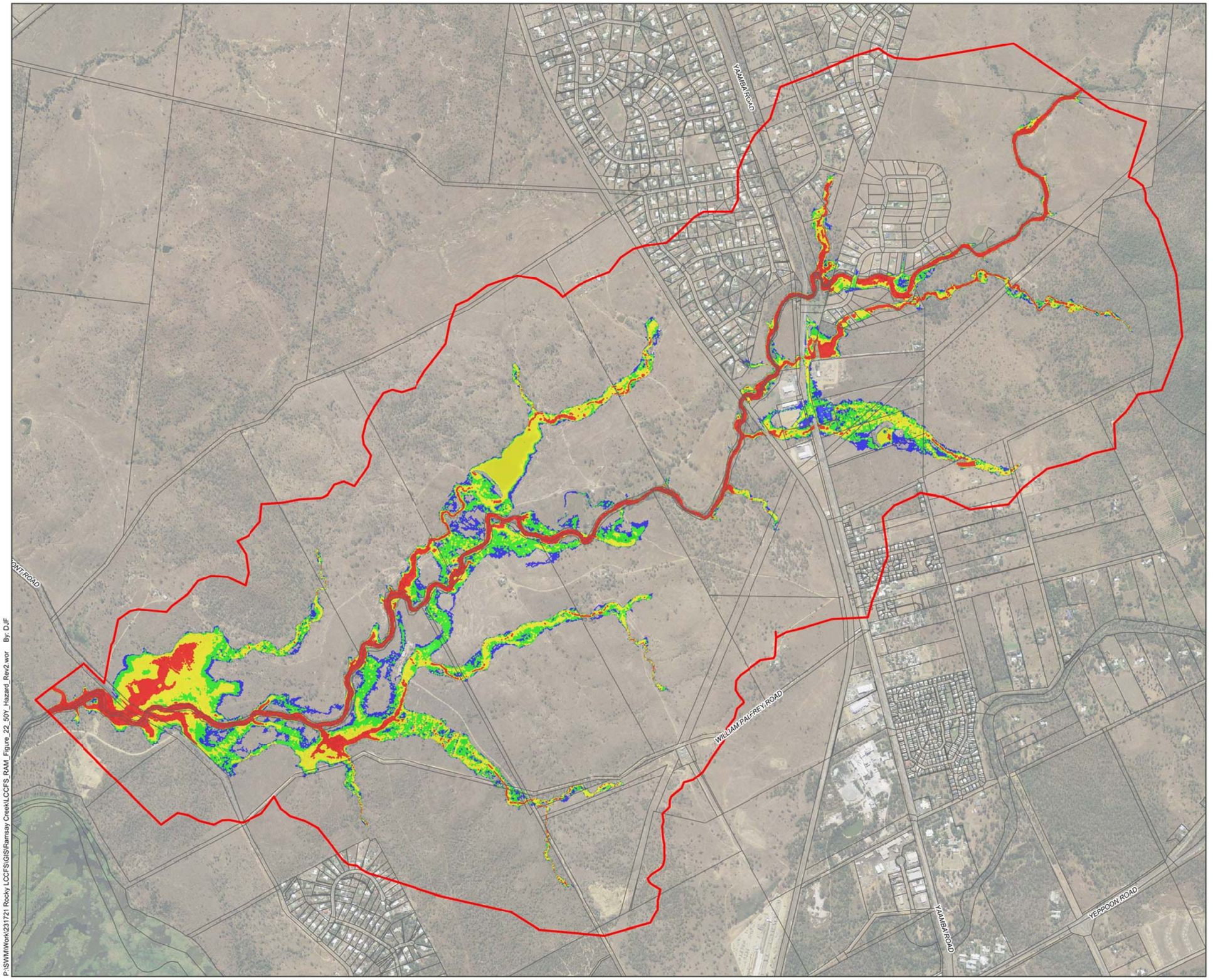
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 21: Existing Conditions - 50 Year ARI Peak Depths



aurecon

Rockhampton Regional Council

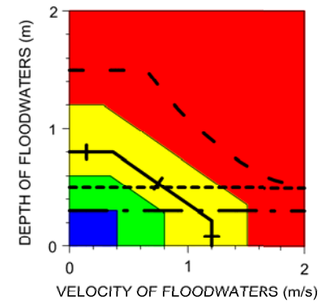
Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

- Low
- Medium
- High
- Extreme

Hazard Thresholds

- Wading Limit - Children
- Safe to Use Small Cars
- Wading Limit - Adults
- Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_22_50Y_Hazard_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 22: Existing Conditions - 50 Year ARI Peak Hazard

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_23_100Y_PWE_VV_Rev2.wor By: DJF

Local Creek Catchments Flood Study: Ramsay Creek

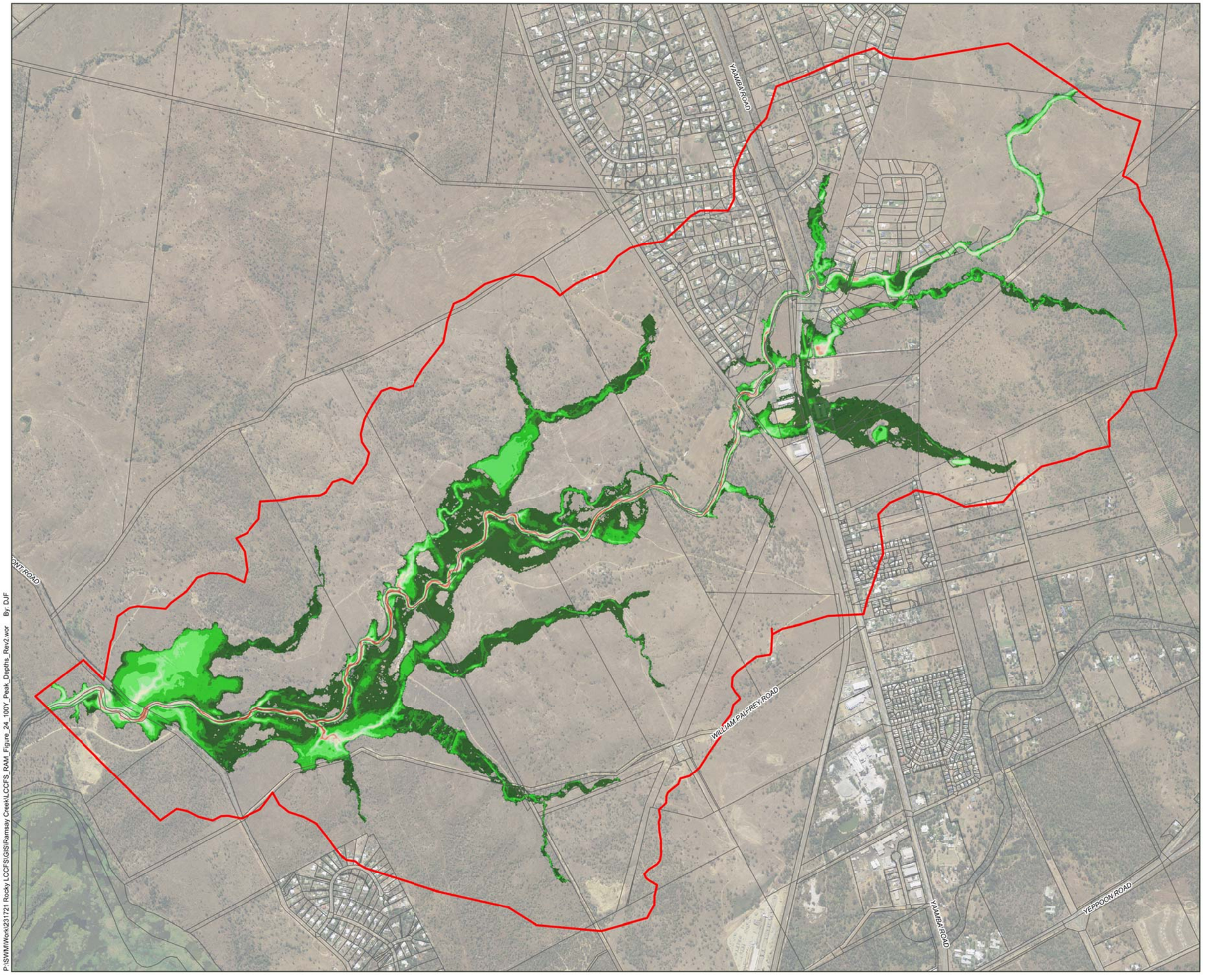
Figure 23: Existing Conditions - 100 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- Cadastre
- TUFLOW Model Extents

Depth (m)

0.0 to 0.3	2.5 to 3.0
0.3 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_24_100Y_Peak_Depths_Rev2.wor By: DJF

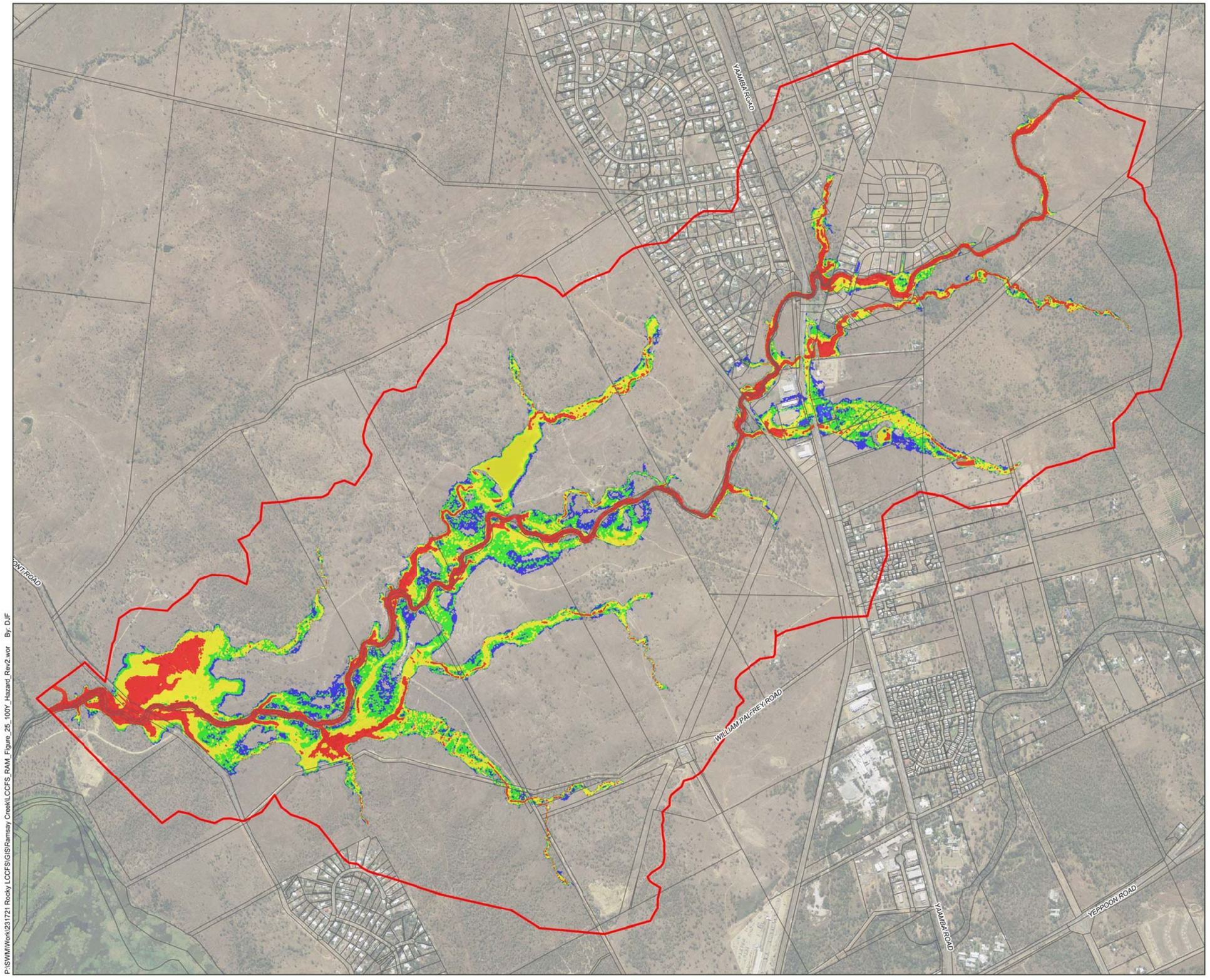
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 24: Existing Conditions - 100 Year ARI Peak Depths



aurecon

Rockhampton Regional Council

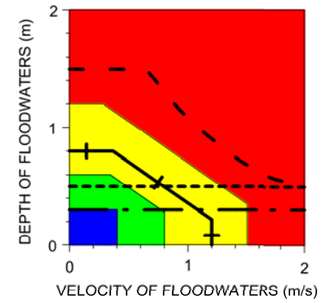
Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

Low
Medium
High
Extreme

Hazard Thresholds

Wading Limit - Children
Wading Limit - Adults
Safe to Use Small Cars
Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_25_100Y_Hazard_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 25: Existing Conditions - 100 Year ARI Peak Hazard

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

0 1000 (m)

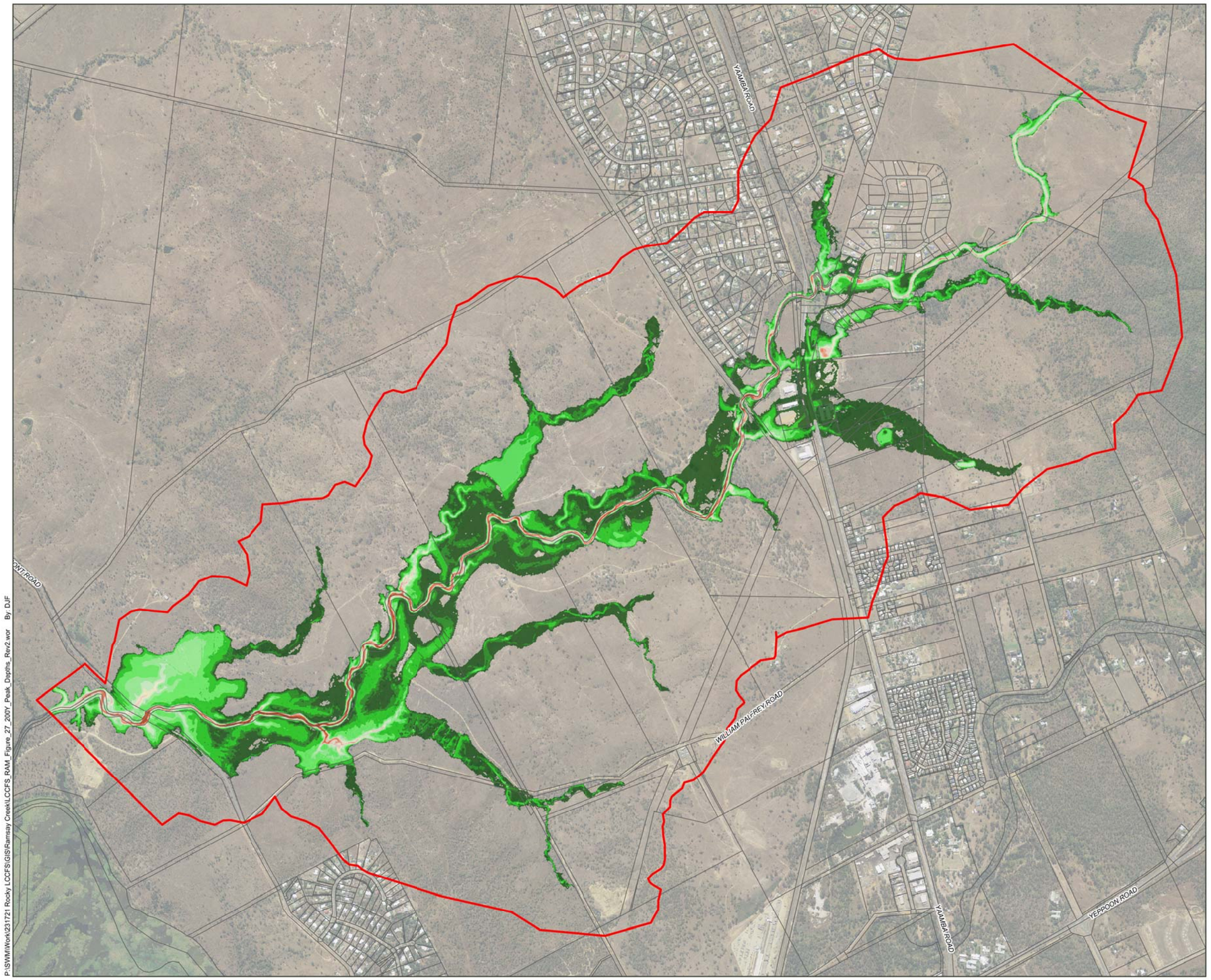
Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 26: Existing Conditions - 200 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_26_200Y_PWE_VV_Rev2.wor By: DJF



aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents

Depth (m)

0.0 to 0.3	2.5 to 3.0
0.3 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_27_200Y_Peak_Depths_Rev2.wor By: DJF

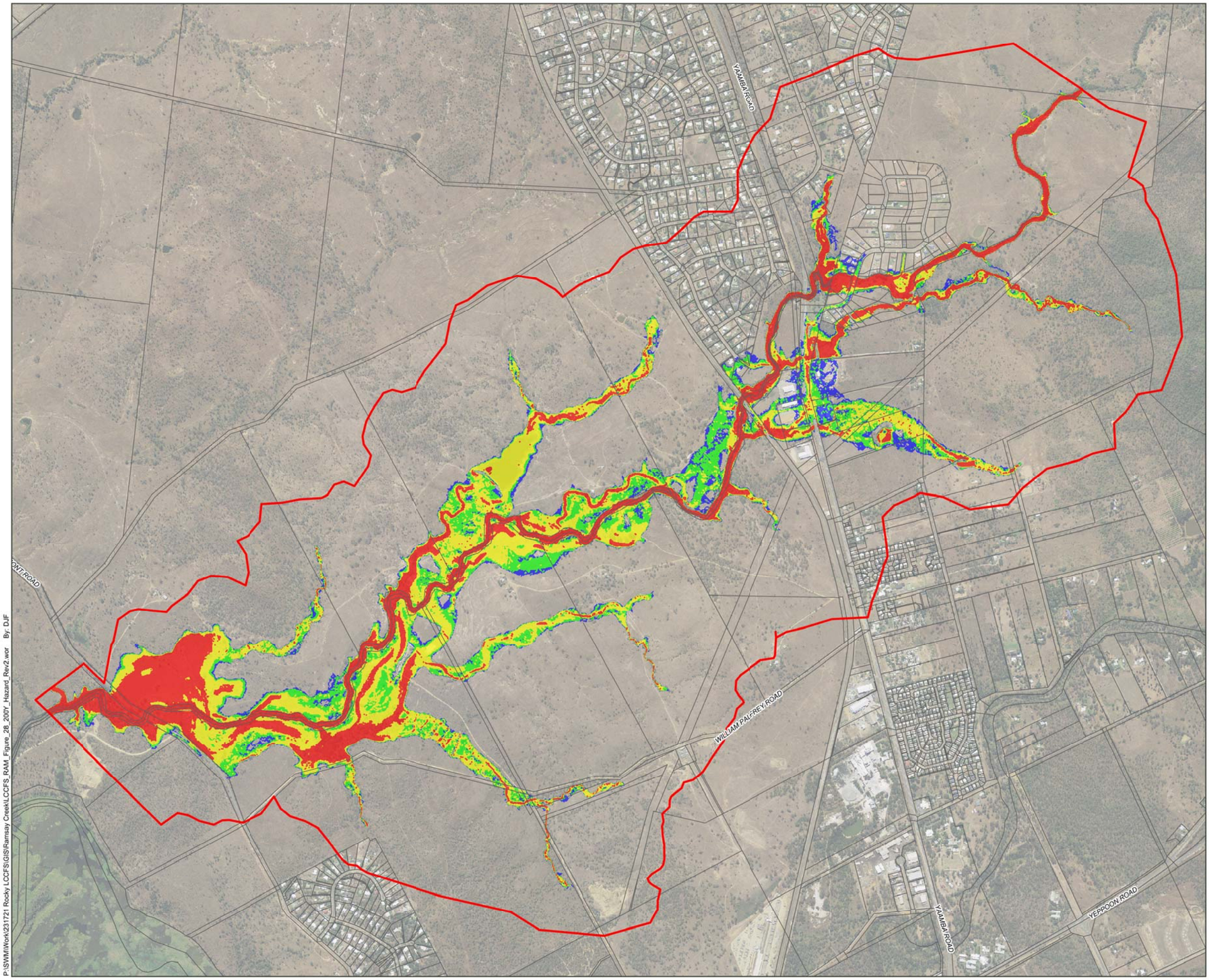
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 27: Existing Conditions - 200 Year ARI Peak Depths



aurecon

Rockhampton Regional Council

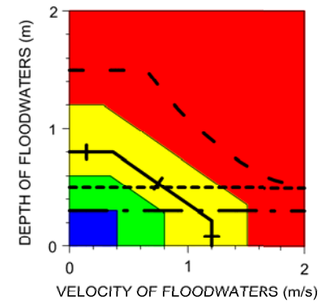
Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

- Low
- Medium
- High
- Extreme

Hazard Thresholds

- Wading Limit - Children
- Safe to Use Small Cars
- Wading Limit - Adults
- Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_28_200Y_Hazard_Rev2.wor By: DJF

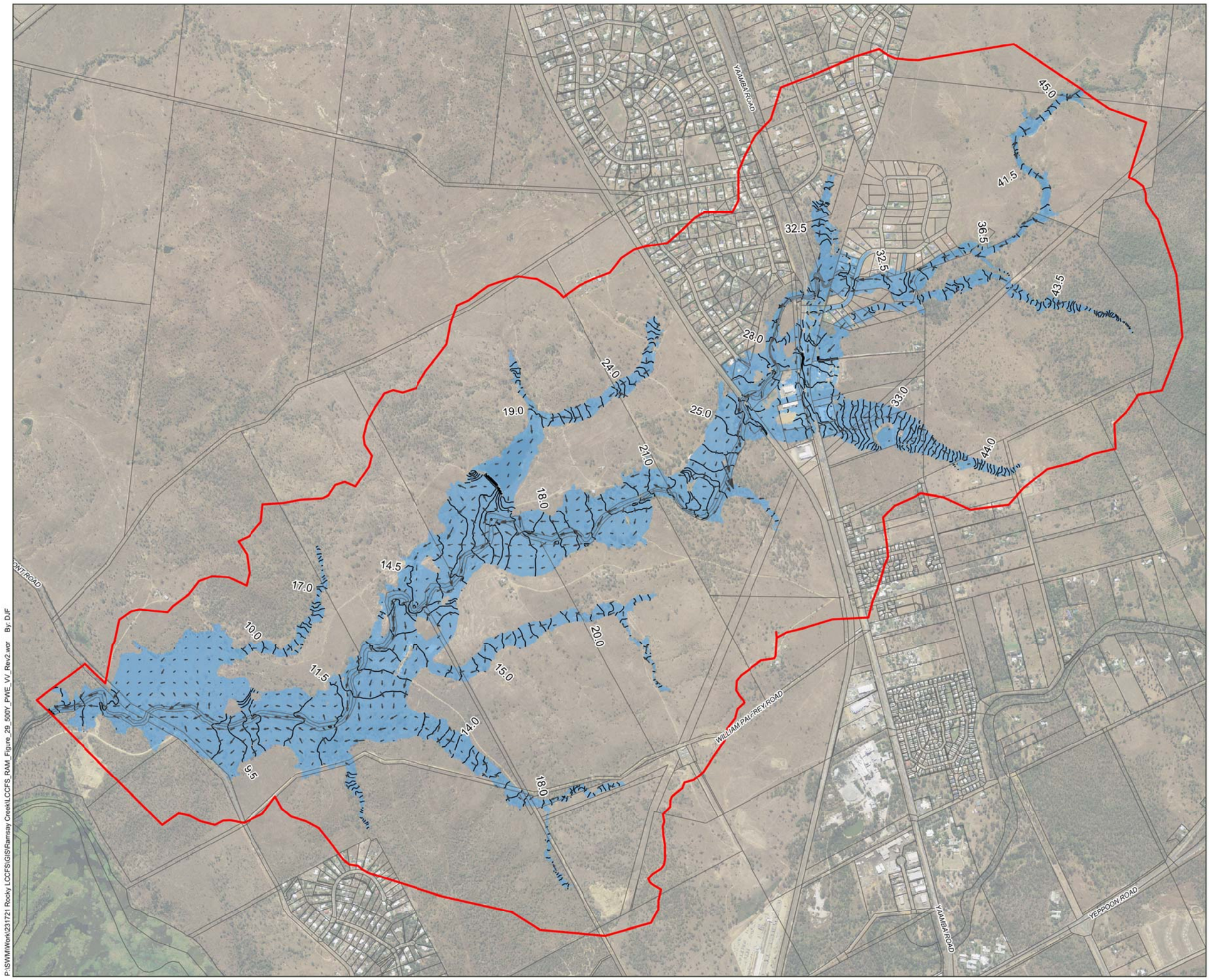
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 28: Existing Conditions - 200 Year ARI Peak Hazard



aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_29_500Y_PWE_VV_Rev2.wor By: DJF

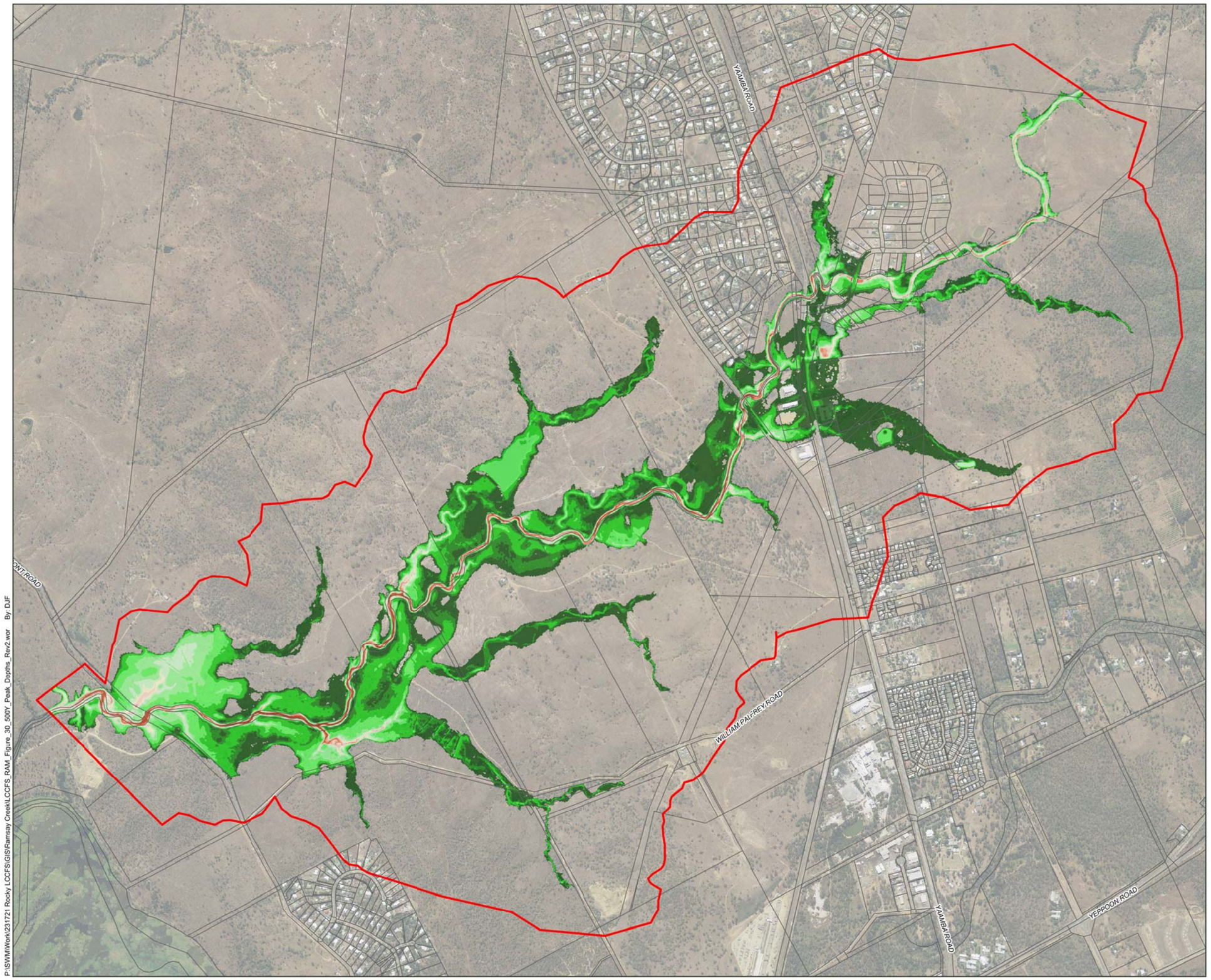
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 29: Existing Conditions - 500 Year ARI Inundation Extents, Peak Water Surface Elevations and Velocities



aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents

Depth (m)

0.0 to 0.3	2.5 to 3.0
0.3 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_30_500Y_Peak_Depths_Rev2.wor By: DJF

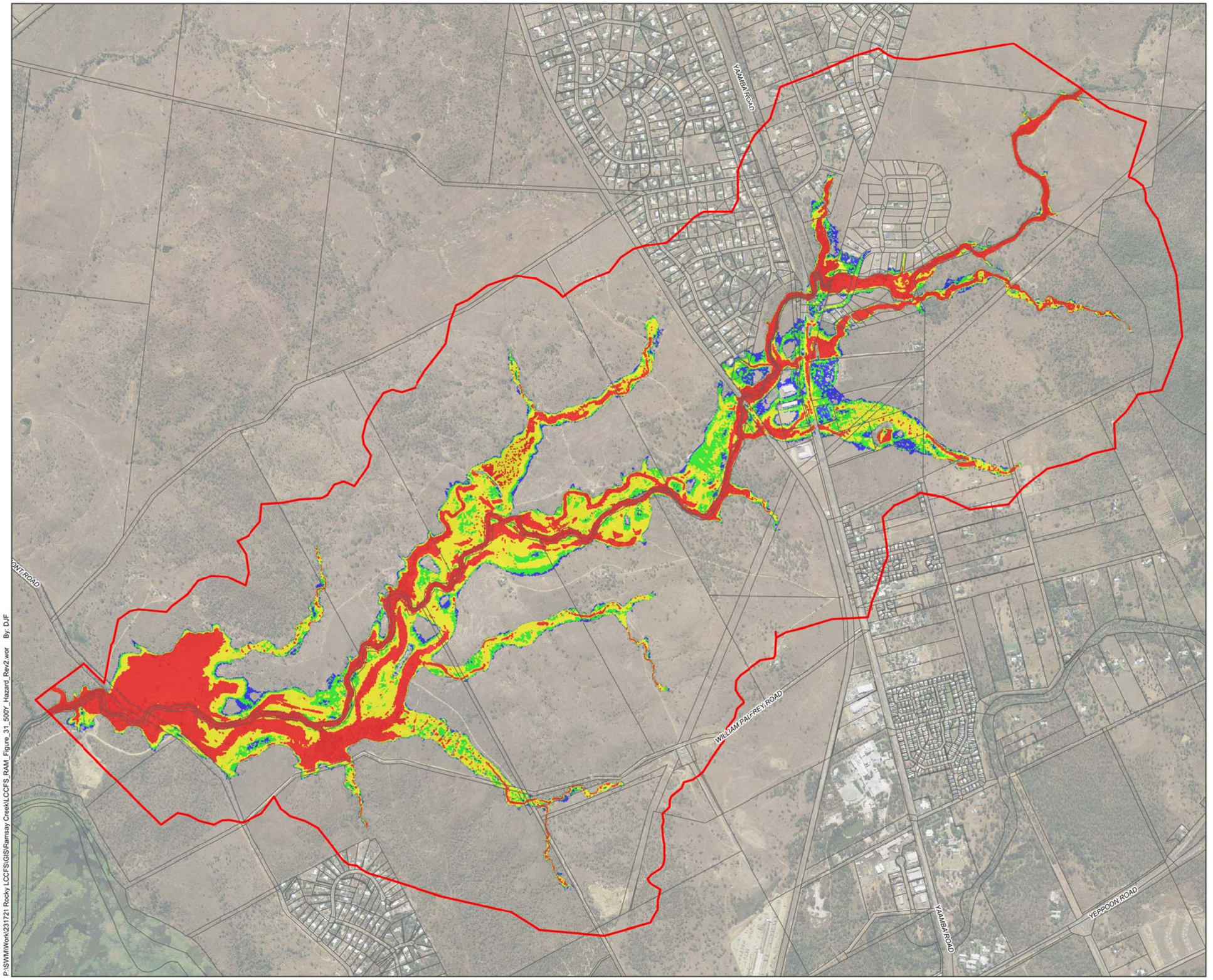
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 30: Existing Conditions - 500 Year ARI Peak Depths



aurecon

Rockhampton Regional Council

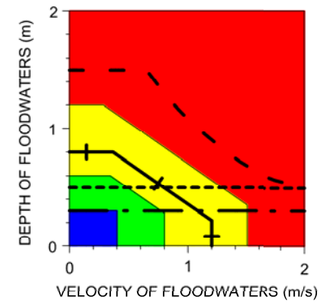
Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

- Low
- Medium
- High
- Extreme

Hazard Thresholds

- Wading Limit - Children
- Safe to Use Small Cars
- Wading Limit - Adults
- Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_31_500Y_Hazard_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 31: Existing Conditions - 500 Year ARI Peak Hazard

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- Inundation Extents
- 0.5m (AHD) Peak Water Surface Elevation Contour
- Velocity Vector
  - represents velocity at time of peak water level
  - reference vector = 3 m/s

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.
7. The flood inundation extent associated with the Probable Maximum Flood (PMF) event does not account for inter-catchment flow.

Date: 29/05/2014 **Version: 2**

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 32: Existing Conditions - PMF Inundation Extents, Peak Water Surface Elevations and Velocities

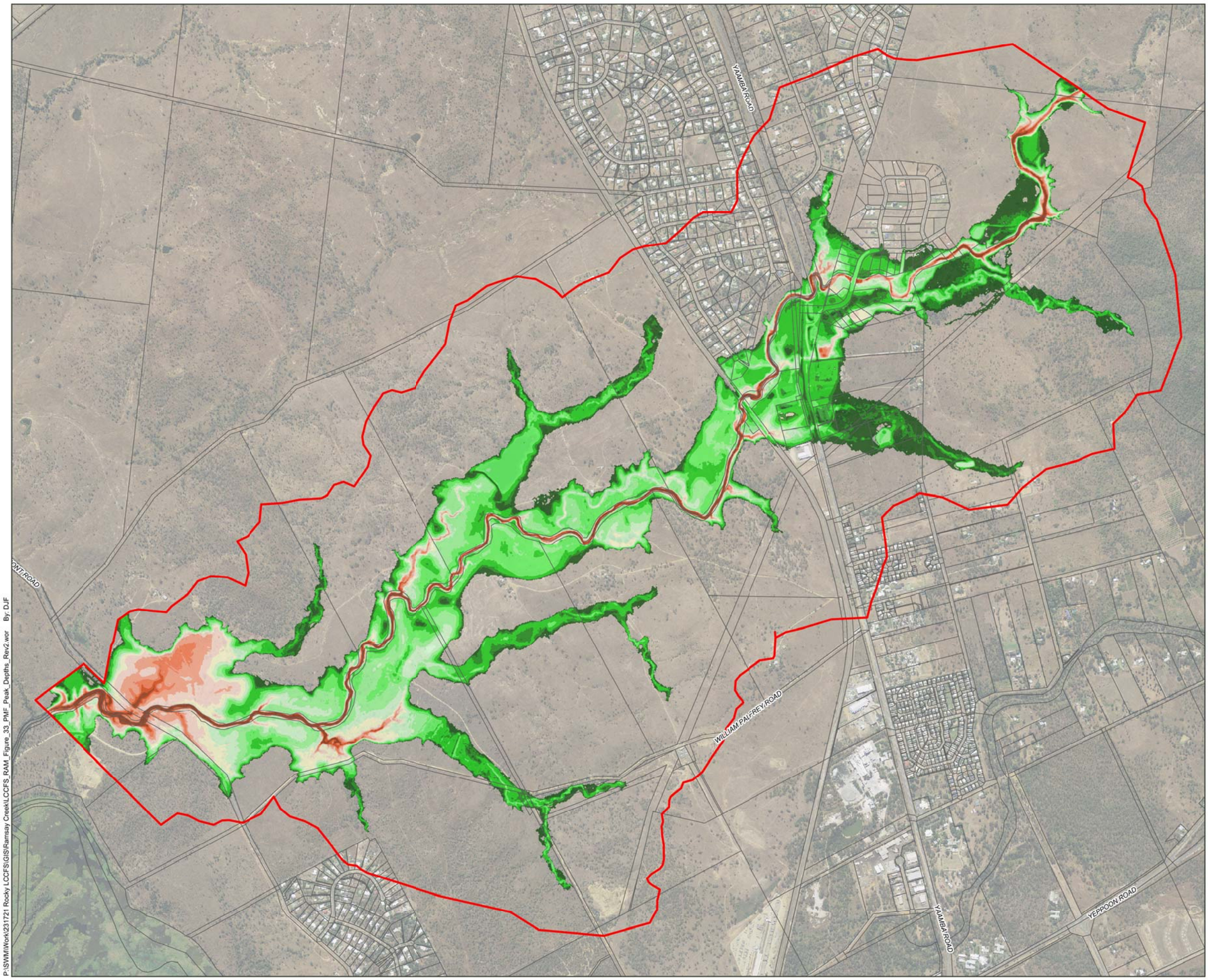
P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_32_PMF_PWE_VV_Rev2.wor By: DJF

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- Cadastre
- TUFLOW Model Extents

Depth (m)

0.0 to 0.3	2.5 to 3.0
0.3 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.
7. The flood inundation extent associated with the Probable Maximum Flood (PMF) event does not account for inter-catchment flow.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_33_PMF_Peak_Depths_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 33: Existing Conditions - PMF Peak Depths

aurecon

Rockhampton Regional Council

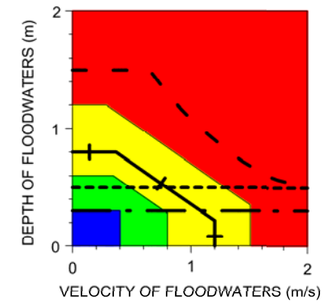
Australian Government
Attorney-General's Department

Queensland Government

Legend

Cadastre

TUFLOW Model Extents



Hazard Categories

Low

Medium

High

Extreme

Hazard Thresholds

Wading Limit - Children

Wading Limit - Adults

Safe to Use Small Cars

Safe to Use 4WDs

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.
7. The flood inundation extent associated with the Probable Maximum Flood (PMF) event does not account for inter-catchment flow.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_34_PMF_Hazard_Rev2.wor By: DJF

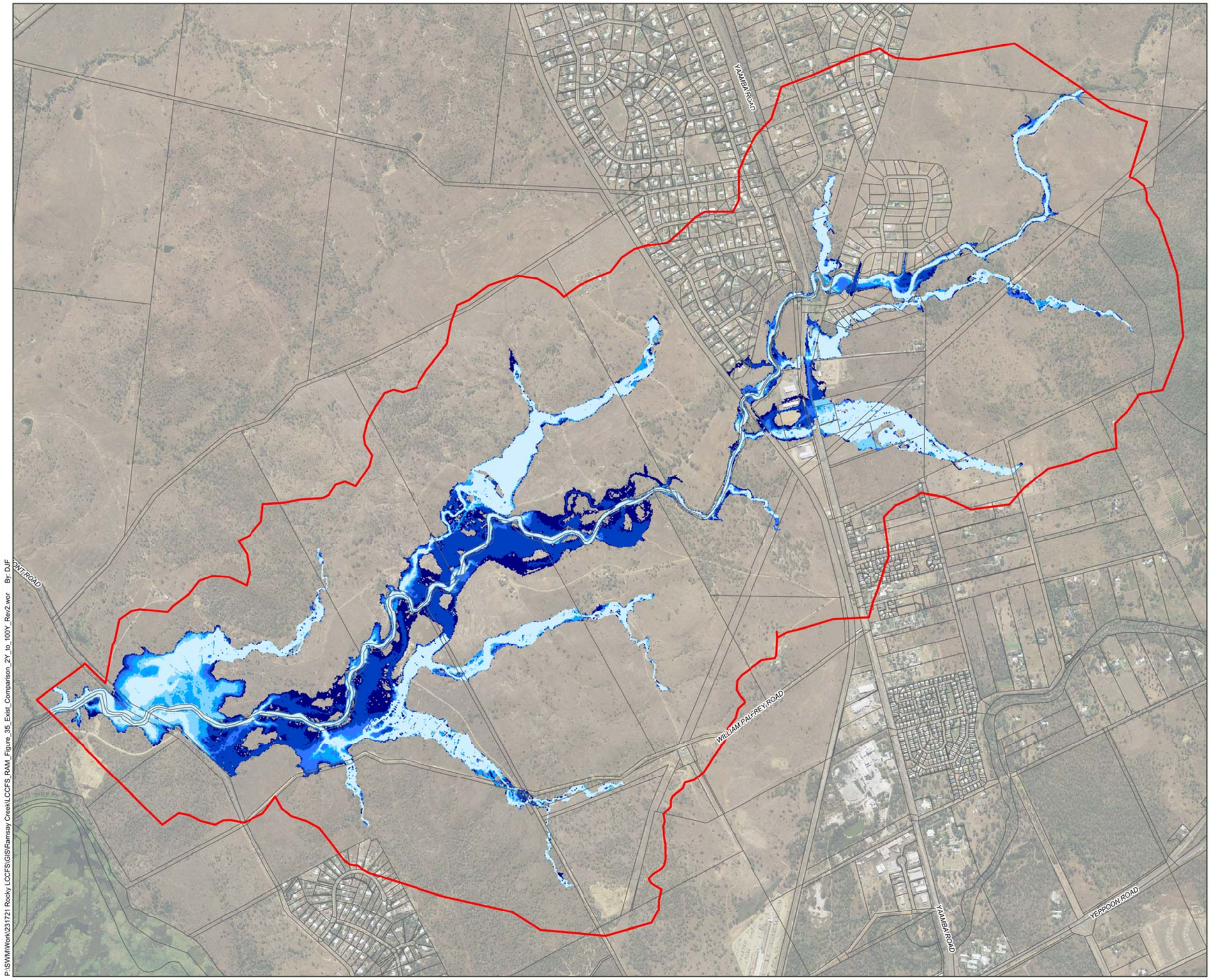
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 34: Existing Conditions - PMF Peak Hazard



aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- 2 Year ARI Inundation Extent
- 5 Year ARI Inundation Extent
- 10 Year ARI Inundation Extent
- 20 Year ARI Inundation Extent
- 50 Year ARI Inundation Extent
- 100 Year ARI Inudation Extent

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localised overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_35_Exist_Comparison_2Y_to_100Y_Rev2.wor By: DJF

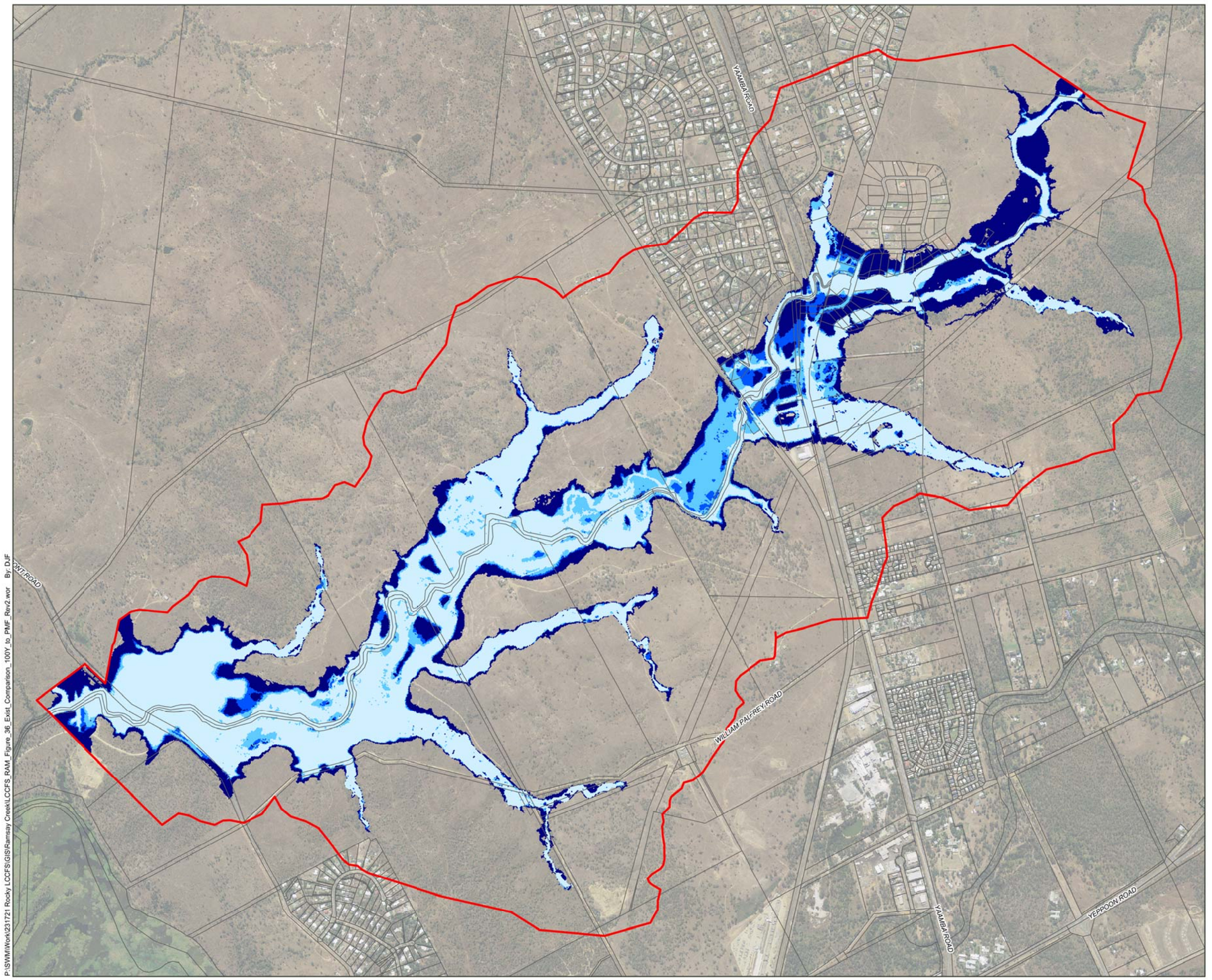
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 35: Existing Conditions - Inundation Extent Comparison - 2 to 100 Year ARI



P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_36_Exist_Comparison_100Y_to_PMF_Rev2.wor By: DJF

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- 100 Year ARI Inundation Extent
- 200 Year ARI Inundation Extent
- 500 Year ARI Inundation Extent
- PMF Inundation Extent

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.
7. The flood inundation extent associated with the Probable Maximum Flood (PMF) event does not account for inter-catchment flow.

Date: 29/05/2014 **Version: 2**

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

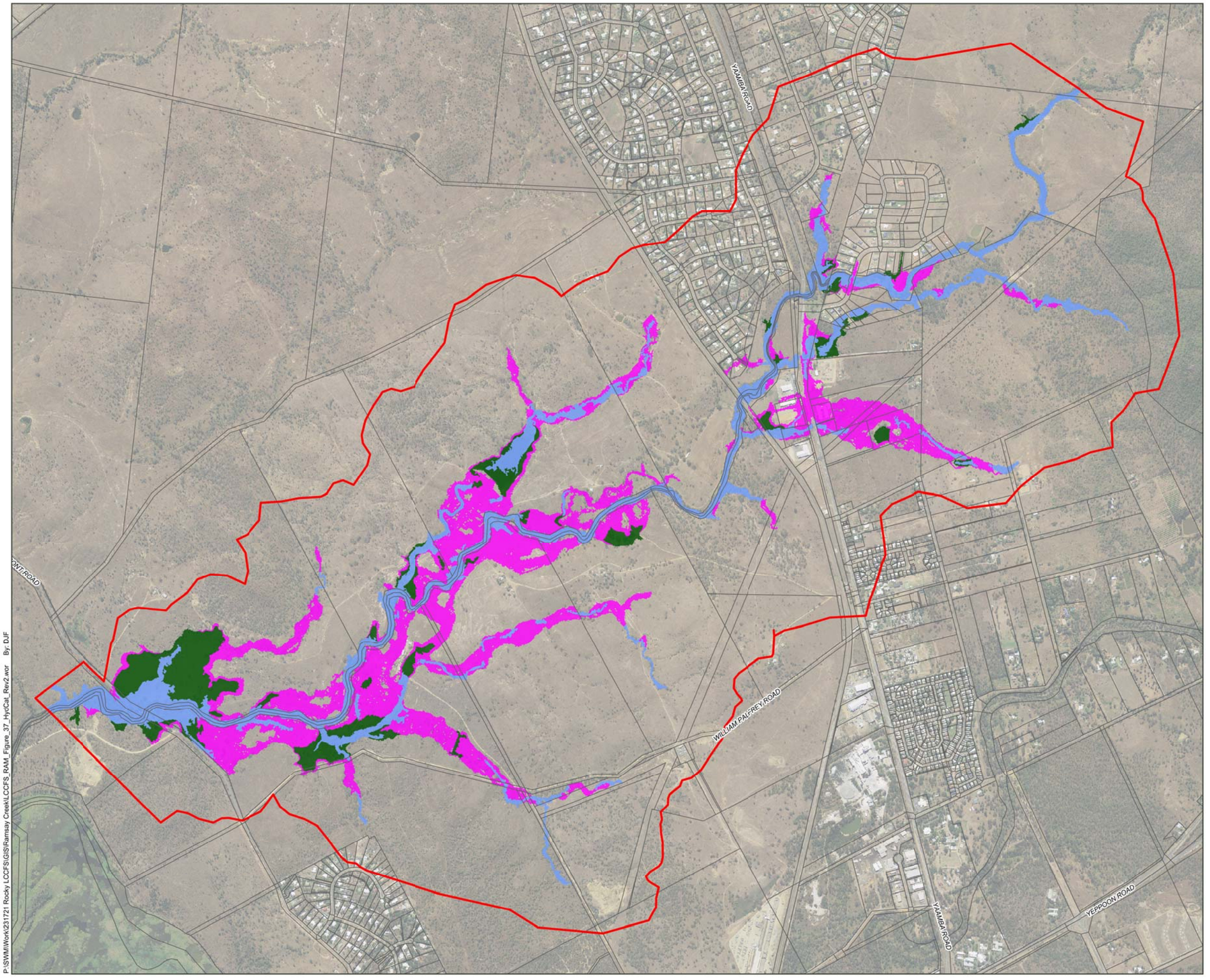
Figure 36: Existing Conditions - Inundation Extent Comparison - 100 Year ARI to PMF

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- Cadastre
- TUFLOW Model Extents

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The flood inundation extents shown in this flood map are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide level on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_37_HydCat_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

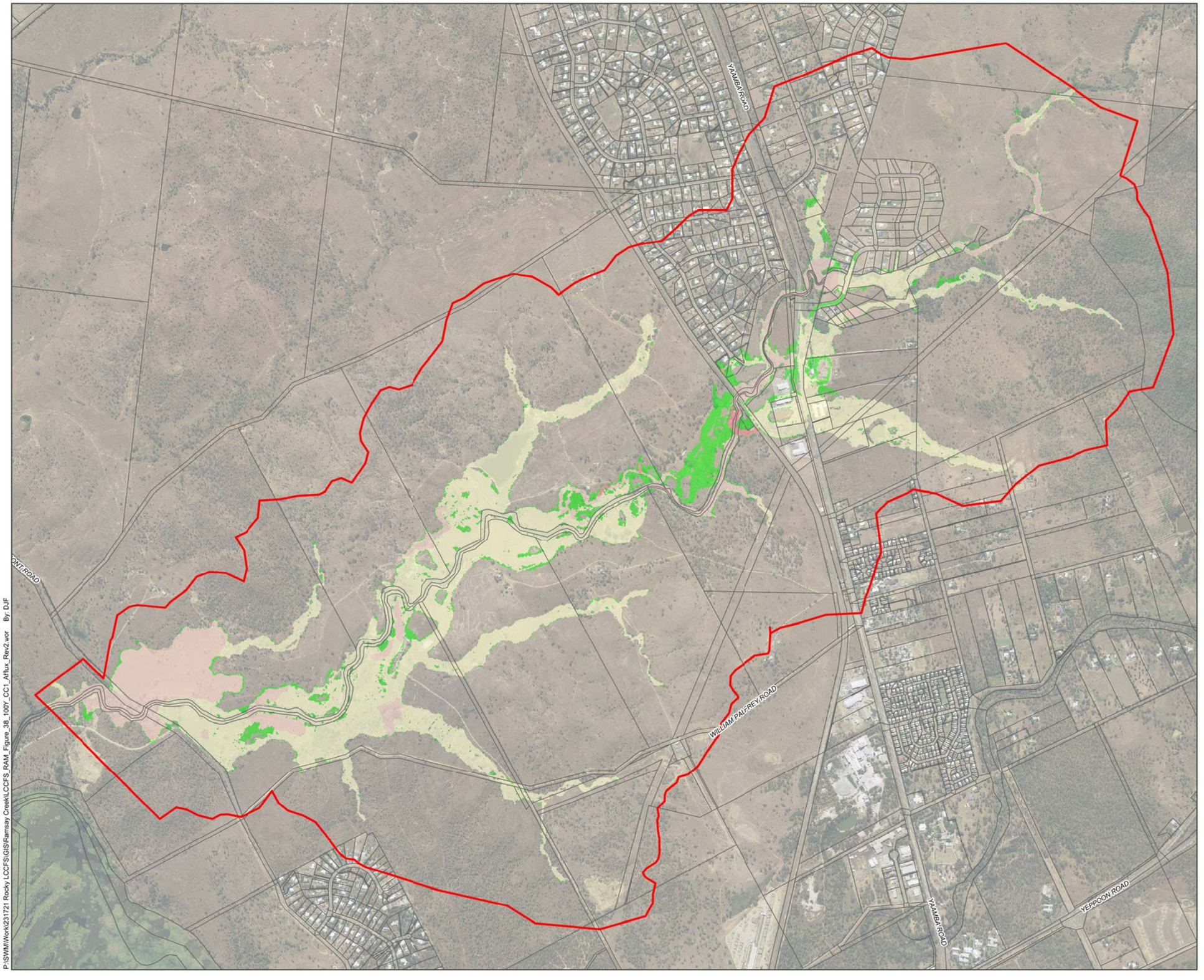
Figure 37: Hydraulic Categories

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- Cadastre
- TUFLOW Model Extents

Afflux (m)

- 0.00 to 0.25
- 0.25 to 0.50
- 0.50 to 0.75
- 0.75 to 1.00
- 1.00 to 1.50
- >1.5
- Was Dry Now Wet

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide leve plus 0.8m on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_38_100Y_CC1_Aflux_Rev2.wor By: DJF

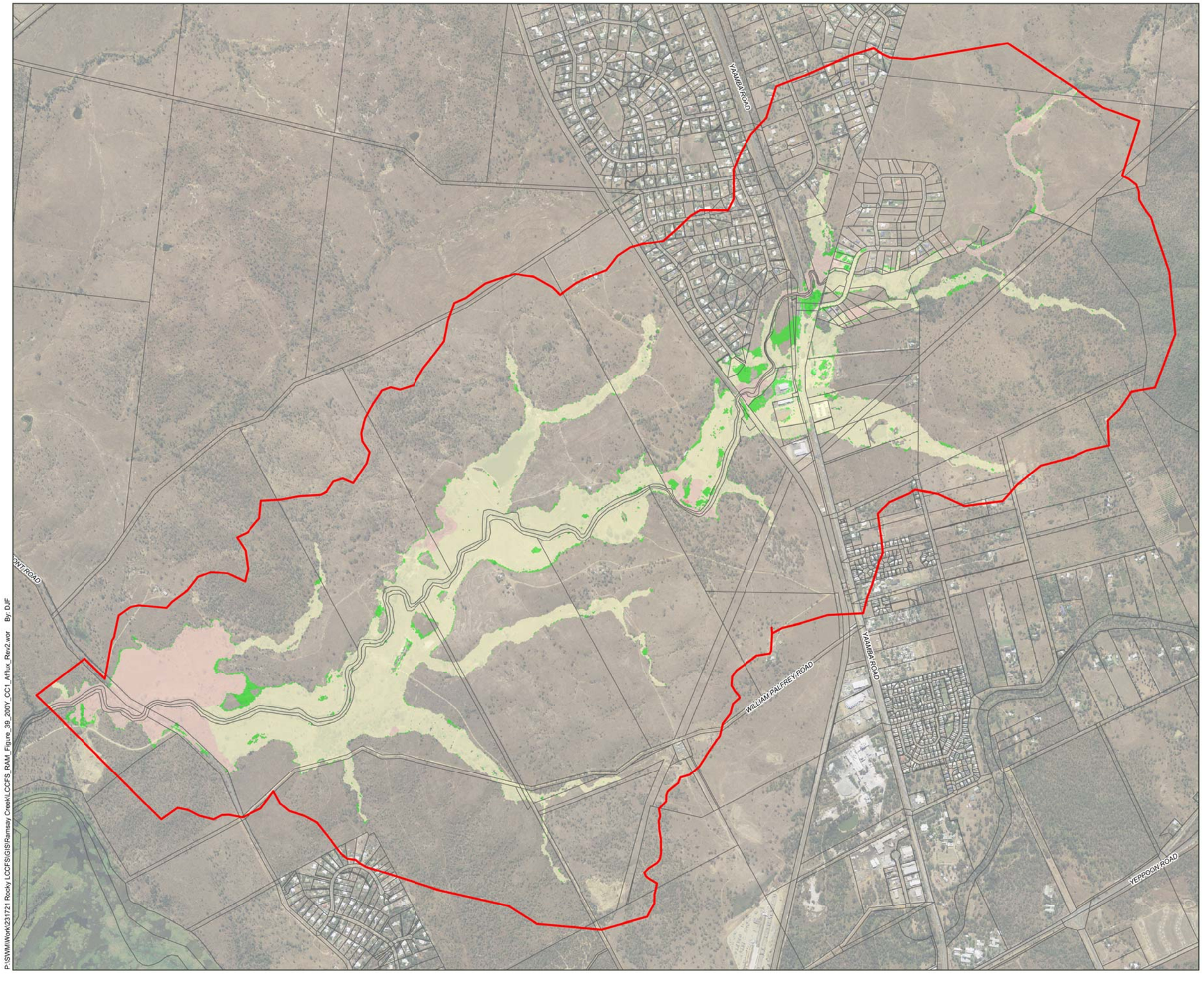
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 38: Climate Change Conditions - Scenario 1 (+20%) Increase in 100 Year ARI Peak Water Levels



aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents

Afflux (m)

- 0.00 to 0.25
- 0.25 to 0.50
- 0.50 to 0.75
- 0.75 to 1.00
- 1.00 to 1.50
- >1.5

- Was Dry Now Wet

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide leve plus 0.8m on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_39_200Y_CC1_Aflux_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

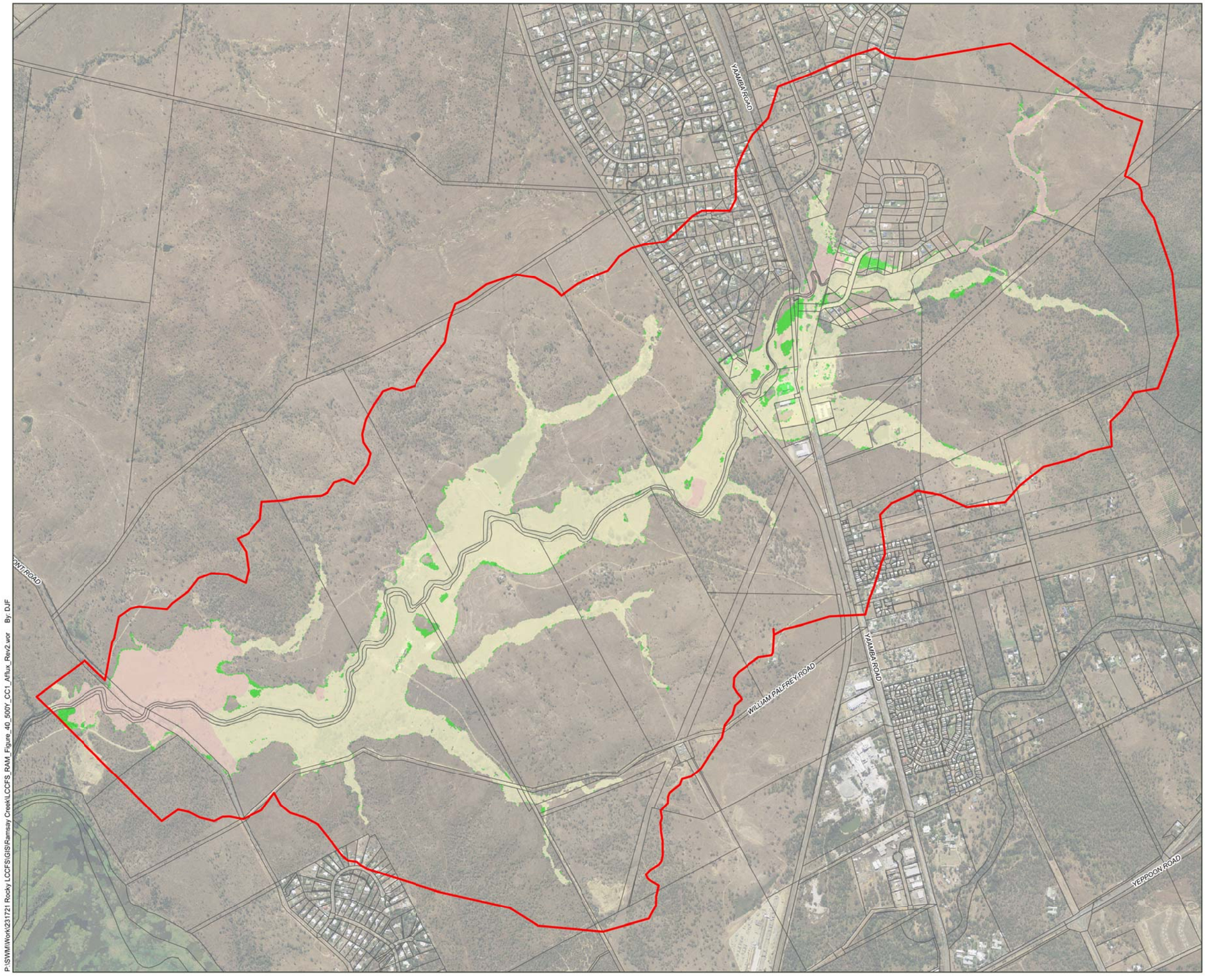
Figure 39: Climate Change Conditions - Scenario 1 (+20%) Increase in 200 Year ARI Peak Water Levels

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- Cadastre
- TUFLOW Model Extents

Afflux (m)

- 0.00 to 0.25
- 0.25 to 0.50
- 0.50 to 0.75
- 0.75 to 1.00
- 1.00 to 1.50
- >1.5

- Was Dry Now Wet

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide leve plus 0.8m on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 40: Climate Change Conditions - Scenario 1 (+20%) Increase in 500 Year ARI Peak Water Levels

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

YAMBARROAD

YAMBARROAD

WILLIAM PALFREY ROAD

YAAMBA ROAD

YEPPOON ROAD

Legend

- Cadastre
- TUFLOW Model Extents
- 100 Year ARI + Climate Change (20%) Event Inundation Extents
- 200 Year ARI + Climate Change (20%) Event Inundation Extents
- 500 Year ARI + Climate Change (20%) Event Inundation Extents

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide leve plus 0.8m on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_41_CC1_100Y_200Y_500Y_Comparison_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

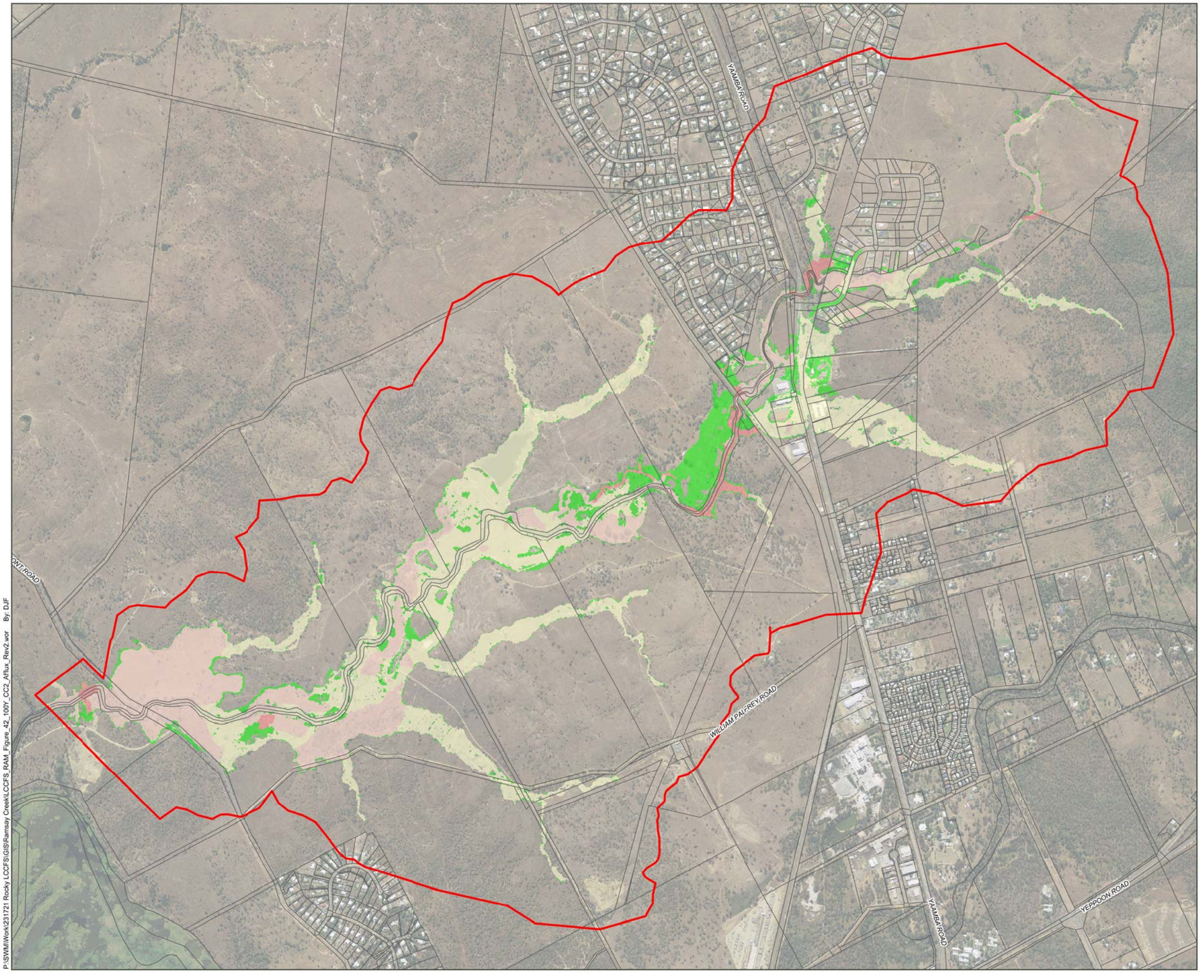
Figure 41: Climate Change Conditions - Inundation Extent Comparison - Scenario 1 (+20%) - 100, 200 & 500 Year ARI

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- Cadastre
- TUFLOW Model Extents

Afflux (m)

- 0.00 to 0.25
- 0.25 to 0.50
- 0.50 to 0.75
- 0.75 to 1.00
- 1.00 to 1.50
- >1.5
- Was Dry Now Wet

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide leve plus 0.8m on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_42_100Y_CC2_Aflux_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

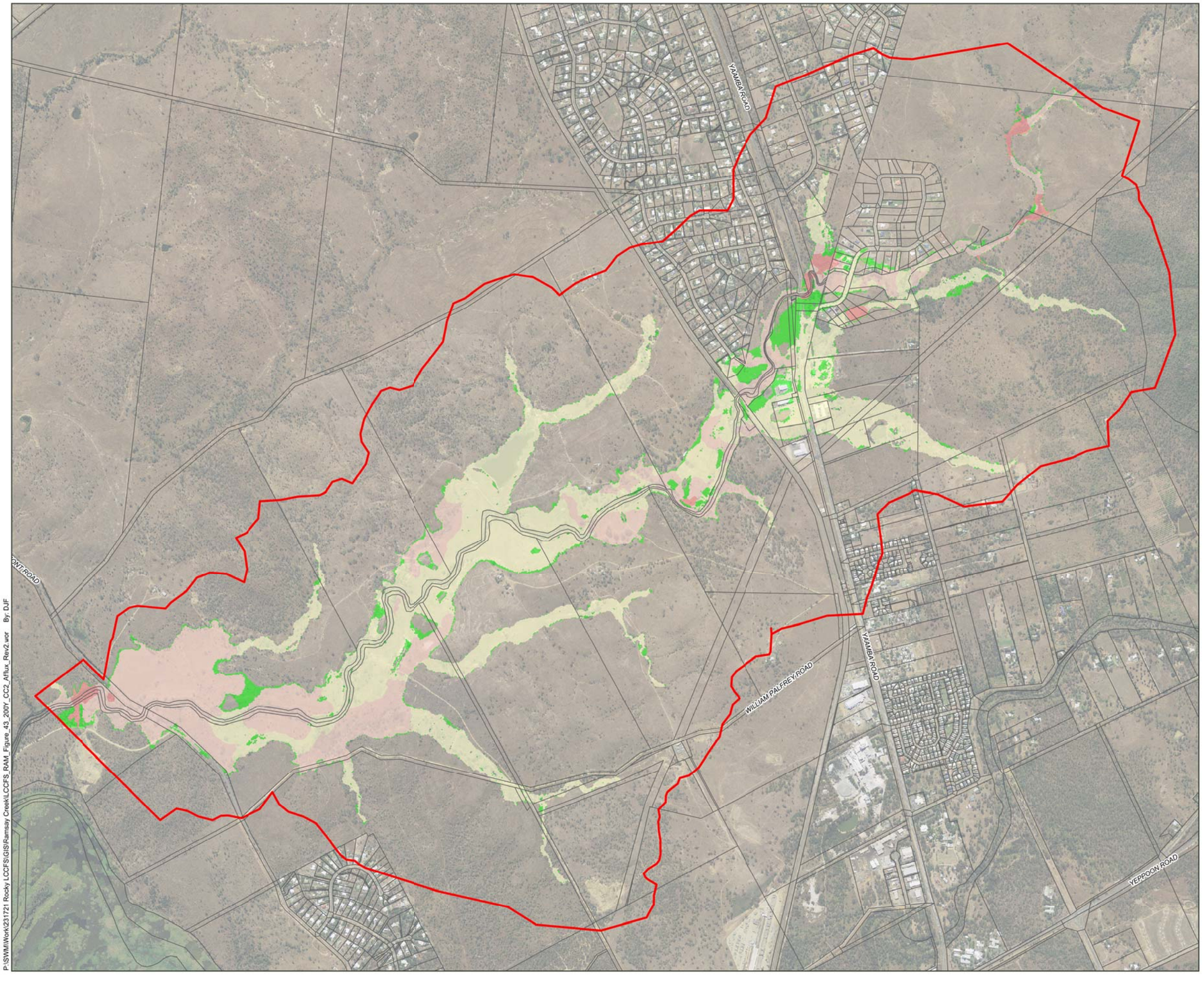
Figure 42: Climate Change Conditions - Scenario 2 (+30%) Increase in 100 Year ARI Peak Water Levels

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_43_200Y_CC2_Aflux_Rev2.wor By: DJF

Legend

- Cadastre
- TUFLOW Model Extents

Afflux (m)
- 0.00 to 0.25
- 0.25 to 0.50
- 0.50 to 0.75
- 0.75 to 1.00
- 1.00 to 1.50
- >1.5

- Was Dry Now Wet

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide leve plus 0.8m on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

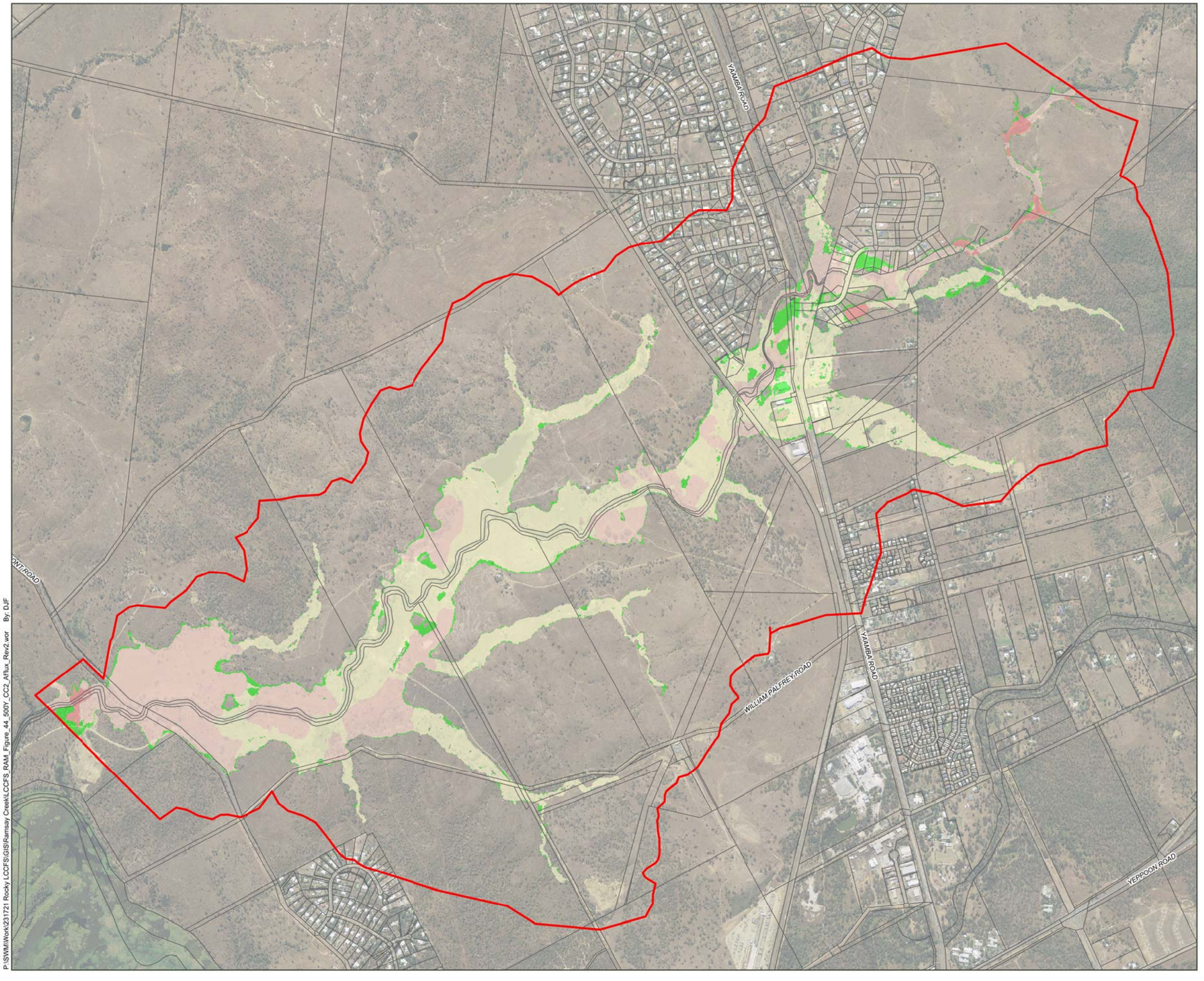
Figure 43: Climate Change Conditions - Scenario 2 (+30%) Increase in 200 Year ARI Peak Water Levels

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_44_500Y_CC2_Aflux_Rev2.wor By: DJF

Legend

- Cadastre
- TUFLOW Model Extents

Afflux (m)

- 0.00 to 0.25
- 0.25 to 0.50
- 0.50 to 0.75
- 0.75 to 1.00
- 1.00 to 1.50
- >1.5
- Was Dry Now Wet

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide leve plus 0.8m on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

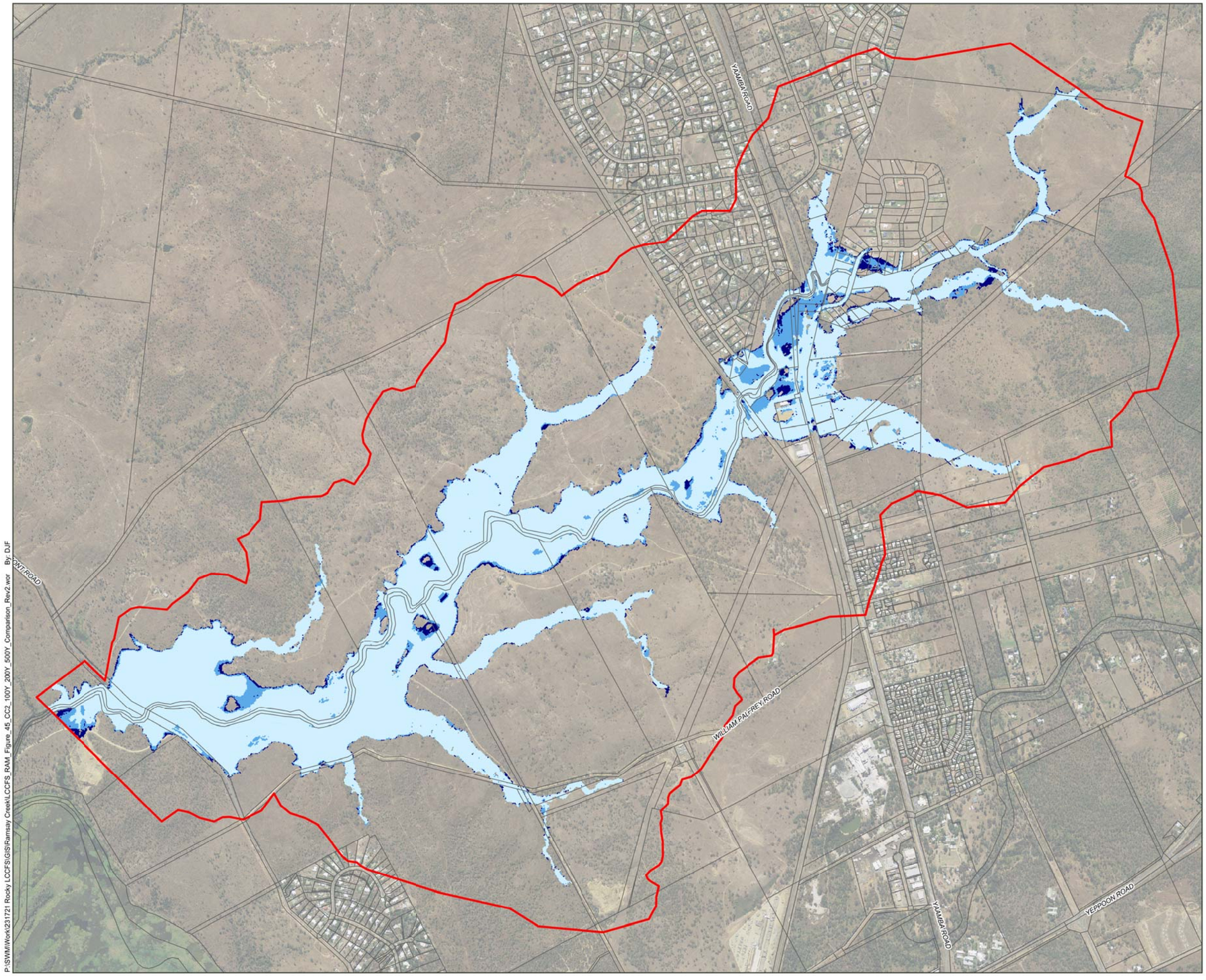
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 44: Climate Change Conditions - Scenario 2 (+30%) Increase in 500 Year ARI Peak Water Levels



aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- 100 Year ARI + Climate Change (30%) Event Inundation Extents
- 200 Year ARI + Climate Change (30%) Event Inundation Extents
- 500 Year ARI + Climate Change (30%) Event Inundation Extents

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide leve plus 0.8m on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

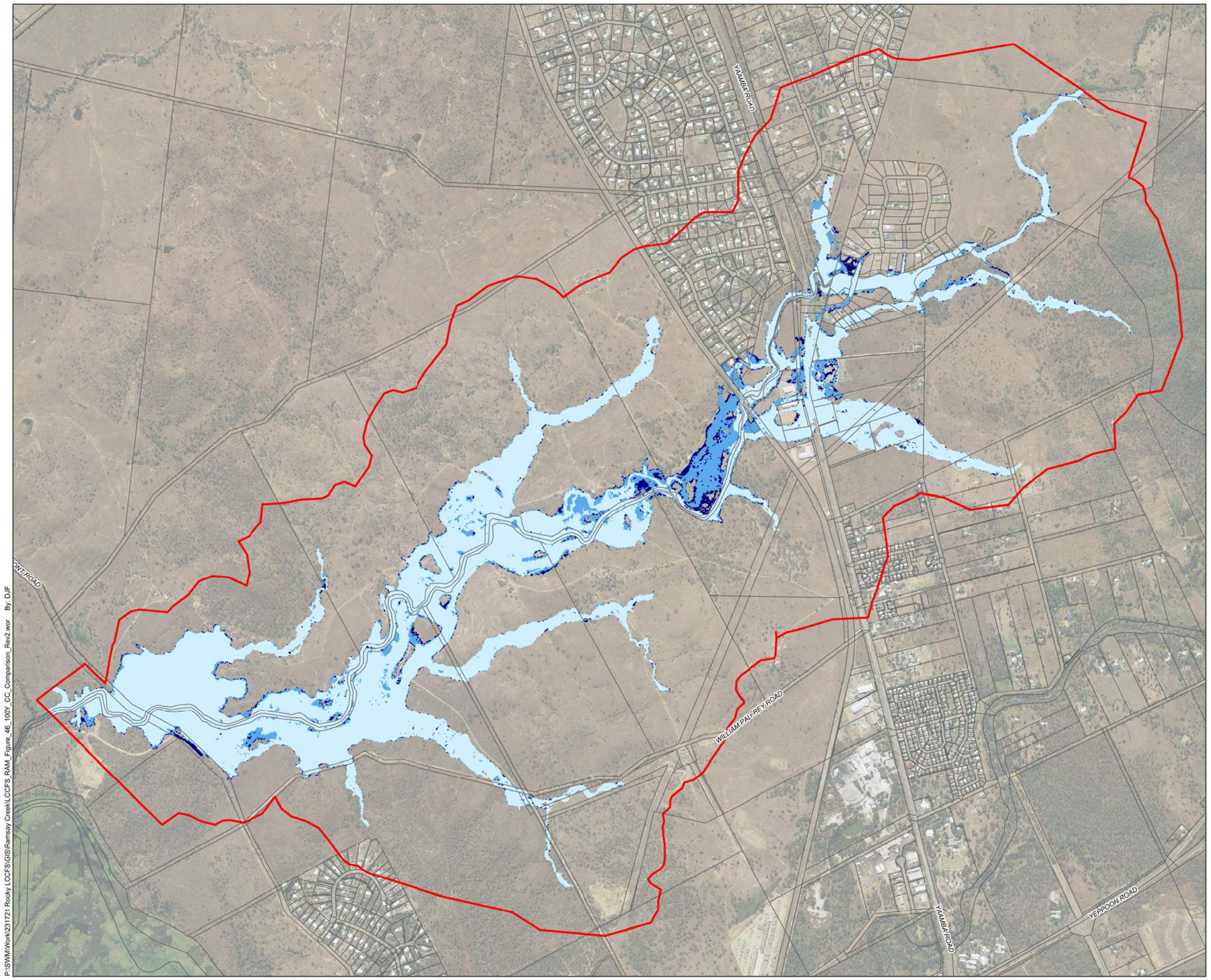
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 45: Climate Change Conditions - Inundation Extent Comparison - Scenario 2 (+30%) - 100, 200 & 500 Year ARI



aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- 100 Year ARI Event Inundation Extents
- 100 Year ARI + Climate Change (20%) Event Inundation Extents
- 100 Year ARI + Climate Change (30%) Event Inundation Extents

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide leve plus 0.8m on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_46_100Y_CC_Comparison_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

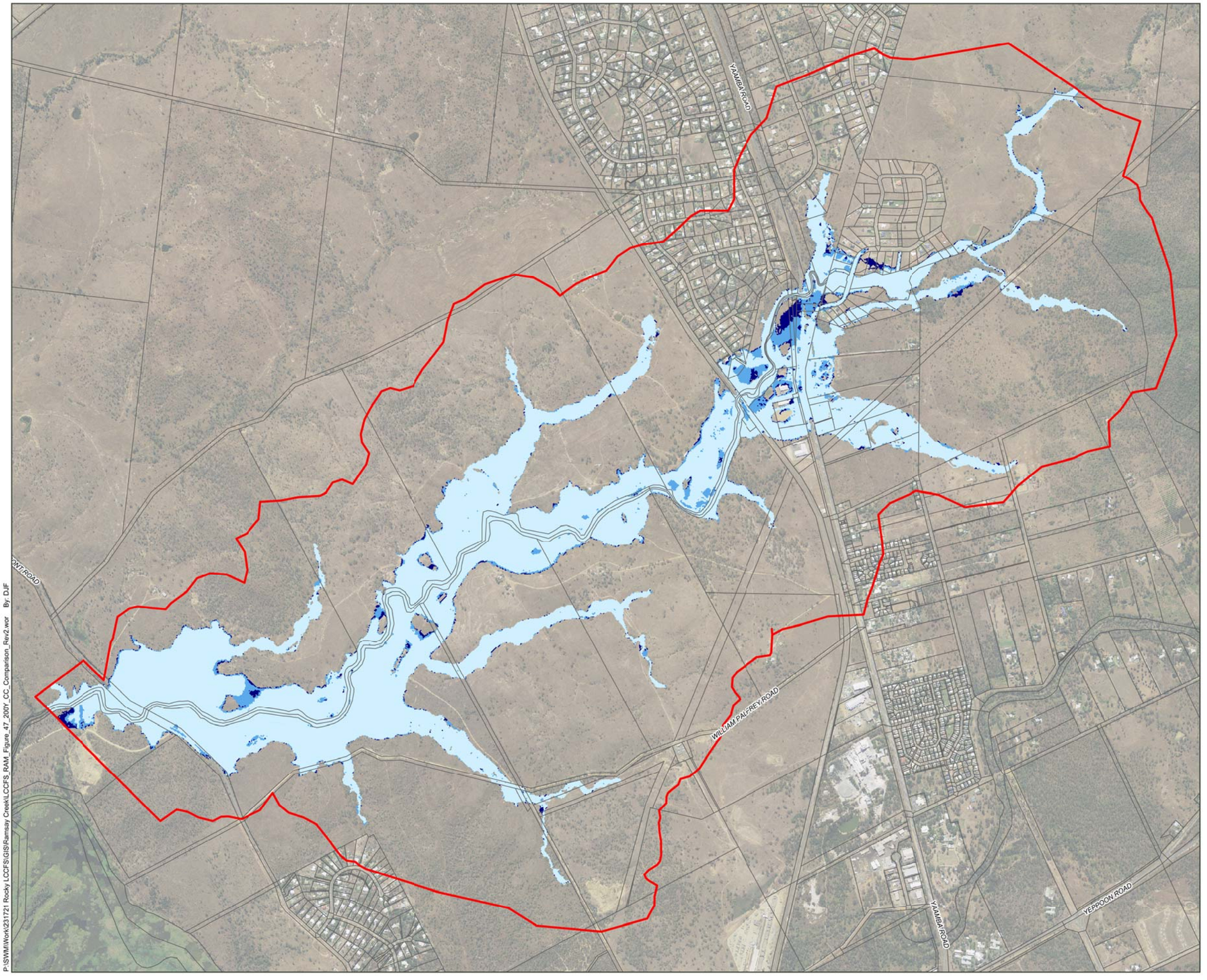
Figure 46: Climate Change Conditions - Inundation Extent Comparison - 100 Year ARI

aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government



Legend

- Cadastre
- TUFLOW Model Extents
- 200 Year ARI Event Inundation Extents
- 200 Year ARI + Climate Change (20%) Event Inundation Extents
- 200 Year ARI + Climate Change (30%) Event Inundation Extents

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide leve plus 0.8m on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_47_200Y_CC_Comparison_Rev2.wor By: DJF

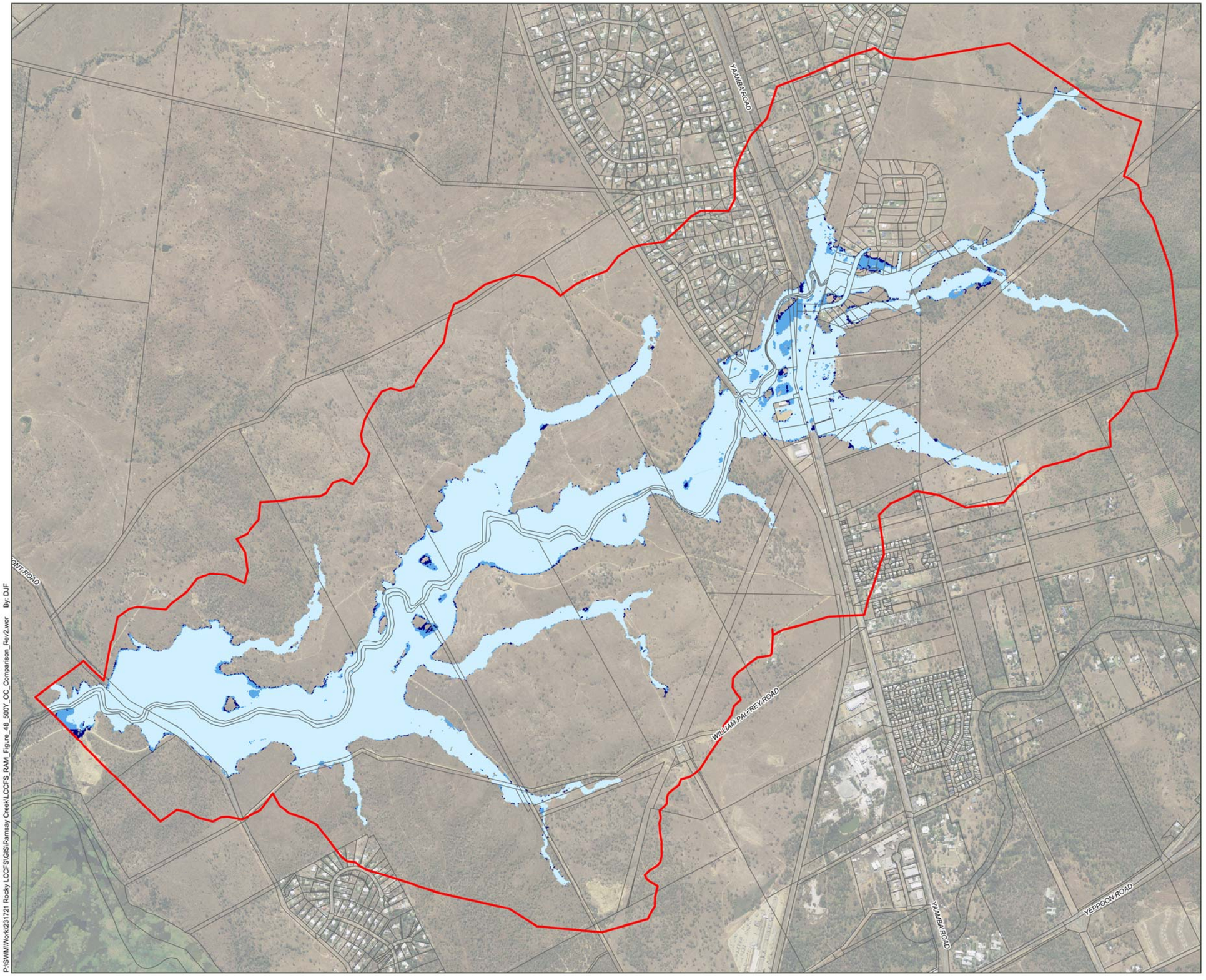
0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 47: Climate Change Conditions - Inundation Extent Comparison - 200 Year ARI



aurecon

Rockhampton Regional Council

Australian Government
Attorney-General's Department

Queensland Government

Legend

- Cadastre
- TUFLOW Model Extents
- 500 Year ARI Event Inundation Extents
- 500 Year ARI + Climate Change (20%) Event Inundation Extents
- 500 Year ARI + Climate Change (30%) Event Inundation Extents

Notes:

1. This map must not be used without consideration of, or reference to, the Explanatory Notes and Disclaimers which are provided on the Local Creek Catchments Flood Study: Ramsay Creek Figure 1 so as to understand the important limitations and conditions on such use.
2. This mapping considers local catchment flooding only. No consideration of regional flooding from the Fitzroy River has been made. No consideration of flooding in areas of piped urban stormwater drainage has been made.
3. This mapping shows inundation within the Ramsay Creek TUFLOW model extents only.
4. Outside of the TUFLOW model boundary, inundation associated with regional flooding has not been shown on this map.
5. Flood inundation of urban areas due to localsed overland flow should be considered indicative only. This study and the associated flood mapping is focused on creek flooding.
6. The inundation extents associated with climate change scenarios are based on a tailwater condition that assumes a concurrent Highest Astronomical Tide leve plus 0.8m on the Fitzroy River.

Date: 29/05/2014 **Version: 2**

P:\SWM\Work\231721 Rocky LCCFS\GIS\Ramsay Creek\LCCFS_RAM_Figure_48_500Y_CC_Comparison_Rev2.wor By: DJF

0 1000 (m)

Scale 1:20 000 (m) (@ A3 size)

Projection: MGA Zone 56

Local Creek Catchments Flood Study: Ramsay Creek

Figure 48: Climate Change Conditions - Inundation Extent Comparison - 500 Year ARI

Appendix B
RAFTS model parameters

Sub-catchment parameters

Sub-Catchment ID	Area (ha)	Slope (%)	% Impervious	Roughness (PerN)
RAM-1	107.3	2.6	0.0	0.086
RAM-2	143.6	1.8	0.1	0.071
RAM-3	90.4	2.9	0.6	0.076
RAM-4	96.5	2.5	0.1	0.096
RAM-5	111.1	3.1	5.0	0.068
RAM-6A	60.0	3.1	21.5	0.063
RAM-6B	52.4	2.1	52.1	0.045
RAM-7	130.0	3.4	0.9	0.079
RAM-8	77.2	1.6	64.7	0.037
RAM-9	21.4	2.2	34.4	0.057
RAM-10	72.1	2.0	7.0	0.068
RAM-11	43.9	1.7	59.8	0.047
RAM-12	69.2	1.6	21.9	0.059
RAM-13	146.6	0.6	6.2	0.068
RAM-14	134.1	1.1	0.0	0.070
RAM-15	143.6	0.6	1.2	0.070
RAM-16	63.7	1.3	0.0	0.070
RAM-17	78.4	1.6	7.3	0.067
RAM-18	154.3	1.1	0.0	0.070
RAM-19	54.2	1.1	1.9	0.070

Link parameters

Link ID	Length (m)	Adopted Velocity (m/s)	Lag Time (mins)
Link_CON-AA	514	1.7	5
Link_CON-AB	182	1.7	2
Link_CON-1A	251	1.7	2
Link_CON-1B	394	1.7	4
Link_CON-2A	109	1.7	1
Link_CON-2B	756	1.7	7
Link_CON-3A	397	1.7	4
Link_CON-3B	264	1.7	3
Link_CON-4A	579	1.7	6
Link_CON-4B	302	1.7	3
Link_DUM-1A	1359	2.5	9
Link_DUM-1B	0	0.0	0
Link_DUM-1C	0	0.0	0
Link_DUM-2A	277	2.5	2
Link_DUM-2B	0	0.0	0
Link_DUM-2C	0	0.0	0
Link_RAM-6A	1263	1.7	12
Link_RAM-6B	545	1.7	5
Link_RAM-8	491	1.7	5
Link_RAM-9	615	1.7	6
Link_RAM-11	267	1.7	3
Link_RAM-13	1792	1.7	18
Link_RAM-15	1334	1.7	13
Link_RAM-17	338	1.0	6
Link_RAM-19A	677	1.0	11
Link_RAM-19B	373	1.0	6

Appendix C
TUFLOW model peak discharges

Design event peak discharges

Results Type	Location	Peak Discharge (m^3/s)					
		2yr	5yr	10yr	20yr	50yr	100yr
1d Culverts	RAM_STI_01	23.2	36.3	47.9	64.3*	76.3*	78.3*
	RAM_XXX_01	5.5	7.8	9.1	11.3	15.9	19.8
	RAM_YAA_02	5.4	8.0	9.6	11.3	12.2*	12.8*
	RAM_YAA_03	3.3	5.2	6.8	9.0*	11.4*	13.7*
	RAM_NOR_01	3.1	4.7	6.1	7.9	12.0	15.3
2d Lines	RAM_YAM_01	25.8	39.9	52.2	70.0	91.0	105.0
	RAM_NCR_02	31.7	48.8	63.7	83.6	105.6	121.5

** Indicates that road is inundated*

Design event critical durations

Results Type	Location	Critical Duration (mins)					
		2yr	5yr	10yr	20yr	50yr	100yr
1d Culverts	RAM_STI_01	180	180	180	120	120	120
	RAM_XXX_01	180	180	180	180	120	120
	RAM_YAA_02	360	180	180	180	120	120
	RAM_YAA_03	180	180	120	120	120	120
	RAM_NOR_01	180	180	120	120	120	120
2d Lines	RAM_YAM_01	180	180	180	120	120	120
	RAM_NCR_01	270	180	180	180	120	120

Appendix D
Discharge hydrographs at key locations

When reviewing the discharge hydrographs, some points to note are:

- In some locations the critical duration varies for different magnitude events. For example, at Yaamba Road, the 180 minute duration is critical for the 2 to 10 year ARI events and the 120 minute duration is critical for the 20 to 100 year ARI events. For this reason the shape of the 2 to 10 year ARI hydrographs at this location is different to that of the hydrographs for the other events
- Where there are culverts, some graphs of the model results show a sharp change in the discharges. This occurs when the flow regime in the culvert changes, such as when the culvert inlet or outlet becomes submerged. Whilst discharge results show significant changes at these locations, the modelled peak water levels do not change

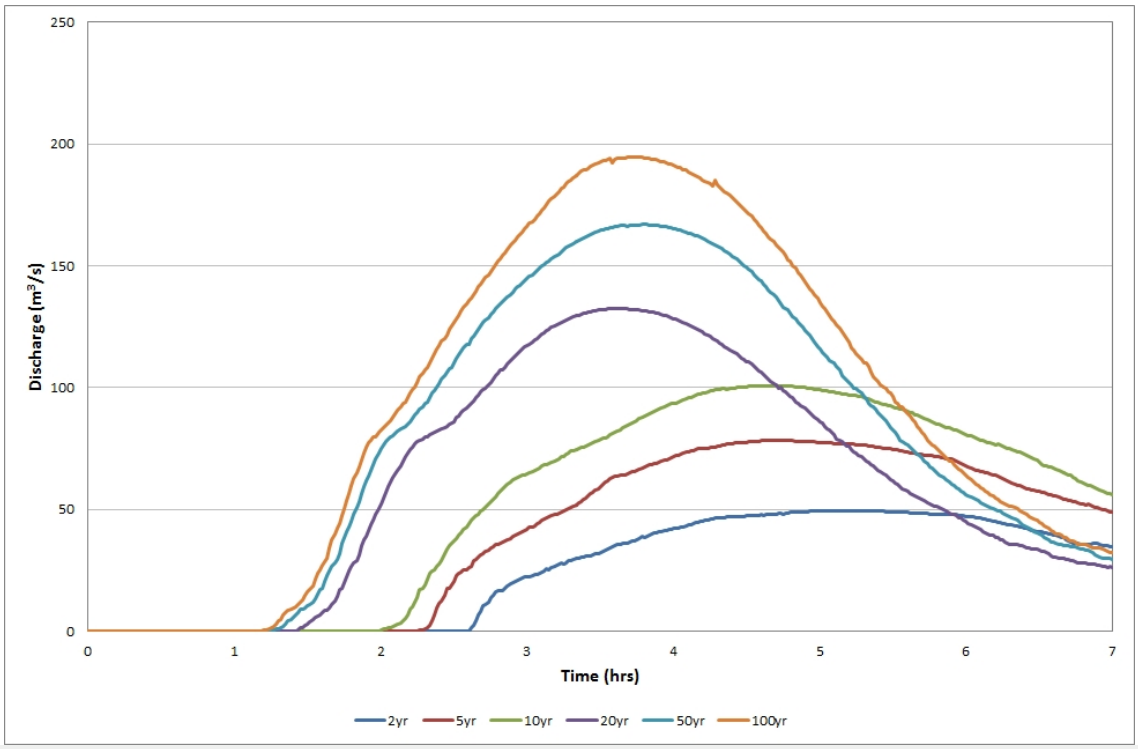


Image 2 | Design Event Discharge Hydrographs – Directly downstream of Belmont Road

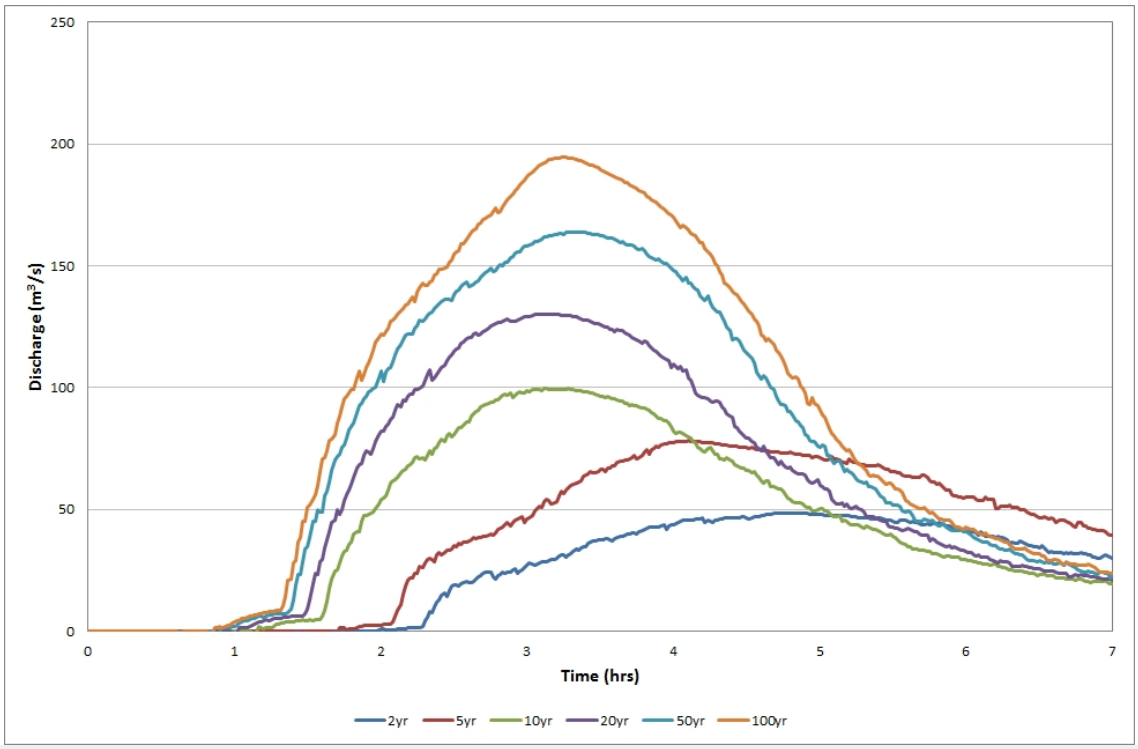


Image 3 | Design Event Discharge Hydrographs – 800m upstream of Belmont Road

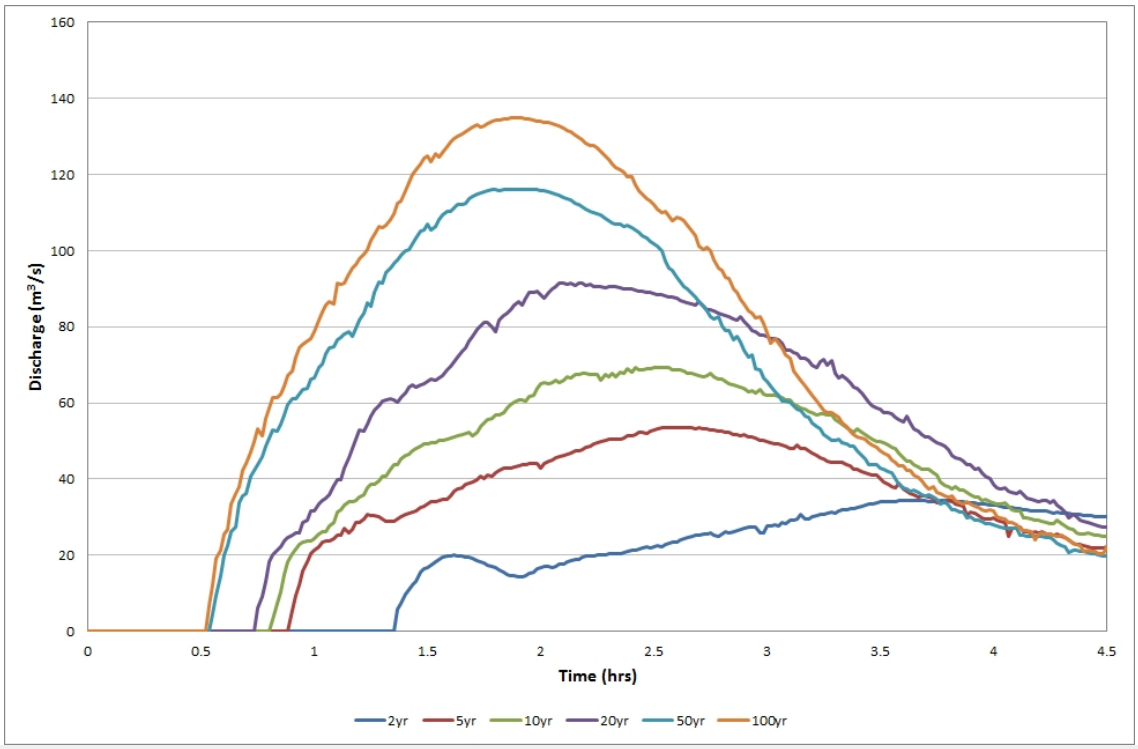


Image 4 | Design Event Discharge Hydrographs – 200m downstream of North Coast Railway

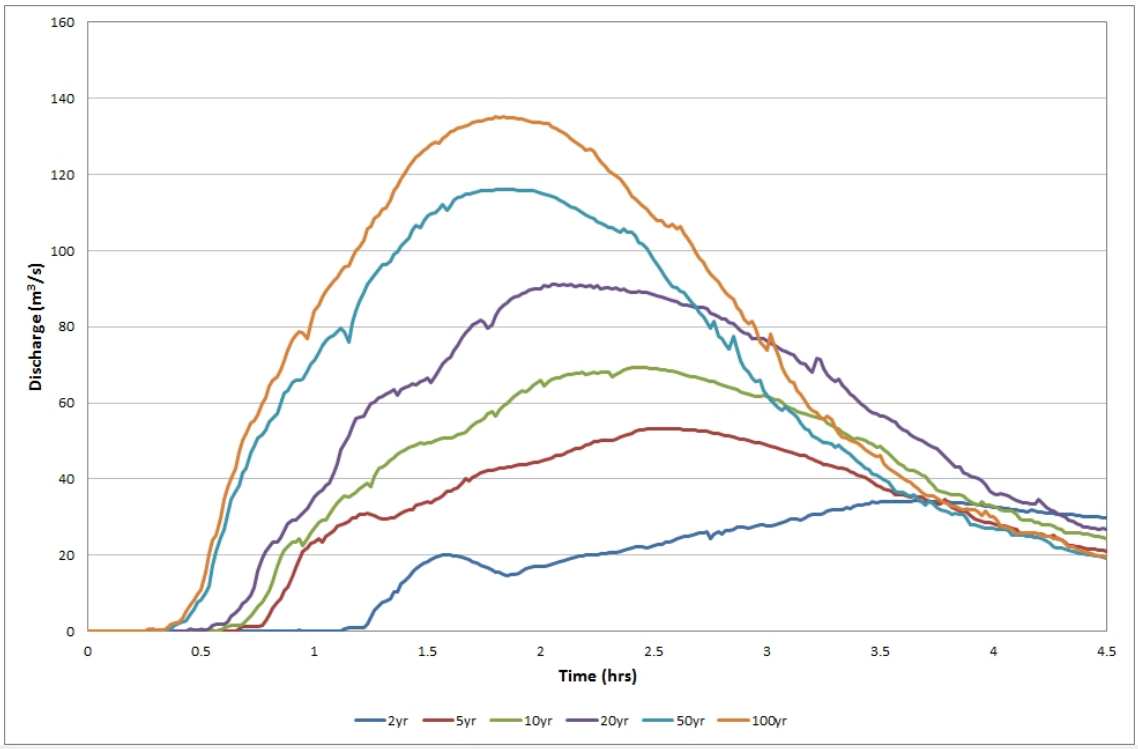


Image 5 | Design Event Discharge Hydrographs – North Coast Railway Total

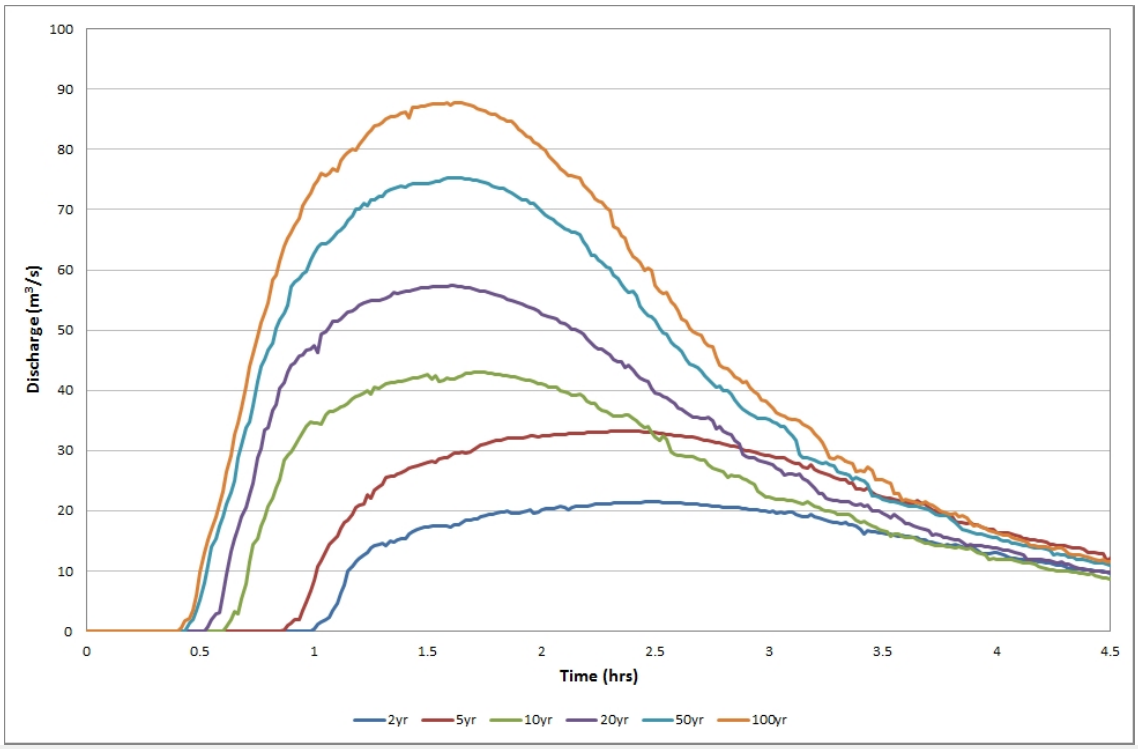


Image 6 | Design Event Discharge Hydrographs – Upstream of Stirling Drive

Appendix E
Critical infrastructure inundation assessment

Roads and rail

ARI at which Road Becomes Inundated (not Closure Level)	Road/Street Name*	Suburb	Road/Street Section Inundated in PMF Event	Location where Road/Street First Becomes Inundated
10yr-20yr	Yaamba Road	Parkhurst	900m long section	Near True blue Motor Inn
50yr-100yr	North Coast Rail Line	Parkhurst	400m long section	South of the bridge

** Based upon major roads information supplied by Council*

Water and sewerage infrastructure

ARI at which Infrastructure Becomes Inundated*	Infrastructure Type	Suburb	Name/Location
500yr-PMF	Pump Station	Parkhurst	Ramsay Park

** ARI was determined based upon the location of the water/sewerage point object, as provided in GIS. It may not be representative of the facility as a whole.*

Critical infrastructure, emergency facilities and possible evacuation shelters

Approx ARI at which Building Location Starts to Become Inundated*	ARI at which Property Starts to Become Inundated	Infrastructure Type	Address	Suburb	Name
There is no critical infrastructure, emergency facilities or possible evacuation shelters within the Ramsay Creek catchment					

** Building locations were determined from the aerial image and are indicative only. This assessment does not take into account building floor levels.*

Aurecon Australia Pty Ltd
ABN 54 005 139 873

Level 14, 32 Turbot Street
Brisbane QLD 4000

Locked Bag 331
Brisbane QLD 4001
Australia

T +61 7 3173 8000
F +61 7 3173 8001
E brisbane@aurecongroup.com
W aurecongroup.com