Regional Floodplain Database:

2013 Model Maintenance Report - Caboolture River (CAB)

Moreton Bay Regional Council

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Regional Floodplain Database 2013 Model Maintenance Report

Caboolture (CAB) December 2013

Moreton Bay Regional Council

Emergency Management EMQ Queensland

Australian Goverment

Attorney-General's Department
Emergency Management Australia

Queensland Government

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Regional Floodplain Database 2013 Model Maintenance Report Caboolture River (CAB) Final Report

Prepared for:	Moreton Bay Regional Council
Prepared by:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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Document Control Sheet

BMT WBM Pty Ltd
Level 8, 200 Creek Street
Brisbane Qld 4000
Australia
PO Box 203, Spring Hill 4004

Tel: +61 7 3831 6744
Fax: + 61 7 3832 3627

ABN 54 010 830 421

www.bmtwbm.com.au

Document:	R.B20303.001.02.Final 2013 Model Maintenance Report.docx
Title:	**Regional Floodplain Database 2013 Model Maintenance Report Caboolture River (CAB) Final Report**
Project Manager:	Anne Kolega
Author:	Melissa Hovey/Anne Kolega
Client:	Moreton Bay Regional Council
Client Contact:	Hester van Zijl
Client Reference:	Regional Floodplain Database

Synopsis: **This report includes the details and findings of the 2013 model maintenance of the Caboolture River model, as part of the Council's Regional Floodplain Database. The report includes the calibration, design event and sensitivity methodology and modelling results.**

REVISION/CHECKING HISTORY

Revision Number	Date	Checked by		Issued by	
0	07/11/2013	AK		MH	
1	02/12/2013	AK		MH	
2	06/12/2013	AK		MH	

DISTRIBUTION

Destination	Revision										
	0	1	2	3	4	5	6	7	8	9	10
Moreton Bay Regional Council	PDF	PDF	PDF +3								
BMT WBM File	PDF	PDF	PDF								
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Contents

List of Figures

List of Tables

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1 Introduction

BMT WBM has developed the Caboolture River (CAB) model as part of Stage 2, Regional Floodplain Database (RFD) (BMT WBM, 2012a). Subsequently, the 10m TUFLOW model was upgraded in November and December 2012 by including additional structures and new development areas provided by Council (BMT WBM, 2012b). This upgraded model was only simulated for one event (1% AEP 12 hour storm duration event).

In 2013, Council has collected additional structure details to further enhance the model performance. Furthermore, a number of new developments have arisen within the Caboolture River catchment, which Council wished to include in the hydraulic model as part of the 2013 model maintenance project, detailed in Section 2.1. Minor changes in the modelling approach were also adopted by Council as part of this study and are described in Section 3. These changes were included in the 5m and 10m hydraulic models, and the models were re-run for all events, including the calibration events and sensitivity analysis.

This report highlights the changes and results from the 2013 model for the simulated events.

2 2013 Maintenance Details

2.1 Model Maintenance

Council consolidated and provided the data for the model maintenance in various formats. Figure 2-1 presents the locations of the additional data incorporated into the 2013 Caboolture River (CAB) model. In summary, the following information was incorporated into the CAB model:

- The 5m model was updated with the features added to the 10m model in the 2012 model update. The following data was included as part of the 2012 model update (BMT WBM, 2012b, document reference L.B18104.010.CAB_Update.pdf).
  - 24 additional culverts at minor roads (e.g., McKean Street, Horne and Pettigrew Street) or along the major roads of the Bruce Highway and the D'Aguilar Highway;
  - Underground stormwater drainage near Lear Jet Drive;
  - 3 additional culverts located in the vicinity of new development areas (at and near Pumicestone Road and at Water Fern Drive);
  - Pumicestone Road survey including the gully crossing Pumicestone Road between King John Drive and Ardrossan Road;
  - The open drain along Lang, Rarity and Ferris Street;
  - Topography change for the new development at Pumicestone Road (The Reserve), at 300SP245773;
  - Topography change for the new development at Morayfield Road (Riverview); and
  - Change in the landuse roughness for the Riverview development near Morayfield Road and for another development at Pumicestone Road, Caboolture (Stage 1) near Ardrossan Road.
- 38 additional culverts at minor road (e.g. Caboolture River Road and Williams Road).
- Refinement of assumed culvert data from the 2012 model with recently surveyed data provided by Council.
- Trunk drainage, primarily in the Beachmere area, and along Francis Street.
- Bridge at Campbell's Pocket Road.
- Drainage paths along Duncan Street and in the industrial development at Lear Jet Drive.
- Sand dune breach to the south of Biggs Avenue, Beachmere.
- Inclusion of 4 areas of new development: Central Lakes, Male Road and Pumicestone Park in Caboolture as well as Trinity Waters in Beachmere. This includes the update of the topography and landuse of these areas and any associated infrastructure.
- Inclusion of updated bathymetric data from the Caboolture River mouth to Morayfield Road.

2.2 TUFLOW Executable Upgrade

As part of the model maintenance, Council decided to utilise the 2013 TUFLOW executable. This version enables the output of Council's adopted hazard categories, which was specifically coded into the TUFLOW executable for Council in July 2013. Compared to the previously adopted TUFLOW executable (2011), it also has a new feature which allows Digital Elevation Models (DEMs) to be read as text files rather than z-points. This increases the efficiency of making changes to the topography, and was another reason to use this version.

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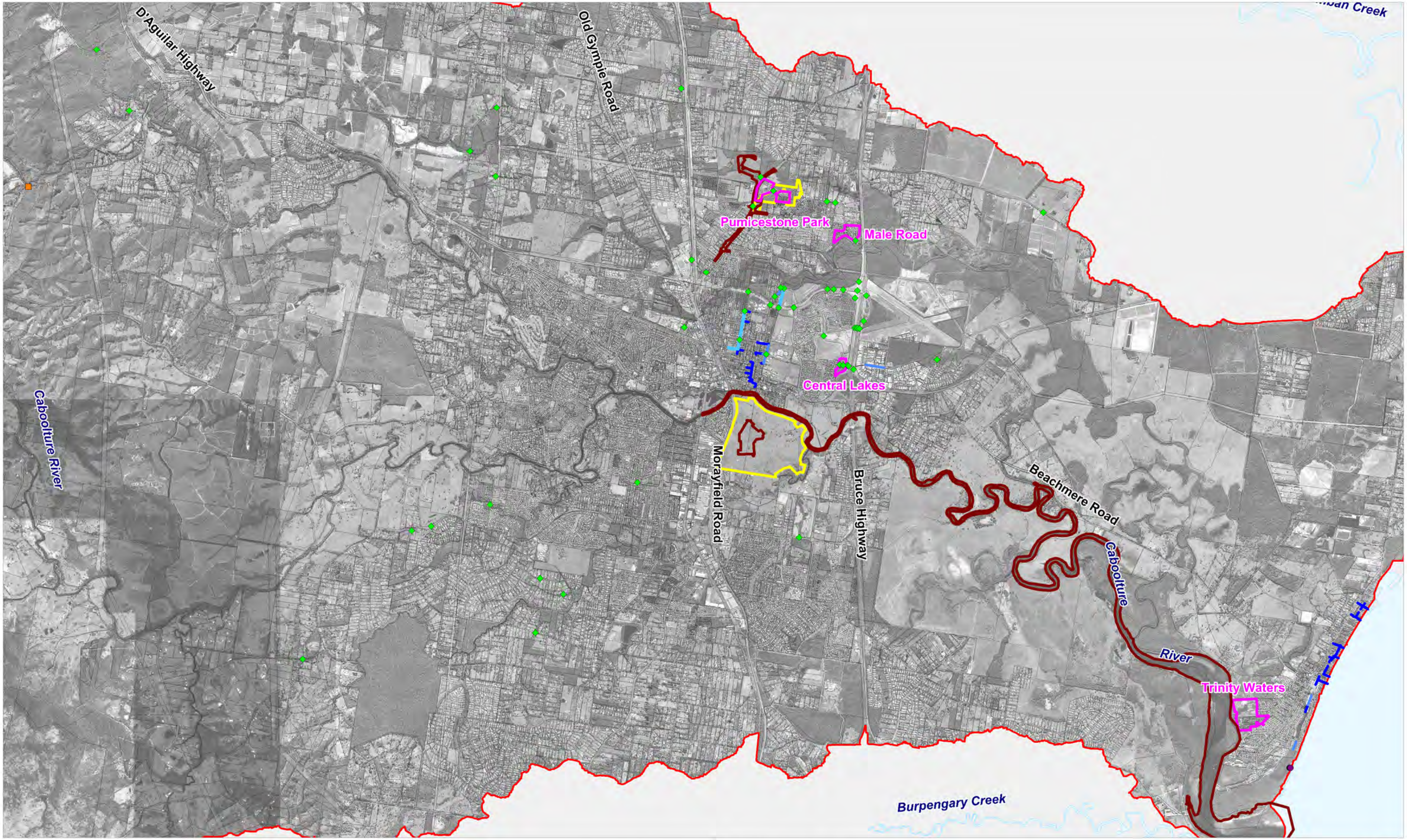

LEGEND

- Caboolture Catchment Boundary
- Cadastral Boundaries

Additional Features

- New Development Areas
- Change in Landuse Roughness
- Change in Topography/Bathymetry
- Bridge
- Culverts
- Dune Breach
- Open Drain Channel
- Underground Drainage

Title:
Caboolture River Model Maintenance Features

Figure: 2-1

Rev: A

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0 1 2km
Approx. Scale

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3 Model Simulations

3.1 Calibration and Verification

The Caboolture River hydraulic model was calibrated and verified against the following two historical events:

- January 2011 (Calibration event); and
- May 2009 (Verification event).

The rainfall, river gauge, floodmark and hydrologic models were not amended as part of the 2013 model maintenance. The TUFLOW model was upgraded, as outlined in Section 2 and the two historic events were simulated. Model calibration as such (with various model parameters) was not undertaken, because Council adopted a specific set of model parameters as part of Stage 2, which were then verified as part of Stage 3 of the Regional Floodplain Database. Additional model calibration will be considered by Council using a significant flood event in the future.

3.2 Design Flood Events

This section describes the design storm conditions used in the hydrodynamic modelling tasks. Design storm events are hypothetical events used to estimate design flood conditions. They are based on a probability of occurrence, usually specified as an Average Exceedance Probability (AEP). For events less than the 50% AEP, the terminology Exceedances per Year (EY) is used.

3.2.1 Critical Duration Assessment

The Stage 2 hydrologic and hydraulic modelling report (BMT WBM, 2012a) utilised the 10%, 1% and PMF events for the Critical Duration Analysis (CDA), based on the 10m model.

However, Council selected the following slightly different methodology as part of the 2013 maintenance study. Council adopted the 1%, 0.1% AEP and PMF events to undertake a CDA. The critical durations selected from the 1% AEP event CDA were applied to all events ranging from the 1EY to the 1% AEP. Similarly, the critical durations selected from the 0.1% AEP event CDA were applied to all events ranging from the 0.5% AEP to the 0.05% AEP. A separate CDA was undertaken for the PMF; however this was undertaken for comparison to the 0.1% AEP event (not for selection of critical durations). All durations simulated for the PMF event were combined (and are subsequently used in Council's RFD and web-based Flood Explorer). The Flood Explorer informs the public about flood behaviour and levels. Stage 2 of the RFD has shown that for most catchment models the selected critical durations were different between the 1% AEP and the PMF events. Council therefore adopted the CDA for the 0.1% AEP to further investigate the critical durations for the large events (between the 1% AEP and the PMF event).

Another change in methodology was the selection of the 5m model used for the 1% AEP CDA; whereas the 10m models were used for the 0.1% AEP and the PMF events.

Table 3-1 summarises the revised methodology undertaken for the Critical Duration Analysis.

Table 3-1 Critical Duration Selection

Assessment Event	Grid Resolution	Assessed Durations	Selected Critical Durations	Adopted Event
1% AEP	5m	3, 6, 12, 24, and 48 hour storm	3, 6 and 12 hour storm	1EY, 50%, 20%, 10%, 5%, 2% and 1% AEP
0.1% AEP	10m	3, 5, 6, 12, 24, 48 and 72 hour storm	3, 6 and 24 hour storm	0.5%, 0.2%, 0.1% and 0.05% AEP
PMF	10m	3, 5, 6, 12, 24, 48 and 72 hour storm	3, 5, 6, 12, 24, 48 and 72 hour storm	PMF

To determine the critical storm durations, the following methodology was adopted:

(1) Hydrologic and hydraulic modelling of a range of storm durations (3hr, 6hr, 12hr, 24hr and 48hr) for the 1% AEP event and (3hr, 5hr, 6hr, 12hr, 24hr, 48hr and 72hr) for the 0.1% AEP and PMF events.

(2) Mapping of the peak flood level results for the 'maximum envelope' of all the storm durations for the three dominant events.

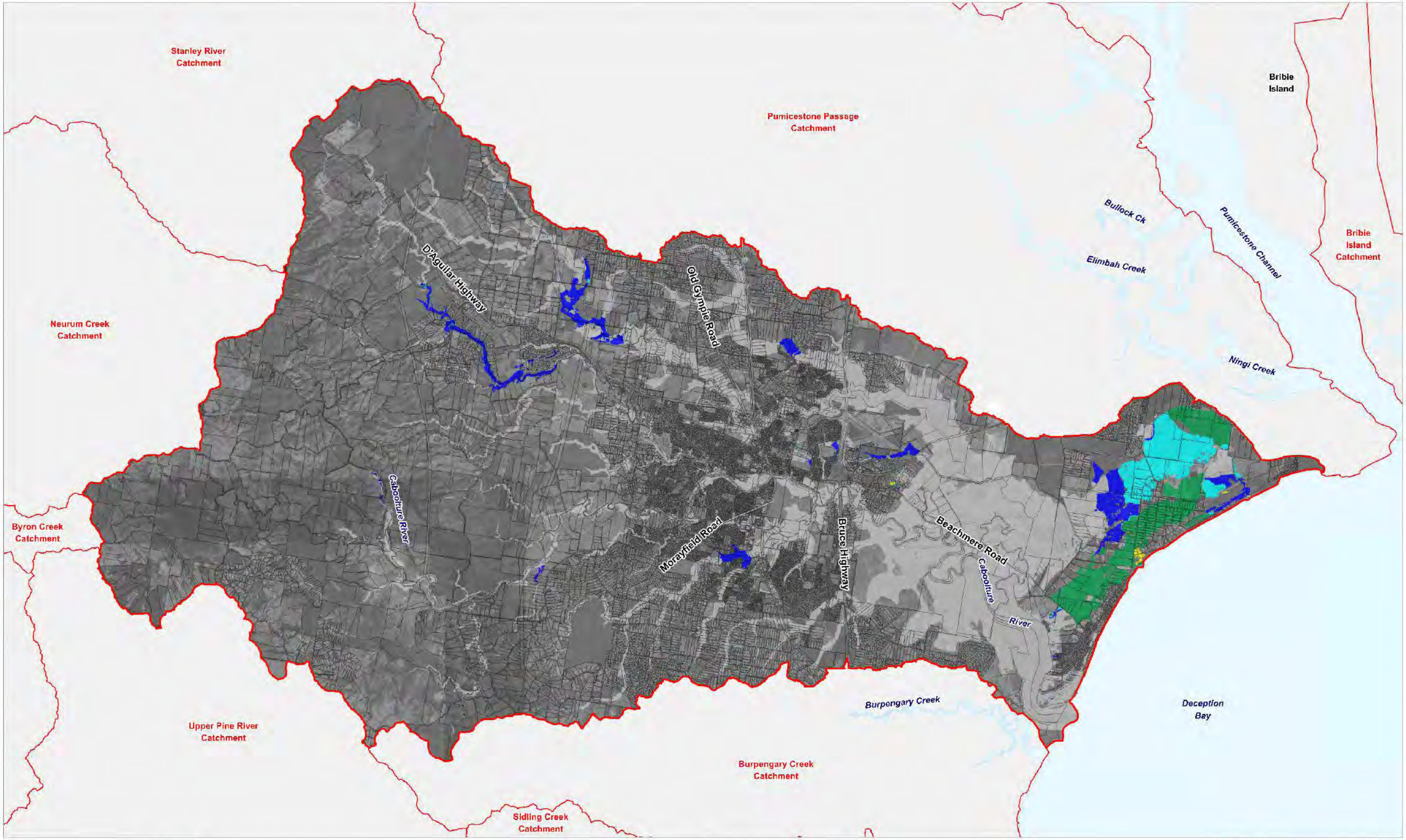
(3) Mapping of the peak flood level results for the 'maximum envelope' of selected storm durations for the three dominant events.

(4) Difference comparison between the mapped peak flood levels for selected critical durations and the results accounting for all storm durations.

(5) Selection of the critical durations was undertaken in consultation with Council and was based on the storm durations generating the highest flood levels across the most widespread areas.

The difference comparison for the 1% and 0.1% AEP peak flood levels (as described in step 4 above) is shown in Figure 3-1 to Figure 3-2. These figures illustrate that the selected critical durations (listed in Table 3-1) generally capture the peak flood levels across the site. However, there are some areas where flood levels are under predicted by up to 0.2m by the selected design storms for the 1% AEP event and flood levels are under predicted by up to 0.1m by the selected design storms for the 0.1% AEP event. The PMF event was not mapped separately because all durations simulated have been combined ('maximum envelope') to define the PMF flood levels.

Similarly to the PMF, all durations simulated for the 1% and the 0.1% AEP events were combined ('maximum envelope') to define the 1% and the 0.1% AEP flood information for inclusion in the RFD and Council's Flood Explorer. However, the remaining events (1EY, 50%, 20%, 10%, 5%, 2% 0.5%, 0.2%, 0.1% and 0.05% AEP events) were only simulated for the adopted critical durations.



LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Peak Flood Level Difference (m)

- <-1.00
- -1.00 to -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- No Change

Title:

Critical Duration Assessment
Peak Flood Level Difference - 1% AEP

Figure: 3-1

Rev: A

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0km 3 6

Approx. Scale

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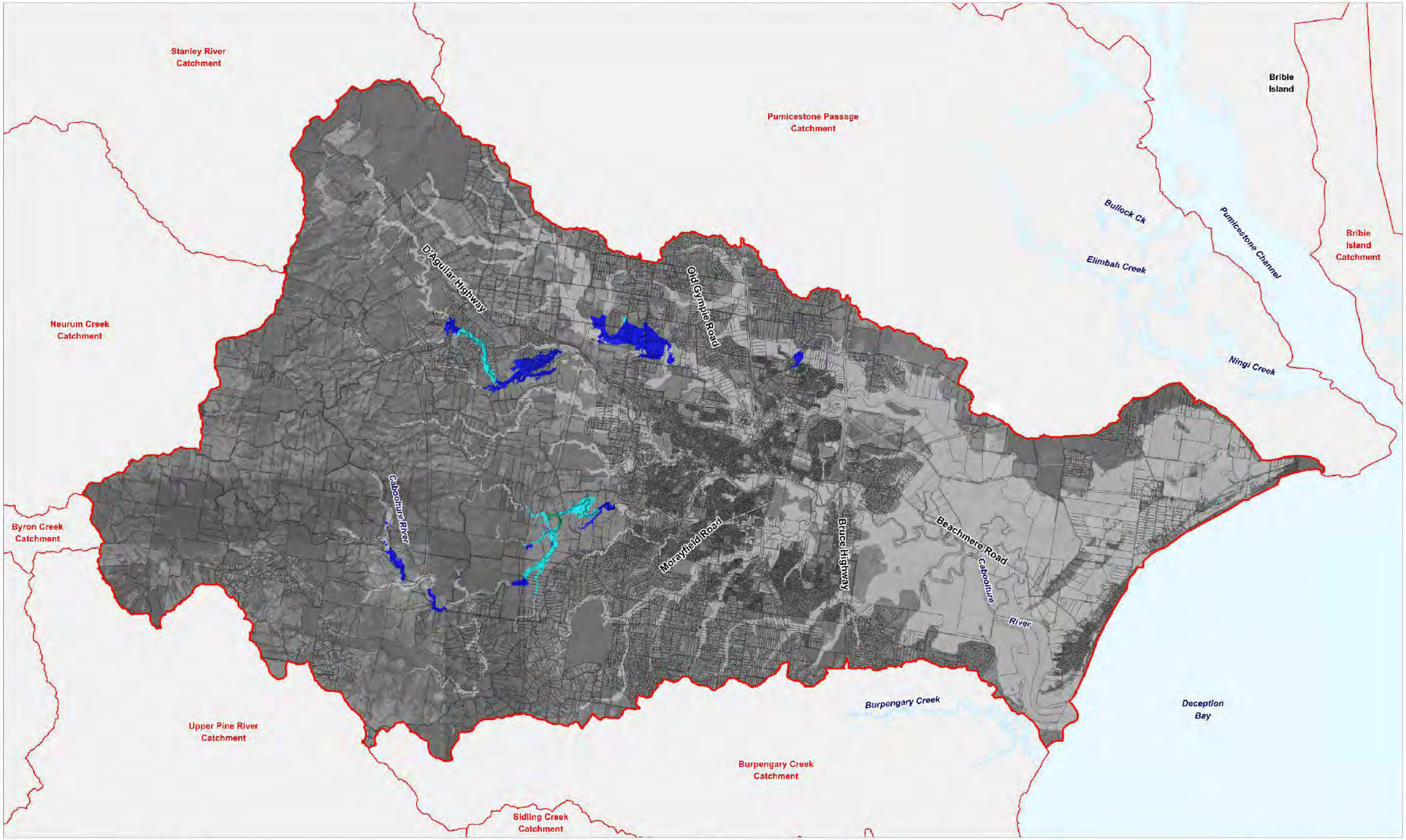

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Peak Flood Level Difference (m)

- <-1.00
- -1.00 to -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- No Change

Title:

Critical Duration Assessment
Peak Flood Level Difference - 0.1% AEP

Figure: **3-2**

Rev: **A**

N 0km 3 6 Approx. Scale

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3.2.2 Design Event Simulations

The Caboolture model was simulated for a range of AEPs and storm durations as outlined in Section 3.2.1 and a 100 Year Embedded Design Storm (EDS). Council requested the use of a single EDS which synthesises a range of storm duration hyetographs into one representative design hyetograph. The EDS is useful for general investigations into changes in model parameters and catchment characteristics, as it reduces the number of model runs required (no need to run multiple storm durations).

Council advised that the 1% AEP 15 minute in 270 minute Embedded Design Storm was to be adopted. The adopted EDS storm was used as the base design storm for the sensitivity analyses.

In summary, the Caboolture model was simulated for the following design events:

- The 1EY, 50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2%, 0.1%, 0.05% AEP events and the PMF events for the three selected critical storm durations; and
- The 1% AEP Embedded Design Storm (EDS) for a 15 minute in 270 minute envelope storm.

3.2.3 Flood Risk Hazard Categories

In 2013, Council adopted specific flood risk hazard categories for the RFD. The new hazard categories are divided into five thresholds, as shown in Table 3-2 and Figure 3-3, which define an escalating scale of hazards in which the risk to life and property become more acute. These categories are defined as follows:

Table 3-2 Council's Adopted Hazard Categories

Category Name	Suitability/Description	Hydraulic Criteria
H_1	Hydraulically suitable for parked or moving cars	v < 0.5m/s and d < 0.3m
H_2	Hydraulically suitable for parked or moving heavy vehicles and wading by able-bodied adults	v < 2m/s, d< 0.8m and v < 3.2 – 4*d
H_3	Hydraulically suitable for light construction (e.g. Timber frame and brick veneer)	v < 2m/s, d <2m and v*d <1
H_4	Hydraulically suitable for heavy construction (e.g. steel frame and reinforced concrete)	v < 2.5m/s, d < 2.5m and v*d < 2.5
H_5	Generally unsuitable	v > 2.5m/s, d > 2.5m and v*d > 2.5

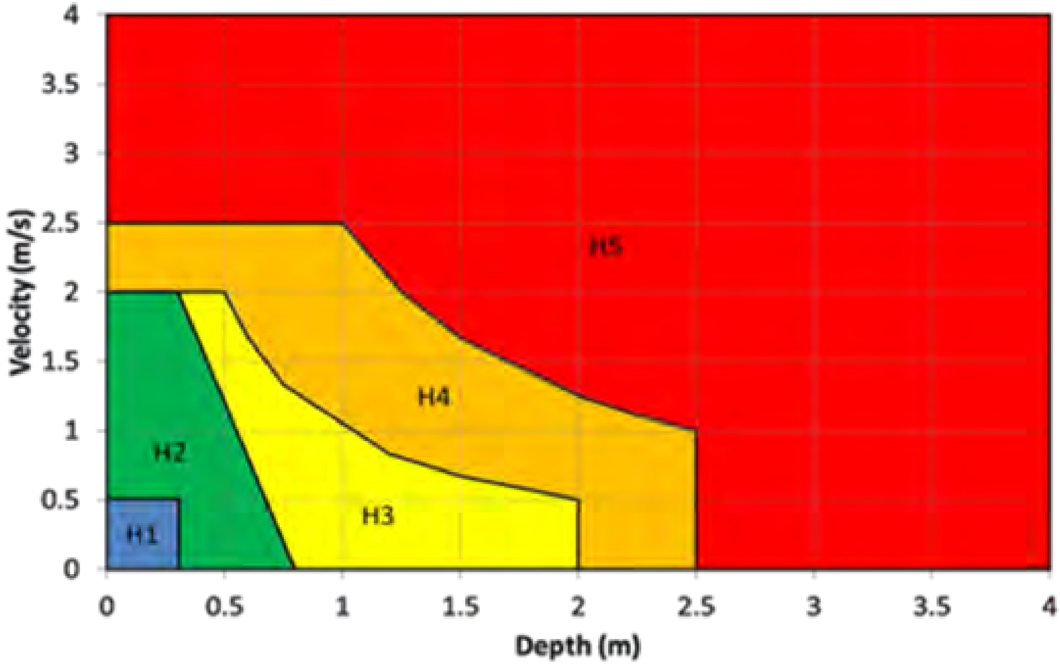


Figure 3-3 Council's Adopted Flood Risk Hazard Categories

3.3 Sensitivity Analysis

The Stage 2 CAB model was simulated for 12 scenarios in total; whereas 15 scenarios have been simulated as part of the 2013 Model Maintenance study. The sensitivity runs S13, S14 and S15 are new; a summary of sensitivity scenarios, the model identifier (ID), title and a description of the fifteen sensitivity simulations are detailed in Table 3-3.

Table 3-3 Sensitivity Analysis Summary

ID	Title	Description
S1	Embedded Design Storm (EDS)	100 Year ARI 15 burst in 270min Embedded Design Storm
S2	Increase Roughness	Increase all Manning's 'n' by 20%
S3	Blockage	Model blockage of culverts (moderate blockage), no blockage is applied to trunk drainage
S4	Climate Change 1	Increase rainfall intensity by 20%
S5	Climate Change 2	Increase downstream boundary to MHWS +0.8m (Sea Level Rise)
S6	Climate Change 3	Increase rainfall intensity and downstream boundary (S4 + S5)
S7	Storm Tide 1	No rainfall, dynamic Storm Tide (100year current) from Storm Tide Hydrograph Calculator (peak at 2.5mAHD)
S8	Storm Tide 2	EDS rainfall with static Storm Tide (100year current) (2.5mAHD)
S9	Storm Tide 3	Increase rainfall intensity by 20% (S4) + Increase downstream boundary (S5) + Static Storm Tide Level (100yr Greenhouse Gas +0.8m) (3.6mAHD)
S10	Future Landuse 1	Increase vegetation in floodplains
S11	Future Landuse 2	Increase residential development (excluding Caboolture West)
S12	Future Landuse 3	Increase vegetation and residential development (S10 +S11)
S13	Future Landuse 4	Increase residential development (including Caboolture West)
S14	Future Landuse 5	Increase vegetation and residential development (including Caboolture West) (S10 +S13)
S15	Storm Tide 4	Increase rainfall intensity by 20% (S4) + Increase downstream boundary (S5) + Static Storm Tide Level (100yr Greenhouse Gas +0.4m) (3.2mAHD)

3.3.1 Hydraulic Roughness Analysis

The sensitivity of the model to landuse roughness (Manning's 'n') parameters was undertaken with the 1% AEP EDS design event. All Manning's 'n' values in the 2D domain were increased by 20%.

3.3.2 Structure Blockage Scenario

The Stage 2 Caboolture model had a blockage factor applied to both culverts and trunk drainage, which was resulting in increased flood levels near culverts and trunk drainage. A review of the model results has shown that this approach was conservative in particular in the vicinity of trunk drainage. Therefore, Council has adopted a revised approach for the blockage scenario as part of the 2013 Model Maintenance study for the Caboolture River, which applies a blockage factor to culverts only (i.e. trunk drainage is unblocked).

A moderate blockage scenario was adopted from the SKM *Floodplain Parameterisation* report (2012b), and includes:

- A full blockage is applied if the culvert diagonal is less than 2.4m; and
- A 15% blockage is applied if the culvert diagonal is greater than 2.4m.

3.3.3 Climate Change and Downstream Boundary Conditions

A climate change and storm tide assessment investigated the possible impact of a storm tide and projected increases in sea level rise and rainfall intensity on flooding in the catchment. In total 7 scenarios were assessed:

- **Climate Change Scenario 1:** Investigated the impact of an increase in rainfall intensity of 20% (as per SKM (2012a) *Boundary Conditions, Joint Probability and Climate Change* Report).
- **Climate Change Scenario 2:** Investigated the impact of an increased downstream boundary of 0.8m due to predicted sea level rise. The 2012 model resulted in a decrease in peak flood levels near the downstream boundary, as an artefact of the SA polygon network used to define inflow locations in the model; specifically at SA polygon GOD_09_00000, refer to Appendix D (Model Quality Report (BMT WBM, 2012a). The model setup was amended for the S5 scenario in the 2013 model by reducing the SA-polygon.
- **Climate Change Scenario 3:** Investigated the impact of an increase in rainfall intensity and an increased downstream boundary. This scenario combines climate change scenarios 1 and 2.
- **Storm Tide Scenario 1:** Modelled a dynamic storm tide. No rainfall is applied and a dynamic storm tide (1% AEP current) boundary was applied (from the *Storm Tide Hydrograph Calculator* spreadsheet, developed by Cardno Lawson Treloar (2010). The MBC-016 reference point was used).
- **Storm Tide Scenario 2:** Investigated the impact of a 1% AEP static storm tide level (2.5mAHD) with concurrent 1% AEP EDS rainfall event.
- **Storm Tide Scenario 3:** Investigated the impact of an increase in rainfall and an increase in sea level rise. An increase in rainfall of 20% was applied combined with a static storm tide level (1% AEP GHG) + 0.8m, resulting in a final static storm tide level of 3.6mAHD.
- **Storm Tide Scenario 4:** Investigated the impact of an increase in rainfall intensity and a moderate increase in sea level. An increase in rainfall of 20% was applied combined with a static storm tide level (1% AEP GHG) + 0.4m, resulting in a final static storm tide level of 3.2m AHD.

3.3.4 Future Landuse Analysis

Five future landuse scenarios were assessed using future landuse data provided by Council. These future scenarios did not include a change in rainfall intensities or sea level rise due to climate change. The 1% AEP EDS flood event was used.

The hydrologic model utilises a 'fraction impervious' parameter which described the proportion of each subcatchment where water is not able to infiltrate, i.e. there are no rainfall losses on paved surfaces. If the fraction impervious increases, there will be more rainfall runoff and quicker concentration of flows. The fraction impervious in each subcatchment of the WBNM model was updated to reflect the future landuse scenario provided by Council.

Landuse is defined in the hydraulic model through the materials layer. This information covers the entire hydraulic model extent and describes landuse and the Manning's 'n' roughness values associated with each type of landuse. The materials layer was updated to reflect the future landuse scenario (change in vegetation density).

The landuse scenarios simulated included:

- **Future Landuse Scenario 1:** Investigated the impact of increased vegetation in the floodplains. This involved changing the 'medium dense vegetation' material class to a 'high dense vegetation' class and changing the 'low grass/grazing' material class to a 'medium dense vegetation' class.
- **Future Landuse Scenario 2:** Investigated the impact of an increase in residential development. The hydrology model was updated with future development (provided by Council) to estimate future inflows for the TUFLOW model.
- **Future Landuse Scenario 3:** Investigated the impact of an increase in residential area and increased vegetation in floodplains. This scenario combines future landuse scenarios 1 and 2.
- **Future Landuse Scenario 4:** Investigated the impact of an increase in residential development, including Caboolture West. The hydrology model was updated with forecast future development (provided by Council) to estimate future inflows for the TUFLOW model.
- **Future Landuse Scenario 5:** Investigated the impact of an increase in residential area (including Caboolture West) and increased vegetation in floodplains. This scenario combines future landuse scenarios 1 and 4.

4 Model Results and Outcomes

4.1 2013 Model Maintenance

4.1.1 Model Maintenance

Figure 4-1 and Figure 4-2 shows the differences between the 2012 Caboolture model and the 2013 model for the 5% and 1% AEP events, respectively. The 5% AEP is based on a comparison between the 3hr, 6hr and 12hr storm combined envelope. The 1% AEP is based on a comparison of an envelope of all the durations simulated (the 3, 6, 12, 24, and 48hr storm).

Negative values mean that the 2013 CAB model results are lower than the 2012 CAB model results and vice versa (positive values mean that the 2013 CAB model results are higher than the 2012 CAB model results).

In the 5% AEP event, flood levels within the middle to lower reaches are generally within ±0.01m. In the upstream reaches, there is an increase in flood levels, generally within 0.01 to 0.05m. However, there are localised areas with increased flood levels up to 0.5m within the upper reaches and in the quarry area near Beachmere.

The 1% AEP event shows a very similar pattern of increases and decreases in flood levels to the 5% AEP event; however the area of changed flood levels is generally vaster. An exception is the Beachmere area where the increase in flood level in the 1% AEP is up to 0.1m (in the 5% AEP up to 0.5m).

Significant decreases in the flood extent occurred in the vicinity of the Caboolture Hospital in particular in both events, due to the inclusion of additional trunk drainage and open drain channels in this area.

Increases in flood levels in the upper reaches and in the quarry area near Beachmere are predominantly due to the change in TUFLOW executable further described in Section 4.1.2.

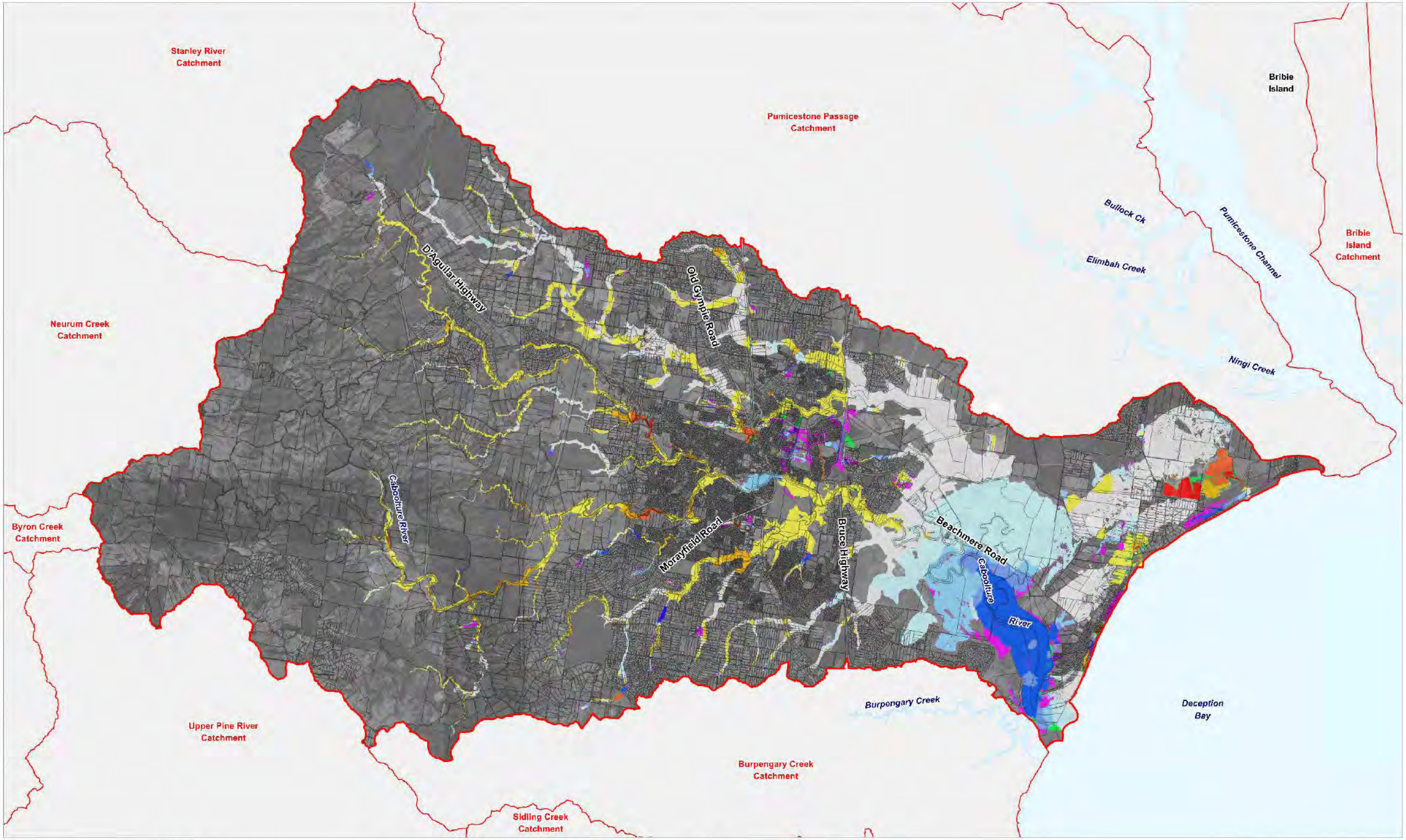
4.1.2 TUFLOW Executable Upgrade

Sensitivity tests between the 2011 and 2013 TUFLOW executable using the CAB model (and the Burpengary Creek model) have shown differences in flood levels. This is due to the change of a combination of the changed methods/parameters used for the 'wetting and drying' and the viscosity coefficients; for more information on the TUFLOW default settings refer to point 47 of the TUFLOW 2011-09 and 2012-05 Release Notes.

The model results from the 2013 TUFLOW executable indicate higher levels for parts of the Caboolture River catchment, as shown in Figure 4-3. Negative values mean that the 2013 TUFLOW executable results are lower than the 2011 TUFLOW executable results and vice versa.

For about two-thirds of the catchment flood levels are generally within ± 0.01m, however peak flood levels increases up to 0.05m occur in the majority of the upper catchment, and there are some localised areas in the upper reaches and in the quarry area near Beachmere with peak flood level increases of up to 0.5m. Decreases in flood levels are generally less widespread across the catchment.

The 2013 TUFLOW executable can be used with the 2011 default settings (by specifying the Pre-2012 Defaults command), which results in exactly the same flood levels. However, in consultation with Council, the 2013 TUFLOW executable with its default settings was adopted for this study.



LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Flood Levels (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Difference in Flood Extent

- Decrease in Inundation Extent
- Increase in Inundation Extent

Title:

2013 CAB Model Versus 2012 CAB Model Peak Flood Level Difference - 5% AEP Event

Figure: 4-1

Rev: A

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0km 3 6

Approx. Scale

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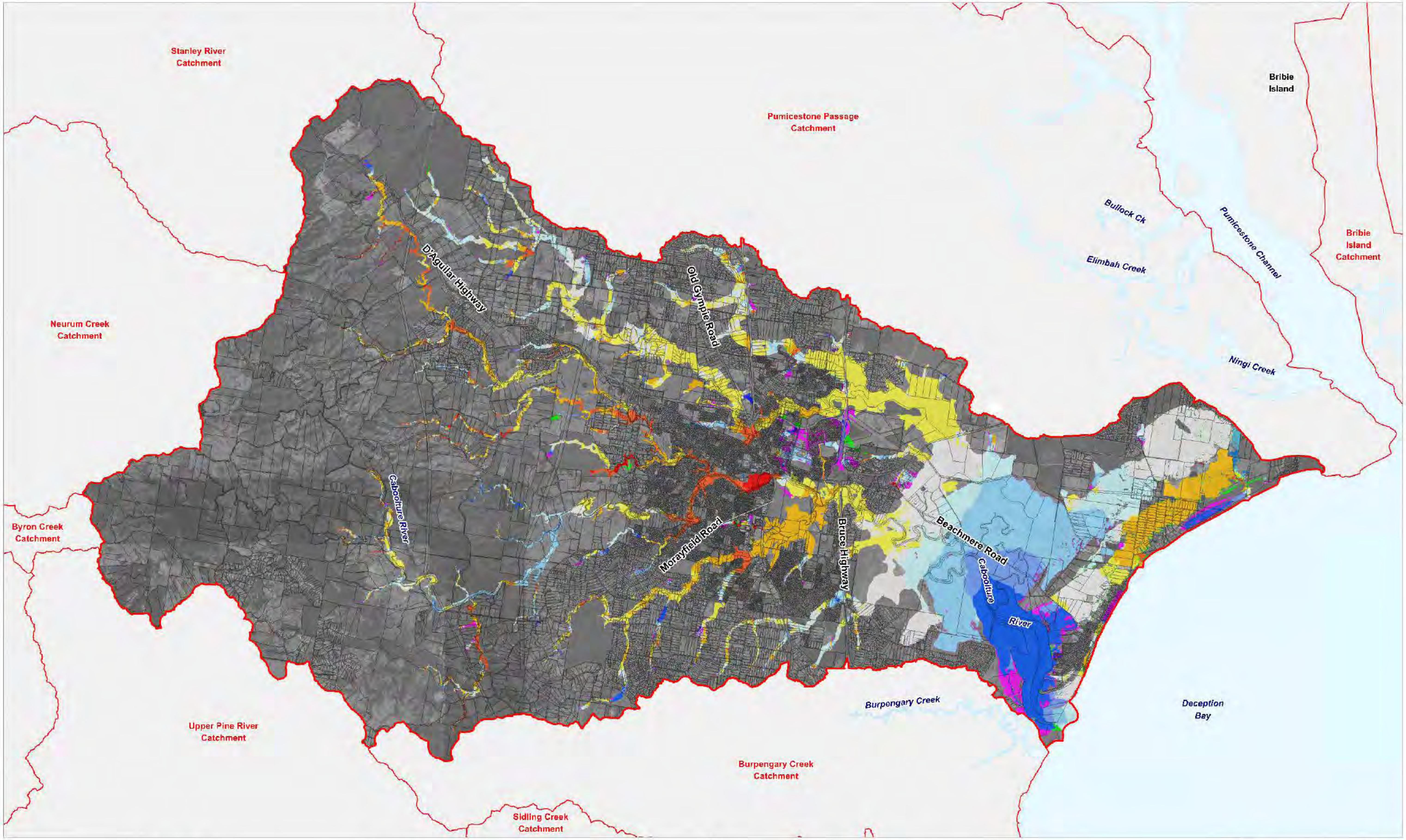

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Flood Levels (m)

< -0.50	0.01 to 0.05
-0.50 to -0.20	0.05 to 0.10
-0.20 to -0.10	0.10 to 0.20
-0.10 to -0.05	0.20 to 0.50
-0.05 to -0.01	> 0.50
-0.01 to 0.01	

Difference in Flood Extent

Decrease in Inundation Extent

Increase in Inundation Extent

Title:

2013 CAB Model Versus 2012 CAB Model Peak Flood Level Difference - 1% AEP Event

Figure: **4-2**

Rev: **A**

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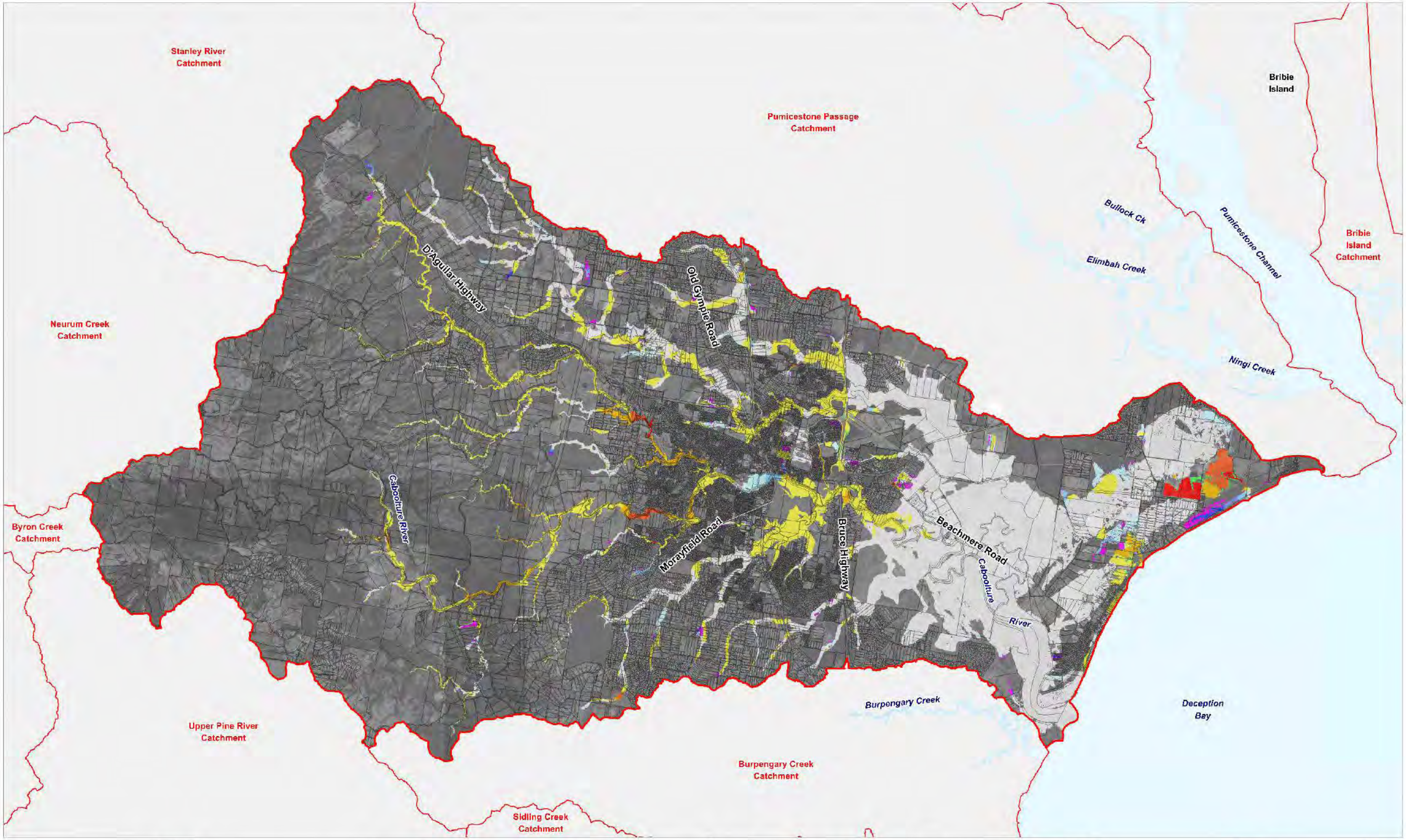

LEGEND

- Caboolture Catchment Boundary
- Cadastral Boundaries

Difference in Peak Flood Levels (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Difference in Flood Extent

- Decrease in Inundation Extent
- Increase in Inundation Extent

Title: **Flood Level Comparison Between 2013 and 2011 TUFLOW Executables 2012 Caboolture River Model 5% AEP 12 Hour Storm**

Figure: 4-3

Rev: A

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Approx. Scale

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4.2 Calibration and Verification

Calibration and verification of the modelling was undertaken for the following two events:

(1) The January 2011 flood event was used as a calibration event; and

(2) The May 2009 flood event was used a verification event.

Reasonable model calibration and verification was achieved considering the timing, peak flood levels and volume for both events. The 2013 CAB model produced similar results to the 2012 model for both events, with the exception of flood levels in the area between King Street, Torrens Road and Bellmere Road. Flood levels in this area have increased for both historic events compared with the 2012 model. This is attributed to the change in the TUFLOW executable used. These changes have not decreased the quality of the modelling results, as the hydrographs at the gauge locations and the flood mark histogram are very similar between the 2012 and 2013 models.

The detailed calibration report comparing the calibration and verification results of the 2012 and 2013 models is provided in Appendix A.

4.3 Design Flood Behaviour

The following data were output by the model at 30 minutes intervals as well as the peak values recorded during each simulation:

(1) Flood Levels (H flag);

(2) Flood Depth (D flag);

(3) Flood Velocity (V flag);

(4) Depth Velocity Product (Z0 flag);

(5) Hazard Categories adopted by Moreton Bay Regional Council (ZMBRC flag);

(6) Stream Power (SP flag); and

(7) Inundation Times (no flag required).

The maximum velocity was used in combination with a ‘Maximum Velocity Cutoff Depth’ of 0.1m. Consequently, the model result files plot the maximum velocity for depths greater than 0.1m; for depths of less than 0.1m the velocity at the peak level is recorded in TUFLOW’s output file. This approach is recommended so as to exclude any high velocities that can occur as an artefact of the modelling during the wetting and drying process.

TUFLOW can provide output relevant to the timing of inundation. In particular:

- The time that a cell first experiences a depth greater than the depth(s) specified; and
- The duration of time that a cell is inundated above the depth(s) specified.

A ‘Time Output Cutoff Depths’ of 0.1m, 0.3m and 1m, were selected. This selection provides further flood information in the catchment; e.g.:

- Establishing when areas are inundated with shallow depths of 0.1m;

- Considering pedestrian and vehicle safety (flood depth between 0.1 and 0.3m); and
- The duration and/or time of inundation for significant flood depths of 1m and more throughout the catchment.

This information can assist in emergency planning by highlighting which areas of the catchment are inundated early in the flood event and also highlighting which regions may be isolated for long durations.

The model results were used to prepare a set of design flood maps, including inundation maps, peak flow velocity maps, hazard maps and stream power maps for the 1% AEP event. The flood conditions on these maps were derived using the envelope (maximum) of all storm durations used in the critical duration analysis. Flood maps are only provided for the 1% AEP event because the focus of this project is on digital data, rather than the provision of flood maps. A description of the digital data provided to Council for incorporation into their RFD is summarised in Section 4.3.1.The flood maps of the 1% AEP event are presented in Appendix B.

4.3.1 Digital Data Provision

The Regional Floodplain Database is focused on structuring model input and output data in a GIS database. Therefore, all model input and output are being provided to Council at the completion of the study. The data includes all model files for the design events (for each storm duration) and sensitivity analyses.

In addition, post processing batch files were provided. The batch files were used to:

- Envelope (derive the maximum of) the critical duration runs and combine these into one file; and
- Convert the envelope file into ESRI readable acii grids (*.asc).

4.4 Sensitivity Analysis Results

The 1% Embedded Design Storm (1% AEP 15 minute in 270 minute) was used as a base case for the sensitivity analysis. The results of the sensitivity analysis are mapped in Appendix C. A comparison of the EDS event with the 1% AEP design flood event with selected critical durations (3, 6, and 12 hour) is shown in Figure C-1. The results indicate that the peak flood levels for the EDS is up to 500mm lower than the envelope of the selected critical durations, predominantly in the downstream area of the catchment.

4.4.1 Hydraulic Roughness Analysis

Increasing Manning's 'n' by 20% has resulted in no changes in peak flood level of more than 100mm across most of the floodplain. There are some areas of dense vegetation in the upper catchment where the peak flood levels are approximately 400mm higher.

4.4.2 Structure Blockage Analysis

As expected, the structure blockage analysis has shown that structure blockages cause an increase in peak flood levels in the vicinity of the blocked structures. In some areas there has been a decrease in flood levels downstream of a structure. The flood level increases are significant in some places, being over 500mm.

A comparison between the flood levels between the improved blockage methodology to the blockage of all of the stormwater network was undertaken. This showed that the results are generally comparable throughout most of the catchment. The improved blockage methodology did result in a reduction of flood levels of up to 1m at the Heritage Plaza and Morayfield shopping centres on Morayfield Road. The model result from the improved blockage methodology also indicates an increase in flood extent in the Caboolture Hospital area (which was not present in the 2013 model).

4.4.3 Climate Change and Downstream Boundary Conditional Analysis

Climate change has a significant impact on flood levels throughout the catchment for all the different scenarios modelled.

An increase in rainfall throughout the catchment has a significant impact on flood levels within the upper catchment, with increases often greater than 500mm. Within the downstream catchment, the impact of the increase in rainfall is within the range of 100mm to 500mm.

Increasing the downstream boundary to simulate the effects of sea level rise causes increases of generally up to 500mm in the downstream part of the catchment. At the entrance of the Caboolture River the increase in levels is more significant, with impacts greater than 500mm up to around Patrick Street in Beachmere.

The model setup was amended for the S5 scenario in the 2013 model by reducing the SA-polygon; refer to Section 3.3.3. Figure C-5 shows the impact maps without the decrease in flood levels near the downstream boundary.

The impacts outlines in the two scenarios above are exacerbated for the combined climate change scenario. The extent of significant impact at the Caboolture River Mouth has increased, with impacts of above 500mm reaching upstream of the junction with King Johns Creek.

The catchment is also sensitive to high tidal surges, with tidal surge peak flood levels being higher than the EDS event by 500mm through most of the downstream catchment. In the middle of the catchment, this impact has decreased to an impact between 100mm and 500mm. This impact is in a largely undeveloped area in the catchment. These impacts are further exacerbated when combined with an increase in rainfall intensity and sea level rise (S9), with increases of greater than 500mm throughout the downstream catchment.

The additional storm surge scenario (S15) produces similar results to S9 outlined above. However, there is a lesser impact in the Beachmere area and to the east of the Bruce Highway, with an increase of between 0.1 and 0.5m (rather than greater than 500mm).

Therefore, it can be concluded that the catchment is sensitive to climate change and high tidal surges.

4.4.4 Future Landuse Analysis

The Caboolture catchment is generally insensitive to changes in vegetation throughout the lower catchment. In the upper catchment, there is an increased sensitivity, with peak flood levels typically increasing in the order of 500mm. There is also a localised decrease in flood levels of up to 200mm around Moodlu. In the lower catchment, there is an area of decreased peak flood levels of up to

200mm along the river to the north of Beachmere, which is shown on the figures representing S10, S12 and S14.

The catchment is highly insensitive to increases in residential development, both including and excluding development in Caboolture West. These scenarios cause no significant impact on peak flood levels across the floodplain.

Therefore, changes in flood levels throughout the catchment are more sensitive to changes in vegetation than increases in residential development.

4.5 Model Limitations and Quality

Watercourses within the Caboolture catchment were represented in the 2D domain, for which the grid resolution is limited to either 5m or 10m. This may not allow adequate representation of the channel conveyance, particularly for smaller, more frequent flood events. In some instances this limitation may lead to the model over or underestimating conveyance in the watercourses. The extent of this over or underestimation will vary according to local topographic factors.

4.6 Model Specification and Run Times

The Caboolture River TUFLOW model has large model run times and a high demand on memory (RAM). Details for various design event, the historic events and the sensitivity event (S1) using the 1% AEP Embedded Design Storm are shown in Table 4-1. The 12 hour storm duration was chosen as it is the longest storm duration modelled.

Table 4-1 Model Specification and Run Time Summary

Event	Model Grid Size	Model Run Time	Model RAM/memory
1 EY 12hr	5m	5 days	9.2 GB
10% AEP 12hr	5m	5 days	9.2 GB
1% AEP 12hr	5m	6 days	9.2 GB
0.2% AEP 12hr	10m	2 days	2.3 GB
0.05% AEP 12hr	10m	4 days	2.3 GB
1% EDS Sensitivity Run S1	10m	18 hours	2.3 GB
January 2011	10m	3 days	2.3 GB
May 2009	10m	3 days	2.3 GB

5 Conclusion

The following two TUFLOW models of the Caboolture River catchment were updated with new development, additional structures, additional bathymetric survey and a sand dune breach:

- A 5m grid resolution model for events up to the 1% AEP event; and
- A 10m grid resolution for events larger than the 1% AEP event (including the sensitivity runs).

A different approach was chosen for the critical duration analysis, as detailed in Section 3.2.1 and for the setup of sensitivity scenarios S3 (Blockage) and S5 (Increased Downstream Boundary).

Additional modelling of three extra sensitivity runs was also undertaken as part of the model maintenance process, including two additional future land use scenario and an additional storm surge scenario.

The model was set up in a manner prescribed by Council specifically for the RFD project to ensure a consistent approach across the whole LGA and to enable the model and model outputs to be integrated into Council's Regional Floodplain Database. Flood maps of the 1% AEP events have been provided within the report, together with the delivery of the model and its outputs for all events in digital format. The outcomes of this work will be included into Council's Flood Explorer and used by Council to analyse and assist with managing flood risk in the Caboolture catchment.

6 References

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Appendix A 2013 Model Maintenance Calibration Report

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A part of BMT in Energy and Environment

2013 Model Maintenance Calibration Report Caboolture River Model

Reference: R.B20303.002.02.Calibration Report.docx
Date: December 2013
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2013 Model Maintenance Calibration Report Caboolture River Model

Prepared for:	Moreton Bay Regional Council
Prepared by:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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BMT WBM Pty Ltd Level 8, 200 Creek Street Brisbane 4000 Queensland Australia PO Box 203 Spring Hill 4004 Tel: +61 7 3831 6744 Fax: + 61 7 3832 3627 ABN 54 010 830 421 www.bmtwbm.com.au	**Document:**	R.B20303.002.02.Calibration Report.docx
	Title:	**2013 Model Maintenance Calibration Report Caboolture River Model**
	Project Manager:	Anne Kolega
	Author:	Anne Kolega
	Client:	Moreton Bay Regional Council
	Client Contact:	Hester van Zijl
	Client Reference:	Regional Floodplain Database
Synopsis:	**This calibration report is part of the 2013 Model Maintenance Report for the Caboolture River. It presents the data and the model results from the 2013 Caboolture River Model for the January 2011 calibration event and the May 2009 verification event.**	

REVISION/CHECKING HISTORY

Revision Number	Date	Checked by		Issued by	
0	17/09/2013	AK	A. Kolega	MH	MElhovey
1	06/11/2013	AK		MH	
2	28/11/2013	AK		MH	

DISTRIBUTION

Destination	Revision										
	0	1	2	3	4	5	6	7	8	9	10
Moreton Bay Regional Council	PDF	PDF	PDF								
BMT WBM File	PDF	PDF	PDF								
BMT WBM Library	PDF	PDF	PDF								

Contents

List of Figures

List of Tables

1 Introduction

BMT WBM has developed the Caboolture River (CAB) model as part of Stage 2, Regional Floodplain Database (RFD) in June 2012, including model calibration to the following two historic events:

- January 2011 (calibration event); and
- May 2009 (verification event).

The 10m model was subsequently upgraded in November and December 2012 by including additional structures and new development areas provided by Council. This upgraded model was only simulated for one event (100 year 12 hour storm duration event).

Since the completion of this model, Council has collected additional structure details to further enhance the model performance, and collected additional data, which were incorporated into the CAB model as part of the 2013 model maintenance project.

This report outlines the calibration data used, the model results from the 2013 model and compares those 2013 model results to the 2012 model results for the two historic events.

Traditional model calibration (with changes to the model parameters) was not undertaken as part of the 2013 maintenance project. Council adopted a specific set of model parameters as part of Stage 2 of the RFD, which were then verified as part of Stage 3 of the RFD. Council envisages to undertaken additional model calibration using additional gauge data recently installed, with a flood event in the future.

2 Data

The rainfall, river gauge, flood mark data and the hydrologic model have not changed as part of the 2013 model maintenance. For details on the rainfall, river gauge, flood mark data and the hydrologic model, refer to the Model Calibration Report Caboolture River Catchment Regional Floodplain Database Stage 2 (BMT WBM, June 2012). The remainder of this section provides a summary of the calibration data.

2.1 Rainfall

There are 12 rainfall gauges located in and around the Caboolture River Catchment. All of these were utilised for the hydrologic modelling for the January 2011 event. The gauge at Beachmere did not record rainfall for the May 2009 event, and was thus not used for the modelling of this event. The rainfall information the January 2011 and May 2009 events were provided by Council.

2.2 River Gauges

There are three river gauges within the catchment: Campbell's Pocket Road, Wamuran; Hausmann Lane, Upper Caboolture and King Street near the Caboolture Water Treatment Plant (WTP). All three gauges were used for a hydrograph comparison for the January 2011 event. The gauge at the Caboolture WTP was not in operation during the May 2009 event; a hydrograph comparison is therefore not provided.

The river gauge information for these two events was provided by Council.

2.3 Flood Marks

Council collected 89 floodmarks for the January 2011 event in the CAB catchment; 6 of these were of high quality and the others were categorised as medium quality.

For the May 2009 event, only 8 floodmarks were available and all floodmarks were categorised as medium quality.

2.4 WBNM Model

The WBNM models were developed using 5 minute interval rainfall from the available rainfall gauges and the hydrography (subcatchment delineation) adopted by Council as part of the 2012 model development. The adopted WBNM models used an initial and continuing loss of 0mm.

3 TUFLOW Model

The TUFLOW model was amended with additional culverts and new development; refer to the 2013 Model Maintenance Report for the full details. The CAB 2013 models were simulated with the 2013 TUFLOW executable, whereas the 2012 calibration models were simulated with the 2010 TUFLOW executable.

The initial calibration of the 2012 Caboolture River (CAB) model to the January 2011 event was undertaken with the Stage 1 Manning's 'n' roughness values; this simulation is run 018 using the following TUFLOW control file: CAB_002a_Jan11_018_10m.tcf.

As part Stage 2 of the RFD, Council undertook a review of the model calibration for the 5 catchments in the LGA that included model calibration, namely:

1. Burpengary Creek;
2. Caboolture River;
3. Upper Pine River; and
4. Stanley River.

Based on this review, Council adopted a different set of Manning's 'n' roughness values; Table 3-1 presents the Stage 1 and Stage 2 Manning's 'n' roughness values.

Table 3-1 Hydraulic Model Landuse Categorisation

Landuse Type	Stage 2 (Updated Model) Manning's 'n' Roughness Coefficient	Stage 1 (Original Model) Manning's 'n' Roughness Coefficient
Roads/Footpaths	0.015	0.015
Waterbodies	0.030	0.030
Low Grass/Grazing*	Ranging from 0.025 at 2 m depth to 0.25 at 0m depth	0.035
Crops	0.040	0.040
Medium Dense Vegetation*	Ranging from 0.075 to 0.15 up to a depth of 1.5m and 0.15 above 1.5m	0.075
Reeds	0.08	0.08
Dense Vegetation*	Ranging from 0.09 to 0.18 up to a depth of 1.5m and 0.18 above 1.5m	0.09
Urban Block (> $2000m^2$)	0.300	0.300
Buildings	1.000	1.000
*Depth varying Manning's roughness was applied.		

Therefore, an additional 2012 CAB calibration model was developed (as part of Stage 2 of the RFD), using Stage 2 roughness values; this is run 020 using the following TUFLOW control file: CAB_002a_Jan11_020_10m.tcf.

It was noted that the Caboolture River calibration using the adopted Stage 2 parameters, was not as successful as the calibration of other catchments.

The 2013 model is based on run 020 and uses the Stage 2 Manning's 'n' roughness values.

4 Model Results

4.1 Comparison of Flood Levels Catchment Wide

Figure 4-1 and Figure 4-2 show the difference in flood levels between the 2013 model and the 2012 model for the January 2011 and May 2009 events, respectively.

From these figures, it can be seen that throughout most of the catchment, in particular upstream of the Bruce Highway, there is an increase in flood levels from the previous model. The largest increases in flood levels occur between King Street, Torrens Road and Bellmere Road. For both events, there is a decrease in levels at the downstream end of the catchment. These differences are predominantly due to different TUFLOW executables used to simulate the 2012 and the 2013 models. The main difference in the two executables are the changed methods/parameters used for the 'wetting and drying' and the viscosity coefficients; for more information refer to point 47 of the TUFLOW 2011-09 and 2012-05 Release Notes. Similar results are shown for the 5% AEP event, provided in Section 2.2 of the main report.

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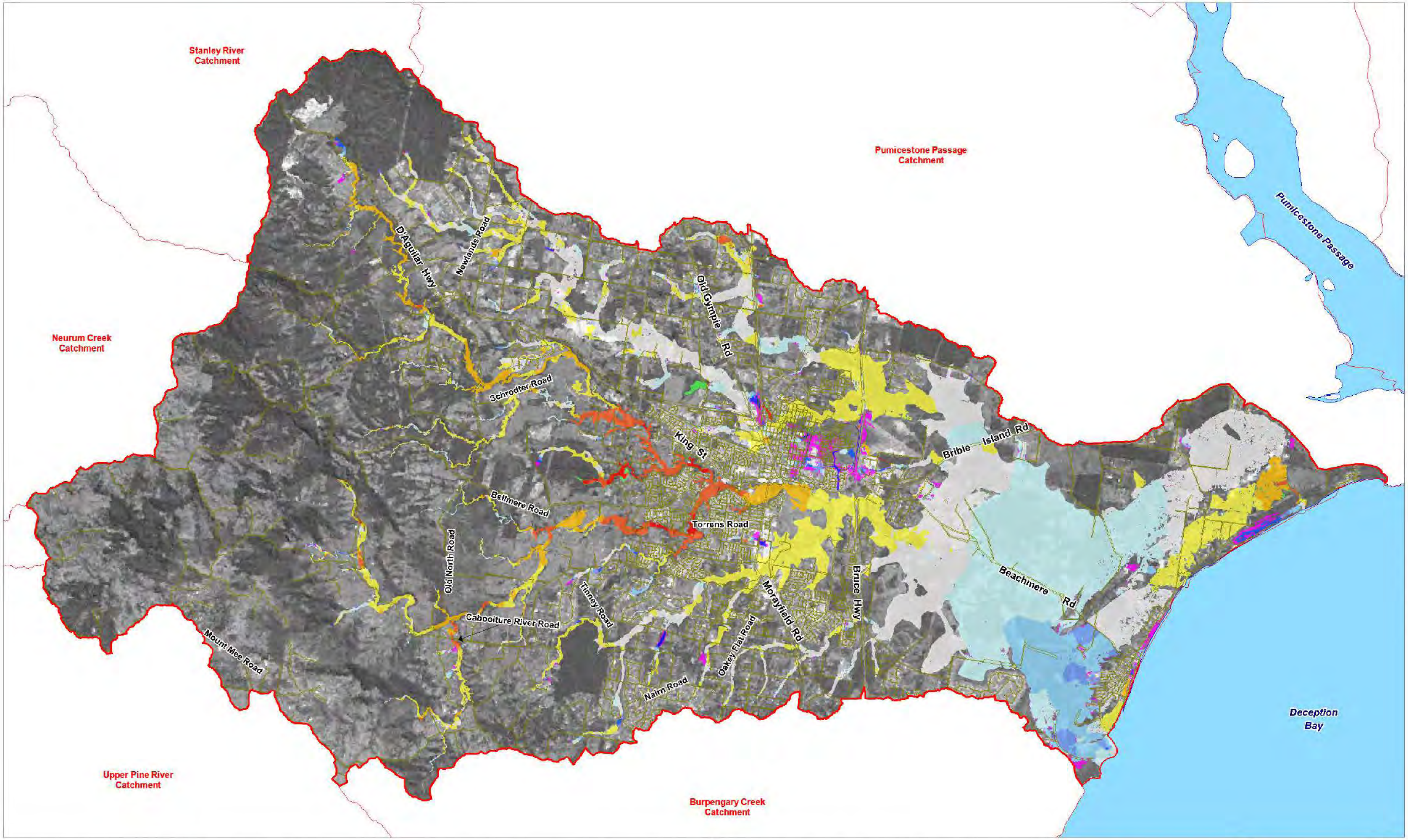

LEGEND

- Caboolture River Catchment
- Roads

Difference in Peak Flood Levels (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Difference in Flood Extent

- Decrease in Inundation Extent
- Increase in Inundation Extent

Title:

January 2011 Event Peak Flood Level Difference 2013 Model Minus 2012 Model

Figure: 4-1

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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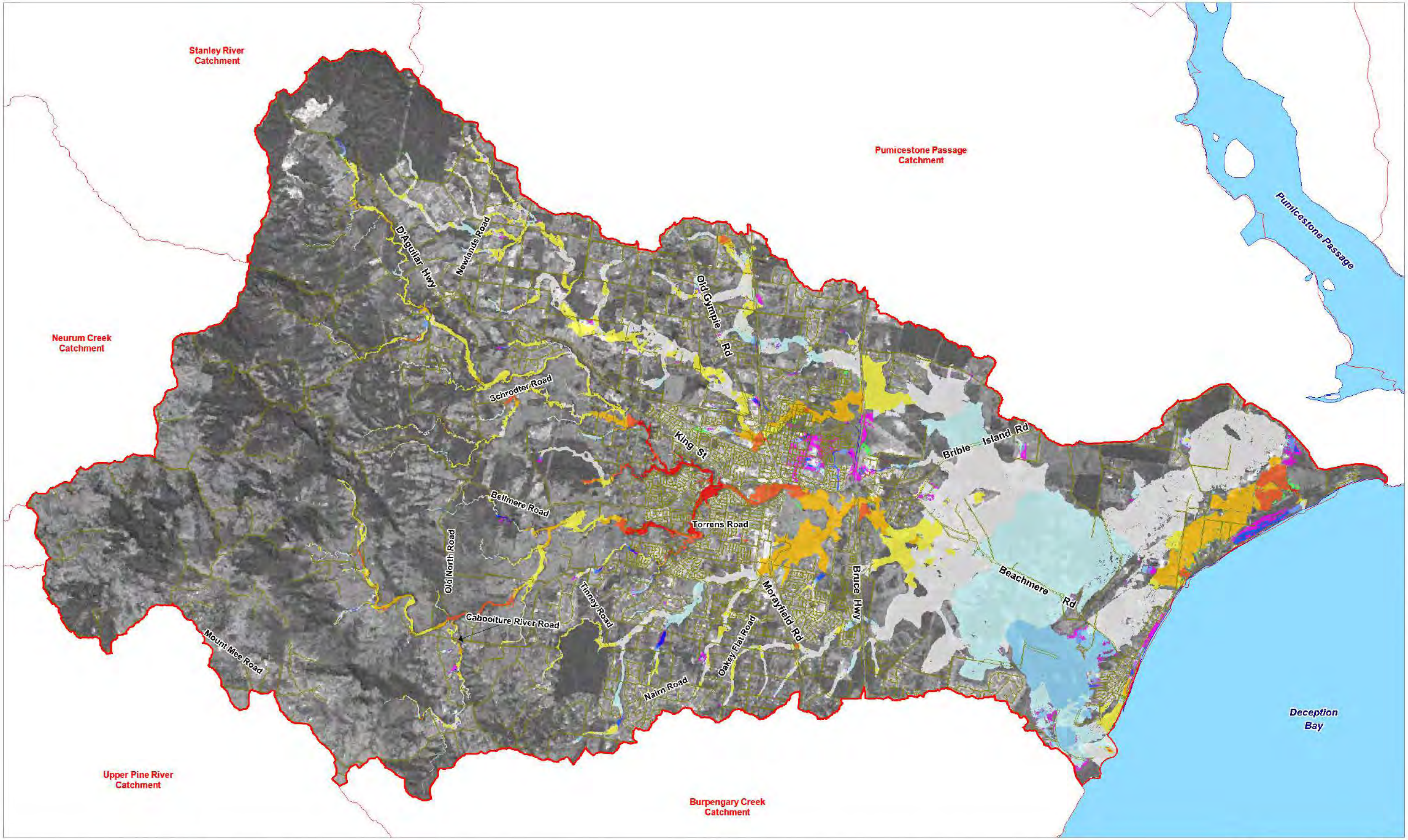

LEGEND

Caboolture River Catchment
Roads

Difference in Peak Flood Levels (m)

< -0.50
-0.50 to -0.20
-0.20 to -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.50
> 0.50

Difference in Flood Extent

Decrease in Inundation Extent
Increase in Inundation Extent

Title:

May 2009 Event Peak Flood Level Difference
2013 Model Minus 2012 Model

Figure: **4-2**

Rev: **A**

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Approx. Scale

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4.2 Hydrograph Comparison

As discussed in Section 3, two CAB calibration models were established in 2012; one using the Stage 1 roughness values, the other using the Stage 2 roughness values.

To demonstrate the difference in flood levels from the roughness values and the differences between the 2012 and 2013 CAB models, this section presents the hydrographs at the river gauge locations from the following Caboolture River models for the January 2011 and May 2009 events:

- 2012 model run 018;
- 2012 model run 020; and
- 2013 model.

4.2.1 January 2011

Three river gauges recorded flood levels during the January 2011 event in the Caboolture River catchment. Hydrographs showing the recorded and modelled flood levels during the January 2011 event (covering the 4 days of the event; 9 – 12 January 2011) are presented in Figure 4-3 to Figure 4-5.

The following key points can be drawn from a comparison of the hydrographs:

- The timing (i.e. the shape of the hydrographs) at all three gauges compares very well between the recorded and the modelled flood levels across the entire four days of the event;
- The model over predicted the peak flood level at the Wamuran Gauge by 1.29m; (1.26m in the 2012 model run 020);
- The model under predicted the peak flood level at the Upper Caboolture Gauge by 1.25m (1.37m in the 2012 model run 020);
- The model under predicted the peak flood level at the Caboolture WTP Gauge by 0.5m (0.66m in the 2012 model run 020); and
- The improvement in peak flood levels at the Caboolture WTP Gauge can be attributed to the additional bathymetry data included in the 2013 model, extending from Morayfield Road to the River mouth.

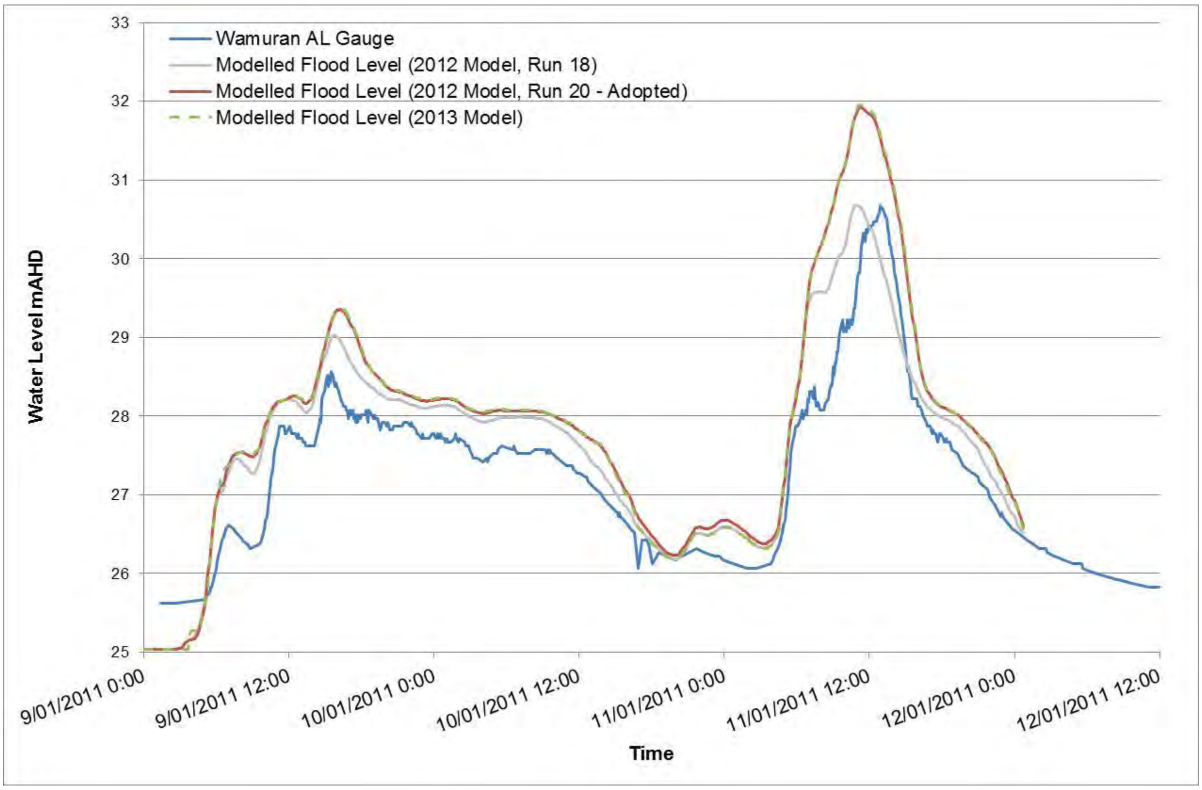


Figure 4-3 Recorded and Modelled Hydrographs at Wamuran Gauge – January 2011 Event

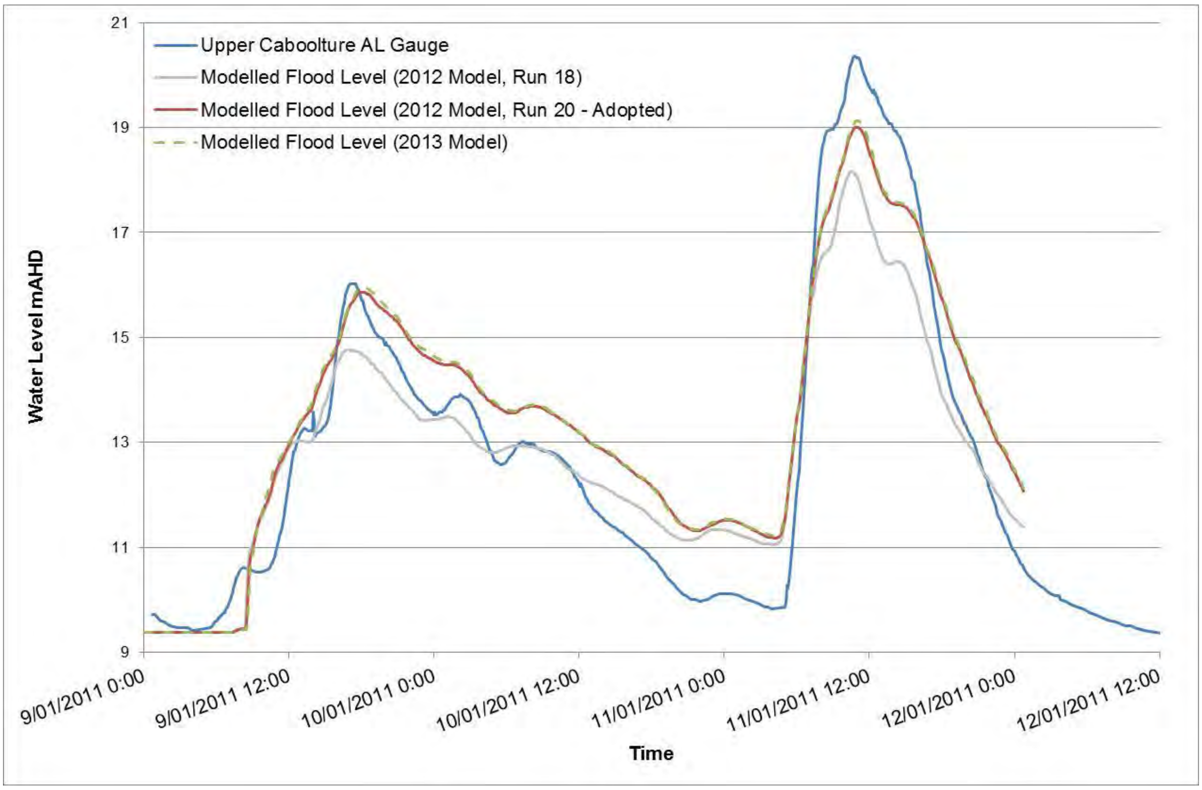


Figure 4-4 Recorded and Modelled Hydrographs at Upper Caboolture Alert Gauge – January 2011 Event

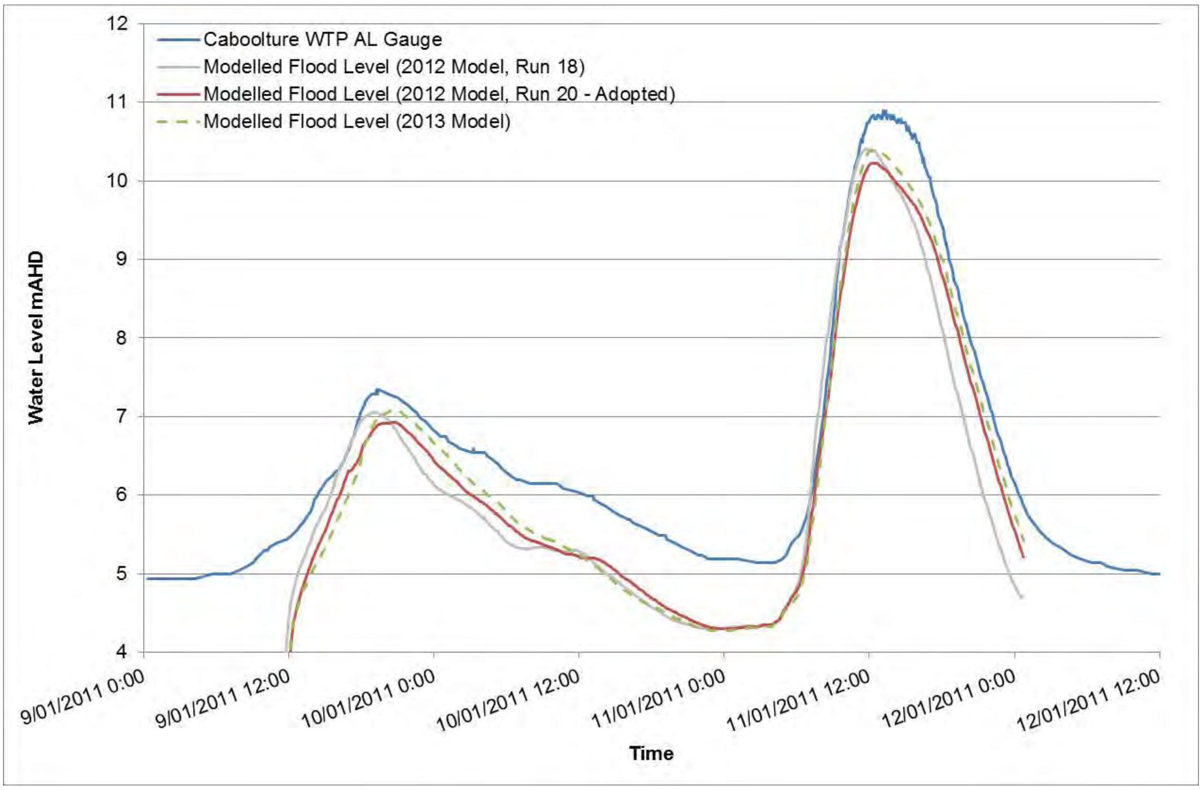


Figure 4-5 Recorded and Modelled Hydrographs at Caboolture Water Treatment Plant Gauge – January 2011 Event

4.2.2 May 2009

The hydrographs for the two gauges which have data from the May 2009 event are presented in Figure 4-6 and Figure 4-7.

At the Wamuran Alert Gauge the timing is comparable to the May 2009 event; however, the model is over predicting flood levels at the main peak by approximately 1.04m (1.03m in the 2012 model run 020).

The hydrograph at the Upper Caboolture gauge shows discrepancies in timing and peak flood levels between the modelled and recorded data. Both models show a poor correlation between the rising limb of the flood, which could have been improved with an increase in initial loss and resulted in a better fit. An adjustment of the initial and continuing losses for this event may have improved the model results.

There is negligible difference between the 2012 Model adopted run (020) and the 2013 Model at these gauge locations.

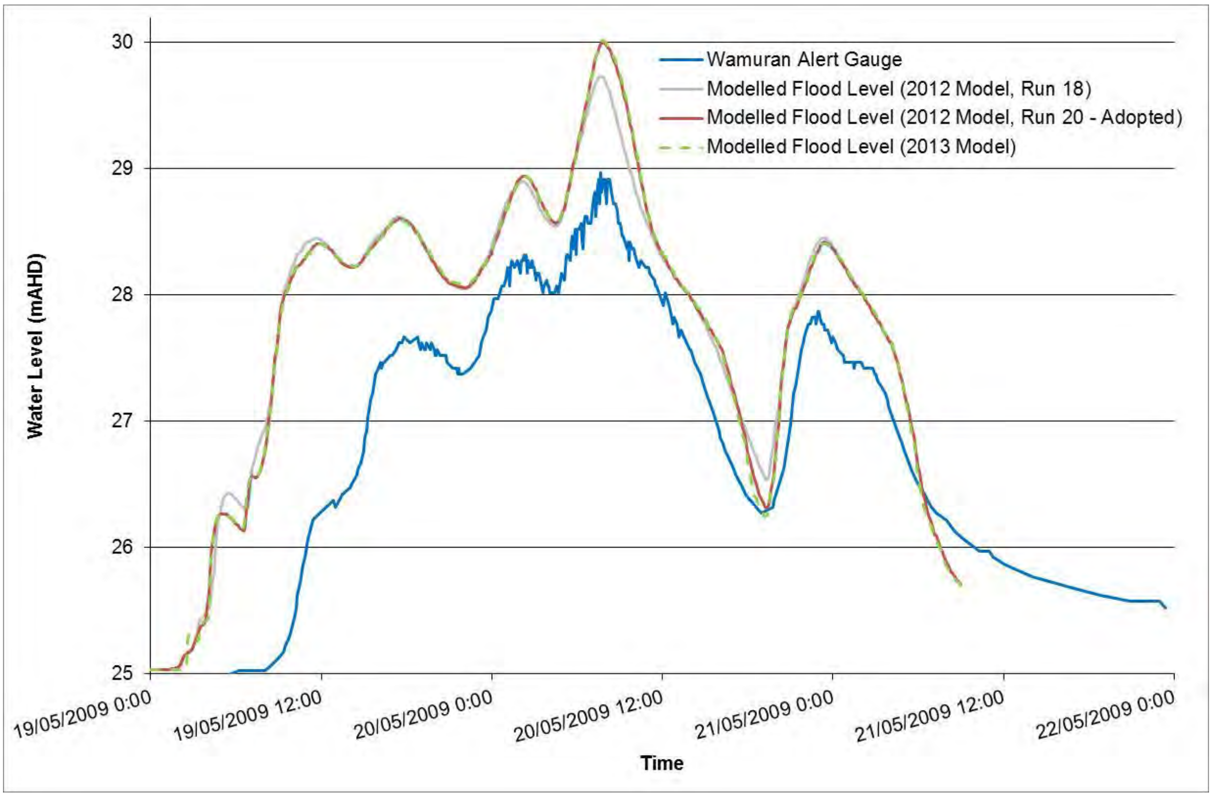


Figure 4-6 Recorded and Modelled Hydrographs at Wamuran Gauge – May 2009 Event

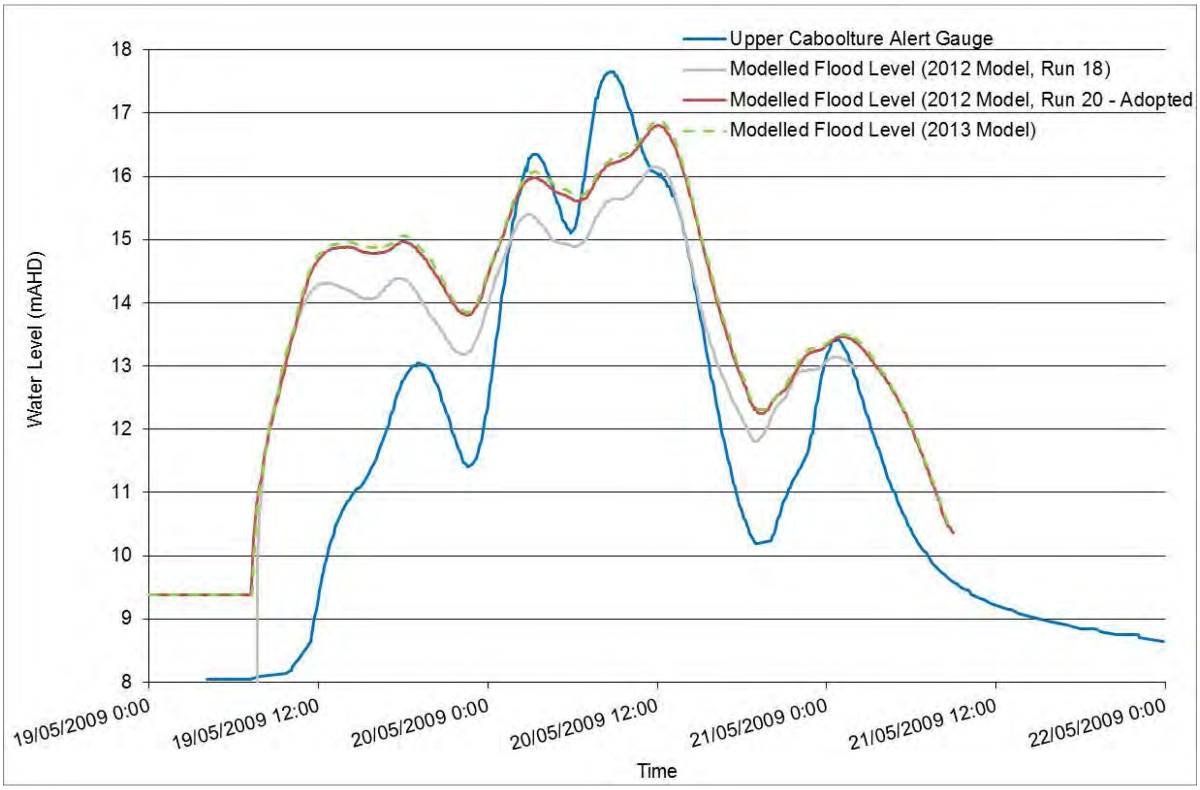


Figure 4-7 Recorded and Modelled Hydrographs at Upper Caboolture Alert Gauge – May 2009 Event

4.3 Flood Mark Comparison

4.3.1 January 2011

As discussed in Section 3, two CAB calibration models were established in 2012; one using the Stage 1 roughness values, the other using the Stage 2 roughness values.

To demonstrate the difference in flood levels from the roughness values and the differences between the 2012 and 2013 CAB models, this section presents the histogram from the following Caboolture River models for the January 2011 event:

- 2012 model run 018;
- 2012 model run 020; and
- 2013 model run 020.

For the 2012 Model, Run 018, there were four flood marks outside the modelled flood extent. The 2012 Model, Run 020 and the 2013 Model both resulted in only two flood marks outside of the modelled flood extent.

The surveyed flood levels at the flood marks were compared to the modelled peak flood levels derived from the calibration model. The difference in flood levels versus the number of flood marks are presented in a histogram in Figure 4-8.

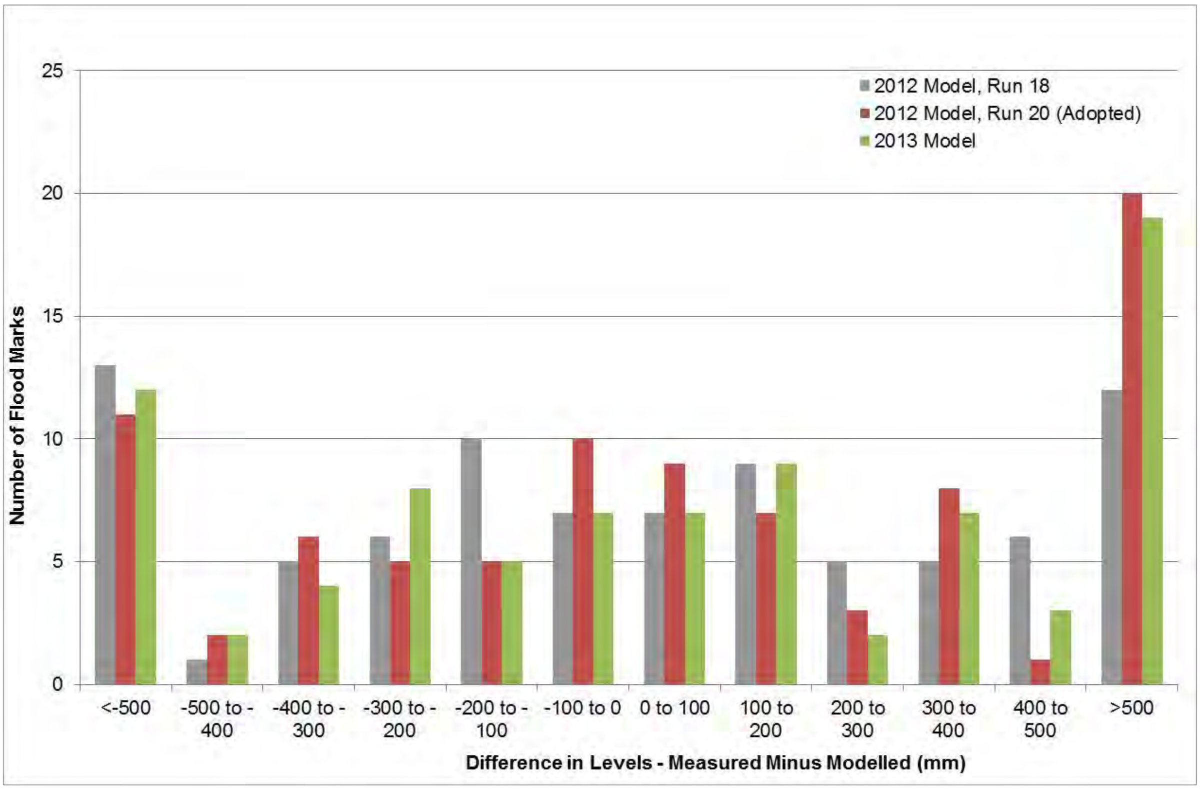


Figure 4-8 Floodmark Histogram – January 2011 Event

The histogram shows a significant portion (42%) of the flood marks are within +/- 300mm, which suggests a reasonable calibration. It was noted that the flood model predicted, in general, significantly lower levels along Caboolture River (south-eastern part of the catchment).

Some flood marks differ significantly between the surveyed and the modelled level (between +/- 2m); however it was also noted that some of the surveyed flood marks located very close together show very different levels, which suggests that some of the flood mark levels may be inaccurate. Also, a discrepancy was found when comparing some of the surveyed flood mark levels with the ground levels used in the model (derived from the LiDAR). For the 89 flood marks in total, 15 flood marks have surveyed flood levels lower than the ground level in the model. Council and BMT WBM have investigated this discrepancy and surmised that the anomalies are likely due to:

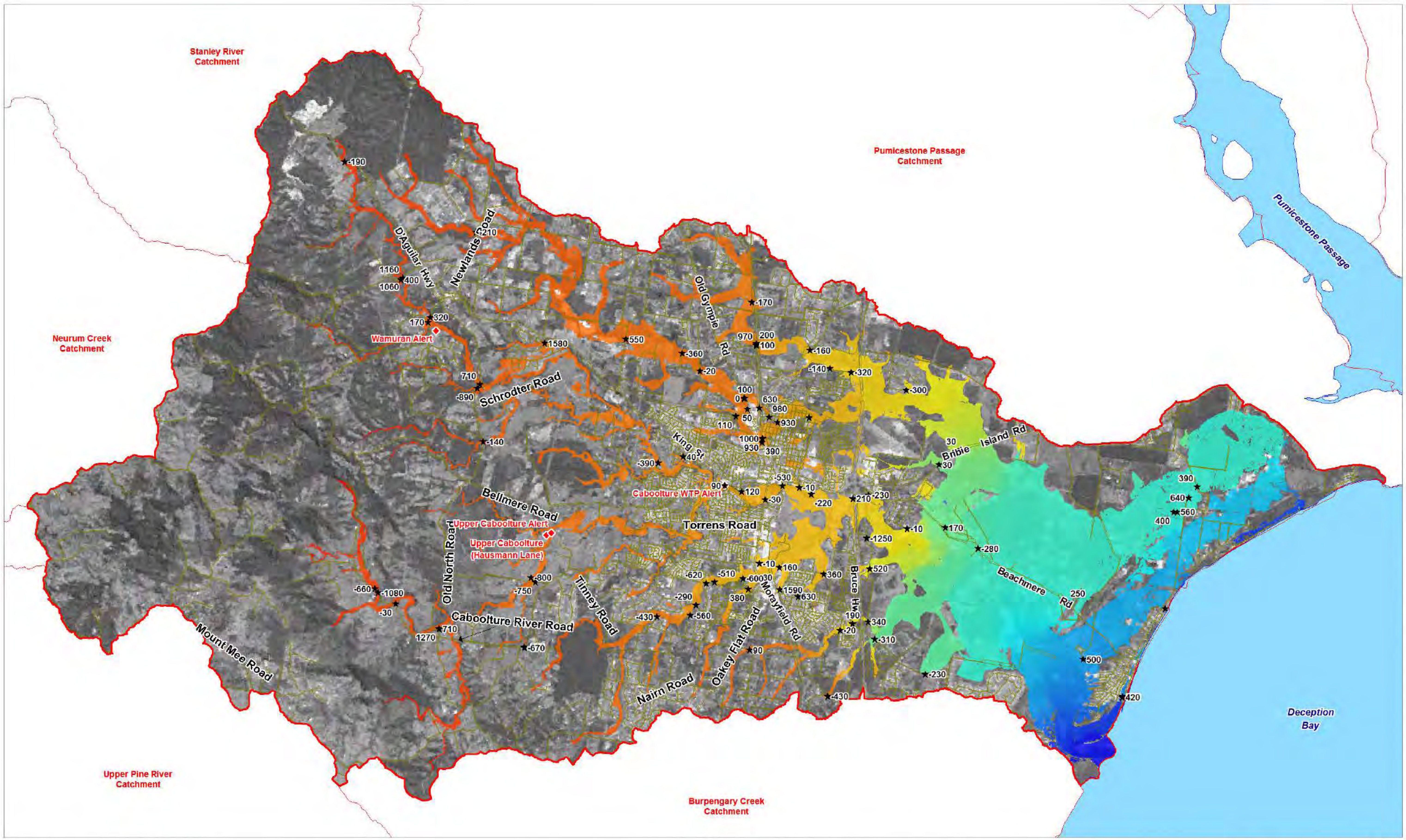
- The difference in the source of the levels (usage of the LiDAR versus ground survey undertaken to collect flood marks); and
- Council used a number of different survey teams to collect the flood mark data.

The flood mark results have also been grouped into key difference ranges for the 3 calibration models, as shown in Table 4-1. The table highlights that the results are quite comparable.

Table 4-1 Comparison of Percentage of Floodmarks within Key Difference Ranges

Difference in Levels	2012 Model, Run 018	2012 Model, Run 020	2013 Model
Within ± 300mm	45%	41%	**42%**
Greater than 300mm	33%	37%	**36%**
Less than 300mm	22%	22%	**21%**

The flood mark locations and the differences in surveyed and modelled peak flood levels in mm are illustrated in Figure 4-9.



LEGEND

Caboolture River Catchment

Roads

Flood Marks indicating the difference in flood levels in mm (modelled minus surveyed)

River Gauges

Title:

January 2011 Event Peak Flood Extent and Flood Marks - Caboolture River Catchment

Figure: 4-9

Rev: A

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N

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Approx. Scale

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Filepath : I:\B20303_I_ak_CAB_Update\DRG\FLD_021_20130718_CAB_Calibration_Jan2011.wor

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4.3.2 May 2009

Table 4-2 present the surveyed and modelled peak flood levels, as well as the difference in water levels in millimetres (mm) at the flood marks. Figure 4-11 shows the flood mark locations and the difference in peak flood levels. Of the 8 surveyed floodmarks, 7 are within ±300m of the modelled peak flood level.

Figure 4-10 presents the histogram for the 3 calibration models, and shows a very similar distribution in particular for run 020 2013 and 2013 models.

Table 4-2 Surveyed and Modelled Flood Level Comparison at Flood Marks – May 2009 Event

Flood Mark ID	Quality	Surveyed Mark Level (mAHD)	Modelled Mark Level (mAHD)	Difference in Flood Level – Modelled minus Surveyed (mm)
CAB206	Medium	8.85	8.77	-80
CAB227	Medium	7.84	7.78	-60
CAB276	Medium	7.02	7.14	120
CAB278	Medium	13.78	13.72	-60
CAB280	Medium	11.36	11.24	-120
CAB289	Medium	8.05	8.36	310
CAB299	Medium	9.55	9.32	-230
CAB323	Medium	19.65	19.91	260

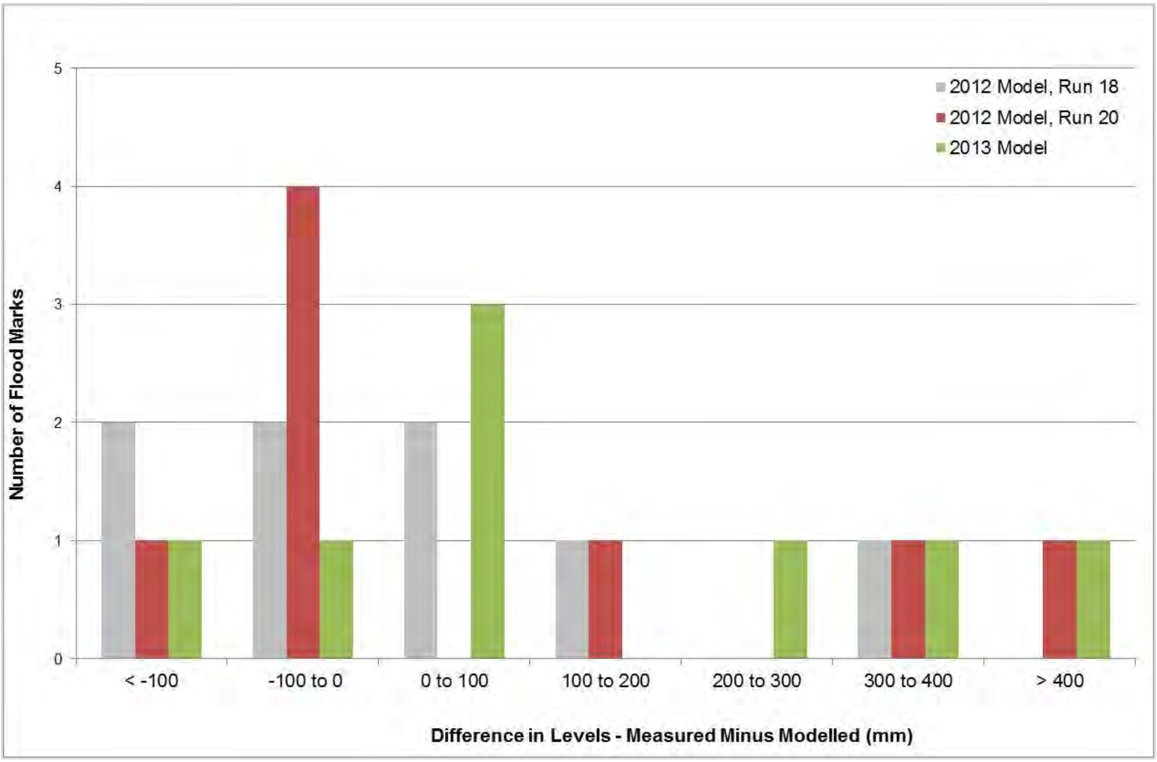

Figure 4-10 Floodmark Histogram – May 2009 Event

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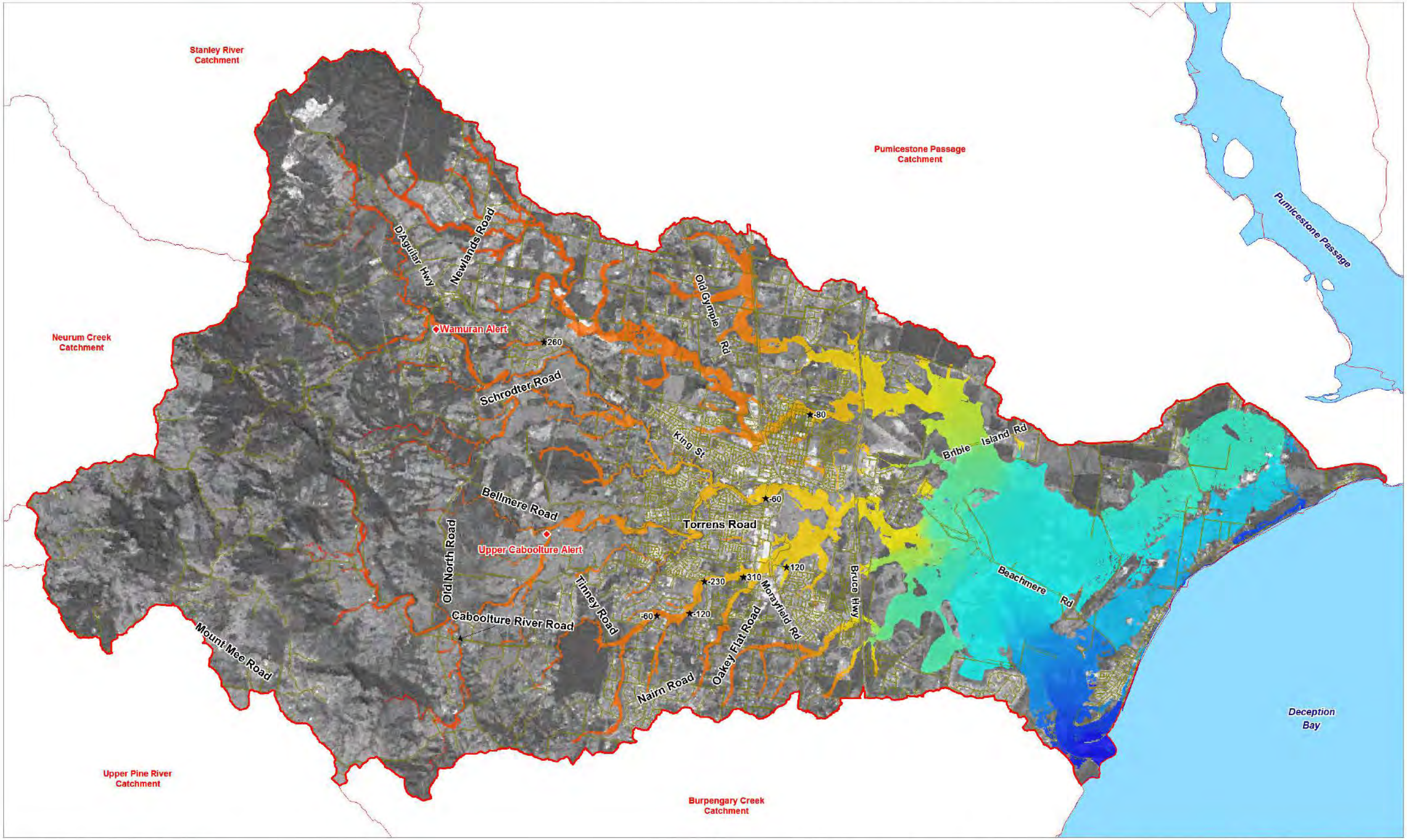

LEGEND

- Caboolture River Catchment
- Roads
- Flood Marks indicating the difference in flood levels in mm (modelled minus surveyed)
- River Gauges

Title:

May 2009 Event Peak Flood Extent and Flood Marks - Caboolture River Catchment

Figure: **4-11**

Rev: **A**

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5 Conclusion

The 2013 CAB model was simulated for the two historic events; the January 2011 and the May 2009 flood event. Model calibration as such (with various model parameters) was not undertaken as Council adopted a specific set of model parameters as part of Stage 2, which were then verified as part of Stage 3 of the Regional Floodplain Database. Council envisages to undertaken additional model calibration using additional gauge data recently installed, with a flood event in the future.

Flood levels in the area between King Street, Torrens Road and Bellmere Road have increased in both historic events. This is attributed to the change in the TUFLOW executable used. These changes have not decreased the quality of the modelling results, as the hydrographs at the gauge locations and the flood mark histogram are very similar between the 2012 and 2013 models (that use Council's adopted Stage 2 roughness values, run 020).

6 References

BMT WBM (2012): *Regional Floodplain Database Hydrologic and Hydraulic Modelling Caboolture (CAB)*

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BMT WBM Brisbane	Level 8, 200 Creek Street Brisbane 4000 PO Box 203 Spring Hill QLD 4004 Tel +61 7 3831 6744 Fax +61 7 3832 3627 Email bmtwbm@bmtwbm.com.au Web www.bmtwml.com.au
BMT WBM Denver	8200 S. Akron Street, #B120 Centennial Denver Colorado 80112 USA Tel +1 303 792 9814 Fax +1 303 792 9742 Email denver@bmtwbm.com Web www.bmtwbm.com
BMT WBM London	1st Floor, International House St Katherine;s Way London E1W1TW Email london@bmtwbm.co.uk Web www.bmtwbm.com.au
BMT WBM Mackay	Suite 1, 138 Wood Street Mackay 4740 PO Box 4447 Mackay QLD 4740 Tel +61 7 4953 5144 Fax +61 7 4953 5132 Email mackay@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Melbourne	Level 5, 99 King Street Melbourne 3000 PO Box 604 Collins Street West VIC 8007 Tel +61 3 8620 6100 Fax +61 3 8620 6105 Email melbourne@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Newcastle	126 Belford Street Broadmeadow 2292 PO Box 266 Broadmeadow NSW 2292 Tel +61 2 4940 8882 Fax +61 2 4940 8887 Email newcastle@bmtwbm.com.au Web www.bmtwbm.com.au
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BMT WBM Sydney	Level 1, 256-258 Norton Street Leichhardt 2040 PO Box 194 Leichhardt NSW 2040 Tel +61 2 8987 2900 Fax +61 2 8987 2999 Email sydney@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Vancouver	Suite 401, 611 Alexander Street Vancouver British Columbia V6E 3W1 Canada Tel +1 604 683 5777 Fax +1 604 608 3232 Email vancouver@bmtwbm.com.au Web www.bmtwbm.com

Appendix B 1% AEP Design Event Maps

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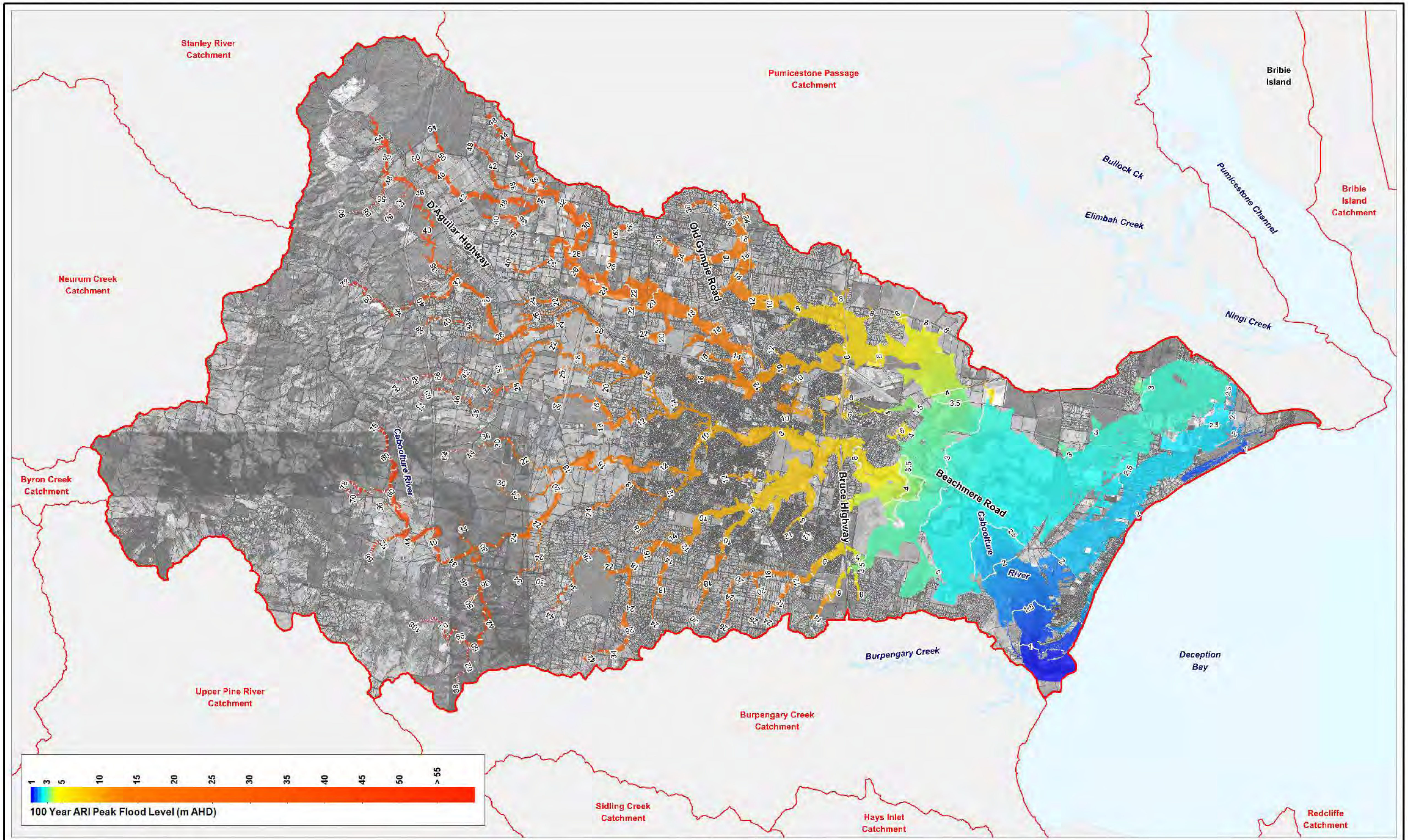

LEGEND

Caboolture Catchment Boundary

Contour Lines [Labelled with 100 Year ARI Peak Flood Level (m AHD)]

Cadastral Boundaries

Title:

Peak Flood Level Map – 1% AEP

Figure: B-1

Rev: A

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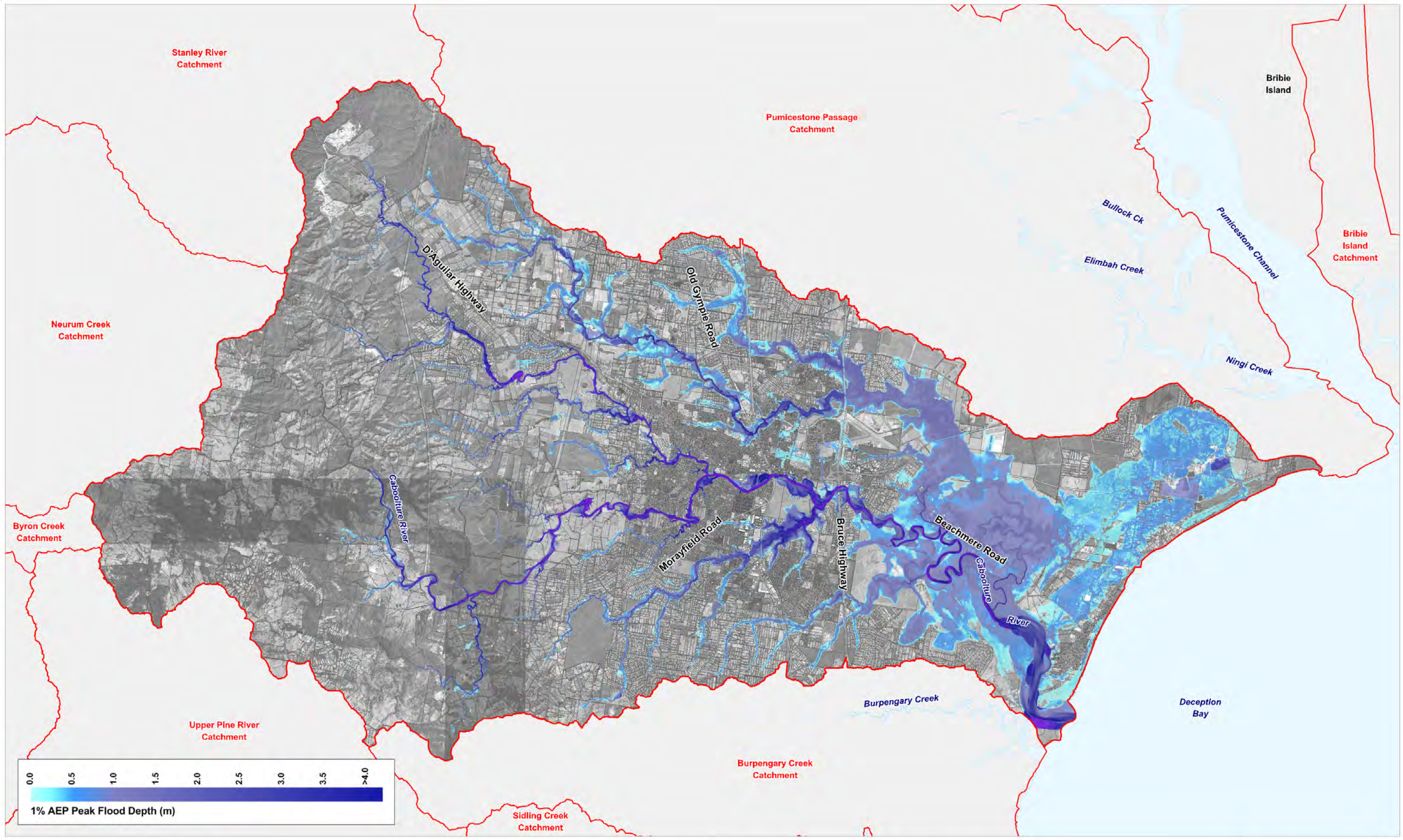

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Title:

Peak Flood Depth Map – 1% AEP

Figure: **B-2**

Rev: **A**

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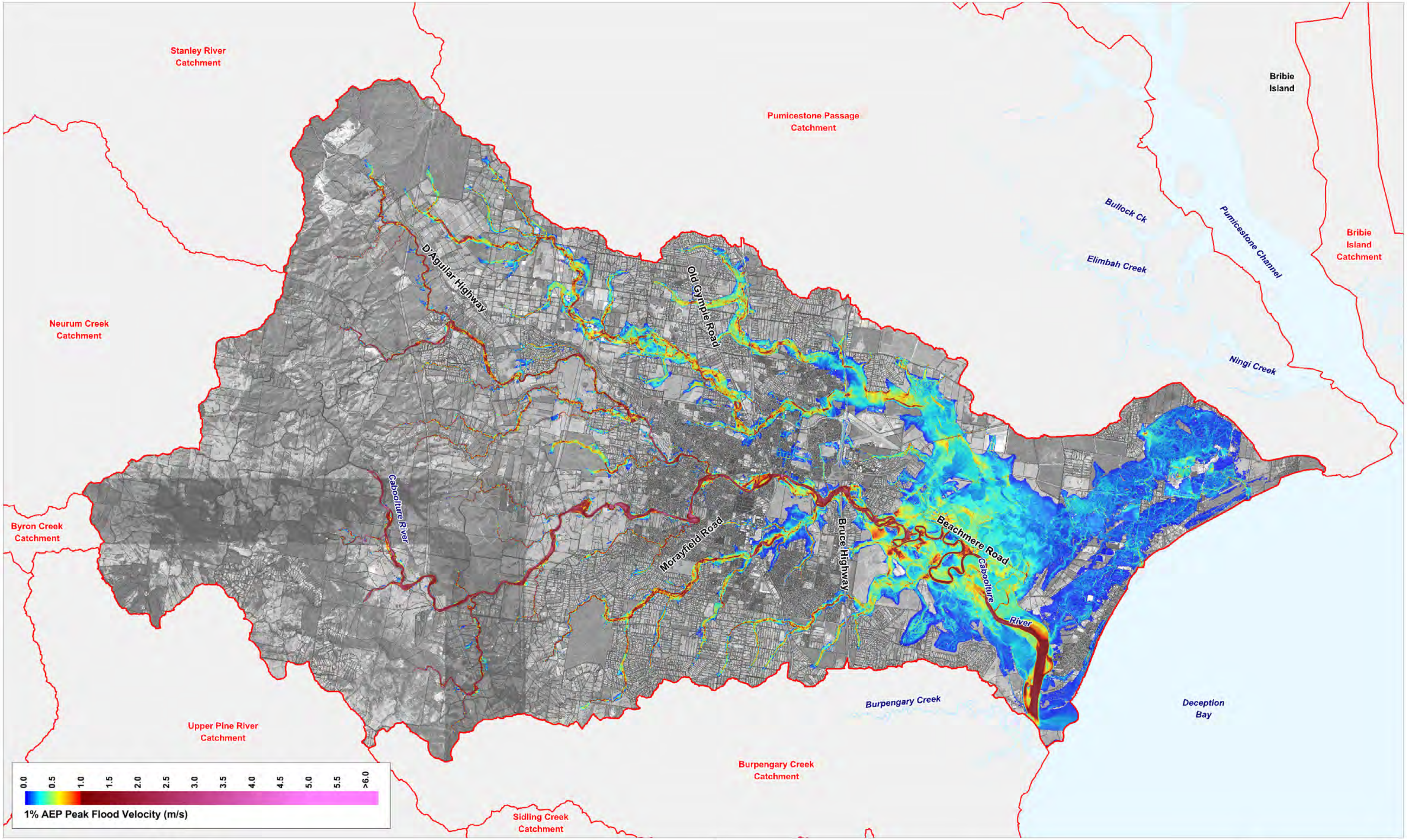

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Title:

Peak Flood Velocity Map – 1% AEP

Figure: B-3

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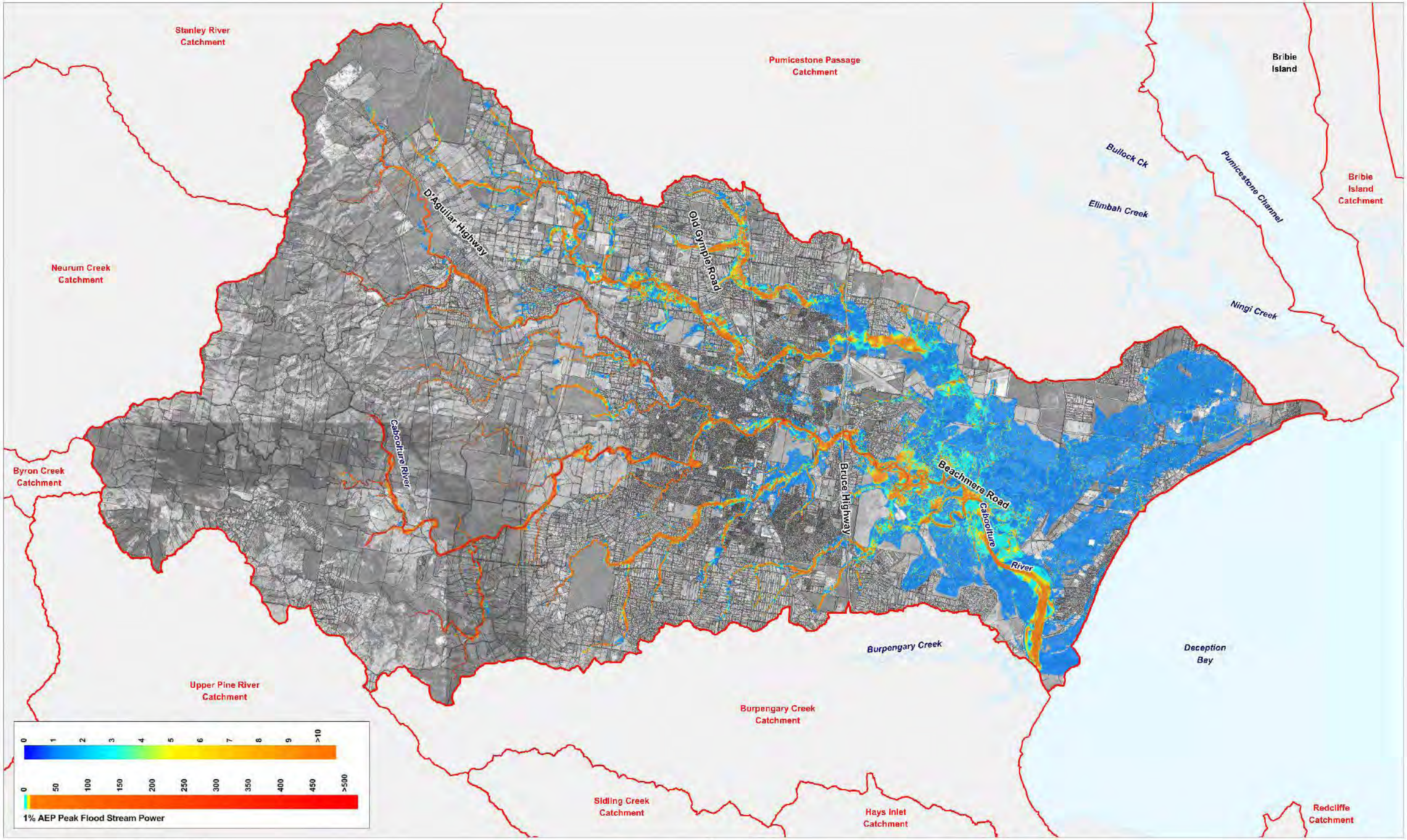

LEGEND

No Window **Caboolture Catchment Boundary**

Cadastral Boundaries

Note:
Stream power is a function of velocity and bed shear stress.

Title:

Peak Flood Stream Power Map – 1% AEP

Figure: **B-4**

Rev: **A**

N

0km 3 6
Approx. Scale

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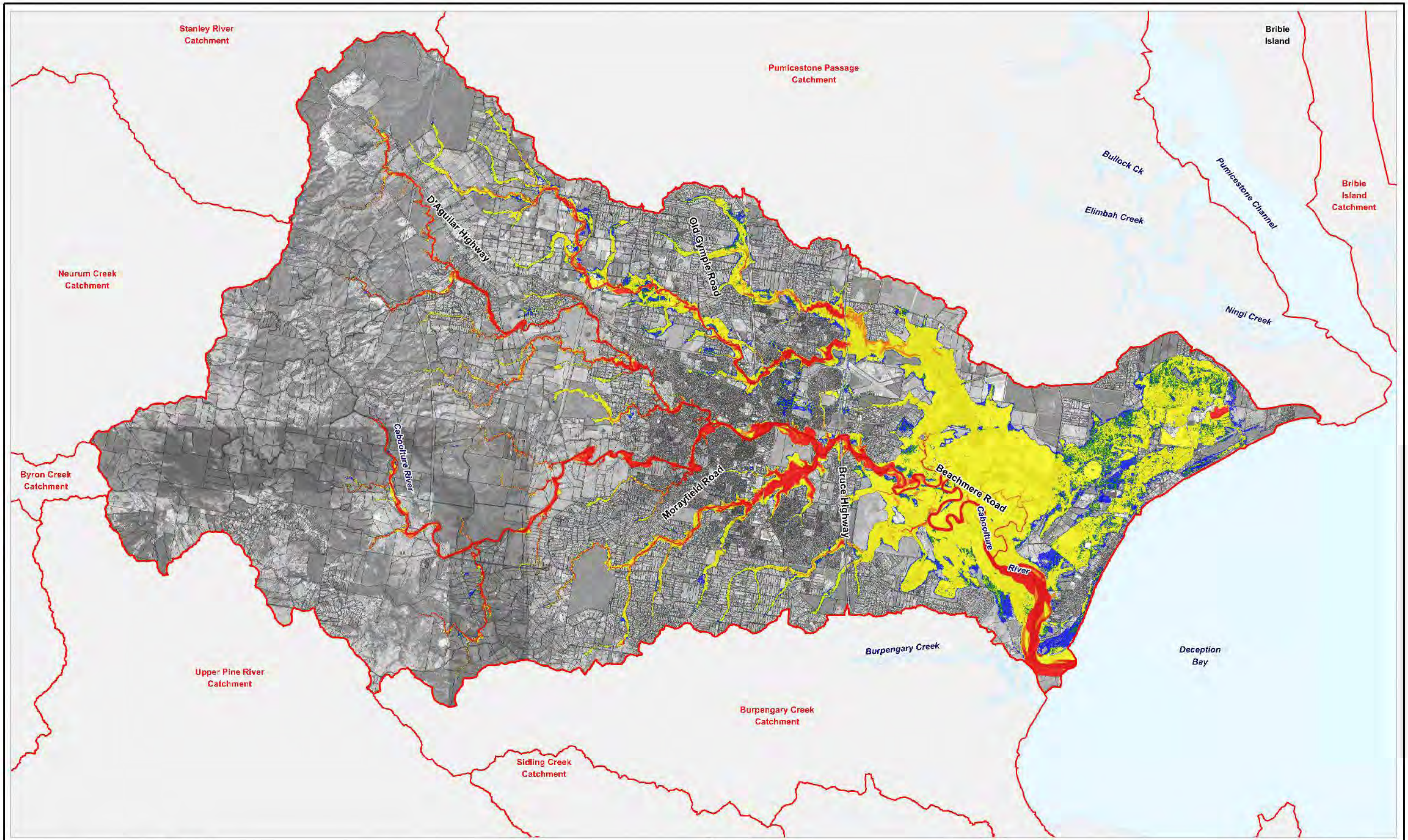
Filepath : I:\B20303_I_ak_CAB_Update\DRG\FLD_044_131024_Peak_Flood_StreamPower_1%AEP.WOR



LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Flood Hazard Category -1% AEP

- H1 - Hydraulically suitable for parked/moving cars
- H2 - Hydraulically suitable for parked/moving heavy vehicles
- H3 - Hydraulically suitable for light construction
- H4 - Hydraulically suitable for heavy construction
- H5 - Generally unsuitable

Title:

Peak Flood Hazard Map – 1% AEP

Figure: **B-5**

Rev: **A**

N

0km 3 6

Approx. Scale

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Filepath : I:\B20303_I_ak_CAB_Update\DRG\FLD_045_131024_Peak_Flood_Hazard_1%AEP.WOR

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Appendix C Sensitivity Analysis Maps

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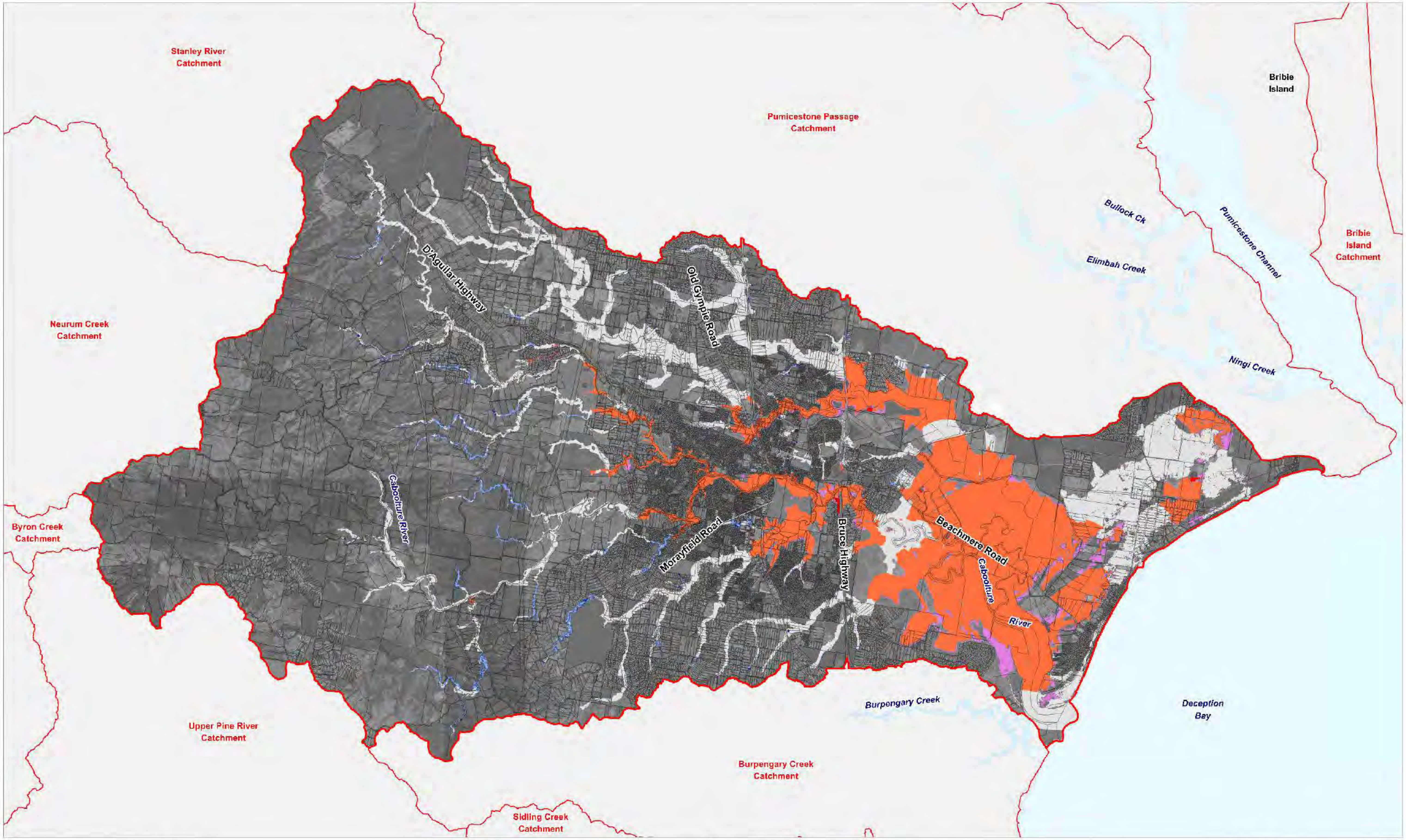

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Increase in Inundation Extent
- Decrease in Inundation Extent

Title:

1% AEP EDS Minus 1% AEP 3 Hour, 6 Hour and 12 Hour Storm

Figure: **C-1**

Rev: **A**

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0km 3 6

Approx. Scale

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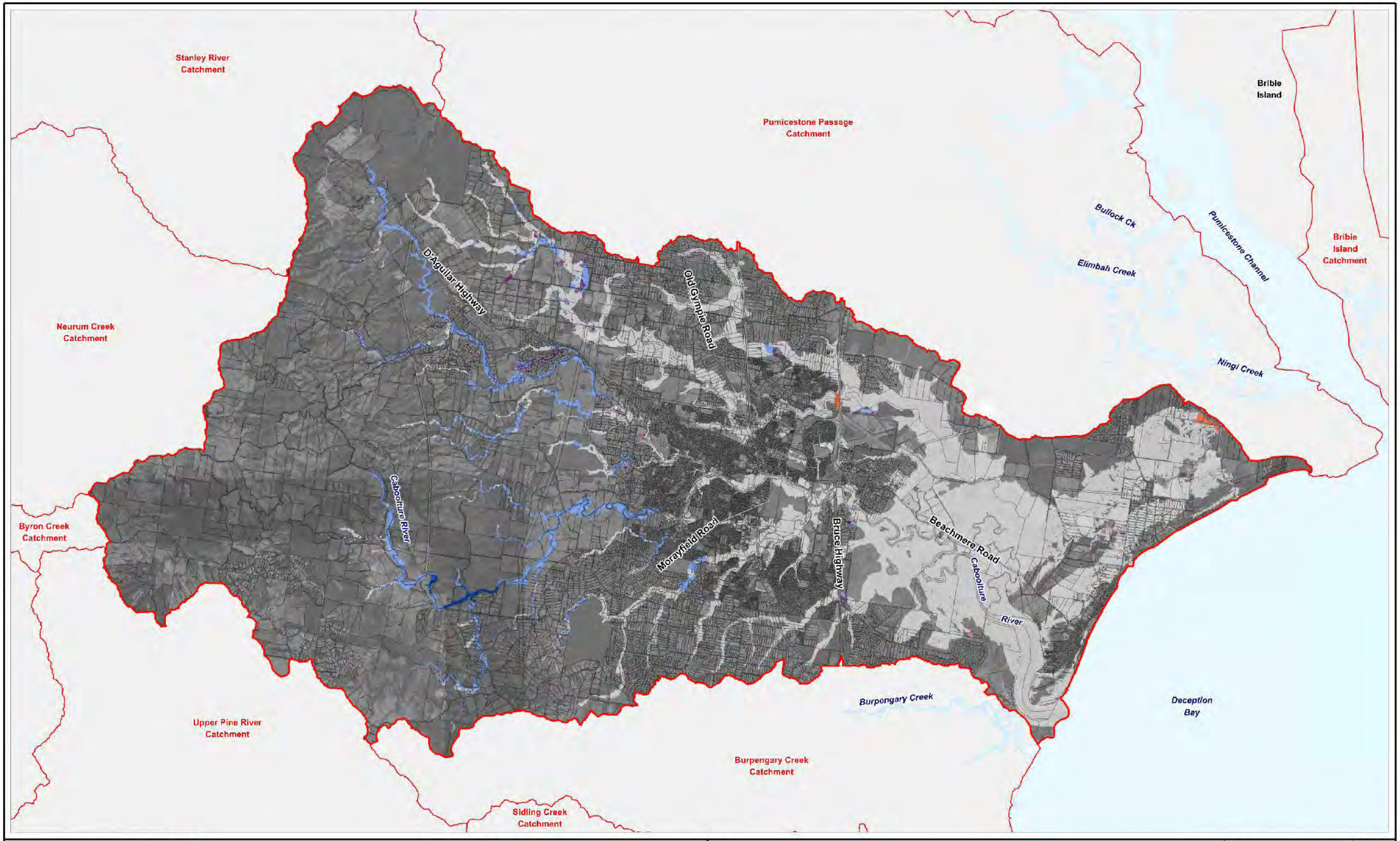

Title:

Increased Roughness Scenario (S2) Minus 1% AEP EDS

Figure: C-2

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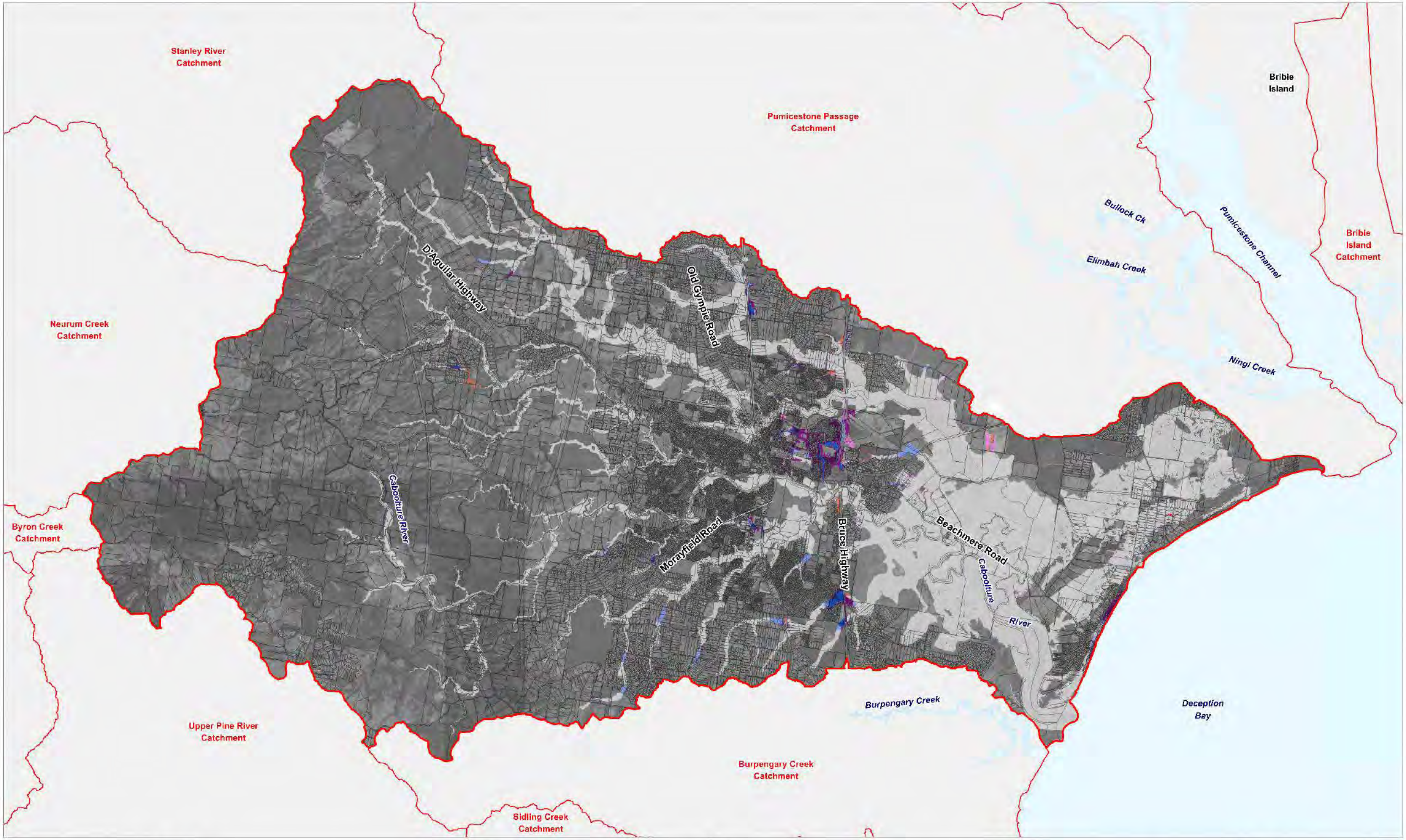

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Increase in Inundation Extent
- Decrease in Inundation Extent

Title:

Culvert Blockage Scenario (S3) Minus 1% AEP EDS

Figure: **C-3**

Rev: **A**

N

0km 3 6

Approx. Scale

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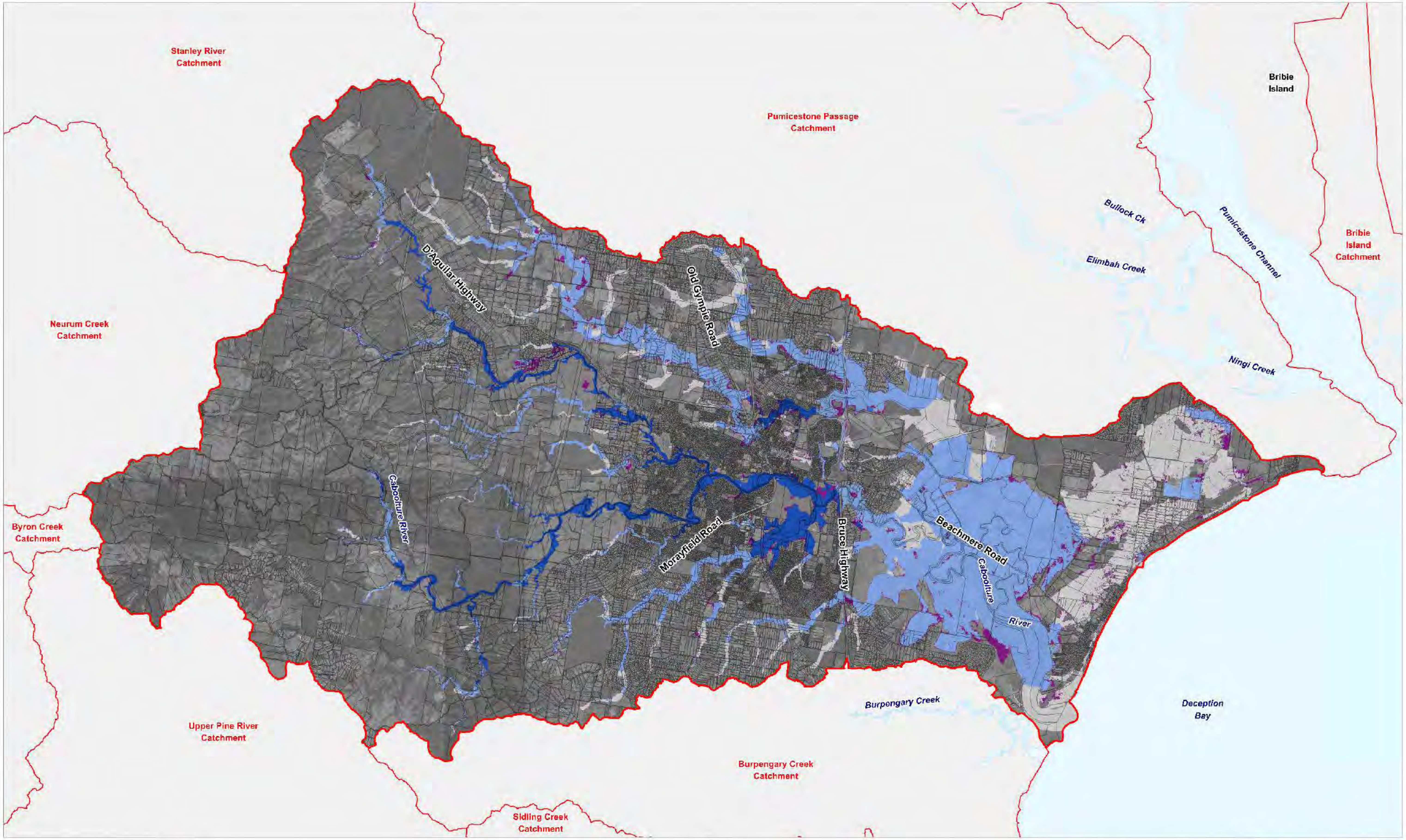

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Increase in Inundation Extent
- Decrease in Inundation Extent

Title:

Increased Rainfall Scenario (S4) Minus 1% AEP EDS

Figure: **C-4**

Rev: **A**

N

0km 3 6

Approx. Scale

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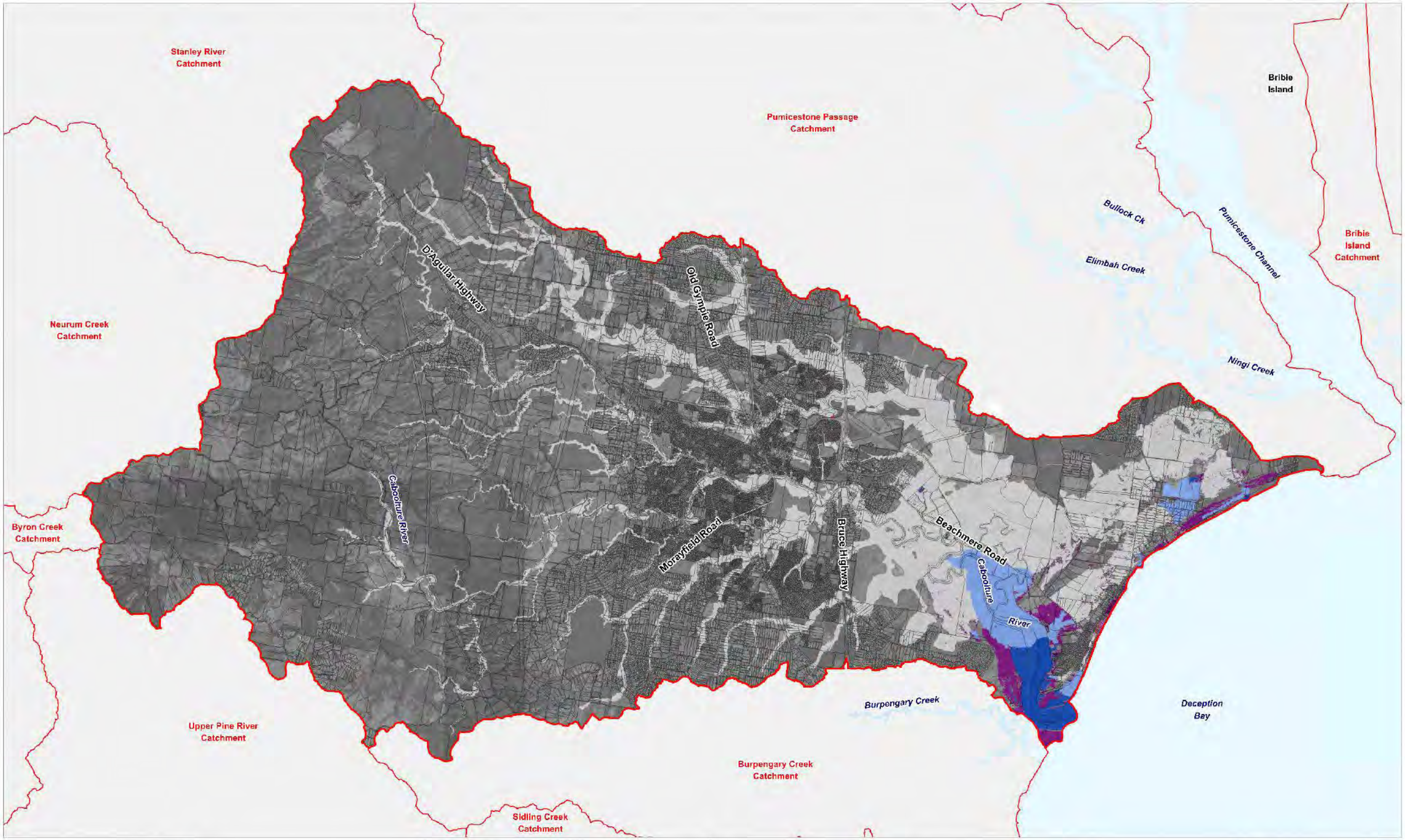

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Increase in Inundation Extent
- Decrease in Inundation Extent

Title:

Increased Downstream Boundary Scenario (S5) Minus 1% AEP EDS

Figure: **C-5**

Rev: **A**

N

0km 3 6

Approx. Scale

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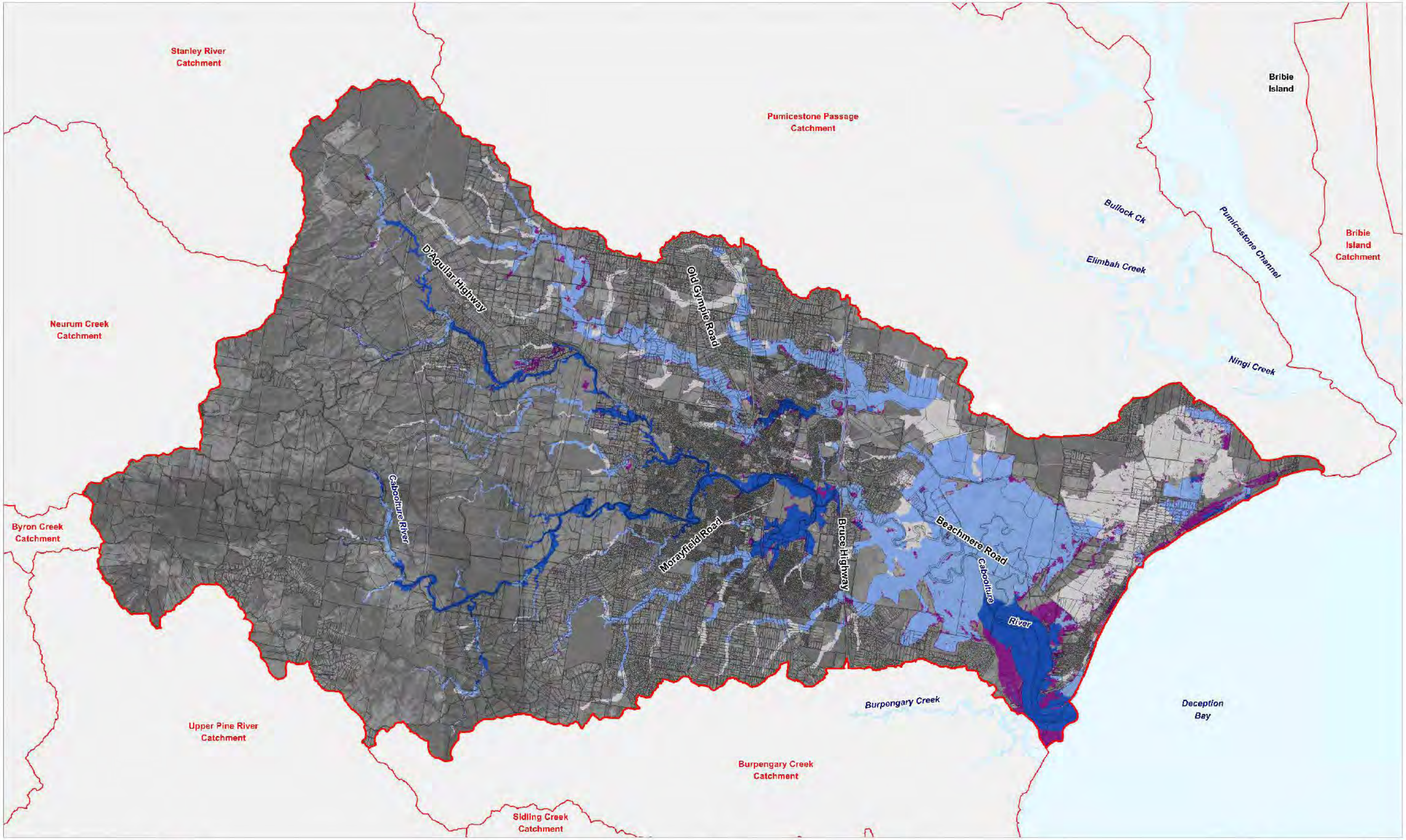

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Increase in Inundation Extent
- Decrease in Inundation Extent

Title:

Increased Downstream Boundary and Rainfall Scenario (S6) Minus 1% AEP EDS

Figure: **C-6**

Rev: **A**

N

0km 3 6

Approx. Scale

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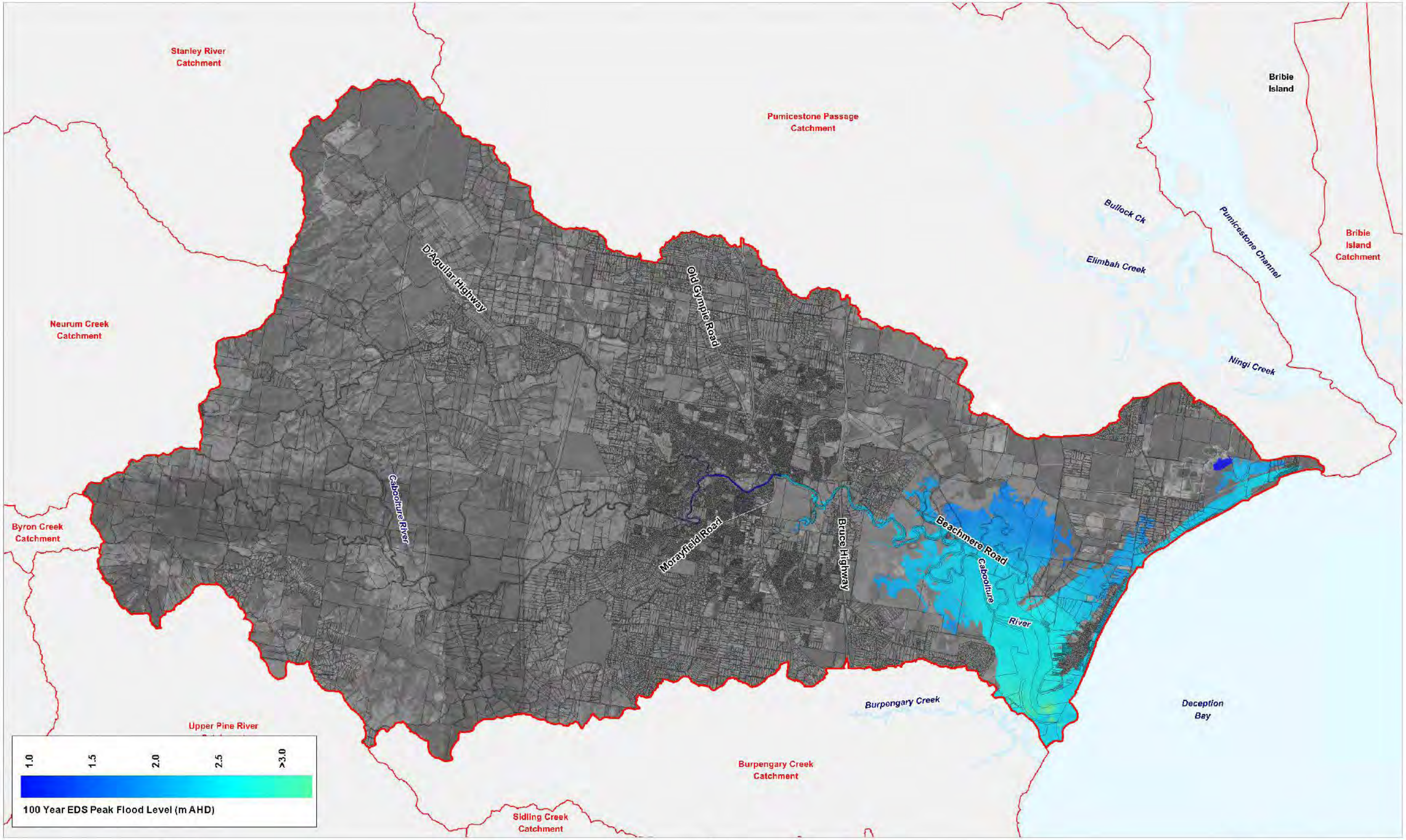

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Title:

Dynamic Storm Tide Peak Flood Level – 1% AEP EDS (S7)

Figure: C-7

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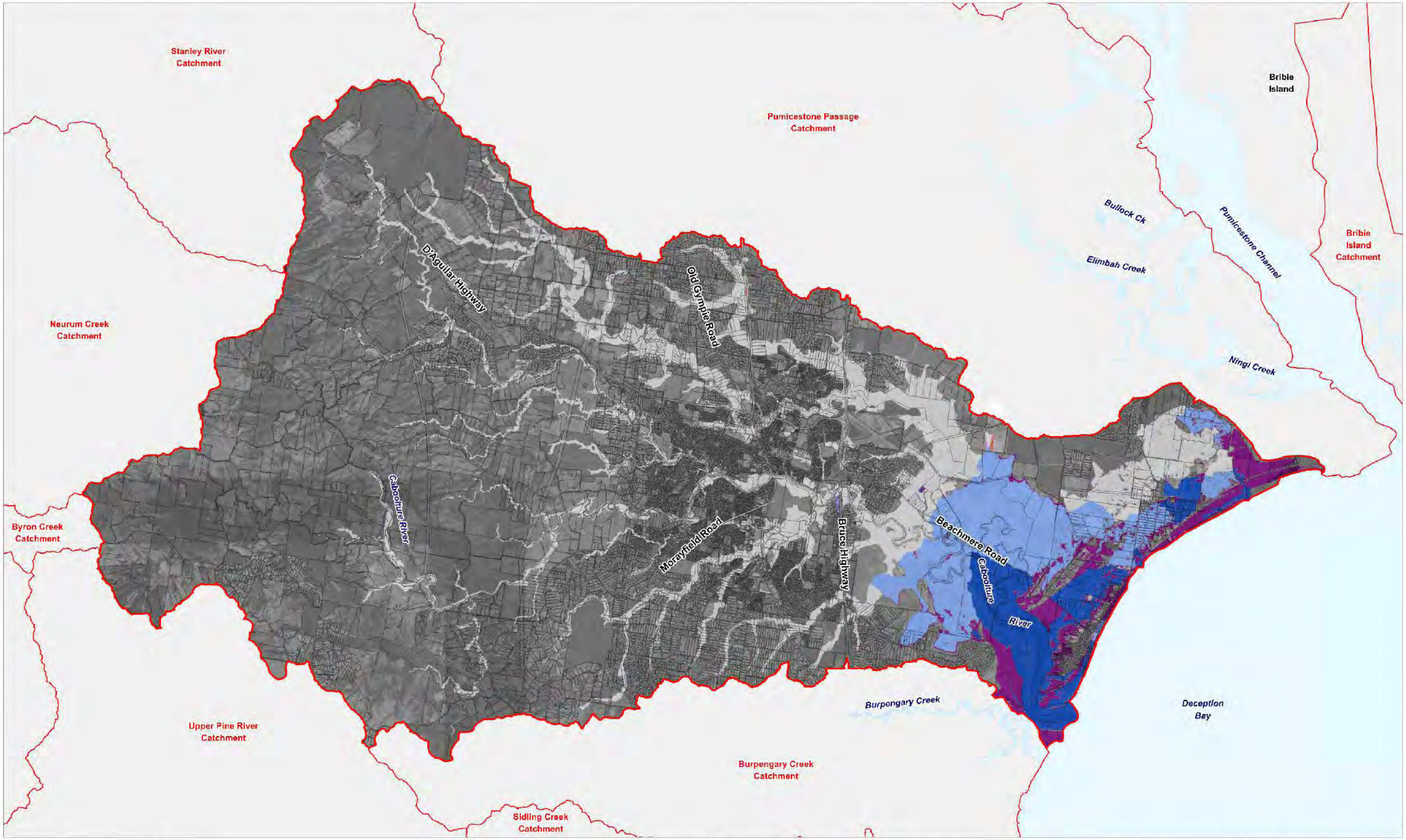

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Increase in Inundation Extent
- Decrease in Inundation Extent

Title:

Static Storm Tide Scenario (S8) Minus 1% AEP EDS

Figure: **C-8**

Rev: **A**

N

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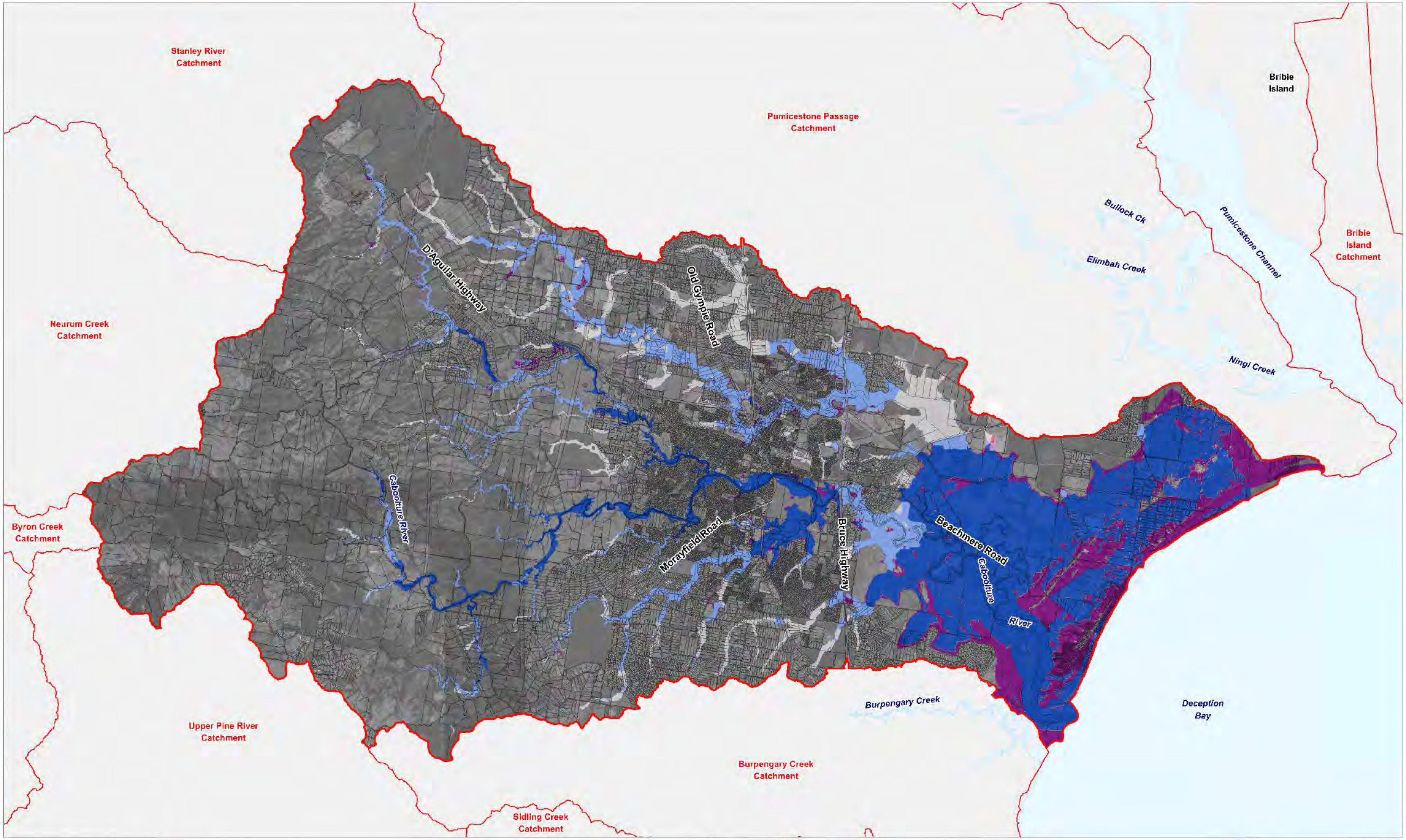
Filepath : I:\B20303_I_ak_CAB_Update\DRG\FLD_013_130624_Static_Storm_tide_Flood_Level_Impact_100Year_EDS.WOR



LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- \> 0.5
- Increase in Inundation Extent
- Decrease in Inundation Extent

Title:

Static Storm Tide, Increased Rainfall and Sea Level Rise Scenario (S9) Minus 1% AEP EDS

Figure: **C-9**

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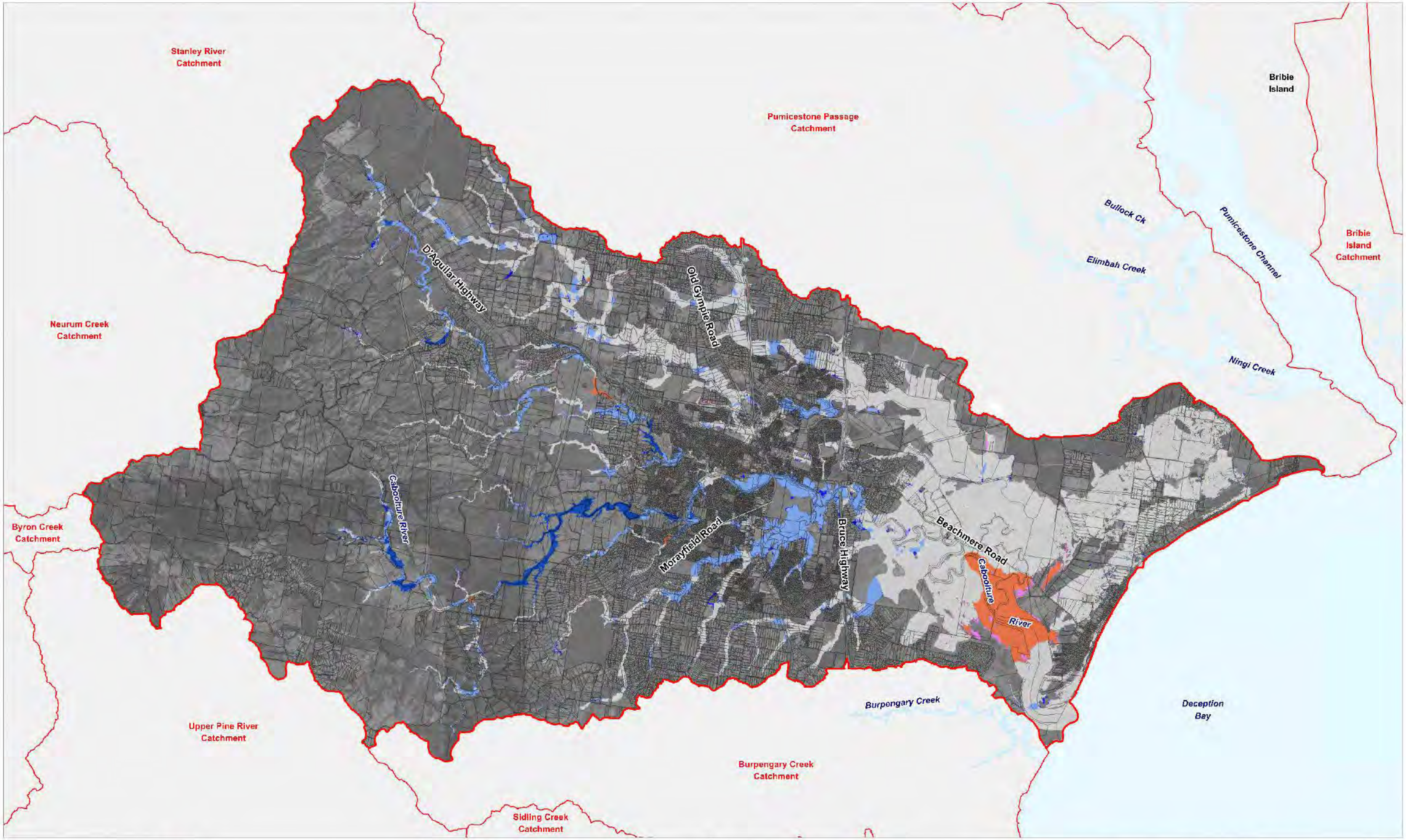

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Increase in Inundation Extent
- Decrease in Inundation Extent

Title:

Increased Vegetation Scenario (S10) Minus 1% AEP EDS

Figure: C-10

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LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Increase in Inundation Extent
- Decrease in Inundation Extent

Title:
Increased Residential Development Scenario, Excluding Caboolutre West, (S11) Minus 1% AEP EDS

Figure: **C-11**

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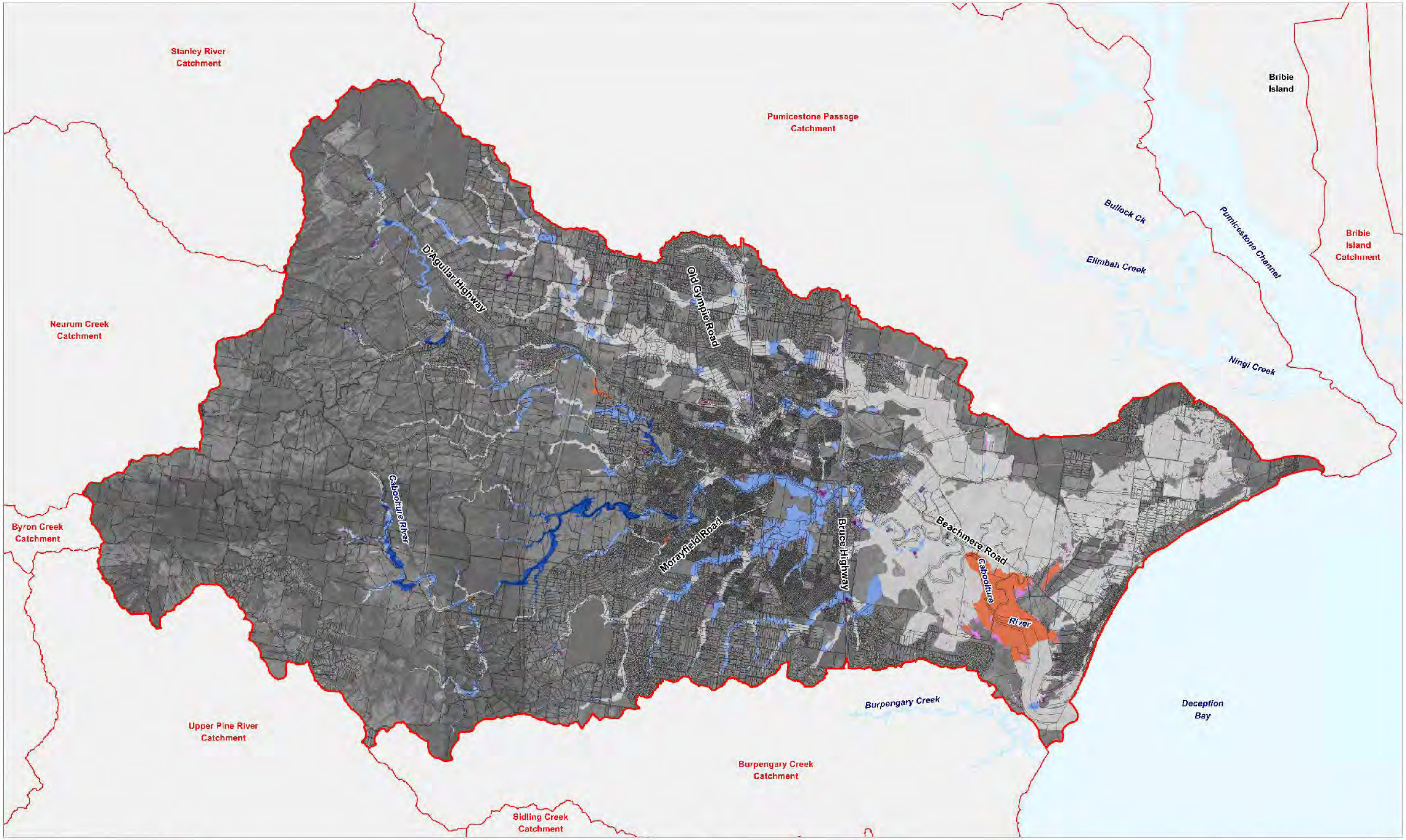

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Increase in Inundation Extent
- Decrease in Inundation Extent

Title:

Increased Residential Development, Excluding Caboolture West, and Vegetation Scenario (S12) Minus 1% AEP EDS

Figure: **C-12**

Rev: **A**

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0km 3 6

Approx. Scale

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Filepath : I:\B20303_I_ak_CAB_Update\DRG\FLD_015_130624_Increased_Veg_And_Res_Dev_Flood_Level_Impact_100Year_EDS.WOR

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Increase in Inundation Extent
- Decrease in Inundation Extent

Title:

Increased Residential Development Scenario, Including Caboolutre West, (S13) Minus 1% AEP EDS

Figure: C-13

Rev: A

N

0km 3 6

Approx. Scale

BMT WBM

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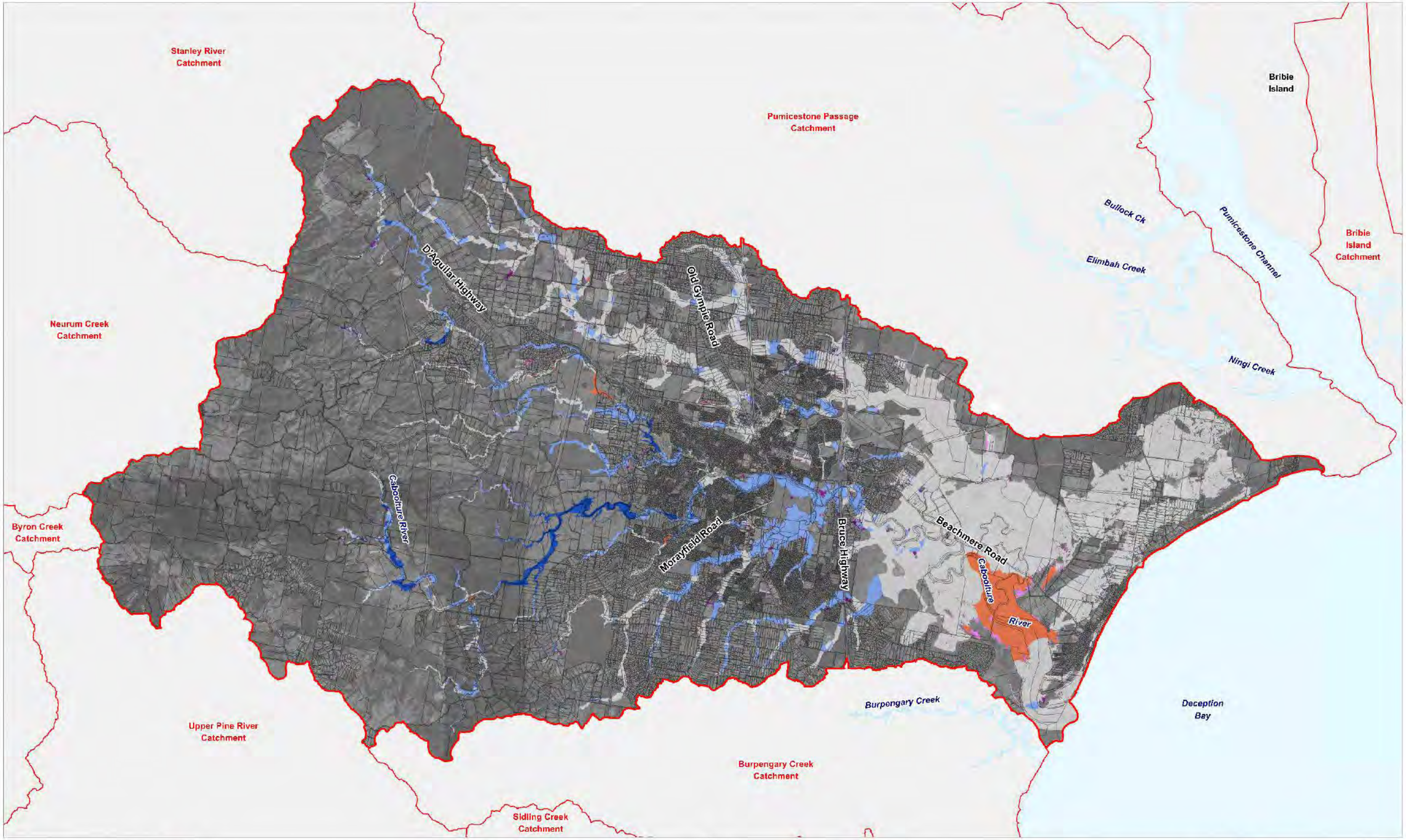

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Increase in Inundation Extent
- Decrease in Inundation Extent

Title:

Increased Residential Development, Including Caboolture West, and Vegetation Scenario (S14) Minus 1% AEP EDS

Figure: C-14

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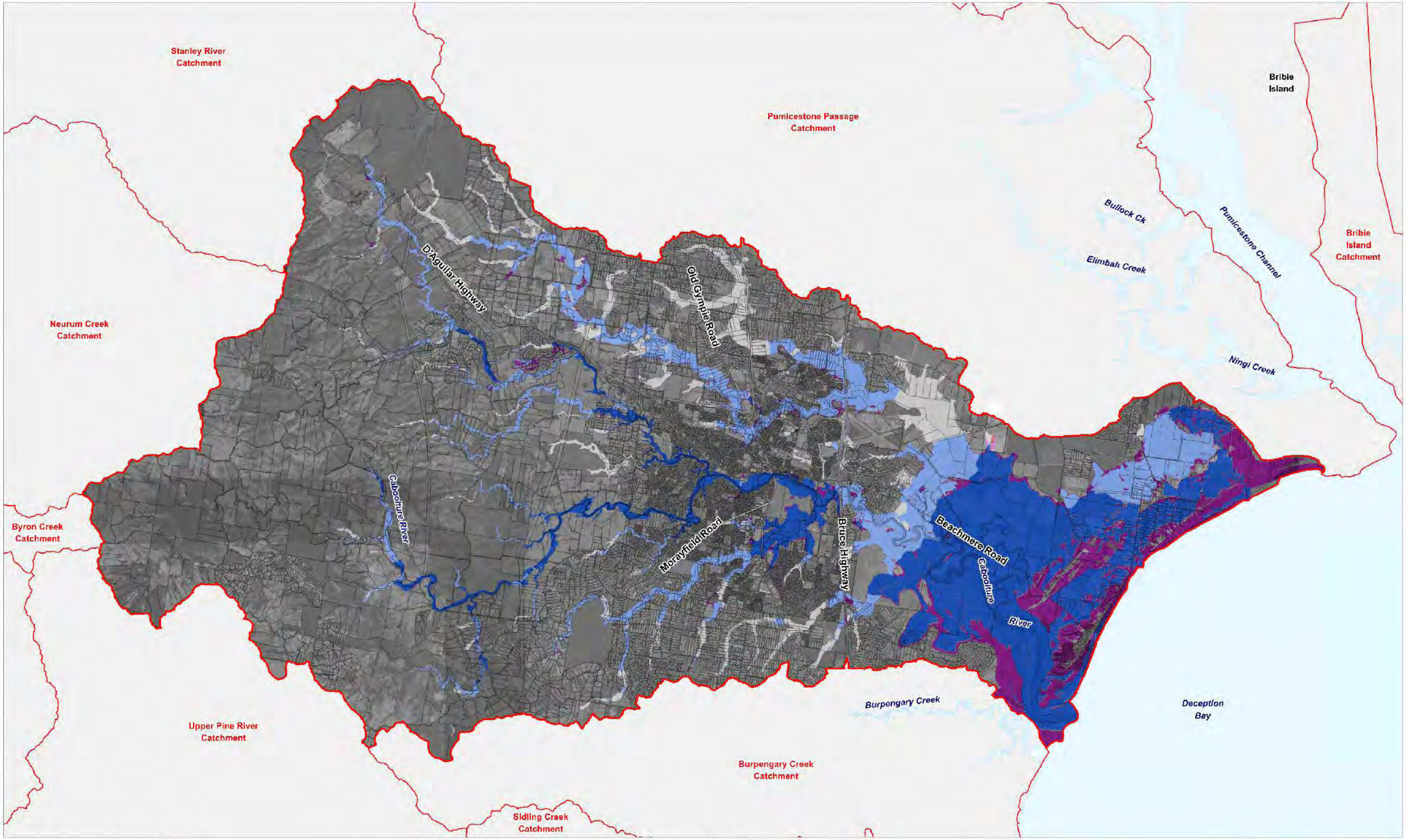

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Increase in Inundation Extent
- Decrease in Inundation Extent

Title:

Static Storm Tide, Increased Rainfall and Sea Level Rise Scenario (S15) Minus 1% AEP EDS

Figure: **C-15**

Rev: **A**

N 0km 3 6 Approx. Scale

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Filepath : I:\B20303_I_ak_CAB_Update\DRG\FLD_039_130624_Static_Storm_tide_+0.4_And_CC_Flood_Level_Impact_100Year_EDS.WOR

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BRW. CLIENT CHOICE AWARDS 2013 WINNER

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BMT WBM Bangalow	6/20 Byron Street, Bangalow 2479 Tel +61 2 6687 0466 Fax +61 2 66870422 Email bmtwbm@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Brisbane	Level 8, 200 Creek Street, Brisbane 4000 PO Box 203, Spring Hill QLD 4004 Tel +61 7 3831 6744 Fax +61 7 3832 3627 Email bmtwbm@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Denver	8200 S. Akron Street, #B120 Centennial, Denver Colorado 80112 USA Tel +1 303 792 9814 Fax +1 303 792 9742 Email denver@bmtwbm.com Web www.bmtwbm.com
BMT WBM London	International House, 1st Floor St Katharine's Way, London E1W 1AY Email london@bmtwbm.co.uk Web www.bmtwbm.com
BMT WBM Mackay	Suite 1, 138 Wood Street, Mackay 4740 PO Box 4447, Mackay QLD 4740 Tel +61 7 4953 5144 Fax +61 7 4953 5132 Email mackay@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Melbourne	Level 5, 99 King Street, Melbourne 3000 PO Box 604, Collins Street West VIC 8007 Tel +61 3 8620 6100 Fax +61 3 8620 6105 Email melbourne@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Newcastle	126 Belford Street, Broadmeadow 2292 PO Box 266, Broadmeadow NSW 2292 Tel +61 2 4940 8882 Fax +61 2 4940 8887 Email newcastle@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Perth	Suite 6, 29 Hood Street, Subiaco 6008 Tel +61 8 9328 2029 Fax +61 8 9486 7588 Email perth@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Sydney	Level 1, 256-258 Norton Street, Leichhardt 2040 PO Box 194, Leichhardt NSW 2040 Tel +61 2 8987 2900 Fax +61 2 8987 2999 Email sydney@bmtwbm.com.au Web www.bmtwbm.com.au
BMT WBM Vancouver	Suite 401, 611 Alexander Street Vancouver British Columbia V6A 1E1 Canada Tel +1 604 683 5777 Fax +1 604 608 3232 Email vancouver@bmtwbm.com Web www.bmtwbm.com