GLADSTONE REGIONAL COUNCIL

Baffle Creek Flood Study

Flood Study Report

January 2019

M38000_009

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M38000_009 BAFFLE CREEK FLOOD STUDY REPORT					
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Signatures					

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1. INTRODUCTION

1.1 Background

Baffle Creek is one of the major waterways within the Gladstone Regional Council (GRC) Local Government Area (LGA). Baffle Creek is located in the southernmost extent of the GRC LGA (see Figure 1.1). GRC have identified that Baffle Creek as being the only major waterway within the GRC LGA to not currently have an up-to-date flood study that is fit-for-purpose and developed in accordance with industry standards and best practice.

Engeny Water Management (Engeny) was commissioned by GRC to undertake a flood study for the Baffle Creek catchment. The purpose of the flood study is to generated design hydrology and hydraulics for design flood events ranging from the 2% AEP flood event up to the Probable Maximum Flood (PMF) event.

Figure 1.1 Catchment location

1.2 Study Scope

The scope of the Baffle Creek Flood Study is as follows:

- Collation and review of available data relating to flooding in the Baffle Creek catchment.
- Development of jointly calibrated hydrologic and 2D hydraulic models of the Baffle Creek catchment.
- Simulate design flood events using the calibrated models and compare to flood frequency data within the catchment.
- Production of reporting and flood mapping products.

1.3 Catchment Description

The Baffle Creek catchment is located between the GRC and Bundaberg Regional Council Local Government Areas (LGAs), approximately 100 km south of Gladstone and 50 km north of Bundaberg. The catchment is shown in Figure 1.2. The total catchment area to the creek mouth is 2,556 km. The Baffle Creek catchment incorporates the following major tributaries; Killarney Creek, Three Mile Creek, House Creek, Colosseum Creek, Granite Creek, Scrubby Creek, Murrays Creek, Euleilah Creek and Bottle Creek, as well as a number of minor tributaries.

The headwaters of Baffle Creek originate in the Mount Stanley State Forest, within the Dawes Range approximately 80 km North West of the catchment outlet. Maximum elevations along Dawes Range in the upper catchment reach 500 mAHD to 700 mAHD. The main channel flows in a generally north-south direction, bordered by the Bulburin National Park (Dawes Range) to the west and a naturally forested ridgeline which forms the border between Baffle Creek and Euleilah Creek to the east. Baffle Creek turn to flow in easterly direction towards the Coral Sea after the confluence with Murrays Creek.

The Baffle Creek catchment is sparsely populated, with land use within the catchment dominated by natural forested areas and agricultural (grazing) uses. The largest Township within the catchment is Mirriam Vale (pop. 422), which is located towards the headwaters of the catchment. Other townships include; Bororen, Lowmead, Rosedale and Baffle Creek.

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0 5 10 15 20 25 km

Scale in metres (1: 50,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure 1-2 Catchment Overview

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1.4 Historic Flooding Events

The Baffle Creek catchment has experienced a number of significant flood events in recent history. Notable recent events include the January 2011, January 2013 and October 2017 flood events.

While the catchment is generally sparsely populated, flooding in the Baffle Creek catchment causes significant periods of isolation which can last for many days in some areas.

A summary of peak flood levels recorded at the Mimdale stream gauging station (DNRM gauge 134001B), located near Lowood on the main Baffle Creek channel, for significant historic events is presented in Table 1.1

Table 1.1 Baffle Creek Significant Flood Events

Event	Peak Mimdale Gauge Level (mAHD)
Dec-1973	24.50
Mar-1992	21.20
Dec-2010	22.50
Jan-2013	27.78
Oct-2017	24.76

2. PROJECT DATA

Table 2.1 summarises the data used for the Baffle Creek Flood Study.

Table 2.1 Study Data

Data	Comments
Digital Elevation Model	Lidar data in xyz format captured in 2009 covering the majority of the Baffle Creek Catchment. Sourced from GRC.
Bathymetric Survey	Survey undertaken for lower reaches of Baffle Creek and Euleilah Creek. Sourced from GRC.
Recorded Water Level at Stream Gauge	Recorded water level for Mimdale Gaging Station downloaded from DNRM website.
Stream Gauge Discharge Rating Curve	Latest rating curve for Mimdale Gaging Station downloaded from DNRM website.
Recorded Rainfall Data	Pluviometer and daily rainfall (20 stations) obtained from BOM and DNRM.
Aerial Photography	Aerial Photo for Baffle Creek catchment provided by GRC. Additional aerial photography was sourced from QLD Globe and Bing Map.
Design Rainfall Data	Latest ARR 2016 rainfall depths obtained from BOM website. Design rainfall losses, aerial reduction factors and temporal patterns sourced form ARR datahub (http://data.arr-software.org/).
Measured Flood Marks	Flood debris marks for January 2013 and October 2017 events surveyed by GRC.

3. HYDROLOGIC MODELLING

3.1 Overview

An URBS hydrologic model of the Baffle Creek catchment has been developed to generate design hydrology ranging from the 2% AEP event to the Probable Maximum Flood (PMF) event for Baffle Creek.

The URBS model has been calibrated to five (5) significant flood events. These events were December 1973, March 1992, December 2010, January 2013 and October 2017.

Design hydrology generated with the URBS hydrologic model has also been validated against at-site Flood Frequency Analysis (FFA) carried out at the Mimdale stream gauging location (134001B) using available gauging records.

3.2 Model Development

The URBS model structure was generated automatically using the CatchmentSIM software. The sub-catchment and channel parameters were determined based on a 67 m cell size Digital Elevation Model (DEM) of the Baffle Creek catchment which was derived from the aerial survey (LiDAR) data supplied by Council. The Baffle Creek catchment was divided into 155 sub-catchments through a combination of automated sub-catchment processing and manual sub-catchment outlet definition. Initially, automated sub-catchment routines were applied to achieve relatively consistent sub-catchment size, with manual outlets then defined where additional delineation was required, e.g. upstream of key townships.

The final catchment delineation is shown in Appendix A.

3.3 Model Calibration

3.3.1 Overview

The Baffle Creek URBS model was calibrated against rainfall and stream flow gauging data within the Baffle Creek catchment. Five flood events were selected for the URBS model calibrations. The calibration process involved the selection of rainfall loss parameters (initial and continuing rainfall losses) and catchment and channel routing parameters (α, β and m) to achieve a reasonable comparison between modelled and recorded flow hydrographs at the Mimdale stream gauging station location.

3.3.2 Calibration Events

The following flood events were selected for the URBS model calibration for the Baffle Creek catchment:

- December 1973 event.

- March 1992 event.
- December 2010 event.
- January 2013 event.
- October 2017 event.

3.3.3 Historical Rainfall Data

Pluviometer and daily rainfall stations in the vicinity of the Baffle Creek catchment which were operational during the calibration flood events are listed in Table 3.1. The locations of the rainfall stations are provided in Figure 1.2.

Rainfall totals for the five calibration events are summarised in Table 3.2.

The time distribution of rainfall recorded at the available pluviometer stations during the five calibration events is displayed in Figure 3.1 to Figure 3.5.

Table 3.1 Rainfall Stations Used for URBS Model Calibration Events

Station Number	Station Name	Station Type	Agency	Latitude (DDMMSS)	Longitude (DDMMSS)
39077	Euleilah Creek	Daily	BOM	-242630	1515106
39084	Rosedale Post Office	Daily	BOM	-243746	1515457
39104	Monto Township	Pluvio	BOM	-245151	1510729
39104	Monto Township	Daily	BOM	-245151	1510729
39123	Gladstone Radar	Pluvio	BOM	-235119	1511546
39128	Bundaberg Aero	Pluvio	BOM	-245425	1521923
39220	Charnwood	Daily	BOM	-243916	1513751
39223	Kolonga	Daily	BOM	-244908	1514242
39252	Ferndale	Daily	BOM	-241144	1512518
39314	Seventeen Seventy	Pluvio	BOM	-240924	1515320
39314	Seventeen Seventy	Daily	BOM	-240924	1515320
39326	Gladstone Airport	Pluvio	BOM	-235211	1511317

Station Number	Station Name	Station Type	Agency	Latitude (DDMMSS)	Longitude (DDMMSS)
39327	Makowata	Daily	BOM	-242630	1513900
134001	Baffle Creek at Mimdale	Pluvio	DNRM	-243049	1514411
134002	Oyster Creek at Rapleys	Pluvio	DNRM	-242235	1514931
135002	Kolan Rv at Springfield	Pluvio	DNRM	-244512	1513514
1350P002	Bania Standalone	Pluvio	DNRM	-245624	1513425
136108	Monal Ck at Upper Monal	Pluvio	DNRM	-243648	1510650
136111	Splinter Ck at Dakiel	Pluvio	DNRM	-244444	1511537
1361P002	Boolaroo Tops Stand	Pluvio	DNRM	-242333	1510205

Table 3.2 Calibration Event Rainfall Totals

Station Number	Station Name	Station Type	Total Rainfall (mm)				
			Dec-1973[1]	Mar-1992[2]	Dec-2010[3]	Jan-2013[4]	Oct-2017[5]
39077	Euleilah Creek	Daily	328.7	219.8	448.4	856.2	409.6
39084	Rosedale Post Office	Daily	246.3	248	199.4	-	687.6
39104	Monto Township	Pluvio	-	111.9	154.6	-	-
39104	Monto Township	Daily	177	-	-	-	201
39123	Gladstone Radar	Pluvio	372.5	-	279.2	709.4	147.8
39128	Bundaberg Aero	Pluvio	-	300.3	391.6	487.4	294.4
39220	Charnwood	Daily	342.7	212.2	400.4	693.2	535
39223	Kolonga	Daily	247.6	242	314.4	650.2	475.8
39252	Ferndale	Daily	613.2	117.6	-	966	-
39314	Seventeen Seventy	Pluvio	-	-	410.8	483.4	-
39314	Seventeen Seventy	Daily	-	271.4	-	-	244.1

Station Number	Station Name	Station Type	Total Rainfall (mm)				
			Dec-1973[1]	Mar-1992[2]	Dec-2010[3]	Jan-2013[4]	Oct-2017[5]
39326	Gladstone Airport	Pluvio	-	-	285.2	730.2	156.2
39327	Makowata	Daily	-	-	572.4	835	665.2
134001	Baffle Creek at Mimdale	Pluvio	-	212.1	537.9	770	439
134002	Oyster Creek at Rapleys	Pluvio	-	-	-	814	-
135002	Kolan Rv at Springfield	Pluvio	-	-	432	736	494
1350P002	Bania Standalone	Pluvio	-	-	411.5	942	540
136108	Monal Ck at Upper Monal	Pluvio	-	191	375	606	293
136111	Splinter Ck at Dakiel	Pluvio	-	-	365	505	290
1361P002	Boolaroo Tops Stand	Pluvio	-	-	695.7	1422.7	376

[1] *Rainfall total from 9 am 17 December 1973 to 9 am 29 December 1973.*

[2] *Rainfall total from 9 am 14 March 1992 to 9 am 24 March 1992.*

[3] *Rainfall total from 9 am 18 December 2010 to 9 am 04 January 2011.*

[4] *Rainfall total from 9 am 21 January 2013 to 9 am 1 February 2011.*

[5] *Rainfall total from 9 am 15 October 2017 to 9 am 24 October 2017.*

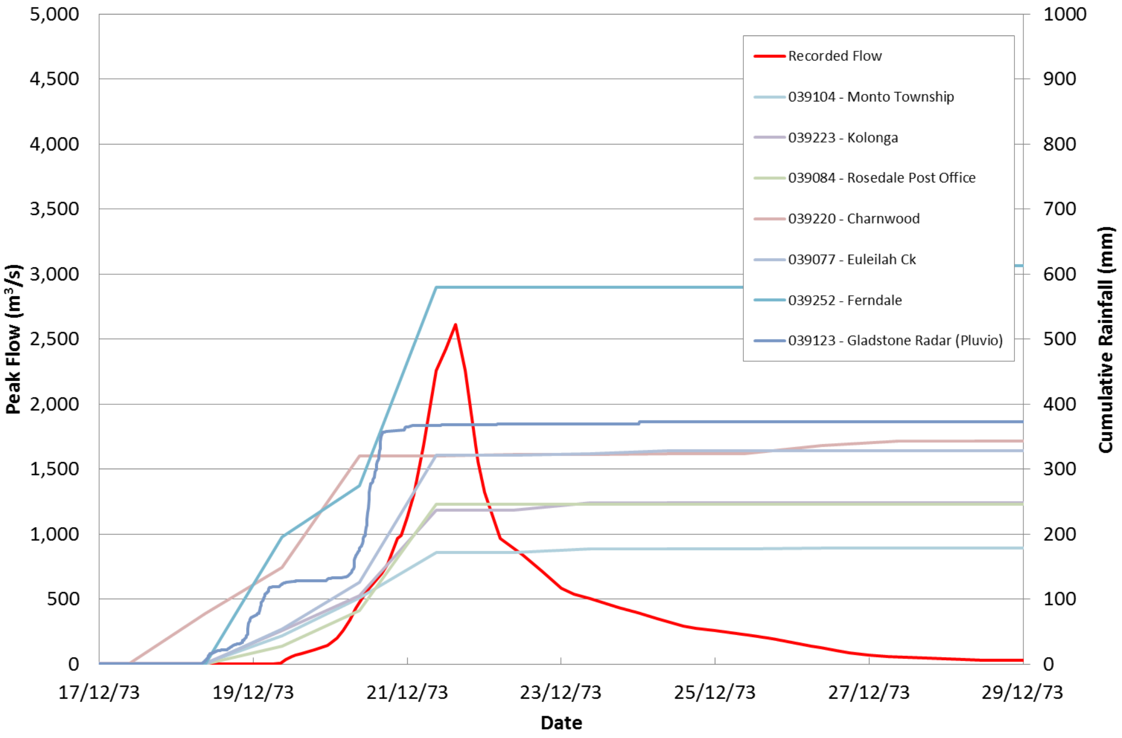


Figure 3.1 Time Distribution of Rainfall – December 1973 Rainfall Event

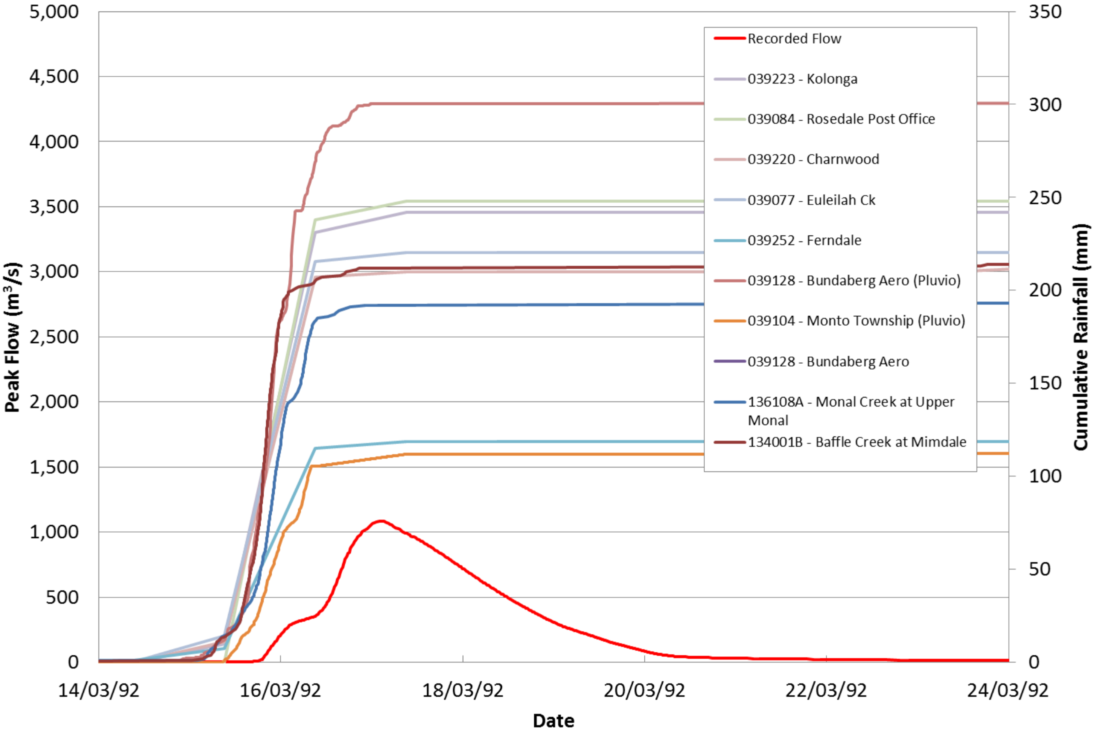


Figure 3.2 Time Distribution of Rainfall – March 1992 Rainfall Event

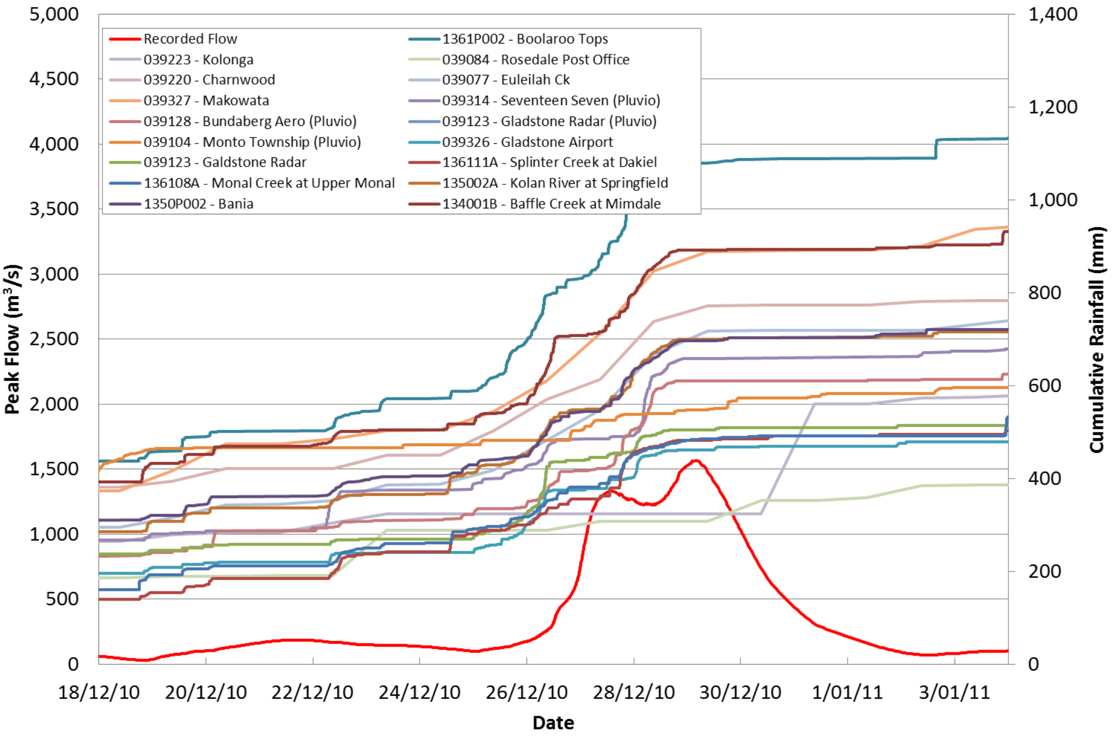


Figure 3.3 Time Distribution of Rainfall – December 2010 Rainfall Event

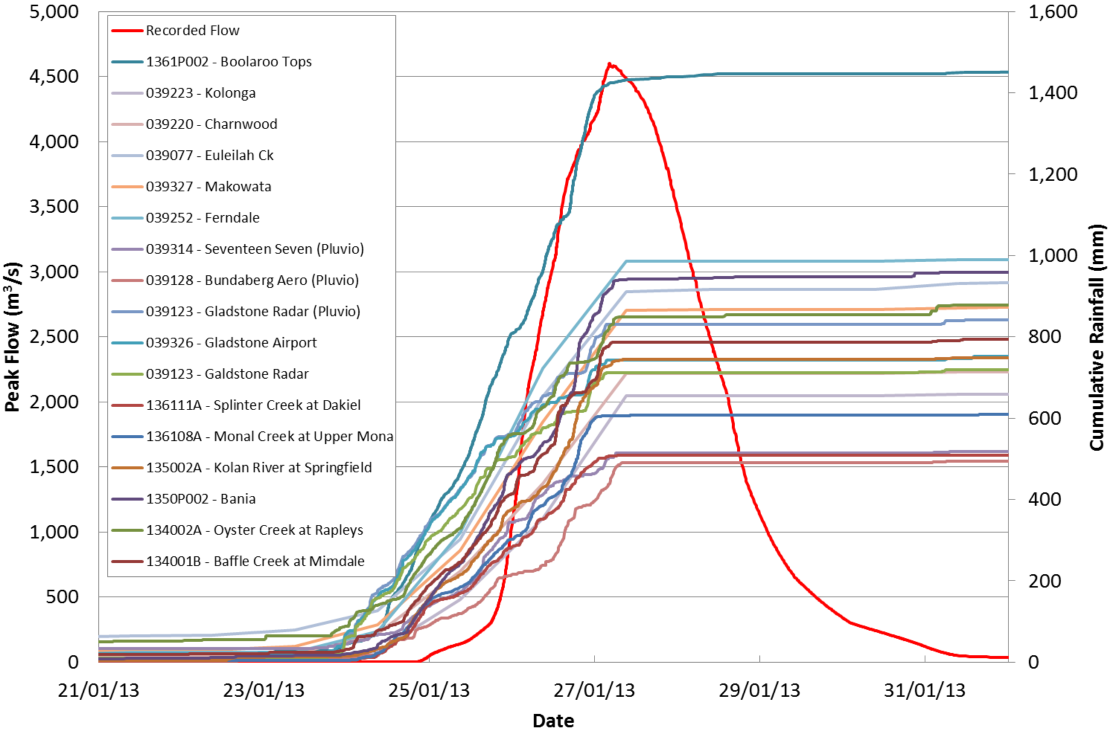


Figure 3.4 Time Distribution of Rainfall – January 2013 Rainfall Event

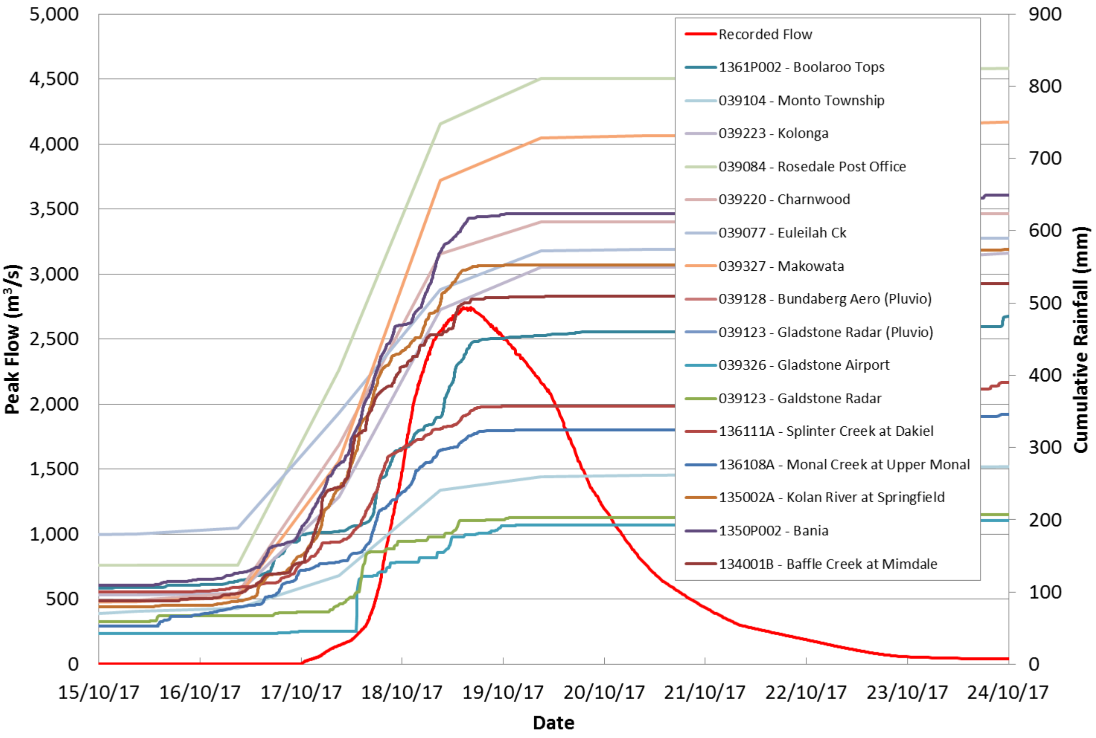


Figure 3.5 Time Distribution of Rainfall – October 2017 Rainfall Event

3.3.4 Comparison of Historic Rainfall with Point Design Values

Figure 3.6 shows a comparison of cumulative historic rainfall totals from the Mimdale gauging station (Dec 73 total taken from Gladstone Aero gauge) with ARR 16 point deign rainfall totals from the same location.

This data gives some appreciation of the relative volume of each historic storm event compared to design values of varying frequency. While this is the case, the data does not necessarily represent the likely return period of the rainfall event across the entire catchment due to spatial variation in measured rainfall.

The largest recorded rainfall event within the Baffle Creek catchment occurred in January 2013 as a result of ex tropical cyclone Oswald. This event caused major rainfall over the Baffle Creek catchment through the period 24th to 27th of January. Based on the rainfall totals presented in Figure 3.6, it can be seen that across the durations considered the AEP of the 2013 rainfall event varied between 2% AEP and 0.2% AEP at the Mimdale gauge.

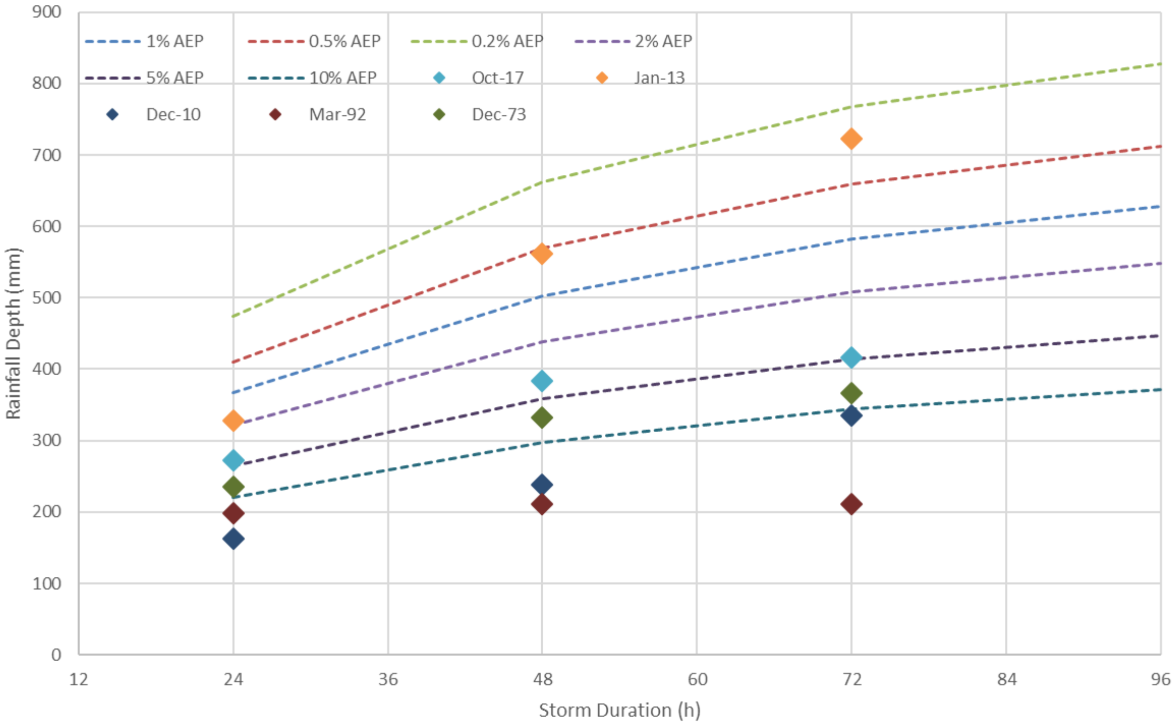


Figure 3.6 Comparison of Design Rainfall Totals and Cumulative Historic Rainfall Depths at Mimdale Gauge (Dec 73 totals taken at Gladstone Aero Gauge)

3.3.5 Stream Gauging Data

Stream gauging stations within the Baffle Creek catchment are summarised in Table 3.3. Locations of these gauging stations are shown in Figure 1.2.

Table 3.3 Baffle Creek Catchment Stream Gauging Stations

Station Number	Station Name	Catchment Area (km²)	Owner Agency	Highest Gauged Level (mAHD)	Highest Gauged Flow (m³/s)
134001B	Baffle Creek at Mimdale	1,402	DNRM	22.91	1,852
134002A	Oyster Creek at Rapleys	194	DNRM	2.26	1

The following observations are made in relation to the stream gauging data:

- Stream gauging station 134002A (Oyster Creek at Rapleys) has very limited gauged flows, which means no verification of the adopted rating for this gauge can be made. Data from this gauge has not been used in the calibration process.

- Inspection of the DEM in the vicinity of DNRM gauge 134001B (Baffle Creek at Mimdale) shows that flow bypassing of the gauge will occur at a level of 23.6 mAHD (approximately 2,200 m^3/s). Flow data from the gauging station will under-predict flow rates at levels above 23.6 mAHD as the gauge rating is unlikely to take into account the portion of the flow bypass the gauge.

3.3.6 Calibration Event Simulations

The five (5) calibration events were simulated using the URBS model as follows:

- A rainfall depth was assigned to each sub-catchment based on a weighted average depth calculated using the nearest pluviograph station data.

- The temporal pattern of rainfall was determined for each sub-catchment by assigning the temporal pattern from the nearest pluviometer station (distance from pluviometer station to sub-catchment centroid).

A joint-calibration approach was adopted to calibrate the hydrologic and hydraulic models. The URBS model was initially calibrated by varying model parameters to achieve the best possible comparison between the modelled flood hydrographs and recorded flood hydrographs at the Mimdale stream gauging station. Sub-catchment runoff hydrographs (i.e. without stream routing) were then applied to the hydraulic model and modelled peak levels and timing compared to recorded flood levels at the gauging station. Several subsequent iterations of adjusting hydrologic and hydraulic model parameters was undertaken to determine a set of calibration parameters that produced the closet agreement between modelled and gauged results in the hydraulic model.

Refer to Section 4.3 for discussion of hydraulic modelling results for the calibration events.

The following URBS model parameters were varied for the calibration:

- Initial rainfall loss, IL.

- Continuing rainfall loss, CL.

- Channel lag parameter, α.

- Catchment lag parameter, β.

- Catchment non-linearity parameter, m.

The model parameters determined for each calibration event are listed in Table 3.4. Figure 3.7 to Figure 3.11 show the modelled and recorded flood hydrographs at the Mimdale stream gauging station.

The following observations are made about the selected calibration parameters and calibration event results:

- Adopted α values were relatively consistent across all modelled historic events. No stream-routed hydrographs have been used in the flood modelling process as all stream routing has been undertaken in the TUFLOW hydraulic model. The α value was adopted to give similar peak flood timing and flows as the TUFLOW model to inform calibration iteration and critical duration analyses.

- Adopted β=3 values were consistent across all modelled historic events. The adopted β value was selected such that timing and flood levels at the Mimdale gauge location within the TUFLOW model aligned with recorded gauged levels.

- Adopted CL values varies between 0 to 1 mm/hr. The adopted CL values are relatively consistent across all events simulated.

- Adopted IL values for the calibration events were reasonably consistent. A higher IL (100 mm) value was required in the Dec-1973 event required to match flood hydrograph shape at the beginning of event. It is considered that the spatial distribution of rainfall for this event is not well represented by the limited available gauging and this has contributed to the large initial loss for this event.

- In all calibration events considered, significantly higher flows than those derived from the DNRM rating curve at Mimdale were required to achieve the actual recorded flood levels. While it has been identified that break-out and subsequent by-pass of flows occurs at levels above 23.6 mAHD, the results for the smaller magnitude events (Mar-92, Dec-10) indicate potential issues with the DNRM rating curve at elevations above 21 mAHD.

- Modelled peak flows for the Jan-2013 event are likely to be significantly lower than those actually recorded. Even with minimal losses applied to the recorded rainfall, peak flood levels for the Jan-2013 event could not be achieved at the Mimdale gauging station.

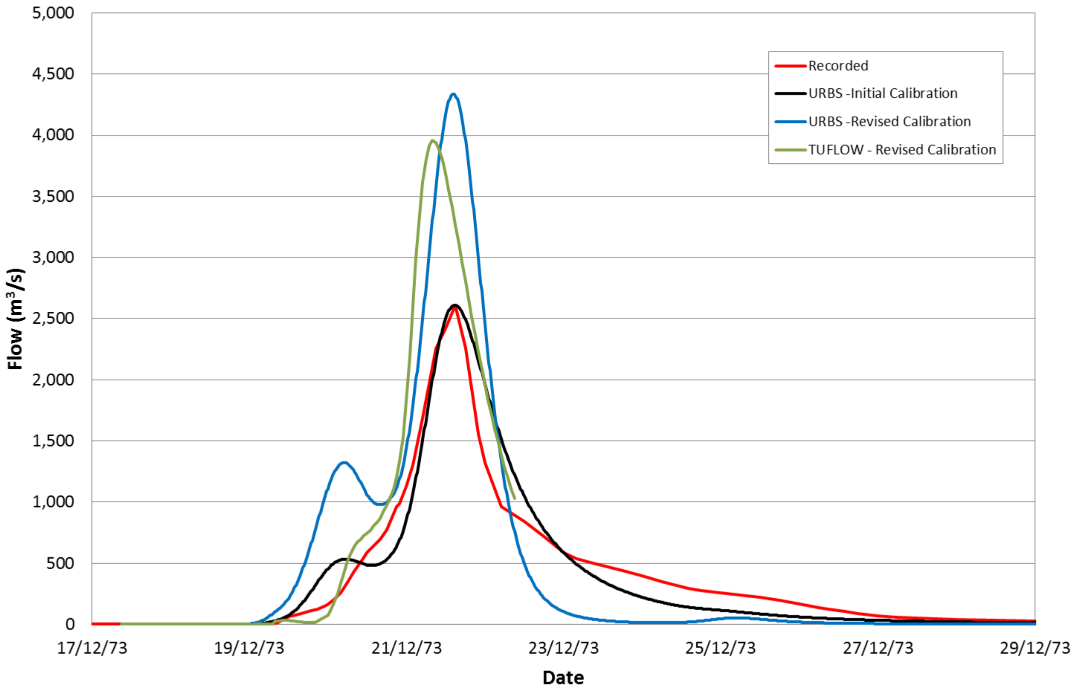


Figure 3.7 URBS Model Calibration Results at Mimdale GS – December 1973 Rainfall Event

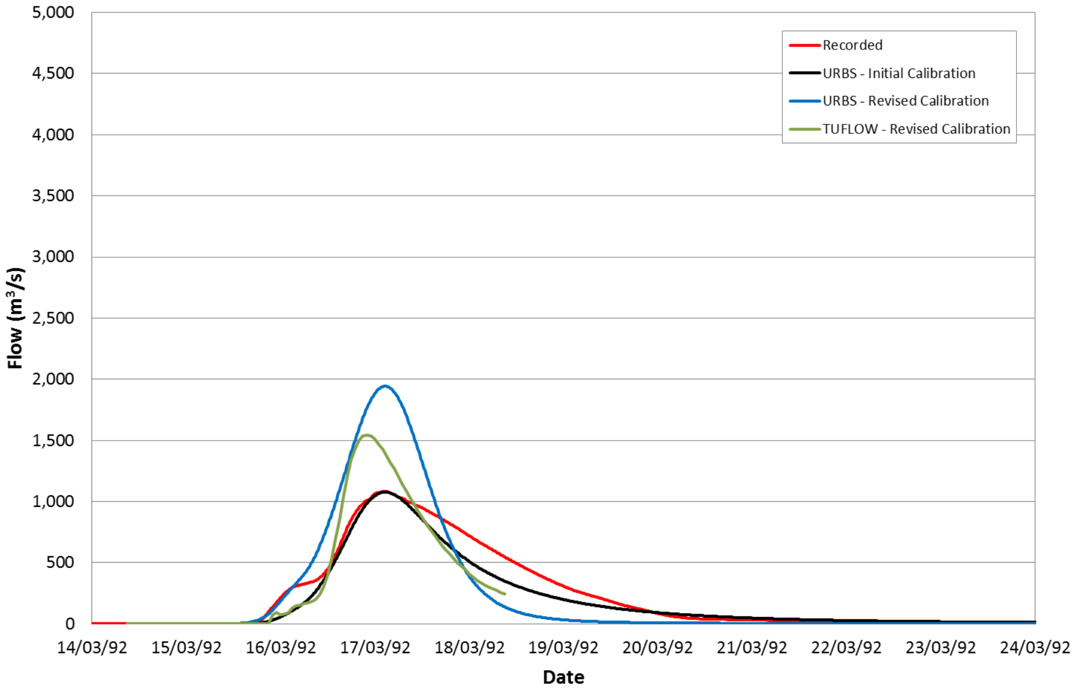


Figure 3.8 URBS Model Calibration Results at Mimdale GS – March 1992 Rainfall Event

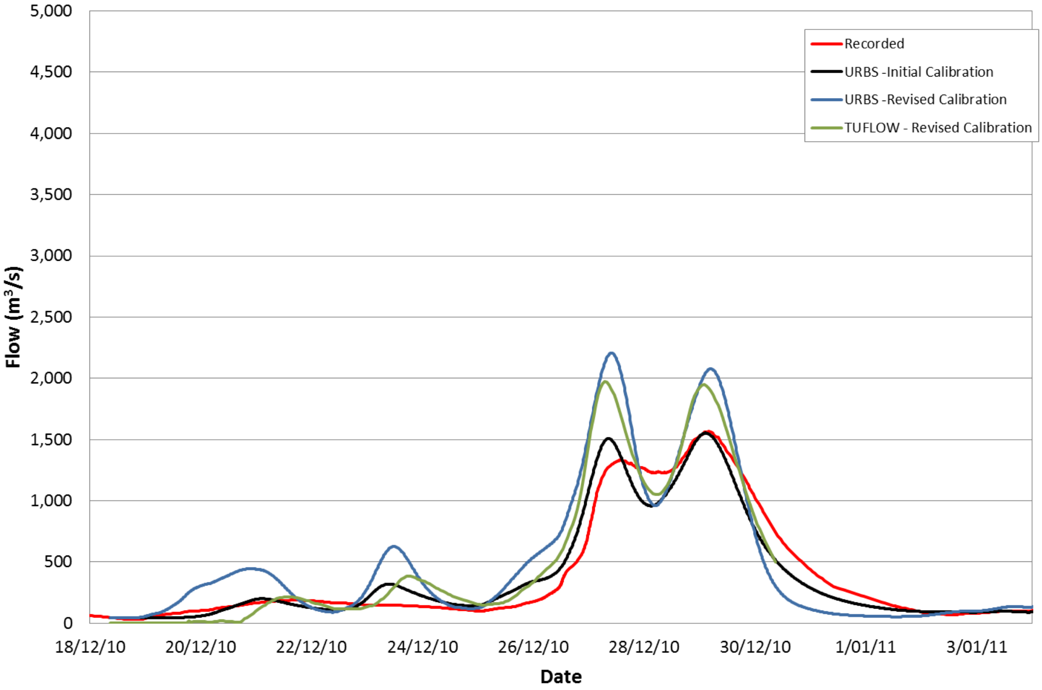


Figure 3.9 URBS Model Calibration Results at Mimdale GS – December 2010 Rainfall Event

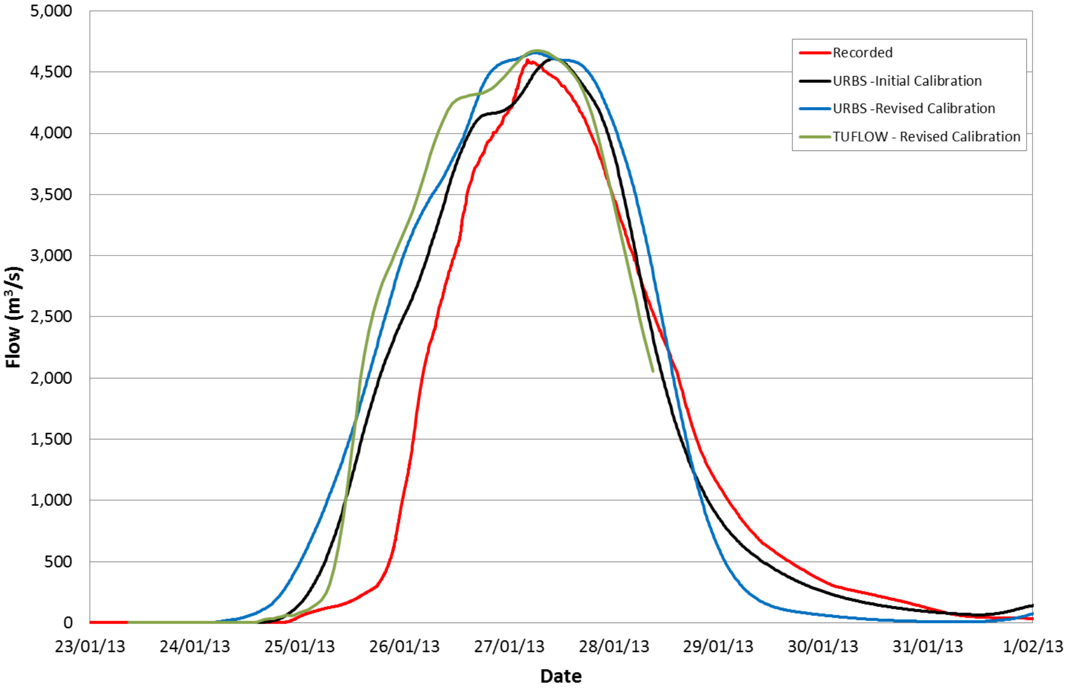


Figure 3.10 URBS Model Calibration Results at Mimdale GS – January 2013 Rainfall Event

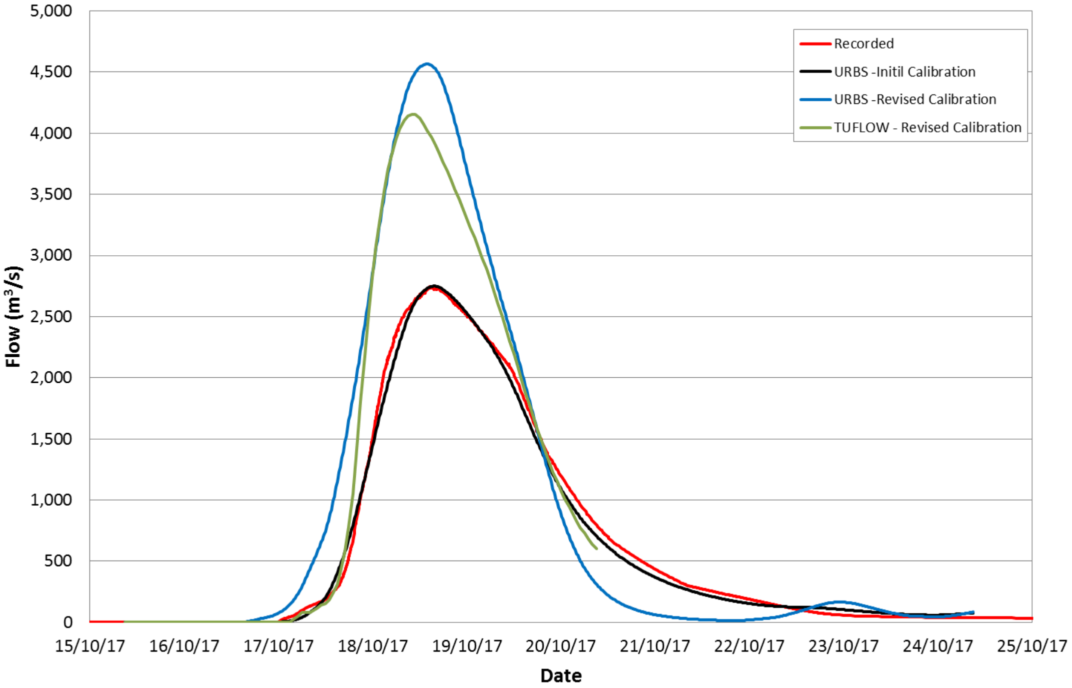


Figure 3.11 URBS Model Calibration Results at Mimdale GS – October 2017 Rainfall Event

Discussion of URBS parameters adopted for design event simulations is presented in Section 3.4.5.

Table 3.4 Baffle Creek URBS Model Calibration Parameters

Event	Initial Loss (mm)	Continuing Loss (mm/hr)	α	β	m
Dec-73	55	1	0.013	3	0.8
Mar-92	10	0.7	0.016	3	0.8
Dec-10	20	0	0.013	3	0.8
Jan-13	20	0	0.015	3	0.8
Oct-17	20	0.5	0.013	3	0.8

3.4 Design Event Simulations

3.4.1 Overview

The calibrated URBS model was used to derive the design flood hydrology for the Baffle Creek catchment for flood events ranging from the 2% AEP flood event up to the PMF event. The design flood hydrology was derived using the design flood estimation methods described in the 2016 revision of Australian Rainfall and Runoff (ARR 16) (Ball et al., 2016).

3.4.2 Design Rainfall

Design rainfall data for the Baffle Creek catchment was derived for rainfall events between the 2% AEP event and the Probable Maximum Precipitation (PMP) event. The design rainfall data was derived using the following methods:

- Rainfall totals in the AEP range 2% to 0.2% were generated for several sub-catchment centroids using the BoM IFD tool (www.bom.gov.au/water/designRainfalls/revised-ifd/). From the rainfall totals generated, two (2) sets of rainfall totals were adopted were adopted to represent spatial variation of rainfall intensity within the Baffle Creek catchment.
- PMP rainfall estimates were calculated using the Revised Generalised Tropical Storm Method, GTSM-R (BOM, 2003) for all durations considered. The AEP of the PMP was assigned a value of 1: 390,000 in accordance with Figure 8.3.2 Book 8 of the 2016 revision of ARR 16 (Ball et al., 2016).
- Rainfall totals for AEPs between 1:2,000 and the PMP were interpolated by the URBS software using the procedures described in Book 8 of ARR 16 (Ball et al, 2016).
- The ensemble temporal patterns approach was adopted for design event simulations. Areal patterns from the 'East Coast North' region were used for design event up to the 0.2% AEP event. The ensemble temporal patterns supplied in the Revised Generalised Tropical Storm Method, GTSM-R (BOM, 2003) were adopted for the PMF event.

Design rainfall totals (point values) for the chosen IFD location are summarised in Table 3.5.

Table 3.5 Baffle Creek Design Rainfall Totals

AEP (1 in Y)	Storm Duration (hours)					
	18	24	48	72	96	120
50	283	324	446	517	559	582
100	322	372	514	593	641	667

AEP (1 in Y)	Storm Duration (hours)					
	18	24	48	72	96	120
200	367	424	581	674	728	756
500	433	500	677	785	847	881
390,000 (PMP)	-	1280	1690	2040	2320	2460

3.4.3 Areal Reduction Factor

Aerial reduction factors (ARF) consistent with the recommendations in ARR 16 Book 2, Table 2.4.1 (Ball et al, 2016) were automatically generated by the URBS software. ARFs for the Baffle Creek catchment were calculated using a focal location at the Mimdale gauging station (catchment area = 1,401 km^2).

3.4.4 Design Rainfall Losses

Design storm rainfall losses (IL=17 mm and CL=2.9 mm/h) were sourced from the ARR 16 Data Hub (http://data.arr-software.org) for storm events up to 1:100 AEP. The URBS software automatically applies median pre-burst losses sourced from the Data Hub to the storm IL value. Where initial burst depths exceed the IL value, zero (0 mm) has been applied.

Based on the results of the calibration process a CL value of 1 mm/h has been adopted for design event simulations.

Zero initial and continuing loss values have been adopted for the PMP-DF and PMF events. IL values were interpolated for storm events between the 1:100 AEP and PMP-DF events using a log-normal interpolation method as recommended in ARR 16 Section 4.3.2.2.

3.4.5 URBS Model Parameters

Based on the results of the URBS model calibration, the URBS model parameters shown in Table 3.6 were adopted for the design event simulations. These parameters were selected to reflect the URBS model calibration parameters.

Table 3.6 URBS Model Parameters Adopted for Design Event Simulations

Parameter	Value
Initial Loss (mm)	Varies
Continuing Loss (mm/hr)	1

Parameter	Value
α	0.015
β	3
m	0.8

3.4.6 Critical Duration Analysis

A critical duration and temporal pattern selection process was undertaken using the URBS hydrologic model. Design flood events for durations from 6 h to 120 h were simulated with the model and the critical duration assessed at a number location throughout the catchment. A selection of representative design event temporal patterns was made for each identified critical duration. Table 3.7 summarises the identified critical durations and selected ensemble temporal patterns.

Table 3.7 Design Event Critical Durations and Selected Temporal Patterns.

AEP	Critical Durations	Selected Ensembles
2%	18h, 36h,72h, 96h	18h – Ensemble 3 36h – Ensemble 2 72h – Ensemble 10 96h – Ensemble 1
1%		
1% (2100 Climate Change)		
0.5%		
0.2%		
PMF	36h, 72h	36h – Ensemble 3 72h – Ensemble 3, Ensemble 8

3.5 Flood Frequency

3.5.1 Overview

A Flood Frequency Analysis (FFA) was undertaken for the Mimdale stream gauging station (134001B) based on the available historic streamflow records. The FFA was performed on annual peak flows recorded at the Mimdale gauging station. The FFA (Log Pearson Type III distribution) was based on 47 years of estimated annual peak flows.

The following modifications to the Annual Maximum Sequence (AMS) were made:

- The January 2013 flood event was excluded from the analysis as a high-outlier. Analysis of the rainfall during this event indicates that the AEP of the rainfall likely exceeded 1% AEP by a significant margin.
- The peak flows for the next two (2) highest recorded events (October 2017 and December 1973) were taken from the results of the TUFLOW model at the Mimdale gauging station. The hydrologic calibration process indicated that there are potential issues with the DNRM rating for the Mimdale gauge, particularly in higher flow events.

3.5.2 FFA Results

Results of the FFA are presented in Table 3.8, along with comparisons to peak design flood flows at the gauging location from the URBS and TUFLOW models. Modelled results show reasonable alignment with peak flows derived from the FFA. FFA results give higher peak flow estimates for design floods 1% AEP and greater, however modelled results fall within 95%/5% confidence limits.

Table 3.8 FFA Results, Mimdale Gauging Station (134001B)

AEP	Expected Value (m^3/s)	5% Confidence Limit (m^3/s)	95% Confidence Limit (m^3/s)	TUFLOW Results (m^3/s)
10%	1,498	946	2,671	-
5%	2,310	1,401	4,408	-
2%	3,626	2,097	7,460	3,740
1%	4,795	2,687	10,360	4,360

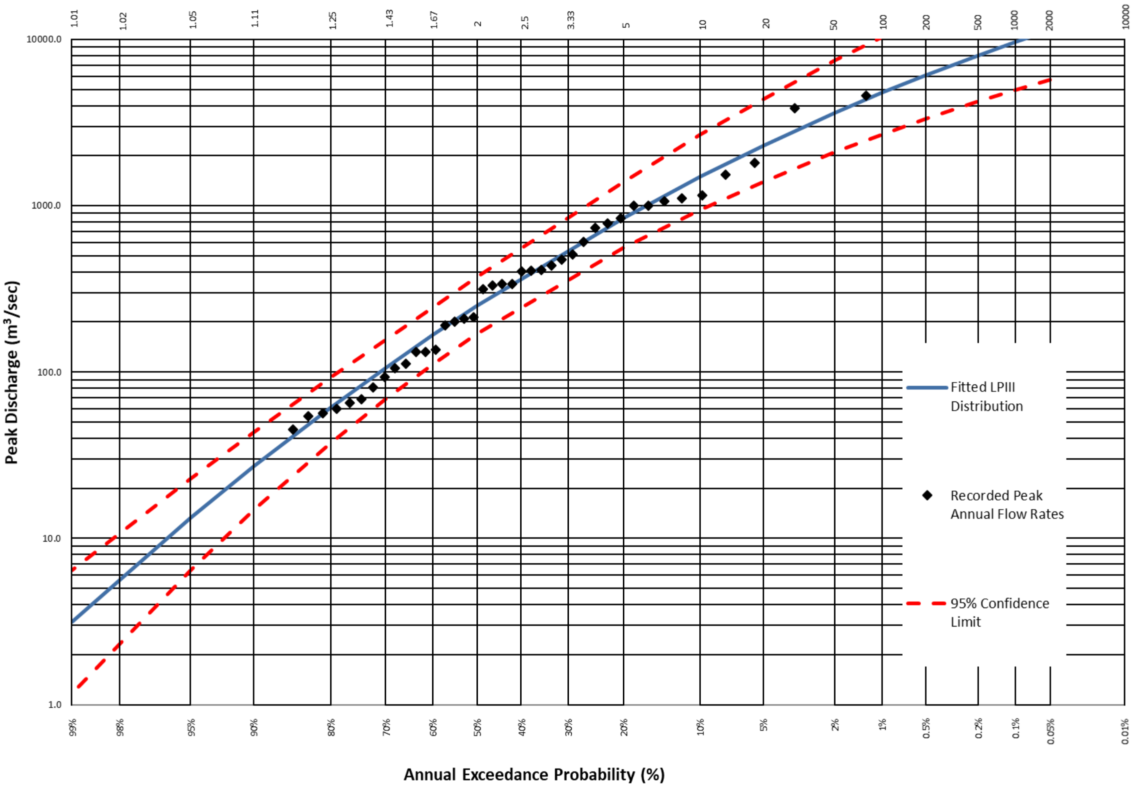


Figure 3.12 FFA results, Mimdale gauging station (134001B)

4. HYDRAULIC MODELLING

4.1 Overview

Flooding characteristics of the Baffle Creek catchment were assessed using a 2D hydraulic model (TUFLOW) covering the catchment extent. The TUFLOW HPC software package was used as this allows maximum grid resolution. The hydraulic model was used to perform all stream routing within the catchment.

4.2 Model Development

4.2.1 Model Extent and Topography

The model extent from top of Baffle creek catchment where Lidar data available to the creek mouth.

Two sources of topographic data were used to develop the TUFLOW model bathymetry:

- A 5 m DEM derived from the 2014 LiDAR aerial survey was used as the basis for the model topography. The 2D model domain for both modelling approaches covers the entire extent of the Baffle Creek catchment.
- Bathymetric survey was incorporated in the TUFLOW model for a 50 km reach of Baffle Creek and its tributaries.

Given the entire Baffle Creek catchment was included in the TUFLOW model, an adopted grid of 10 m was the smallest grid size could be selected to feasibly run the model in TUFLOW.

4.2.2 Hydraulic Roughness

The hydraulic roughness (Manning’s ‘n’) applied in the TUFLOW model was based on the aerial photography for the catchment and publicly available vegetation mapping products. Manning’s ‘n’ values adopted were based on industry standard values consistent with the latest AR&R update (Ball et al., 2016) and Queensland Urban Drainage Manual (QUDM) (IPWEA, 2017). Manning’s n values adopted in TUFLOW are listed in Table 4.1.

Table 4.1 Adopted Manning’s n Values

Manning’s n	Description
0.015	Waterbody/open channel
0.060	Open Paddock with Moderate Trees
0.070	Medium Vegetation

Manning’s n	Description
0.090	Medium-Dense Vegetation
0.100	Dense Vegetation

4.2.3 Boundary Conditions

Historic Flood Events

For all historic flood events modelled as part of the calibration process, with the exception of the January 2013 and October 2017 flood events, a tidal water level boundary was applied. A Mean High Water Spring (MHWS = 0.90 mAHD) level has been assumed for these events. For these calibration events recorded flood levels are only available at the Mimdale gauging station which is not affected by the assumed tidal condition.

For the January 2013 and October 2017 flood events, actual recorded tidal levels were applied as a time-varying water level boundary.

Design Flood Events

Fixed water levels boundaries have been adopted for all design flood event simulations. Two different tidal conditions have been assessed for each design flood event, there are:

- MHWS (0.90 mAHD).
- Highest Astronomical Tide (HAT) (1.51 mAHD).

4.3 Model Calibration

The Baffle Creek hydraulic model was calibrated to the five (5) historic flood events used in the downstream hydrologic model calibration (refer Section 3.3). The model has been calibrated to stream height gauging data at Mimdale (134001B) and Oyster Creek at Rapleys (134002A).

Comparison results between the recorded water levels at Mimdale GS and the TUFLOW modelled levels for the calibration events considered are shown in Figure 4.1 to Figure 4.5. The TUFLOW model reasonable reproduces peak flood levels and overall hydrograph shape for all calibration events, with the exception of the Jan-13 flood event. Predicted levels for the Jan-13 at the Mimdale gauge are significantly lower than recorded. It is likely that this is due to poor capture of spatial variation in rainfall intensity an area of more intense rainfall upstream of the Mimdale gauge has not been captured within the available gauging data.

Comparison results between the recorded water levels at Rapley’s GS and the TUFLOW modelled levels for the 2013 and 2017 calibration events are shown in Figure 4.6 and Figure

4.7 respectively. For the January 2013 event, similar behaviour to the Mimdale gauging station is observed, with a lower peak level being predicted. For the October 2017 flood event, peak levels from the TUFLOW model are within 190 mm of those recorded at the gauge, however some discrepancies in flood timing is observed. Given the sparseness of pluviographic rainfall stations within the Oyster Creek/Euleilah Creek systems this is not unexpected.

Comparison levels for the supplied flood debris survey (Jan-13 event) are shown in Figure 4.8. Based on the suppled 2013 flood debris survey, the following observations are made:

- In the vicinity of the Mimdale gauging station comparison of modelled results and the observed survey points are consistent with the results at the gauging station, i.e. modelled results are significantly lower.

- From the confluence of Murrays Creek to the Baffle Creek mouth, modelled results show closer alignment with the surveyed results. Modelled results are generally within ±0.5 m of the surveyed results in this reach of the creek.

- Modelled results show close alignment with the surveyed results in Euleilah Creek, with modelled and surveyed results within ±0.2 m.

Flood debris survey was also supplied for the October 2017 flood event. On inspection and comparison with modelled results for the 2107 event, the supplied survey showed significant deviation from the gauged stream height values. Surveyed results showed much lower levels than expected based on the actual gauged results. It was considered that the gauged stream heights represent the more reliable source of flood level data and as such the calibration for the October 2017 event was based on this data only.

Based on the calibration simulation results it is considered that the TUFLOW model is reasonably calibrated and is suitable for the purpose of developing design flood information for the Baffle Creek catchment.

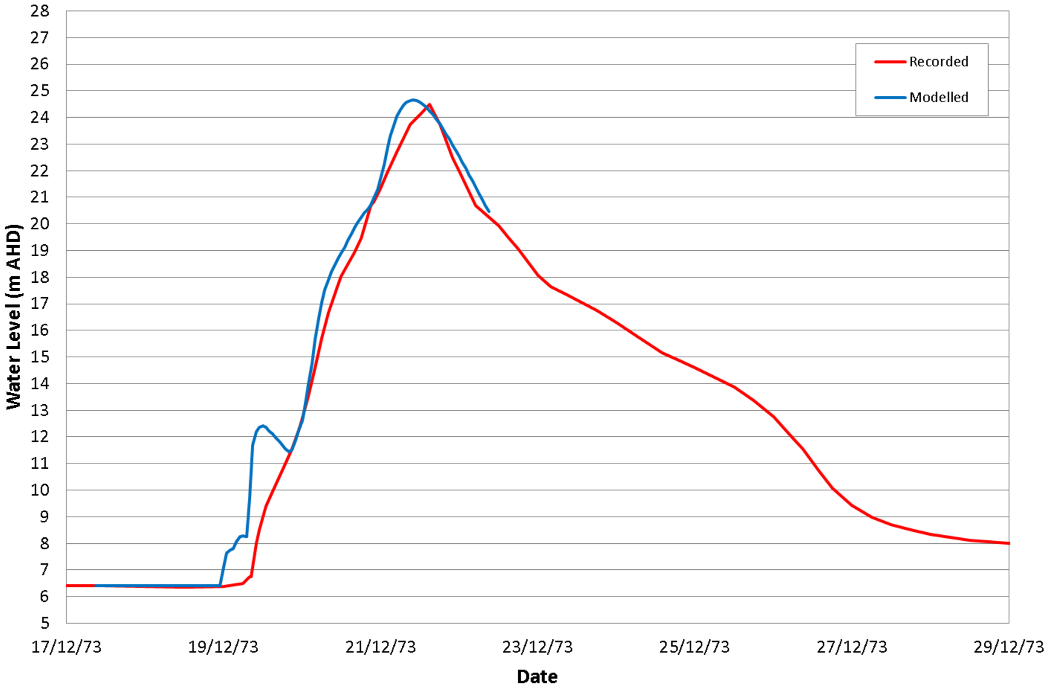


Figure 4.1 TUFLOW Model Calibration Results at Mimdale GS – December 1973 Event

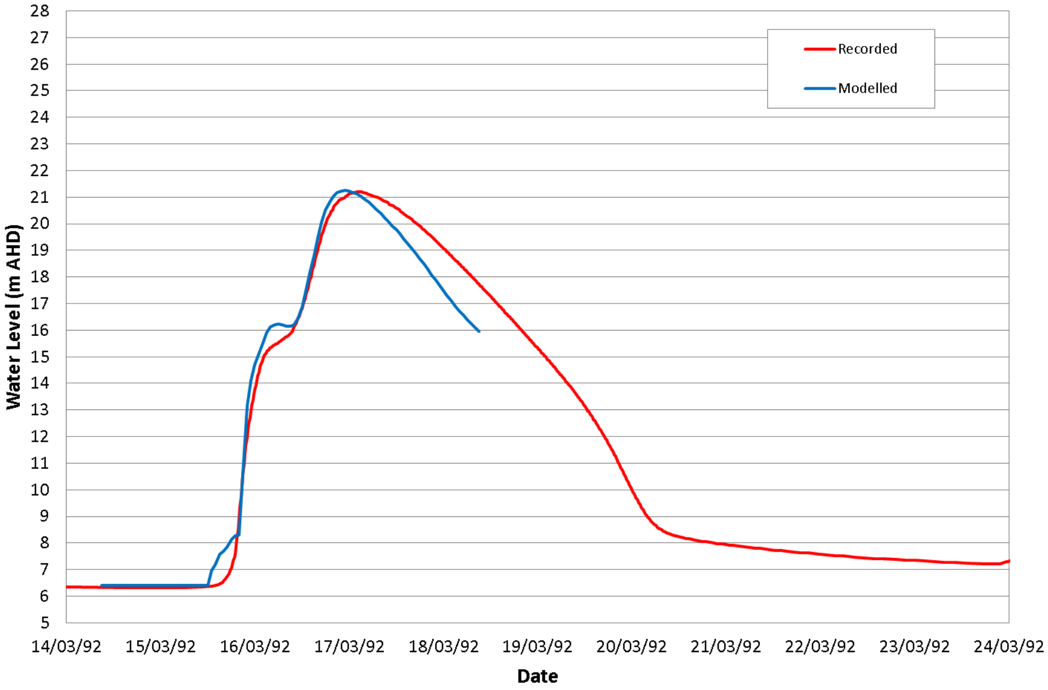


Figure 4.2 TUFLOW Model Calibration Results at Mimdale GS – March 1992 Event

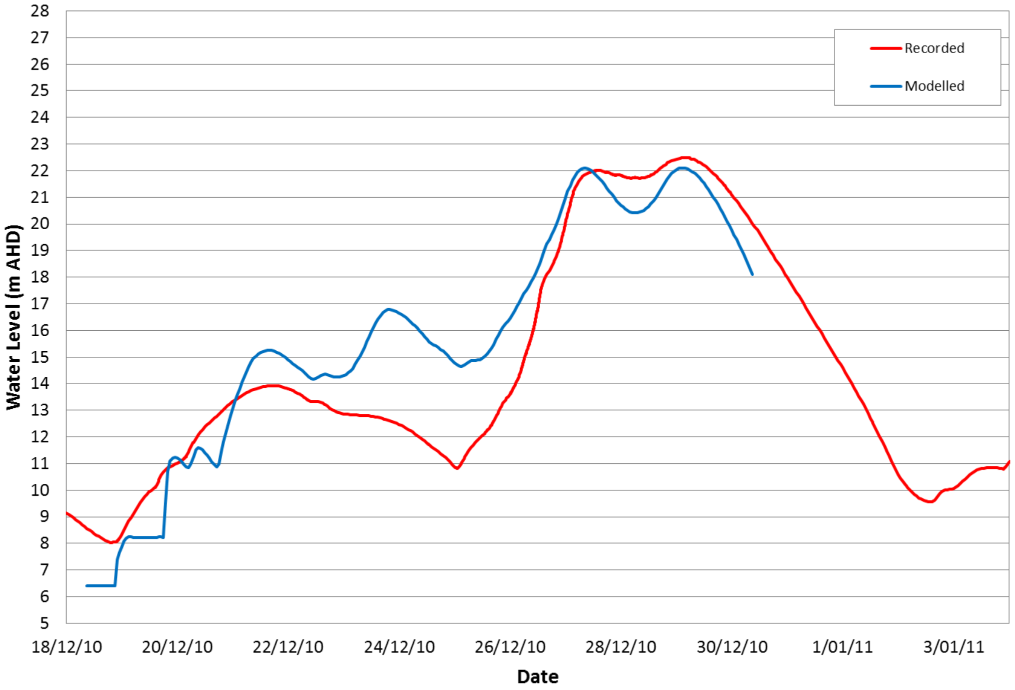


Figure 4.3 TUFLOW Model Calibration Results at Mimdale GS – December 2010 Event

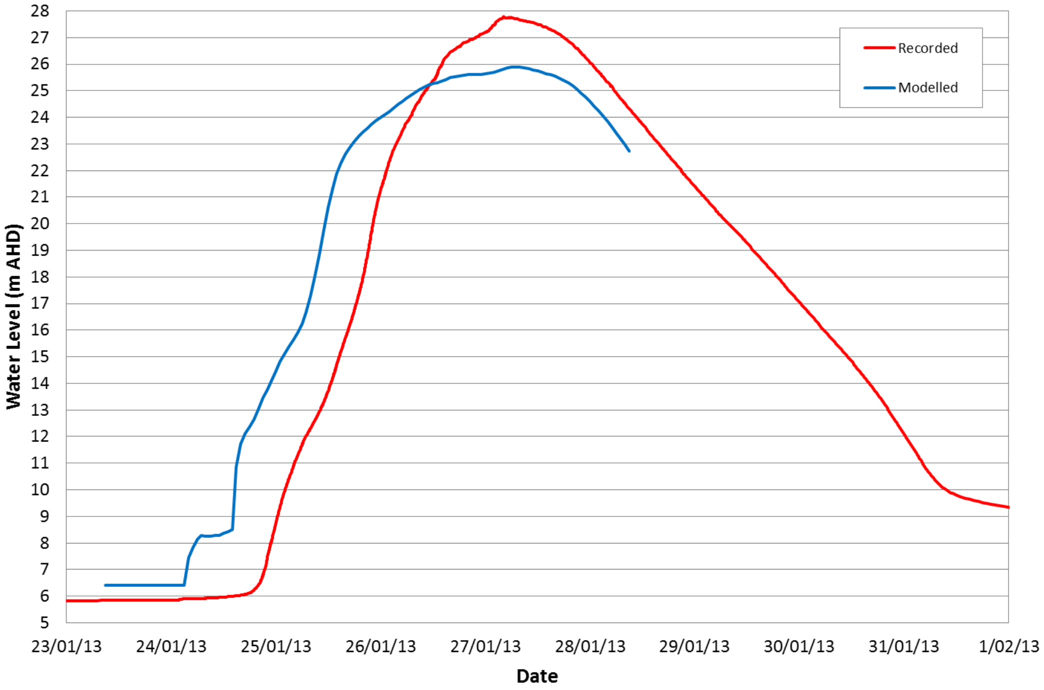


Figure 4.4 TUFLOW Model Calibration Results at Mimdale GS – January 2013 Event

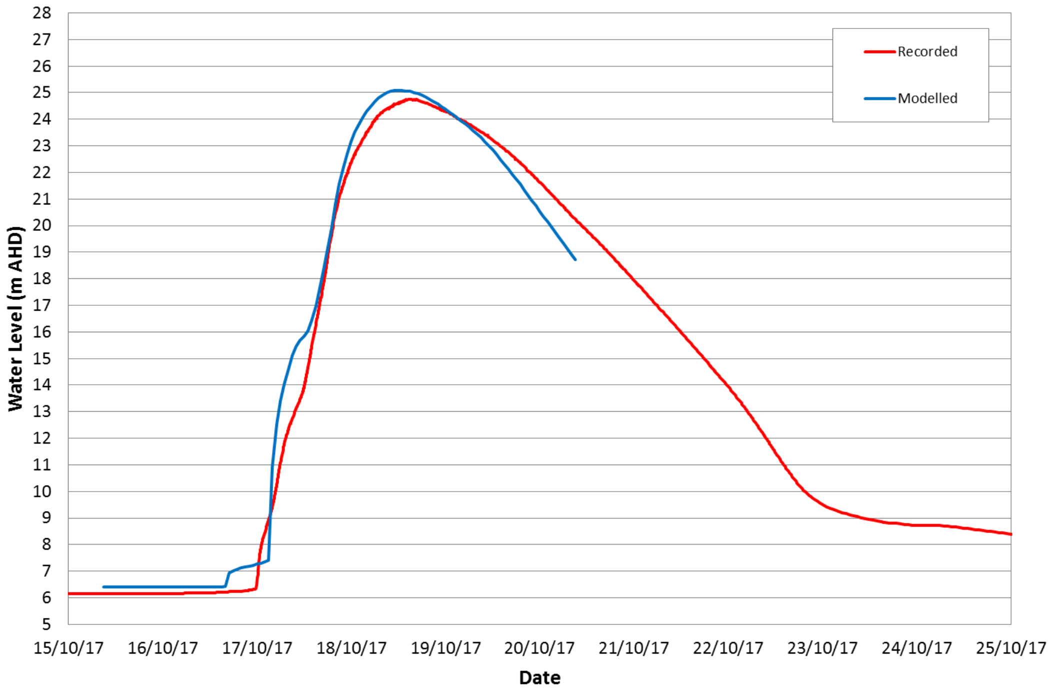


Figure 4.5 TUFLOW Model Calibration Results at Mimdale GS – October 2017 Event

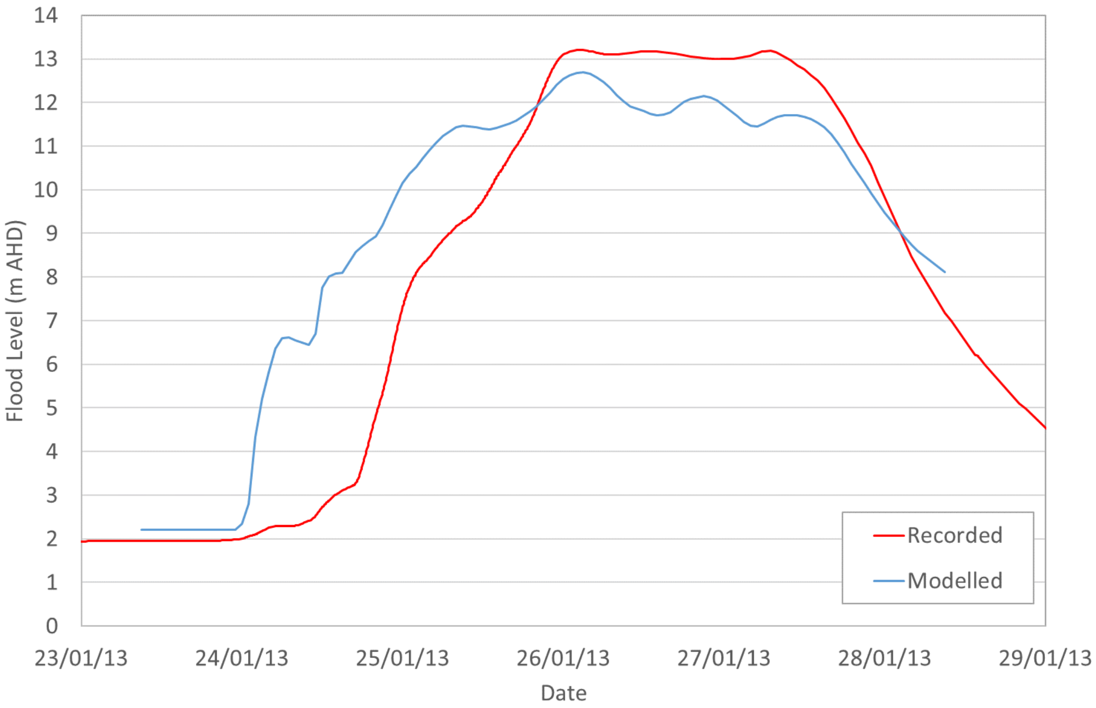


Figure 4.6 TUFLOW Model Calibration Results at Oyster Creek at Rapleys GS – January 2013 Event

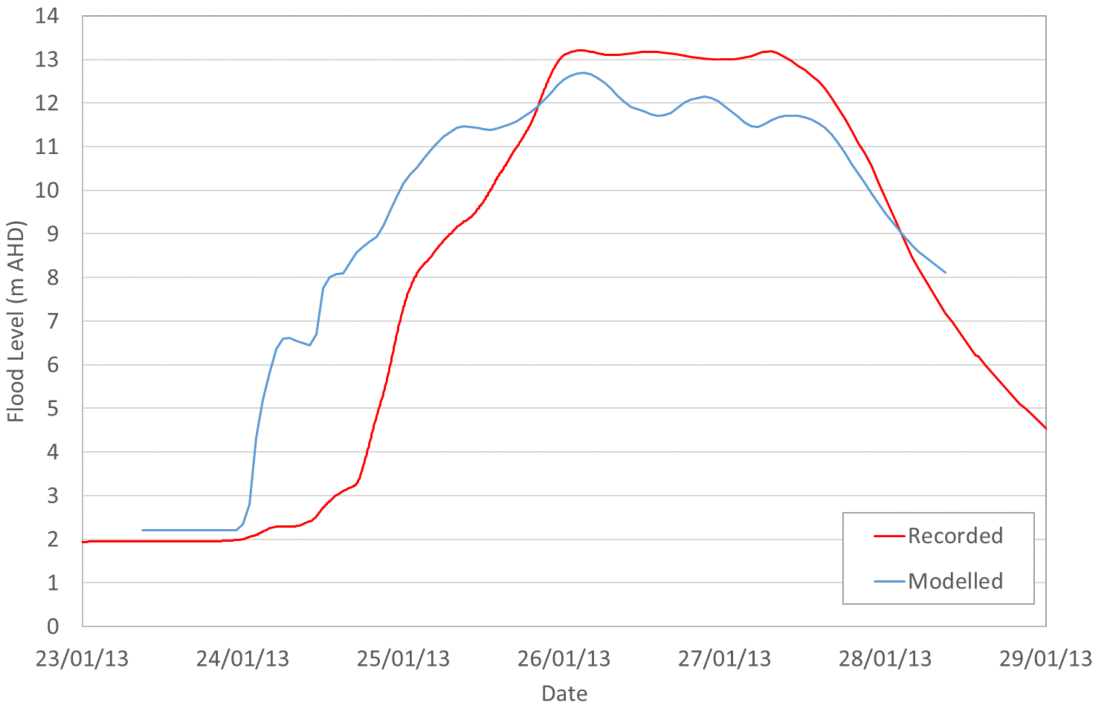
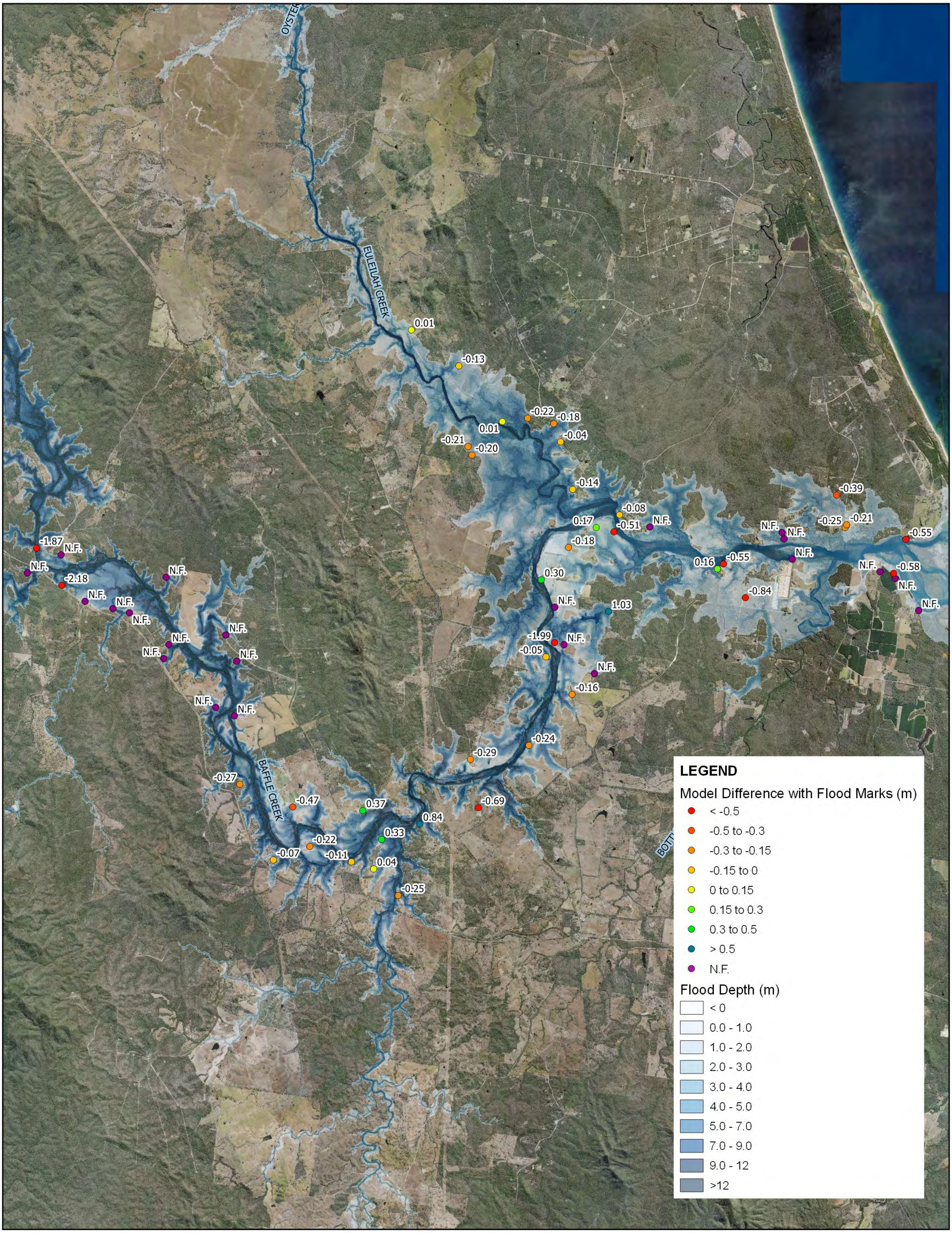


Figure 4.7 TUFLOW Model Calibration Results at Oyster Creek at Rapleys GS – October 2017 Event



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2.5 0 2.5 km

Scale in metres (1: 120,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure 4-8 Janurary 2013 Flood Marks and Model Results

Job Number: M38000_009
Revision: 0
Drawn: AJ
Checked: AC
Date: 9/10/2018

4.4 Design Event Results

4.4.1 Peak Flood Level Results

Peak design flood levels for a selection of AEP events at a number of key locations along Baffle Creek are summarised in Table 4.2.

Flood mapping for the Defined Flood Event (1% AEP, 2100 climate change) is presented in Appendix B.

Table 4.2 Peak Design Flood Levels (mAHD)

Location	AEP						
	2% (HAT)	1% (HAT)	1% (MHWS)	1% AEP 2100 (HAT)	0.5% (HAT)	0.2% (HAT)	PMF (HAT)
Bororen	60.84	60.86	60.86	60.89	60.88	60.90	61.47
Mirriam Vale	36.77	37.09	37.09	37.57	37.42	37.87	42.20
Mimdale Gauge	24.46	25.16	25.16	26.16	25.84	26.68	34.09
Lowmead	23.02	23.79	23.79	24.84	24.51	25.39	32.92
Euleilah Creek Confluence	6.90	7.59	7.58	8.30	8.09	8.64	12.94
Colonial Cove	2.92	3.20	3.27	3.70	3.62	4.03	6.73
Winfield Boat Ramp	2.86	3.13	3.21	3.69	3.55	3.97	6.57
Boaga	2.35	2.52	2.67	3.14	3.01	3.42	5.80

4.4.2 Peak Flood Flow Results

Peak design flood flows for a selection of AEP events at a number of locations along Baffle Creek are summarised in Table 4.3.

Table 4.3 Peak Design Flood Flows (m³/s)

Location	AEP						
	2% (HAT)	1% (HAT)	1% (MHWS)	1% AEP (2100)	0.5% (HAT)	0.2% (HAT)	PMF (HAT)
Bororen	330	390	390	500	460	570	2,110
Mirriam Vale	1,160	1,350	1,350	1,670	1,570	1,890	6,510
Mimdale Gauge	3,740	4,360	4,360	5,320	5,000	5,860	18,160
Lowmead	3,770	4,400	4,400	5,370	5,050	5,920	18,230
Euleilah Creek Confluence	4,410	5,330	5,330	6,820	6,340	7,680	21,770
Colonial Cove	4,490	5,510	5,500	6,980	6,550	7,910	21,500
Winfield Boat Ramp	4,490	5,515	5,510	6,990	6,560	7,930	21,680
Boaga	4,490	5,515	5,510	6,990	6,560	7,930	21,680

4.4.3 Floodplain Functionality Mapping

For the floodplain functionality mapping, the floodplain is divided up into three categories as per the hydraulic character:

- **Floodway:** the areas of floodplain that convey significant volumes of water during a flood. They are generally flow conveyance areas and as such have deeper flow and or higher velocities.

- **Flood Storage:** the areas of floodplain that are important for the temporary storage of floodwaters during the passage of a flood.

- **Flood Fringe:** the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. As such, flood fringe areas generally have low flood depth and velocities.

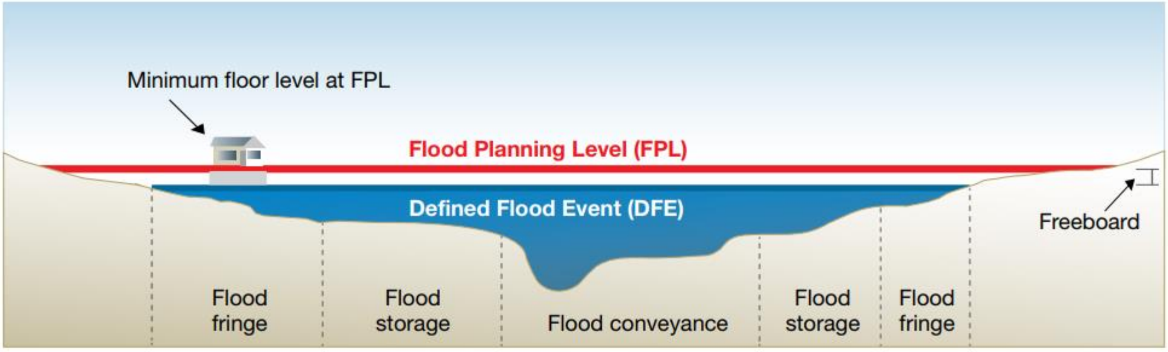

Figure 4.9 Cross-section of the Floodplain Showing Hydraulic Categorisation - extracted from *Managing the floodplain: a guide to best practice in flood risk management in Australia* (AIDR, 2013).

There are no prescriptive methods for quantifying hydraulic categorisation within a given floodplain, with current guidance material such as *Managing the floodplain: a guide to best practice in flood risk management in Australia* (AIDR, 2013) and the *NSW Floodplain Development Manual* (DIPNR, 2005) providing essentially qualitative definitions. This is not unexpected given that the definition of floodplain function will vary with catchment characteristics and the nature of flooding.

Table 4.4 summarises the definitions of floodplain function (hydraulic categorisation) adopted for this study. The adopted values are generally consistent with those recommended in the paper *Mapping of Floodways and Floodplain Development Zones Using 2D Models* (Syme, 2011).

Table 4.4 Hydraulic categorisation definitions

Flood Function	Definition Adopted
Floodway	Velocity-depth product > 1 m/s (in the DFE)
Flood storage	Velocity-depth product ≤ 1 m^2/s and ≥ 0.1 m^2/s (in the DFE)
Flood fringe	Velocity-depth product < 0.1 m^2/s (in the DFE)

Mapped results of the Baffle Creek floodplain hydraulic categorisation are provided in Appendix C.

5. SUMMARY AND CONCLUSIONS

Engeny were engaged by Gladstone Regional Council to undertake an updated flood study for the Baffle Creek. The purpose of the flood study was to generated design hydrology and hydraulics for design flood events ranging from the 2% AEP flood event up to the Probable Maximum Flood (PMF) event.

To undertake the updated study, a URBS hydrologic model and 2D TUFLOW hydraulic model were developed in accordance with the procedures in the latest revision of *Australian Rainfall and Runoff* (ARR 16).

Joint Calibration

The hydrologic and hydraulic models were jointly calibrated to five (5) historic flood events. The flood events considered were; December 1973, March 1992, December 2010, January 2013 and October 2017.

- Reasonable alignment between recorded flood levels (both peak level and timing) and modelled results were observed for the December 1973, March 1992, December 2010 and October 2017 flood events.
- Comparison of modelled and recorded flood levels at the Mimdale gauging station for the January 2013 flood event showed modelled results significantly lower than those recorded during the event. This is likely due to poor spatial distribution of recorded rainfall.
- Comparison of January 2013 modelled peak flood levels with supplied flood debris survey indicated reasonable alignment for the lower reaches of the Baffle Creek catchment and with surveyed levels in Euleilah Creek.
- While a good match was generally observed between the modelled and recorded flood levels for the historic flood events at the Mimdale gauging station, calculated peak flows for these events were significantly higher than those predicted using the DNRM rating curve. Results from the hydraulic modelling indicate that the Mimdale rating curve may not provide accurate estimate of large flood flows.

Based on the results of the joint calibration process it was determined that the jointly calibrated hydrologic and hydraulic models provide a reasonable representation of the Baffle Creek catchment runoff and flood routing characteristics.

Design Events

Based on the required scope, design flood events between the 2% AEP and PMF event have been simulated using the calibrated flood model. Two (2) different tidal conditions have been considered (MHWS, HAT) and a climate change scenario considering a 2100 planning horizon (20% increase in rainfall intensities).

Design flows at the Mimdale gauging station were validated against design flow estimates derived from a Flood Frequency Analysis (FFA) undertaken on the historic streamflow records at the gauging station. The FFA was undertaken using a total of 46 years' of streamflow records. The January 2013 event was excluded as a high-outlier and the next two largest flood flows (December 1973 and October 2017) replaced with flows calculated from the TUFLOW model, due to the identified issues with the DNRM rating curve. The results of the FFA and design flow validation results are presented in Table 5.1. The modelled design flood flows align well with those derived from the FFA.

Table 5.1 FFA Results, Mimdale Gauging Station (134001B)

AEP	Expected Value (m^3/s)	5% Confidence Limit (m^3/s)	95% Confidence Limit (m^3/s)	TUFLOW Results (m^3/s)
10%	1,498	946	2,671	-
5%	2,310	1,401	4,408	-
2%	3,626	2,097	7,460	3,740
1%	4,795	2,687	10,360	4,360

Peak flood level mapping for the Defined Flood Event (DFE), as well as flood function mapping has been produced as part of this study. Digital flood modelling output for key hydraulic parameters (water level, depth, velocity and hazard) for design AEP event between the 2% and PMF events have been developed in conjunction with this reporting.

6. QUALIFICATIONS

a. In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b. Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

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g. This report does not provide legal advice.

7. REFERENCES

AIDR (2013), *Managing the floodplain: a guide to best practice in flood risk management in Australia.*

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2016, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia.

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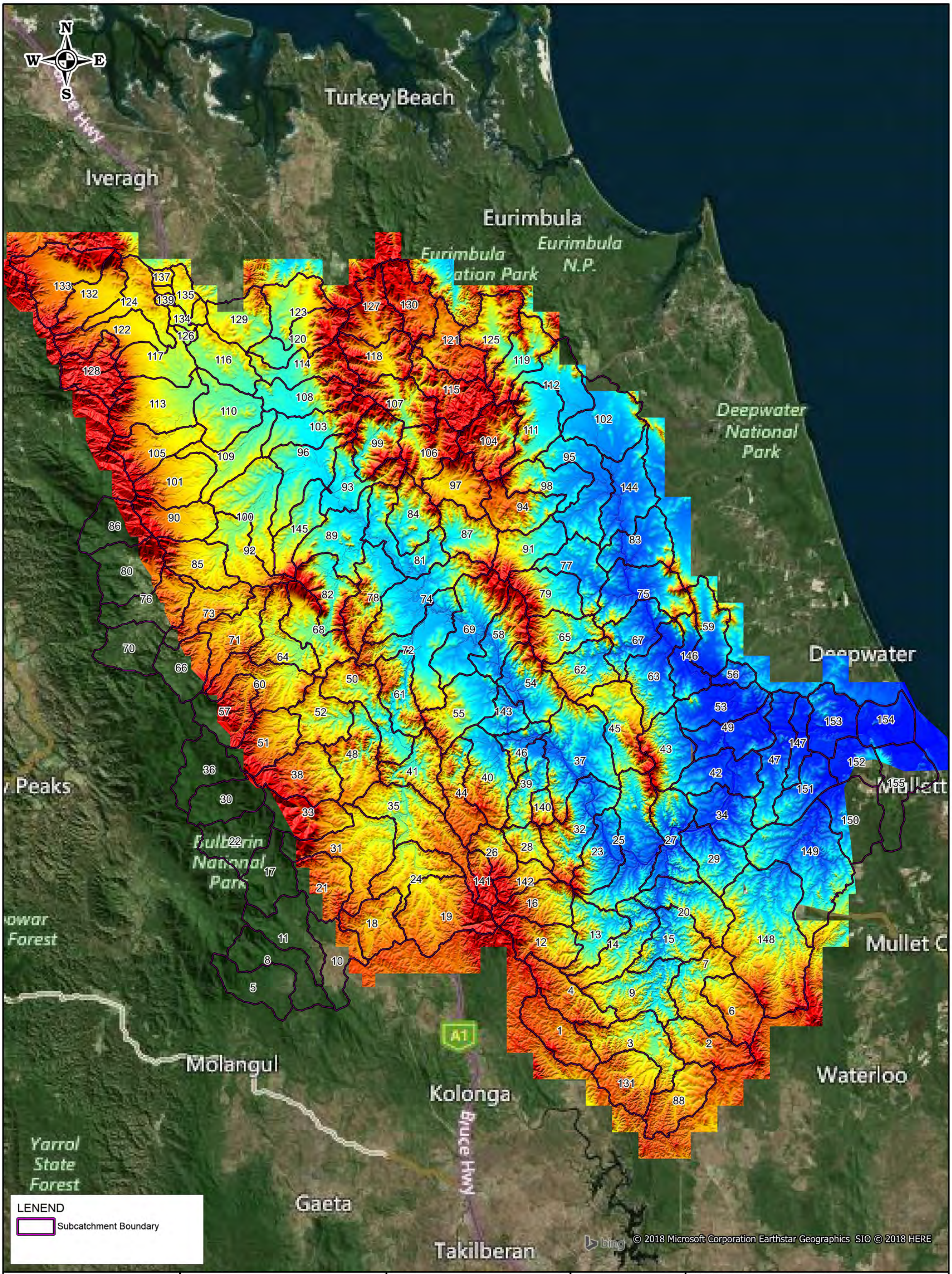
DIPNR (2005), *NSW Floodplain Development Manual.*

Syme (2011), *Mapping of Floodways and Floodplain Development Zones Using 2D Models.* FMA Conference, San Diego 2011.

APPENDIX A

Hydrologic Model Setup



GLADSTONE REGIONAL COUNCIL

ENGENY WATER MANAGEMENT

0 5 10
Scale in Km (1:250,000 @ A3)
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

DATE	02/03/18
DRAWN	RJM
JOB NO.	M38000-009

Gladstone Regional Council
Baffle Creek Flood Study

Subcatchment Boundaries

A3 Figure 1 0

Subcat. #	Area (Km^2)	Slope (%)	Subcat. #	Area (Km^2)	Slope (%)	Subcat. #	Area (Km^2)	Slope (%)
1	16.44	0.58	53	16.79	0.17	105	16.04	1.29
2	15.40	1.00	54	18.02	0.78	106	15.00	1.13
3	20.97	0.41	55	19.05	0.62	107	15.06	1.13
4	15.33	0.74	56	4.63	0.63	108	16.42	0.68
5	16.84	1.86	57	16.59	2.01	109	15.36	0.33
6	15.06	0.83	58	15.02	0.75	110	19.47	0.21
7	18.34	0.68	59	15.02	0.37	111	18.19	0.63
8	18.22	2.21	60	19.42	0.78	112	16.49	0.36
9	21.31	0.50	61	15.10	0.42	113	24.93	0.80
10	15.26	0.68	62	15.68	1.04	114	15.01	0.74
11	17.47	1.37	63	19.03	0.49	115	18.70	1.98
12	15.03	0.94	64	16.21	0.35	116	15.36	0.22
13	15.03	0.44	65	15.03	0.87	117	15.19	0.37
14	17.07	0.60	66	15.03	2.11	118	15.36	1.18
15	16.02	0.35	67	15.81	0.61	119	15.06	0.86
16	15.20	1.52	68	17.35	0.38	120	15.64	0.56
17	16.43	2.59	69	25.65	0.69	121	16.42	1.09
18	15.07	0.16	70	15.31	1.90	122	15.05	0.60
19	28.11	1.03	71	16.72	0.87	123	15.09	0.32
20	18.13	0.73	72	25.32	0.43	124	15.66	0.24
21	16.53	0.89	73	15.17	0.41	125	17.44	1.02
22	17.24	4.57	74	23.11	0.41	126	1.52	0.46
23	15.50	0.57	75	22.70	0.57	127	15.08	1.31
24	15.94	0.16	76	17.36	1.04	128	15.01	2.67
25	28.72	0.45	77	15.05	0.47	129	15.78	0.38
26	9.00	1.09	78	18.20	0.51	130	16.30	1.47
27	18.55	0.34	79	15.52	1.09	131	16.42	0.92
28	7.68	1.03	80	20.47	2.98	132	15.72	0.82
29	15.70	0.40	81	18.09	0.03	133	24.52	1.51
30	15.09	3.59	82	15.26	0.78	134	2.26	0.44
31	27.89	0.59	83	16.34	0.59	135	5.20	0.27
32	22.61	0.87	84	15.11	0.64	136	2.04	0.59
33	16.03	1.86	85	15.15	0.73	137	1.93	0.91
34	15.68	0.53	86	15.03	6.08	138	0.98	1.08
35	26.26	0.74	87	15.08	0.89	139	1.13	1.10
36	16.79	5.21	88	17.06	0.80	140	4.06	1.96
37	30.80	0.67	89	19.61	0.35	141	6.00	3.98
38	19.78	1.35	90	15.03	1.16	142	7.37	2.00
39	11.52	0.40	91	15.00	0.70	143	7.64	0.61
40	20.44	0.86	92	15.07	0.38	144	20.56	0.30
41	15.44	0.85	93	15.02	0.36	145	13.34	0.39
42	16.92	0.34	94	15.01	0.80	146	11.51	0.36
43	16.08	0.88	95	21.81	0.23	147	7.77	0.25
44	15.19	0.72	96	20.39	0.28	148	56.83	0.42
45	20.03	0.96	97	15.15	1.00	149	40.87	0.23
46	7.85	0.81	98	15.00	0.60	150	20.49	0.23
47	18.56	0.30	99	15.01	0.67	151	13.01	0.19
48	18.68	0.75	100	22.67	0.37	152	10.81	0.16
49	16.17	0.25	101	17.61	0.98	153	15.40	0.16
50	20.71	0.51	102	23.68	0.15	154	13.92	0.10
51	17.27	1.82	103	17.47	0.62	155	21.12	0.21
52	15.02	0.53	104	17.89	2.41			

```
Baffle Ck
MODEL: SPLIT
USES: L, CS, Sc
DEFAULT PARAMTERS: alpha = 0.05 m = 0.8 beta = 2.5 n = 1 x = 0
CATCHMENT DATA FILE = Baffle.cat
RAIN #128 L = 4.228 Sc = 0.0309
ROUTE THRU #122 L = 3.1947 Sc = 0.0033
ADD RAIN #122 L = 3.1947 Sc = 0.0033
STORE.
RAIN #133 L = 3.965 Sc = 0.0148
ROUTE THRU #132 L = 1.3608 Sc = 0.0016
ADD RAIN #132 L = 1.3608 Sc = 0.0016
ROUTE THRU #124 L = 3.1056 Sc = 0.0021
ADD RAIN #124 L = 3.1056 Sc = 0.0021
GET.
ROUTE THRU #117 L = 1.8281 Sc = 0.0005
ADD RAIN #117 L = 1.8281 Sc = 0.0005
STORE.
RAIN #105 L = 3.359 Sc = 0.0230
GET.
ROUTE THRU #113 L = 0.8060 Sc = 0.0011
ADD RAIN #113 L = 0.8060 Sc = 0.0011
ROUTE THRU #110 L = 2.9730 Sc = 0.0015
ADD RAIN #110 L = 2.9730 Sc = 0.0015
STORE.
RAIN #101 L = 4.070 Sc = 0.0211
GET.
ROUTE THRU #109 L = 0.5857 Sc = 0.0040
ADD RAIN #109 L = 0.5857 Sc = 0.0040
STORE.
RAIN #137 L = 0.977 Sc = 0.0074
STORE.
RAIN #138 L = 0.815 Sc = 0.0107
STORE.
RAIN #139 L = 0.809 Sc = 0.0111
GET.
GET.
ROUTE THRU #135 L = 2.1212 Sc = 0.0022
ADD RAIN #135 L = 2.1212 Sc = 0.0022
STORE.
RAIN #136 L = 1.094 Sc = 0.0060
GET.
ROUTE THRU #134 L = 0.1908 Sc = 0.0022
ADD RAIN #134 L = 0.1908 Sc = 0.0022
ROUTE THRU #126 L = 0.3656 Sc = 0.0017
ADD RAIN #126 L = 0.3656 Sc = 0.0017
ROUTE THRU #116 L = 3.1537 Sc = 0.0015
ADD RAIN #116 L = 3.1537 Sc = 0.0015
STORE.
RAIN #129 L = 3.333 Sc = 0.0031
ROUTE THRU #123 L = 0.9783 Sc = 0.0015
ADD RAIN #123 L = 0.9783 Sc = 0.0015
ROUTE THRU #120 L = 0.7133 Sc = 0.0005
ADD RAIN #120 L = 0.7133 Sc = 0.0005
ROUTE THRU #114 L = 1.0213 Sc = 0.0014
ADD RAIN #114 L = 1.0213 Sc = 0.0014
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GET.
ROUTE THRU #108 L = 1.3125 Sc = 0.0016
ADD RAIN #108 L = 1.3125 Sc = 0.0016
GET.
ROUTE THRU #103 L = 2.2584 Sc = 0.0011
ADD RAIN #103 L = 2.2584 Sc = 0.0011
STORE.
RAIN #85 L = 2.991 Sc = 0.0092
STORE.
RAIN #90 L = 4.059 Sc = 0.0160
GET.
ROUTE THRU #92 L = 1.7313 Sc = 0.0017
ADD RAIN #92 L = 1.7313 Sc = 0.0017
ROUTE THRU #100 L = 2.4173 Sc = 0.0025
ADD RAIN #100 L = 2.4173 Sc = 0.0025
STORE.
RAIN #145 L = 4.449 Sc = 0.0088
GET.
GET.
ROUTE THRU #96 L = 1.5764 Sc = 0.0012
ADD RAIN #96 L = 1.5764 Sc = 0.0012
STORE.
RAIN #97 L = 2.816 Sc = 0.0142
ROUTE THRU #106 L = 2.2275 Sc = 0.0028
ADD RAIN #106 L = 2.2275 Sc = 0.0028
STORE.
RAIN #127 L = 3.100 Sc = 0.0137
ROUTE THRU #118 L = 1.4666 Sc = 0.0035
ADD RAIN #118 L = 1.4666 Sc = 0.0035
STORE.
RAIN #130 L = 3.757 Sc = 0.0177
ROUTE THRU #121 L = 1.9846 Sc = 0.0047
ADD RAIN #121 L = 1.9846 Sc = 0.0047
ROUTE THRU #115 L = 1.2877 Sc = 0.0041
ADD RAIN #115 L = 1.2877 Sc = 0.0041
GET.
GET.
ROUTE THRU #107 L = 1.8170 Sc = 0.0036
ADD RAIN #107 L = 1.8170 Sc = 0.0036
ROUTE THRU #99 L = 3.3298 Sc = 0.0019
ADD RAIN #99 L = 3.3298 Sc = 0.0019
GET.
ROUTE THRU #93 L = 2.4401 Sc = 0.0005
ADD RAIN #93 L = 2.4401 Sc = 0.0005
STORE.
RAIN #70 L = 3.216 Sc = 0.0204
STORE.
RAIN #86 L = 2.509 Sc = 0.0745
ROUTE THRU #80 L = 1.9997 Sc = 0.0104
ADD RAIN #80 L = 1.9997 Sc = 0.0104
GET.
ROUTE THRU #76 L = 1.5579 Sc = 0.0026
ADD RAIN #76 L = 1.5579 Sc = 0.0026
PRINT.A76*
ROUTE THRU #73 L = 2.6247 Sc = 0.0016
ADD RAIN #73 L = 2.6247 Sc = 0.0016
```

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STORE.
RAIN #66 L = 3.048 Sc = 0.0307
GET.
ROUTE THRU #71 L = 0.8630 Sc = 0.0027
ADD RAIN #71 L = 0.8630 Sc = 0.0027
STORE.
RAIN #57 L = 4.440 Sc = 0.0226
ROUTE THRU #60 L = 1.8870 Sc = 0.0054
ADD RAIN #60 L = 1.8870 Sc = 0.0054
GET.
ROUTE THRU #64 L = 2.7303 Sc = 0.0012
ADD RAIN #64 L = 2.7303 Sc = 0.0012
ROUTE THRU #68 L = 1.9247 Sc = 0.0005
ADD RAIN #68 L = 1.9247 Sc = 0.0005
ROUTE THRU #82 L = 3.0509 Sc = 0.0015
ADD RAIN #82 L = 3.0509 Sc = 0.0015
GET.
ROUTE THRU #89 L = 0.9182 Sc = 0.0008
ADD RAIN #89 L = 0.9182 Sc = 0.0008
STORE.
RAIN #84 L = 3.611 Sc = 0.0077
STORE.
RAIN #87 L = 2.943 Sc = 0.0067
GET.
GET.
ROUTE THRU #81 L = 3.9133 Sc = 0.0005
ADD RAIN #81 L = 3.9133 Sc = 0.0005
STORE.
RAIN #78 L = 3.952 Sc = 0.0078
GET.
ROUTE THRU #74 L = 1.4801 Sc = 0.0005
ADD RAIN #74 L = 1.4801 Sc = 0.0005
STORE.
RAIN #5 L = 4.984 Sc = 0.0298
ROUTE THRU #8 L = 1.1570 Sc = 0.0064
ADD RAIN #8 L = 1.1570 Sc = 0.0064
STORE.
RAIN #36 L = 2.998 Sc = 0.0464
ROUTE THRU #30 L = 1.5522 Sc = 0.0080
ADD RAIN #30 L = 1.5522 Sc = 0.0080
ROUTE THRU #22 L = 1.4935 Sc = 0.0028
ADD RAIN #22 L = 1.4935 Sc = 0.0028
ROUTE THRU #17 L = 2.1516 Sc = 0.0036
ADD RAIN #17 L = 2.1516 Sc = 0.0036
GET.
ROUTE THRU #11 L = 2.7775 Sc = 0.0053
ADD RAIN #11 L = 2.7775 Sc = 0.0053
ROUTE THRU #10 L = 2.6219 Sc = 0.0034
ADD RAIN #10 L = 2.6219 Sc = 0.0034
PRINT.B10*
ROUTE THRU #18 L = 3.6481 Sc = 0.0007
ADD RAIN #18 L = 3.6481 Sc = 0.0007
STORE.
RAIN #19 L = 4.276 Sc = 0.0179
GET.
ROUTE THRU #24 L = 3.5829 Sc = 0.0005
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ADD RAIN #24 L = 3.5829 Sc = 0.0005
STORE.
RAIN #21 L = 3.245 Sc = 0.0075
STORE.
RAIN #33 L = 4.392 Sc = 0.0274
GET.
ROUTE THRU #31 L = 3.6916 Sc = 0.0031
ADD RAIN #31 L = 3.6916 Sc = 0.0031
GET.
ROUTE THRU #35 L = 2.7286 Sc = 0.0020
ADD RAIN #35 L = 2.7286 Sc = 0.0020
ROUTE THRU #41 L = 2.1710 Sc = 0.0020
ADD RAIN #41 L = 2.1710 Sc = 0.0020
STORE.
RAIN #38 L = 5.028 Sc = 0.0224
STORE.
RAIN #51 L = 3.660 Sc = 0.0322
ROUTE THRU #52 L = 2.2793 Sc = 0.0029
ADD RAIN #52 L = 2.2793 Sc = 0.0029
GET.
ROUTE THRU #48 L = 1.1598 Sc = 0.0044
ADD RAIN #48 L = 1.1598 Sc = 0.0044
GET.
ROUTE THRU #50 L = 1.5547 Sc = 0.0011
ADD RAIN #50 L = 1.5547 Sc = 0.0011
ROUTE THRU #61 L = 3.2478 Sc = 0.0012
ADD RAIN #61 L = 3.2478 Sc = 0.0012
GET.
ROUTE THRU #72 L = 1.1976 Sc = 0.0012
ADD RAIN #72 L = 1.1976 Sc = 0.0012
ROUTE THRU #69 L = 2.4340 Sc = 0.0005
ADD RAIN #69 L = 2.4340 Sc = 0.0005
ROUTE THRU #58 L = 1.9366 Sc = 0.0006
ADD RAIN #58 L = 1.9366 Sc = 0.0006
ROUTE THRU #54 L = 1.5247 Sc = 0.0006
ADD RAIN #54 L = 1.5247 Sc = 0.0006
STORE.
RAIN #55 L = 4.010 Sc = 0.0067
GET.
ROUTE THRU #143 L = 1.7446 Sc = 0.0005
ADD RAIN #143 L = 1.7446 Sc = 0.0005
PRINT.Mimdale*
STORE.
RAIN #44 L = 5.366 Sc = 0.0076
ROUTE THRU #40 L = 1.2515 Sc = 0.0035
ADD RAIN #40 L = 1.2515 Sc = 0.0035
GET.
ROUTE THRU #46 L = 1.4674 Sc = 0.0005
ADD RAIN #46 L = 1.4674 Sc = 0.0005
STORE.
RAIN #142 L = 2.424 Sc = 0.0304
STORE.
RAIN #141 L = 2.457 Sc = 0.0448
ROUTE THRU #26 L = 1.2424 Sc = 0.0023
ADD RAIN #26 L = 1.2424 Sc = 0.0023
GET.
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ROUTE THRU #28 L = 0.7825 Sc = 0.0051
ADD RAIN #28 L = 0.7825 Sc = 0.0051
STORE.
RAIN #140 L = 1.376 Sc = 0.0160
GET.
ROUTE THRU #39 L = 4.5848 Sc = 0.0031
ADD RAIN #39 L = 4.5848 Sc = 0.0031
STORE.
RAIN #45 L = 3.823 Sc = 0.0087
GET.
GET.
ROUTE THRU #37 L = 2.1775 Sc = 0.0005
ADD RAIN #37 L = 2.1775 Sc = 0.0005
ROUTE THRU #32 L = 2.1620 Sc = 0.0005
ADD RAIN #32 L = 2.1620 Sc = 0.0005
ROUTE THRU #23 L = 2.4768 Sc = 0.0005
ADD RAIN #23 L = 2.4768 Sc = 0.0005
ROUTE THRU #25 L = 2.0008 Sc = 0.0005
ADD RAIN #25 L = 2.0008 Sc = 0.0005
STORE.
RAIN #1 L = 4.150 Sc = 0.0051
STORE.
RAIN #88 L = 3.334 Sc = 0.0077
STORE.
RAIN #131 L = 3.231 Sc = 0.0085
GET.
GET.
ROUTE THRU #3 L = 3.5345 Sc = 0.0030
ADD RAIN #3 L = 3.5345 Sc = 0.0030
STORE.
RAIN #2 L = 4.804 Sc = 0.0102
STORE.
RAIN #4 L = 4.468 Sc = 0.0073
STORE.
RAIN #6 L = 3.674 Sc = 0.0086
ROUTE THRU #7 L = 1.7569 Sc = 0.0028
ADD RAIN #7 L = 1.7569 Sc = 0.0028
GET.
GET.
GET.
ROUTE THRU #9 L = 2.7515 Sc = 0.0027
ADD RAIN #9 L = 2.7515 Sc = 0.0027
STORE.
RAIN #12 L = 4.615 Sc = 0.0131
STORE.
RAIN #16 L = 4.341 Sc = 0.0166
GET.
ROUTE THRU #13 L = 2.9727 Sc = 0.0031
ADD RAIN #13 L = 2.9727 Sc = 0.0031
ROUTE THRU #14 L = 1.2561 Sc = 0.0038
ADD RAIN #14 L = 1.2561 Sc = 0.0038
GET.
ROUTE THRU #15 L = 2.7386 Sc = 0.0009
ADD RAIN #15 L = 2.7386 Sc = 0.0009
ROUTE THRU #20 L = 1.3028 Sc = 0.0021
ADD RAIN #20 L = 1.3028 Sc = 0.0021
```

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GET.
ROUTE THRU #27 L = 1.8154 Sc = 0.0005
ADD RAIN #27 L = 1.8154 Sc = 0.0005
ROUTE THRU #29 L = 1.1611 Sc = 0.0005
ADD RAIN #29 L = 1.1611 Sc = 0.0005
ROUTE THRU #34 L = 1.5386 Sc = 0.0011
ADD RAIN #34 L = 1.5386 Sc = 0.0011
ROUTE THRU #42 L = 1.9423 Sc = 0.0005
ADD RAIN #42 L = 1.9423 Sc = 0.0005
STORE.
RAIN #91 L = 4.069 Sc = 0.0134
STORE.
RAIN #94 L = 4.947 Sc = 0.0073
ROUTE THRU #98 L = 1.3542 Sc = 0.0042
ADD RAIN #98 L = 1.3542 Sc = 0.0042
GET.
ROUTE THRU #95 L = 0.9071 Sc = 0.0005
ADD RAIN #95 L = 0.9071 Sc = 0.0005
STORE.
RAIN #104 L = 3.062 Sc = 0.0246
ROUTE THRU #111 L = 2.8568 Sc = 0.0036
ADD RAIN #111 L = 2.8568 Sc = 0.0036
STORE.
RAIN #125 L = 3.185 Sc = 0.0085
ROUTE THRU #119 L = 1.4721 Sc = 0.0033
ADD RAIN #119 L = 1.4721 Sc = 0.0033
GET.
ROUTE THRU #112 L = 1.4263 Sc = 0.0027
ADD RAIN #112 L = 1.4263 Sc = 0.0027
ROUTE THRU #102 L = 2.5263 Sc = 0.0005
ADD RAIN #102 L = 2.5263 Sc = 0.0005
GET.
ROUTE THRU #144 L = 2.8980 Sc = 0.0017
ADD RAIN #144 L = 2.8980 Sc = 0.0017
PRINT.Rapleys*
ROUTE THRU #83 L = 1.2932 Sc = 0.0005
ADD RAIN #83 L = 1.2932 Sc = 0.0005
STORE.
RAIN #79 L = 2.928 Sc = 0.0176
ROUTE THRU #77 L = 1.1528 Sc = 0.0029
ADD RAIN #77 L = 1.1528 Sc = 0.0029
GET.
ROUTE THRU #75 L = 1.7431 Sc = 0.0005
ADD RAIN #75 L = 1.7431 Sc = 0.0005
STORE.
RAIN #65 L = 3.040 Sc = 0.0127
ROUTE THRU #62 L = 1.2462 Sc = 0.0047
ADD RAIN #62 L = 1.2462 Sc = 0.0047
GET.
ROUTE THRU #67 L = 1.5922 Sc = 0.0005
ADD RAIN #67 L = 1.5922 Sc = 0.0005
ROUTE THRU #63 L = 0.7152 Sc = 0.0005
ADD RAIN #63 L = 0.7152 Sc = 0.0005
ROUTE THRU #146 L = 2.0235 Sc = 0.0005
ADD RAIN #146 L = 2.0235 Sc = 0.0005
STORE.
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RAIN #59 L = 4.513 Sc = 0.0048
GET.
ROUTE THRU #56 L = 0.4820 Sc = 0.0038
ADD RAIN #56 L = 0.4820 Sc = 0.0038
ROUTE THRU #53 L = 2.8619 Sc = 0.0005
ADD RAIN #53 L = 2.8619 Sc = 0.0005
STORE.
RAIN #43 L = 2.744 Sc = 0.0144
GET.
GET.
ROUTE THRU #49 L = 2.8666 Sc = 0.0005
ADD RAIN #49 L = 2.8666 Sc = 0.0005
ROUTE THRU #47 L = 1.1438 Sc = 0.0005
ADD RAIN #47 L = 1.1438 Sc = 0.0005
ROUTE THRU #147 L = 0.3737 Sc = 0.0005
ADD RAIN #147 L = 0.3737 Sc = 0.0005
{additional subcatchments}
ROUTE THRU #153 L = 3.2 Sc = 0.0013
ADD RAIN #153 L = 3.2 Sc = 0.0013
STORE. {153}
RAIN #148 L = 8.9 Sc = 0.0045
ROUTE THRU #149 L = 7.8 Sc = 0.0028
ADD RAIN #149 L = 7.8 Sc = 0.0028
ROUTE THRU #150 L = 3.8 Sc = 0.0037
ADD RAIN #150 L = 3.8 Sc = 0.0037
STORE. {150}
RAIN #151 L = 3.4 Sc = 0.0025
GET. {150}
ROUTE THRU #152 L = 4.1 Sc = 0.0025
ADD RAIN #152 L = 4.1 Sc = 0.0025
PRINT.C152*
GET. {153}
ROUTE THRU #154 L = 2.6 Sc = 0.0004
ADD RAIN #154 L = 2.6 Sc = 0.0004
ROUTE THRU #155 L = 4.9 Sc = 0.0029
ADD RAIN #155 L = 4.9 Sc = 0.0029
END OF CATCHMENT DATA.
155 PLUVIOGRAPHS:
LOCATION. Baffle001
1 SUBAREAS: 1
LOCATION. Baffle002
1 SUBAREAS: 2
LOCATION. Baffle003
1 SUBAREAS: 3
LOCATION. Baffle004
1 SUBAREAS: 4
LOCATION. Baffle005
1 SUBAREAS: 5
LOCATION. Baffle006
1 SUBAREAS: 6
LOCATION. Baffle007
1 SUBAREAS: 7
LOCATION. Baffle008
1 SUBAREAS: 8
LOCATION. Baffle009
1 SUBAREAS: 9
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LOCATION. Baffle010
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LOCATION. Baffle012
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LOCATION. Baffle037
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LOCATION. Baffle065
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LOCATION. Baffle150
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LOCATION. Baffle155
1 SUBAREAS: 155
END OF PLUVIOGRAPH DATA.
2 GAUGING STATIONS:
LOCATION.Mimdale
LOCATION.Rapleys
END OF GAUGING STATIONS.
```

APPENDIX B

Flood Extent Figures

Level 7, 500 Queen Street, Brisbane
PO Box 10183 Brisbane
www.engeny.com.au
P: 07 3221 7174
F: 07 3236 2399

ENGENY
WATER MANAGEMENT

GLADSTONE
REGIONAL COUNCIL

5 0 5 km

Scale in metres (1: 250,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure B1 Defined Flood Event
(1% AEP + CC) Peak Flood Extent

Job Number: M38000_009
Revision: 1
Drawn: AJ
Checked: AC
Date: 23/1/2019

Level 7, 500 Queen Street, Brisbane
PO Box 10183 Brisbane
www.engeny.com.au
P: 07 3221 7174
F: 07 3236 2399

100 0 100 m

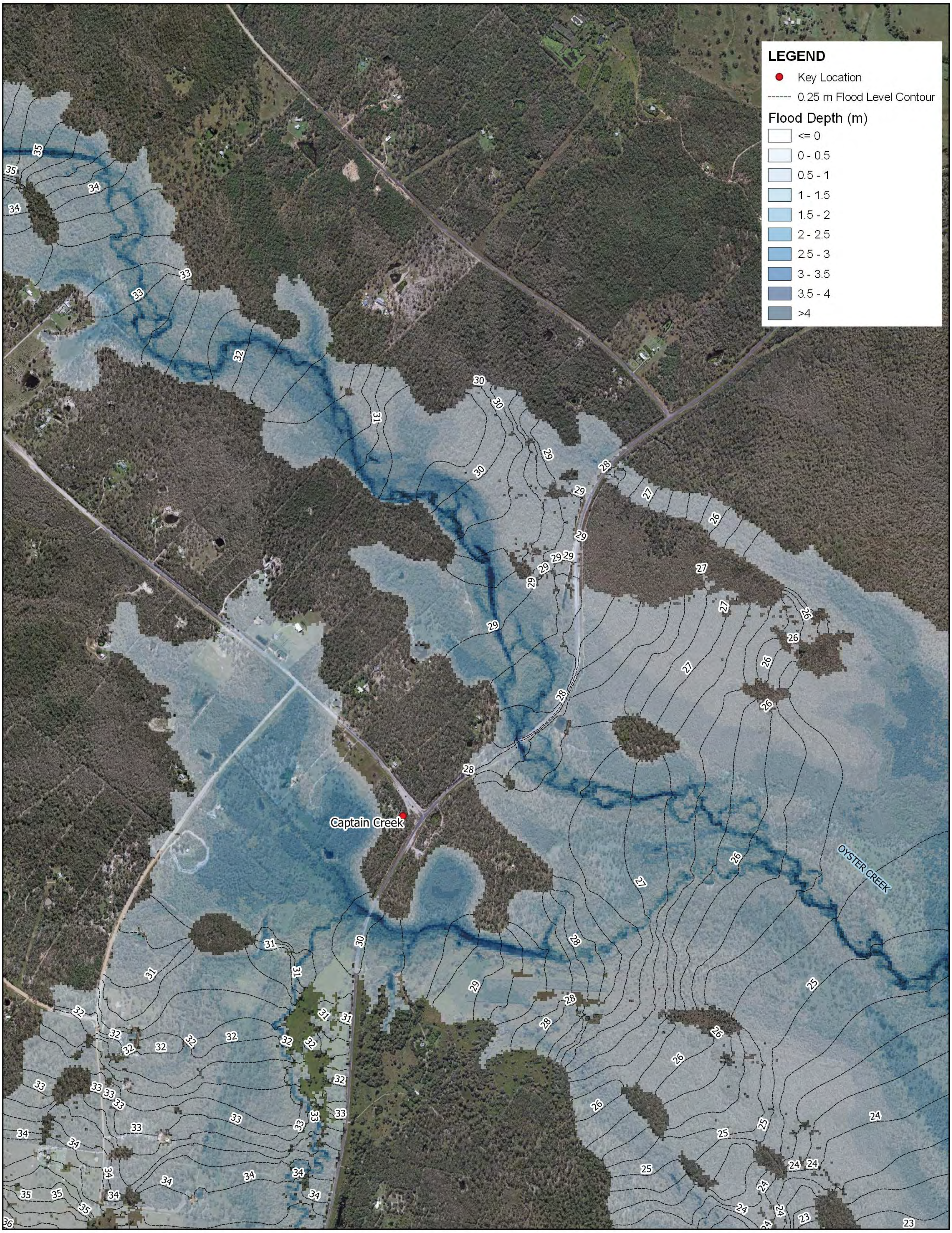
Scale in metres (1: 7,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure B2 Bororen Defined Flood Event (1% AEP + CC) Peak Flood Extent

Job Number: M38000_009
Revision: 0
Drawn: AJ
Checked: AC
Date: 4/12/2018



200 0 200 m

Scale in metres (1: 15,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

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Baffle Creek Flood Study

Figure B3 Captain Creek Defined Flood Event (1% AEP + CC) Peak Flood Extent

Job Number: M38000_009
Revision: 1
Drawn: AJ
Checked: AC
Date: 4/12/2018

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100 0 100 m

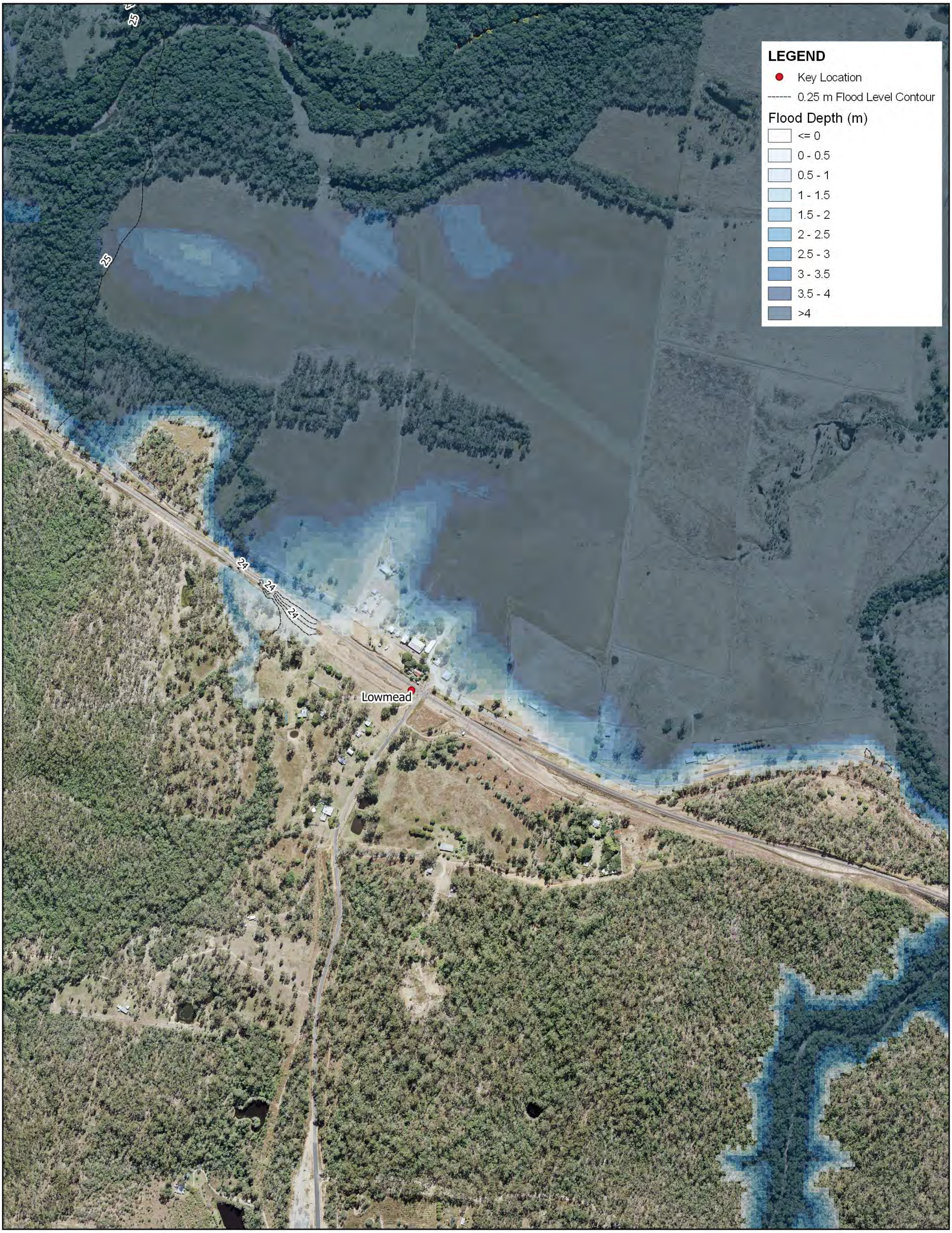
Scale in metres (1: 7,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure B4 Miriam Vale Defined Flood Event (1% AEP + CC) Peak Flood Extent

Job Number: M38000_009
Revision: 0
Drawn: AJ
Checked: AC
Date: 4/12/2018



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100 0 100 m

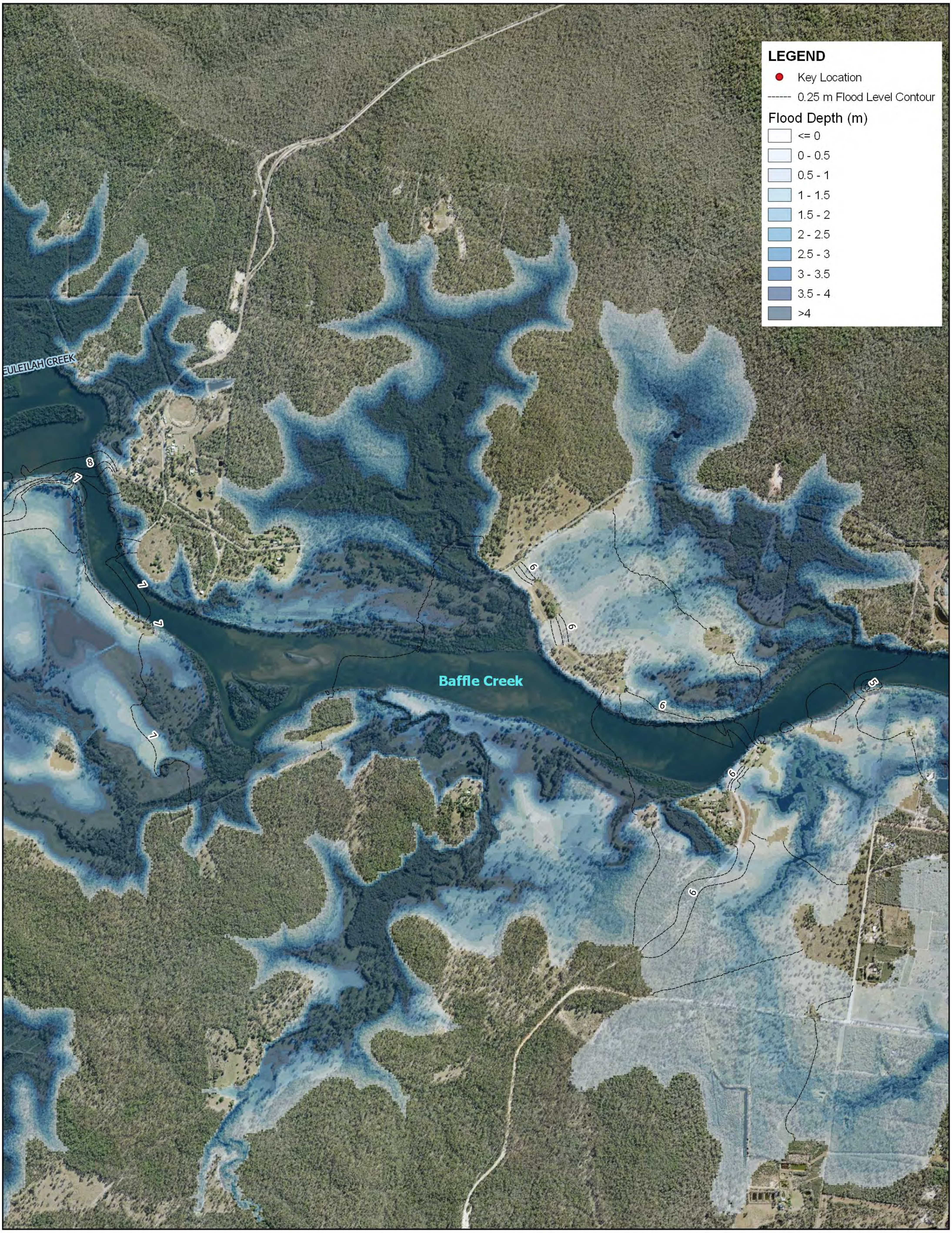
Scale in metres (1: 7,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure B5 Lowmead Defined Flood Event (1% AEP + CC) Peak Flood Extent

Job Number: M38000_009
Revision: 0
Drawn: AJ
Checked: AC
Date: 4/12/2018



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300 0 300 m

Scale in metres (1: 20,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure B6 Baffle Creek Defined Flood Event (1% AEP + CC) Peak Flood Extent

Job Number: M38000_009
Revision: 1
Drawn: AJ
Checked: AC
Date: 23/1/2019

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300 0 300 m

Scale in metres (1: 20,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

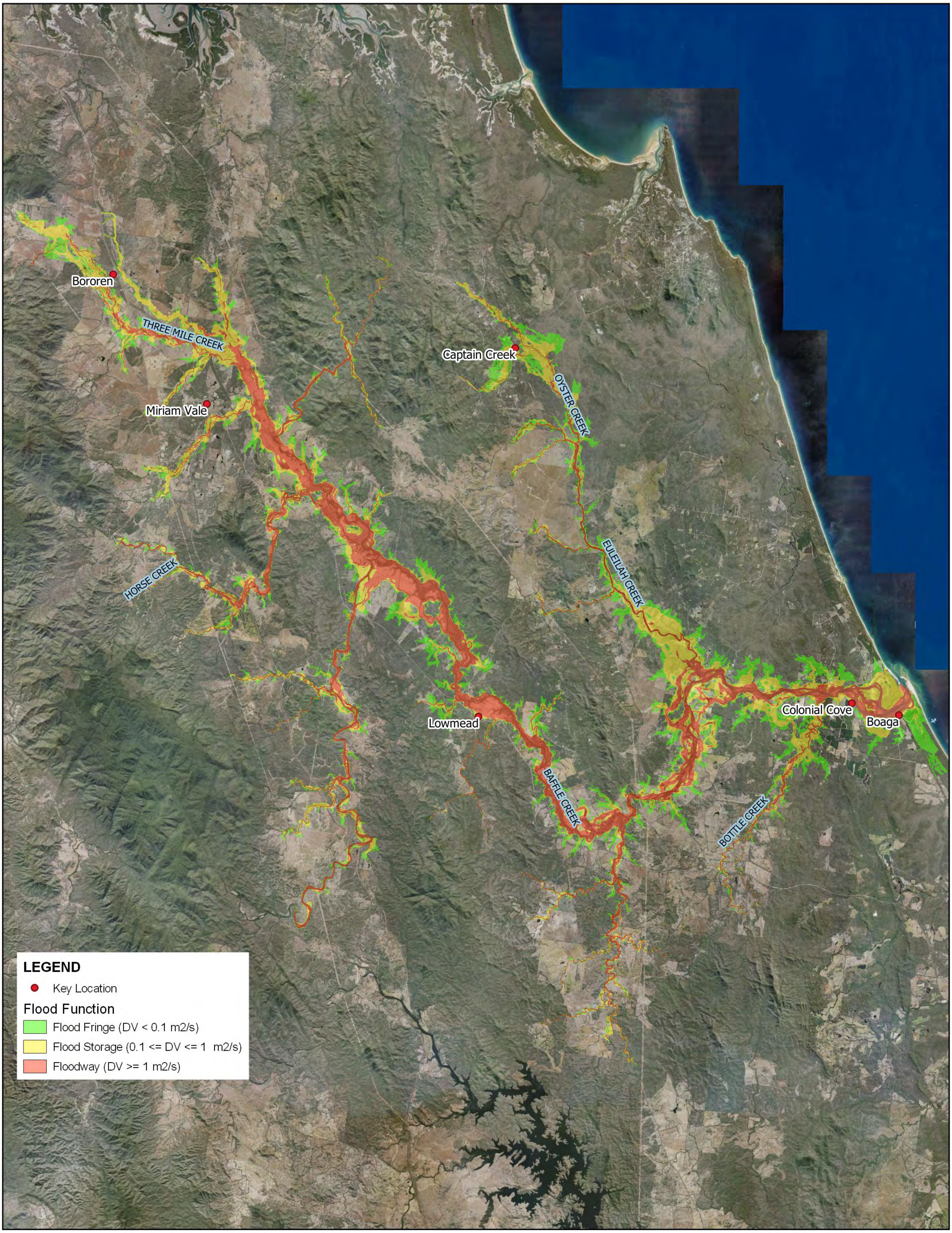
Baffle Creek Flood Study

Figure B7 Colonial Cove and Boaga
Defined Flood Event (1% AEP + CC)
Peak Flood Extent

Job Number:
M38000_009
Revision: 1
Drawn: AJ
Checked: AC
Date: 23/1/2019

APPENDIX C

Floodplain Functionality Figures



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5 0 5 km

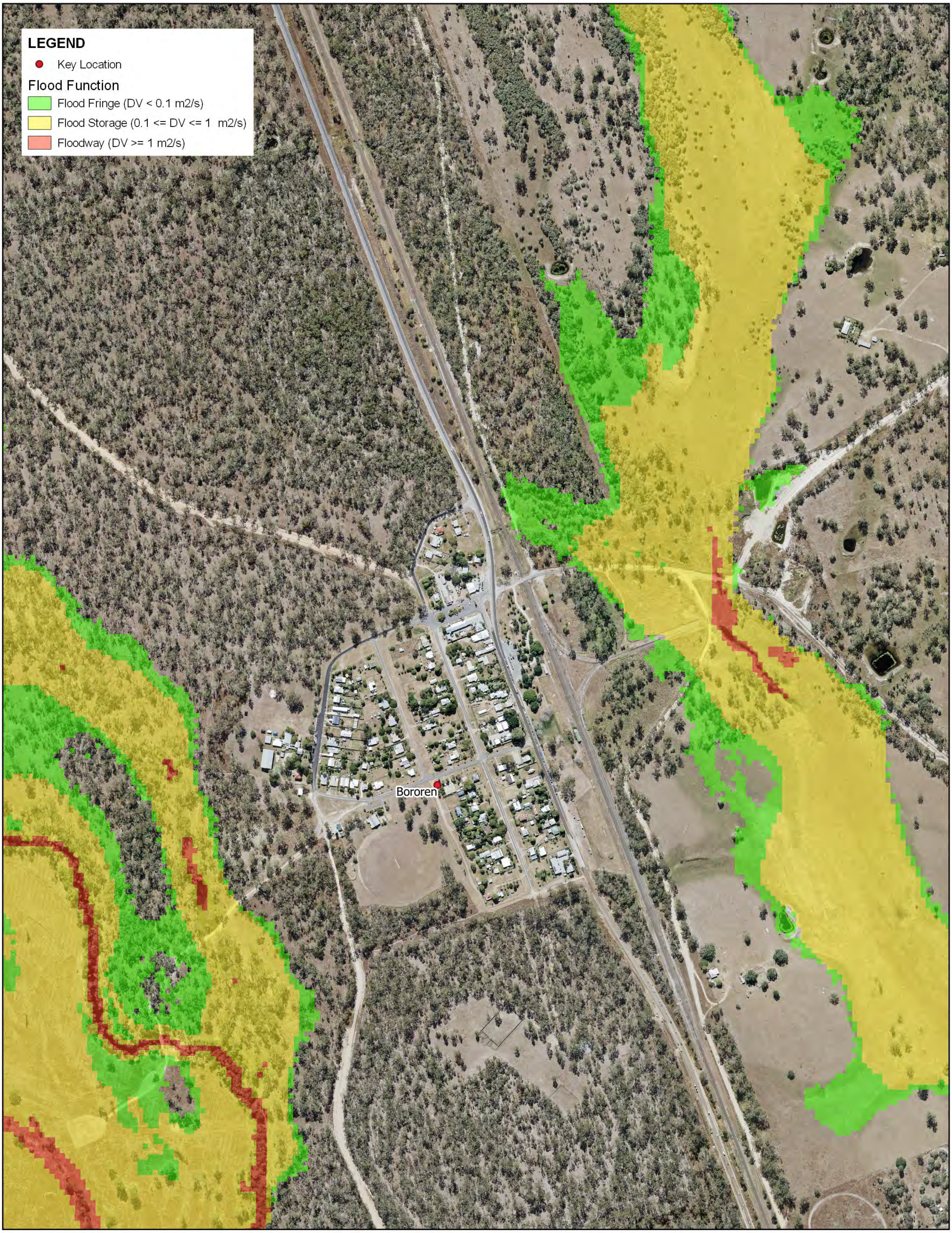
Scale in metres (1: 250,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure C1 Defined Flood Event (1% AEP + CC) Floodplain Functionality Map

Job Number:
M38000_009
Revision: 1
Drawn: AJ
Checked: AC
Date: 23/1/2019



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100 0 100 m

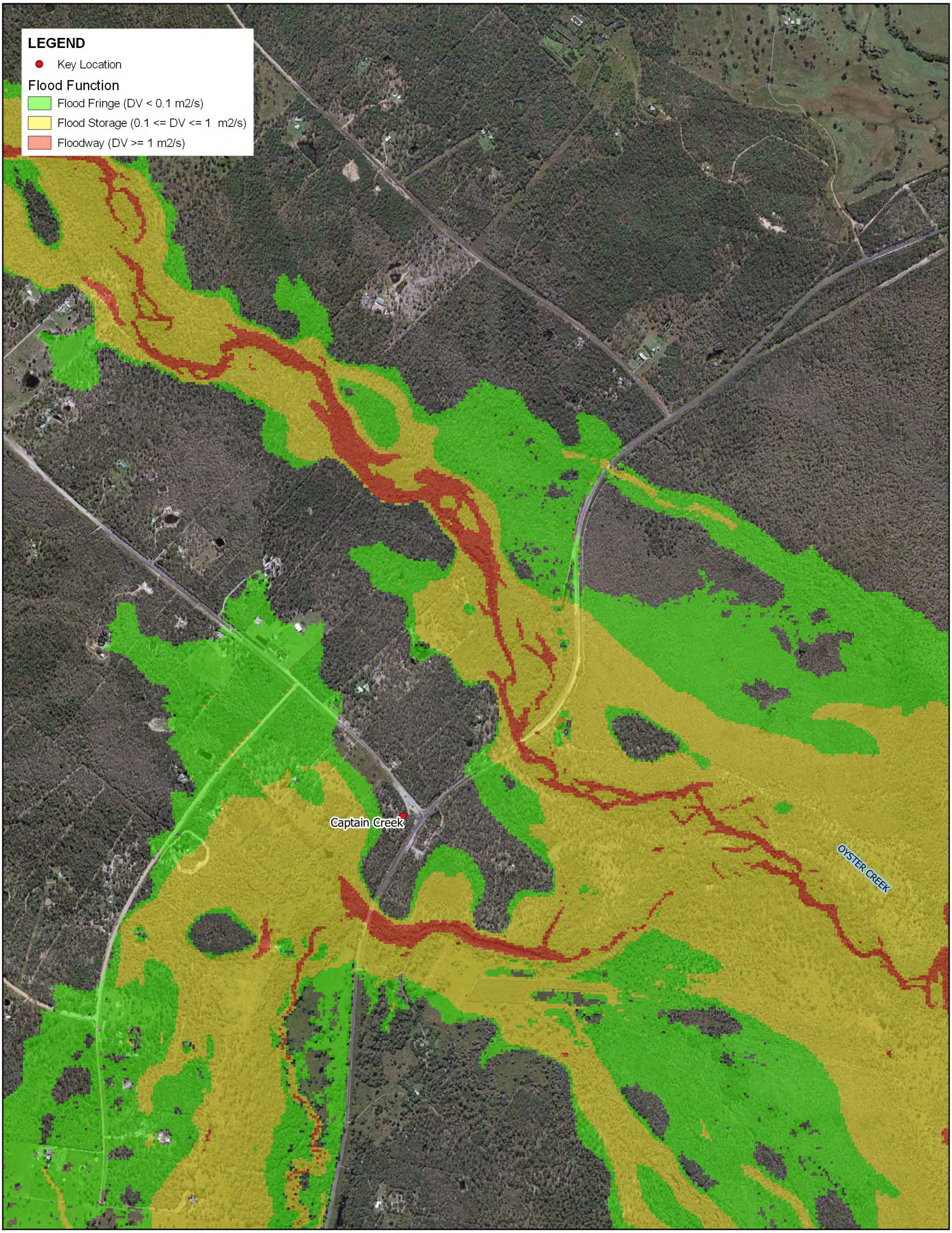
Scale in metres (1: 7,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure C2 Bororen
Defined Flood Event (1% AEP + CC)
Floodplain Functionality Map

Job Number: M38000_009
Revision: 0
Drawn: AJ
Checked: AC
Date: 4/12/2018



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200 0 200 m

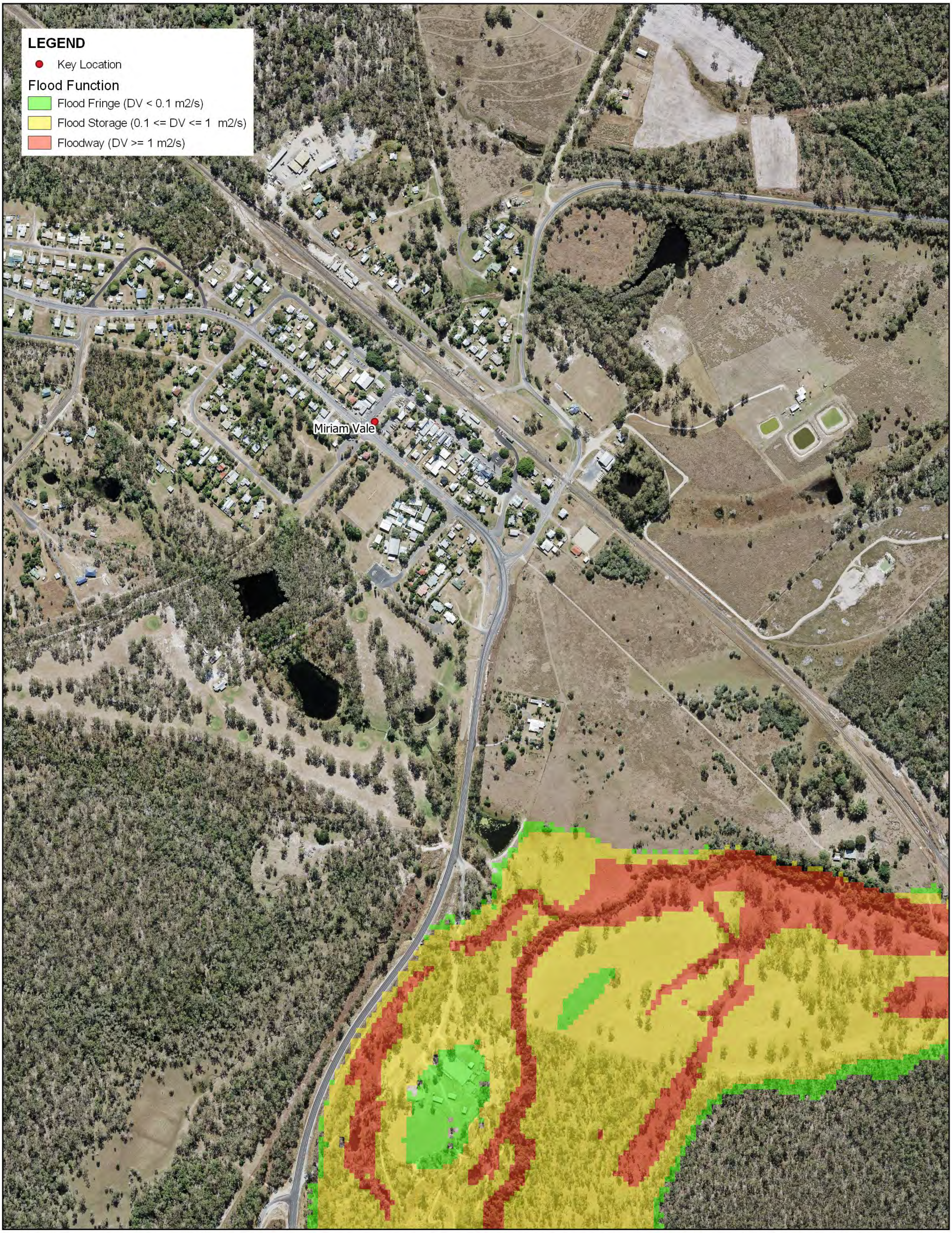
Scale in metres (1: 15,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure C3 Captain Creek
Defined Flood Event (1% AEP + CC)
Floodplain Functionality Map

Job Number: M38000_009
Revision: 0
Drawn: AJ
Checked: AC
Date: 4/12/2018



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100 0 100 m

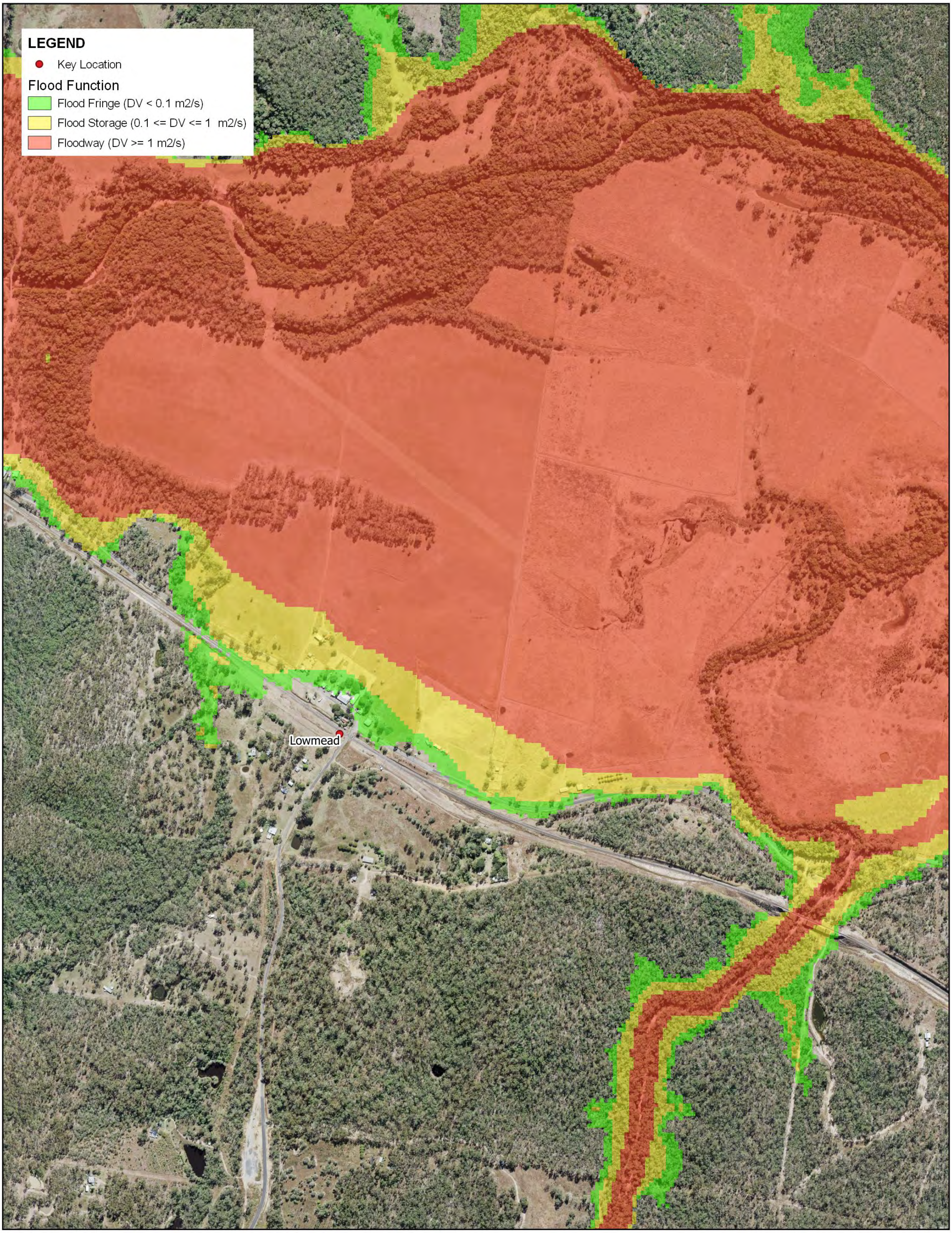
Scale in metres (1: 7,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure C4 Miriam Vale
Defined Flood Event (1% AEP + CC)
Floodplain Functionality Map

Job Number: M38000_009
Revision: 0
Drawn: AJ
Checked: AC
Date: 4/12/2018



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100 0 100 m

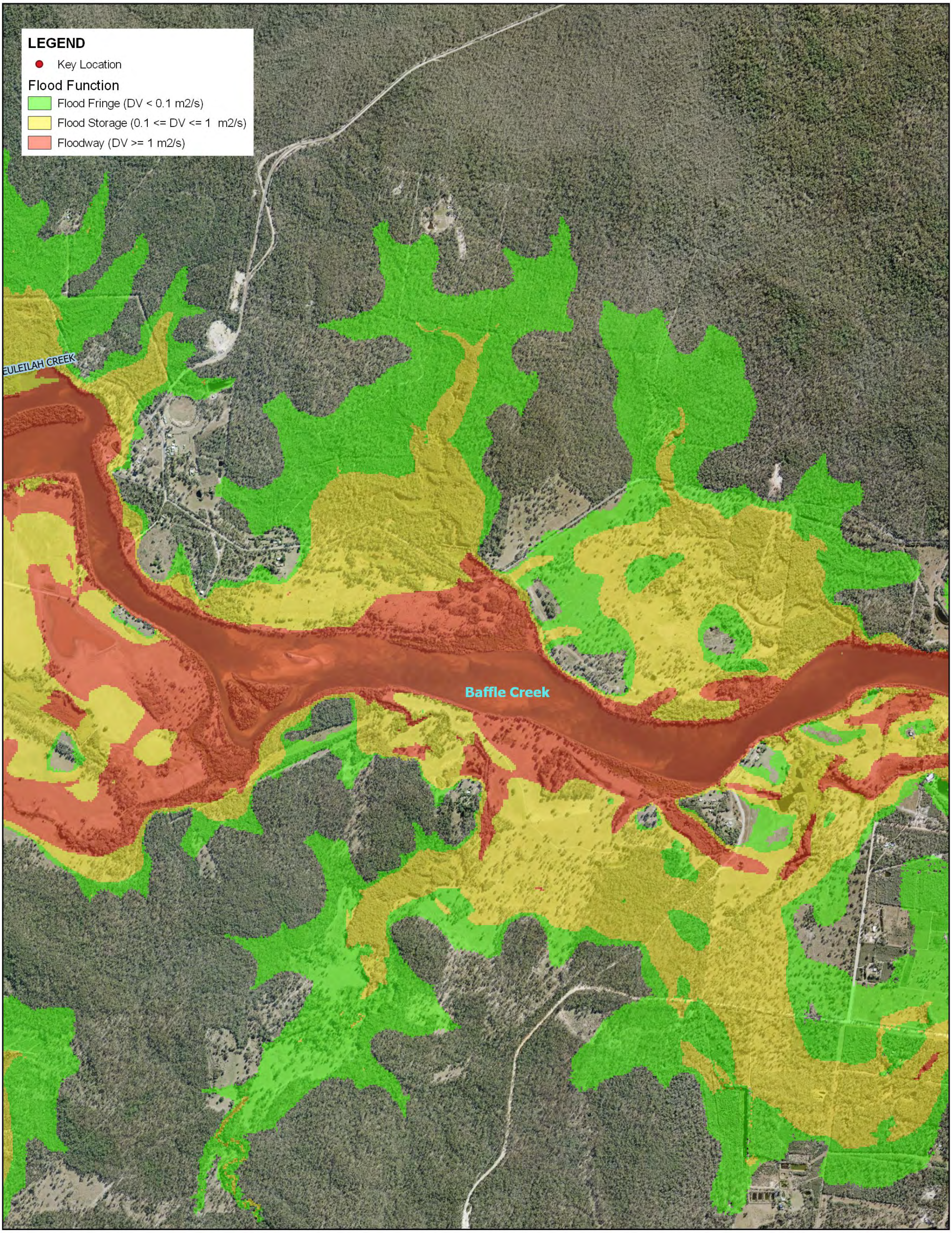
Scale in metres (1: 7,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure C5 Lowmead
Defined Flood Event (1% AEP + CC)
Floodplain Functionality Map

Job Number:
M38000_009
Revision: 0
Drawn: AJ
Checked: AC
Date: 4/12/2018



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300 0 300 m

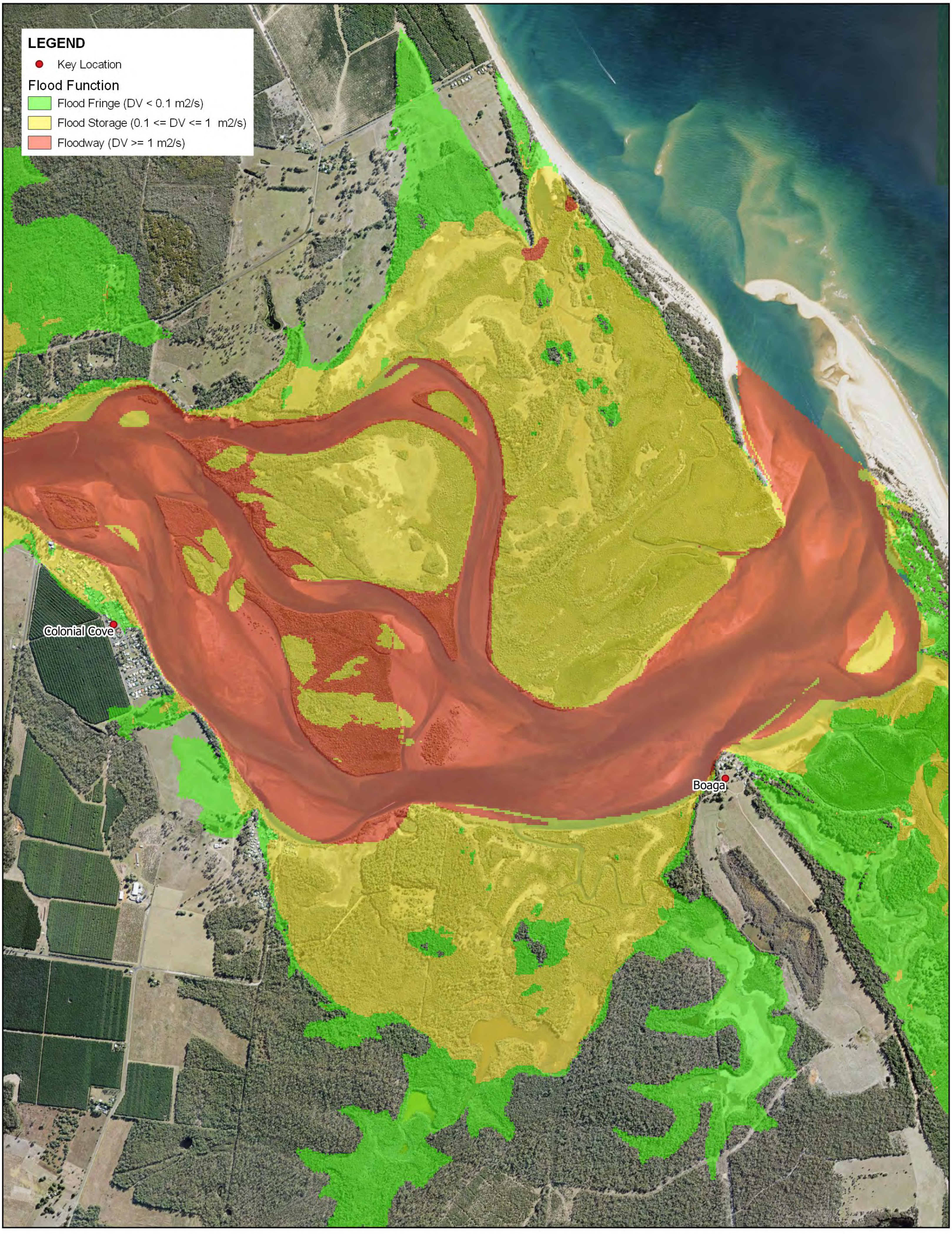
Scale in metres (1: 20,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure C6 Baffle Creek
Defined Flood Event (1% AEP + CC)
Floodplain Functionality Map

Job Number: M38000_009
Revision: 1
Drawn: AJ
Checked: AC
Date: 23/1/2019



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300 0 300 m

Scale in metres (1: 20,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Baffle Creek Flood Study

Figure C7 Colonial Cove and Boaga
Defined Flood Event (1% AEP + CC)
Floodplain Functionality Map

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