Flood Studies

TOOWOOMBA REGION
Rich traditions. Bold ambitions.

Letter Reports: Preparation of 1% Annual Exceedance Probability (AEP) Mapping for Cambooya, Jondaryan, Kulpi and Mt Tyson

June 2014 • *Endorsed on 25 February 2015*

GENERAL NOTE

These reports/documents are a base source of information that will be continually refined over time.

DISCLAIMER

18 June 2014

Toowoomba Regional Council
PO Box 3021
TOOWOOMBA VILLAGE FAIR QLD 4350

Our ref: 41/27840
5586

Your ref:

Dear Megan,

Preparation of 1% AEP Mapping
WP02 - Kulpi

1 Introduction

The Toowoomba Regional Council (TRC) SP 51 Flood Studies Project included a number of historical studies which used the flooding during December 2010 or January 2011 as the basis for assessing the steady-state hydraulic behaviour of those floods. The studies found that most events probably had an AEP of approximately 1% or smaller which makes them suitable for use in the preparation of planning schemes as discussed in the State Planning Policy 1/03[1] . However at some locations the AEP of the December 2010/January 2011 event was found to be greater than 1%. The AEP of the historical event that occurred at Kulpi is estimated to be approximately 2% (SKM[2], 2014).

GHD have been engaged to apply the 1% AEP peak discharge to the existing hydraulic model, and produce flood maps of Kulpi. This letter report serves as an addendum to the SKM report and further details of the model development are provided in that report.

2 Estimation of Peak Discharge & Inflow Locations

Two catchments contribute flow to the Kulpi area; Middle Creek, and a tributary of Middle Creek. SKM (2014) estimated the 1% AEP discharge using the Quantile Regression Technique (QRT[3]) for both catchments and these are tabulated in Table 1.

Table 1 Estimated Discharge

Catchment	Area (km^2)	Estimated 1% AEP Discharge (m^3/s)	Validated Model Peak Discharge (m^3/s)	% Difference in Peak Discharge
Middle Creek	56.1	260	200	30%
Middle Creek Tributary	2.9	35.3	25.8	37%

[1] Mitigating the Adverse Impacts of Flood, Bushfire and Landslide prepared by the Queensland Government Departments of Local Government and Planning, and Emergency Services (LGPES)

[2] SKM 2014, SP051 Flood Studies – Work Package 2 – Historical Studies for Kulpi and Mount Tyson, SKM, South Brisbane.

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

GHD Pty Ltd ABN 39 008 488 373
Suite 4 Level 2, 1-3 Annand Street Toowoomba QLD 4350 PO Box 1642 Toowoomba QLD 4350 Australia
T 61 7 4633 8000 F 61 7 4613 1687 E tbamail@ghd.com W www.ghd.com

The above peak discharges were applied to the model at the existing locations defined in the model. The Middle Creek catchment has two inflow locations in the north-east corner of the model, and this inflow was proportioned appropriately between the two locations. Inflow locations and discharges are displayed in Table 2.

Table 2 Inflow Locations

Catchment	Location (Model Coordinates)	Discharge (m³/s)
Middle Creek 1	1108,1245 – 1322,1245	247
Middle Creek 2	1377,979 – 1377,1062	13
Middle Creek Tributary	1016,0 – 1111,0	35.3

3 Hydraulic Modelling

It was assumed that the existing validated hydraulic model was satisfactory as the modelling base for this assessment. The above steady-state inflows were applied to the validated MIKE FLOOD model developed by SKM (2014). No other changes were made to the hydraulic model. The following flood inundation maps were produced from the results:

- Peak Water Depth
- Peak Water Surface Elevation
- Hazard Category
- Hydraulic Category

These maps accompany this letter.

No sensitivity analyses were performed for this assessment as the influence of peak flow rate and surface roughness is documented in the SKM report.

4 Conclusion

The flood extents presented here are larger than those shown for the model validation. This is to be expected given the 1% AEP peak flow rates are larger (See Table 1). This letter report has addressed the peer review comments[4] relating to this assessment.

We thank TRC for the opportunity to undertake this work, Should you have any queries regarding this letter, please do not hesitate to contact me.

[4] GHD Letter from Peer Reviewer (T Loxton) to TRC (M Phillips), dated 30 May 2014

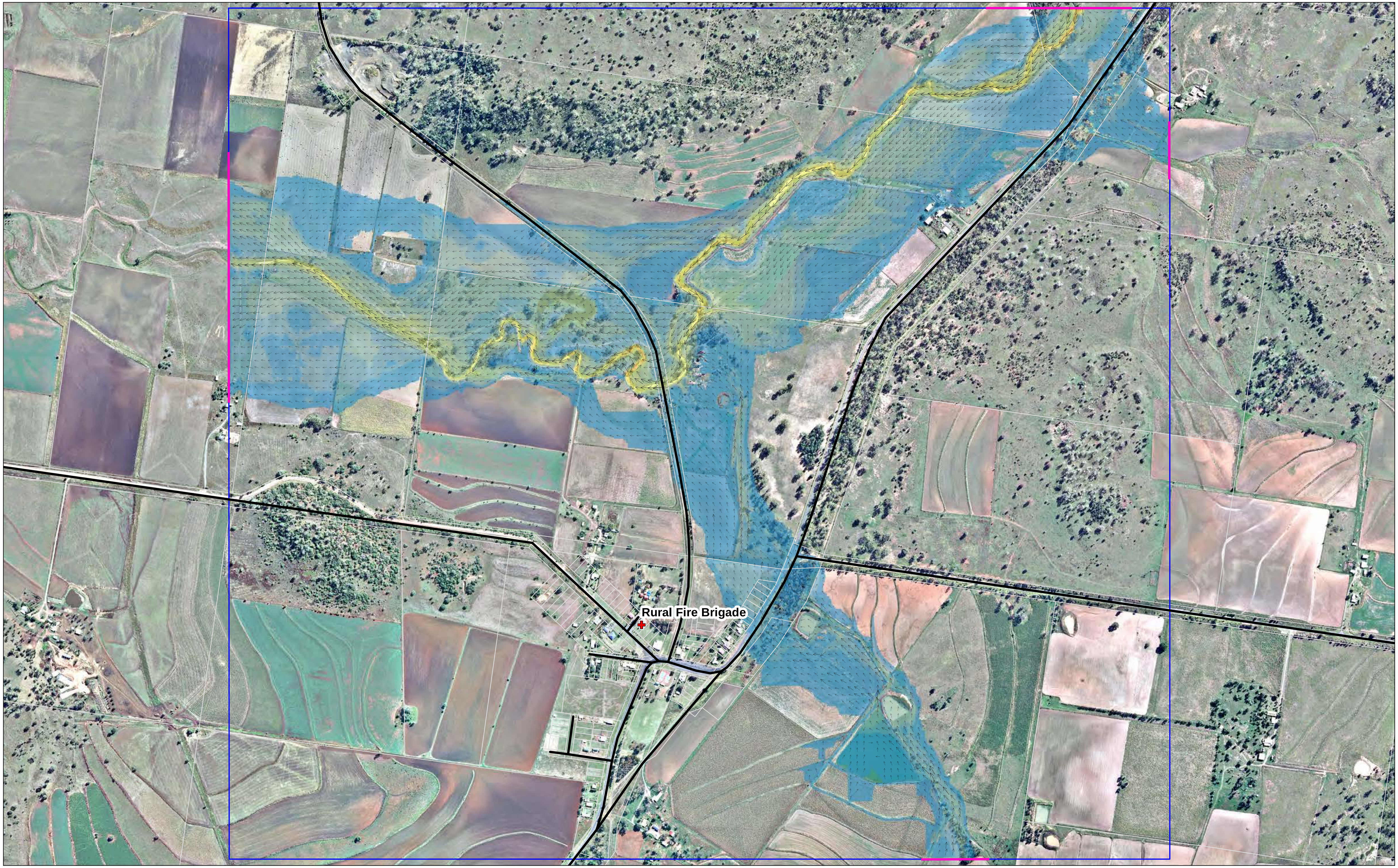
Yours sincerely,

Paul Muir
Agricultural Engineer
61 7 4633 8009

Attachments:

Figure 1 – Peak Water Depth
Figure 2 – Peak Water Surface Elevation
Figure 3 – Hazard Category
Figure 4 – Hydraulic Category

cc: Toby Loxton, GHD



TOOWOOMBA REGIONAL COUNCIL

1:10,000 (at A3)

0 75 150 300
Meters

GDA 1994 MGA Zone 56

N

Legend

- Emergency Services
- Model Boundaries
- Road Centrelines
- Model Extent
- Cadastre

Flood Depth (m)

0 - 0.25 | 0.25 - 0.5 | 0.5 - 1.0 | 1.0 - 1.5 | 1.5 - 2.0 | 2.0 - 2.5 | 2.5 - 3.0 | 3.0 - 3.5 | 3.5 - 4.0 | 4.0 - 4.5

Velocity (m/s)

0 - 1 | 1 - 2 | 2 - 3 | > 3

Figure 1
SP 051 Flood Studies
Work Package 2 - Kulpi
1% AEP Flood Depth & Velocities

![TOOWOOMBA REGIONAL COUNCIL]

1:10,000 (at A3)

0 75 150 300

Meters

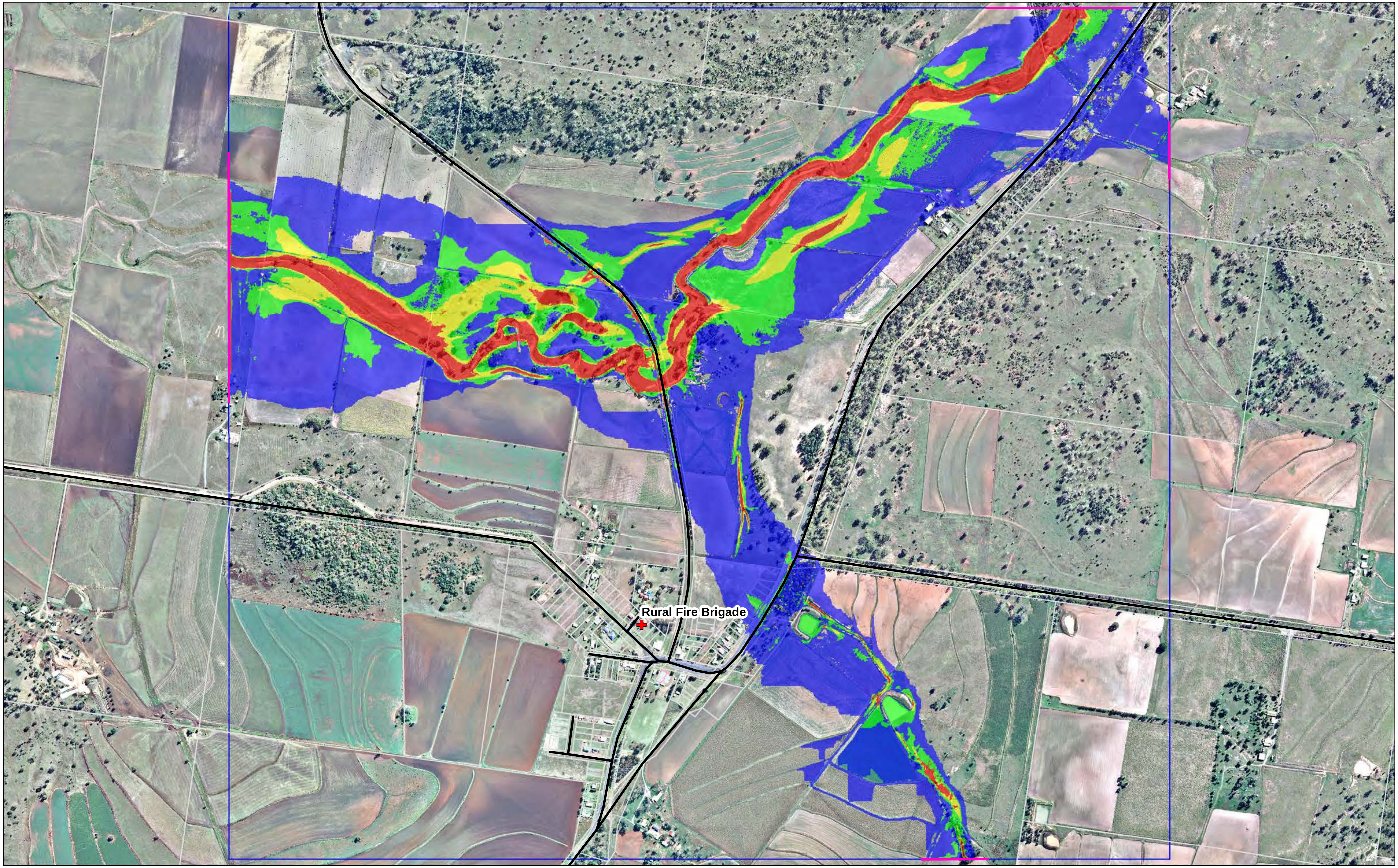
GDA 1994 MGA Zone 56

N

Legend

- Emergency Services
- Water Surface Contour (0.2m interval)
- Model Boundaries
- Road Centrelines
- Inundation Extent
- Model Extent
- Cadastre

Figure 2
SP 051 Flood Studies
Work Package 2 - Kulpi
1% AEP Flood Level



TOOWOOMBA REGIONAL COUNCIL

1:10,000 (at A3)

0 75 150 300

Meters

GDA 1994 MGA Zone 56

N

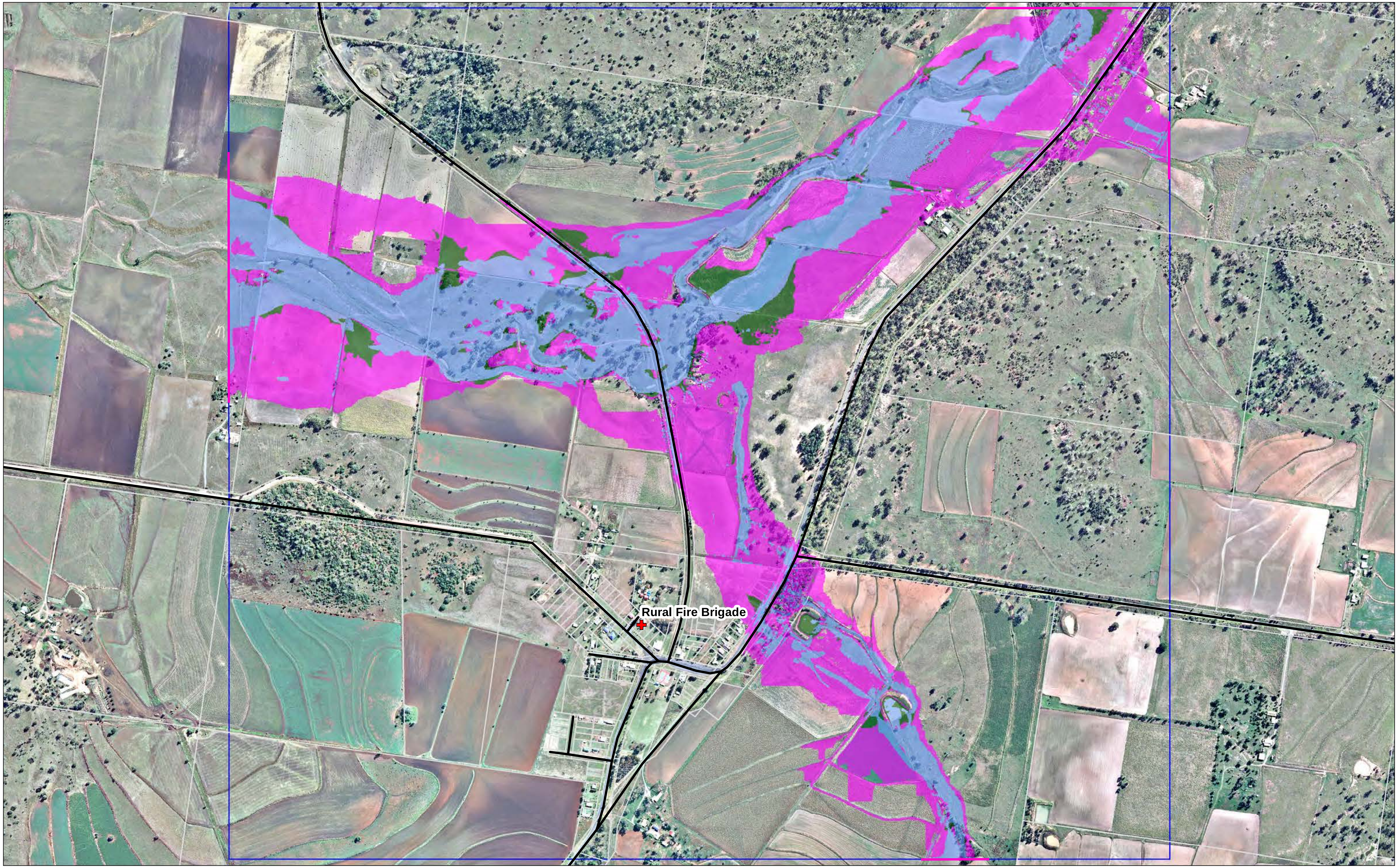
Legend

- Emergency Services
- Model Extent
- Model Boundaries
- Road Centrelines
- Cadastre

Hazard Category

- Low
- Significant
- High
- Extreme

Figure 3
SP 051 Flood Studies
Work Package 2 - Kulpi
1% AEP Flood Hazard



TOOWOOMBA REGIONAL COUNCIL

1:10,000 (at A3)

0 75 150 300
Meters

GDA 1994 MGA Zone 56

N

Legend

- Emergency Services
- Model Extent
- Model Boundaries
- Road Centrelines
- Cadastre

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

Figure 4
SP 051 Flood Studies
Work Package 2 - Kulpi
1% AEP Flood Hydraulic Category

18 June 2014

Toowoomba Regional Council
PO Box 3021
TOOWOOMBA VILLAGE FAIR QLD 4350

Our ref: 41/27840
5587

Your ref:

Dear Megan,

Preparation of 1% AEP Mapping
WP02 - Mount Tyson

1 Introduction

The Toowoomba Regional Council (TRC) SP 51 Flood Studies Project included a number of historical studies which used the flooding during December 2010 or January 2011 as the basis for assessing the steady-state hydraulic behaviour of those floods. The studies found that most events probably had an AEP of approximately 1% or smaller which makes them suitable for use in the preparation of planning schemes as discussed in the State Planning Policy 1/03[1]. However at some locations the AEP of the December 2010/January 2011 event was found to be greater than 1%. The AEP of the historical event that occurred at Mount Tyson is estimated to be 5% (SKM[2], 2014).

GHD have been engaged to apply the 1% AEP peak discharge to the hydraulic model, and produce flood maps of Mount Tyson. This letter report serves as an addendum to the SKM report and further details of the model development are provided in that report.

2 Estimation of Peak Discharge & Inflow Locations

Two unnamed tributaries pass either side of Mount Tyson. SKM (2014) estimated the 1% AEP discharge using the Quantile Regression Technique (QRT[3]) for both catchments, and the small contributing catchments on the ridge between the two tributaries. However GHD has revised this delineation using a 1:25,000 scale topographic map and the updated discharges are tabulated in Table 1. The revised catchment delineation is contained in Figure 1. The total peak contribution for the catchment for the validated model as calculated by SKM is 80 m^3/s. The total 1% AEP contribution calculated by GHD is 234 m^3/s, an increase of 193%.

[1] Mitigating the Adverse Impacts of Flood, Bushfire and Landslide prepared by the Queensland Government Departments of Local Government and Planning, and Emergency Services (LGPES).

[2] SKM 2014, SP051 Flood Studies – Work Package 2 – Historical Studies for Kulpi and Mount Tyson, SKM, South Brisbane

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

Table 1 Estimated Discharges

Catchment	Area (km²)	Estimated 1% AEP Discharge (m³/s)
Mount Tyson 1	0.8	17
Mount Tyson 2	1.22	22
Mount Tyson 3	9.7	85
Mount Tyson 4	14.5	110

The above peak discharges were applied to the model at the existing locations defined in the model. The inflow from the Mount Tyson 3 catchment was equally distributed at three locations, given its relative size compared to Mount Tyson catchments 1 and 2. Inflow locations and discharges are displayed in Table 2.

Table 2 Inflow Locations

Catchment	Location (Model Coordinates)	Discharge (m³/s)
Mount Tyson 1	708,281	17
Mount Tyson 2	502,289	22
Mount Tyson 3a	607,412	28
Mount Tyson 3b	338,512	28
Mount Tyson 3c	138,697	28
Mount Tyson 4	679,6 – 679,15	110

3 Hydraulic Modelling

It was assumed that the existing validated hydraulic model was satisfactory as the modelling base for this assessment. The above steady-state inflows were applied to the validated MIKE FLOOD model developed by SKM (2014).The only change to the model in addition to the inflow locations was the widening of the downstream boundary. The following flood inundation maps were produced from the results:

- Peak Water Depth
- Peak Water Surface Elevation
- Hazard Category
- Hydraulic Category

These maps accompany this letter.

No sensitivity analyses were performed for this assessment as the influence of peak flow rate and surface roughness is documented in the SKM report.

4 Conclusion

The flood extents presented here are larger than those shown for the model validation. This is to be expected given the 1% AEP peak flow rates are larger (See Section 2). This letter report has addressed the peer review comments[4] relating to this assessment.

We thank TRC for the opportunity to undertake this work, Should you have any queries regarding this letter, please do not hesitate to contact me.

Yours sincerely,

Paul Muir
Agricultural Engineer
61 7 4633 8009

Attachments:
Figure 1 – Catchment Delineation
Figure 2 – Peak Water Depth
Figure 3 – Peak Water Surface Elevation
Figure 4 – Hazard Category
Figure 5 – Hydraulic Category

cc: Toby Loxton, GHD

[4] GHD Letter from Peer Reviewer (T Loxton) to TRC (M Phillips), dated 30 May 2014

1:30,000 (at A3)

0 250 500 750 1,000

Metres

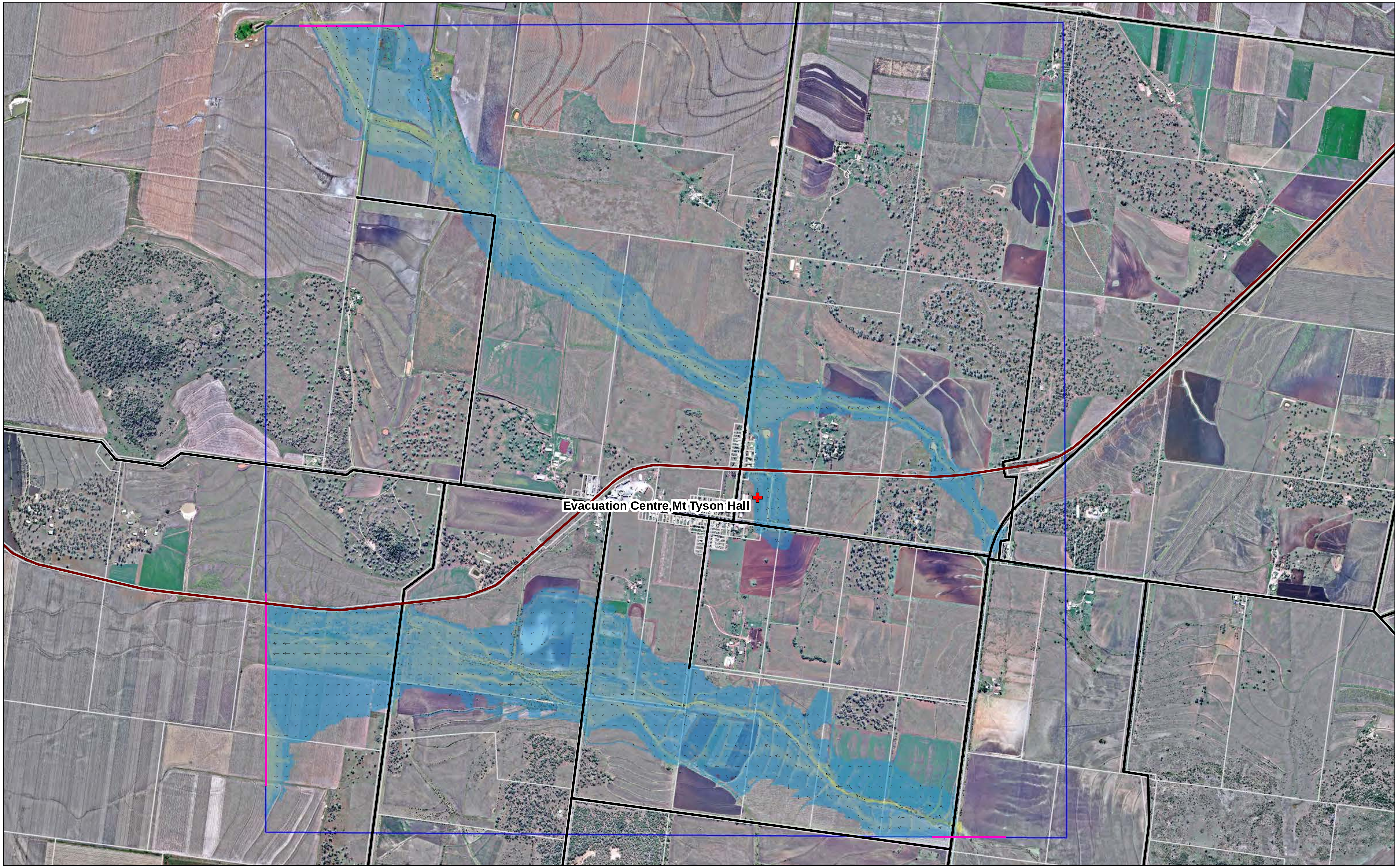
GDA 1994 MGA Zone 56

N

Legend

Catchment Boundary

Figure 1
SP 051 Flood Studies
Work Package 2 - Mount Tyson
Catchment Boundaries



1:20,000 (at A3)

0 150 300 600
Meters

GDA 1994 MGA Zone 56

N

TOOWOOMBA REGIONAL COUNCIL

Legend

- Emergency Services
- Rail Alignments
- Model Boundaries
- Road Centrelines
- Model Extent
- Cadastre

Flood Depth (m)

0 - 0.25	1.5 - 2.0
0.25 - 0.5	2.0 - 2.5
0.5 - 1.0	2.5 - 3.0
1.0 - 1.5	

Velocity (m/s)

0 - 1	2 - 3
1 - 2	> 3

Figure 2
SP 051 Flood Studies
Work Package 2 - Mount Tyson
1% AEP Flood Depth & Velocities

TOOWOOMBA REGIONAL COUNCIL

1:20,000 (at A3)

0 150 300 600
Meters

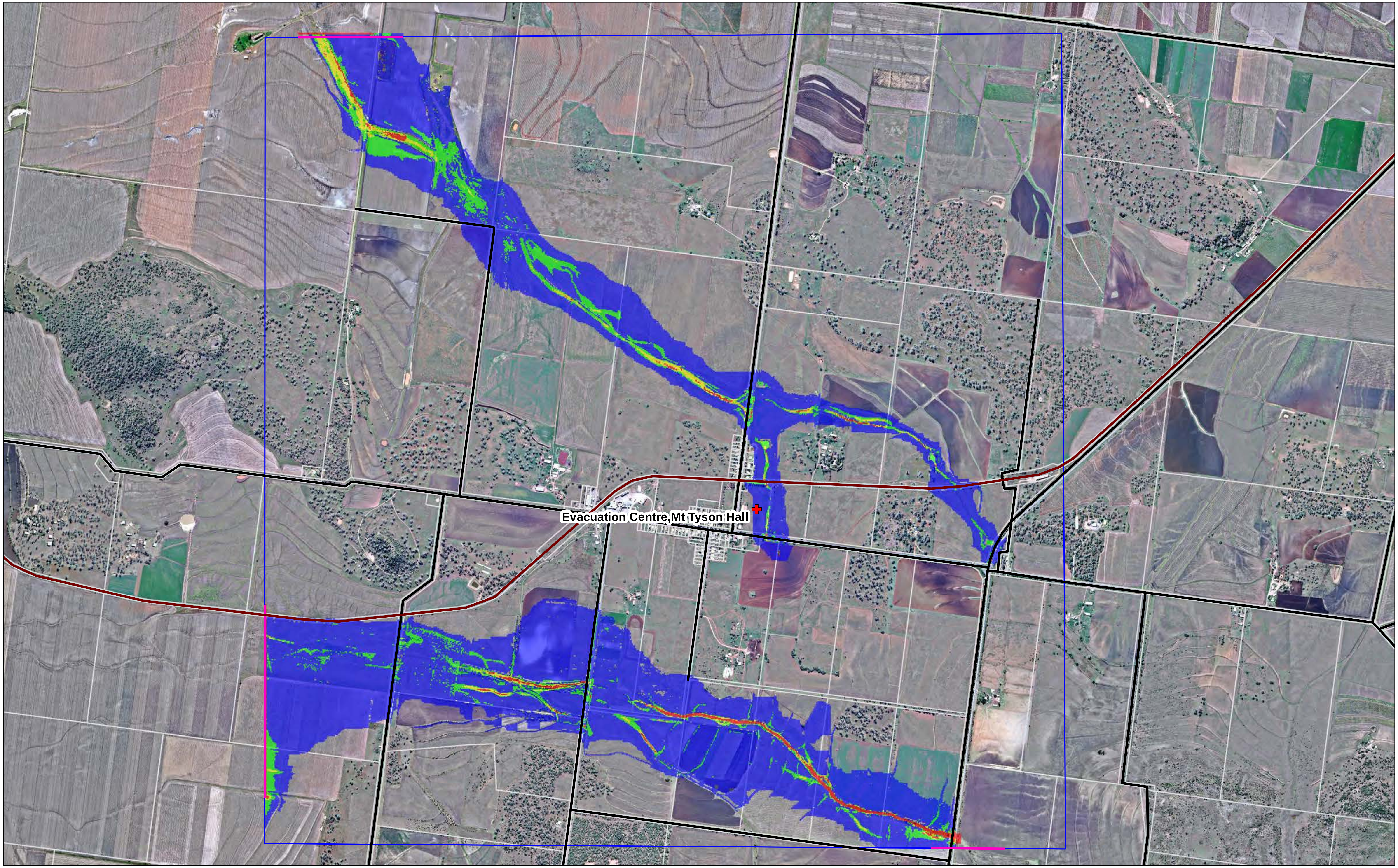
GDA 1994 MGA Zone 56

N

Legend

- Emergency Location
- Water Surface Contour (0.2m interval)
- Model Boundaries
- Road Centrelines
- Rail Alignments
- Model Extent
- Inundation Extent
- Cadastre

Figure 3
SP 051 Flood Studies
Work Package 2 - Mount Tyson
1% AEP Flood Level



TOOWOOMBA REGIONAL COUNCIL

1:20,000 (at A3)

0 150 300 600

Meters

GDA 1994 MGA Zone 56

N

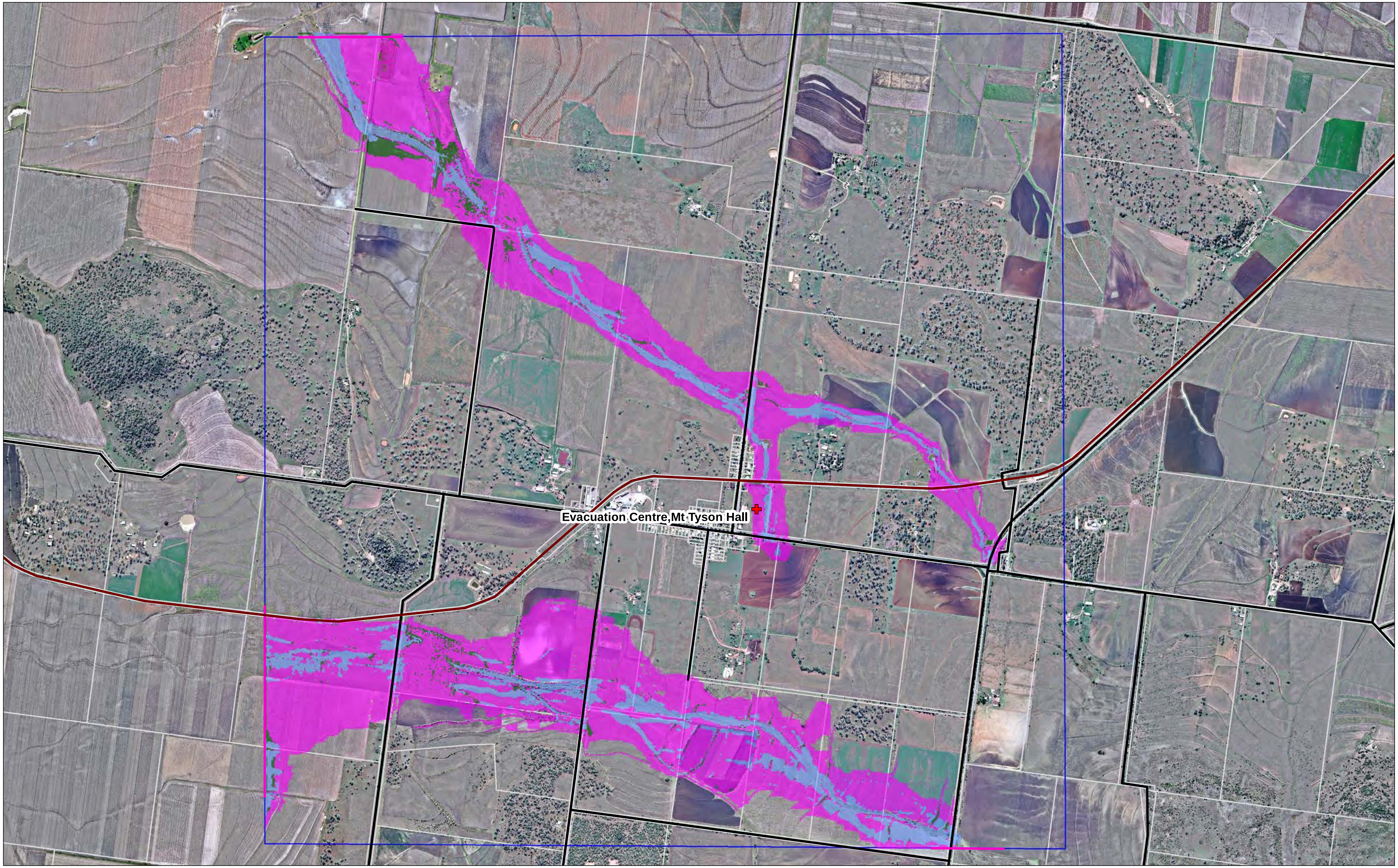
Legend

- Emergency Services
- Rail Alignments
- Model Boundaries
- Road Centrelines
- Model Extent
- Cadastre

Hazard Category

- Low
- Significant
- High
- Extreme

Figure 4
SP 051 Flood Studies
Work Package 2 - Mount Tyson
1% AEP Flood Hazard



TOOWOOMBA REGIONAL COUNCIL

1:20,000 (at A3)

0 150 300 600

Meters

GDA 1994 MGA Zone 56

N

Legend

Emergency Services
Rail Alignments
Model Boundaries
Road Centrelines
Model Extent
Cadastre

Hydraulic Category

Floodway
Flood Storage
Flood Fringe

Figure 5
SP 051 Flood Studies
Work Package 2 - Mount Tyson
1% AEP Flood Hydraulic Category

18 June 2014

Toowoomba Regional Council
PO Box 3021
TOOWOOMBA VILLAGE FAIR QLD 4350

Our ref: 41/27840
5588

Your ref:

Dear Megan,

Preparation of 1% AEP Mapping
WP03 - Jondaryan

1 Introduction

The Toowoomba Regional Council (TRC) SP 51 Flood Studies Project included a number of historical studies which used the flooding during December 2010 or January 2011 as the basis for assessing the steady-state hydraulic behaviour of those floods. The studies found that most events probably had an AEP of approximately 1% or smaller which makes them suitable for use in the preparation of planning schemes as discussed in the State Planning Policy 1/03[1]. However at some locations the AEP of the December 2010/January 2011 event was found to be greater than 1%. The AEP of the historical event that occurred at Jondaryan is estimated to be approximately 1 in 40 (WRM & DHI[2], 2014).

GHD have been engaged to apply the 1% AEP peak discharge to the hydraulic model developed by WRM & DHI, and produce flood maps of Jondaryan. This letter report serves as an addendum to the WRM & DHI report and further details of the model development are provided in that report.

2 Estimation of Peak Discharge & Inflow Locations

Jondaryan is located on Lagoon Creek and yields a catchment of 135 km² (see Figure 1). The 1% AEP discharge for the catchment was estimated using the Quantile Regression Technique (QRT[3]) and is tabulated in Table 1.

Table 1 Estimated Discharge

Catchment	Estimated 1% AEP Discharge (m³/s)	Validated Model Peak Discharge (m³/s)	% Difference in Peak Discharge
Lagoon Creek	450	300	50%

The above peak discharge was applied to the model at the existing location defined in the model and is displayed in Table 2.

[1] Mitigating the Adverse Impacts of Flood, Bushfire and Landslide prepared by the Queensland Government Departments of Local Government and Planning, and Emergency Services (LGPES).

[2] WRM & DHI 2014, Work Package 3 Historical Study for Jondaryan Final Report, WRM & DHI, Brisbane.

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

Table 2 Inflow Location

Catchment	Location (Model Coordinates)	Discharge (m^3/s)
Lagoon Creek	1200,865 – 1200,990	450

3 Hydraulic Modelling

It was assumed that the existing validated hydraulic model was satisfactory as the modelling base for this assessment. The above steady-state inflows were applied to the validated MIKE FLOOD model developed by WRM & DHI (2014). No other changes were made to the model. The following flood inundation maps were produced from the results:

- Peak Water Depth
- Peak Water Surface Elevation
- Hazard Category
- Hydraulic Category

These maps accompany this letter.

No sensitivity analyses were performed for this assessment as the influence of peak flow rate and surface roughness is documented in the WRM & DHI report.

4 Conclusion

The flood extents presented here are larger than those shown for the model validation. This is to be expected given the 1% AEP peak flow rates are larger (See Table 1). This letter report has addressed the peer review comments[4] relating to this assessment.

We thank TRC for the opportunity to undertake this work, Should you have any queries regarding this letter, please do not hesitate to contact me.

Yours sincerely,

Paul Muir
Agricultural Engineer
61 7 4633 8009

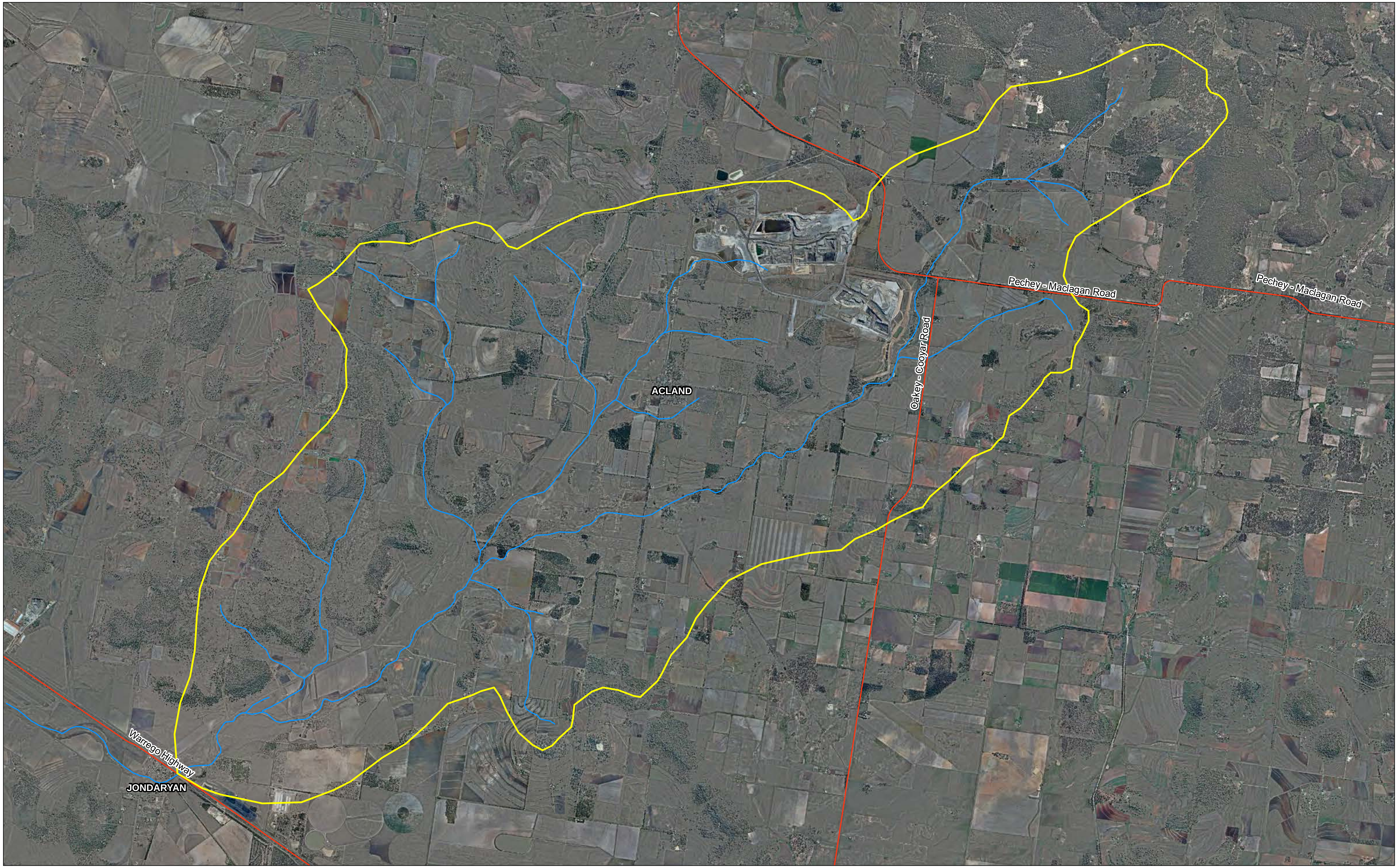
Attachments:

Figure 1 – Catchment Delineation
Figure 2 – Peak Water Depth

[4] GHD Letter from Peer Reviewer (T Loxton) to TRC (M Phillips), dated 30 May 2014

Figure 3 – Peak Water Surface Elevation
Figure 4 – Hazard Category
Figure 5 – Hydraulic Category

cc: Toby Loxton, GHD



1:65,000 (at A3)

0 625 1,250 2,500
Meters

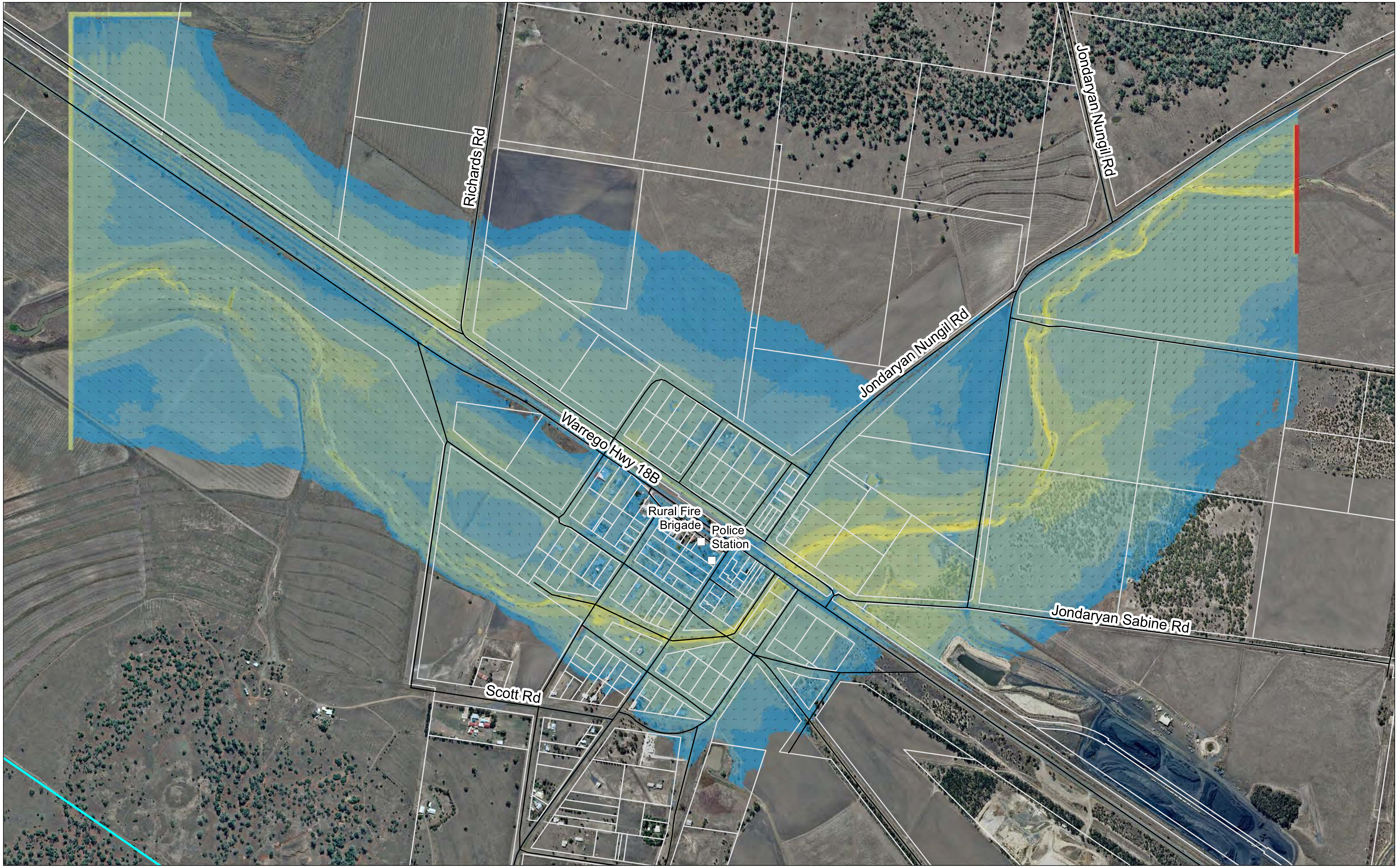
GDA 1994 MGA Zone 56

N

Legend

- Lagoon Ck Catchment to Jondaryan
- Major Road
- Watercourse

SP051 Flood Studies
Work Package 3 Jondaryan
Figure 1 - Lagoon Creek Catchment



TOOWOOMBA REGIONAL COUNCIL

1:10,000 (at A3)

0 100 200 400
Meters

N

GDA 1994 MGA Zone 56

Legend

Peak Water Depth [m]

0 - 0.25, 0.25 - 0.5, 0.5 - 1, 1 - 1.5, 1.5 - 2, 2 - 2.5, 2.5 - 3, 3 - 3.5, 3.5 - 4, 4 - 4.5, 4.5 - 5, >5

Roads

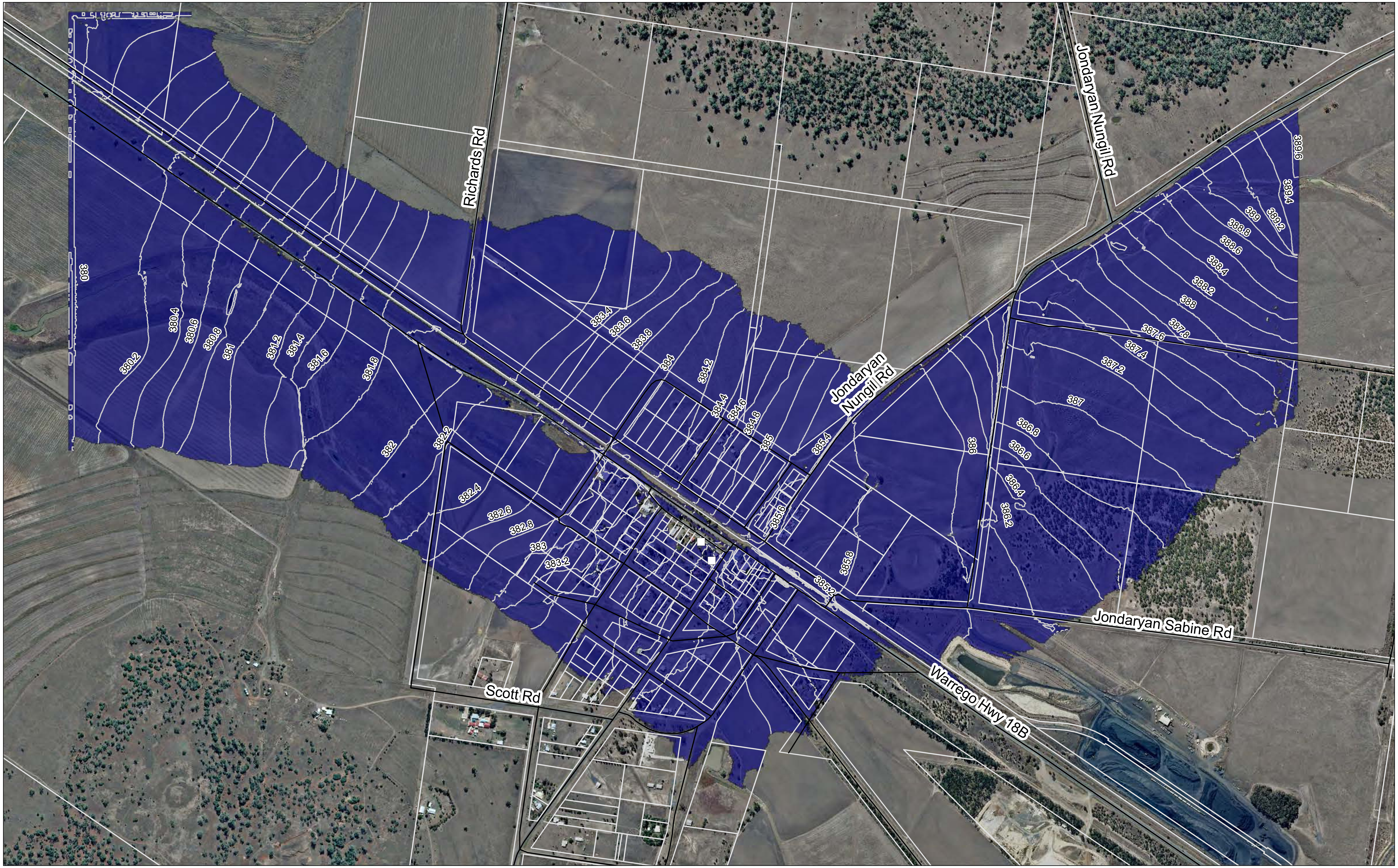
Cadastre

Emergency Services

Velocity (m/s)

0 - 1
1 - 2
2 - 3
> 3

SP051 Flood Studies
Work Package 3 Jondaryan
Figure 2 - 1% AEP
Peak Water Depth & Velocity



TOOWOOMBA REGIONAL COUNCIL

1:10,000 (at A3)

0 100 200 400
Meters

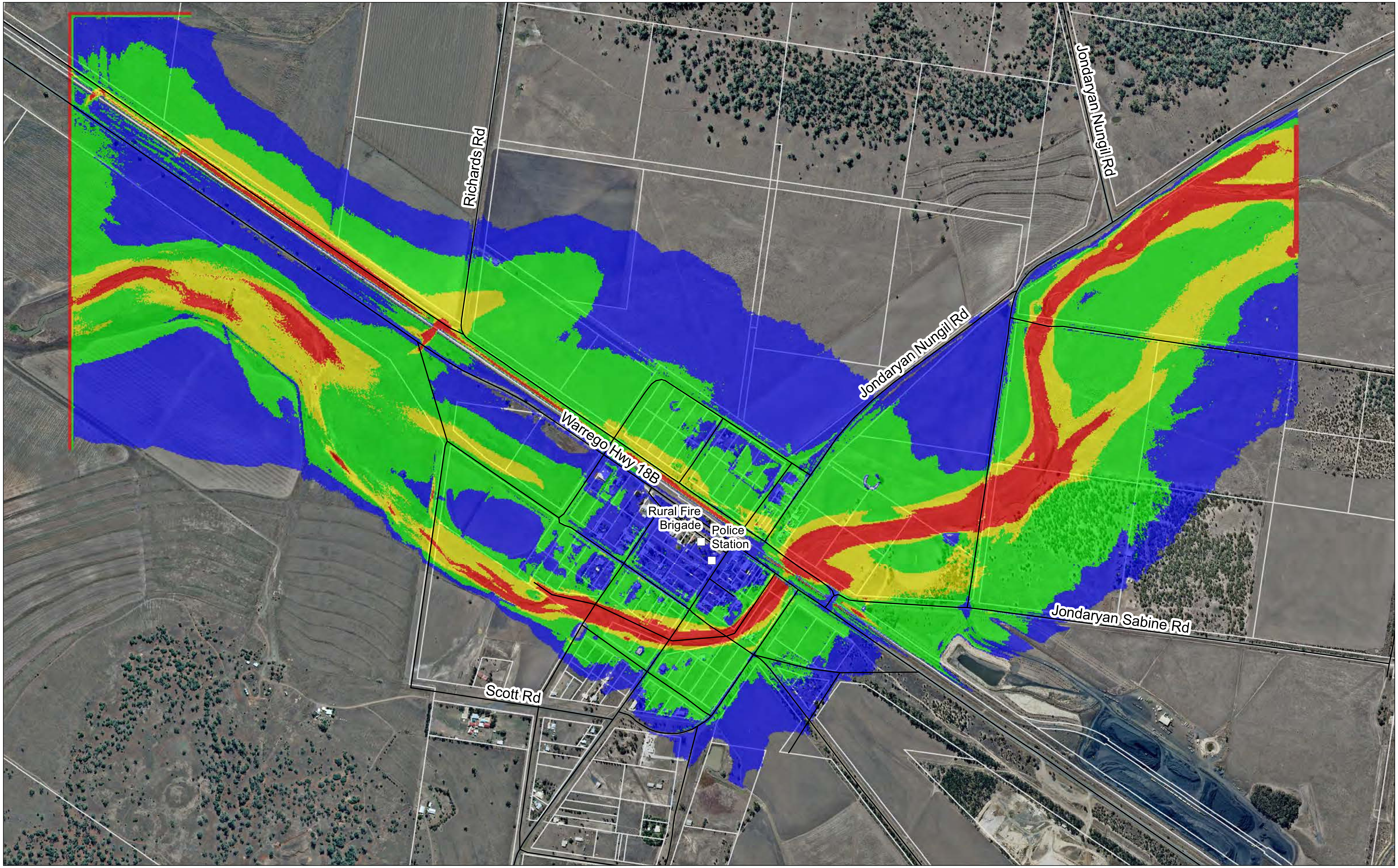
GDA 1994 MGA Zone 56

N

Legend

- Roads
- Cadastre
- Emergency Services
- Inundation Extent
- Water Surface Contour (0.2m Interval)

SP051 Flood Studies
Work Package 3 Jondaryan
Figure 3 - 1% AEP
Water Surface Elevation



TOOWOOMBA REGIONAL COUNCIL

1:10,000 (at A3)

0 100 200 400

Meters

GDA 1994 MGA Zone 56

N

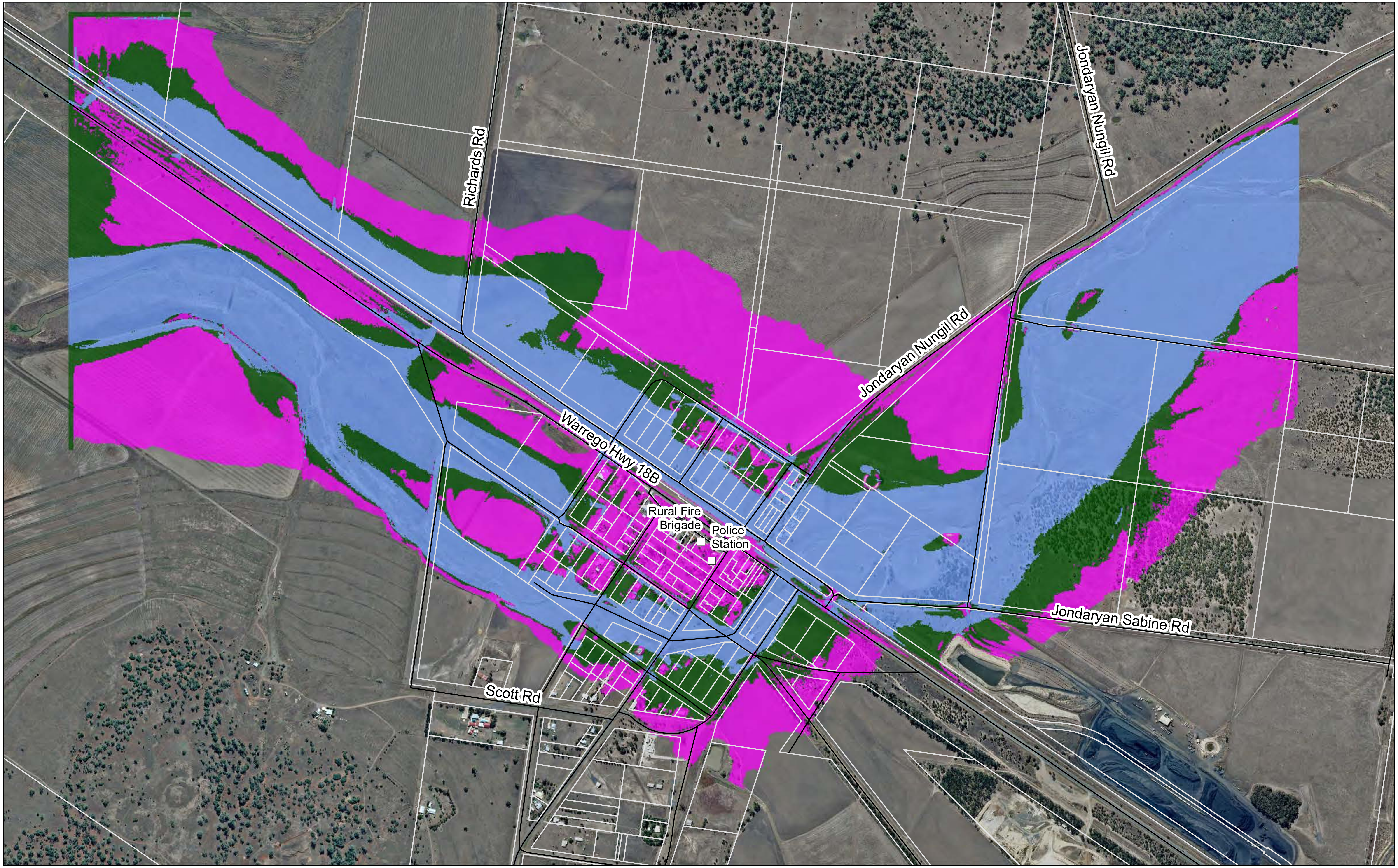
Legend

- Roads
- Emergency Services
- Cadastre

Hazard Category

- Low
- Significant
- High
- Extreme

SP051 Flood Studies
Work Package 3 Jondaryan
Figure 4 - 1% AEP
Hazard Category



TOOWOOMBA REGIONAL COUNCIL

1:10,000 (at A3)

0 100 200 400
Meters
GDA 1994 MGA Zone 56

N

Legend

Hydraulic Category
- Floodway
- Flood Storage
- Flood Fringe

- Roads
- Cadastre
- Emergency Services

SP051 Flood Studies
Work Package 3 Jondaryan
Figure 5 - 1% AEP
Hydraulic Category

18 June 2014

Toowoomba Regional Council
PO Box 3021
TOOWOOMBA VILLAGE FAIR QLD 4350

Our ref: 41/27840 5589

Your ref:

Dear Megan,

Preparation of 1% AEP Mapping
WP05 - Cambooya

1 Introduction

The Toowoomba Regional Council (TRC) SP 51 Flood Studies Project included a number of historical studies which used the flooding during December 2010 or January 2011 as the basis for assessing the hydraulic behaviour of those floods. The studies found that most events probably had an AEP of approximately 1% or smaller which makes them suitable for use in the preparation of planning schemes as discussed in the State Planning Policy 1/03[1]. However at some locations the AEP of the December 2010/January 2011 event was found to be greater than 1%. The AEP of the historical event that occurred at Cambooya is estimated to be 5% (Water Technology[2], 2014).

GHD have been engaged to apply the 1% AEP discharge to the hydraulic model, and produce flood maps of Cambooya. This letter report serves as an addendum to the Water Technology report and further details of the model development are provided in that report.

2 Estimation of Peak Discharge & Inflow Locations

Cambooya is located immediately downstream of the confluence of Hodgson and Oaky Creeks. Water Technology (WT) (2014) estimated the 1% AEP discharge for both catchments using the Rational method and the Australian Regional Flood Frequency (ARFF) model. The 1% AEP discharge was estimated using the Quantile Regression Technique (QRT[3]) for comparison. The estimated discharges are tabulated in Table 1.

---

[1] Mitigating the Adverse Impacts of Flood, Bushfire and Landslide prepared by the Queensland Government Departments of Local Government and Planning, and Emergency Services (LGPES).

[2] Water Technology 2014, SP051 Flood Studies – Work Package 5 – Historical Studies for: Cambooya, Greenmount and East Greenmount; Overland Flow Path Studies for Cambooya and Greenmount Final Report, Water Technology, Brisbane.

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

Table 1 Estimated 1% AEP Discharges (m^3/s)

Catchment	Area (km^2)	Rational Method (WT, 2014)	ARFF Model (WT, 2014)	QRT (GHD, 2014)	Validated Model Peak Discharge (m^3/s)	% Difference in Peak Discharge
Hodgson Creek (AAB)	88.1	419.5	393.5	360	235	79%
Oaky Creek (AR)	19.9	168.3	154.2	137	81	108%

The Rational method result was adopted as a conservative estimate, and was applied to the hydraulic model at the existing locations defined in the model. These locations are displayed in Table 2. The Rational method was also chosen to be consistent with the hydraulic modelling presented by Water Technology.

Table 2 Inflow Locations

Catchment	Location (Model Coordinates)	Discharge (m^3/s)
Hodgson Creek	1246,457 – 1246,538	419.5
Oaky Creek	903,782 - 910,782	168.3

3 Hydraulic Modelling

It was assumed that the existing validated hydraulic model was satisfactory as the modelling base for this assessment. The above steady-state inflows were applied to the validated MIKE FLOOD model developed by Water Technology (2014). The only change to the model was the widening of the downstream boundary. The following flood inundation maps were produced from the results:

- Peak Water Depth
- Peak Water Surface Elevation
- Hazard Category
- Hydraulic Category

These maps accompany this letter.

No sensitivity analyses were performed for this assessment as the influence of peak flow rate and surface roughness is documented in the Water Technology report.

4 Conclusion

The flood extents presented here are larger than those shown for the model validation. This is to be expected given the 1% AEP peak flow rates are larger (See Table 1). This letter report has addressed the peer review comments[4] relating to this assessment.

We thank TRC for the opportunity to undertake this work, Should you have any queries regarding this letter, please do not hesitate to contact me.

Yours sincerely,

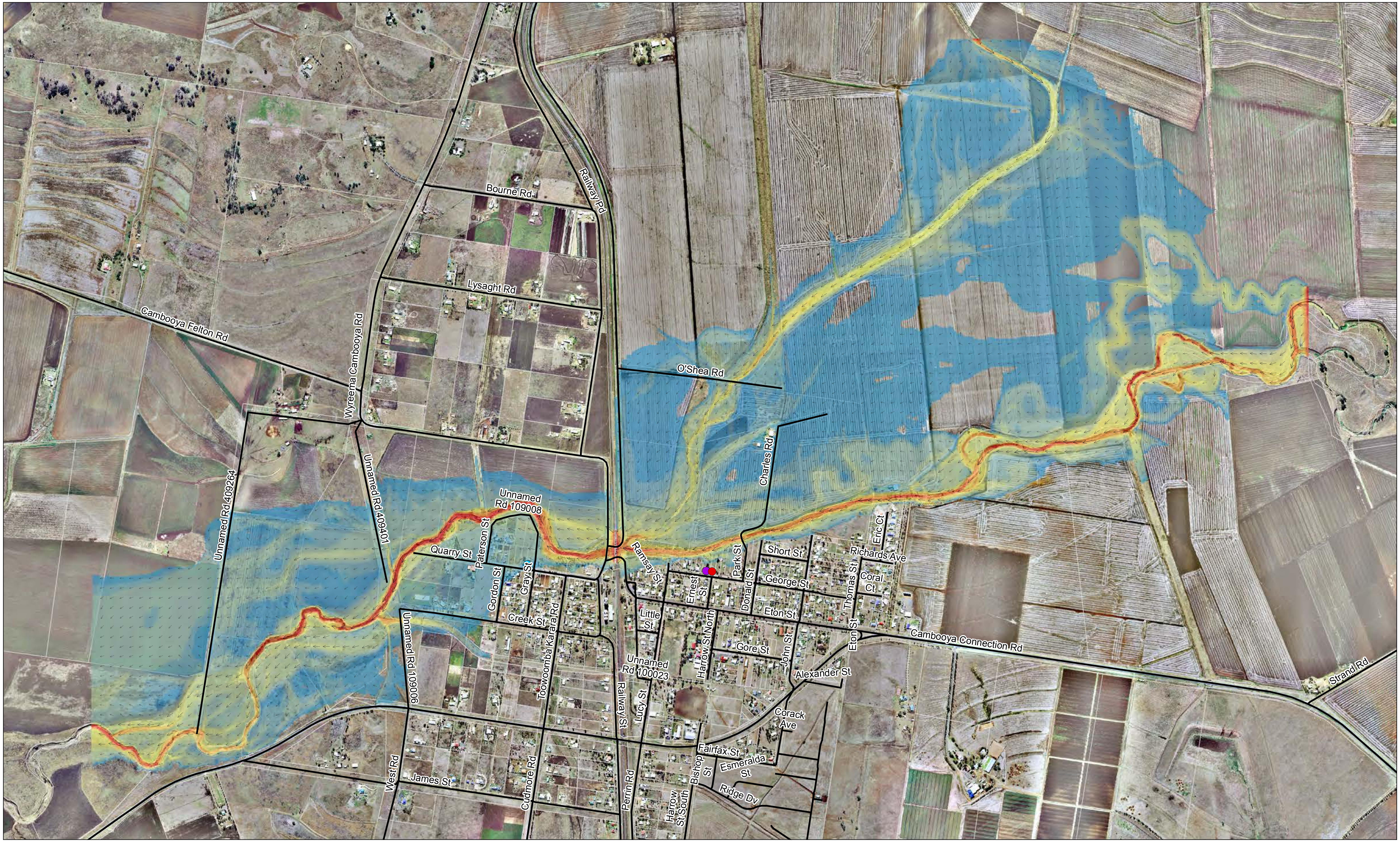
Paul Muir
Agricultural Engineer
61 7 4633 8009

Attachments:

Figure 1 – Peak Water Depth
Figure 2 – Peak Water Surface Elevation
Figure 3 – Hazard Category
Figure 4 – Hydraulic Category

cc: Toby Loxton, GHD

[4] GHD Letter from Peer Reviewer (T Loxton) to TRC (M Phillips), dated 30 May 2014



1:14,000 (at A3)

0 100 200 300 400
Metres

GDA 1994 MGA Zone 56

N

TOOWOOMBA REGIONAL COUNCIL

Legend

- Road
- Police Station
- Rural Fire Brigade
- SES
- Cadastre

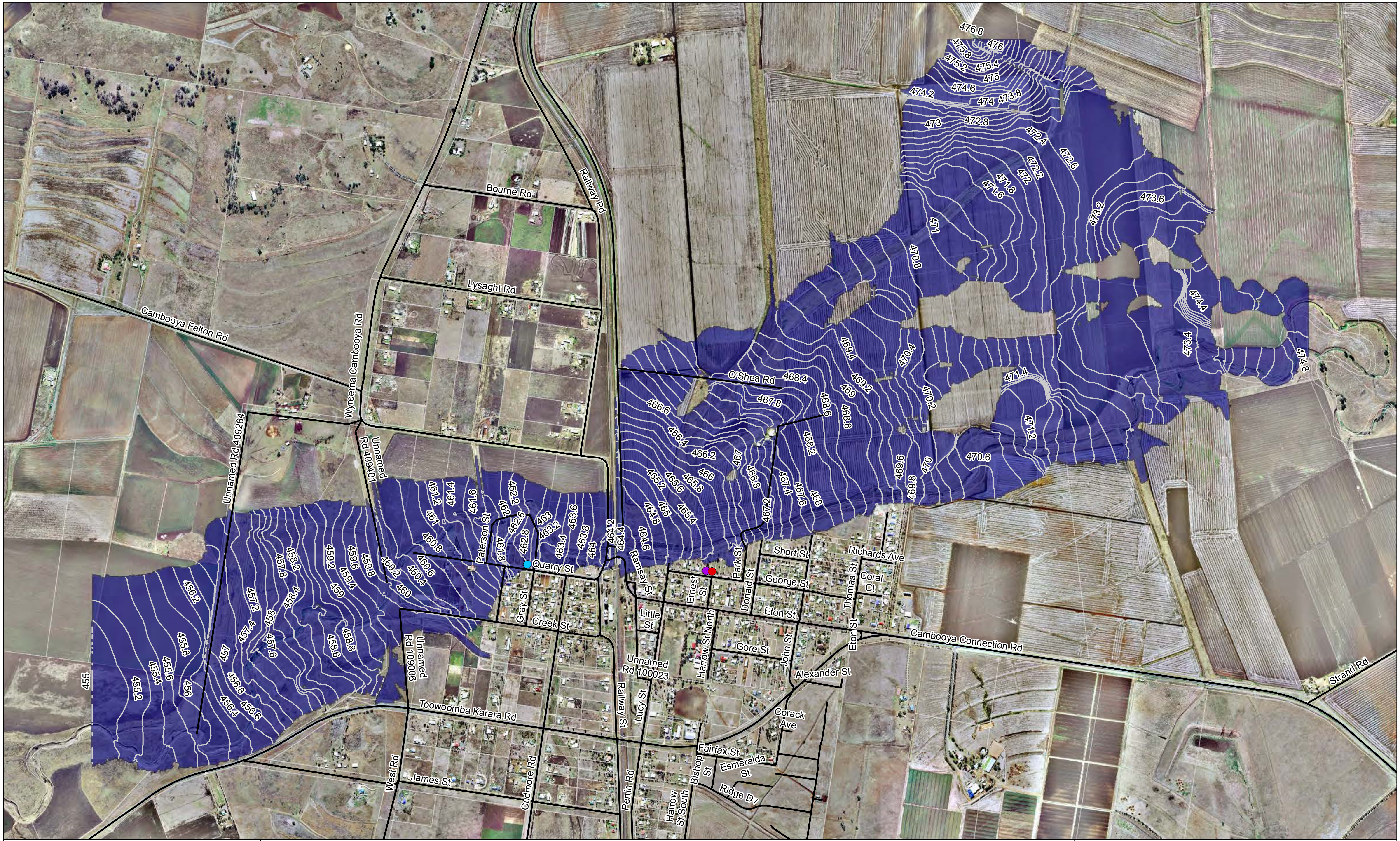
Flood Depth

0 - 0.25	1.0 - 1.5	2.5 - 3.0	4.0 - 4.5
0.25 - 0.5	1.5 - 2.0	3.0 - 3.5	4.5 - 5.0
0.5 - 1.0	2.0 - 2.5	3.5 - 4.0	>5.0

Velocity (m/s)

0 - 1	2 - 3
1 - 2	> 3

Figure 1
SP 051 Flood Studies
Work Package 5 - Cambooya
1% AEP Peak Flood Depth & Velocity

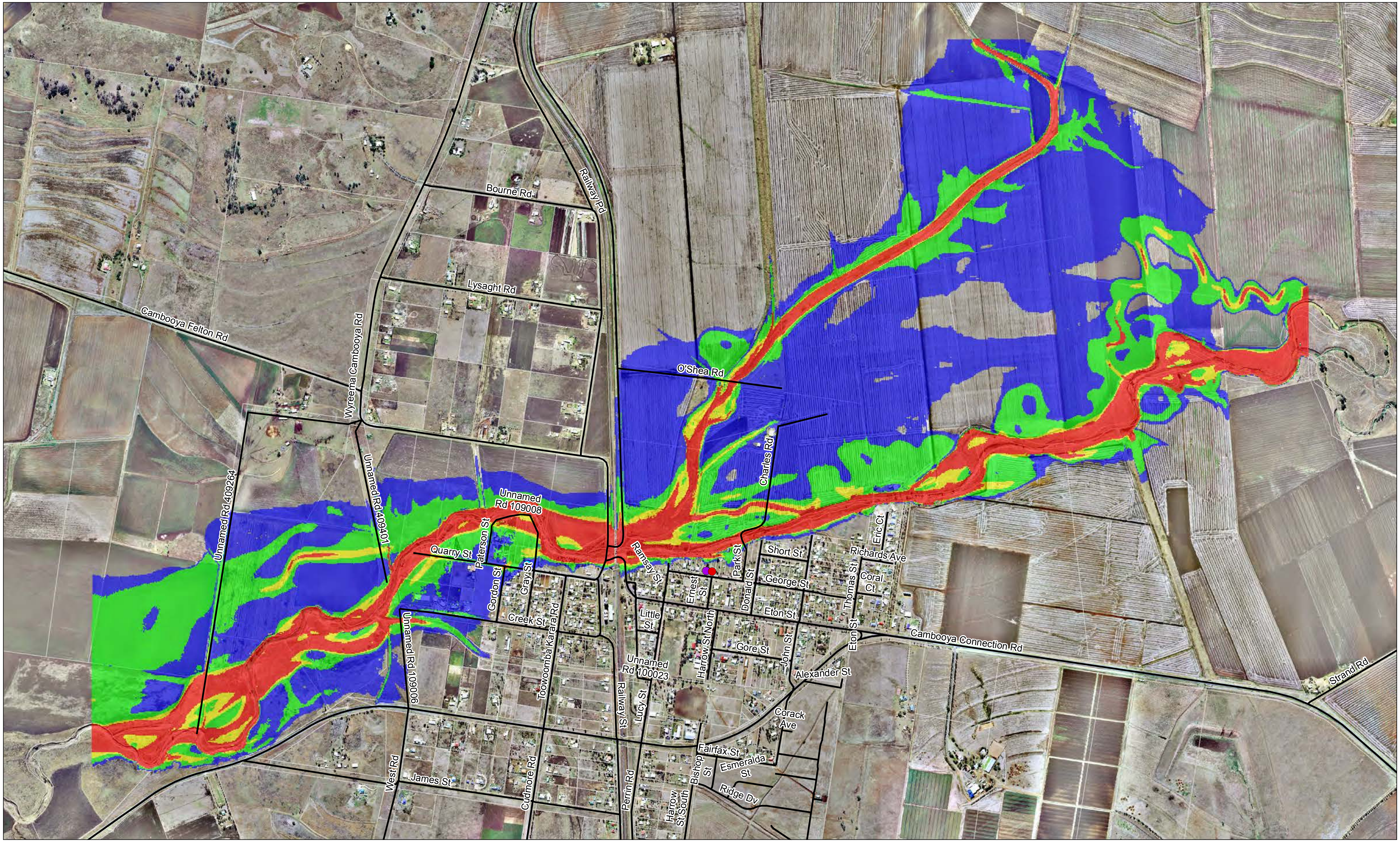


TOOWOOMBA REGIONAL COUNCIL	1:14,000 (at A3)
	0 100 200 300 400 Metres
	GDA 1994 MGA Zone 56
	N

Legend

- Police Station
- Rural Fire Brigade
- SES
- Inundation Extent
- Cadastre
- Road
- Water Surface Contour (0.2m interval)

Figure 2
SP 051 Flood Studies
Work Package 5 - Cambooya
1% AEP Flood Level



1:14,000 (at A3)

0 100 200 300 400

Metres

GDA 1994 MGA Zone 56

N

TOOWOOMBA REGIONAL COUNCIL

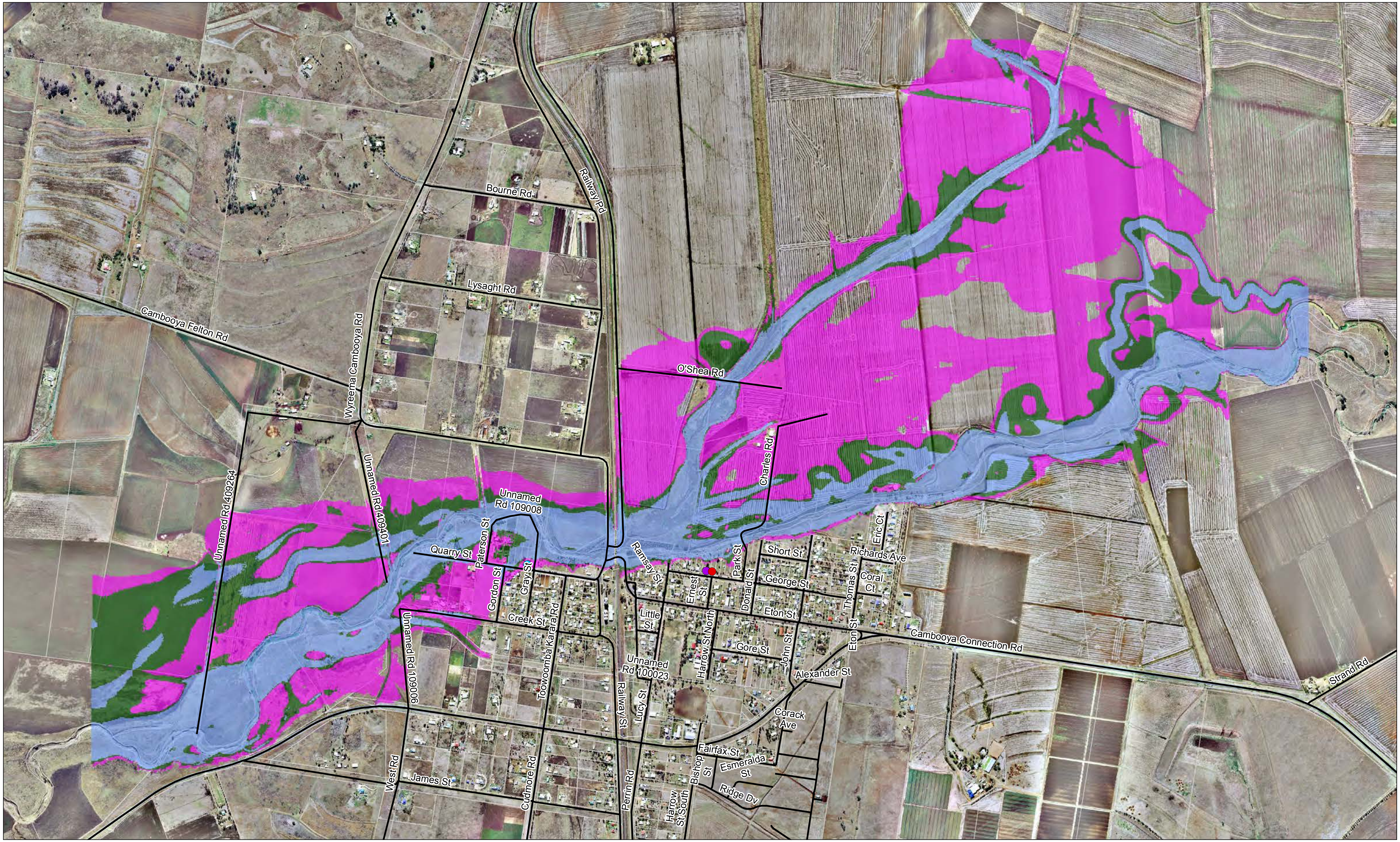
Legend

- Police Station
- Rural Fire Brigade
- SES
- Road
- Cadastre

Hazard Category

- Low
- Significant
- High
- Extreme

Figure 3
SP 051 Flood Studies
Work Package 5 - Cambooya
1% AEP Flood Hazard



TOOWOOMBA REGIONAL COUNCIL

1:14,000 (at A3)

0 100 200 300 400

Metres

GDA 1994 MGA Zone 56

N

Legend

- Police Station
- Rural Fire Brigade
- SES
- Road
- Cadastre

Hydraulic Category

- Floodway
- Flood Storage
- Flood Fringe

Figure 4
SP 051 Flood Studies
Work Package 5 - Cambooya
1% AEP Flood Hydraulic Category

TOOWOOMBA REGION

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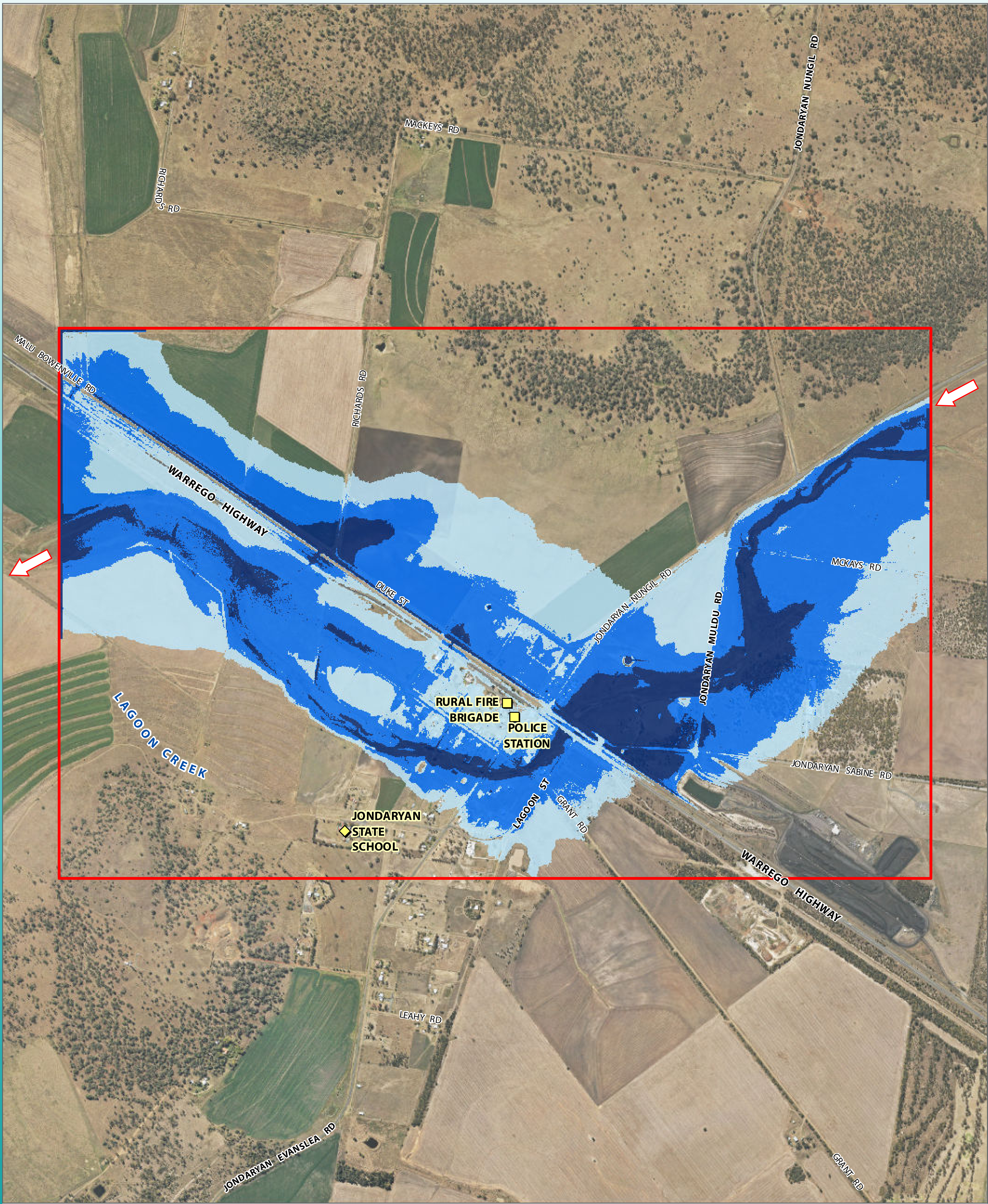
JONDARYAN



TOOWOOMBA REGIONAL COUNCIL

1:14,500 (at A3)

0 150 300 450 600

Metres

N

1% AEP FLOOD DEPTH RIVERINE

Water Depth (m)		
0 - 0.5	Model Extent
0.5 - 1	DirectionFlow
1+	Emergency Services
	School

\\mapdata\spatialdata\Projects\Spatial Services\Incident Management\114743\114743_JON_D_AEP1_A3.mxd Author/Date: purvesa 12/02/2015

Flood Studies

TOOWOOMBA REGION
Rich traditions. Bold ambitions.

Historical Study for Jondaryan

August 2014 • *Endorsed on 25 February 2015*

GENERAL NOTE

These reports/documents are a base source of information that will be continually refined over time.

DISCLAIMER

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REPORT TITLE: Work Package 3 – Historical Study for Jondaryan, Final Report
CLIENT: Toowoomba Regional Council
REPORT NUMBER: 0965-01-G6

Revision Number	Report Date	Description	Report Author	Reviewer
DRAFT 1	10 October 2013	Draft Validation Report	MB	TV/SM
DRAFT 2	5 December 2013	Draft Report	MB	TV/SM
FINAL 1	20 February 2014	Final Report	MB	TV/SM
FINAL 2	24 March 2014	Final Report (rev 1)	MB	TV/SM
FINAL 3	11 April 2014	Final Report (rev 2)	MB	TV/SM
FINAL 4	21 August 2014	Final Report (rev 3)	MB	TV/SM

For and on behalf of
WRM Water & Environment Pty Ltd

Sharmil Markar
Director

EXECUTIVE SUMMARY

Toowoomba Regional Council (TRC) appointed WRM Water and Environment Pty Ltd (WRM) in association with DHI Water and Environment Pty Ltd (DHI) to carry out hydraulic investigations of flooding in the town of Jondaryan. The hydraulic modelling was undertaken using a coupled MIKE FLOOD 1D/2D hydrodynamic model.

The majority of the data for the construction of the hydraulic model was derived from a 1m LiDAR Digital Elevation Model (DEM) provided by TRC. A site visit was undertaken on September 3rd, 2013. The purpose of the site visit was to allow the project team to identify key drainage features within the catchment, survey structures with potential significant hydraulic impact, gain a general feel for the floodplain and collect information on previous flood events from identified stakeholders.

The validation data consisted of sixteen observed spot water levels for the January 2011 event. The MIKE FLOOD model was validated to this event by scaling steady state flows until a good match between observed and modelled flood levels was achieved. All predicted levels were within the required accuracy of ±0.5m except for two outliers, which appear to be erroneous level observations.

Information used is the best information available at this time for the purposes of this study. Marks observed and other anecdotal information obtained after flood events have been obtained from a range of sources and have varying degrees of certainty.

The hydraulic model results show that Jondaryan was greatly affected by flooding from the Lagoon Creek during the January 2011 event. The Warrego Highway, which provides access to the town from the south-east and north-west, was cut off during the event. Hazard mapping for the January 2011 event classifies parts of Jondaryan as areas of significant to extreme hazard.

An analysis of model sensitivity to adopted flow, roughness and blockage of hydraulic structures shows a small variation in the overall flood extent for all sensitivity analysis scenarios, except for an area upstream of the Warrego Highway. There, an increase in the adopted flow, roughness or hydraulic structure blockage would result in a larger flood extent when compared to the baseline scenario. Peak water levels are most sensitive to changes in roughness. A 30% reduction in Manning's M values (or an equivalent increase in Manning's 'n' values) results in a maximum water level increase of 16cm at selected validation points.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

1 INTRODUCTION

1.1 BACKGROUND

Toowoomba Regional Council (TRC) is a large local government area located in the Darling Downs part of Queensland, Australia. TRC comprises an area of nearly 13,000 km^2 with a population of approximately 172,000 people in 33 towns. In 2009 TRC commenced the Toowoomba Regional Planning Project (RPP) to develop one integrated planning scheme policy covering the entire Council area. Later that year TRC commissioned Water Technology Pty Ltd to collate and review the existing flood data in the region and provide advice on the applicability of the data for use in the Planning Scheme. One of the findings from the study was that only a small portion of the Council area is covered by high/medium quality flood mapping.

In 2012 the State Government approved Council adopting the Toowoomba Regional Planning Scheme with a set of conditions to be met to ensure the scheme was compliant with nominated State Planning Policies. To meet the conditions established by the State Government, a scoping study was completed by Council to identify the information required to meet the specified conditions. The study highlighted the need to investigate the flood behaviour and flood risk in several towns in the region.

WRM in association with DHI was commissioned by TRC to undertake a historical study for the town of Jondaryan. The historical study will provide Council with information needed for land development control, infrastructure development and management, emergency planning, and emergency response in the study area.

This report describes the methodology, available data, and development of a hydraulic model used for a historical event simulation for Jondaryan. The report also assesses the sensitivity of the adopted flow, roughness and blockage of hydraulic structures on predicted results. The report ends with concluding remarks and recommendations to further improve the model accuracy.

1.2 SCOPE OF PROJECT

The primary objective of this project was to define the nature and extent of flood behaviour in the Jondaryan study area to enable TRC to:

- "*Develop a Flood Risk Management Study and plan to address the flood hazards identified in the flood studies;* and
- *Amend the Toowoomba Regional Planning Scheme to appropriately reflect the flood requirements of State Planning Policy 1/03 and the recommendations of the Queensland Commission of Inquiry*" (TRC, 2013).

The project was divided into a number of phases. The scope of each phase is briefly outlined below.

Information Review and Project Start-Up

- Completion of project briefing;
- Development of stakeholder consultation strategy;
- Site visit; and
- Collection and review of available data.

MIKE FLOOD Model Development

- Development of a coupled 1D/2D MIKE FLOOD model; and
- Adjusting parameters to ensure model stability.

Model Validation

- The model was validated by adjusting steady-state flows to achieve the following target:
  - All spot levels within ± 0.5m

Sensitivity Analysis

- Assessment of model sensitivity to flow, roughness and blockage of hydraulic structures.

Deliverables

- Report detailing methodology, validation and sensitivity analysis results including A3 flood maps; and
- Handover of all model setup and result files.

1.3 STUDY AREA

Jondaryan is a small town located approximately 40 km north-west of Toowoomba on the Lagoon Creek floodplain. The primary source of flood risk to the town is Lagoon Creek which splits the town and cuts off entry to the town via the Warrego Highway. According to a Jondaryan resident, the township and surrounding rural areas experience minor flooding almost every year.

Land use within the study area is primarily rural. Within the local area of the Jondaryan township the land use is predominantly residential. The study area is shown in Figure 1.1.

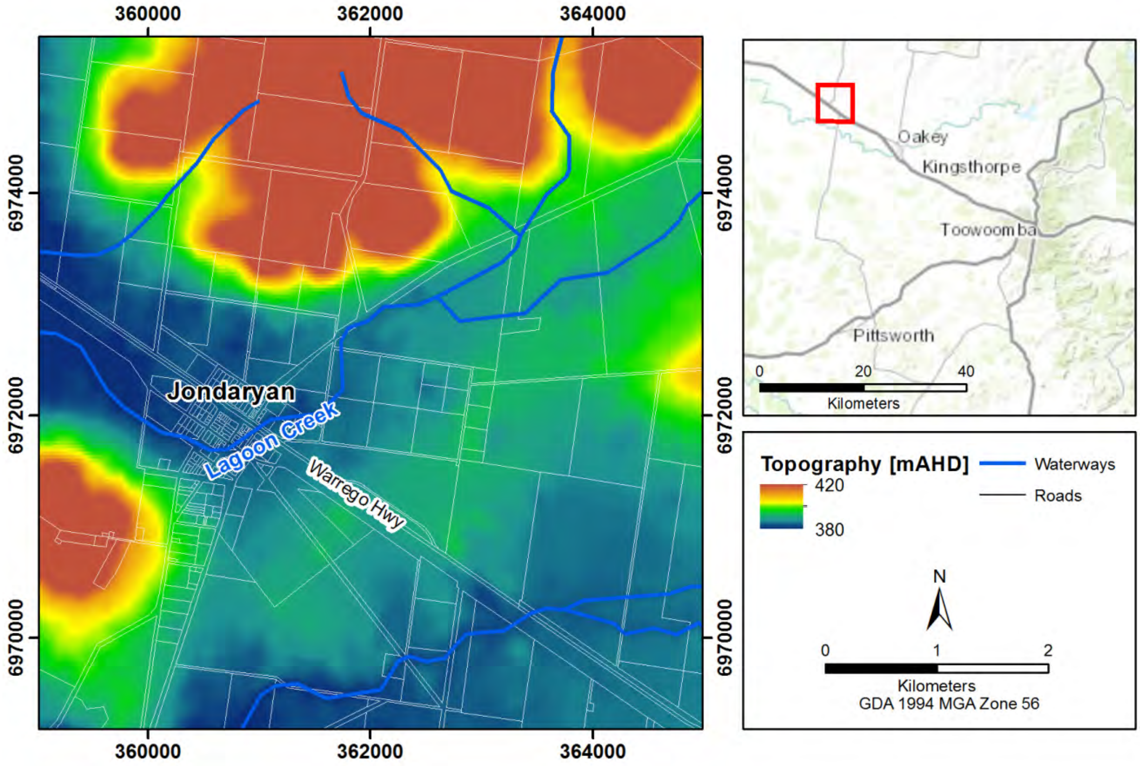


Figure 1.1 Study Area

2 AVAILABLE DATA

2.1 TOPOGRAPHIC DATA

Tiles of 1m LiDAR-derived gridded topographic data were provided by TRC. The 1m tiles were merged to create a seamless 1m Digital Elevation Model (DEM) of the study area, see Figure 2.2.

2.2 GIS LAYERS

The available GIS layers provided by TRC included:

- Aerial photography;
- Cadastral data;
- Road and rail network;
- Structures with a likely hydraulic impact;
- Land use data;
- Future planning scheme; and
- Location of emergency services.

2.3 SITE VISIT

A site visit was undertaken on September 3rd, 2013. The purpose of the site visit was to allow the project team to identify key drainage features within the catchment, survey structures with potential significant hydraulic impact, gain a general feel for the floodplain and collect information on previous flood events from identified stakeholders. All information collected during the site visit including photos, structure geometry data and a GIS layer showing the location of the structures was delivered as part of the study.

2.4 PREVIOUS STUDIES

In 2013 SKM undertook a Level 2 flood study for Jondaryan as part of Queensland Reconstruction Authority's *Queensland Flood Mapping Program (QFMP)* (SKM, 2013). The QFMP program involved collecting historical flood information and undertaking flood investigations and flood hazard mapping for approximately 100 "at risk" towns in Queensland, following the significant flooding in Queensland in the summer of 2010/2011.

The model developed by SKM was built using a 10m grid. It was validated to the January 2011 event by adjusting steady state flows until a good match between modelled and observed spot water levels was achieved, the modelled peak discharge for this study was 180m³/s. The January 2011 validation data consisted of two spot water levels, see Figure 2.1.

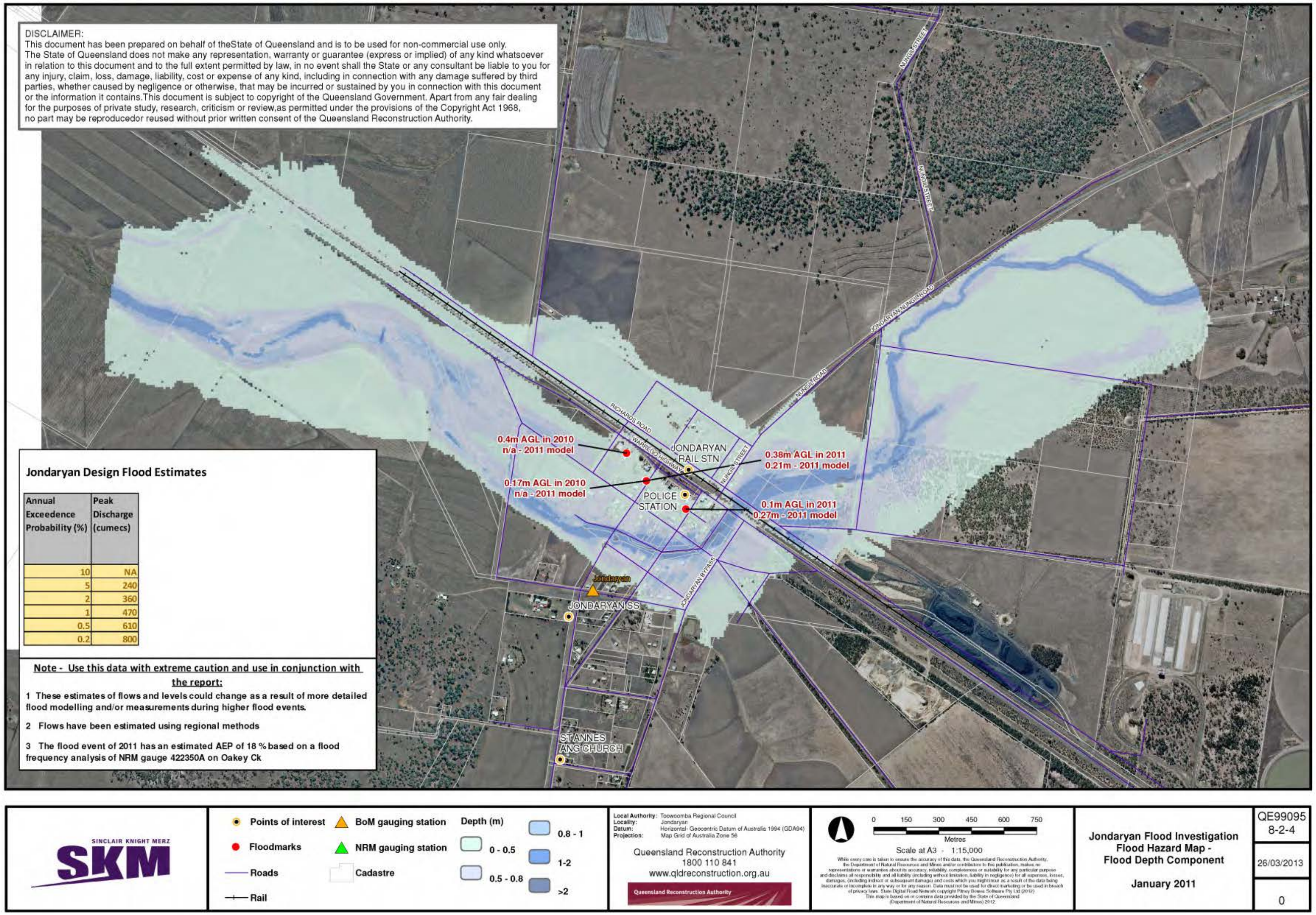


Figure 2.1 Modelled January 2011 Flood Extent (SKM, 2013)

2.5 HISTORICAL FLOOD INFORMATION

Three major flood events occurred in Jondaryan in the summer of 2010/2011. These events occurred on the 27th of December 2010, 6th of January 2011 and 11th of January 2011 (Arthur and Burton, 2011). The last of the three events resulted in the most severe flooding in the township. Available recorded historical flood information for the January 2011 event was supplied by TRC. Photographic evidence of inundated areas during the December 2010 and January 2011 events was obtained from Jondaryan residents. However, the photographs could not be used to estimate additional peak flood levels. All available validation data is shown in Figure 2.2 and summarised in Table 4.1. The spot levels with ID2 and ID11 correspond to the two spot levels the SKM model was validated against, see Figure 2.1.

Please note that TRC has collected flood data for this study from a variety of sources including debris marks, flood marks visible and accessible at the time of survey after the January 2011 flood, eyewitness accounts, community consultation, etc. It is possible that some the flood data available to TRC may not be accurate or complete.

Information used is the best information available at this time for the purposes of this study. Marks observed and other anecdotal information obtained after flood events have been obtained from a range of sources and have varying degrees of certainty.

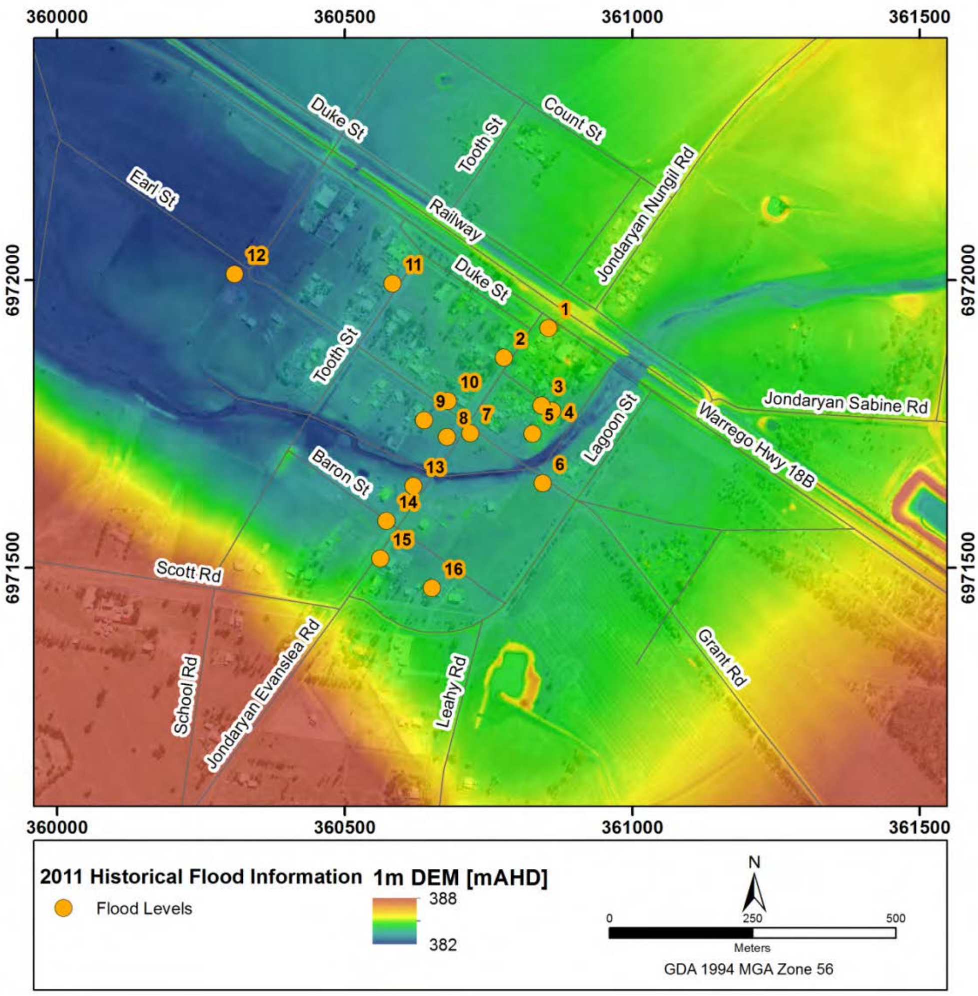


Figure 2.2 LiDAR Derived DEM Extent and Available Historical Flood Information

Following the completion of the MIKE FLOOD model validation, TRC also supplied flood lines in Jondaryan for the November 1974, December 1991, February 1994 and May 1996 flood events. Based on a comparison of historical flood extents it was found that the January 2011 event was the largest event in the last 40 years. As the MIKE FLOOD model was successfully validated to the most recent and largest flood event with the most extensive validation dataset (see Section 4) it is believed little would be gained in validating the model to the additional historical events where the data reliability is less certain.

3 HYDRODYNAMIC MODEL DEVELOPMENT

3.1 OVERVIEW

The following section documents the development and validation of the hydrodynamic model, selection of key model parameters and assumptions made. The hydrodynamic model was developed in the MIKE FLOOD Release 2012 (Service Pack 2), which was the most recent version available at the time of the project. MIKE FLOOD is a software program that allows coupling of a MIKE 11 (1D) model and a MIKE 21 (2D) model to run together in parallel. The fundamental principle of MIKE FLOOD is that features smaller than the MIKE 21 grid resolution (e.g. small channels and structures) can be represented in MIKE 11, with linkages (couples) that transfer water levels and discharges between MIKE 11 and MIKE 21 at each time step. The MIKE FLOOD model schematisation (DHI, 2013) was agreed with TRC prior to the commencement of model development.

3.2 MIKE 21 MODEL

The 2D model domain for Jondaryan extends approximately 2.4km upstream of the Warrego Highway Crossing along Lagoon Creek to approximately 2.7km downstream of the crossing as shown in Figure 3.1. The model domain is approximately 3.6km by 3.3km.

3.2.1 Bathymetry

The MIKE 21 model incorporates a detailed elevation model (bathymetry) of the ground surface. The DEM used in this model was created from the 1m DEM supplied by TRC; the DEM was then resampled to a 3m grid resolution. Due to the small grid size it was not necessary to update the 'base' bathymetry with crest levels of major roads and the railway extracted from the 1m DEM.

Small flow structures and crossings on secondary flow paths were implemented as they were represented in the source DEM data. These structures were not incorporated as 1D elements and the 2D bathymetry was not adjusted to reflect any geometry or associated control levels. This implies that most small culverts and structures were assumed to be 100% blocked during a flood, thus producing a conservative estimate of the flood extent.

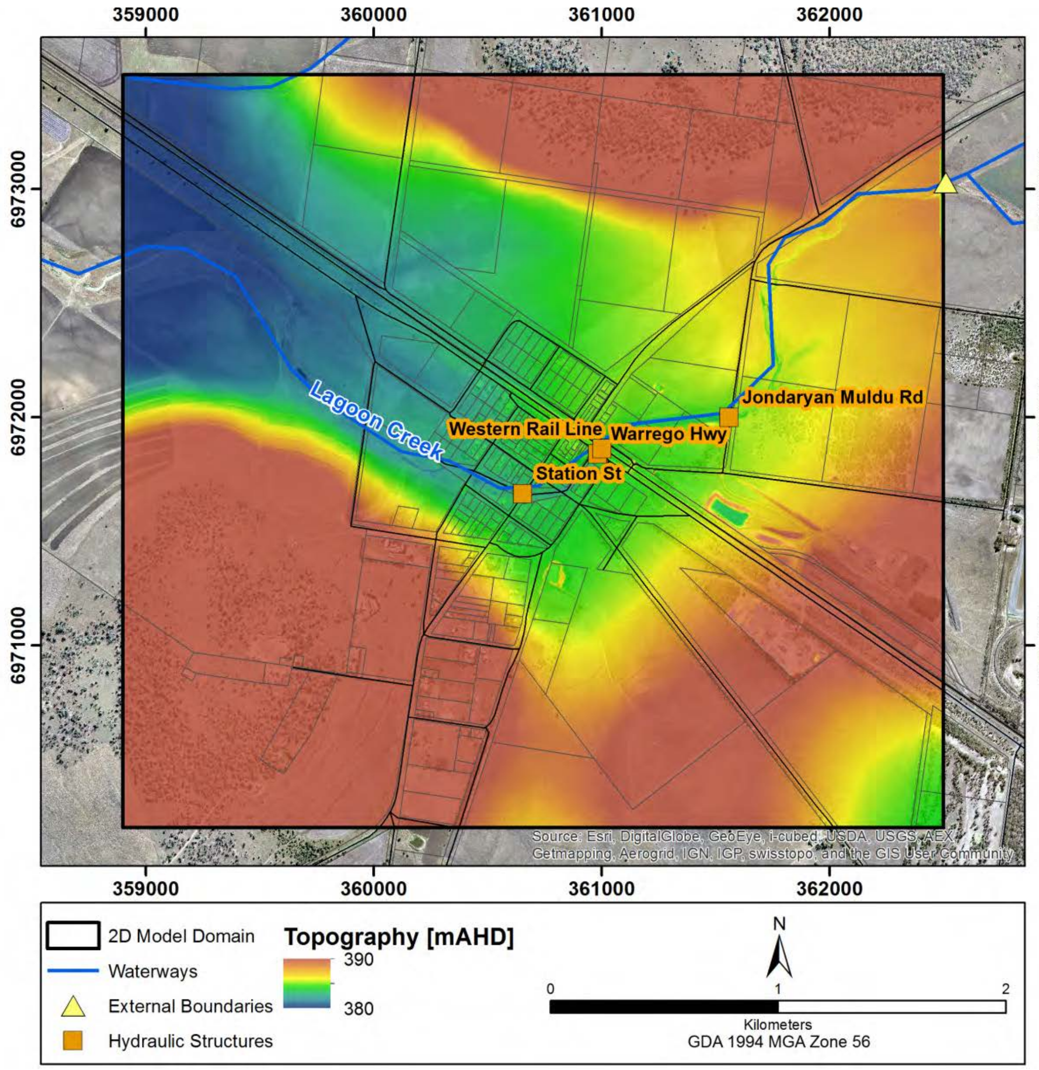


Figure 3.1 MIKE FLOOD Model Setup

3.2.2 Hydraulic Roughness

MIKE 21 models require the specification of hydraulic roughness to be applied in each cell, either as a constant value or in the form of a map (grid) of roughness values. A spatially distributed roughness map for the model domain was created based on the land uses classes provided by TRC as well as vegetation coverage identified from the aerial photography, also supplied by TRC. Five distinct land use classes were identified within the study area. The adopted hydraulic roughness values (Manning's 'n' and its reciprocal Manning's 'M') for each class are shown in Table 3.1. These values were based on DHI's previous experience in Queensland, whilst also taking into account Australian Rainfall and Runoff (ARR) Revision Project's valid Manning's 'n' ranges for different land use types (Smith and Wasko, 2012). It should be noted that the adopted Manning's 'n' value for 'Developed Areas' is slightly lower than the ARR recommended range of roughness values for this land use type. This is due to the coarse delineation of 'Developed Areas' based on land use classes, resulting in a Manning's 'n' value of 0.083 being applied to buildings as well as some open pervious areas. The spatial distribution of roughness is presented in Figure 3.2.

Table 3.1 Adopted Hydraulic Roughness Values in MIKE FLOOD

Land Use	Manning's 'M'	Manning's 'n'	Range of Manning's 'n' Values[a]
Floodplain	25	0.04	0.03 – 0.05
Roads	40	0.025	0.02 – 0.03
Developed Areas	12	0.083	0.10 – 0.20
Waterways	30	0.033	0.02 – 0.04
Dense Vegetation	10	0.1	0.07 – 0.12

Notes: [a] (Smith and Wasko, 2012)

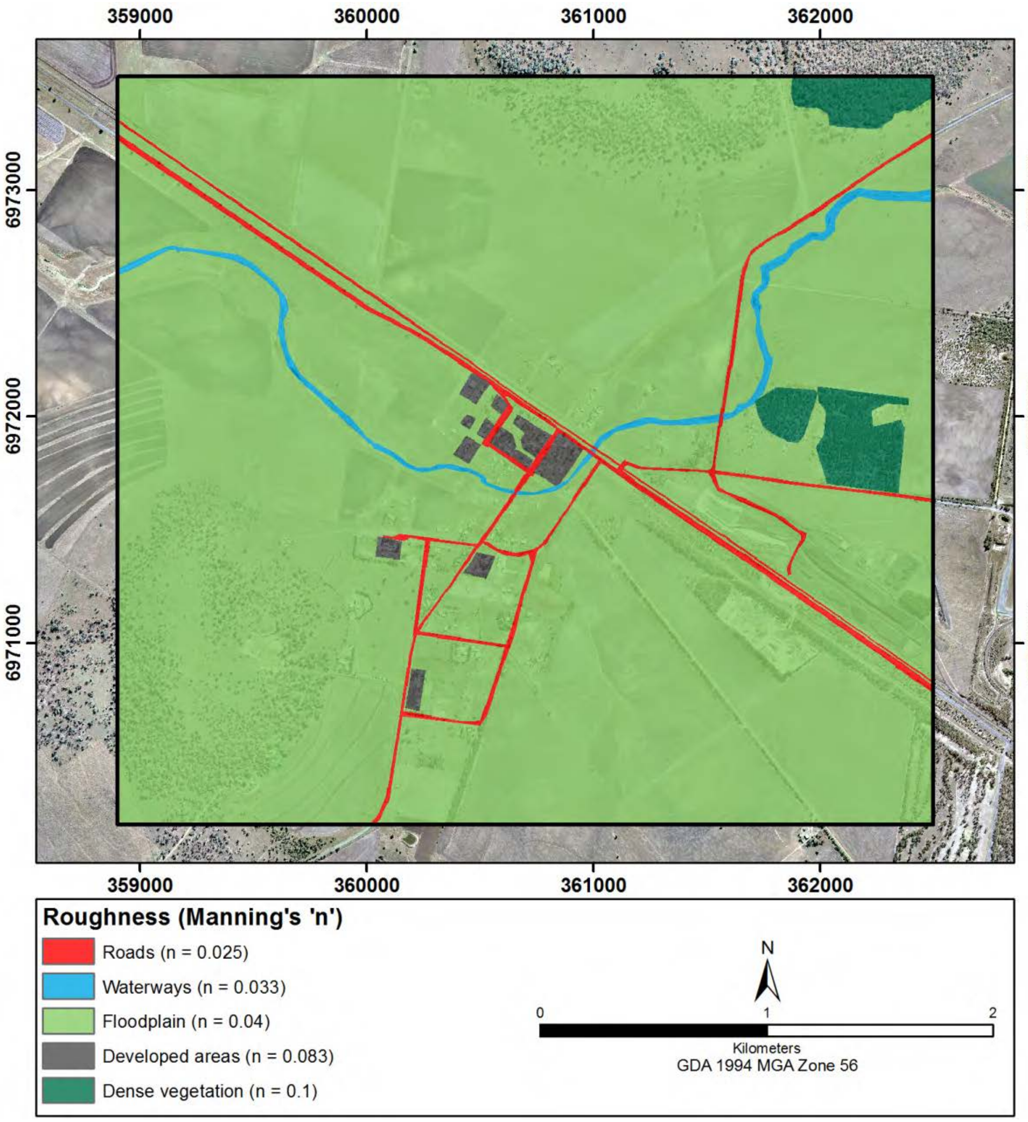


Figure 3.2 Spatial Distribution of Roughness

3.2.3 Flooding and Drying Depths

In the MIKE FLOOD Release 2012, there is a new 'Inland Flooding' option available which results in much improved mass balances in urban flooding and floodplain applications. Continuity is fully preserved during the flooding and drying process, as the water depths at the points which are dried out are saved and then reused when the point becomes flooded again. A flooding depth of 0.05 m and a drying depth of 0.02 m were adopted in this study.

3.2.4 Eddy Viscosity

Eddy viscosity is used to represent sub-grid scale turbulence to provide the modeller with the opportunity to enhance or retard the natural generation of flow eddies in the solution scheme for the purpose of matching observed flow phenomena. A velocity based eddy viscosity formulation was applied and is recommended in floodplain applications.

Values for eddy viscosity can be calculated using a number of empirical formulas related to grid size and time step. Selecting an eddy viscosity value that is too high will result in the modelled flow having a more uniform velocity distribution tending to distribute more of the total flow to the floodplain. Selecting an eddy viscosity value that is too low can result in significant variability in the velocity field, formation of large modelled eddies in areas of no physical manifestation of this hydraulic phenomenon and contribute to model instability.

In this study, the eddy viscosity was set to 0.5 m^2/s, which is consistent with the model resolution and based on DHI's previous experience with selection of secondary model parameters. At a small number of locations associated with 1D/2D couples an eddy viscosity of 5 m^2/s was used to improve model stability.

3.2.5 Model Boundaries

A steady state flow of 300m^3/s was applied to the model at one open inflow boundary, see Figure 3.1. The steady state flow was increased by 50m^3/s until a good match between observed and modelled water levels was achieved. It was not possible to implement a Q-h relationship at the downstream boundary due to the extent of flooding. One downstream open model boundary was specified using a constant water level of 380mAHD. The level was chosen based on the topographic features in the downstream part of the model domain. The model boundary was positioned as far downstream of the area of interest as possible to minimise backwater effects from assumptions made at the boundary location.

3.2.6 Time Step and Save Step

A 0.3 second time step was used in the Jondaryan model based on Courant number considerations. The save step in MIKE 21 was set to 30 minutes.

3.3 MIKE 11 MODEL

3.3.1 Network and Structures

The MIKE 11 network consists of three short branches used to model structures with potential significant hydraulic impact. These structures are identified in Table 3.2 and located in Figure 3.1. Structure dimensions were implemented based on the measurements taken during the site visit. Invert levels of structures and their waterway length were estimated from the 1m DEM and aerial photography, respectively.

3.3.2 Cross-Sections

The cross-sections defined at the upstream and downstream ends of each MIKE 11 branch were extracted from the 1m DEM. Cross-sections upstream and downstream of structures were enlarged if they were smaller than the structure dimensions. This is necessary to ensure a realistic head loss across the structure.

3.3.3 Time Step and Save Step

When MIKE 11 and MIKE 21 models are coupled, MIKE 11 is forced to use the same time step as MIKE 21. The MIKE 11 results were saved every 5 minutes.

3.4 MIKE FLOOD MODEL

A total of four coupling points were implemented in the MIKE FLOOD model. The structures and couple types are listed in Table 3.2. Photographs of the structures taken during the site visit are shown in Appendix A. As all modelled structures have a waterway length greater than two MIKE 21 grid cells (6m) they were all modelled using the 'Standard' link type, where structure submergence and overtopping is modelled in MIKE 11 and MIKE 21, respectively.

Table 3.2 Structures Implemented in MIKE FLOOD

Structure	Link Type	Modelled Structure	Height/Width	Comments
Jondaryan Muldu Road	Standard	Culvert	1.2m/0.9m and 1.2m/1.05m	9 rectangular culverts
Warrego Highway (culverts)	Standard	Culvert	2.1m/1.56m	22 rectangular culverts
Western Rail Line (bridge)	Standard	Bridge	-	Geometry based on 1m DEM and site visit photos (see Appendix A)
Station Street	Standard	Culvert	2.38m/0.9m	2 rectangular culverts

3.4.1 Standard/Structure Link Options

The standard/structure link parameters adopted in the MIKE FLOOD model are summarised in Table 3.3. The momentum factor was set to 1 at all explicit links. An exponential smoothing factor of 0.2 was adopted.

Table 3.3 Adopted Standard/Structure Link Parameters

Parameter	Value/Option
Momentum factor	1
Extrapolation factor	0
Add/Replace Flow	Replace
Depth Adjustment	Yes
Exponential Smoothing Factor	0.2

4 ASSESSMENT OF MODEL PERFORMANCE

The MIKE FLOOD model was validated for the January 2011 flood event by scaling inflows until a satisfactory match with observed flood levels was achieved. The fit between modelled and observed flood levels is summarised in Table 4.1. Peak flood surface elevation, peak water depth, flood hazard and hydraulic category maps for the January 2011 event are included in Appendix C of this report.

Table 4.1 Measured and Modelled Flood Levels

ID	Location	Observed Flood Level (m AHD)	Modelled Flood Level (m AHD)	Difference (m)
1	Jondaryan Hotel (corner of Warrego Highway and Station Street)	384.54	384.79	0.25
2	3 Station Street (driveway)	383.85	384.05	0.20
3	1 Short Street (driveway)	384.23	384.30	0.07
4	1 Short Street (flood point next to house)	384.46	384.43	-0.03
5	1 Short Street (flood point next to shed)	383.96	384.13	0.17
6	4 Earl Street (next to road)	384.30	384.25	-0.05
7	6 Earl Street (near corner of Earl Street and Station Street)	383.86	383.96	0.10
8	11 Station Street (near footpath)	383.82	383.93	0.11
9	11 Station Street (back of house)	384.72	383.84	-0.88
10	11 Earl Street (near property fence line)	383.83	383.87	0.04
11	3 Tooth Street (power pole)	383.38	383.43	0.05
12	32 Earl Street (end of street near power poles)	382.91	382.65	-0.26
13	15 Station Street (property fence near footpath)	384.12	383.88	-0.24
14	15 Baron Street (power pole next to footpath)	383.77	383.80	0.03
15	18 Station Street (driveway)	383.48	384.06	0.58
16	4 Baron Street (back of house)	384.00	384.08	0.08

All differences between measured and observed water levels are within the targeted ±0.5 m except for two outliers where the model overestimates and underestimates the flood level by 58cm and 88cm, respectively. Given the magnitude of the discrepancy between the observed levels at these two locations and the observed levels at the surrounding locations, the two readings are most likely erroneous. At 11 Station Street (back of house) the observed level is 384.72mAHD and the surrounding observed levels are all approximately 1m lower. At 18 Station Street the observed level is 383.48mAHD and observed flood marks downstream are all approximately 0.3m higher.

The discharge of 300m^3/s applied in this study is significantly larger than the flow of 180m^3/s used in the SKM model (see Section 2.4). The SKM model used a 10m grid whilst a 3m grid was used in this study. It is expected that a better representation of the actual channel conveyance would be achieved in the finer scale MIKE FLOOD model. In addition, the SKM model was only validated to two locations compared to sixteen locations in this study (including the two validation points used by SKM). The SKM study overestimated the flood level at 3 Station Street (ID2) by 17cm and underestimated the flood level at 3 Tooth Street (ID11) by 17cm, see Figure 2.1. The MIKE FLOOD model overestimates the observed levels at these locations by 20cm and 5cm, respectively. An analysis of the differences listed in Table 4.1 indicates an overall average model bias of +0.04m and an average absolute error of 0.12m if the two outliers (ID 9 and ID 15) are excluded.

The predicted head losses at the hydraulic structures are listed in Appendix B. It is worth noting that the Warrego Highway head loss is less than the Western Rail Line bridge head loss, both with the same flow. Based on the relative size of bridge span widths and culvert widths, one would expect the Western Rail Line bridge head loss to be less than the Warrego Highway head loss. The higher head loss at the railway bridge is most likely caused by the fact that a default expansion loss has been adopted for the railway bridge, whereas the bridge flow is unlikely to fully expand in the distance upstream of Warrego Highway. However, as there are no measured levels upstream of the railway line, it is not possible to validate the modelled head losses. It is therefore recommended to collect data on head losses through the Warrego Highway and Western Rail Line structures and update the model with this information when available.

5 SENSITIVITY ANALYSIS

5.1 OVERVIEW

The model was tested for sensitivity to flow, roughness and blockage of hydraulic structures. The January 2011 event was used as the baseline scenario. The following four sensitivity runs were undertaken:

- ±30% variation in flow;
- Increase in roughness (30% reduction in Manning's 'M'); and
- 50% blockage of hydraulic structures.

The sensitivity to blockage of structures was assessed as follows:

- The width of rectangular culverts was halved while maintaining the existing invert and obvert levels; and
- The pier blockage factor was set to 0.5 for bridge openings.

5.2 RESULTS

Structure head losses, discharges and velocities for the four sensitivity runs are listed in Appendix B. Maps of the model sensitivity to flow, roughness and blockage of structures are included in Appendix D. A small variation in the overall flood extent was observed for all sensitivity analysis scenarios, except for an area upstream of Warrego Highway. There, an increase in the adopted flow, roughness or hydraulic structure blockage would result in a larger flood extent when compared to the baseline scenario.

A comparison of the modelled surface elevation for the validation event and all sensitivity analysis scenarios is listed in Table 5.1 at selected validation points. The peak water levels are most sensitive to changes in roughness. A 30% reduction in Manning's M values (or an equivalent increase in Manning's 'n' values) results in a maximum water level increase of 16cm at the selected validation points.

Table 5.1 Modelled Surface Elevation at Selected Validation Points for All Sensitivity Analysis Scenarios

Sensitivity Analysis	ID1	ID4	ID6	ID10	ID11	ID12	ID13	ID16
Baseline [mAHD]	384.79	384.43	384.25	383.87	383.43	382.65	383.88	384.08
Flow +30% [mAHD]	384.86	384.5	384.34	383.95	383.48	382.74	383.98	384.17
Difference [m]	**0.07**	**0.07**	**0.09**	**0.08**	**0.05**	**0.09**	**0.1**	**0.09**
Flow -30% [mAHD]	-	-	384.13	383.78	383.33	382.55	383.76	383.97
Difference [m]	**-**	**-**	**-0.12**	**-0.09**	**-0.1**	**-0.1**	**-0.12**	**-0.11**
Manning's 'M' -30% [mAHD]	384.82	384.56	384.38	384	383.55	382.81	384.02	384.19
Difference [m]	**0.03**	**0.13**	**0.13**	**0.13**	**0.12**	**0.16**	**0.14**	**0.11**
50% Blockage [mAHD]	384.82	-	384.21	383.81	383.55	382.6	383.78	384.01
Difference [m]	**0.03**	**-**	**-0.04**	**-0.06**	**0.12**	**-0.05**	**-0.1**	**-0.07**

6 SUMMARY AND CONCLUSIONS

The primary objective of this historical study was to define the nature and extent of flood behaviour in the Jondaryan study area to enable Toowoomba Regional Council to develop a Flood Risk Management Study and amend the regional planning scheme to reflect flood requirements of the State Planning Policy and the recommendations of the Queensland Commission of Inquiry.

A coupled 1D/2D (MIKE FLOOD) hydraulic model has been successfully developed and validated for the Jondaryan study area. The model was validated for the January 2011 flood event, the validation results were demonstrated graphically and the modelled flood levels matched within the specified targets of the observed flood levels.

The hydraulic model results show that Jondaryan was greatly affected by flooding from the Lagoon Creek during the January 2011 event. The Warrego Highway, which provides access to the town from the south-east and north-west, was cut off during the event. Based on a comparison of flood extents in Jondaryan since the November 1974 flood, it was found that the January 2011 event was the largest event in the last 40 years.

A sensitivity analysis was undertaken to assess model sensitivity to adopted flow, roughness and blockage of hydraulic structures. A small variation in the overall flood extent was observed for all sensitivity analysis scenarios, except for an area upstream of the Warrego Highway. There, an increase in the adopted flow, roughness or hydraulic structure blockage would result in a larger flood extent when compared to the baseline scenario. This highlights the need for collection of additional flood level data at the Western Rail Line bridge and the Warrego Highway culvert crossing, to provide data to calibrate head losses through the structures.

Peak flood surface elevation, peak water depth, flood hazard and hydraulic category maps are included in Appendix C of this report. Hazard mapping for the January 2011 event classified parts of Jondaryan as areas of significant to extreme hazard. Maps of the model sensitivity to flow, roughness and blockage of structures are included in Appendix D. Digital mapping and model data files were also delivered as part of the study.

7 RECOMMENDATIONS

The following recommendations should be considered to improve the accuracy of the model performance.

1. Detailed calibration for at least two historical flood events should be performed to improve the model accuracy if more flood level data becomes available. As the model has only been validated against sixteen flood level observations, two of which appear to be erroneous; the model results should be used with caution.
2. Should a flood event occur it is recommended that peak flood levels and extents are collected as a minimum to further aid validation of the model. This should include measuring peak flood levels upstream and downstream of each of the major hydraulic structures across the creek, to provide data to calibrate head losses across the structures.
3. Model sensitivity to assumed downstream boundary levels was not part of the scope of the study, but could be considered.

8 REFERENCES

Arthur, B.A. and Burton, I., 2011	Report on the *Aftermath of Jondaryan Flood Seminar* held in the Jondaryan Public Hall on March 2, 2011. Report compiled on March 22, 2011.
DHI, 2013	Hydraulic Model Development. Proposed Model Schematisation. September, 2013.
Smith, G. and Wasko, C., 2012	Australian Rainfall and Runoff, Revision Project 15: *Two Dimensional Simulations in Urban Areas - Representation of Buildings in 2D Numerical Flood Models*. Engineers Australia, Barton, ACT, February 2012.
SKM, 2013	Flood hazard mapping – Jondaryan (Bundle 8). Final Report. March, 2013.
Toowoomba Regional Council, 2013	SP 051 Flood Studies. Local Buy Contract BUS 226-0212. Engineering Consultancy Services. Work Package 3 – Historical Studies for: Brookstead, Clifton, Crows Nest, Jondaryan and Millmerran. Project Brief.

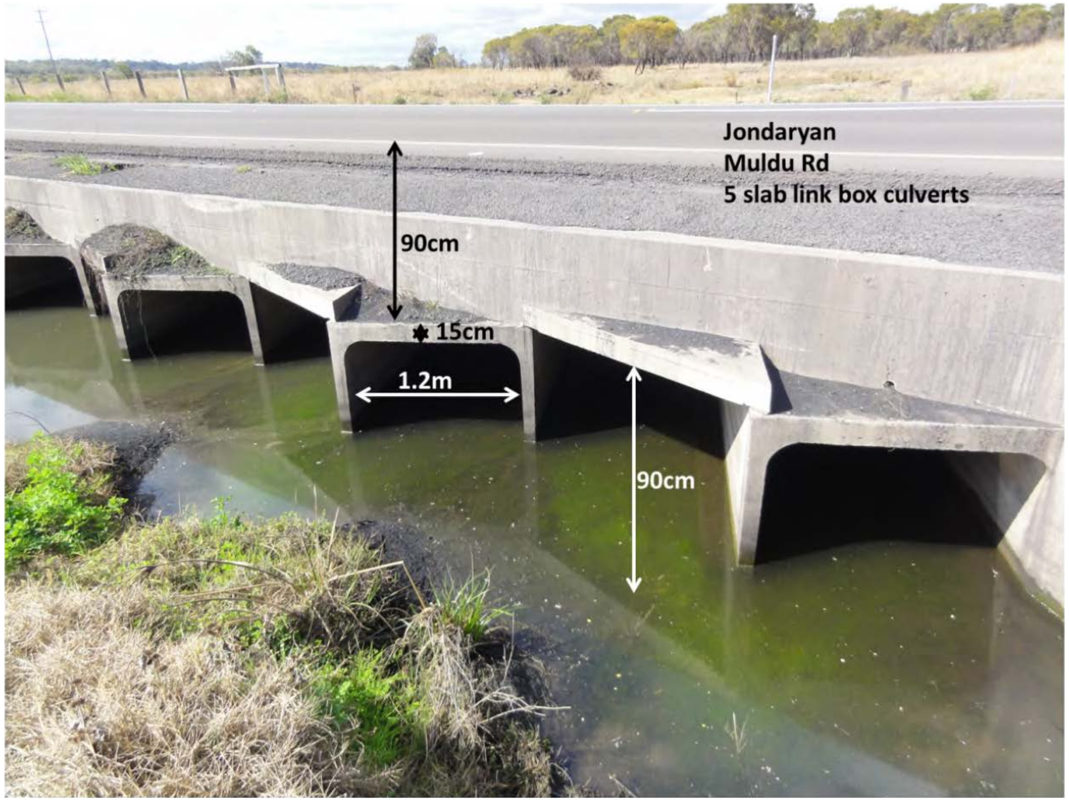
9 DISCLAIMER

Information used is the best information available at this time for the purposes of this study. Marks observed and other anecdotal information obtained after flood events have been obtained from a range of sources and have varying degrees of certainty.

While every care is taken by the Toowoomba Regional Council (TRC) to ensure the accuracy of the data used in the study and published in the report, Toowoomba Regional Council makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaim all responsibility and all liability whether in contract, negligence or otherwise for all expenses, losses, damages (including indirect or consequential damage) and costs which may be incurred in any way and for any reason as a result of data being inaccurate or incomplete.

APPENDIX A

STRUCTURE ATTRIBUTES



Jondaryan Muldu Road
Crossing over Lagoon
Creek

Location:
-27.368223
151.600202

Warrego Highway (culverts)
Crossing over Lagoon
Creek

Location:
-27.369628
151.594355

Western Rail Line (bridge)
Crossing over Lagoon
Creek

Location:
-27.369423
151.594548

Station Street
Crossing over Lagoon
Creek

Location:
-27.371196
151.59097

APPENDIX B

STRUCTURE HEAD LOSSES, DISCHARGES AND VELOCITIES

Table B.1 Head Losses, Discharges and Velocities at Structures - January 2011 Validation Event

Structure	Upstream Water Level (mAHD)	Road Level (mAHD)	Downstream Water Level (mAHD)	Structure Invert (mAHD)	Structure Obvert (mAHD)	Head Loss* (m)	Peak Discharge** (m^3/s)	Peak Velocity*** (m/s)	Road Overtopped
Jondaryan Muldu Road	386.05	385.20	385.93	383.50	384.4/384.55	0.12	18	1.8	✓
Warrego Highway (culverts)	385.19	384.60	385.09	382.57	384.13	0.10	116	1.6	✓
Warrego Rail Line (bridge)	385.41	385.40	385.16	382.82	384.60	0.25	116	2.3	✓
Station Street	384.00	382.80	383.93	381.60	382.50	0.07	5	1.2	✓

Table B.2 Head Losses, Discharges and Velocities at Structures - Sensitivity Analysis (+30% Flow)

Structure	Upstream Water Level (mAHD)	Road Level (mAHD)	Downstream Water Level (mAHD)	Structure Invert (mAHD)	Structure Obvert (mAHD)	Head Loss* (m)	Peak Discharge** (m^3/s)	Peak Velocity*** (m/s)	Road Overtopped
Jondaryan Muldu Road	386.16	385.20	386.04	383.50	384.4/384.55	0.12	18	1.4	✓
Warrego Highway (culverts)	385.27	384.60	385.16	382.57	384.13	0.11	118	1.7	✓
Warrego Rail Line (bridge)	385.50	385.40	385.23	382.82	384.60	0.27	118	2.2	✓
Station Street	384.08	382.80	384.01	381.60	382.50	0.07	7	1.1	✓

* The head loss is calculated as the difference between the upstream and downstream peak water levels in MIKE 11
** Peak discharge is reported through the culvert or bridge
*** Peak velocity is reported through the culvert or bridge

Table B.3 Head Losses, Discharges and Velocities at Structures - Sensitivity Analysis (-30% Flow)

Structure	Upstream Water Level (mAHD)	Road Level (mAHD)	Downstream Water Level (mAHD)	Structure Invert (mAHD)	Structure Obvert (mAHD)	Head Loss* (m)	Peak Discharge** (m³/s)	Peak Velocity*** (m/s)	Road Overtopped
Jondaryan Muldu Road	385.89	385.20	385.79	383.50	384.4/384.55	0.10	18	1.3	✓
Warrego Highway (culverts)	385.09	384.60	385.00	382.57	384.13	0.09	113	1.6	✓
Warrego Rail Line (bridge)	385.29	385.40	385.06	382.82	384.60	0.23	113	2.2	
Station Street	383.89	382.80	383.82	381.60	382.50	0.07	5	1.1	✓

Table B.4 Head Losses, Discharges and Velocities at Structures - Sensitivity Analysis (-30% Manning's 'M')

Structure	Upstream Water Level (mAHD)	Road Level (mAHD)	Downstream Water Level (mAHD)	Structure Invert (mAHD)	Structure Obvert (mAHD)	Head Loss* (m)	Peak Discharge** (m³/s)	Peak Velocity*** (m/s)	Road Overtopped
Jondaryan Muldu Road	386.13	385.20	386.06	383.50	384.4/384.55	0.07	18	1.1	✓
Warrego Highway (culverts)	385.25	384.60	385.16	382.57	384.13	0.09	106	1.5	✓
Warrego Rail Line (bridge)	385.44	385.40	385.22	382.82	384.60	0.22	106	2.1	✓
Station Street	384.10	382.80	384.06	381.60	382.50	0.04	6	0.9	✓

* The head loss is calculated as the difference between the upstream and downstream peak water levels in MIKE 11
** Peak discharge is reported through the culvert or bridge
*** Peak velocity is reported through the culvert or bridge

Table B.5 Head Losses, Discharges and Velocities at Structures - Sensitivity Analysis (50% Blockage)

Structure	Upstream Water Level (mAHD)	Road Level (mAHD)	Downstream Water Level (mAHD)	Structure Invert (mAHD)	Structure Obvert (mAHD)	Head Loss* (m)	Peak Discharge** (m^3/s)	Peak Velocity*** (m/s)	Road Overtopped
Jondaryan Muldu Road	386.10	385.20	385.88	383.50	384.4/384.55	0.22	12	1.5	✓
Warrego Highway (culverts)	385.13	384.60	384.83	382.57	384.13	0.30	76	2.1	✓
Warrego Rail Line (bridge)	385.53	385.40	385.11	382.82	384.60	0.42	76	2.7	✓
Station Street	383.96	382.80	383.82	381.60	382.50	0.14	4	1.3	✓

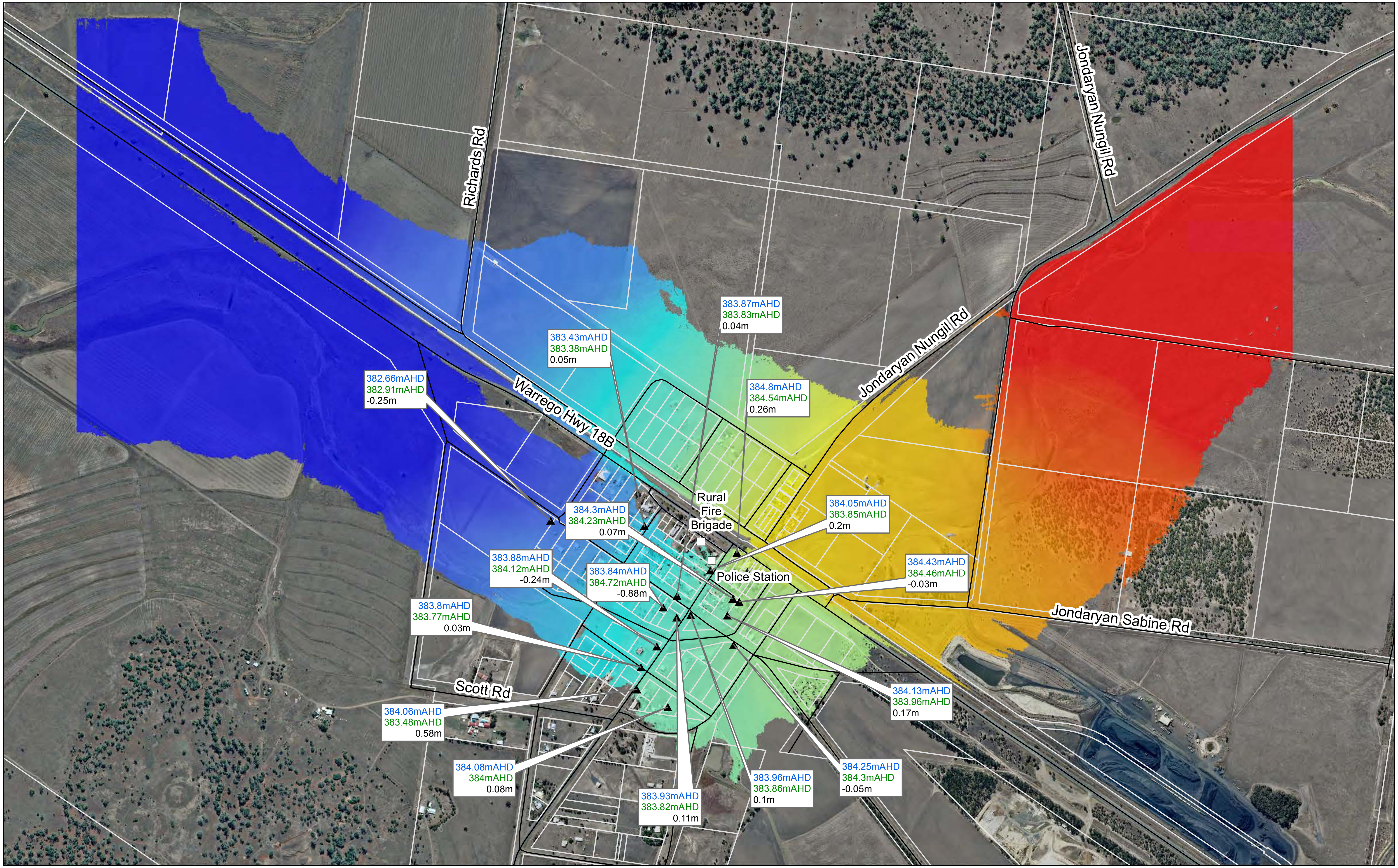
* The head loss is calculated as the difference between the upstream and downstream peak water levels in MIKE 11

** Peak discharge is reported through the culvert or bridge

*** Peak velocity is reported through the culvert or bridge

APPENDIX C

VALIDATION MAPPING



TOOWOOMBA REGIONAL COUNCIL

1:10,000 (at A3)

0 100 200 400
Meters

GDA 1994 MGA Zone 56

N

Legend

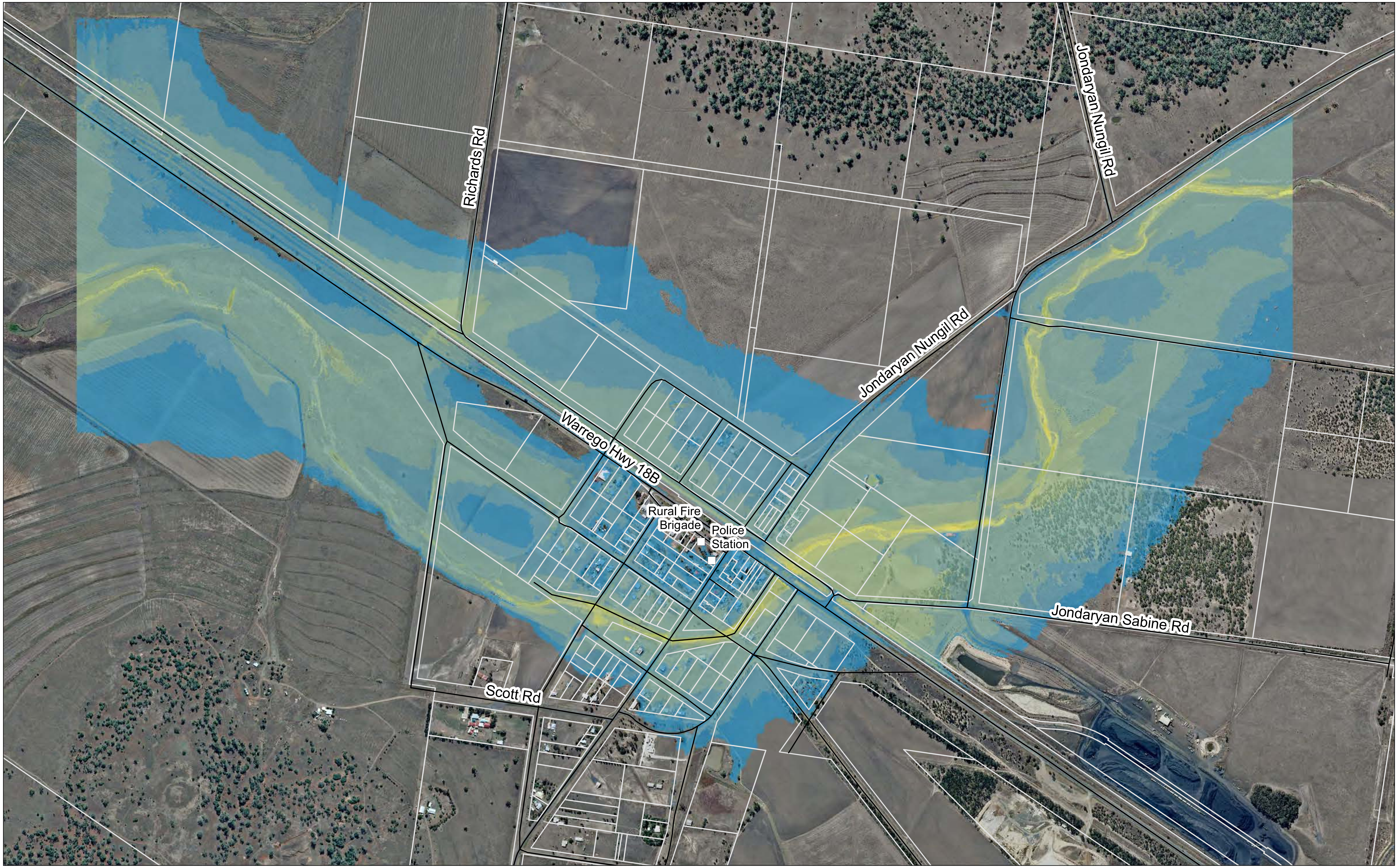
Surface Elevation [mAHD]
387
382

Roads
Cadastre
Emergency Services

2011 Validation Data
▲ Flood Levels

Modelled
Observed
Modelled-Observed

SP051 Flood Studies
Work Package 3 Jondaryan
January 2011
Water Surface Elevation



TOOWOOMBA REGIONAL COUNCIL

1:10,000 (at A3)

0 100 200 400
Meters

GDA 1994 MGA Zone 56

N

Legend

Peak Water Depth [m]

0 - 0.25, 0.25 - 0.5, 0.5 - 1, 1 - 1.5, 1.5 - 2, 2 - 2.5, 2.5 - 3, 3 - 3.5, 3.5 - 4, 4 - 4.5, 4.5 - 5, >5

Roads

Cadastre

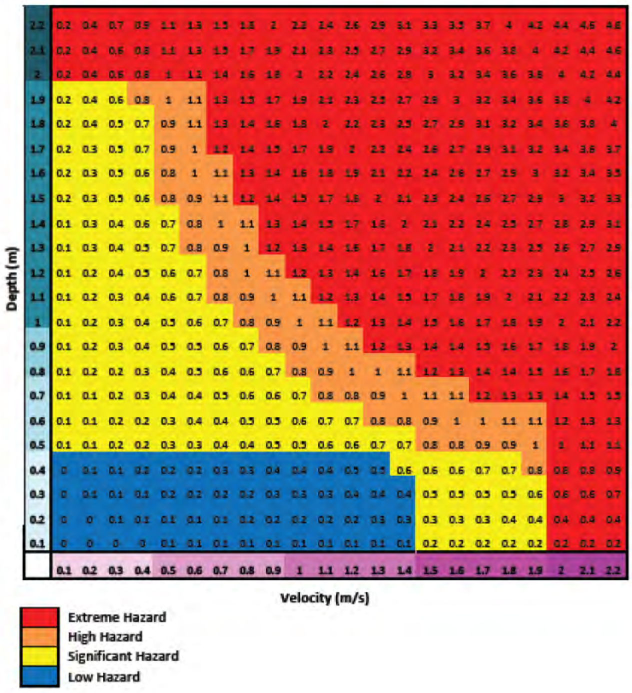
Emergency Services

Disclaimer: The flood information contained in the maps is based on debris lines and marks that were visible and accessible at the time of recording after the January 2011 flood extent and may not be accurate or complete and reliance should not be placed on it. Toowoomba Regional Council makes no representations or warranties about the accuracy, reliability, completeness or suitability for any particular purpose and disclaim all responsibility and all liability whether in contract, negligence or otherwise for all expenses, losses, damages (including indirect or consequential damage) and costs which may be incurred in any way and for any reason as a result of the flood information contained in the maps being inaccurate or incomplete.

SP051 Flood Studies
Work Package 3 Jondaryan
January 2011
Water Depth

Hazard Category Mapping

Flood hazard categories are as defined in Schedule 4 of the Queensland Reconstruction Authority's *Planning for stronger, more resilient floodplains* (2012), see Figure C.1.



Rules

	Low	Significant	High	Extreme
Depth	<0.5	<2	<2	2+
Velocity	<1.5	<2	<2	2+
DxV Ratio	<0.6	0.6 to <0.8	0.8 to <1.2	1.2 +

Rationale

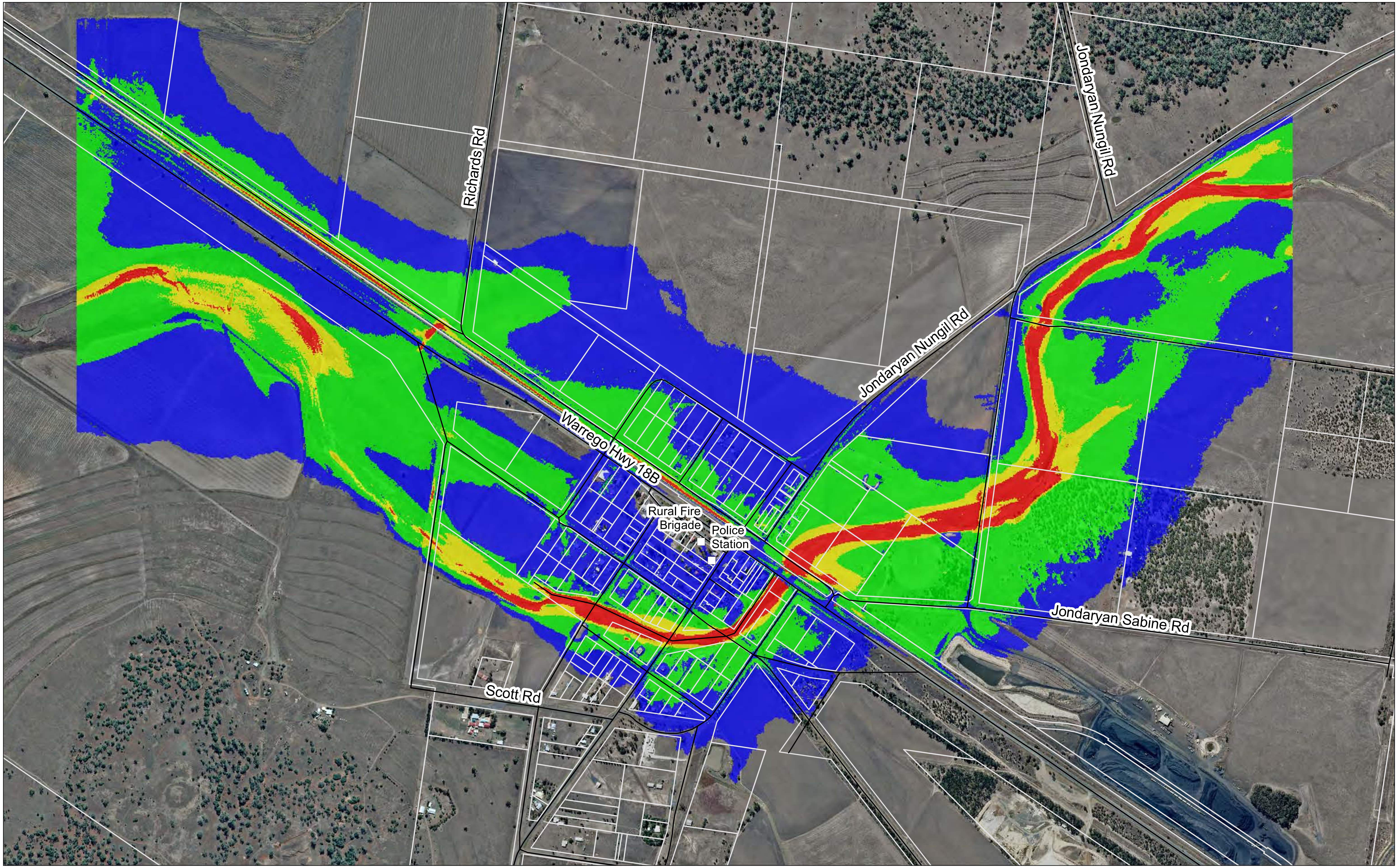
1. **Low** – self evacuation possible for adults and children, vehicle stability within tolerance for large 4WD
2. **Significant** – working limit for trained safety workers, Vehicle evac unsuitable, Building Code limitation
3. **High** – limit of uncompromised stability for adults (dangerous to most)
4. **Extreme** – in excess of known stability limits

Figure C.1 Adopted Flood Hazard Classification

Hydraulic Category Mapping

The following hydraulic categories were adopted.

- 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



SP051 Flood Studies
Work Package 3 Jondaryan
January 2011
Hazard Category

TOOWOOMBA REGIONAL COUNCIL

1:10,000 (at A3)

0 100 200 400
Meters
GDA 1994 MGA Zone 56

N

Legend

Hazard Category
- Low
- Significant
- High
- Extreme

- Roads
- Cadastre
- Emergency Services

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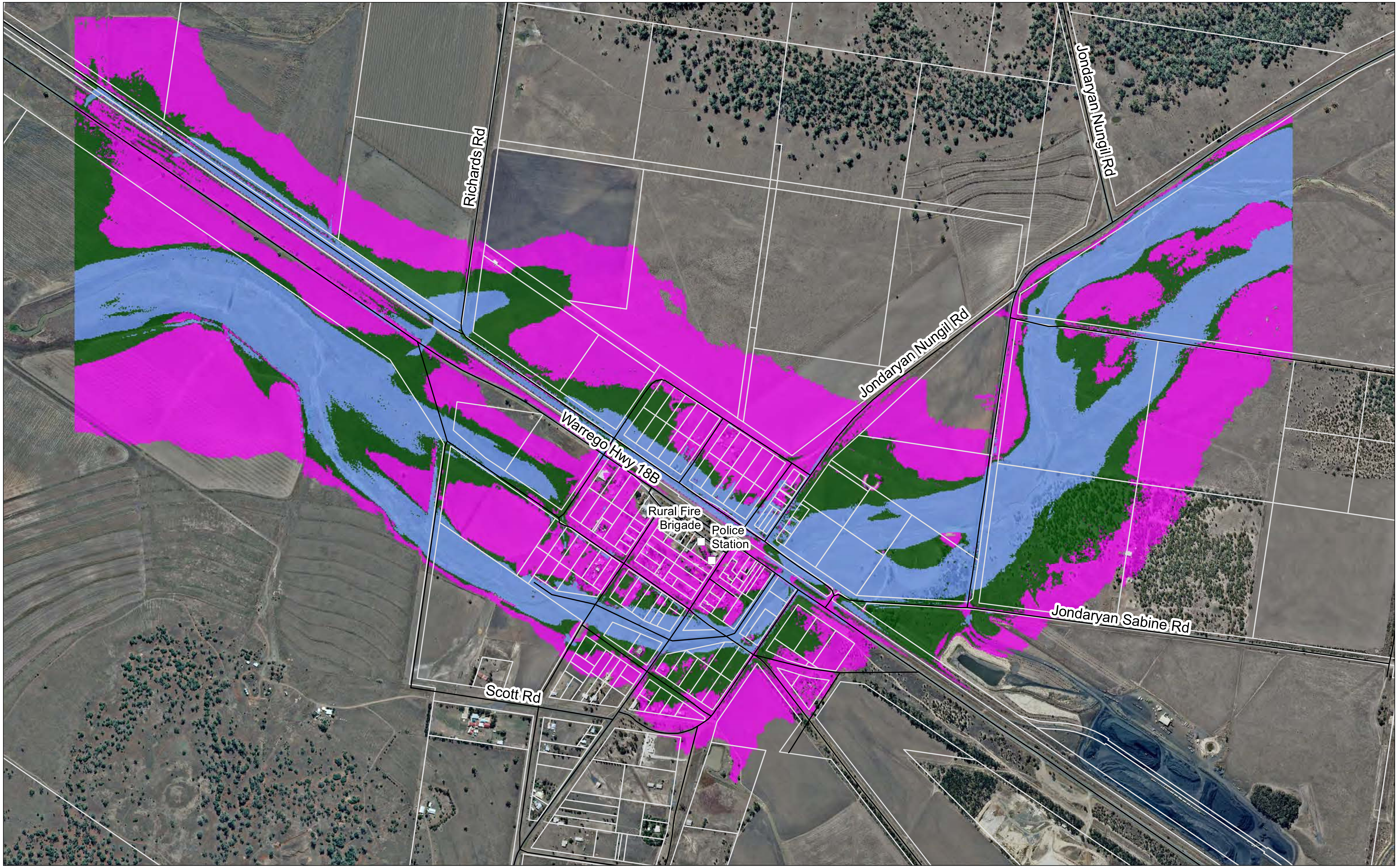

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1:10,000 (at A3)

0 100 200 400

Meters

GDA 1994 MGA Zone 56

N

Legend

Hydraulic Category

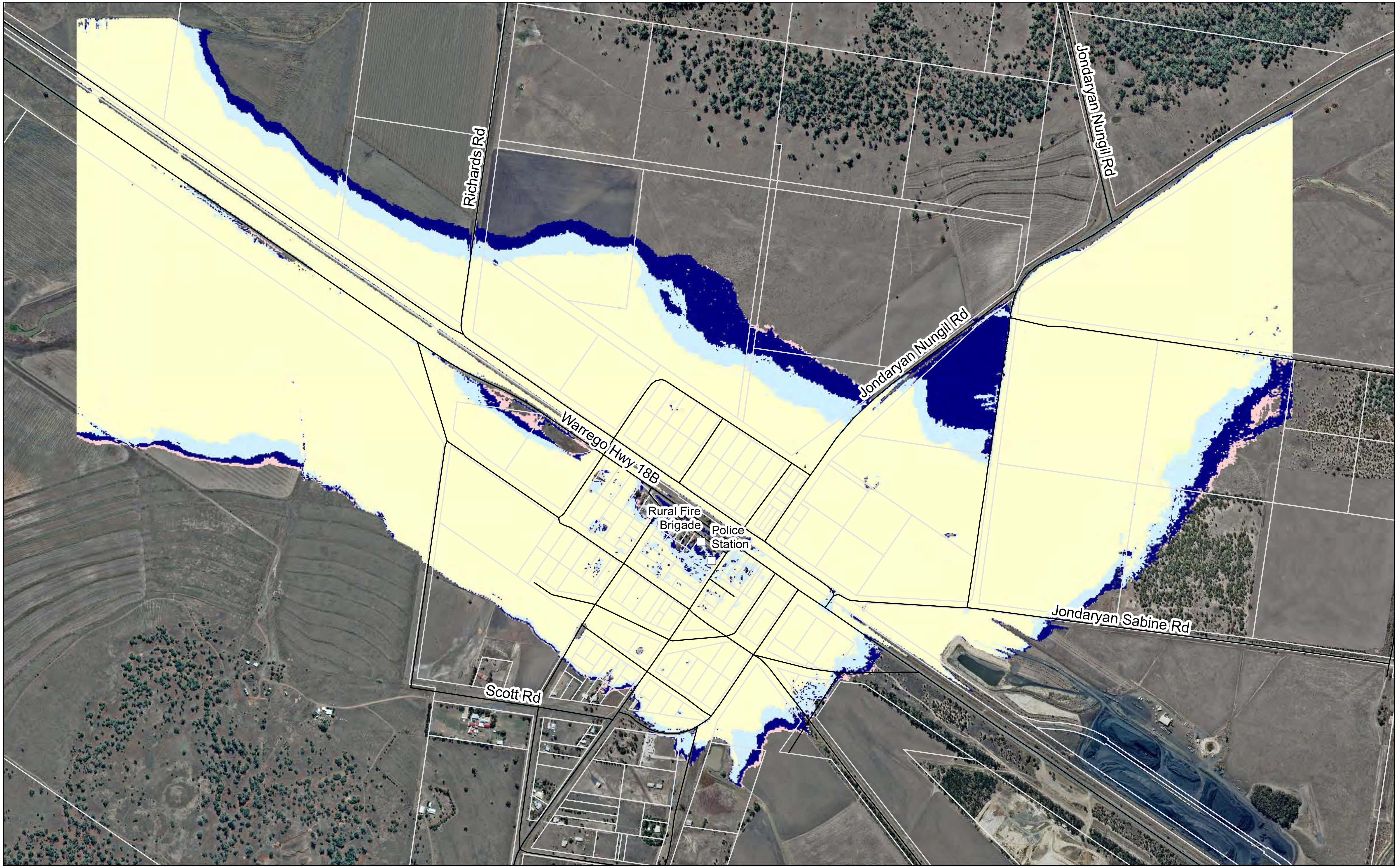
- Flood Fringe
- Flood Storage
- Floodway
- Roads
- Cadastre
- Emergency Services

Disclaimer: The flood information contained in the maps is based on debris lines and marks that were visible and accessible at the time of recording after the January 2011 flood extent and may not be accurate or complete and reliance should not be placed on it. Toowoomba Regional Council makes no representations or warranties about the accuracy, reliability, completeness or suitability for any particular purpose and disclaim all responsibility and all liability whether in contract, negligence or otherwise for all expenses, losses, damages (including indirect or consequential damage) and costs which may be incurred in any way and for any reason as a result of the flood information contained in the maps being inaccurate or incomplete.

SP051 Flood Studies
Work Package 3 Jondaryan
January 2011
Hydraulic Category

APPENDIX D

SENSITIVITY ANALYSIS MAPPING



TOOWOOMBA REGIONAL COUNCIL

1:10,000 (at A3)

0 100 200 400

Meters

GDA 1994 MGA Zone 56

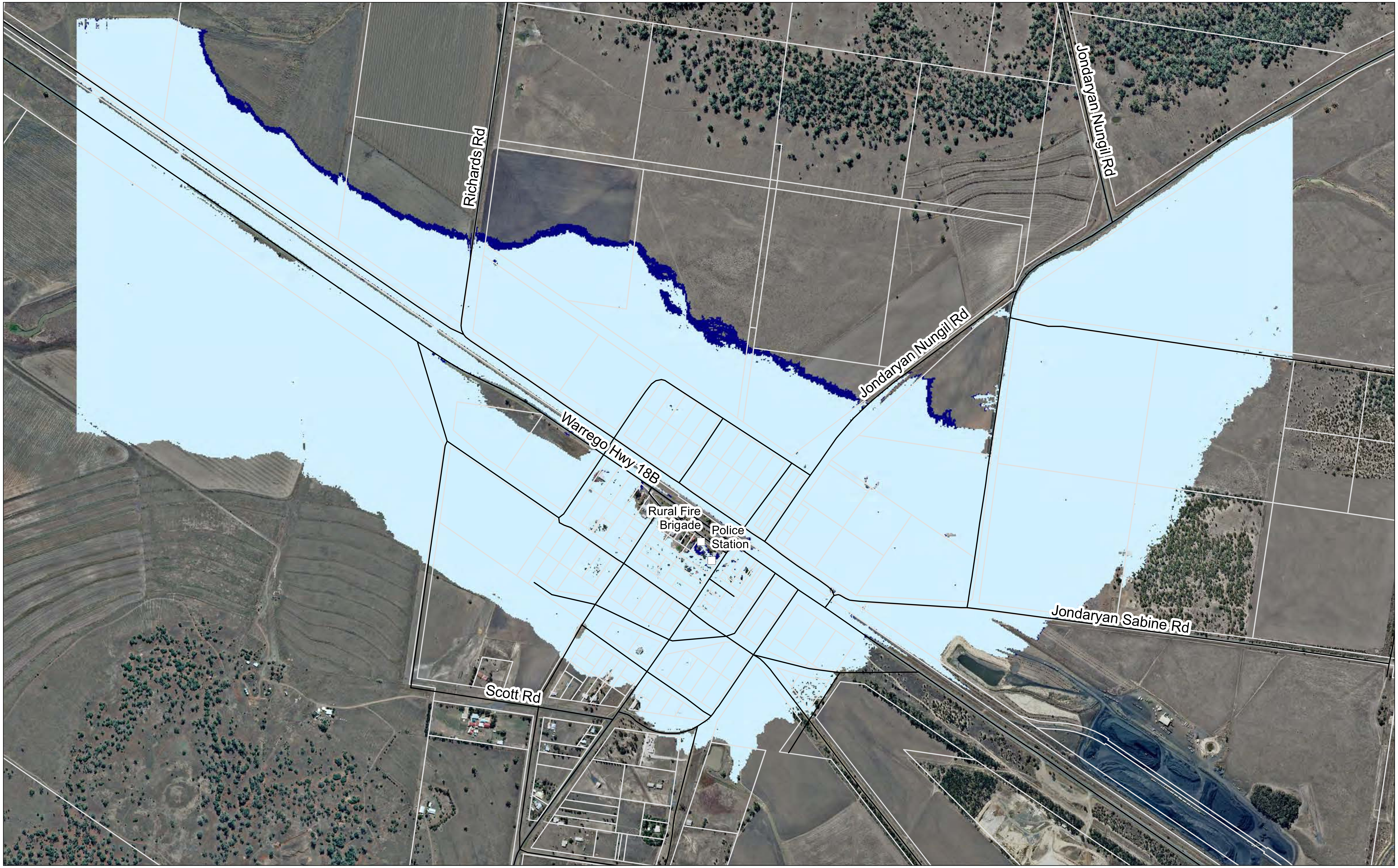
N

Legend

Inundation Extent

- 30% Reduction in Flow
- Baseline
- 30% Increase in Flow
- 30% Increase in Roughness
- Emergency Services
- Roads
- Cadastre

SP051 Flood Studies
Work Package 3 Jondaryan
Sensitivity to Flow and Roughness



1:10,000 (at A3)

0 100 200 400
Meters
GDA 1994 MGA Zone 56

N

TOOWOOMBA REGIONAL COUNCIL

Legend

Inundation Extent
- Baseline
- 50% Blockage of Structures

- Emergency Services
- Roads
- Cadastre

SP051 Flood Studies
Work Package 3 Jondaryan
Sensitivity to Blockage of Structures

TOOWOOMBA REGION

131 872 | info@tr.qld.gov.au | www.tr.qld.gov.au
PO Box 3021 Toowoomba QLD 4350 | Toowoomba Regional Council

yoursay.toowoombaRC.qld.gov.au/flood-resilience

A safer, stronger, more resilient region

Financially, socially and environmentally sustainable

TOOWOOMBA REGION
Rich traditions. Bold ambitions.

Jondaryan Flood Studies Information Sheet

WHY UNDERTAKE FLOOD STUDIES?

Following extensive flooding across the Toowoomba region, we commissioned a number of flood studies to better understand how flooding can impact our communities. These studies are now complete and available on our website.

The flood studies found that flood behaviour can be complex and vary between locations, depending on landscape, infrastructure and rainfall pattern.

SOME BASIC FLOOD TERMS

1. **Overland flow** – short duration flooding of backyards, drainage paths, streets and rural properties caused by stormwater as it makes its way into the creek/river system;

2. **Creek flooding** – short to medium duration flooding caused by creeks rising and breaking their banks, which can then flood nearby homes, businesses and rural properties;

3. **River flooding** – longer duration flooding caused by significant rises in a river which can break its banks in the same way as smaller creeks.

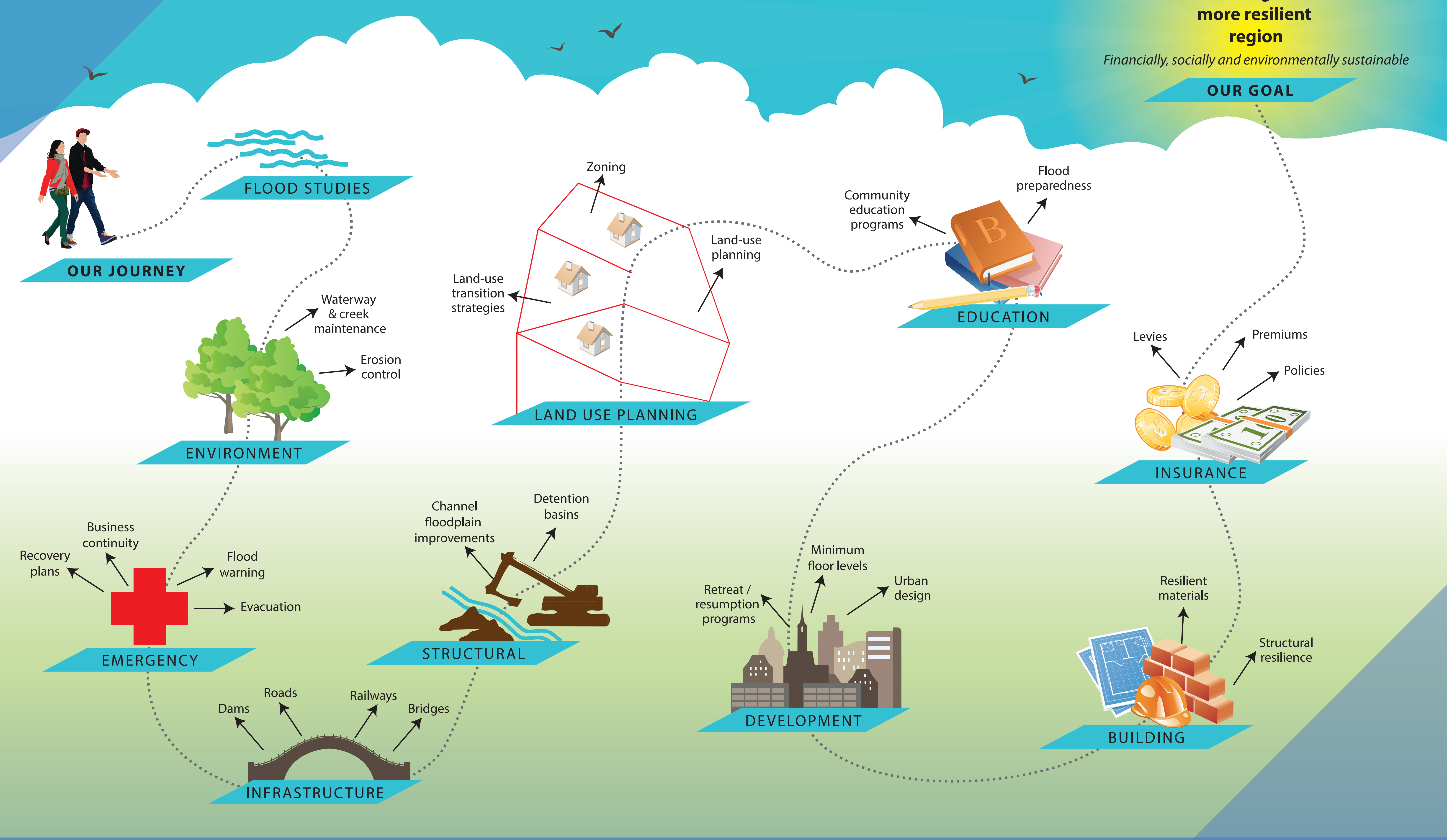
Most of the studies undertaken or commissioned by Council relate to the first two types of flooding – overland flow and creek flooding. It's important to note that these types of flooding can occur separately or together.

KEY MESSAGES

1. Council has a legislative requirement to undertake flood management and the whole community needs to be involved.
2. Flood studies are a foundation and an essential step towards our goal of a safer, stronger, more resilient region.
3. Flood studies have been undertaken by specialist engineers and incorporate the latest data, modelling techniques and community input.
4. Community consultation enables two-way information sharing about the project to increase community awareness, enhance decision making and help achieve our goal of a safer, stronger, more resilient region.

Flood + us - our journey

Steps on the path to achieving our goal



Jondaryan Flood Studies Information Sheet

WHAT'S JONDARYAN'S FLOOD STORY?

A flood study and flood maps are now available for Jondaryan residents. The primary source of flood risk to the town is from creek flooding.

Jondaryan has a long history of flooding including three major flood events in the summer of 2010/2011 - 27 December 2010, 6 January 2011 and 11 January 2011. The event of 11 January 2011 was the most significant and is the subject of the historical flood study undertaken by engineers. The historical study has shown that rising waters within Lagoon Creek was the principal source of flooding and caused flooding to the majority of town, north of Scott Road. The Warrego Highway, both east and west of town, was cut off during the event. Previous significant floods were recorded in November 1974, December 1991, February 1994 and May 1996. Based on a comparison of historical flood extents, it was found that the January 2011 flood was the largest event in the last 40 years.

A further assessment was carried out to compare the 2011 event against a 1% Annual Exceedance Probability event – meaning there is a 1% chance in any year of an event of this size or larger occurring. While the flood depth in the model does vary from the 2011 event in some areas, this comparison concluded that the 2011 event was less than a 1% event.

Annual Exceedance Probability (AEP) means the chance of a flood of a given size or larger size occurring in any one year, usually expressed as a percentage.

COMMUNITY INVOLVEMENT

Improving the way we prepare for and respond to flooding as a community is very important to us. Many residents in our region contributed information to build and validate our flood knowledge during the region-wide consultation sessions and other flood studies engagement opportunities.

Community involvement with this project continues to help our region become safer, stronger and more resilient. We encourage you to access the flood study information online and stay up to date with the project by visiting the web address below.

GET INFORMED

You can access our region's current flood studies and maps by heading to
http://yoursay.toowoombarc.qld.gov.au/flood-resilience
For more information, please contact the project team by phone, email or post.

Phone: 131 872

Email: info@tr.qld.gov.au

Post: Strategic Planning & Economic Development,
Toowoomba Regional Council, PO Box 3021, Toowoomba Q 4350.

TOOWOOMBA REGION