Regional Floodplain Database:

Hydrologic and Hydraulic Modelling - Caboolture River (CAB)

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Regional Floodplain Database Hydrologic and Hydraulic Modelling

Caboolture (CAB) **June 2012**

Moreton Bay Regional Council

Emergency Management EMQ Queensland

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Queensland Government

Regional Floodplain Database Hydrologic and Hydraulic Modelling Caboolture (CAB)

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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 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.B18104.006.02.P4_CAB_Hydraulic_Model_Report_doublesided.doc ***Project Manager :*** Richard Sharpe ***Client :*** Moreton Bay Regional Council ***Client Contact:*** Hester van Ziji ***Client Reference*** Regional Floodplain Database

Title :	Regional Floodplain Database, Hydrologic and Hydraulic Modelling: Caboolture (CAB)
Author :	Melissa Hovey \ Richard Sharpe
Synopsis :	Report outlining the study data, methodology and delivery of the detailed modelling of the Caboolture catchment, as part of Moreton Bay Regional Council's Regional Floodplain Database (Stage 2, Package 4) project.

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1 INTRODUCTION

Moreton Bay Regional Council (MBRC) is currently undertaking Stage 2 of developing the Regional Floodplain Database (RFD). The RFD includes the development of coupled hydrologic and hydraulic models for the entire local government area (LGA) that are capable of seamless interaction with a spatial database to deliver detailed information about flood behaviour across the region.

Stage 2 includes the detailed hydrologic and hydraulic modelling of 5 packages, which cover 11 catchments in the MBRC LGA. This report discusses the study data, methodology and results for Stage 2, Package 4 of the RFD (i.e the detailed hydrologic and hydraulic modelling) for the Caboolture catchment. Furthermore, this stage will form the basis of Stage 3 of the RFD, which aims to analyse the results of the detailed modelling for the purposes of understanding and managing flood risk in the MBRC LGA.

1.1 Scope

The detailed models of the Caboolture catchment will provide MBRC with an enhanced understanding of the flood behaviour in the catchment for a large range of flood events, from the 1 year Average Recurrence Interval (ARI) event to the Probable Maximum Flood (PMF). The detailed model was developed from a pre-existing broad scale model that was developed by MBRC as part of the RFD. The following primary alterations were made to convert the broad scale model to a detailed model:

- The model computational grid resolution was refined from 10m to 5m;
- The latest 2009 LiDAR (**L**ight **D**etection **A**nd **R**anging) topographic data was used, incorporating terrain modifiers to enhance the capture of road embankments and stream lines in the Digital Elevation Model (DEM);
- Additional hydraulic structures were included in the model; and
- Utilisation of detailed land use delineation (developed as part of Stage 1, but not included in broadscale models).

A broad range of design flood events were simulated, as well as a number of sensitivity analyses which investigated the influence of various parameters and conditions on model results. The model results provide detailed flood information such as levels, depths, velocities, hazard, flood extents and the time at which flooding occurs.

1.2 Objectives

Key objectives of this study are as follows:

- Utilise the existing broadscale model to develop a detailed and dynamically linked two-dimensional and one-dimensional (2D/1D) hydrodynamic model of the Caboolture Catchment using input data that were determined and provided by MBRC or other consultants; and
- Provision of all relevant flood information obtained from the modelling, which will form the base input data for Stage 3 of the RFD.

1.3 General Approach

The general approach for this study is summarised as follows:

- Review existing broad scale WBNM hydrologic model and results;
- Review existing broad scale TUFLOW modelling;
- Refine the TUFLOW modelling to include a refined grid size and any additional structure and topographical information;
- Investigate the feasibility of calibrating and/or verifying the combined WBNM and TUFLOW models using two historical events. There was sufficient historical information available for this task, therefore calibration was undertaken;
- Undertake a critical storm duration assessment for the 10 year ARI event, 100 year ARI event and the PMF;
- Simulate a large range of design flood events (1, 2, 5,10, 20, 50,100, 200, 500, 1000, 2000 year ARI events and PMF events) for up to three selected critical durations;
- Assess model sensitivity to future landuse patterns, Manning's 'n', structure blockage, climate change and downstream boundary conditions;
- Provide a concise report describing the adopted methodology, study data, model results and findings. The emphasis of the RFD project is on digital data management. Therefore only the 100 year ARI event was mapped in this report; and
- Compilation of models and model outputs for provision to MBRC.

1.4 Related Sub-Projects (RFD Stage 1 and Stage 2 Pilot)

The following RFD sub-projects provide input data and/or methodologies for the Caboolture Stage 2 models:

- **1D – Hydrologic and Hydraulic Modelling (Broadscale),** sub-project 1D defined model naming conventions and model protocols to be used in this sub-project (BMT WBM, 2010);
- **1E – Floodplain Topography (2009 LiDAR) including 1F, 2E, 2I,** sub-project 1E provided the topographic information, such as model Z points layer and digital elevation models (DEM). This was achieved using a bespoke DEM tool developed for the RFD (Worley Parsons, 2010a);
- **1G – Hydrography (MBRC),** sub-project 1G supplied the subcatchment delineation of the catchment including stream lines and junctions (used in the WBNM model);
- **1H – Floodplain Landuse,** sub-project 1H delivered the current percentage impervious cover (utilised in the hydrologic model) and the roughness Manning's 'n' values (utilised in the hydraulic model) (SKM, 2010);
- **1I – Rainfall and Stream Gauges Information Summary (MBRC),** sub-project 1I summarised available rainfall and stream gauge information for the study area;
- **2C – Floodplain Structures (Culverts),** sub-project 2C supplied the GIS layer of the culverts to be included in the model (Aurecon, 2010). A TUFLOW-specific MapInfo file was provided,

however appropriate model linkages between the culvert data and the 2D domain had to be established;

- **2D - Floodplain Structures (Bridges),** sub-project 2D provided a GIS layer of the major bridges and foot bridges (Aurecon, 2010). A TUFLOW-specific MapInfo file was provided;
- **2F – Floodplain Structures (Trunk Underground Drainage),** sub-project 2F provided trunk underground drainage information;
- **2G - Floodplain Structures (Basins),** sub-project 2G consolidated and surveyed the existing basin information in the study area (Aurecon, 2010);
- **2I - Floodplain Structures (Channels),** sub-project 2I identified channels within the catchment (Aurecon, 2010);
- **2J – Floodplain Landuse (Historic and Future),** sub-project 2J defined the historic and future percentage impervious cover (utilised in the hydrologic model) and the roughness (Manning's 'n') values representing landuse for historical events (utilised in the hydraulic model) (SKM, 2010);
- **2K – Flood Information Historic Flooding,** sub-project 2K collected and surveyed flood levels for the historic May 2009 and February 1999 flood event (GHD, 2010);
- **2L – Design Rainfall and Infiltration Loss,** sub-project 2L developed the hydrologic models for the catchment and provided the design rainfall hydrographs for the pilot study (Burpengary Creek catchment) TUFLOW models (Worley Parsons, 2010b). A similar methodology was adopted for the Caboolture catchment;
- **2M – Boundary Conditions, Joint Probability and Climate Risk Scenarios,** sub-project 2M defined the boundary conditions and provided recommendations in regards to joint probability (i.e. occurrence of storm surge in combination with river flooding events, or river flooding in combination with local tributary flooding). This project also recommended certain sea level rise and rainfall intensity values to assess Climate Risk Scenarios (SKM, 2012a); and
- **2N – Floodplain Parameterisation,** sub-project 2N provided recommendations of the floodplain parameters, such as a range of values for various impervious percentages for various landuse types (i.e. residential or rural landuse, dense vegetation), a range of values for various roughness types (i.e. long grass, dense vegetation) and structure losses (SKM, 2012b).

2 AVAILABLE DATA

The following provides a list of the data available for this study:

- **Floodplain Topography** – MBRC provided a DEM and Z points that were generated using a tool that was developed and run by Worley Parsons. The DEM resolution was 2.5m (half the 2D computational grid resolution). The topography is based on LiDAR data collected in 2009 and provided by the Department of Environment and Resource Management (DERM);
- **Hydrography (MBCR)** – Catchment delineation and hydrology model dataset provided by MBRC;
- **Floodplain Landuse** (Current and Future) – Polygon data for 9 different landuse categories established as part of Stage 1;
- **Floodplain Structures (Culverts and Bridges)** – As-constructed bridge plans for selected minor roads in MBRC LGA (provided by MBRC where available). Additional structure survey data, as undertaken by MBRC when no structure data was available. State controlled roads and minor road GIS layers provided by MBRC;
- **Design Rainfall** – Amendment of WBNM models, development of design simulations and provision of design rainfall hydrographs (from the 1 year ARI to the PMF);
- **Boundary Conditions, Joint Probability and Climate Risk Scenarios** – Report with recommendations for boundary conditions, joint probability and climate change scenarios; and
- **Floodplain Parameterisation** information, specifically about impervious percentages for various landuse types, roughness types and structure losses.

3 METHODOLOGY

3.1 Data Review

A number of data reviews were undertaken by BMT WBM. These reviews concern:

- The infrastructure data within the catchments;
- The historical flooding information of the catchments; and
- The broadscale subcatchment delineations.

The review and analysis of these data was compiled into three reports and issued to MRBC prior to completion of a draft detailed model. A summary of the data review reports is described below.

3.1.1 Infrastructure Data Assessment

This report reviewed the available infrastructure data provided by MBRC and the Department of Transport and Main Roads (DTMR) and identified any infrastructure data that needed to be collected for the detailed modelling of the Caboolture Catchment. Furthermore, this required data was prioritised into two categories: Priority A data (data which is critical for a high quality model) and Priority B data (all other data for which assumptions can be used and still achieve a relatively high quality model).

The key findings from this report include:

- 9 DTMR bridge and culvert structures were prioritised as category A, along with 14 additional crossings;
- 3 DTMR bridge and culvert structures were prioritised as category B, along with 41 additional crossings; and
- The details for the Caboolture River weir were required.

A full copy of this report is provided in Appendix A.

3.1.2 Calibration and Validation

The available information on historical flooding was provided by MBRC and reviewed as part of this report, along with the collection of gauge data from the Bureau of Meteorology (BoM). The feasibility of using historic flood events for calibrating the Caboolture model was assessed. The assessment concluded that there is sufficient data available in the catchment to perform calibration and validation to historical flood events, which was as follows:

- The January 2011 flood event was used for the model calibration; and
- The May 2009 flood event was used for the model verification.

A full copy of this report is provided in Appendix C.

3.1.3 Hydrography Review

The subcatchment delineation completed as part of Stage 1 was reviewed; a copy of the report letter is provided in Appendix B. The review recommended refinement of the subcatchment delineation in some locations (in the upper reaches of the catchment). MBRC adopted most of these recommendations, and re-issued the subcatchment delineation.

3.2 Hydrologic Model

The existing hydrological WBNM model for the Caboolture catchment was reviewed and updated using relevant data, utilising the WBNM 2010 beta version. The WBNM software was nominated by MBRC as the hydrologic software package for the RDF, and was used to model the design events (utilising existing landuse) and a future landuse scenario.

The subcatchment delineation and hydrology model were supplied by MBRC. Detailed hydrologic model parameters, such as adopted losses, design gauge locations and Intensity Frequency Duration (IFD) data, was based on methods adopted for the Burpengary Stage 2 Pilot Study and SKM (2010). The following methods were used for definition of design storms:

- 1 year ARI to 100 year ARI – AR&R (The Institution of Engineers Australia, 2001) was used to define rainfall depths and rainfall temporal patterns for storm events from 1 year ARI to 100 year ARI;
- 200 year ARI to 2000 year ARI – CRC Forge was used to define rainfall depths and temporal patterns were based on the temporal patterns adopted for the PMF events; and
- PMF – The Generalised Short Duration Method (GSDM) and the Revised Generalised Tropical Storm Method (GTSMR) were used, depending on the storm duration, to determine the Probable Maximum Precipitation and rainfall temporal patterns.

The flows derived from the hydrologic model were used as inflow to the hydraulic model.

3.3 Hydraulic Model

3.3.1 Model Software

Because of the complex nature of floodplain flow patterns in urban and rural catchments, MBRC has adopted TUFLOW, a dynamically-linked 2D/1D hydrodynamic numerical model, to predict the flood behaviour of the catchments in their LGA. TUFLOW has the ability to:

- Accurately represent overland flow paths, including flow diversion and breakouts (2D modelling);
- Model the waterway structures of the entire catchment with a relatively high level of accuracy (1D or 2D modelling);
- Dynamically link components of the 1D models (i.e. culverts) to any point in the 2D model area; and
- Produce high quality flood map output (i.e. flood extent, flood levels, depths, velocities, hazard and stream power), which are fully compatible with Geographic Information Systems (GIS).

3.3.2 Model Geometry

The TUFLOW model was based on two sets of Z points provided by MBRC for two computational grid resolutions: 5m and 10m. These Z point layers were used to develop a 5m grid model and a 10m grid model. The 5m grid resolution model was used for events up to and including the 100 year ARI Event. The 10m model was used for events larger than the 100 year ARI event, and also included the sensitivity runs. The two grid resolutions were adopted due to the catchment size and the model run times; i.e. the 10 grid resolution model was used to expedite the model run times. The origin of the Z points was used to set the origin of the 2D domain, and 2D domain orientation was set to zero (or horizontal; i.e. no rotation).

The elevation information was based on 2009 ALS data that was processed using a bespoke tool (processed by Worley Parsons). Stream and road modifiers were developed and supplied to MBRC to be incorporated in the DEM tool. These terrain modifiers generate break lines to capture streams gullies and road embankments in the Z points layer and DEM.

Figure 3-1 illustrates the Caboolture model layout.

3.3.3 Model Structures

The Caboolture catchment is moderately urbanised with large vegetated areas, particularly in the upper catchment. The waterways within the catchment were represented in the 2D domain using break line terrain modifiers, with invert levels inspected from a combination of the supplied DEM. Culvert crossings were typically represented in the model as 1D structures, with flow over these structures modelled within the 2D domain. Bridges and footbridges were represented in the 2D domain (using TUFLOW layered flow constriction features). The hydraulic structure details were provided by MBRC in the form of engineering drawings or digital data derived from a survey.

The adopted exit and entry loss coefficients applied to the hydraulic structures were based on values reported in SKM (2012b). Structure locations are shown on Figure 3-1.

3.3.4 Landuse Mapping

Landuse mapping was used to define the spatially varying hydraulic roughness within the hydraulic model. In total, ten different types of landuse were mapped and provided by MRBC, together with associated Manning’s ‘n’ values as presented in Table 3-1 and Figure 3-2.

Table 3-1 Hydraulic Model Landuse Categorisation

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

Three of the landuse categories used a depth varying Manning's roughness. This allows the Manning's roughness to be adjusted depending on the depth of water flowing over a surface. For example, when there is a small depth of water over grass, the resistance is high, and thus the Manning's roughness should be high. However, as the water gets deeper, the resistance of the grass is less, thus the Manning's roughness should be low. The depth varying Manning's roughness allows this to be represented.

In highly developed blocks, larger than 2000m^2, the urban block category was used (Manning's 'n' of 0.3). For areas outside the high density residential development, an individual building layer, showing the footprint of the building was used (Manning's 'n' of 1.0).

3.3.5 Model Boundaries

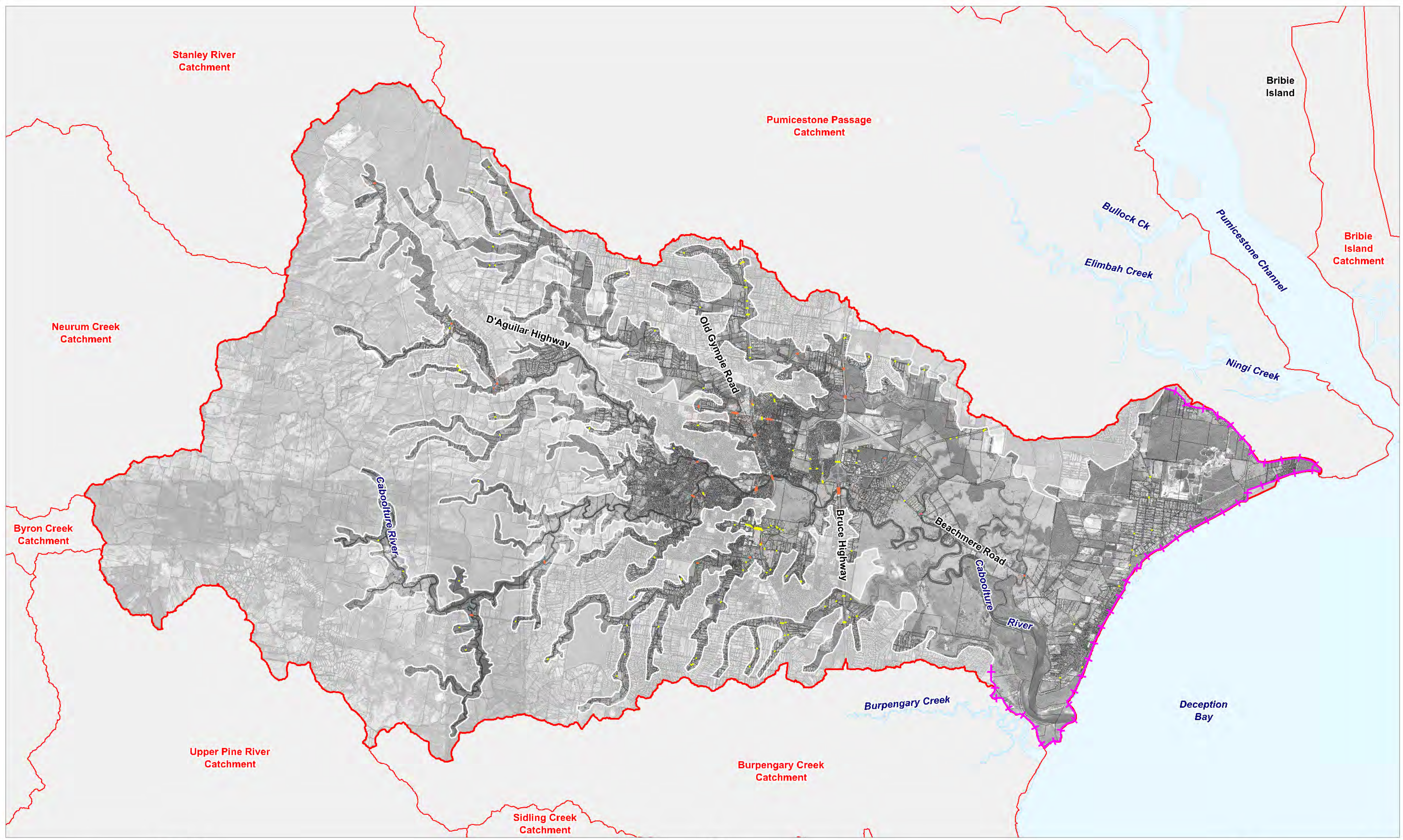
The results of the WBNM hydrologic model were used to generate rainfall inflows for the hydraulic model for all design events, as discussed in Section 0. The inflows were applied to the 2D domain using a flow-time source boundary spread over each subcatchment. This technique applies the inflow at the lowest grid cell in a subcatchment initially and then subsequently to all wet cells in that subcatchment.

The downstream boundary conditions, joint probability and climate change scenarios were based on recommendations in SKM (2012a). A static flood level was applied at the downstream boundary utilising the mean high water spring (MHWS) for all design events (see Table 3-2).

Sensitivity tests were undertaken for the downstream boundary (refer to Section 3.6).

Table 3-2 Downstream Boundary Water Level

Description	Level (mAHD)
Mean High Water Spring Tide (MHWS)	0.82



LEGEND

- Caboolture Catchment Boundary
- Hydraulic Model Boundary
- Cadastral Boundaries
- Downstream Boundary
- Culvert
- Bridge

Title:

Hydraulic Model Layout

Figure: 3-1

Rev: A

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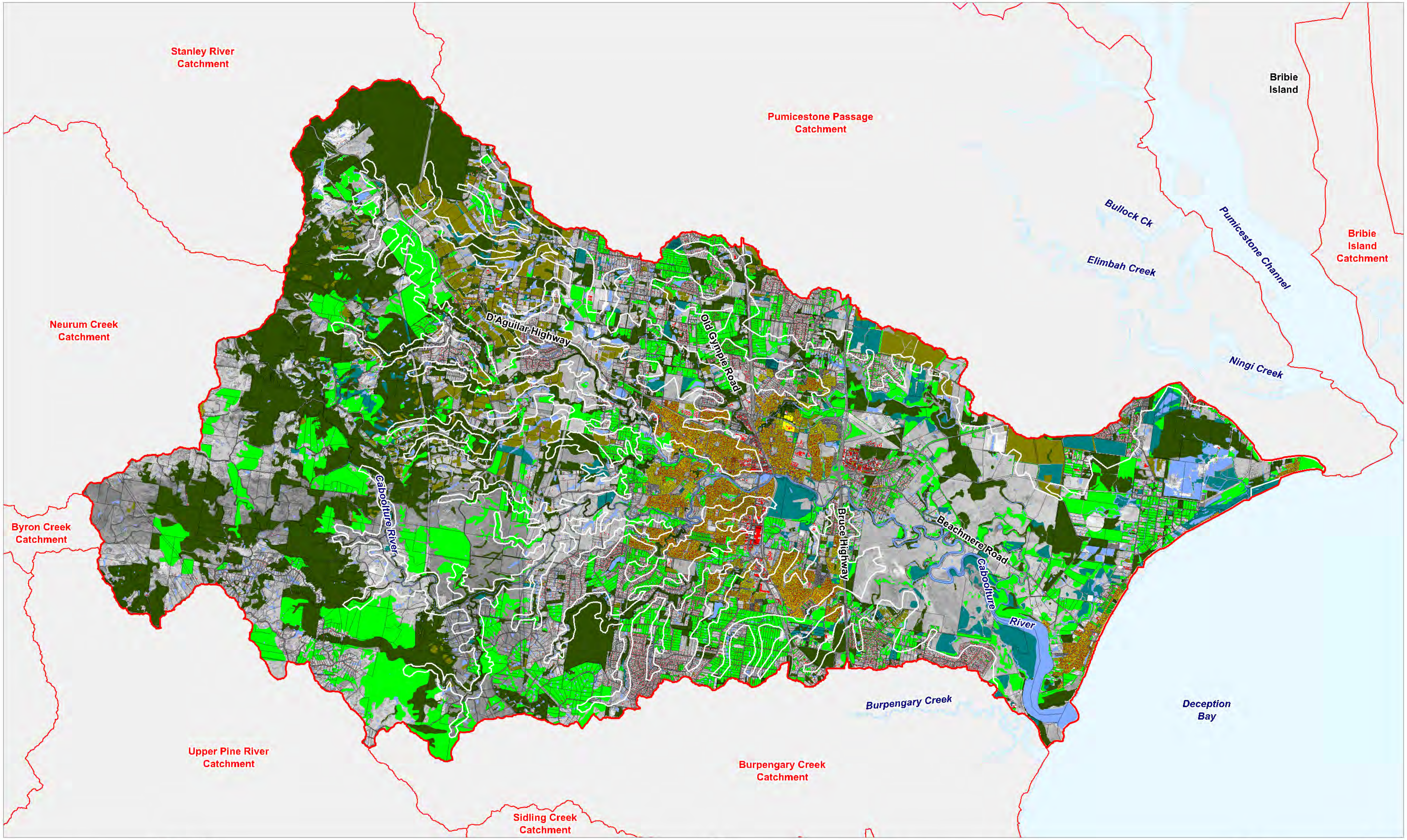

LEGEND

- Caboolture Catchment Boundary
- Hydraulic Model Boundary
- Cadastral Boundaries

Landuse

- Buildings
- Urban Blocks
- Roads/Footpaths
- Waterbodies
- Reeds
- Crops
- Medium Dense Vegetation
- Dense Vegetation

Title: **Landuse Mapping – Existing Conditions**

Figure: 3-2

Rev: A

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3.4 Model Calibration and Verification

Where possible, MBRC have sought to calibrate and verify the models in their LGA to historical flood events. The Caboolture catchment hydraulic model was calibrated and verified against the following two historical events:

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

These events were chosen due to the availability of rainfall and river stream gauge data and the availability of flood marks. A detailed flood survey was undertaken, and the flood marks collected by MBRC were provided for comparison with the modelled results. Details of the calibration feasibility assessment are documented in Appendix C.

3.5 Design Flood Events

This section describes the design storm conditions that were used in the hydrodynamic modelling. Design storm events are hypothetical events that are used to estimate design flood conditions. They are based on probability of occurrence, usually specified as an Average Recurrence Interval (ARI).

3.5.1 Critical Storm Duration Assessment

An assessment of critical storm durations (storm duration/s that results in the highest peak flood level) was undertaken. The critical durations were selected based on the hydraulic model results, rather than the hydrological model results. This means that the selected critical durations were selected based upon the maximum flood levels rather than flows. Separate assessments were undertaken for three representative flood events;

- 10 year ARI event, to represent smaller events (1, 2, 5 and 10 year ARI events);
- 100 year ARI event, to represent larger events (20, 50 and 100 year ARI events); and
- Probable maximum flood (PMF), to represent extreme events (200, 500, 1000 and 2000 year ARI events and the PMF).

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

1. Hydrologic and hydraulic modelling of a range of storm durations (1hr, 3hr, 6hr, 12hr, 24hr and 48hr) for the 10 year, 100 year and PMF events; 5 hour storm duration was also tested for the PMF event.
2. Mapping of the peak flood level results for the ‘maximum envelope’ of all the storm durations for the three representative events.
3. Mapping of the peak flood level results for the ‘maximum envelope’ of selected storm durations for the three representative events.
4. Difference comparison between the mapped peak flood levels for selected critical durations and the results accounting for *all* storm durations.

5. The critical duration combination resulting in the lead difference compared with the mapping of the full envelope of durations was adopted. Selection of the critical durations was based on the storm durations generating the highest flood levels across the most widespread and developed areas.

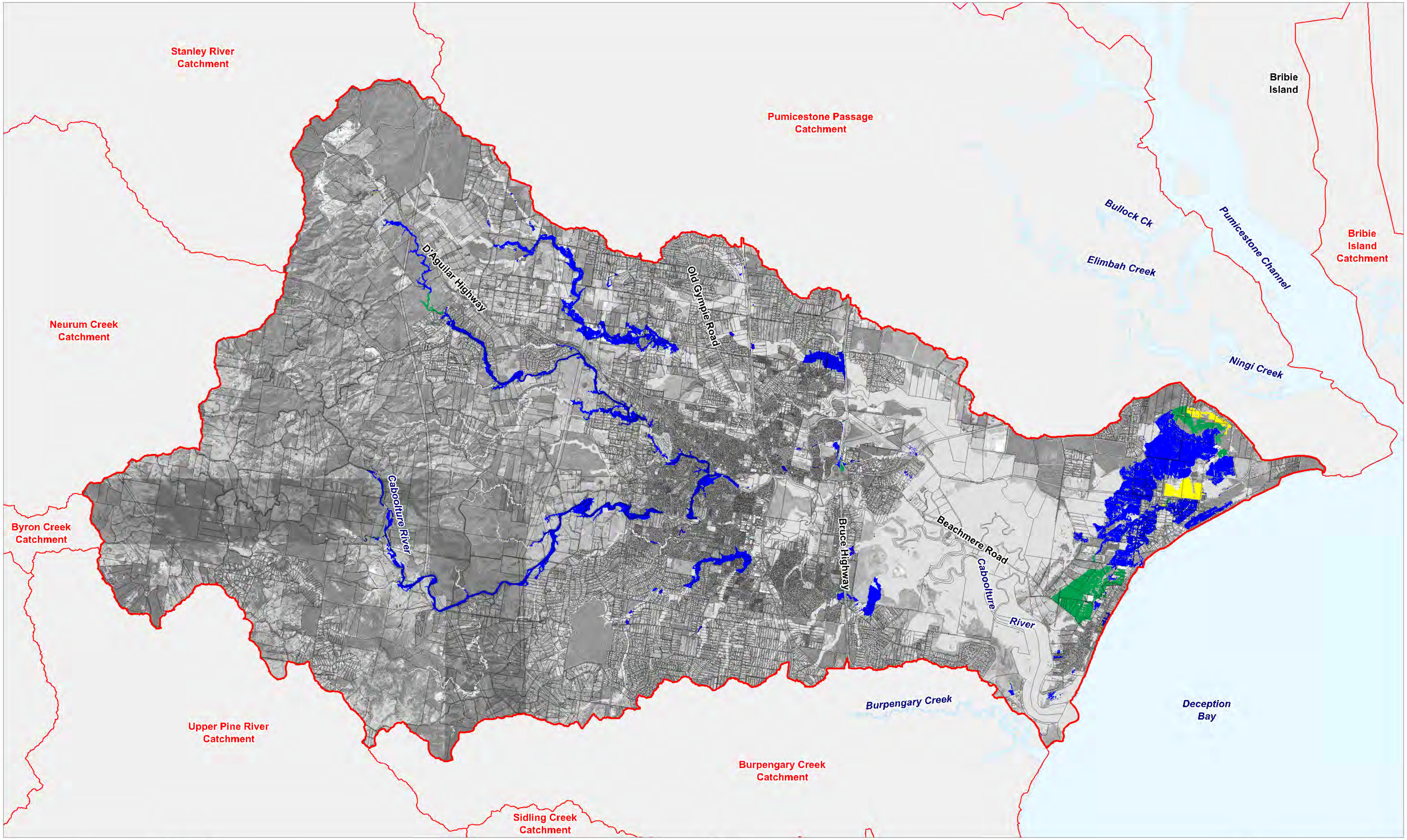
A summary of the selected critical storm durations for all events assessed is outlined in Table 3-3.

The difference comparison for the 10 and 100 year ARI and the PMF peak flood levels (as described in step 4 above) is shown in Figure 3-3 to Figure 3-5. The figures illustrate that the selected critical durations generally capture the peak flood levels across the site in developed areas. There are some localised areas where flood levels are under predicted.

Table 3-3 Critical Storm Duration Selection

Assessment Event	Selected Critical Durations	Adopted Event
10 year ARI	3, 6 and 12 hour storm	1, 2, 5 and 10 year ARI
100 year ARI	3, 6 and 12 hour storm	20, 50 and 100 year ARI
Probable Maximum Flood	3, 5 and 24 hour storm	200, 500, 1000, 2000 year ARI and PMF

This process was undertaken in consultation with MBRC, as their knowledge on local catchment and development issues was a factor in the decision-making and selection of the 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 -0.01
- No Change

Title:

Critical Duration Assessment
Peak Flood Level Difference – 10 Year ARI

Figure: 3-3

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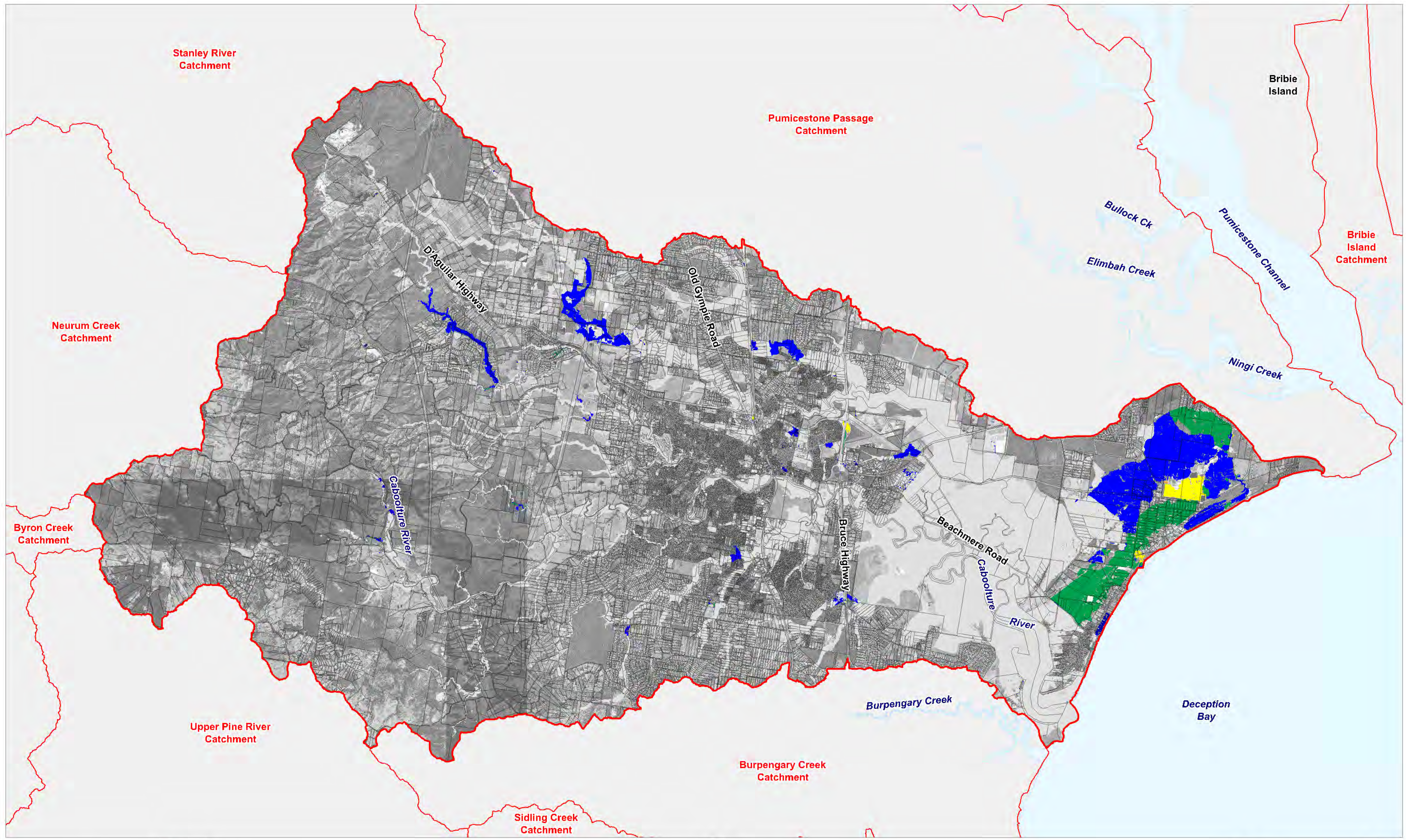

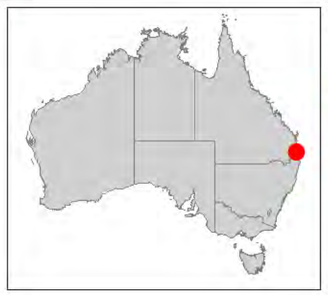

LEGEND

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 -0.01
- No Change

Title:

Critical Duration Assessment
Peak Flood Level Difference – 100 Year ARI

Figure: 3-4

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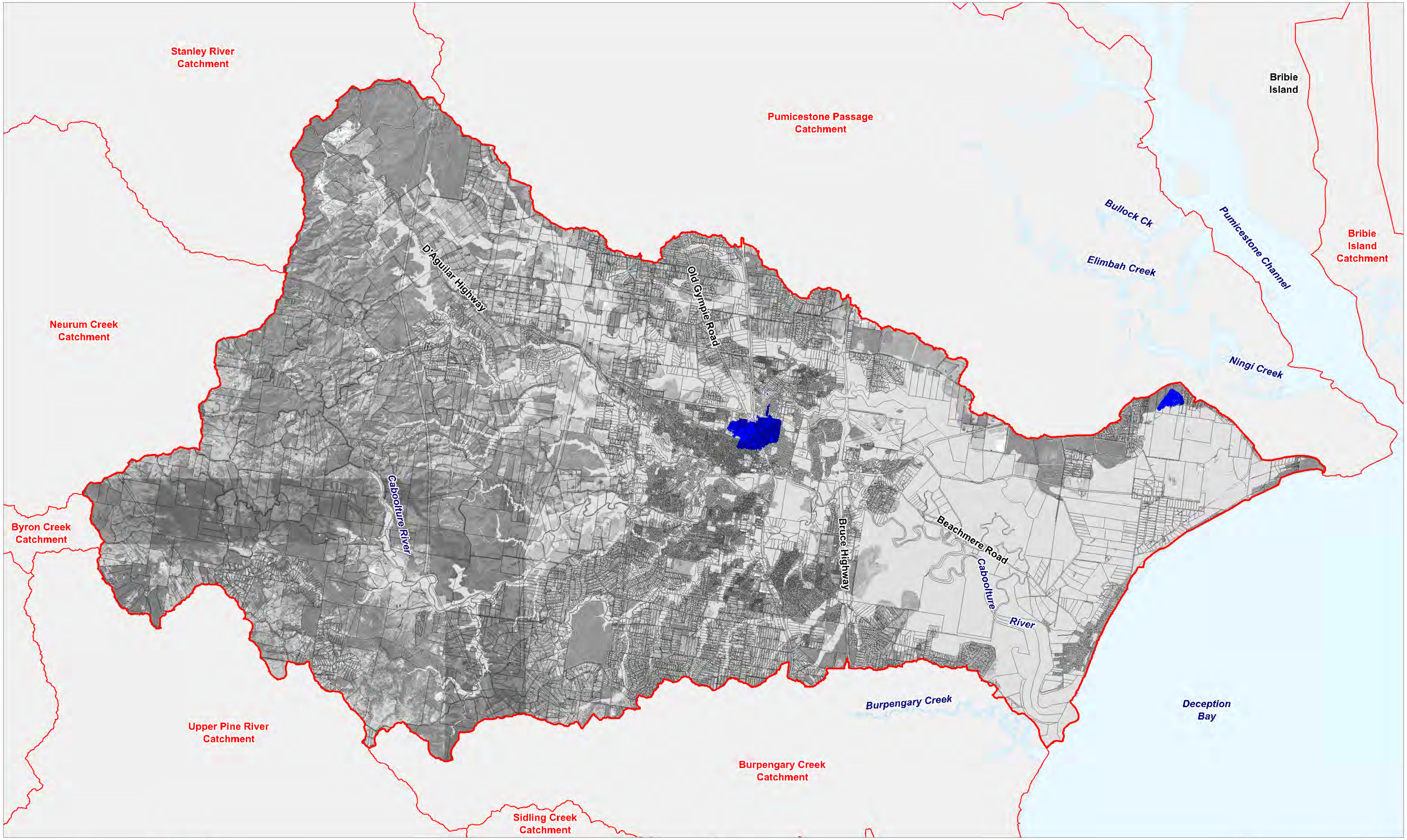

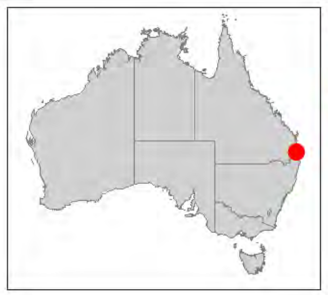

LEGEND

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 -0.01
- No Change

Title:

Critical Duration Assessment
Peak Flood Level Difference – PMF

Figure: **3-5**

Rev: **A**

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3.5.2 Design Event Simulations

The Caboolture model was simulated for a range of ARI and storm durations and a 100 Year Embedded Design Storm (EDS). MBRC 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).

MBRC advised that the100 year ARI 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 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000 year ARI events and the PMF events for the selected critical storm durations; and
- The 100 year Embedded Design Storm (EDS) for a 15 minute in 270 minute envelope storm.

3.6 Sensitivity Analysis

3.6.1 Future Landuse Analysis

Three future landuse scenarios were assessed using future landuse data provided by MBRC. The future scenarios did not include a change in rainfall intensities or sea level rise due to climate change. The 100 year 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 MBRC.

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 forecast future development (provided by MBRC) 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.

3.6.2 Hydraulic Roughness Analysis

The sensitivity of the model to landuse roughness (Manning's 'n') parameters was undertaken with the 100 year EDS design event. All Manning's 'n' values in the 2D domain were increased by 20%.

3.6.3 Structure Blockage Analysis

A blockage scenario was run to simulate the effects of waterway crossing (culverts) becoming blocked during a flood event. This is a reasonably common occurrence and is the result of debris being washed into the waterways during a flood. Recent storm event showed that blockages are generally caused by debris, or larger items, such as tree stems, wood planks, shopping trolleys or even cars. Blockages reduce the capacity for water to flow through stormwater infrastructure and force water out of the channel, often increasing overland flooding.

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.

3.6.4 Climate Change and Downstream Boundary Condition Analysis

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 6 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;
- **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 (100 year 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 100 year static storm tide level (2.5mAHD) with concurrent 100 year EDS rainfall event; and
- S**torm 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 (100 year GHG) + 0.8m, resulting in a final static storm tide level of 3.6mAHD.

4 RESULTS AND OUTCOMES

4.1 Calibration and Verification

4.1.1 Overview

Calibration and verification of the modeling 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 as a verification event.

Measured rainfall data was used in the hydrology model to estimate runoff flows through the catchment. These flows were then routed through the TUFLOW model, with the downstream boundary adjusted to represent the expected tidal conditions during the historical events.

MBRC provided a number of surveyed peak flood marks in the catchment for the two historical events. Measured water levels at three stream gauges were also provided for the analysis: Wamuran, Upper Caboolture and Caboolture Water Treatment Plant (WTP) gauges. These measured water levels were compared to the modelled water levels, and the model parameters were adjusted a number of times to improve the correlation between measured and modelled flood levels. Full details of the calibration/verification can be found in the model calibration report in Appendix C.

Following the calibration and verification exercise (and subsequent to the model calibration report in Appendix C), MBRC selected the final hydraulic roughness parameters in light of the calibration results across the whole region. These hydraulic roughness values are listed in Table 3-1. The results using the final adopted parameters are discussed below.

4.1.2 January 2011 Results

Comparisons of the measured and modelled water levels for the January 2011 flood are shown in Figure 4-1 to Figure 4-4.

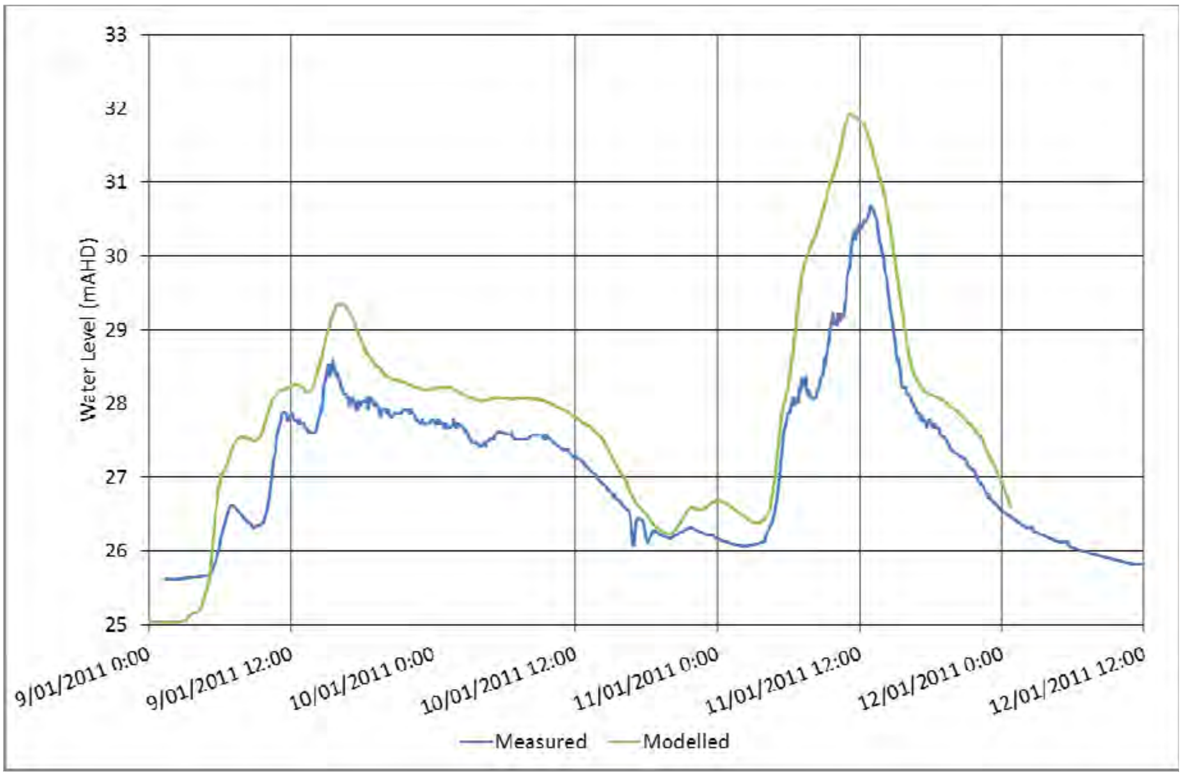

Figure 4-1 Flood Level Comparison at Wamuran Gauge for January 2011

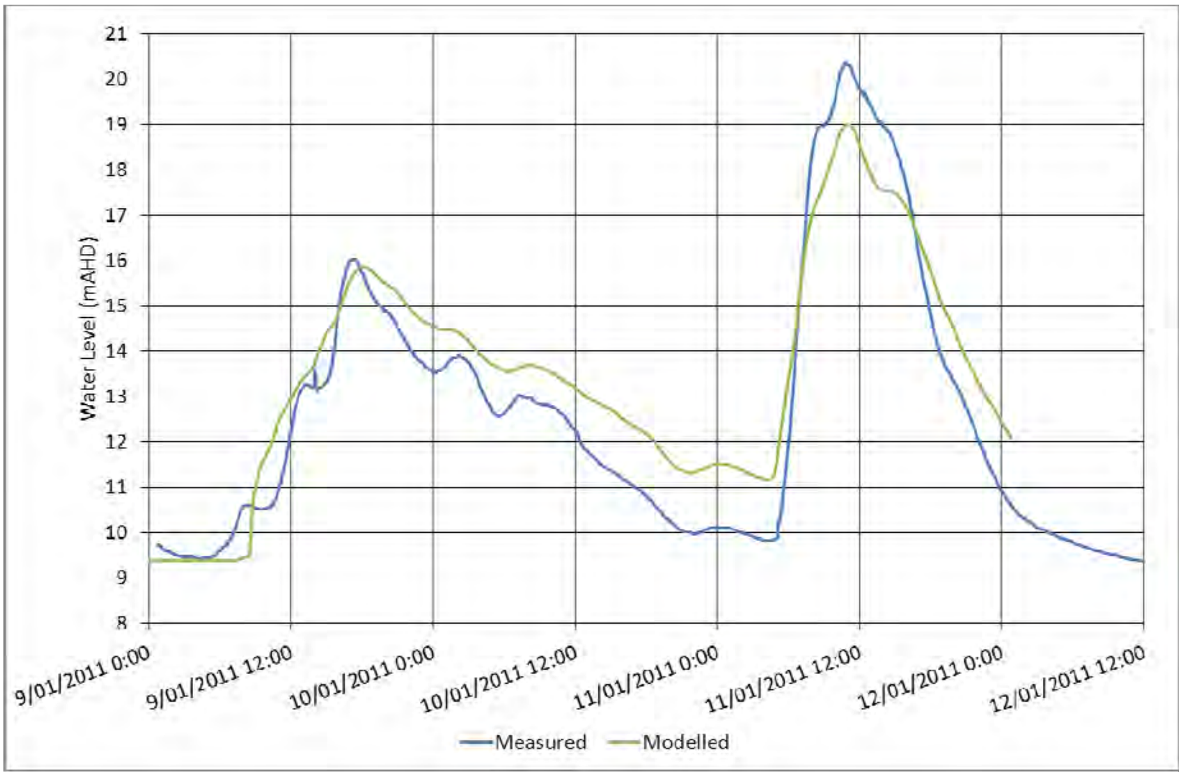

Figure 4-2 Flood Level Comparison at Upper Caboolture Gauge for January 2011

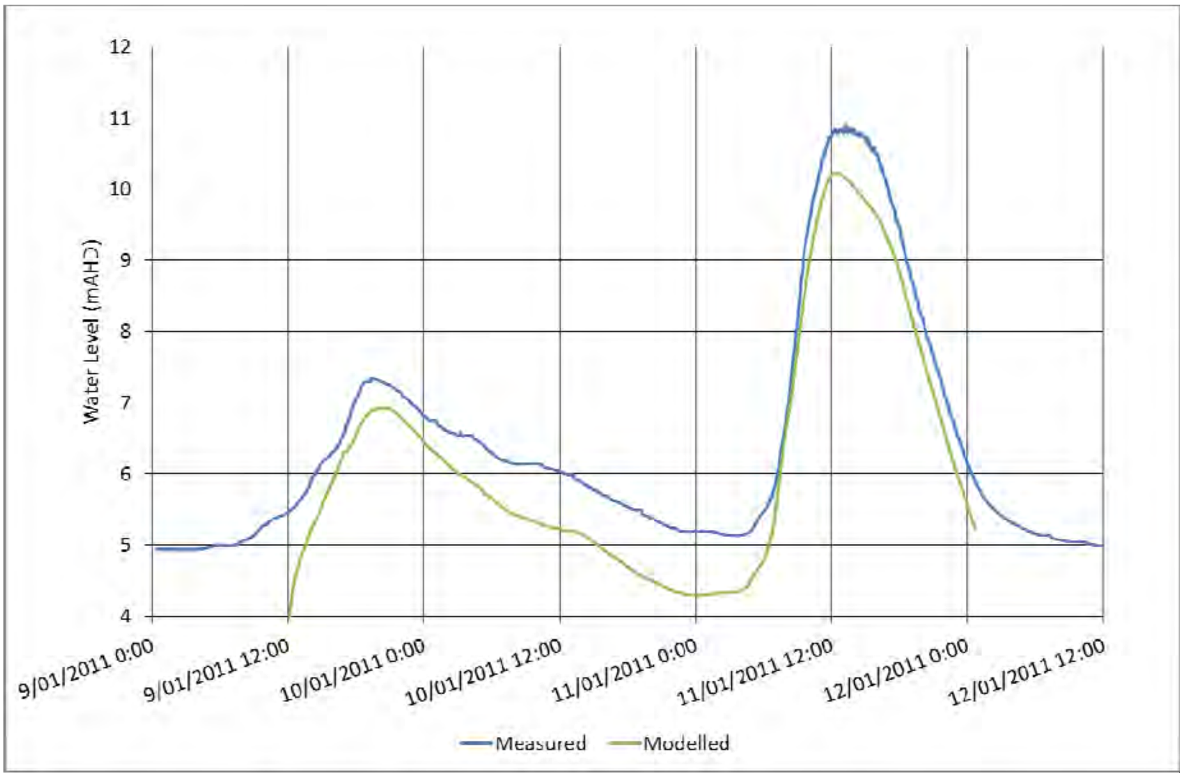

Figure 4-3 Flood Level Comparison at Caboolture WTP Gauge for January 2011

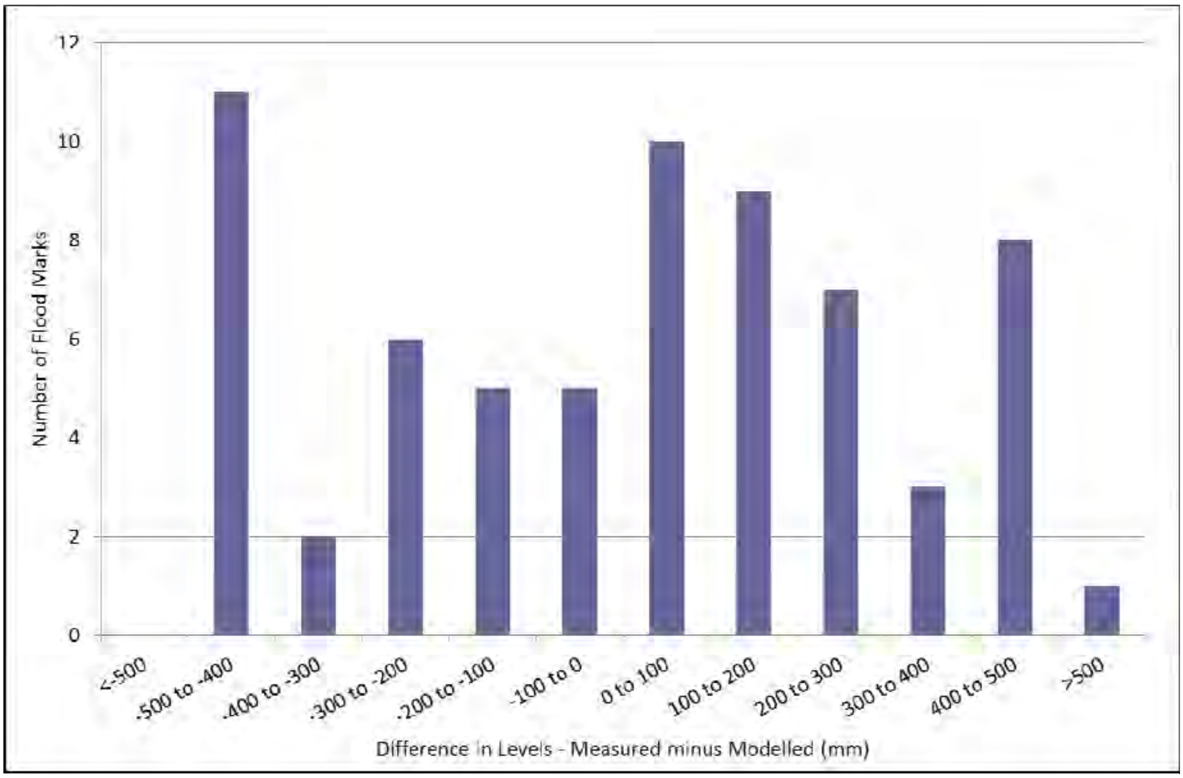

Figure 4-4 Flood Mark Histogram for January 2011 Flood

Comparison of the modelled and measured levels at the three gauges indicates that:

- The model over predicted the peak flood level at the Wamuran gauge by 1.26m;
- The model under predicted the peak flood level at the Upper Caboolture gauge by 1.37m;
- The model under predicted the peak flood level at the Caboolture WTP gauge by 0.66m; and
- The general profiles of the modelled and measured hydrographs match relatively well.

Comparison of the surveyed flood marks with modelled peak flood levels indicates that:

- 41% of the surveyed flood marks were within 0.3m of the modelled peak flood level;
- 37% of the surveyed flood marks were more than 0.3m higher than the modelled peak flood level; and
- 22% of the surveyed flood marks were more than 0.3m lower than the modelled peak flood levels.

4.1.3 May 2009 Results

Comparisons of the measured and modelled water levels for the January 2011 flood are shown in Figure 4-5 to Figure 4-7.

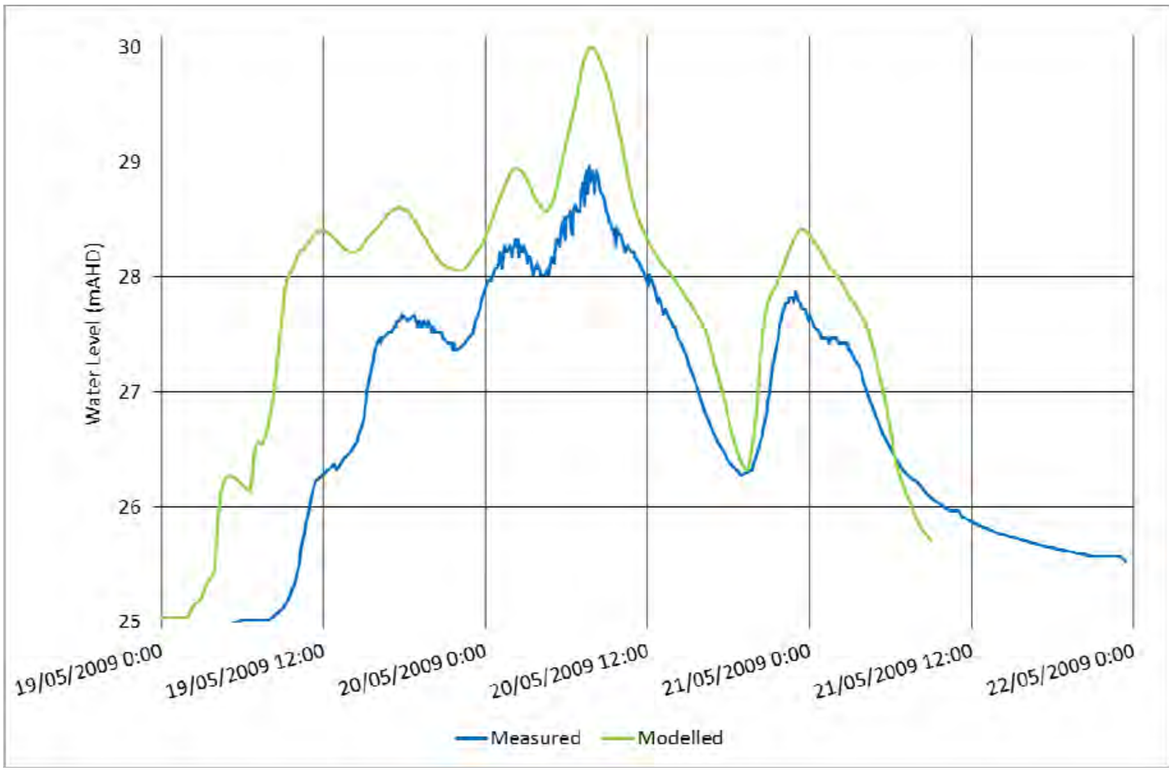

Figure 4-5 Flood Level Comparison at Wamuran Gauge for May 2009

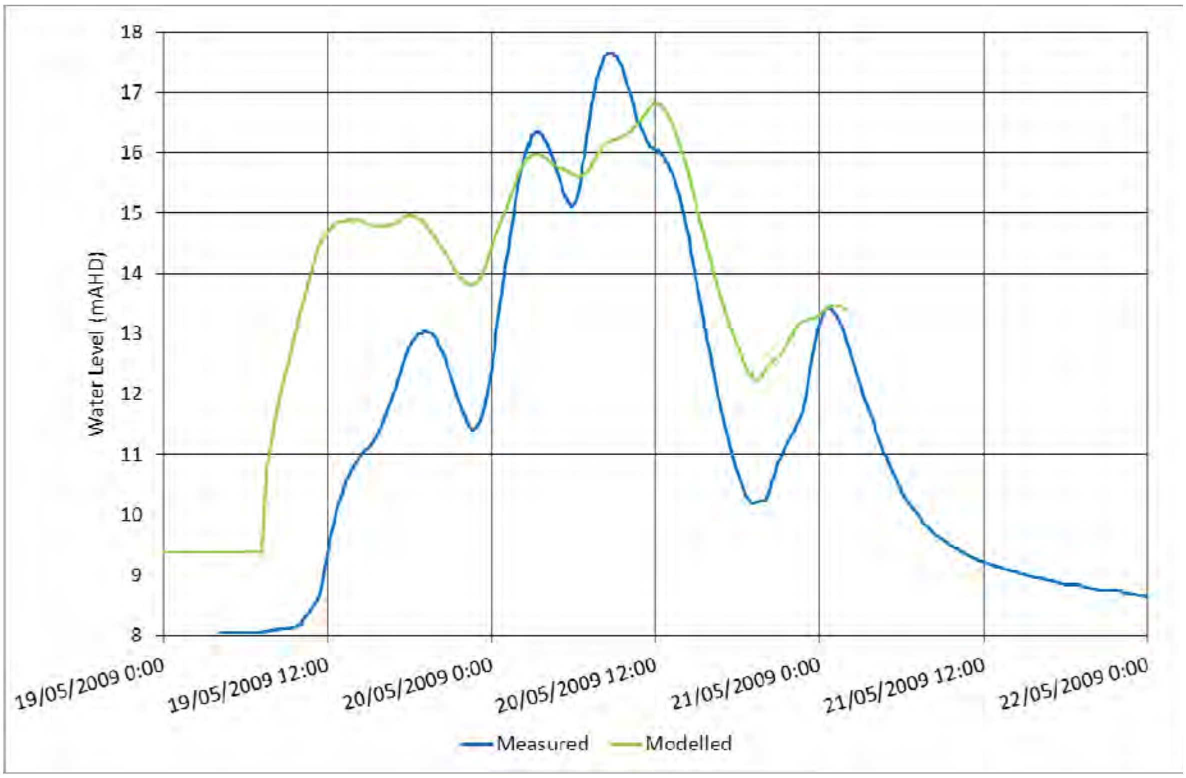

Figure 4-6 Flood Level Comparison at Upper Caboolture Gauge for May 2009

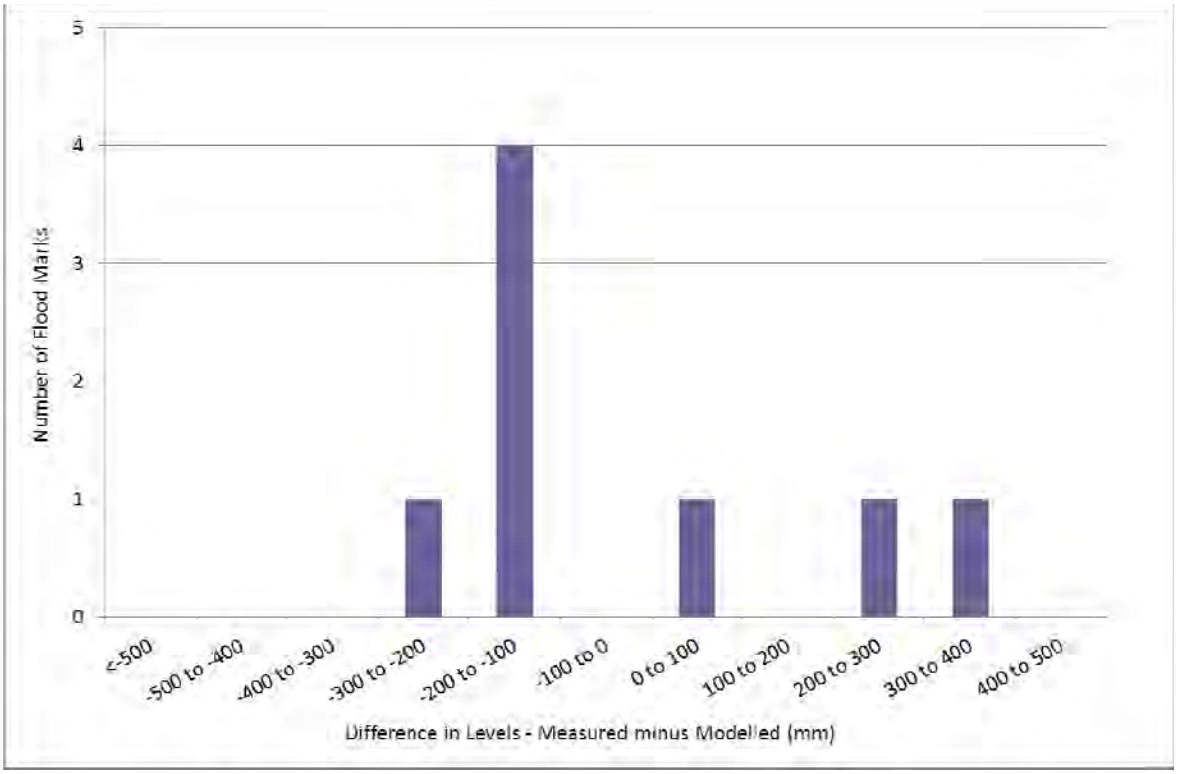

Figure 4-7 Flood Mark Histogram for May 2009 Flood

Of the 8 surveyed flood marks, 7 were within 0.3m of the modelled peak flood level. The model over predicted the peak flood level at Wamuran gauge by 0.98m and under predicted the peak flood level at the Upper Caboolture Gauge by 0.9m.

4.1.4 Conclusion

The model results indicate that the model replicates the historical flood behavior reasonably well. However there are some noticeable discrepancies. This may, in part, be due to insufficient data to enable the model to adequately capture the spatial distribution of rainfall patterns across the catchment. Inspection of radar data for the January 2012 event indicates that the location of the rain gauges (and rainfall interpolation between the gauges) 'missed' a zone of high rainfall in the western part of the catchment (as discussed in the model calibration report, Appendix C). Limitations in the model design may also have contributed to discrepancies between modelled and measured flood levels, particularly in upper parts of the catchment.

Localised model adjustments may have resulted in better "fit" between the measured and modelled results. However such a course of action would be counter to Council's objective for a regionally consistent model library. Localised model adjustments may also mask underlying modelling uncertainties and input data limitations. The adopted parameter set was therefore considered on-balance to be appropriate to this model. It is also noted that this decision was reached by Council having regard to similar calibration and verification exercises in adjoining catchments. These results therefore need to be considered in the context of a regional calibration approach across multiple model domains.

4.2 Design Flood Behaviour

4.2.1 Model Results

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. Flood Hazard based on NSW Floodplain Development Manual (DIPNR, 2005) (Z1 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 100 year ARI flood 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 100 year ARI design 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 MBRC for incorporation into their RFD is summarised in Section 4.2.2. The flood maps of the 100 year ARI design storm event are presented in Appendix E.

4.2.2 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 MBRC 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).

4.3 Sensitivity Analysis

The 100 year Embedded Design Storm (100 year ARI 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 F. A comparison of the EDS event with the 100 year design flood event with selected critical durations (3, 6 and 12 hour) is shown in Figure F1. The results indicate that peak flood levels for the EDS is up to 500mm lower than the envelope of selected critical durations, predominantly in the downstream part of the catchment. Therefore, it is recommended that future sensitivity analyses undertaken during model upgrades use the selected critical duration design events rather than the EDS event in order to eliminate these under predictions.

4.3.1 Future Landuse Analysis

The Caboolture catchment is generally insensitive to changes in vegetation throughout most of the catchment, with some areas of increased sensitivity in the upstream catchment. Furthermore, the catchment is highly insensitive to increases in residential development. These results reflect what would be expected, as the catchment is highly vegetated, particularly around the watercourses.

Increases in peak flood levels through the catchment as a result of the changes to vegetation are in the order of 500mm in some of the upper reaches of the catchment. There is a localised decrease in flood levels of up to 500mm upstream of Wamuran.

An increase in residential development has no significant impact on peak flood levels across the floodplain.

4.3.2 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, apart from some areas of dense vegetation in the upper catchment where the impact is approximately 400mm.

4.3.3 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, and in some areas there has been a decrease in flood levels downstream of a structure. These flood level increases are significant in some places, being over 0.5m.

4.3.4 Climate Change and Downstream Boundary Conditions Analysis

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

An increase in rainfall through the catchment has a significant impact on flood levels within the upper catchment, with increases often greater than 500mm. In the downstream catchment, the impact of the increase in rainfall is in 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. There is also a localised decrease in levels in the water bodies near Bayside Drive in Godwin Beach.

The impacts outlined in the two scenarios above are exacerbated for the combined climate change scenario. Impacts within the middle of the catchment are particularly impacted, with an increase of impacts of up between 100mm to 500mm.

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, decreasing to a difference of between 100mm to 500mm towards the middle of the catchment. However, much of this area is undeveloped. These differences are further exacerbated when combined with an increase in rainfall intensity and sea level rise, with increases of greater than 500mm throughout most of the downstream catchment.

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

4.4 Model Limitations

Watercourses within the Caboolture catchment were represented in the 2D domain, for which the grid resolution is limited to either 5mor 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.

5 CONCLUSION

Two TUFLOW models of the Caboolture catchment were developed:

i. A 5m grid resolution model for events smaller than the 100 year ARI event; and

ii. A 10m grid resolution model for events larger than the 100 year ARI event (including sensitivity runs).

The model was set up in a manner prescribed by MBRC 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 MBRC's Regional Floodplain Database. The main focus of the project is delivery of the model and its outputs in digital format, therefore only a selection of results have been presented in this report. The outcomes of this work will be used in stage 3 of the RFD to analyse and assist with managing flood risk in the Caboolture catchment.

6 REFERENCES

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GHD (2010): *Moreton Bay Regional Council Regional Floodplain Database Sub-project 2K Historic Flood Information*

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SKM (2012b): *MBRC Regional Floodplain Database Floodplain Parameterisation*

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Worley Parsons (2010b): *Design Rainfall - Burpengary Pilot Project*

APPENDIX A

A part of BMT in Energy and Environment

Infrastructure Data Assessment Report Caboolture River Catchment Regional Council's Regional Floodplain Database Stage 2

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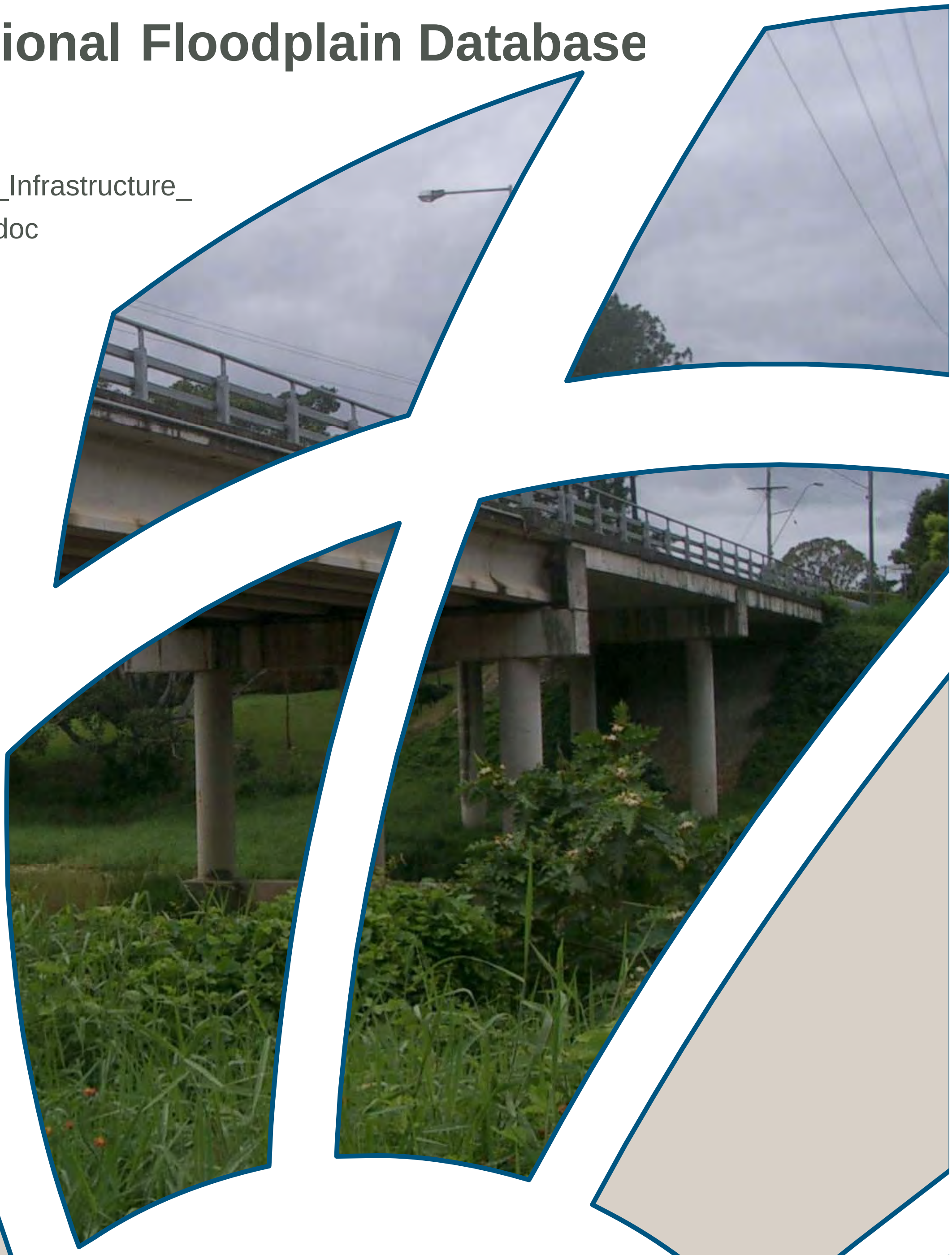
June 2012



Infrastructure Data Assessment Report Caboolture River Catchment Regional Floodplain Database Stage 2

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

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	Client : ***Client Contact:*** ***Client Reference***	Moreton Bay Regional Council Steve Roso / Hester van Zijl Regional Floodplain Database Stage 2

Title :	Infrastructure Data Assessment Report for the Caboolture River Catchment as part of Moreton Bay Regional Council's Regional Floodplain Database Stage 2
Author :	Anne Kolega / Richard Sharpe
Synopsis :	Infrastructure Data Assessment Report including the review and prioritisation of available and required infrastructure data for the detailed modelling of the Caboolture River catchment for Moreton Bay Regional Councils RFD Stage 2

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CONTENTS

LIST OF FIGURES

1 INTRODUCTION

1.1 Background

Moreton Bay Regional Council (MBRC) is currently undertaking Stage 2 of developing a Regional Floodplain Database (RFD). The RFD includes the development of coupled hydrologic and hydraulic models for the entire local government area (LGA) that are capable of seamless interaction with a spatial database to deliver detailed information about flood behaviour across the region.

Stage 2 includes the detailed hydrologic and hydraulic modelling of 5 packages, which cover 11 catchments in MBRC LGA. This *Infrastructure Data Assessment report* forms part of the hydrologic and hydraulic modelling report of the Caboolture River catchment RFD Stage 2, Package 4.

1.2 Scope

The scope of this report can be summarised in the following key points:

- Review available information provided by Council and the Department of Transport and Main Roads (DTMR);
- Undertake a gap analysis based on the broadscale model results and other data provided by Council (i.e. cadastre, local roads, state controlled roads, topographic data);
- Identify infrastructure data that need to be collected for the detailed modelling;
- Prioritise the additional infrastructure data required; and
- Document methodology and required infrastructure data in an Infrastructure Data Assessment report.

1.3 Objective

The objective is to prioritise additional required data, based on the philosophy that detailed information is to be collected to develop a high quality model, with the 100 year ARI flood behaviour being of particular interest, more than smaller events.

Priority A data involves data that is critical for a high quality model; Priority B is to include all remaining data for which assumptions, such as field inspection and desktop measurements, could be used *and* achieve a relatively high quality model.

This report has been provided to MBRC for review and further negotiation of required data considering the broader RFD objectives and potential budget constraints for all 5 packages.

2 AVAILABLE DATA FOR GAP ANALYSIS

The infrastructure data assessment was based on the following data being available at commencement of the study:

- Topographic data: The topography is based on LiDAR (**Li**ght **D**etection **A**nd **R**anging) data collected in 2009 and provided by Department of Environment and Resource Management (DERM). The LiDAR data was used to create a 2.5m grid Digital Elevation Model (DEM);
- Hydrography Dataset provided by MBRC in September 2010;
- State controlled roads and minor roads GIS layers provided by MBRC in September 2010;
- As-constructed bridge plans for selected structures along state controlled roads provided by DTMR where available. The categorisation of high, medium and low priority for the DTMR structures was previously undertaken by Aurecon. Based on this desktop assessment, Council requested the as-constructed plans from DTMR to speed up the data consolidation process;
- As-constructed bridge plans for selected minor roads in MBRC LGA were provided by MBRC where available;
- MBRC undertook further survey of structures in the Caboolture River catchment, where no structure data was available. The selection of the structure to be surveyed wa mainly based on aerial photography;
- The flood extents from the Stage 1 broadscale model sub-project were utilised to locate potential structures; and
- A site visit undertaken in the Caboolture River catchment on 1 October 2010.

3 DATA CAPTURE METHODOLOGY

3.1 General Methodology

This section describes the methodology for the gap analysis and data prioritisation. All available data outlined in Section 0 were converted into GIS layers and reviewed. The state controlled roads layers were overlaid with the broadscale flood extent in the probable maximum flood (PMF) event to locate waterway structures. Each crossing was marked, if none of the available data already existed in these locations (gap analysis).

The DTMR structures that have previously been categorised as *medium* and *low* priority were reviewed and prioritised.

The data prioritisation was undertaken based on the following considerations:

- The location of the structures within the catchment; e.g. structure data were considered lower priority at the upstream end of tributaries;
- The vicinity to denser populated areas; e.g. rural areas in the upper part of the catchment were considered lower priority;
- The height of a bridge structure, e.g. if the road and structure soffit is well above the water level (i.e. River Drive Bridge across Caboolture River, refer to Figure B-5), it is anticipated that a flow constriction can be applied to the model based on photos and the site visit; and
- The flood gradient and flood behaviour in the vicinity of the structures based on the broadscale model results; where a structure is located within a wide floodplain and not within the major flowpath, (downstream part of the catchment along Beachmere Road), details were considered of lower priority.

The outcomes of the gap analysis and prioritisation are presented in the section below.

3.2 Data Prioritisation (A and B)

3.2.1 Bridges and Culverts

The gap analysis in the Caboolture River catchment identified the following summary of available data and potential additional structure locations:

- MBRC bridge plans were provided for 5 structures;
- MBRC provided recently collected survey data for additional approximately 95 structures;
- DTMR bridges (high, medium and low category) were identified at approximately 30 locations; and
- Structures with no available information have been located at 55 road and flood extent crossings. Figure A-1 in the Appendix provides a summary of the available and the additional structures identified from the gap analysis. The data prioritisation undertaken in category A and B for the additional locations and the remaining DTMR structures are illustrated in Figure A-2.

The data prioritisation results in the following summary for bridges and culverts:

- 9 DTMR structures prioritised as category A (that were previously categorised "medium");
- 3 DTMR structures prioritised as category B (that were previously categorised "low");
- 14 additional crossings (bridges or culverts) prioritised as category A; and
- 41 additional crossings (bridges or culverts) prioritised as category B.

In consultation with MBRC, it is anticipated that Council will source and provide the DTMR as-constructed bridge plans (at least for priority A). It should be noted that some of the crossings may include the intersections of the waterway with roads and railway, for instance along Beerburrum Road.

3.2.2 Channels

During the site visit, a channel along Rarity Street was identified with an approximate width of 5m and an approximate depth of 1m. It was confirmed that this channel was included in the DEM provided.

3.2.3 Detention Basins

No major detention basins were identified in the Caboolture River catchment; minor basins and/or wetlands have been identified based on the DEM.

3.2.4 Caboolture River Weir

The Caboolture River weir is currently not included in the DEM. Details of the weir, such as survey of the weir crest is required for inclusion in the model. This information may be sourced from SEQwater. The weir is located to the east of Morayfield Road and to the south of Lower King Street.

Figure 3-1 Location of Caboolture River Weir

3.2.5 Bathymetry

Bathymetry was collected by MBRC in May 2009 as part of Stage 1. Therefore, no additional bathymetry data is required.

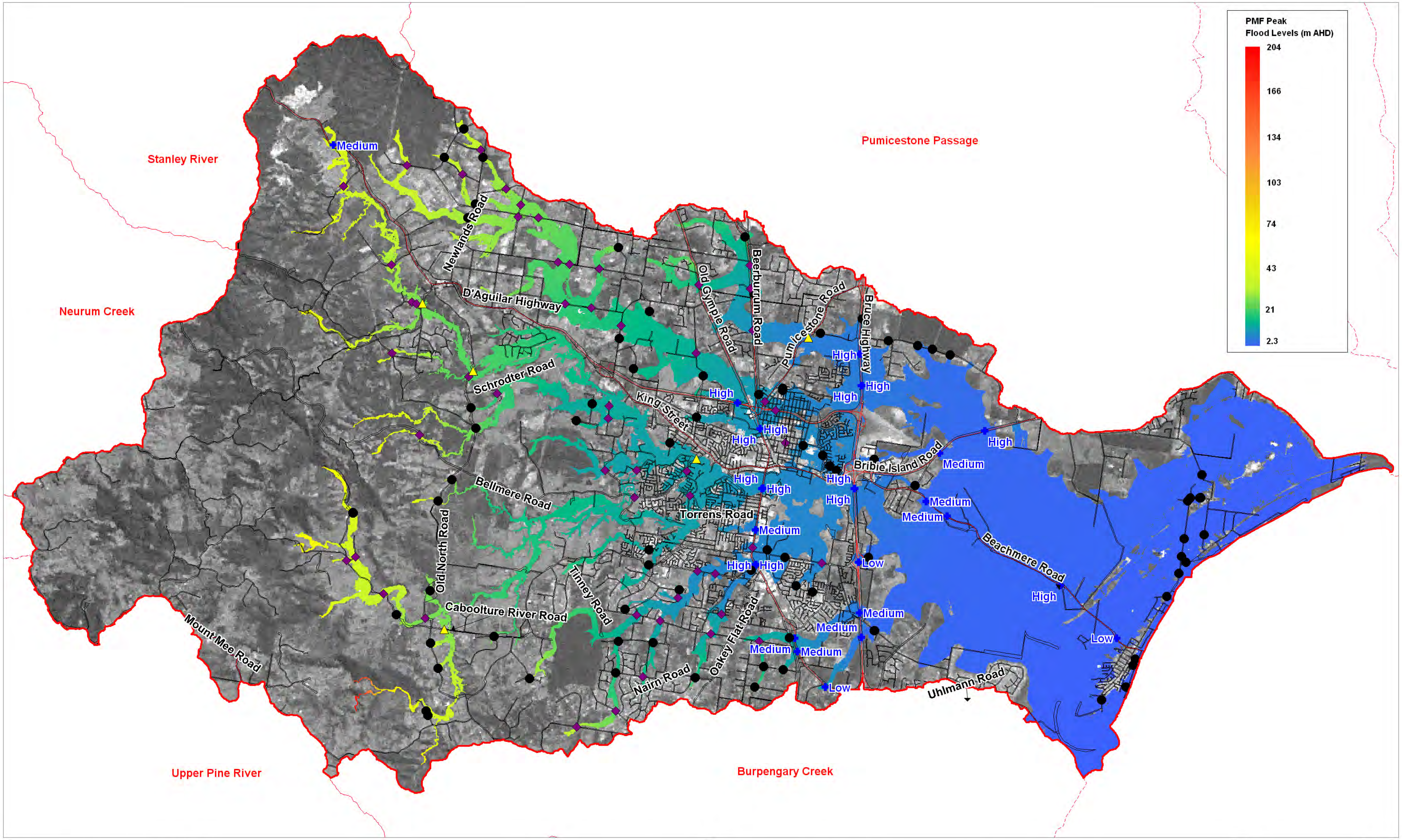
4 CONCLUSION AND RECOMMENDATION

This Infrastructure Data Assessment report has summarised available structure data as well as locations where additional structure data is required. The additional structures have been prioritised in two categories.

Priority A data involves data that is critical for a high quality model; Priority B includes all remaining data for which assumptions, such as field inspection and desktop measurements could be used *and* achieve a relatively high quality model.

The development of the Regional Floodplain Database (RFD) will be used not only for the purposes of the RFD, but can also be used for other asset data management purposes by Moreton Bay Regional Council, and therefore this is a good opportunity for Council to collect additional data on waterway structures, especially in the former Caboolture Shire Council and Redcliffe City Council areas.

APPENDIX A: MAPS



LEGEND

- Caboolture Catchment
- Road Reserves
- DMTR Structures (previous categories)
- Structures Surveyed by MBRC
- Bridges with As-Construction Plans provided by MBRC
- Additional Identified Structures
- State Controlled Roads
- Minor Roads and Road Reserves

Title:

Infrastructure Data Summary - Caboolture River

Figure: A-1

Rev: A

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Approx. Scale

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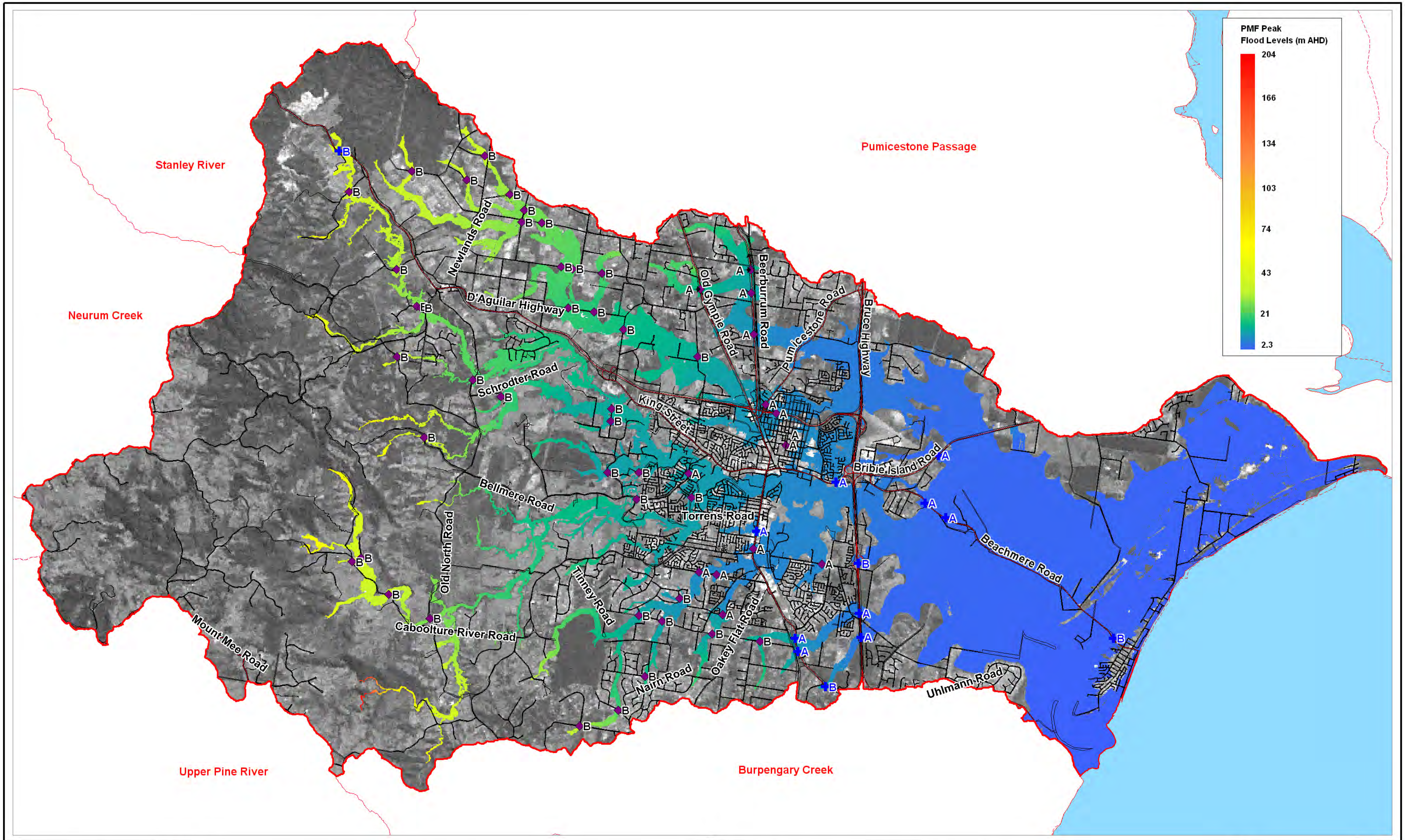

LEGEND

- Caboolture Catchment
- Road Reserves
- DMTR Structures (previous categories)
- Additional Identified Structures
- State Controlled Roads
- Minor Roads and Road Reserves

Title:

Data Prioritisation Map- Caboolture River

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APPENDIX B: SITE VISIT PHOTOS

Figure B- 1 Channel along Rarity Street Upstream and Downstream of McKean Street

Figure B- 2 Beerburrum Road looking towards the Railway, south

Figure B- 3 Beerburrum Road looking towards the Railway, north

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Figure B- 6 Six Mile Creek Bridge (Priority B)

Figure B- 7 Sheep Creek Bridge, Walkers Road near Koala Drive

Figure B- 8 Sheep Creek Bridge, Along Walkers Road and west of Petersen Road

Figure B- 9 Sheep Creek, Caboolture River Road

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, Unit 120** **Centennial Denver Colorado 80112 USA** **Tel +1 303 792 9814 Fax +1 303 792 9742** **Email denver@bmtwbm.com** **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**
BMT WBM Perth	**Unit 6, 29 Hood Street, Subiaco 6008** **Tel +61 8 9322 1577 Fax +61 8 9226 0832** **Email perth@bmtwbm.com.au** **Web www.bmtwbm.com.au**
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BMT WBM Vancouver	**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.au**

APPENDIX B

BMT WBM Pty Ltd
Level 11, 490 Upper Edward 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.wbmpl.com.au

Our Ref: AK: L.B18104.002.Hydrography Review.doc

10 December 2010

Hester van Zijl
Waterways & Coastal Planning, Infrastructure Planning
Moreton Bay Regional Council

Attention: Hester van Zijl

Dear Hester,

RE: Hydrography Review Report for the Hays Inlet, Redcliffe and Caboolture River Catchments Regional Floodplain Database Stage 2, Packages 2 and 4

1 Background

Moreton Bay Regional Council (MBRC) is currently developing a Regional Floodplain Database (RFD). The RFD includes the development and storage of hydrologic and hydraulic models for the entire Local Government Area (LGA). These model input and output data will be included in a spatial database to store detailed information about flood behaviour across the region.

Stage 2 of the RFD comprises the detailed modelling of 11 catchments (5 packages) covering the MBRC LGA.

This *Hydrography Review Report* forms part of the modelling of the following two packages, RFD, Stage 2:

- Hays Inlet and Redcliffe catchments (package 2); and
- Caboolture River catchment (package 4).

2 Scope

The scope of this hydrography review can be summarised by the following key points:

- Review the subcatchment delineation as part of Stage 1 (broadscale modelling);
- Review previous flood studies within the Hays Inlet, Redcliffe and Caboolture River catchments (provided by MBRC);
- Identify areas that are to be refined; and
- Propose changes and provide a report and digital data to MBRC for review.

MBRC will review the proposed changes and confirm acceptance prior to the amendment of models. This staged approach ensures that detailed Quality Assurance checks are performed and that Council is heavily involved in the study, which will enhance future usage of the models and data within Council. Council's review is also important to consider catchment delineation for modelling of proposed development (that MBRC is aware of to date). It also ensures consistency with Council's naming and identifier (ID) conventions.

3 Objective

The main objective of this task is to create a solid level of detail for future modelling within the catchments, which is consistent with Council's hydrography dataset and the adopted identifiers.

This task focuses on the supply of a **digital** dataset, which can be utilised and amended by MBRC.

4 Hydrography Review Data

The following data was utilised for this assessment:

- Hydrography dataset (catchment delineation) provided by MBRC in September 2010;
- Flood extent (100 Year Embedded Design Storm) derived from RFD, Stage 1, broadscale modelling (BMT WBM, 2010);
- Flood extent (100 Year ARI) of the previous flood study for the Caboolture River catchment (Australian Water Engineering, 1994) provided by MBRC in November 2010;
- Flood extent from combined and transition flood study results (100 Year ARI) based on previous flood studies and storm surge studies in the Hays Inlet and Redcliffe catchments (various consultants). The Hays Inlet catchment was previous split into two subcatchments, formerly called Saltwater and Freshwater Creek catchments; and
- Digital Elevation Model for the three catchments provided by MBRC in September 2010 and based on LiDAR data collected in 2009 and derived from the Department of Environment and Resource Management (DERM).

5 Methodology

The original subcatchment delineation was reviewed utilising the data outlined above. It was noted that in some localised areas the resolution of the original subcatchment delineation is too coarse to replicate the flood extent from the previous studies. These areas were identified by comparing the flood extent from the previous studies with the flood extent from the broadscale models, and checking for areas where the flood extent from the previous studies covered additional tributaries or extended further upstream. The difference in the flood extent is due to the subcatchment breakdown, the associated distribution of flow within each subcatchment and/or the location of the inflows to the hydraulic model.

6 Proposed Changes

Subcatchments that were considered too coarse were subdivided, thereby refining the hydrography and the associated future model output and flood information across the catchments. The proposed changes to the subcatchments are illustrated in Figures 1 and 2. Figures 1 and 2 also show the original subcatchment delineation and the flood extent from the broadscale models and the previous studies in the Hays Inlet and Redcliffe catchments and the Caboolture River catchment respectively.

Accompanying this report, two digital datasets have been provided to MBRC on 08 December 2010:

- *DWCP_Hydro_Catchments_Minor_BMTWBMrevised.TAB*, comprising all subcatchments including the proposed subcatchments; and
- *Proposed_catchment_delineation.TAB* including only the catchments that we propose to change within the three catchments of Redcliffe, Hays Inlet and Caboolture.

The following subcatchments are proposed to be subdivided:

Subcatchment Identifier	Catchment	Minor Basin
FWC_01_14222	Freshwater Creek	Hays Inlet
FWC_02_01351	Freshwater Creek	Hays Inlet
FWC_05_00000	Freshwater Creek	Hays Inlet
FWC_05_00808	Freshwater Creek	Hays Inlet
FWC_08_02696	Freshwater Creek	Hays Inlet
SWC_01_18277	Saltwater Creek	Hays Inlet
SWC_01_18995	Saltwater Creek	Hays Inlet
SWC_02_00000	Saltwater Creek	Hays Inlet
SWC_02_00970	Saltwater Creek	Hays Inlet
SWC_04_00264	Saltwater Creek	Hays Inlet
SWC_08_00418	Saltwater Creek	Hays Inlet
SWC_12_03272	Saltwater Creek	Hays Inlet
SWC_14_04906	Saltwater Creek	Hays Inlet
SWC_14_05488	Saltwater Creek	Hays Inlet
SWC_20_00619	Saltwater Creek	Hays Inlet
SWC_22_01072	Saltwater Creek	Hays Inlet
SWC_24_00639	Saltwater Creek	Hays Inlet
SWC_26_01113	Saltwater Creek	Hays Inlet
SWC_28_01496	Saltwater Creek	Hays Inlet
SWC_32_01672	Saltwater Creek	Hays Inlet
SWC_40_00247	Saltwater Creek	Hays Inlet
GYM_01_08692	Gympie Creek	Caboolture River
GYM_04_01218	Gympie Creek	Caboolture River
GYM_06_00322	Gympie Creek	Caboolture River
WAR_01_12320	Wararba Creek	Caboolture River
WAR_01_13474	Wararba Creek	Caboolture River
WAR_44_00000	Wararba Creek	Caboolture River
WAR_50_04019	Wararba Creek	Caboolture River
WAR_50_06071	Wararba Creek	Caboolture River
WAR_52_00000	Wararba Creek	Caboolture River

The subcatchment breakdown for the subcatchment with the ID “WAR_50_06071” is suggested for consistency of subcatchment sizes in this vicinity (not because of previous flood studies).

7 Recommendation

We recommend that Council reviews the proposed changes and provides feedback on the proposed changes. Based on this feedback we will adopt a final catchment breakdown and update the hydrologic model based on the agreed catchment breakdown as necessary.

8 Reference

BMT WBM (2010), Hydraulic Modelling (Broadscale) Regional Floodplain Database, Stage 1, Sub-project 1D prepared for Moreton Bay Regional Council; and

Australian Water Engineering, 1994, Caboolture Flood Study comprising Caboolture River, King John and Lagoon Creek, prepared for Caboolture Shire Council.

Please contact myself or Richard Sharpe should you wish to discuss the report.

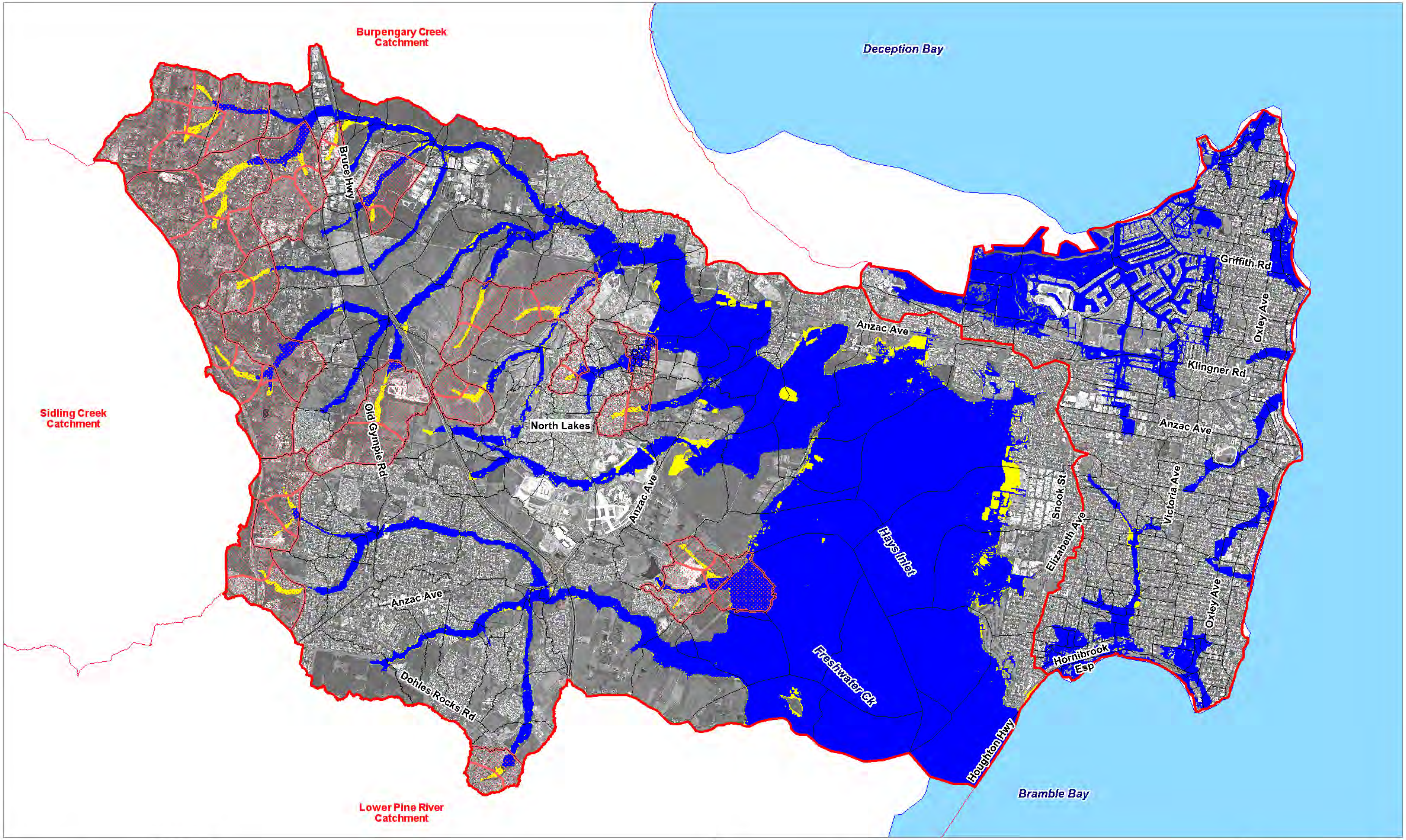
Yours faithfully
BMT WBM Pty Ltd

Anne Kolega

Enclosed:

Figure 1: Hydrography Review and Proposed Changes Hays Inlet and Redcliffe Catchments

Figure 2: Hydrography Review and Proposed Changes Caboolture River Catchment



LEGEND

- Redcliffe Catchment
- Hays Inlet Catchment
- Stage 1 Flood Extent (100 Year EDS)
- Previous Study Flood Extent (100 Year ARI)
- Original Catchment Delineation
- Proposed Catchment Delineation

Title:

Hydrography Review and Proposed Changes
Hays Inlet and Redcliffe Catchments

Figure: 1

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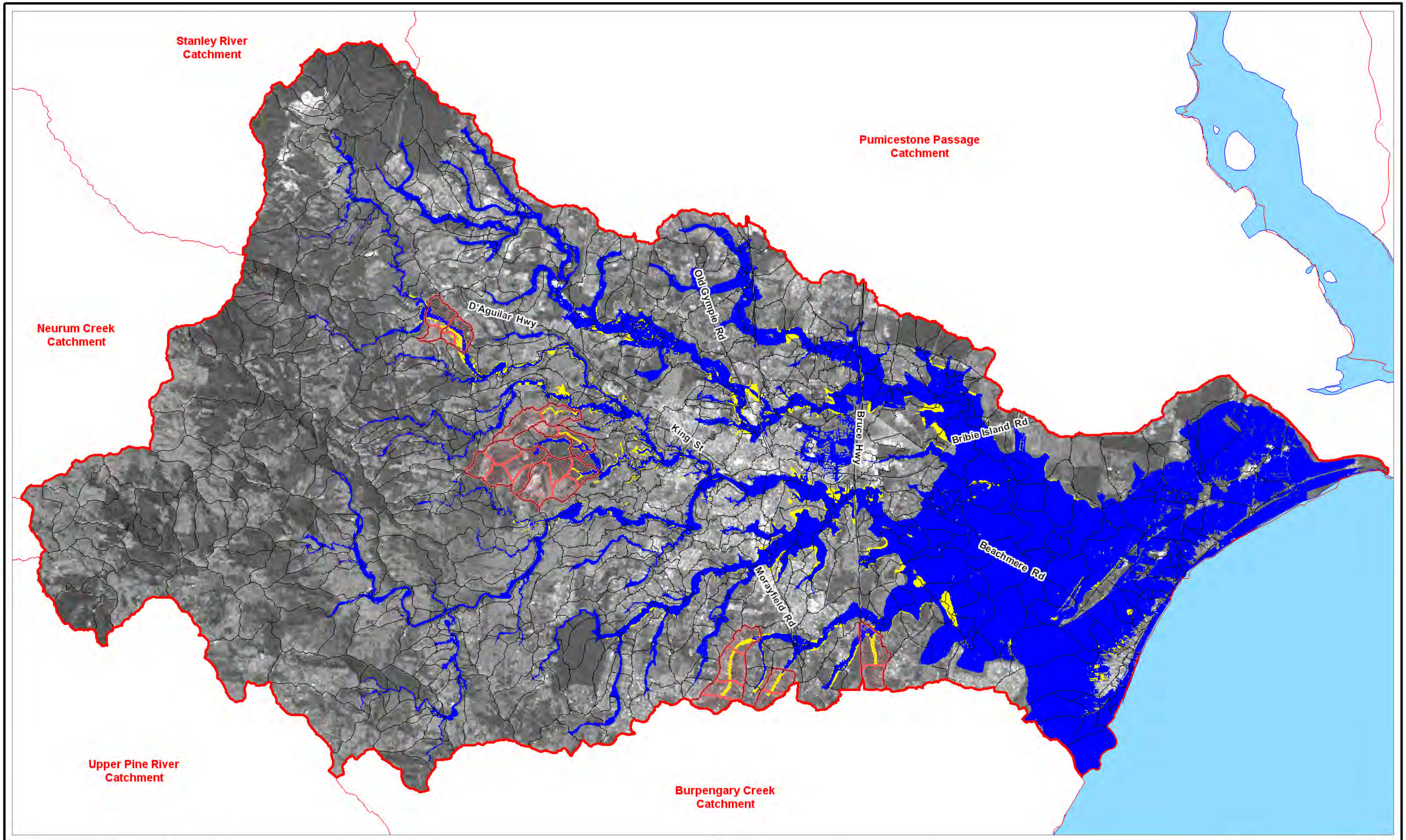

LEGEND

- Caboolture River Catchment
- Stage 1 Flood Extent (100 Year EDS)
- Previous Study Flood Extent (100 Year ARI)
- Original Catchment Delineation
- Proposed Catchment Delineation

Title:

Hydrography Review and Proposed Changes
Caboolture River Catchment

Figure: 2

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APPENDIX C

A part of BMT in Energy and Environment

Calibration Feasibility Report Caboolture Catchment Regional Floodplain Database Stage 2

R.B18104.004.01.P4_CAB_Calibration_
Feasibility_Report_doublesided.doc
June 2012

Calibration Feasibility Report
Caboolture Catchment
Regional Floodplain Database
Stage 2

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BMT WBM Pty Ltd
Level 11, 490 Upper Edward 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.wbmpl.com.au

Document :	R.B18104.004.01.P4_CAB_Calibration_Feasibility_Report_doublesided.doc
Project Manager :	Anne Kolega
Client :	Moreton Bay Regional Council
Client Contact:	Steve Roso
Client Reference	Regional Floodplain Database

Title :	Calibration Feasibility Report Caboolture Catchment Regional Floodplain Database Stage 2
Author :	Anne Kolega \ Richard Sharpe
Synopsis :	Calibration Feasibility Report including the review of available rainfall and river gauge data for the calibration of the combined hydrologic and hydraulic model developed for the Caboolture River catchment for Moreton Bay Regional Councils RFD Stage 2.

REVISION/CHECKING HISTORY

REVISION NUMBER	DATE OF ISSUE	CHECKED BY		ISSUED BY	
0	21 January	R.Sharpe		A.Kolega	
1	15 June 2012	M Hovey		R Sharpe	

DISTRIBUTION

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	0	1	2	3
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CONTENTS

LIST OF FIGURES

1 INTRODUCTION

1.1 Background

Moreton Bay Regional Council (MBRC) is currently undertaking Stage 2 of developing the Regional Floodplain Database (RFD). The RFD includes the development of coupled hydrologic and hydraulic models for the entire local government area (LGA) that are capable of seamless interaction with a spatial database to deliver detailed information about flood behaviour across the region.

Stage 2 includes the detailed hydrologic and hydraulic modelling of 5 packages, which cover 11 catchments in the MBRC LGA. This *Calibration Feasibility Report* forms part of the hydrologic and hydraulic modelling report being developed for the Caboolture River catchment RFD Stage 2, Package 4. Through Stage 2 of the RFD, a hydraulic model of the Caboolture River catchment will be developed. The aim of this assessment is to investigate the feasibility of calibrating the Caboolture River hydraulic model by considering the quantity and quality of rainfall gauge, river gauge and other information on flooding in the catchment.

Significant flood events were reported in 1972, 1974, 1988, 1989, 1991, 1996, 1999, 2009 and most recent in January 2011. The highest flood on record is the January 2011 flood event. Following on from the January 2011 event, MBRC has been very active in collecting the relevant data in a timely manner for the Caboolture River and other catchments in the LGA, such as the Pine River. Council also invited the community to provide photos, flood marks and other relevant information to Council via their RFD website. Because this event occurred so recently, it is anticipated that a number of flood level marks will be available for the Caboolture River catchment, in addition to the hydrographs for three river gauges.

This recent flood event is expected to greatly improve flood awareness within the community and may lead to improved acceptance of the RFD and, by calibrating the model to this flood event, the associated flood model results.

1.2 Scope

The scope of this calibration feasibility assessment and report can be summarised as follows:

- Review available information on historical flooding provided by MBRC and sourced from MBRC and Queensland Department of Environment and Resource Management (DERM);
- Collect river stream gauge data available from the Bureau of Meteorology (BoM);
- Document available data for model calibration, such as rainfall and river levels; and
- Assess the feasibility of various historic flood events to be utilised for calibrating the Caboolture River model.

2 HISTORIC FLOOD EVENTS

Based on the recorded flood levels illustrated in Figure 2-1 significant flood events occurred in 1972, 1974, 1988, 1989, 1991, 1996, 1999, 2009 and most recent in January 2011. The three largest events on record are the 1974, 1991 and 2011 floods. It is understood that Figure 2-1 does not include information for the 2011 event; hydrographs for this event for the three river gauges are provided in Appendix A.

The highest flood level on record is from the January 2011 flood event.

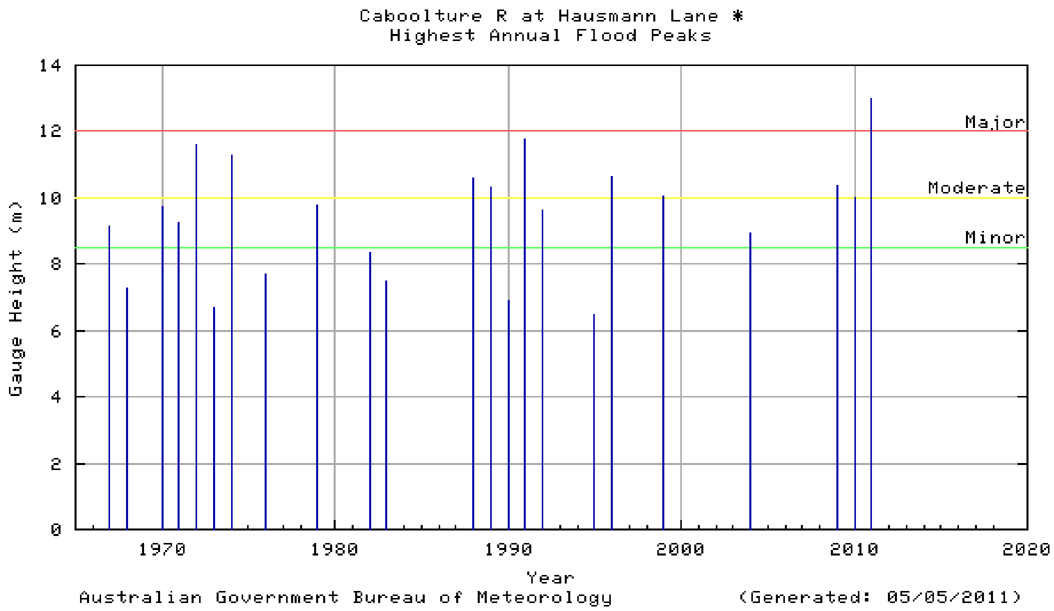


Figure 2-1 Historic Peak Flood Levels Caboolture River at Hausmann Lane

3 AVAILABLE DATA

3.1 Stream Gauge Data

MBRC has provided available river gauges data across the LGA. Within the Caboolture River catchment, river gauge (height) data was received from MBRC for the Caboolture River gauge at Hausmann Lane (station 142001, owned by DERM). Three additional stream gauge data were subsequently requested from the BoM.

Table 3-1 summarises the available river gauge data obtained from both the BoM and MBRC for the Caboolture River catchment, and Figure 3-2 illustrates the location of these gauges.

Table 3-1 Stream Gauge Summary

Stream Gauge	Station No	Owner	Start Date	End Date
Caboolture River At Hausmann Lane	142001	DERM	01/1965	ongoing
Upper Caboolture Alert	142819 / 540357	BoM	01/2004	ongoing
Caboolture Water Treatment Plans (WTP) Alert	142815 / 540243	BoM	01/1999	ongoing
Wamuran Alert	142816 / 540244	BoM	09/1998	ongoing

Table 3-1 shows that most of the river gauge data have been collected for approximately the last ten years, which is a very short duration compared to other catchments in the LGA.

3.1.1 Flood Classification

Figure 3-1 illustrates the flood classification of minor, moderate and major floods and the historic flood events for the Caboolture River at Caboolture WTP (http://www.bom.gov.au/hydro/flood/qld/brochures/caboolture/caboolture.shtml).

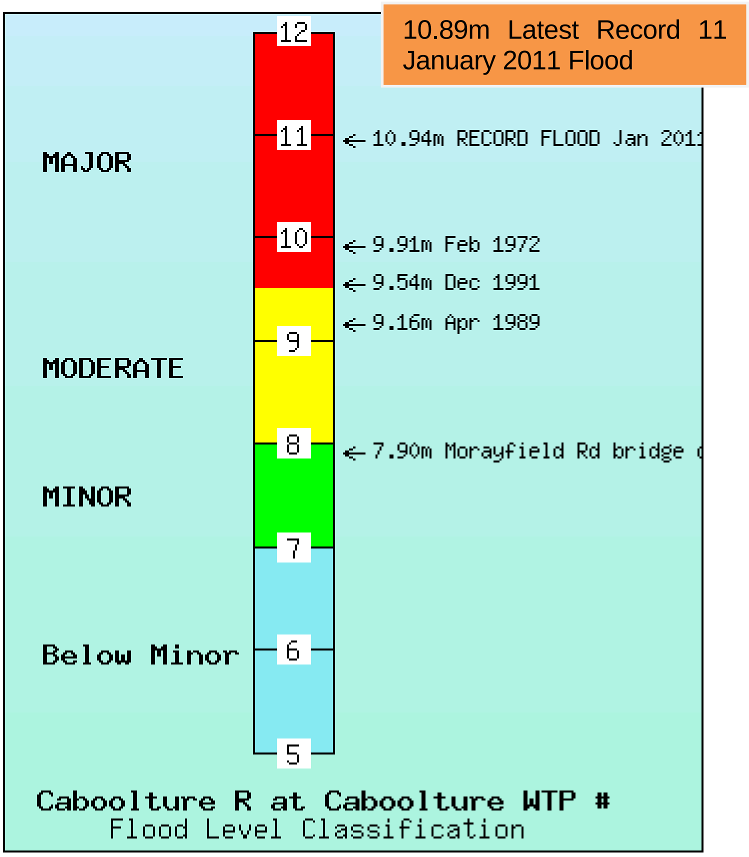


Figure 3-1 Flood Level Classification Diagram

3.2 Rainfall Data

Rainfall gauge data was also provided by MBRC comprising the three categories:

- Rainfall Daily;
- Rainfall Alert; and
- Pluviometer (6-minute interval records).

Review was undertaken to identify relevant rainfall data from stations that are located within the Caboolture catchment. Table 3-2 summarises the rainfall data for the Caboolture River catchment and Figure 3-2 shows the gauge locations.

It is further noted that no pluviometer data was available within the Caboolture River catchment. As such, several pluviometer stations in the neighbouring catchments of the Caboolture River Catchment have been included.

Table 3-2 Rainfall Data Summary

Sensor Name	Sensor Type	BoM Station	Start Date	End Date
Caboolture WTP Alert	Rainfall Alert	540243	01/1998	ongoing
Moorina Alert	Rainfall Alert	540358	01/2004	ongoing
Morayfield Alert	Rainfall Alert	040979	05/2006	ongoing
Round Mt Reservoir	Rainfall Alert	540241	11/1998	ongoing
Upper Caboolture Alert	Rainfall Alert	540357	01/2004	ongoing
Upper Caboolture TM	Rainfall Alert	540208	01/1995	ongoing
Wamuran Alert	Rainfall Alert	540244	09/1998	ongoing
Beachmere Sands Retirement Resort	Rainfall Daily	040972	04/2006	ongoing
Caboolture Post Office	Rainfall Daily	040038	01/1970	09/1999
Moorina	Rainfall Daily	040970	01/2000	ongoing
Morayfield Mark Station	Rainfall Daily	040774	9/04/1988	ongoing
Beerwah CSIRO Station	Pluviometer (nearby)	040553	1/11/1973	30/04/1983
Dayboro Post Office	Pluviometer (nearby)	040063	14/04/1969	01/1999
Dayboro Strong Rd	Pluviometer (nearby)	040425	1/11/1997	30/07/2006
Mt Byron	Pluviometer (nearby)	040309	24/09/1975	21/03/1980
Redcliffe-	Pluviometer (nearby)	040958	18/11/2004	30/04/2006
Redcliffe Council	Pluviometer (nearby)	040697	30/05/1989	30/11/2004

3.3 Historic Flood Levels (Caboolture Shire Council)

Historic flood levels recorded by the former Caboolture Shire Council were also provided by MBRC. This data comprises in total 15 historic storm events ranging from 1893 through to 2009. In 1983 there was only one historic level recorded. The highest numbers of recorded levels were collected for the following storm events:

50 recorded levels February 1972;

42 recorded levels February 1999;

36 recorded levels April 1989;

31 recorded levels December 1991; and

7 recorded levels December 1970.

The locations of the flood marks for all historic events are shown in Figure 3-2.

3.4 Water Quality Event Monitoring and Maximum Height Indicators

Maximum height indicators provided by MBRC were reviewed and it is noted that none are located within the Caboolture catchment.

Water Quality Event Monitoring Gauges owned by MBRC were also reviewed, with the following two gauges located within the Caboolture catchment:

Caboolture River (Site ID: MBRC-016) at River Road, Caboolture; and

Wararba Creek (Site ID: MBRC-015) at Wararba Crescent, Caboolture.

These gauges record water levels, rainfall and turbidity and were installed in 2009. They may be used as additional information on flood levels for model calibration. The gauge locations are illustrated in Figure 3-2.

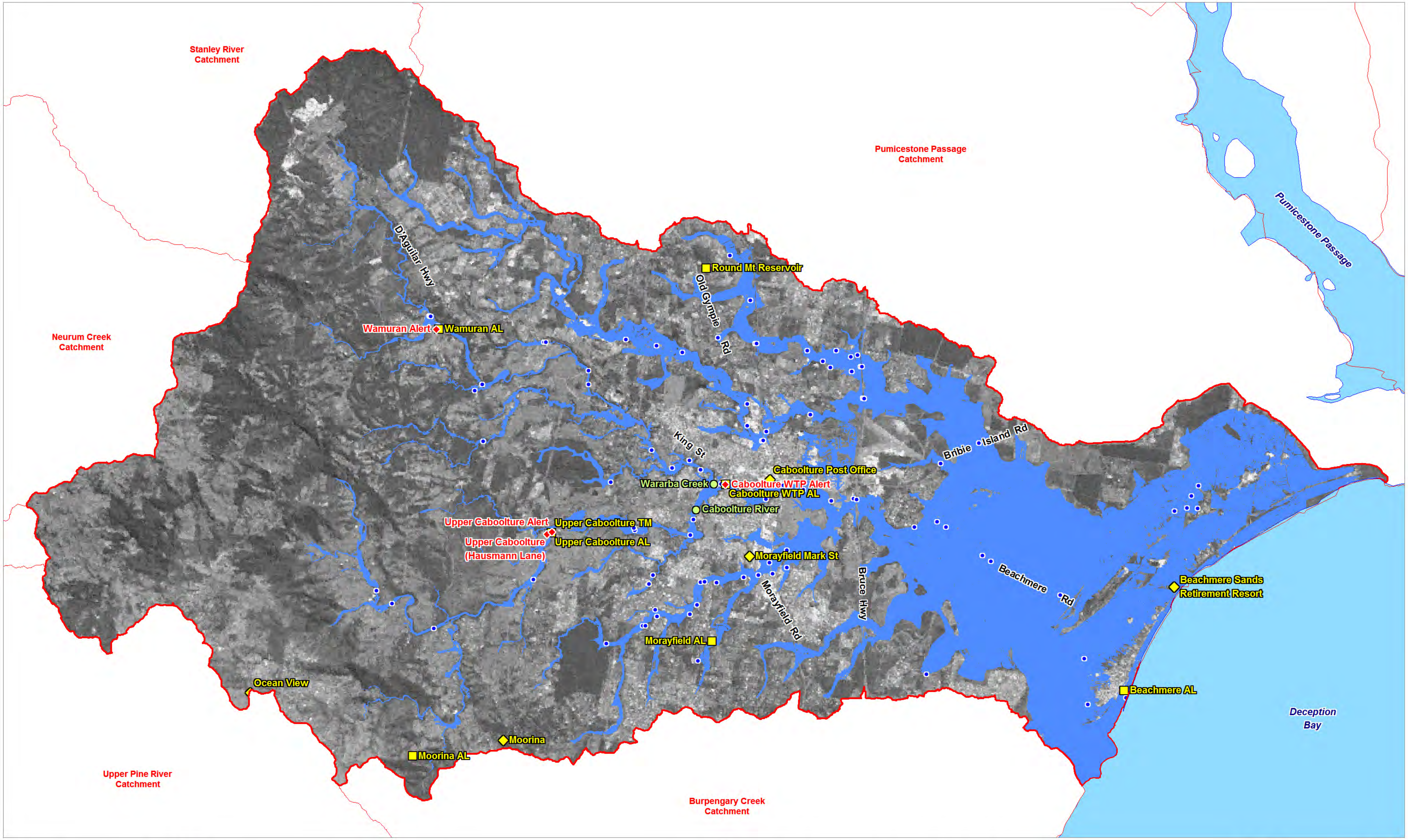
3.5 Resident Survey

MBRC have issued a questionnaire to residents to collate historical flood information, such as flood extents, levels (if available), flood marks and photos. This survey was first undertaken in 2010. In January 2011, MBRC issued another media release to the community through the local newspaper that asks for provision of any available flood information to Council. This data is currently being collated by MBRC through the RFD project website. Information can be provided via E-mail (flood@moretonbay.qld.gov.au or an on-line Flood Data Form (http://www.moretonbay.qld.gov.au/general.aspx?ekfrm=74810&libID=77442).

This data will be available for model calibration.

3.6 Floodmark and Photo Collection January 2011 Event

The January 2011 flood event in the Caboolture River Catchment has provided an excellent opportunity to collate an expansive and reliable set of flood data throughout the catchment. MBRC have been active in capturing this flood information, which includes flood levels, and photographs throughout the catchment. It is anticipated that the January 2011 flood information will be a good resource for model calibration.



LEGEND

- Caboolture River Catchment
- 100 Year Embedded Design Storm Flood Extent (Based on Broadscale Model)
- Rainfall Gauges (Alert)
- Rainfall Gauges (Daily)
- River Gauges
- Water Quality Event Monitoring Gauges
- Flood Levels from Former Caboolture Shire Council

Title:

Rainfall and River Stream Gauge Locations
Caboolture River Catchment

Figure: **3-2**

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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4 CONCLUSION

River gauge data is crucial for a high quality model calibration due to the ability to not only calibrate to the peak flood level, but also to the flood volume and the timing. The number of available gauges across the catchment also has a great effect on the quality of model calibration; generally the more gauge data available the better, and a good spread of the gauges over various tributaries in the catchment is also advantageous.

River gauges were mainly available for the last ten years within Caboolture River catchment (noting that the Caboolture River gauge at Hausmann Lane has been operational since 1965). Therefore, historic flood events from the last ten years are preferred for model calibration. More recent flood events are preferable for model calibration because it is less likely that the catchment's topography and landuse have changed significantly.

The severity of the flood is also important. For this particular study a minor flood event (e.g. the 5 or 10 year ARI event) is less useful for calibration compared to larger flood events (e.g. 50 or 100 year ARI event). This is because the study includes modelling of large flood events, and calibrating to large flood events will test both in-bank and out-of-bank flow in the hydraulic model.

There are a number of daily and alert rainfall gauges within the catchment, however pluviometers are located outside the catchment. For model calibration the pluviographs are preferred compared to daily stations because the records are more detailed. This is of particular importance for the January 2011 event, where the storm event occurred within one day (refer to Appendix A for hydrograph).

The lack of pluviometers within the Caboolture River may reduce the quality of model calibration because the rainfall data is the most important input data for model calibration and rainfall intensities can vary significantly across the Caboolture and neighbouring catchments. The January 2011 event had high rainfall at the western part of the Caboolture catchment, but less rainfall was recorded towards the coast and Deception Bay. The neighbouring catchments, Hays Inlet and Redcliffe, did not experience a major flood event in 2011. It is anticipated that the pluviometers at Mt Byron and Somerset Dam may be suitable for calibration.

Based on the severity of the flood event, the availability and frequency of rainfall and, more importantly, river stream gauge data (as well as additional peak flood level information), model calibration is possible for the following events:

January 2011;

February 1999; and

December 1991.

The feasibility of calibrating to the December 1991 event is limited because no river stream gauge data is available. Therefore, the January 2011 and February 1999 events are the most feasible historic events for model calibration

5 RECOMMENDATION

It is recommended that the January 2011 event be used for model calibration for the following reasons:

- It is the largest flood event on record;
- Most recent event and therefore the catchment has not changed in topography or landuse;
- Likely to have the best coverage of flood level marks throughout the catchment;
- Availability of 3 river stream gauges; and
- Availability of a number of rainfall gauges within and around the Caboolture River catchment.

It is recommended that the February 1999 event may be used for model verification.

Additional consideration for the calibration process and the overall RFD project comprise the following key points:

- A tolerance of +-250mm to +-500mm should be aimed for when comparing the modelled and recorded peak flood levels, as recommended in the Flood Design Guide – Chapter 7 (Crowder, 2009); and
- Review of the final hydraulic parameters and coefficients used for calibration in various catchments across the LGA may be considered in order to establish an overall impression on variances in these parameters across the LGA.

6 REFERENCE

Bureau of Meteorology, 2011, *Water Resources Station Catalogue*, viewed 18 January 2011, <http://www.bom.gov.au/hydro/wrsc>

Bureau of Meteorology, 2011, *Flood Warning System of the Pine and Caboolture Rivers*, viewed 18 December 2010, <http://www.bom.gov.au/hydro/flood/qld/brochures/caboolture/caboolture.shtml>

Crowder R A, 2009, Flood Design Guide, Chapter 7, published by the Environment Agency (UK) <http://evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide.aspx>

Moreton Bay Regional Council, 2011, *Share your flood data*, viewed 18 January 2011, <http://www.moretonbay.qld.gov.au/general.aspx?ekfrm=74810&libID=77442>

APPENDIX A: RECORDED HYDROGRAPHS JANUARY 2011 EVENT

IDQ65389

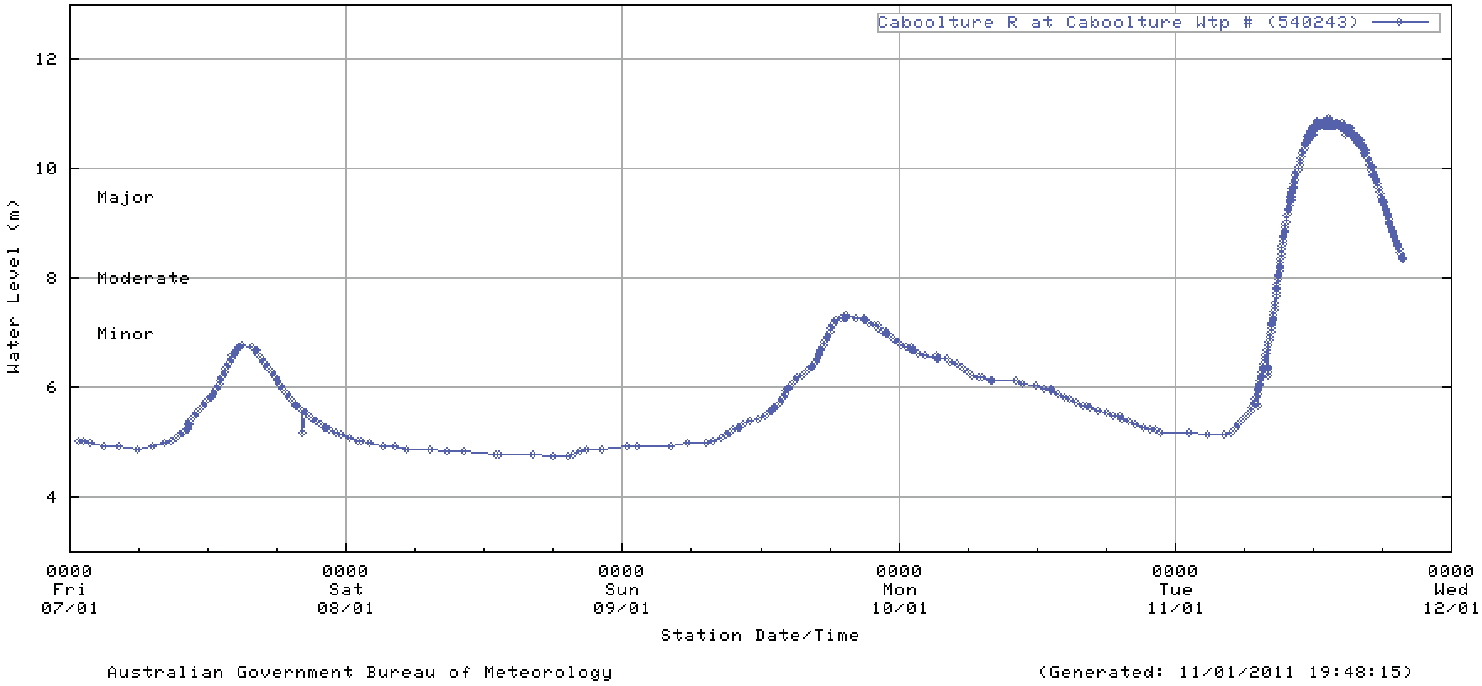
Latest River Heights for Caboolture R at Caboolture Wtp

Issued at 7:48 pm EST Tuesday 11 January 2011

About river heights plots | About this Plot

Station details: Station Number: 540243 Name: Caboolture R at Caboolture Wtp # Owner: MBRC:142815
Flood levels: Minor: 7.00 Moderate: 8.00 Major: 9.50

Data from the previous 4 days.



Data as Table | Previous Station | Next Station | Back to Bulletin

About this plot

1. The river height data is the latest available operational data provided for flood warning purposes and has not been quality controlled.
2. Stations marked with * or # indicate that the data is provided from automatic equipment.
3. Stations marked with * are Telephone Telemetry Devices and are nominally polled once a day and more often during floods.
4. Stations marked with # are ALERT Radio Telemetry and report every 3 hours and more often when the water level changes.
5. All river height reports are in metres and are shown in local time.
6. Heights or depths above/below roads, bridges, dam spillways and weirs are given as a guide only. For road open/closed information, see the RACQ website.
7. This product includes data made available to the Bureau by other agencies. Separate approval may be required to use the data for other purposes. Refer to Listing of Operating Agencies for Station Ownership.
8. Where data is supplied from a Department of Environment and Resource Management (DERM) Monitoring Site, please follow this link to get advice on data use and copyright.
9. For other Station details: Flood Classifications, Road Crossings, Survey/AHD Details, Maps

IDQ65389

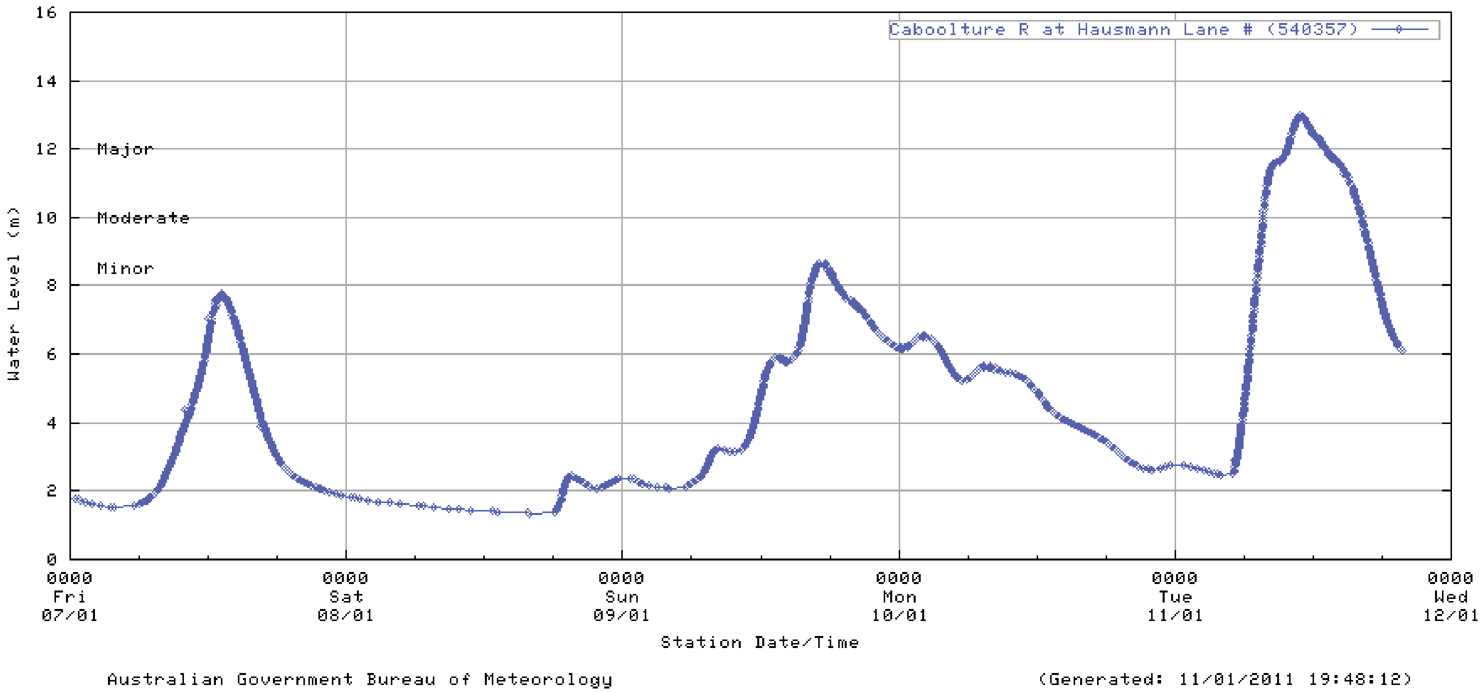
Latest River Heights for Caboolture R at Hausmann Lane

Issued at 8:19 pm EST Tuesday 11 January 2011

About river heights plots | About this Plot

Station details: Station Number: 540357 Name: Caboolture R at Hausmann Lane # Owner: MBRC:142819
Flood levels: Minor: 8.50 Moderate: 10.00 Major: 12.00

Data from the previous 4 days.



Data as Table | Previous Station | Next Station | Back to Bulletin

About this plot

1. The river height data is the latest available operational data provided for flood warning purposes and has not been quality controlled.
2. Stations marked with * or # indicate that the data is provided from automatic equipment.
3. Stations marked with * are Telephone Telemetry Devices and are nominally polled once a day and more often during floods.
4. Stations marked with # are ALERT Radio Telemetry and report every 3 hours and more often when the water level changes.
5. All river height reports are in metres and are shown in local time.
6. Heights or depths above/below roads, bridges, dam spillways and weirs are given as a guide only. For road open/closed information, see the RACQ website.
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9. For other Station details: Flood Classifications, Road Crossings, Survey/AHD Details, Maps

IDQ65389

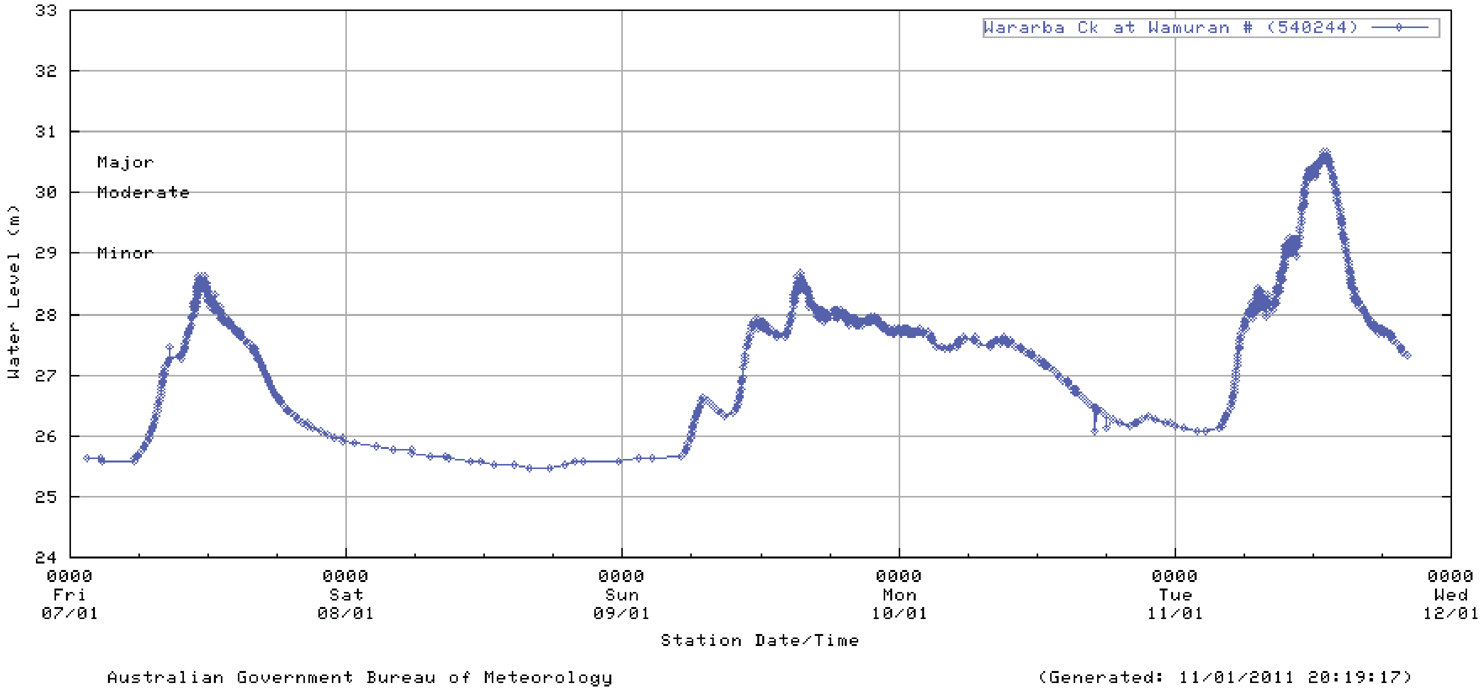
Latest River Heights for Wararba Ck at Wamuran

Issued at 8:19 pm EST Tuesday 11 January 2011

About river heights plots | About this Plot

Station details: Station Number: 540244 Name: Wararba Ck at Wamuran # Owner: MBRC:142816
Flood levels: Minor: 29.00 Moderate: 30.00 Major: 30.50

Data from the previous 4 days.



Data as Table | Previous Station | Next Station | Back to Bulletin

About this plot

1. The river height data is the latest available operational data provided for flood warning purposes and has not been quality controlled.
2. Stations marked with * or # indicate that the data is provided from automatic equipment.
3. Stations marked with * are Telephone Telemetry Devices and are nominally polled once a day and more often during floods.
4. Stations marked with # are ALERT Radio Telemetry and report every 3 hours and more often when the water level changes.
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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.bmtwbm.com.au

BMT WBM Denver

8200 S. Akron Street, Unit 120
Centennial Denver Colorado 80112 USA
Tel +1 303 792 9814 Fax +1 303 792 9742
Email denver@bmtwbm.com
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

BMT WBM Perth

Unit 6, 29 Hood Street, Subiaco 6008
Tel +61 8 9322 1577 Fax +61 8 9226 0832
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 9713 4836 Fax +61 2 9713 4890
Email sydney@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Vancouver

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.au

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Model Calibration Report
Caboolture River Catchment
Regional Floodplain Database
Stage 2

R.B18104.005.02.P4_CAB_Model_Calibration
_Report_doublesided.doc
June 2012

Model Calibration Report
Caboolture River Catchment
Regional Floodplain Database
Stage 2

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Title :	Model Calibration Report Caboolture River Catchment Regional Floodplain Database Stage 2
Author :	Anne Kolega
Synopsis :	This report includes the details and findings of the combined hydrologic and hydraulic model calibration and verification of the developed Caboolture River model for the January 2011 and May 2009 flood events. This report is part of Council Regional Floodplain Database, Stage 2.

REVISION/CHECKING HISTORY

REVISION NUMBER	DATE OF ISSUE	CHECKED BY		ISSUED BY	
0	07/10/2011	R. Sharpe		A. Kolega	
1	10/10/2011	R. Sharpe		A. Kolega	
2	15/06/2012	M Hovey	MHovey	R Sharpe	RJSharpe

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LIST OF TABLES

1 INTRODUCTION

This report documents a component of the assessment undertaken to develop the detailed Caboolture River TUFLOW model, undertaken for the Regional Floodplain Database (RFD), Stage 2, Package 4. The modelling tasks completed include the combined hydrologic and hydraulic model calibration and verification to two historic flood events.

The January 2011and May 2009 historic flood events were selected for this purpose. As adopted by Council and recommended in the *Calibration Feasibility Report* (BMT WBM, 2011) the January 2011 event was utilised for the model calibration due to the flood event being the largest flood on record within the Caboolture River catchment. The May 2009 event was chosen by Council for model verification for consistency with other catchments across the RFD.

Model calibration is an important process of developing a flood model. Model calibration also helps to understand the resolution, accuracy and potential limitations of the developed model. The model calibration is therefore an important step in the development of the RFD. MBRC is aware of the importance of model calibration, in particular when utilising the models to assess future development and for communication consultation. Council has therefore paid great attention to the model calibration phase of the project. Based on available rainfall, river gauge and flood mark data, model calibration was feasible and subsequently commissioned in the following five catchments as part of RFD:

- Burpengary Creek (pilot study);
- Caboolture River;
- Sideling Creek;
- Upper Pine River; and
- Stanley River.

This report outlines the data used, results and discussion of the model calibration for the Caboolture River catchment.

2 JANUARY 2011 CALIBRATION EVENT

2.1 Rainfall Data

To represent the rainfall during the event, records from 12 gauges were utilised in the hydrologic model established for the January 2011 event. The recorded cumulative rainfall depths in millimetre (mm) for these rainfall gauges are illustrated in Figure 2-1. Spatially these gauges are positioned well within and around the catchment, thus resulting in reasonably good coverage of the study area. Figure 2-2 presents the location of the rainfall gauge locations utilised for the model calibration.

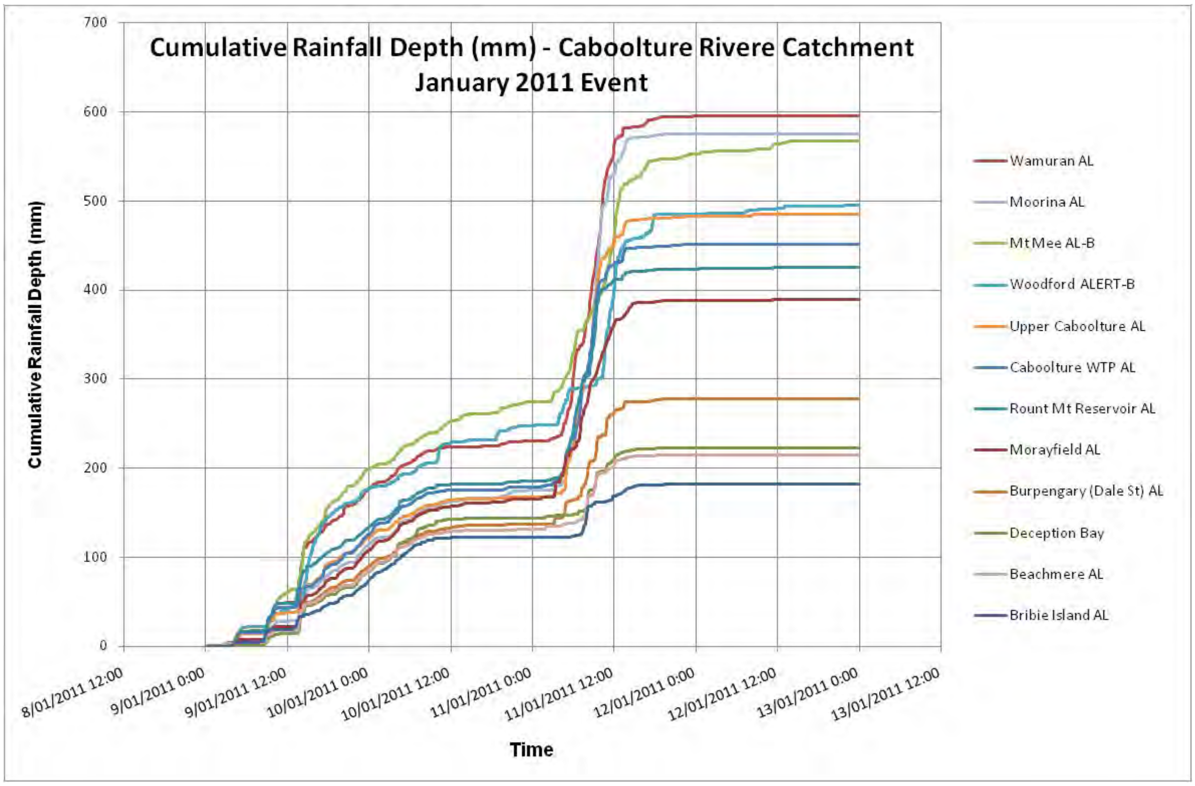
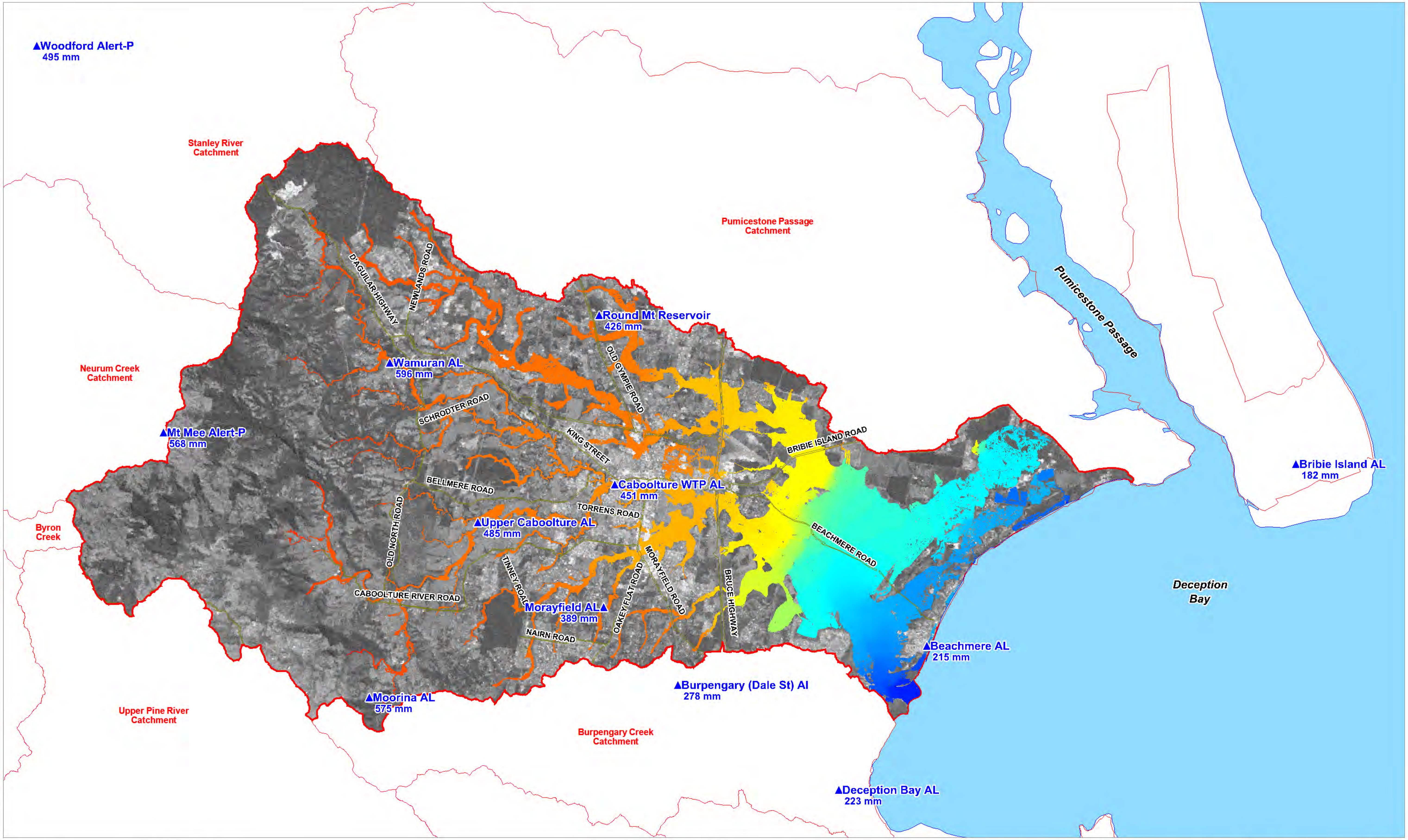


Figure 2-1 Cumulative Rainfall Depths (mm) – Caboolture River Catchment January 2011 Event

Analysis of the recorded rainfall data between the 9th and 12th of January 2011 suggest a similar trend in the timing of the rainfall bursts over the 4 day period. However, it is noted that the cumulative rainfall depth over 4 days results in significantly varied magnitudes across the Caboolture River catchment. Cumulative rainfall depths range from approximately 500 to 600mm within the west of the catchment, where as cumulative rainfall depths range from 200 to 300mm towards the east.



LEGEND

Caboolture River Catchment

Roads

▲ Rainfall Gauge

278mm Total 4 Day Rainfall Depth (mm) 9 to 12 January 2011

Title:

Rainfall Gauge Locations utilised in the Model Calibration January 2011 Event

Figure: **2-2**

Rev: **A**

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2.2 Modelling

2.2.1 Hydrologic Model

The hydrologic WBNM model was developed using 5 minute interval rainfall from the 12 rainfall gauges described in Section 2.1. Within the developed model, subcatchment information was based on the hydrography (subcatchment delineation) adopted by Council. The default values for the model setup were used for most of the WBNM parameters (i.e. nonlinearity exponent, stream routing); however a catchment lag factor of 1.6 was adopted by Council. The default value is 1.7. Three hydrologic models were setup utilising the parameters and amendments described in Table 2-1.

Table 2-1 Hydrologic Model Parameters Calibration Event

Run ID	Initial Loss (mm)	Continuing Loss (mm/h)	Additional Model Parameter Updates
1	0	2.5	NA
2	0	2.5	Adjusted sub-catchment delineation for SSC_01_03043
3 Adopted	**0**	**0**	**Adjusted sub-catchment delineation for SSC_01_03043**

2.2.2 Hydraulic Model

The hydraulic model used for this assessment represents a modified model compared with the base case TUFLOW model (CAB_002a_E_ 100Y_01hrs 008). The updates included minor amendments of the model development, such as the inclusion of a number of structures, based on recommendations from BMT WBM and Council's model review and additional data collection. The modified model adopted a 10m grid resolution, compared to a 5m resolution used by the base case model. The increase in cell resolution was required due to the excessive model run times (>1 week) for simulation of the 3 day rainfall event in January 2011 using the base case TUFLOW model.

In consultation with Council, the base case TUFLOW model was converted into a 10m grid TUFLOW model for model calibration and verification. A comparison of the 5m and the 10m model results for the 100 Year Embedded Design Storm was undertaken. The differences in the flood extent and flood levels, due to the different model resolutions, were negligible. This comparison has been discussed with Council, and the 10m model has been adopted for the model calibration and verification.

As part of the model calibration assessment various hydraulic models were setup and simulated utilising the inflows derived from the WBNM hydrologic modelling and downstream tide levels provided by Marine Safety Queensland (MSQ). The various model scenarios, summarised in Table 2-2 were used to test the sensitivity of the model results to changes in hydraulic roughness and model inflow values.

Of the assessed model scenarios, the adopted TUFLOW calibration model used hydraulic parameters (i.e. roughness values) consistent with those adopted by Council for the Burpengary Creek pilot study.

Table 2-2 Hydraulic Model Parameters Calibration Event

Run ID	Inflows	Manning's n for Dense Vegetation	Manning's n for Medium Dense Vegetation	Inflows	TUFLOW Run ID
1	WBNM Run 1	0.09 (original)	0.075 (original)	100%	009
2	WBNM Run 2	0.12	0.075	100%	010
3	WBNM Run 2	0.12	0.090	100%	011
4	WBNM Run 3	0.12	0.075	100%	012
5	WBNM Run 3	0.12	0.075	110%	013
6	WBNM Run 3	0.12	0.075	120%	014
7	WBNM Run 3	0.12	0.075	150%	015
8 Adopted	**WBNM Run 3 / Adopted**	**0.09**	**0.075**	**100%**	**018**

2.3 Results

The combined hydrologic and hydraulic model results are provided in detail for the adopted simulation model runs in this chapter. A summary of the findings from the additional model runs described in Table 2-2 are provided in Sections 2.4.

2.3.1 Hydrograph Comparison at the River Gauge Locations

Three river gauges recorded flood levels during the January 2011 event in the Caboolture River catchment. Shown in Figure 2-3, these gauges are located at the following locations:

- Cambells Pocket Road, Wamuran;
- Hausmann Lane, Upper Caboolture; and
- King Street near the Caboolture water treatment plant (WTP).

The Wamuran and the Upper Caboolture gauges are located in the upper part of the catchment, whereas the Caboolture WTP gauge is within the centre part of the catchment.

Hydrographs showing the recorded and the modelled flood levels during the January 2011 event (covering the 4 days 9-12 January 2011) are presented in Appendix A. The volume of water flowing past the gauges was estimated using the following approach:

1. Model results were used to estimate rating curves at the gauges;
2. Modelled and measured flows at the gauges were estimated using the rating curves developed in step 1; and
3. The modelled and measured volumes of water flowing past the gauges were estimated as the area under the flow hydrographs determined in step 2.

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 4 days of the event;
- The model is overestimating volume at the Wamuran Gauge and underestimating volume at the Caboolture WTP Gauge;
- The hydrograph comparison between the recorded and modelled flood levels at the Caboolture WTP gauge indicate the model under predicting the volume; and
- Peak flood levels vary between the gauge locations; a difference of approximately 200mm at Wamuran, 600mm at Caboolture WTP and 1.95m at Upper Caboolture Gauge.

2.3.2 Floodmarks

Council has provided 89 flood marks for the January 2011 event within the Caboolture River catchment; 6 of these were categorised as being of high quality, the others being of medium quality. The flood level height at these flood mark locations were surveyed by Council following the January 2011 event (within approximately 1-3 weeks). Only two of the 89 flood marks were located outside the modelled flood extent (by more than 10m). A 10m buffer was chosen in accordance with the 10m resolution of the hydraulic model. This shows that the flood mark locations compared well with the modelled flood extent.

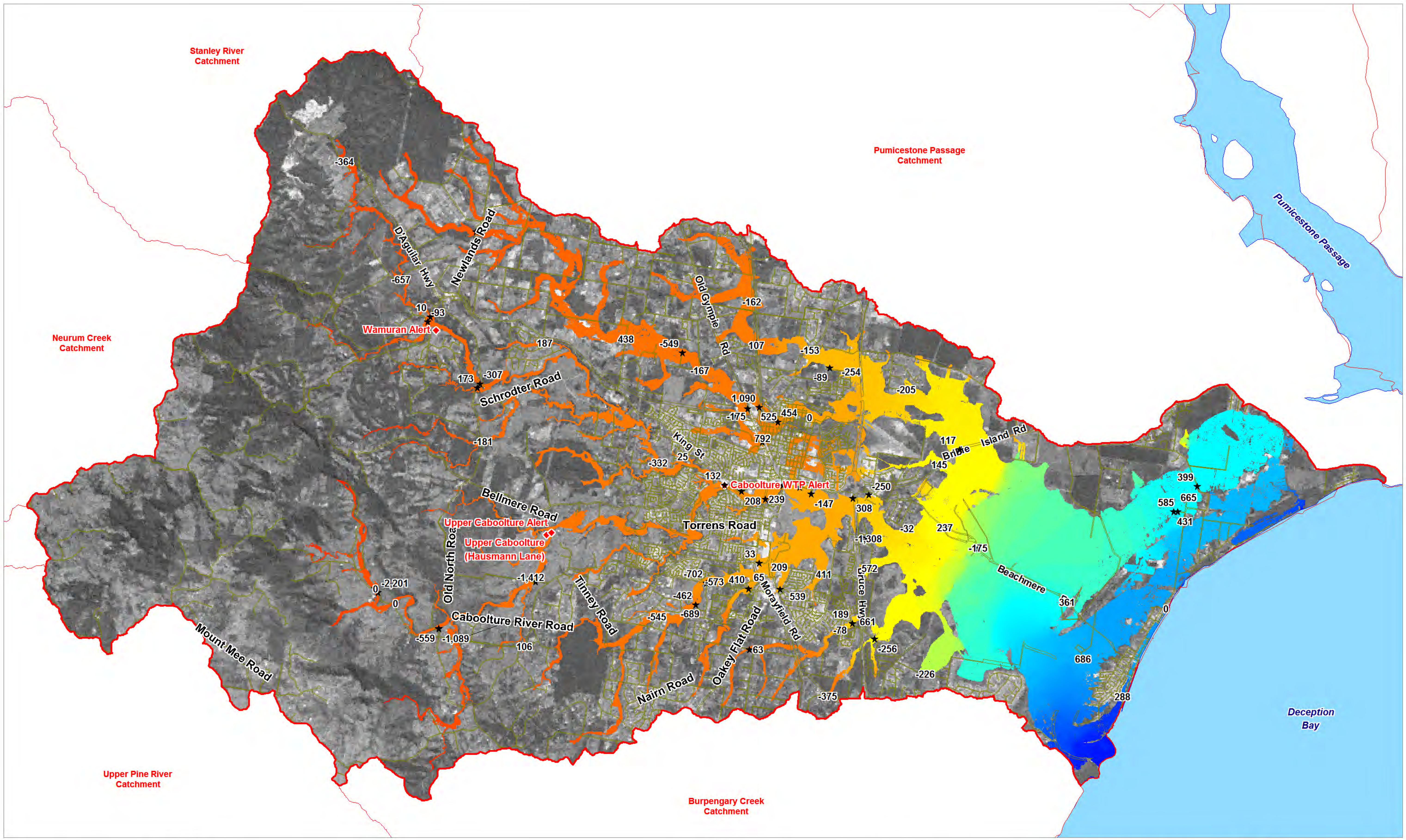
The surveyed flood levels at the flood marks were compared to the modelled peak flood levels derived from the calibration model. The difference in flood levels versus the number of flood marks have been provided to Council via a histogram presented in Appendix B. The difference was calculated by subtracting the modelled levels from the surveyed levels; therefore if the difference is positive the model predicted higher levels compared to the surveyed level and vice versa.

The histogram shows that the majority of the flood marks show difference in flood levels between +/- 200 mm, 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 interpretation of wrack marks / peak flood levels may have varied amongst the survey teams.



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: 2-3

Rev: B

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Approx. Scale

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2.4 Summary of Results of Additional Simulations

In total, eight calibration scenarios were simulated for the January 2011 event. Detailed results have been provided for the adopted scenario in the previous section and a summary of the results from the additional simulation are provided in this Section as follows:

- The increase in Manning's n for dense vegetation and the adjusted subcatchment delineation (difference between run 009 and 010) resulted in higher flood levels, in particular in the upper part of the catchment. Flood level increased by about 0.5m at the Wamuran and by about 0.3m at Upper Caboolture gauge. Flood levels reduced by 0.04m at the Caboolture WTP gauge;
- An increase in the Manning's n value for medium dense vegetation (comparing TUFLOW run 010 and 011) resulted in a difference in flood levels at the three river gauges by less than 0.02m;
- A reduction of the continuing loss (CL) value in the hydrologic model from 2.5mm/hr to 0 mm/hr resulted in better results when comparing flood levels at flood marks;
- The increase in flows globally by 10% and 20% generally increase flood levels, and therefore resulted in better outcomes when comparing the peak flood levels at the flood marks in the south-western part of the catchment (along Caboolture River), results were worse for the northern part of the catchment; and
- An increase in flow globally by 50% resulted in overestimation of flood levels in particular in the northern part of the catchment (along Wararba Creek).

2.5 Rainfall Radar Data

Radar data for the January 2011 event has been sourced from the Bureau of Meteorology utilising the 128km radar loop at Brisbane. The data was provided in GIS shape files of 10 minute interval rainfall. The data comprises rainfall intensity categories (and the associated rainfall depths) for each polygon, as illustrated in Figure 2-4. This data was converted into 432 grids (of each time interval for the 3 days) between the 9 and 12 January 2011. The grids were then combined into one grid of the 3 day rainfall depth total in millimetres.

This combined grid was used for a comparison of the records derived from the rainfall gauge stations and the radar data. The comparison of the radar and gauge data, and the 3 day rainfall depth grid from the radar data is illustrated in Figure 2-4.

The comparison shows the following main outcomes:

- The total rainfall from the radar is consistently higher for all gauge locations. The radar data would therefore need to be scaled if being utilised to calibrate the model;
- The radar/gauge rainfall depth ratio varies ranging from about 0.6 in the east of the catchment to 0.9 towards the west of the catchment, indicating that the scaling factor is slightly different across the catchment; and
- The radar grid clearly shows areas of very heavy rainfall in particular in the western part of the catchment, which was not represented by the location and records of the gauge data. It shows that the spatial distribution of rainfall intensities is better represented by the radar data.

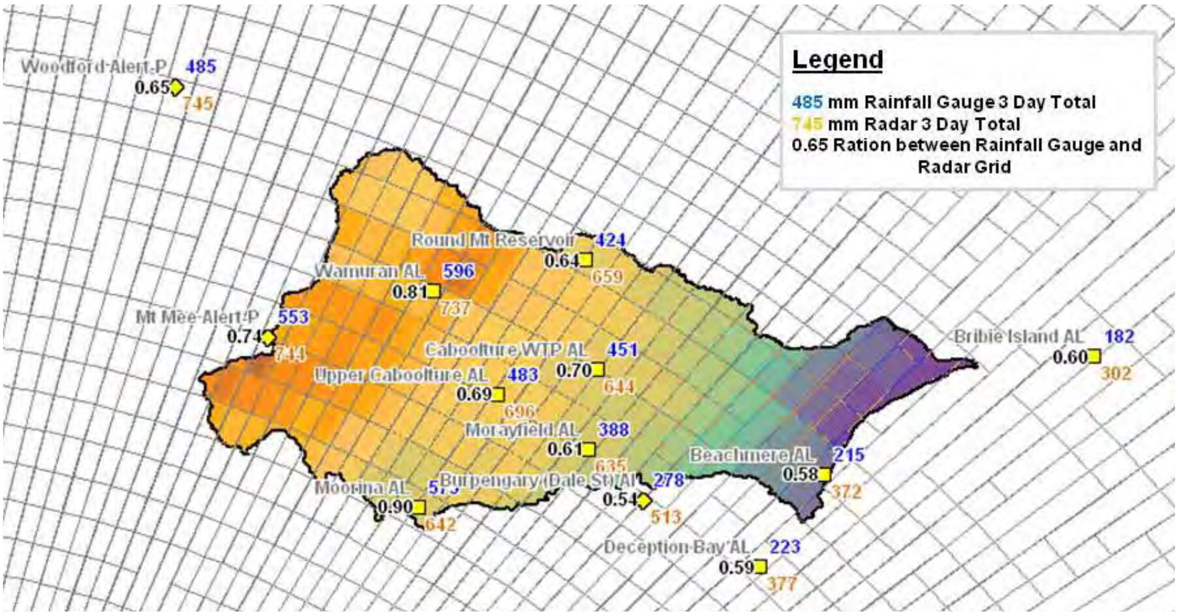


Figure 2-4 Comparison of Radar and Rainfall Gauge Totals, January 2011 Event

2.6 Discussion January 2011 Event

The following key points have been drawn from the January 2011 model calibration results and the review of the radar data:

- Radar data indicates that heavy rainfall occurred in the western part of the catchment, which was not fully captured by the rainfall gauges due to their locations. This under representation of heavy rainfall in the adopted model simulation results in an underestimation of runoff volume, in particular in the south western part of the catchment. An improved model calibration could have been achieved by utilising additional 'dummy rainfall gauges' generated using the radar data, in particular in the area of heavy rainfall, in the hydrologic model. This possibility was proposed to Council, but was not further investigated, as the previous runs already provided in indication of the likely affects of this improved model calibration and it would have not affected the adoption of hydraulic parameters across the RFD;
- The Caboolture River in the south western part of the catchment may have been better represented (as discussed in the above mentioned point). This is also shown by the model results from the scenario with an increased flow of 110 or 120% flow in this particular area (not globally). This scenario would have also resulted in an increase in the volume of water;
- Reasonable timing was achieved when comparing the hydrographs at the river gauges;
- The flood marks, when used as flood extent markers, indicate that the modelled flood extent correlates very well with the surveyed flood marks (i.e. only 2 of 89 were outside the modelled flood extent); and
- There is a discrepancy within the flood mark dataset when comparing the flood levels and the ground levels (about half of the flood marks show a difference between the flood levels and the ground levels of +/-300mm).

3 MAY 2009 VERIFICATION EVENT

3.1 Rainfall Data

Records from 12 gauges were utilised in the hydrologic model established for the May 2009 event to represent the rainfall. The recorded cumulative rainfall depth in millimetre (mm) for these rainfall gauges is illustrated in Figure 3-1. Spatially these gauges are positioned well within and around the catchment, thus resulting in reasonably good coverage of the study area. The utilised records from the gauge locations are the same as for the January 2011 event, except for Beachmere, which did not record rainfall in 2009. The gauge locations are illustrated in Figure 2-2.

The majority of the cumulative rainfall depth at these gauges range between 320mm and 400mm, indicating that the rainfall was equally distributed across the catchment during the May 2009 event. The lowest record of 209mm was recorded at the Woodford gauge and the two highest rainfall depths of 457mm and 444mm were recorded at the Deception Bay and Burpengary (Dale Street) gauges.

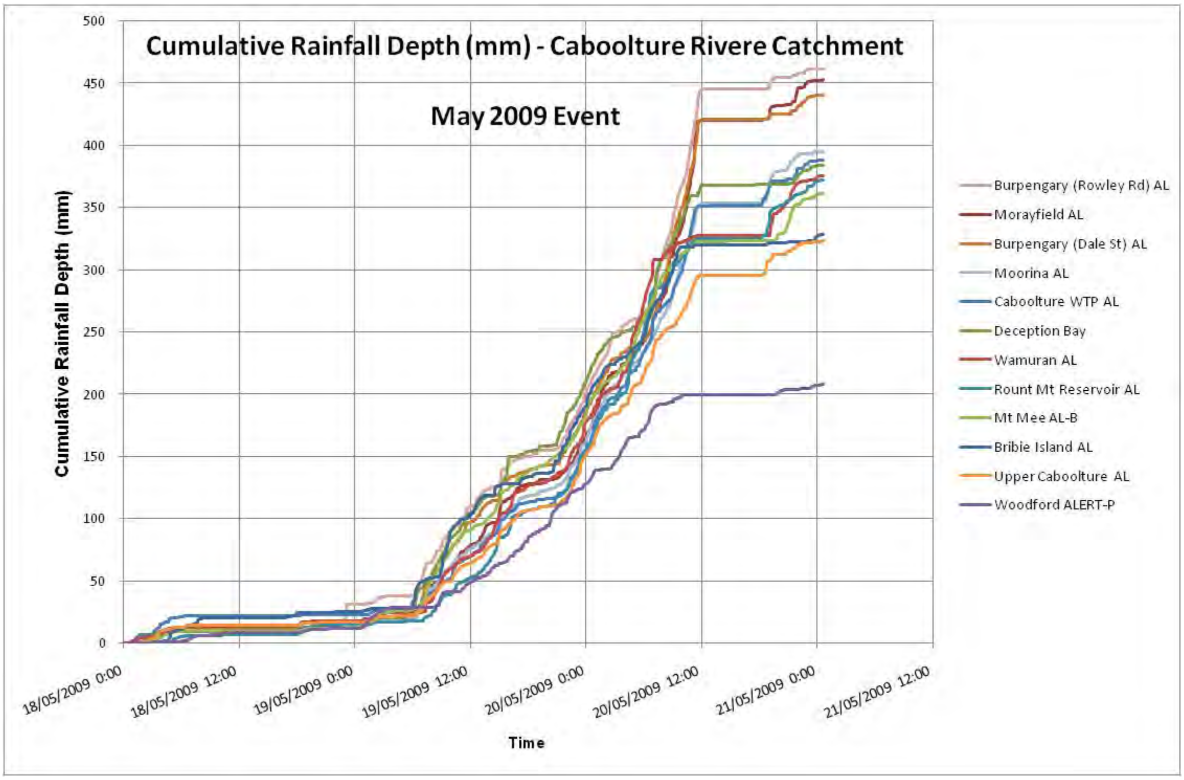


Figure 3-1 Cumulative Rainfall Depths (mm) – Caboolture River Catchment May 2009 Event

3.2 Modelling

3.2.1 Hydrologic Model

The adopted model calibration parameters from the January 2011 event were used for the May 2009 model verification event.

3.2.2 Hydraulic Model

The adopted model calibration parameters (from the January 2011 event), inflows from the hydrologic WBNM model and downstream boundary derived from MSQ representing the tide levels, were used for the May 2009 model verification event. Only one scenario, consistent with the adopted 2011 event calibration scenario, was simulated.

3.3 Results

3.3.1 Hydrograph Comparison at the River Gauge Locations

The Caboolture WTP gauge was not operational during the event, with all recorded levels showing a constant level of 1.99m. Therefore only two gauges were available in the May 2009 event. The hydrographs for the Wamuran and the Upper Caboolture gauges are provided in Appendix C.

The hydrograph at the Upper Caboolture gauge shows discrepancies in timing and peak flood levels between the modelled and recorded data. At the Wamuran gauge the timing is comparable to the January 2011 event calibration results; however the model is over predicting flood levels by approximately 0.5m. The poor match for the rising limb of the flood 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.

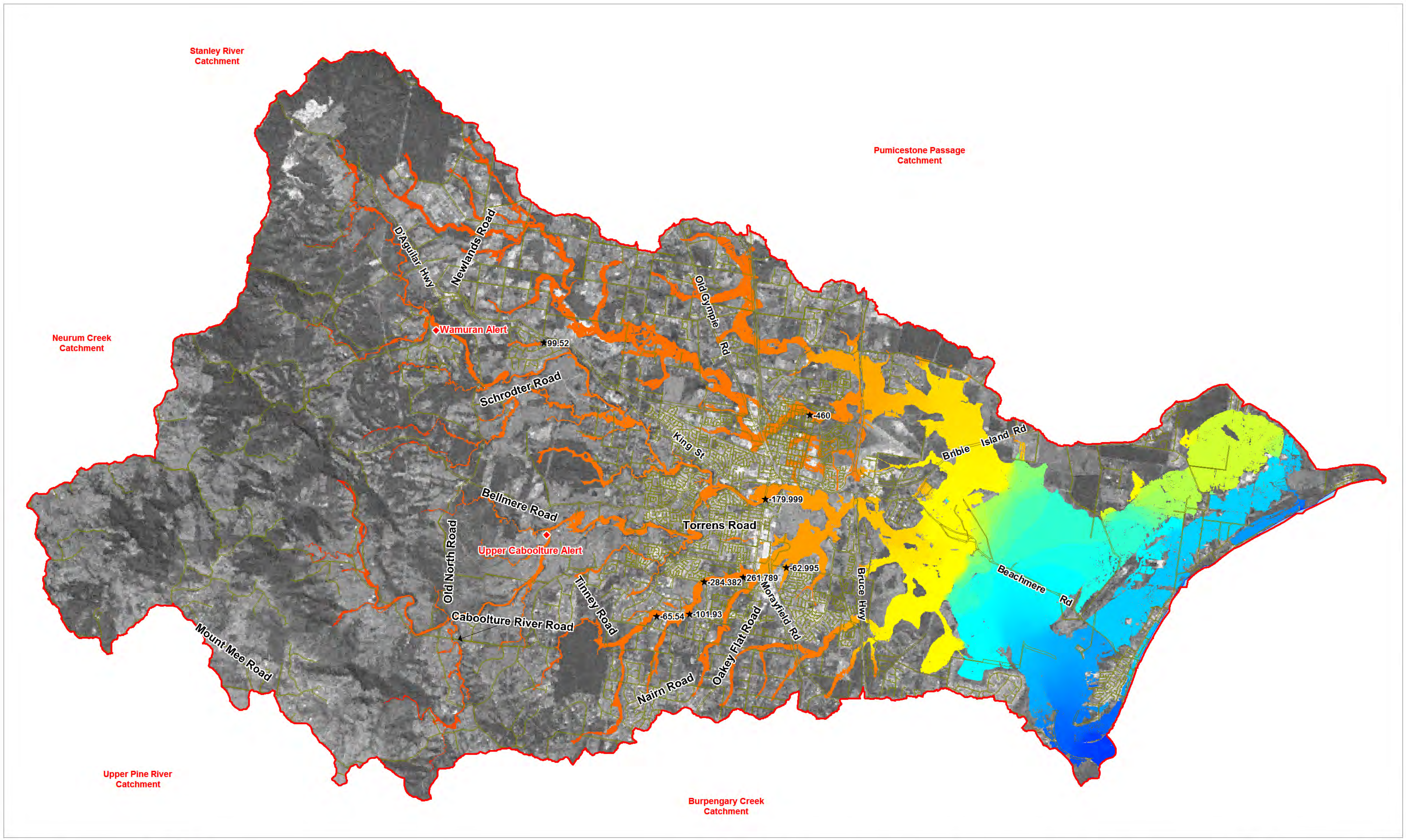
3.3.2 Floodmarks

Council's available records for the May 2009 event comprised of only eight flood marks in the Caboolture River catchment. Most of these marks are within the southern part of the catchment; only one mark is located along Wararba Creek. The flood mark locations and differences in surveyed and modelled flood levels are illustrated in Figure 3-2.and Table 3-1 also presents the surveyed and modelled peak flood levels, as well as the difference in water levels in millimetre (mm) at the flood marks.

Table 3-1 Surveyed and Modelled Flood Level Comparison at Flood Marks

Flood Mark ID	Quality	Surveyed Mark Level (mAHD)	Modelled Mark Level (mAHD)	Difference in Flood Level - Modelled Minus Surveyed (mm)
CAB206	Medium	8.85	8.39	-460
CAB227	Medium	7.84	7.66	-180
CAB276	Medium	7.02	6.96	-63
CAB278	Medium	13.78	13.71	-66
CAB280	Medium	11.36	11.26	-102
CAB289	Medium	8.05	8.31	262
CAB299	Medium	9.55	9.27	-284
CAB323	Medium	19.65	19.75	100

Table 3-1 shows that of the eight available flood marks, two flood marks (one located along Wararba Creek, the other along Caboolture River) had a higher modelled flood level compared to the surveyed flood levels, and six flood marks had lower modelled flood levels. These six flood marks are located along Caboolture River. So, generally the model is under predicting, however the difference in flood levels is relatively low; predominately within a of range of +/-200mm, with two between +/-300 and one at -460mm.



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: **3-2**

Rev: **A**

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4 DISCUSSION

The January 2011 event used for model calibration resulted in the highest flood levels on record at the Upper Caboolture River gauge (Hausmann Lane) and was classified as a major event, based on BoM's classification system. The May 2009 event utilised for model verification was classified as a moderate flood event; for more details refer to the *Calibration Feasibility report Caboolture River catchment*, dated January 2011, reference R.B18104.004.00). These two events provide a good range of magnitude and have the advantage that they occurred recently, thus limiting the changes in the catchment of the landuse, additional waterway structures or change in topography.

The January 2011 model calibration showed reasonable results, considering the three major factors of timing, peak flood levels and volume, however it also highlighted that the peak flood levels in the southern part of the catchment (Caboolture River) were underestimated and the volume was under predicted. This issue may be due to poor spatial distribution of gauges, as indicated by the radar data.

It was therefore important and interesting to simulated an additional historic flood event; the May 2009 event. Unfortunately, a lot less data was available for this event; only two of the three river gauges recorded flood levels in May 2009 and there were only 8 flood mark records available compared to 89 records in January 2011. The May 2009 validation results were slightly better considering the flood marks and the hydrograph comparison at the gauges.

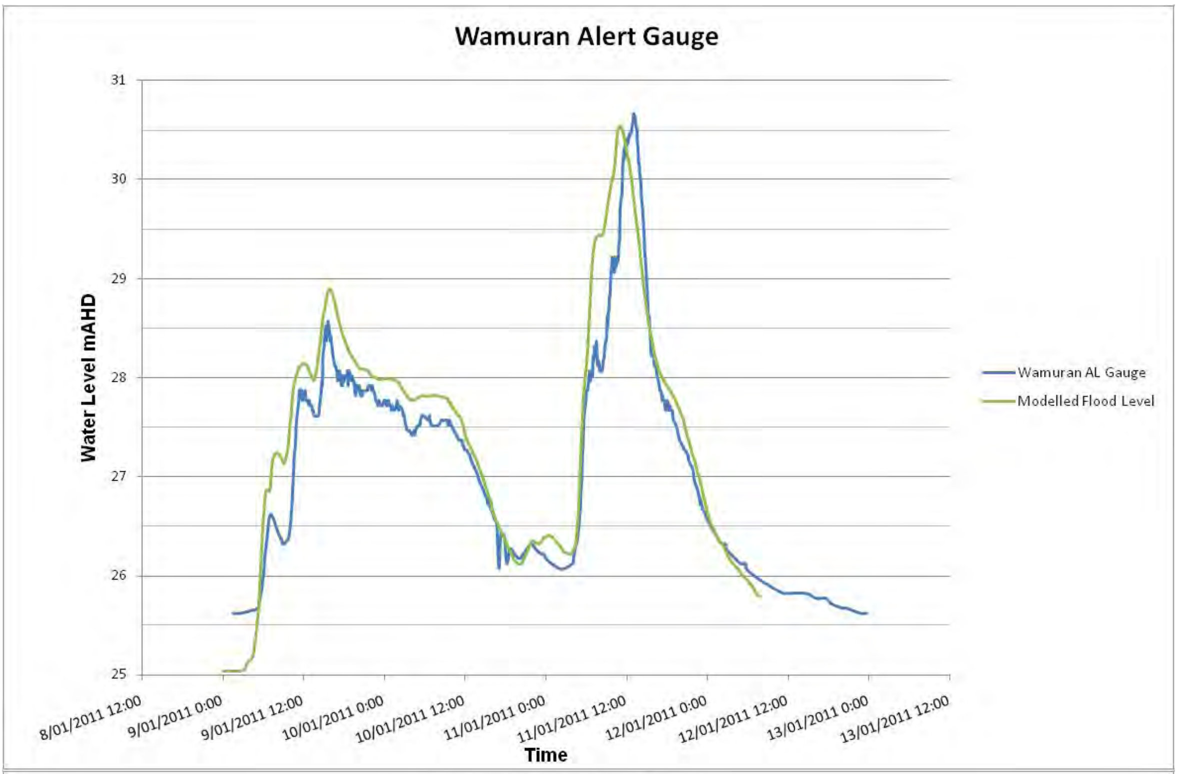
Due to the insufficient representation of the heavy rainfall in the western part of the catchment (identified in the radar data) the January 2011 model event resulted in an under prediction of flood levels. The May 2009 event also showed an under prediction, however to a smaller degree and it should be noted less data was available for this event.

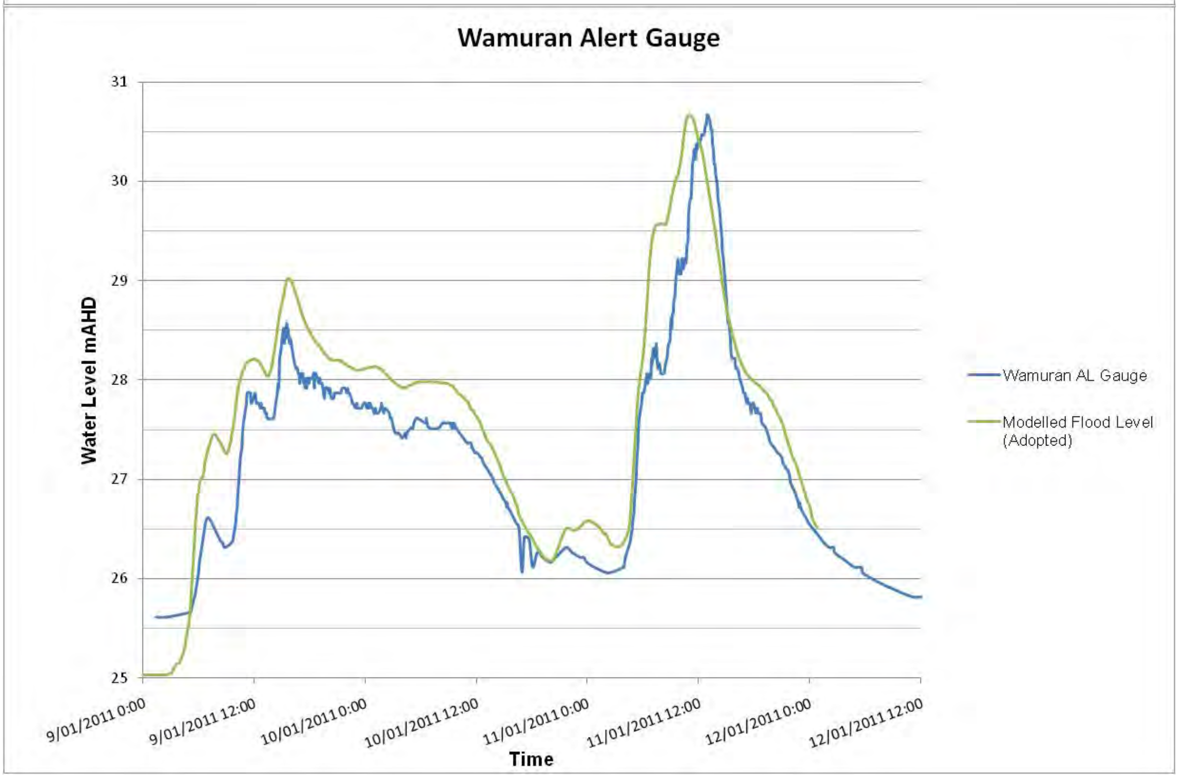
It should be borne in mind that this calibration is for only one catchment in the broader RFD area. Council's approach is to have a holistic model calibration and adoption of hydrologic and hydraulic parameters. The adopted Regional Floodplain Database approach includes the following:

- Utilising a standard set of hydraulic roughness parameters (Manning's n values) for different landuse types for the entire RFD region;
- Defining the percentage impervious and pervious and the landuse (grided approach developed as part of Stage 1) based on LiDAR data; and
- Adopting the two dimensional approach for representation of the river and creeks in the hydraulic model, generally using LiDAR data, bathymetry data was collected in some major river sections.

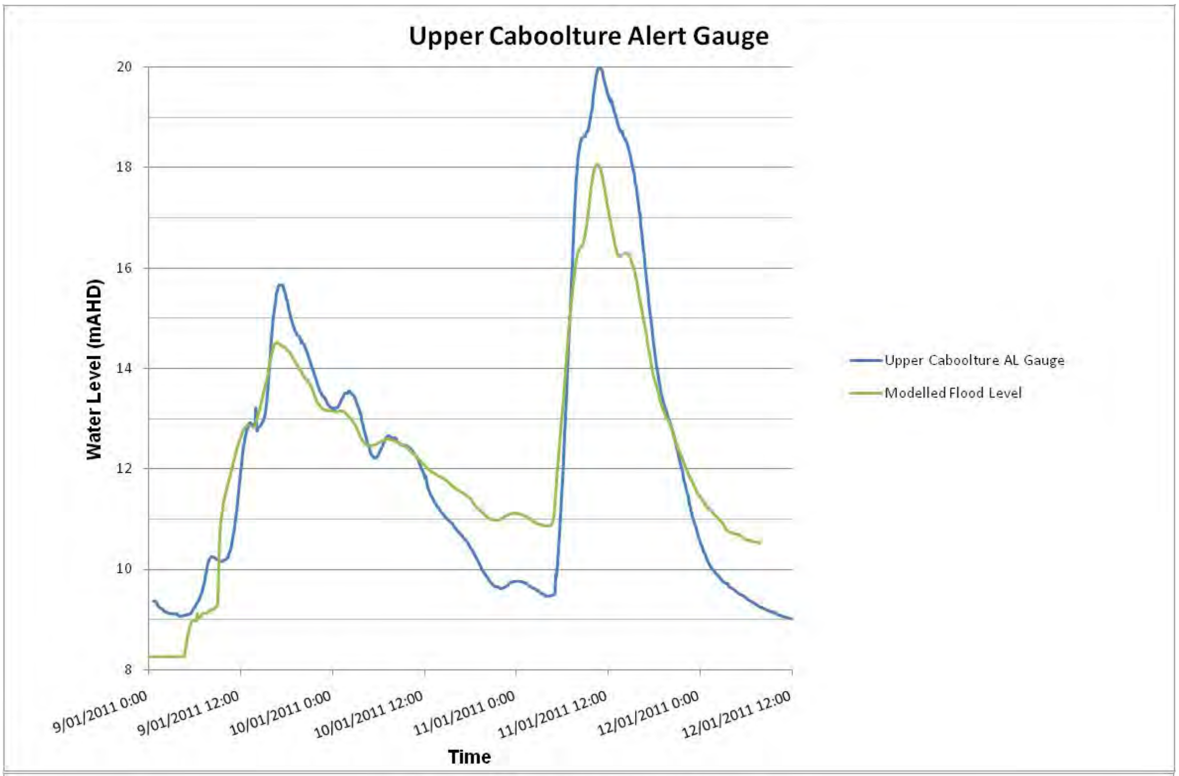
These factors may influence model calibration results in some catchments and localised areas across the RFD.

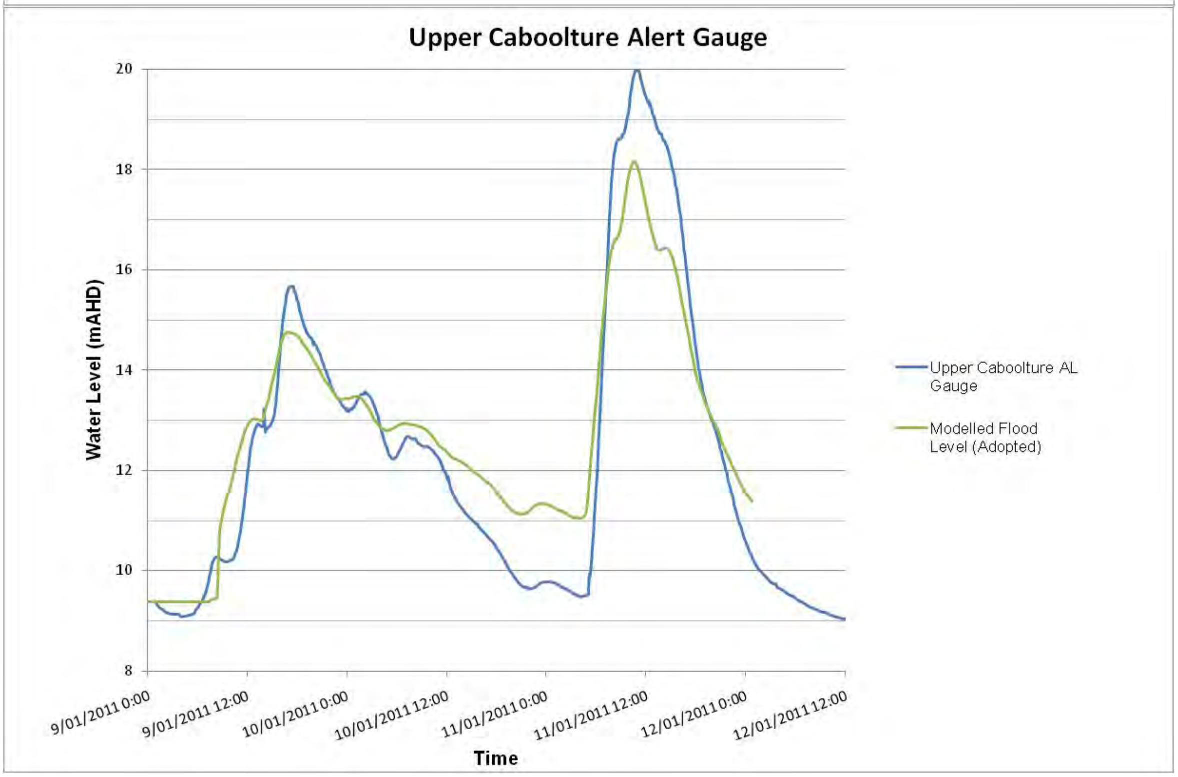
APPENDIX A: RECORDED AND MODELLED HYDROGRAPHS - JANUARY 2011 EVENT

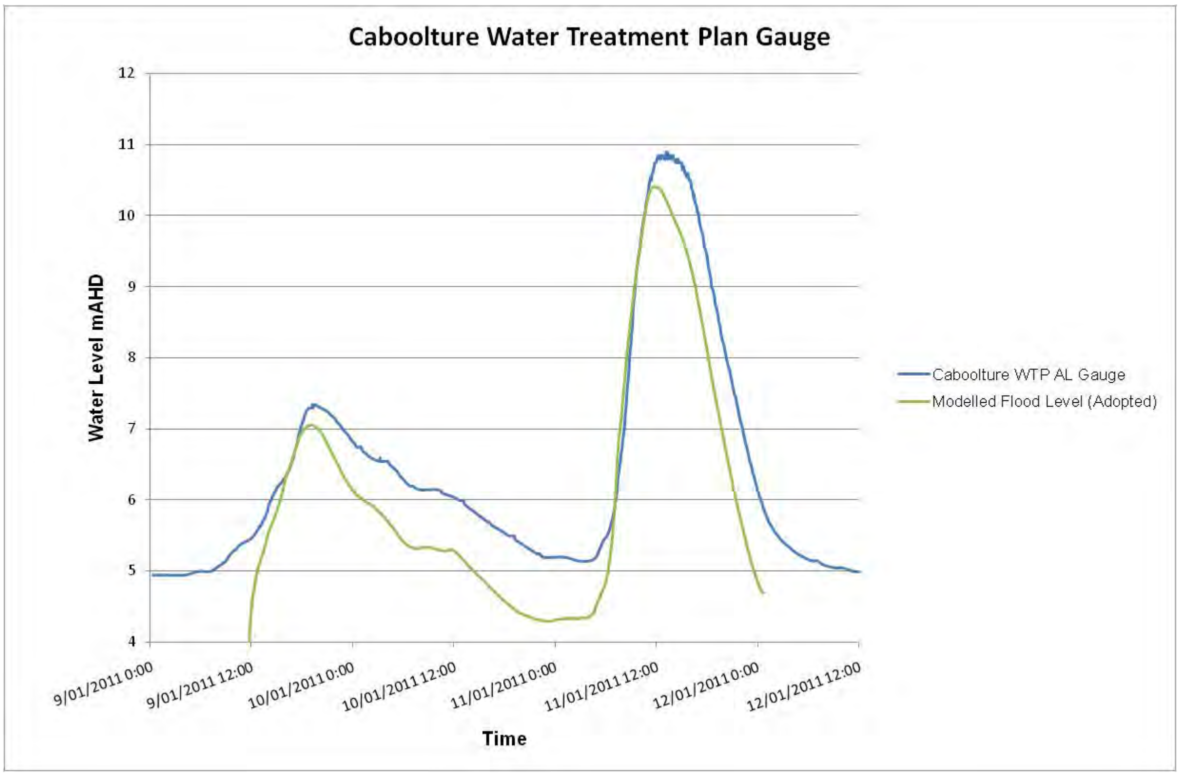




A-2 RECORDED AND MODELLED HYDROGRAPHS - JANUARY 2011 EVENT

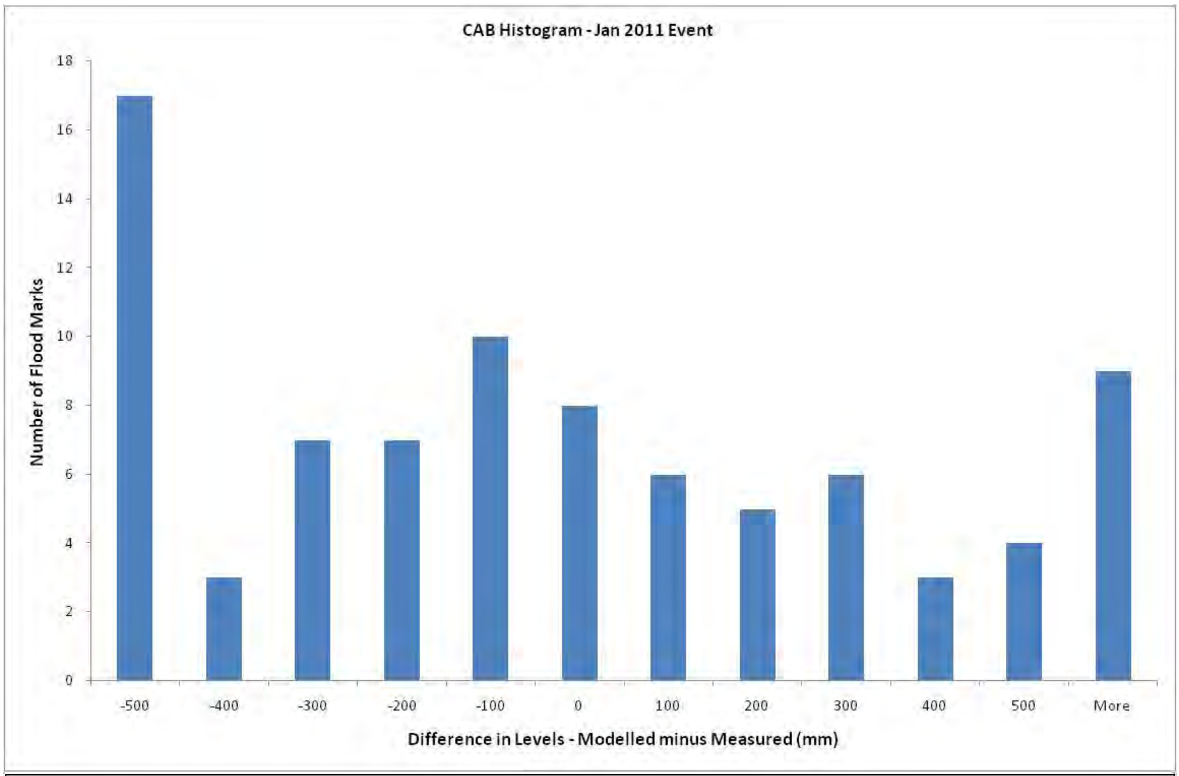


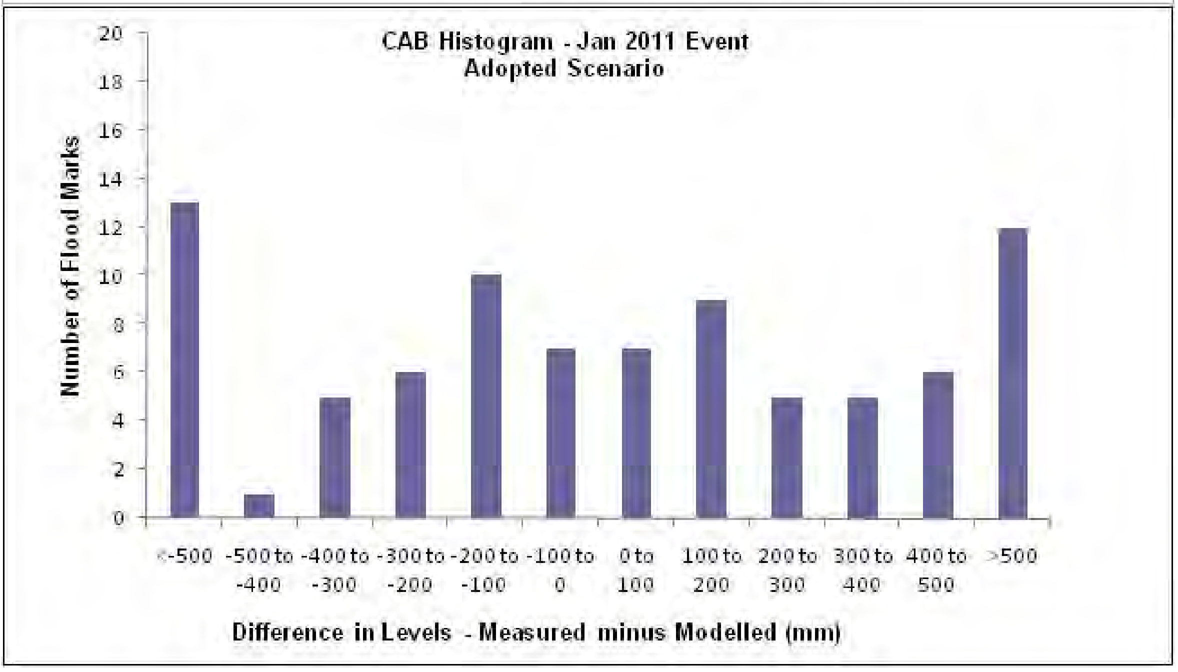




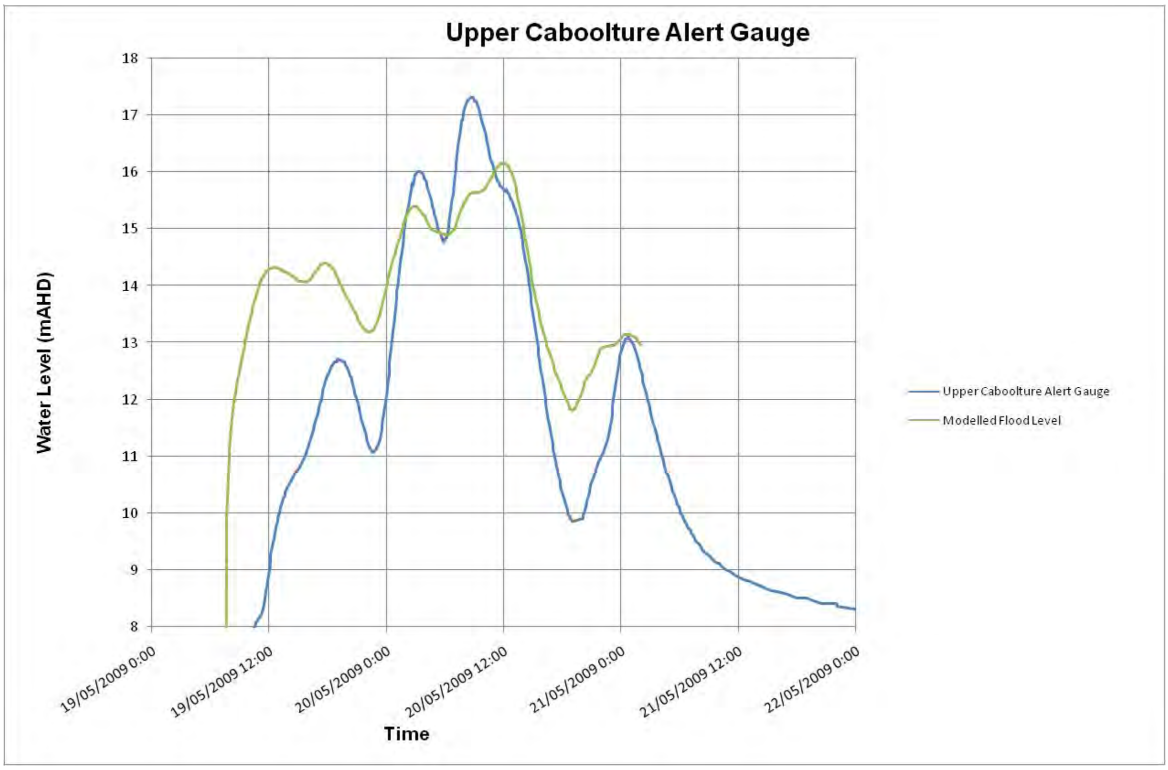
Caboolture Water Treatment Plan Gauge
Water Level mAHD
12
11
10
9
8
7
6
5
4
9/01/2011 0:00
9/01/2011 12:00
10/01/2011 0:00
10/01/2011 12:00
11/01/2011 0:00
11/01/2011 12:00
12/01/2011 0:00
12/01/2011 12:00
Time
Caboolture WTP AL Gauge
Modelled Flood Level (Adopted)

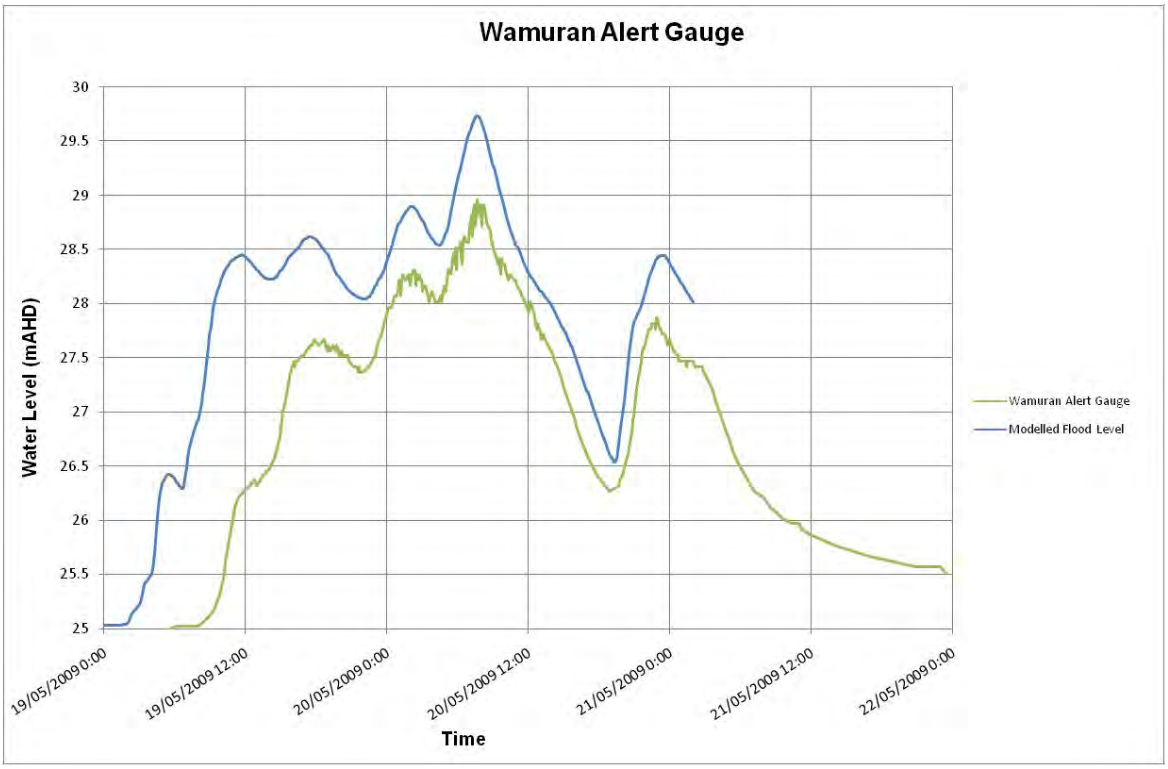
APPENDIX B: FLOOD MARK HISTOGRAM – JANUARY 2011 EVENT





APPENDIX C: RECORDED AND MODELLED HYDROGRAPHS - MAY 2009 EVENT





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BMT WBM Denver	**8200 S. Akron Street, Unit 120** **Centennial Denver Colorado 80112 USA** **Tel +1 303 792 9814 Fax +1 303 792 9742** **Email denver@bmtwbm.com** **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**
BMT WBM Perth	**Unit 6, 29 Hood Street, Subiaco 6008** **Tel +61 8 9322 1577 Fax +61 8 9226 0832** **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 9713 4836 Fax +61 2 9713 4890** **Email sydney@bmtwbm.com.au** **Web www.bmtwbm.com.au**
BMT WBM Vancouver	**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.au**

APPENDIX D

Technical Note

From: Richard Sharpe | To: Moreton Bay Regional Council

Date: 15 June 2012 | CC:

Subject: Modelling Quality Report; Caboolture

1 Background

As part of Moreton Bay Regional Council's (MBRC) Regional Floodplain Database (RFD) project, a detailed TUFLOW model of the Caboolture catchment has been developed. This technical note has been prepared to demonstrate that the Caboolture model has been reviewed, and that the model performance is suitable for the intended use and that the sensibility of the results has been checked.

2 Model Development Process

The following procedure has been implemented in the development of the model:

1. A site visit was undertaken prior to commencing development of the model to gain an appreciation for the catchment;
2. An infrastructure assessment was undertaken. A report was produced from this assessment and submitted to MBRC for their consideration on structure data requirements. This approach ensured that sufficient data was captured for the level of accuracy required from the model;
3. The catchment delineation used in the hydrology was reviewed. This review indicated that the catchment delineation was suitable;
4. A draft TUFLOW model was developed, focussing on the 100 year ARI flood event, and submitted to MBRC for review (on 21st July 2011);
5. MBRC provided feedback from their review of the TUFLOW model on 28th July and 11th August 2011. Alterations following this review are discussed later in this note;
6. A final model was developed and used to simulate all the design and sensitivity events; and
7. Further checking was undertaken to ensure that the model was suitable for simulating the full range of flood events.

Throughout model development, model stability, warnings messages and mass errors were monitored to ensure that the model performance was acceptable. Careful attention was provided to ensuring that flow through the 1D structure elements in the model was stable, as well as flow across the floodplain in the 2D domain.

3 Model Amendments – Post Draft Model Review

Various enhancements were recommended by both BMT WBM and MBRC following the development of the draft model. The following changes were implemented:

1. Changes made to some structures, as per Council's correspondence (28th July 2011, 11th August 2011 and 24th October 2011).
2. Gully/River lines were added, particularly in the steep upper catchment, to increase the stability of the model.

3 For an area of instability in the upper catchment, an interpolated z-point patch has been applied to smooth the topography.

4 The Caboolture weir has been added into the model. The weir has been represented as a z-line for the weir crest, and a z-shape to represent the structure downstream of the crest. For stability, the slope of the downstream face of the weir was given a stepped profile. The materials layer in this area has been adjusted to represent the weir bed and banks.

5 The materials layer has been adjusted along the Caboolture River banks in a steep area of the model to increase the stability of the model.

6 In some areas, the z-points weren't adequately representing the topography of the area. Z-shapes have been added in these areas to ensure that these features are adequately represented.

7 Additional survey data was used to update the details on some culvert structures.

4 Additional Amendments

Additional amendments were necessary for simulating the extreme events. The extent of the active 2D domain was further extended to ensure that the PMF flows were fully captured.

5 Model Performance

The following model performance checks have been undertaken:

- Stability of flow through key structures (e.g. Figure 5-1) was checked during model development. The arrangement of SX connections, structures and embankments has been edited to ensure that stable peak flows have been achieved where necessary;
- Stability of overland flow hydrographs were checked at several locations in the floodplain; (e.g. Figure 5-2);
- TUFLOW warning messages have been minimised. A few negative depth warning messages remain in parts of the catchment. But these are localised and limited to short time periods in the overall simulation; and
- Mass balance errors have been minimised. Mass balance errors range from -0.1% to 0.1% for most events, with up to -0.3% for the PMF.

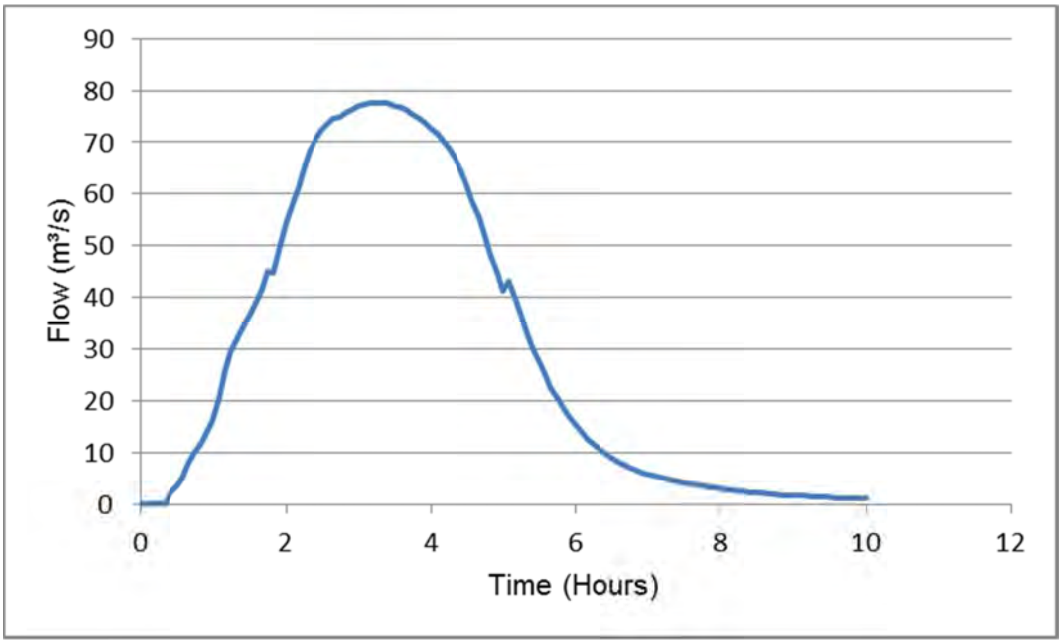


Figure 5-1: Flow through Culvert ID GYM01_04853 at Bruce Highway (100 year ARI; 3 hour storm duration)

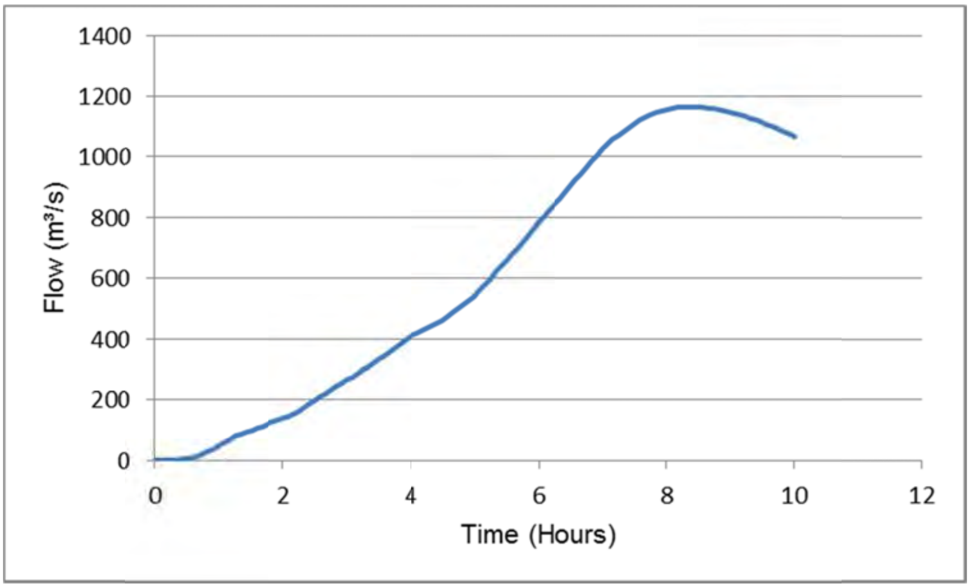


Figure 5-2: Overland Flow Hydrograph at the Downstream End near Harvey Ware Park (100 year ARI; 3 hour storm duration)

6 Downstream Boundary Sensitivity Analysis Anomaly

An anomaly has been detected for climate change scenario S5 (increased sea level). The results of this sensitivity analysis show a decrease in levels near the downstream boundary, highlighted in red in Figure 6-1. This decrease in flood level is incorrect, and has occurred due to the structure of the model.

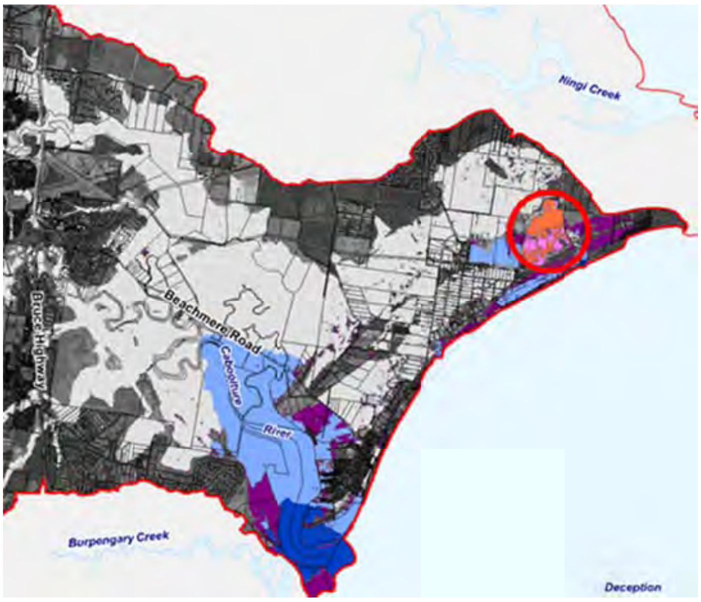


Figure 6-1: Area Showing Decrease in Flood Level Due to Sea Level Rise (Circled)

This decrease in peak flood level is an artefact of the SA polygon network used to define inflow locations in the model; specifically at SA polygon GOD_09_00000. In the base case, the flow for this SA polygon is spread over all wet cells in the subcatchment, which is primarily towards the upper part of the subcatchment (see Figure 6-2).

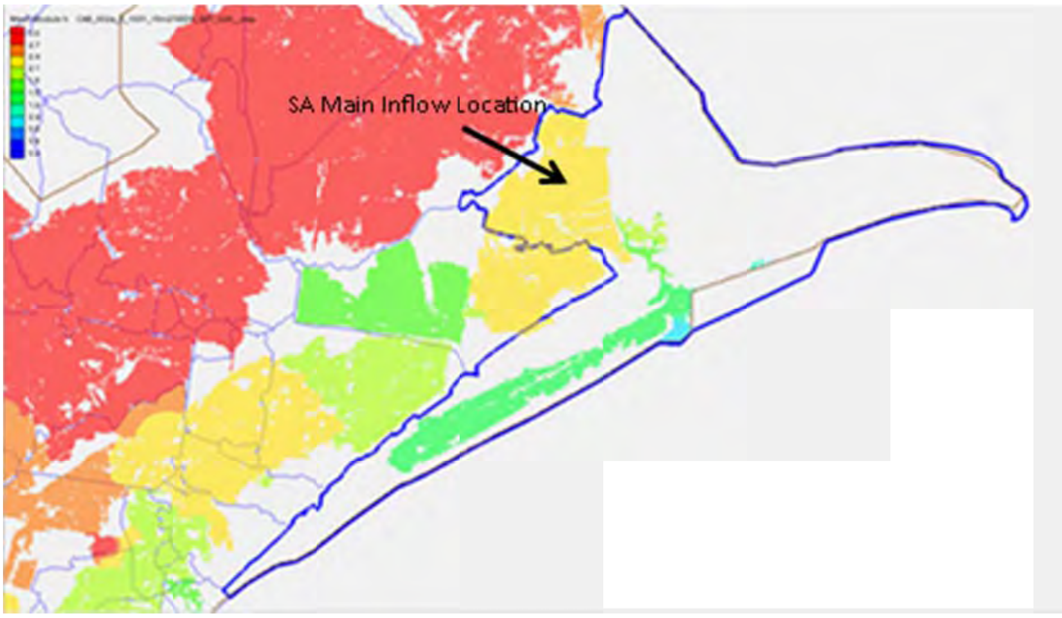


Figure 6-2: Base Case 100 Year EDS Peak Flood Level and SA Polygon GOD_09_00000

However, in the climate change scenario (S5), there is more wet cells closer to the downstream boundary due to the increased water level in the downstream boundary conditions. As a consequence, the flow from the SA polygon is spread over a wider area in the model. In particular, more flow from SA polygon GOD_09_00000 is being spread over the downstream portion of the subcatchment (see Figure 6-3).

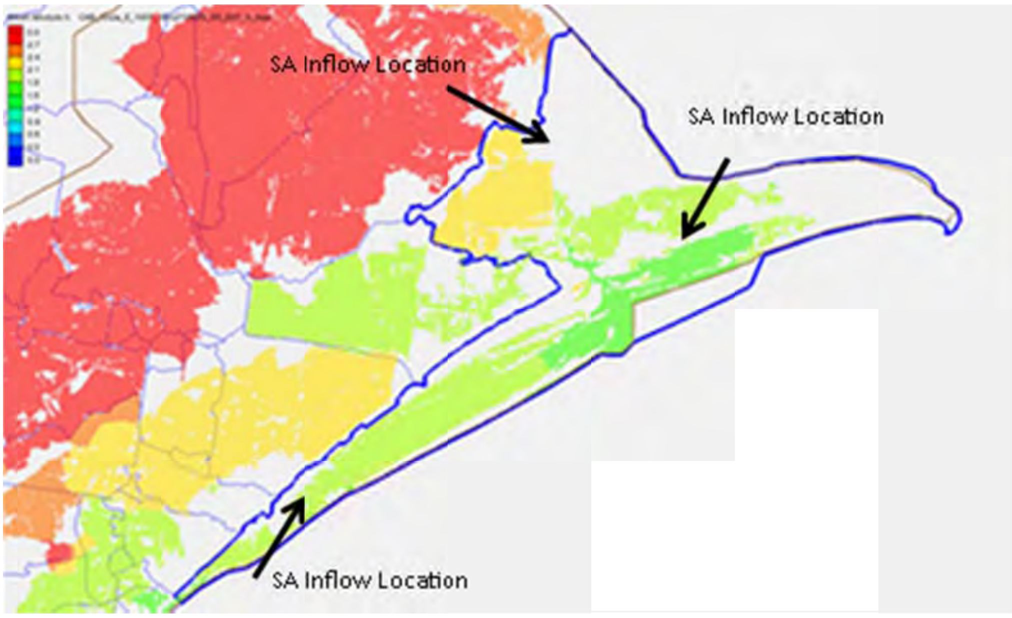


Figure 6-3: Increased Sea Level 100 Year EDS Peak Flood Level and SA Polygon GOD_09_00000

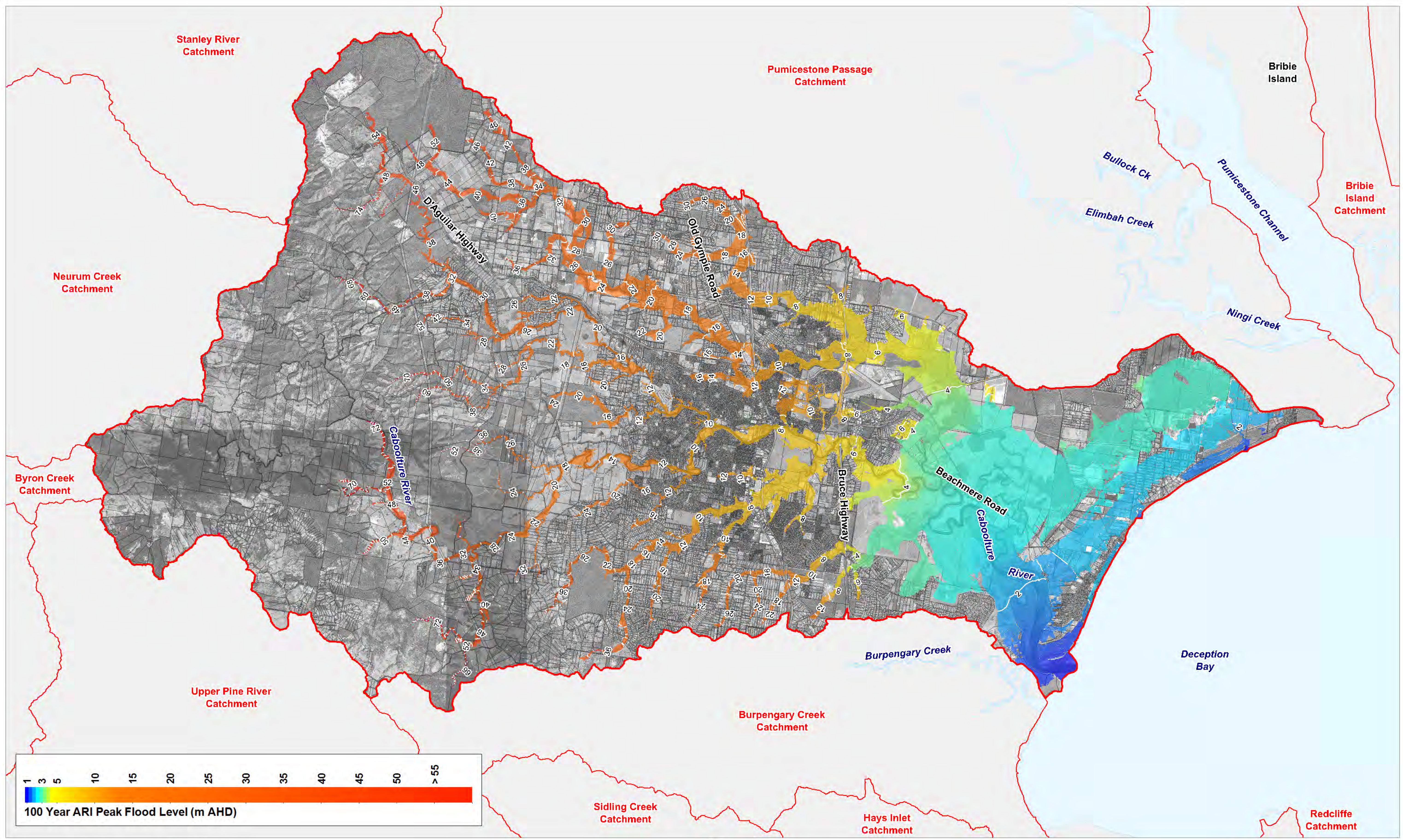
In the base case, the downstream areas were drier. Therefore more flow was apportioned to the upper part of the SA polygon. This resulted in more flow spilling into the area to the west of SA polygon GOD_09_00000 in the existing model, which accounts for the decrease in flood levels highlighted in Figure 6-1. In reality, however, an increase in sea levels will not reduce flood levels in this area.

7 Conclusion

The Caboolture model has been developed with due consideration given to ensuring the quality of the model. The model has been reviewed internally and externally by MBRC. Amendments have been made in light of these reviews, and the overall model performance is suitable for the intended use of the model.

If the model is to be used to undertake sensitivity analysis on the downstream boundary, it should be noted that the current schematisation of the SA polygons should be altered. This is to avoid the issue discussed in Section 6, whereby increased sea levels incorrectly lead to reduced peak flood levels.

APPENDIX E



LEGEND

Caboolture Catchment Boundary

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

Cadastral Boundaries

Title:

Peak Flood Level Map – 100 Year ARI

Figure: **E1**

Rev: **A**

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N

0km 3 6
Approx. Scale

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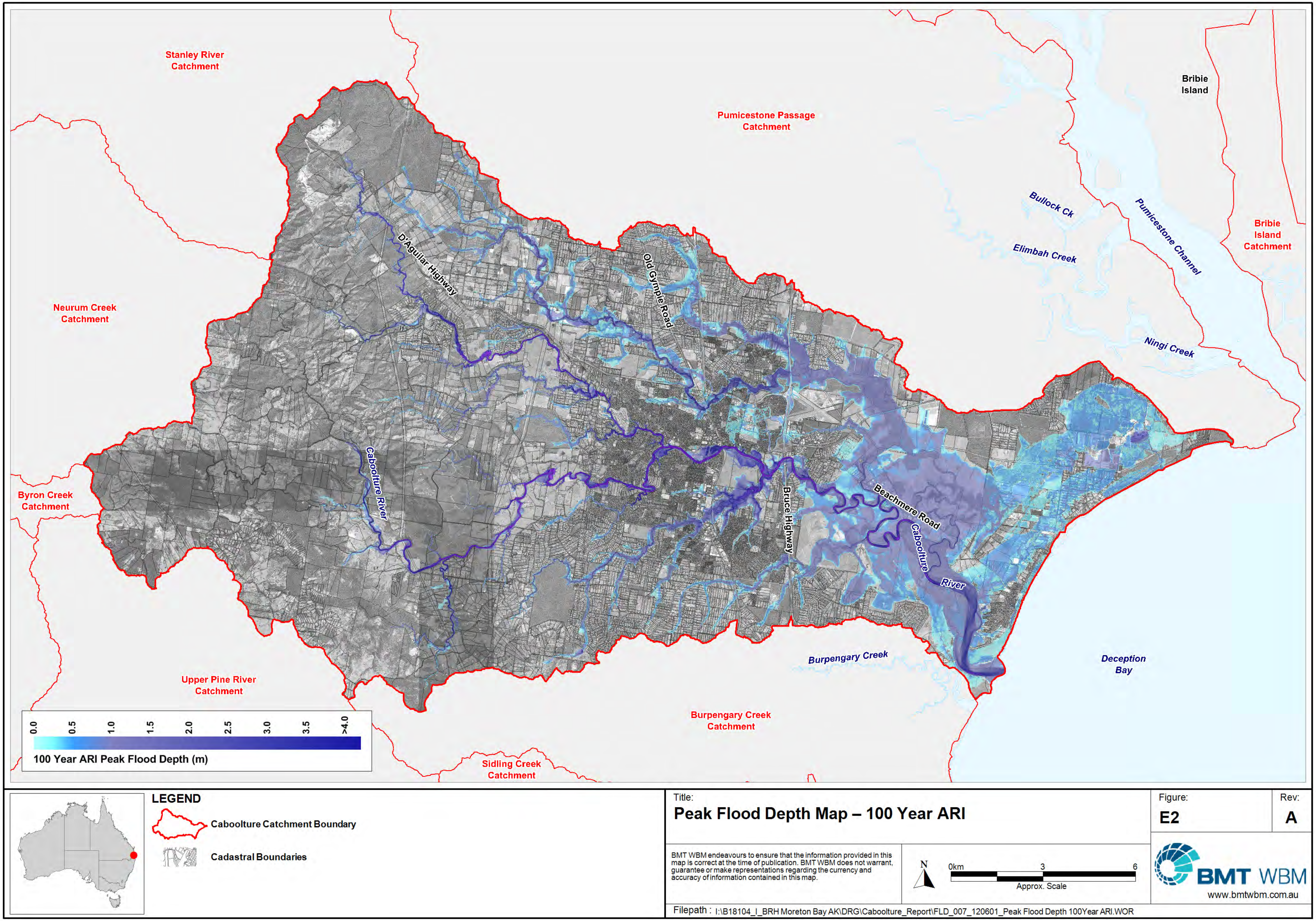

Title:

Peak Flood Depth Map – 100 Year ARI

Figure: E2

Rev: A

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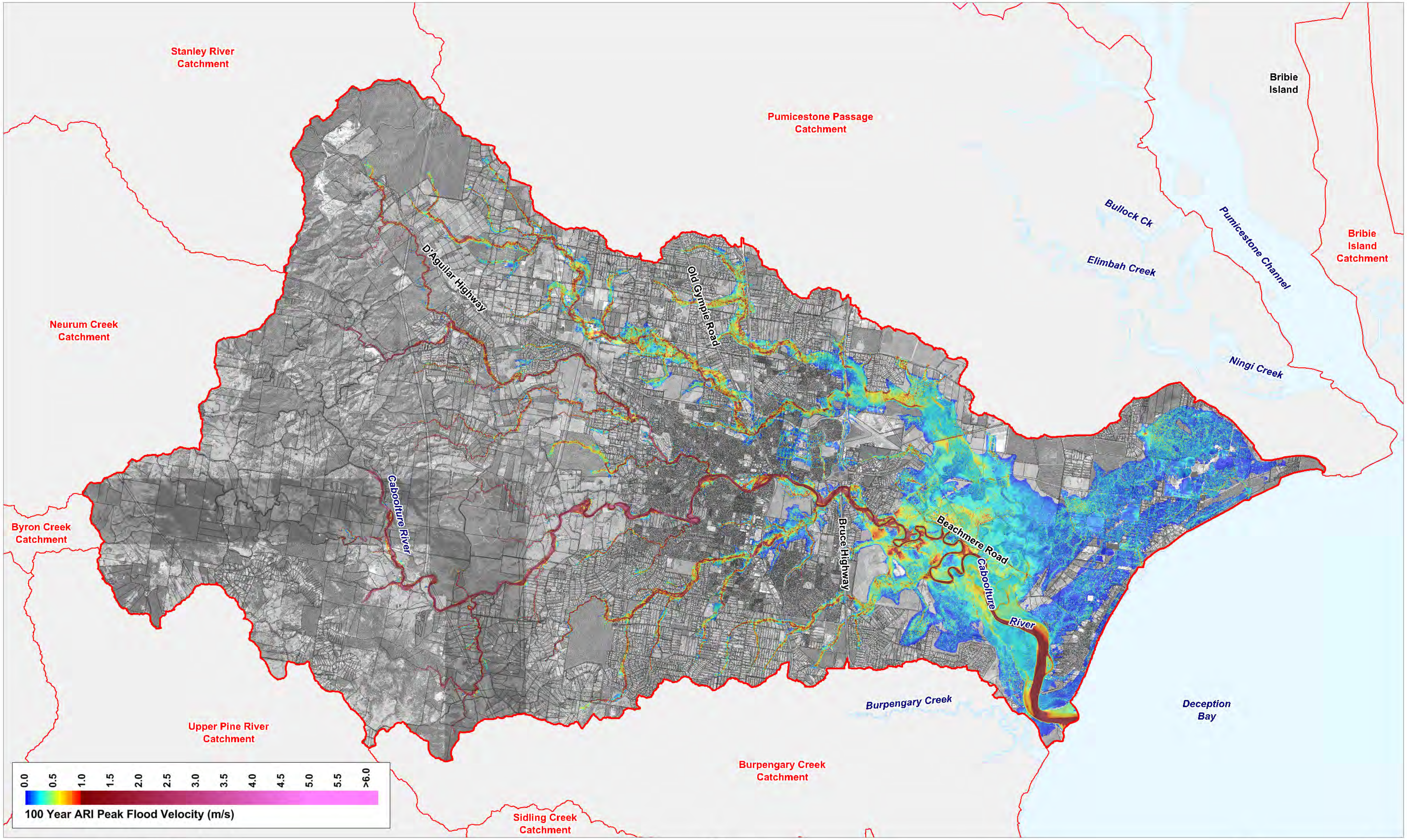

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Title:

Peak Flood Velocity Map – 100 Year ARI

Figure: E3

Rev: A

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Approx. Scale

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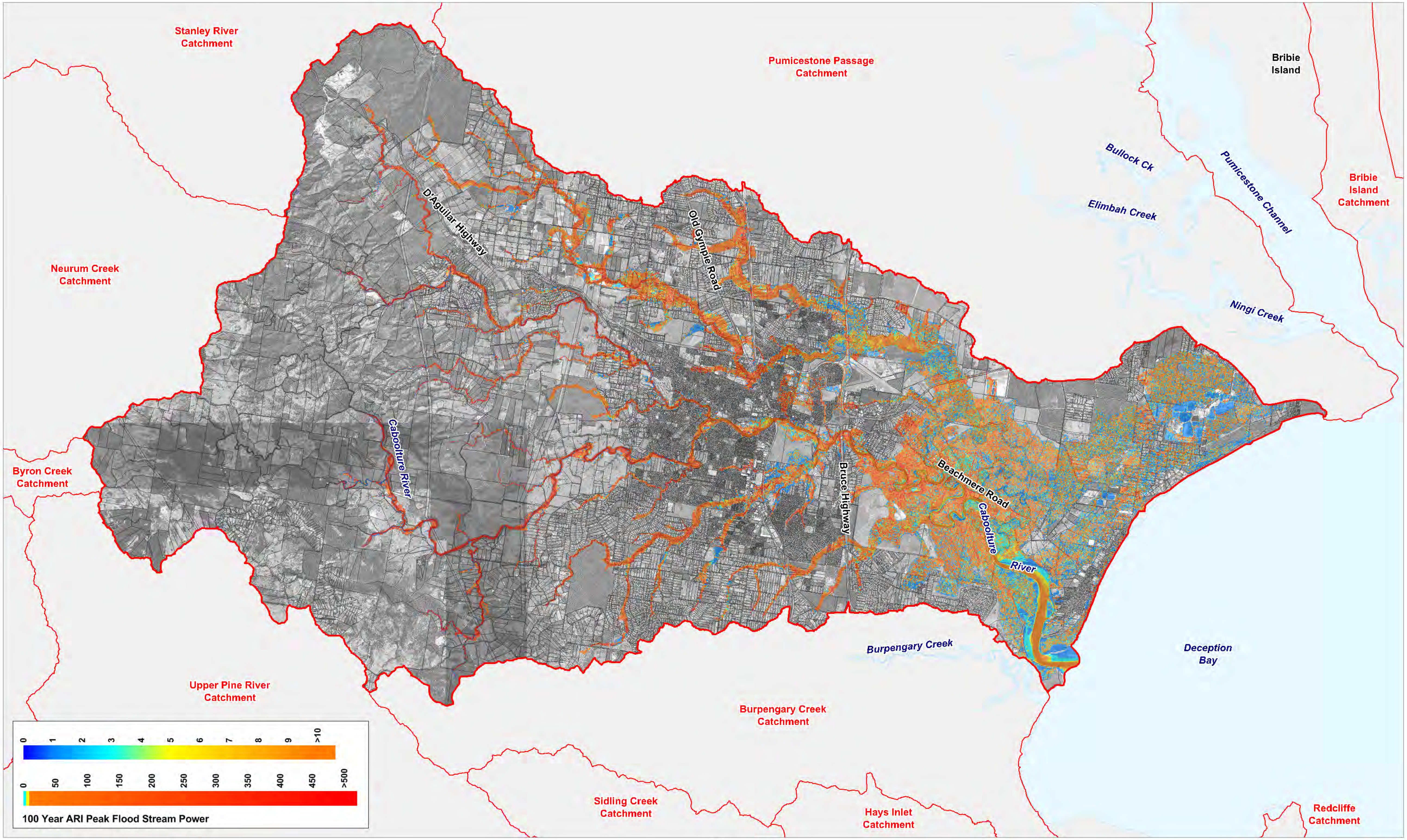
Filepath : I:\B18104_I_BRH Moreton Bay AK\DRG\Caboolture_Report\FLD_008_120601_Peak Flood Velocity 100Year ARI.WOR



LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

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

Title:
Peak Flood Stream Power Map – 100 Year ARI

Figure: **E4**

Rev: **A**

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Approx. Scale

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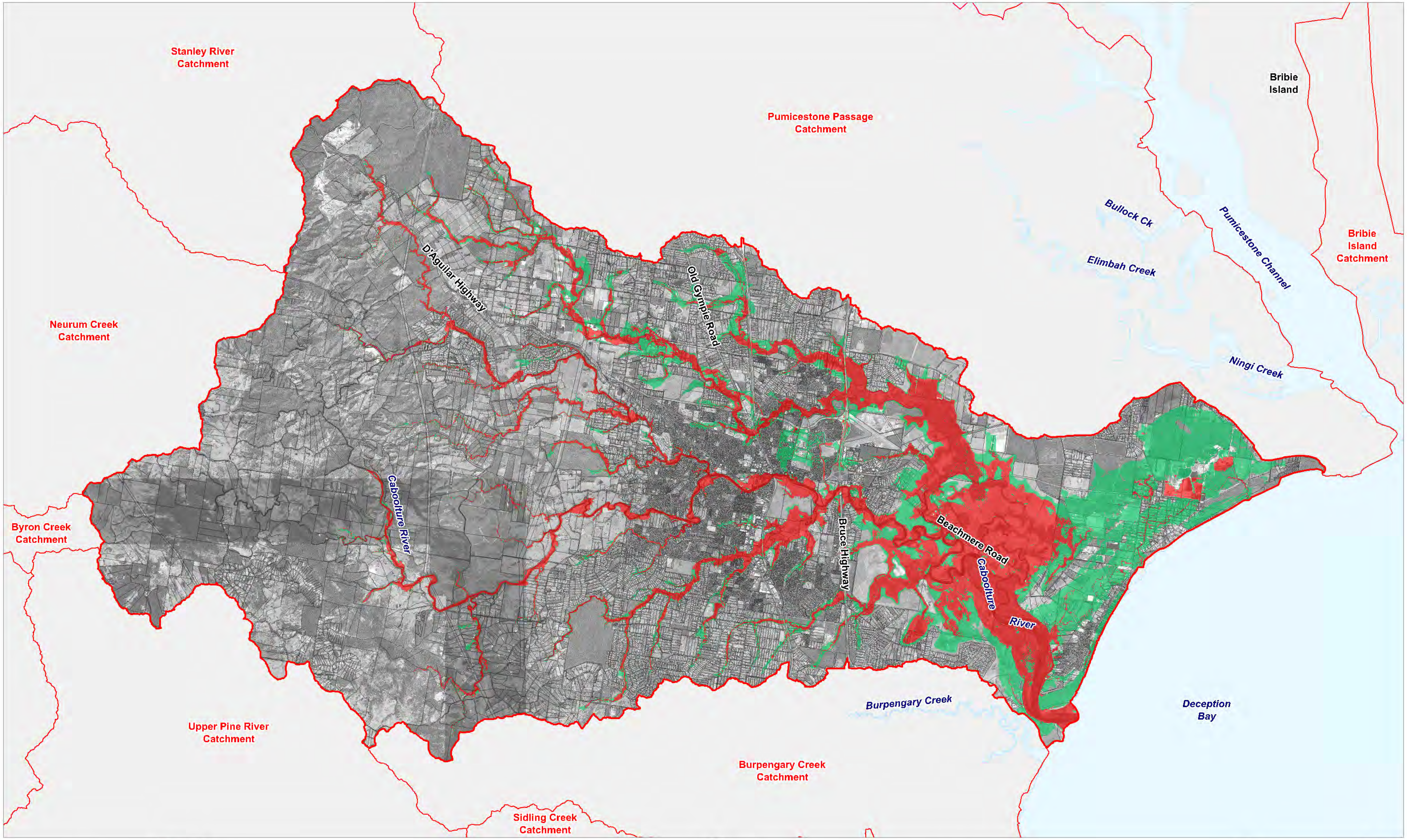

LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

New South Wales Floodplain Development Manual Flood Hazard Category 100 Year ARI Event

Low Hazard

High Hazard

Title:

Peak Flood Hazard Map – 100 Year ARI

Figure: **E5**

Rev: **A**

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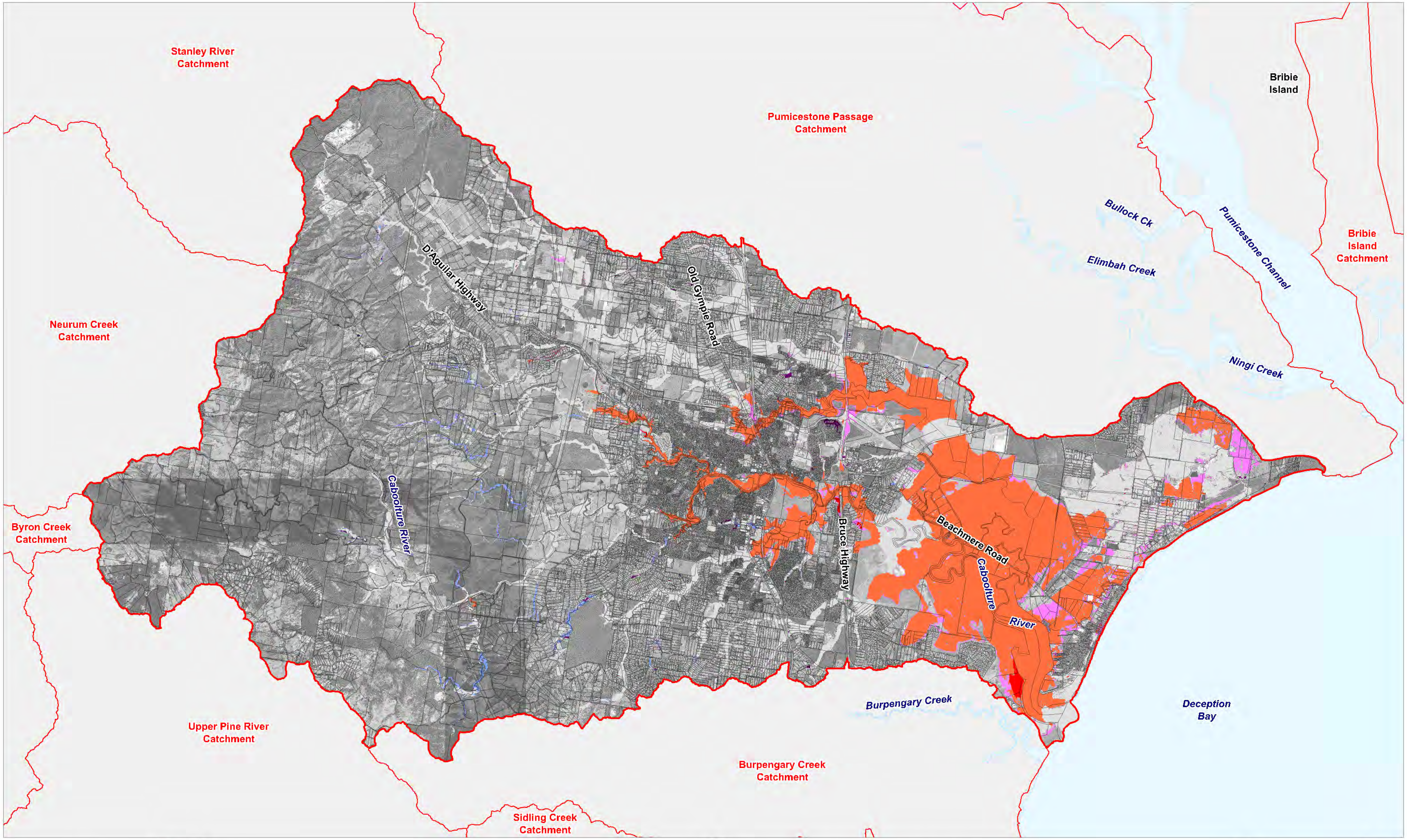
APPENDIX F



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
- Was dry now wet
- Was wet now dry

Title:

100 Year EDS Minus 100 Year 3 Hour, 6 Hour and 12 Hour Storm

Figure: F1

Rev: A

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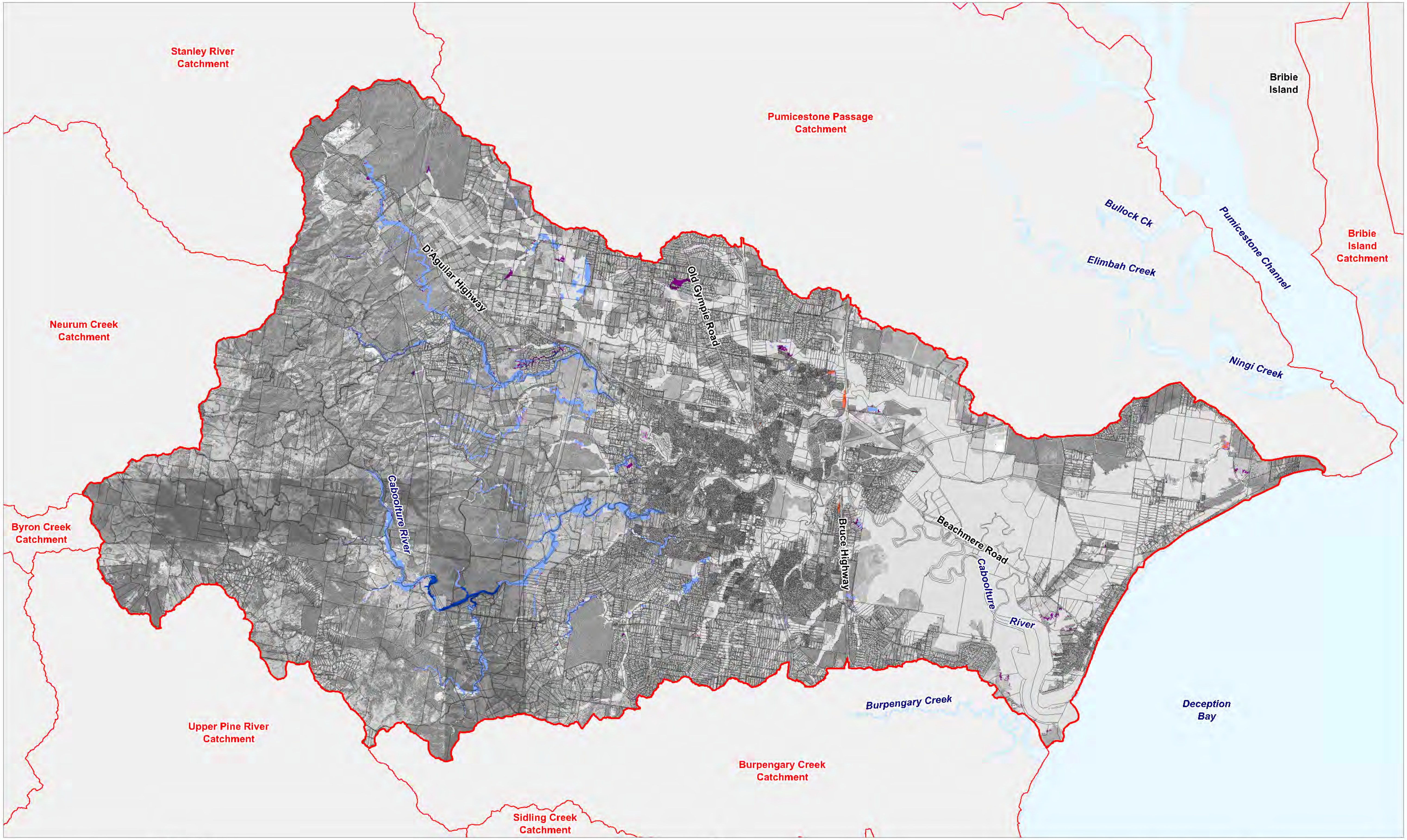

LEGEND

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
- Was dry now wet
- Was wet now dry

Title:

Increased Roughness Scenario (S2) Minus 100 Year EDS

Figure: F2

Rev: A

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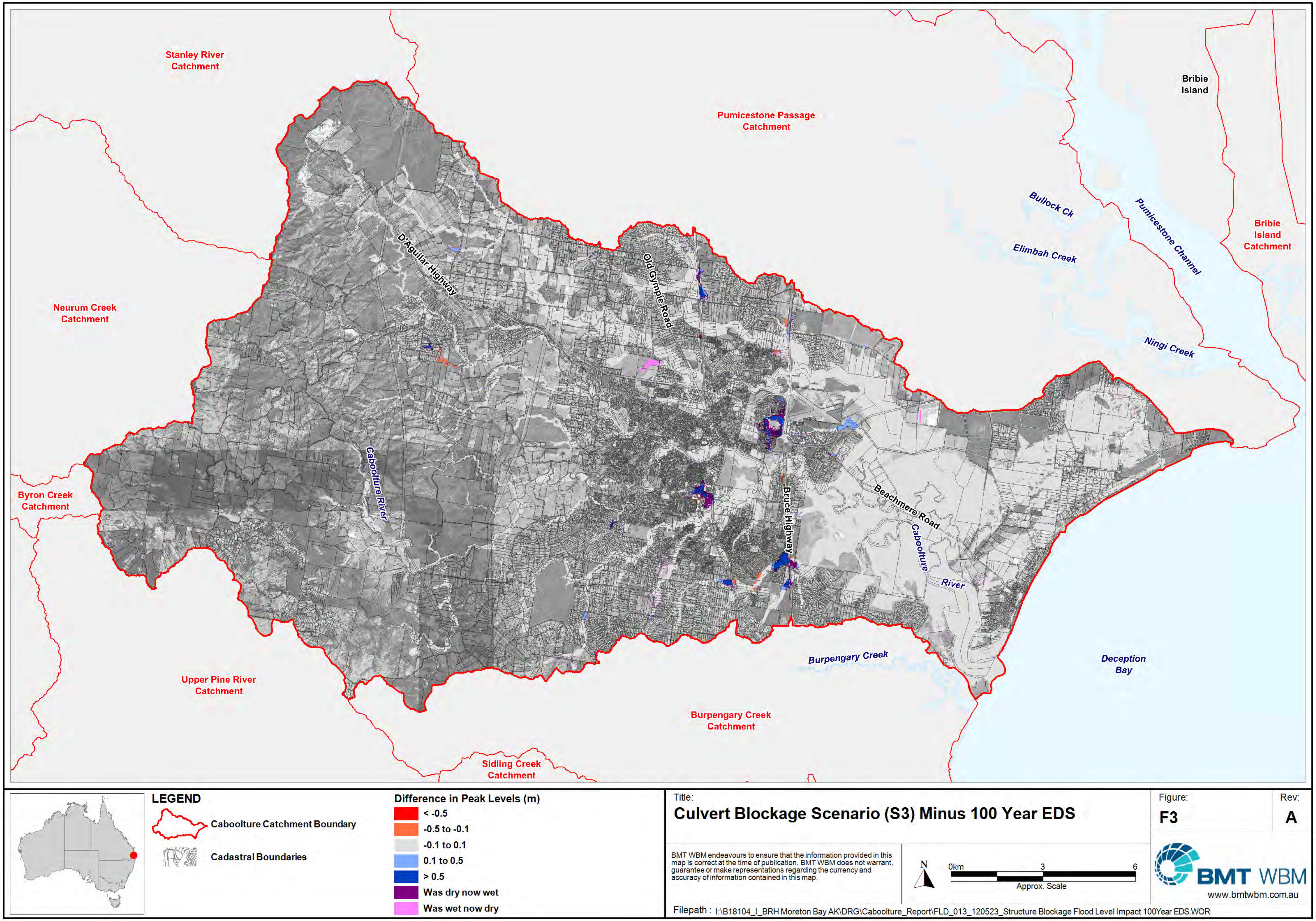

Title:

Culvert Blockage Scenario (S3) Minus 100 Year EDS

Figure: F3

Rev: A

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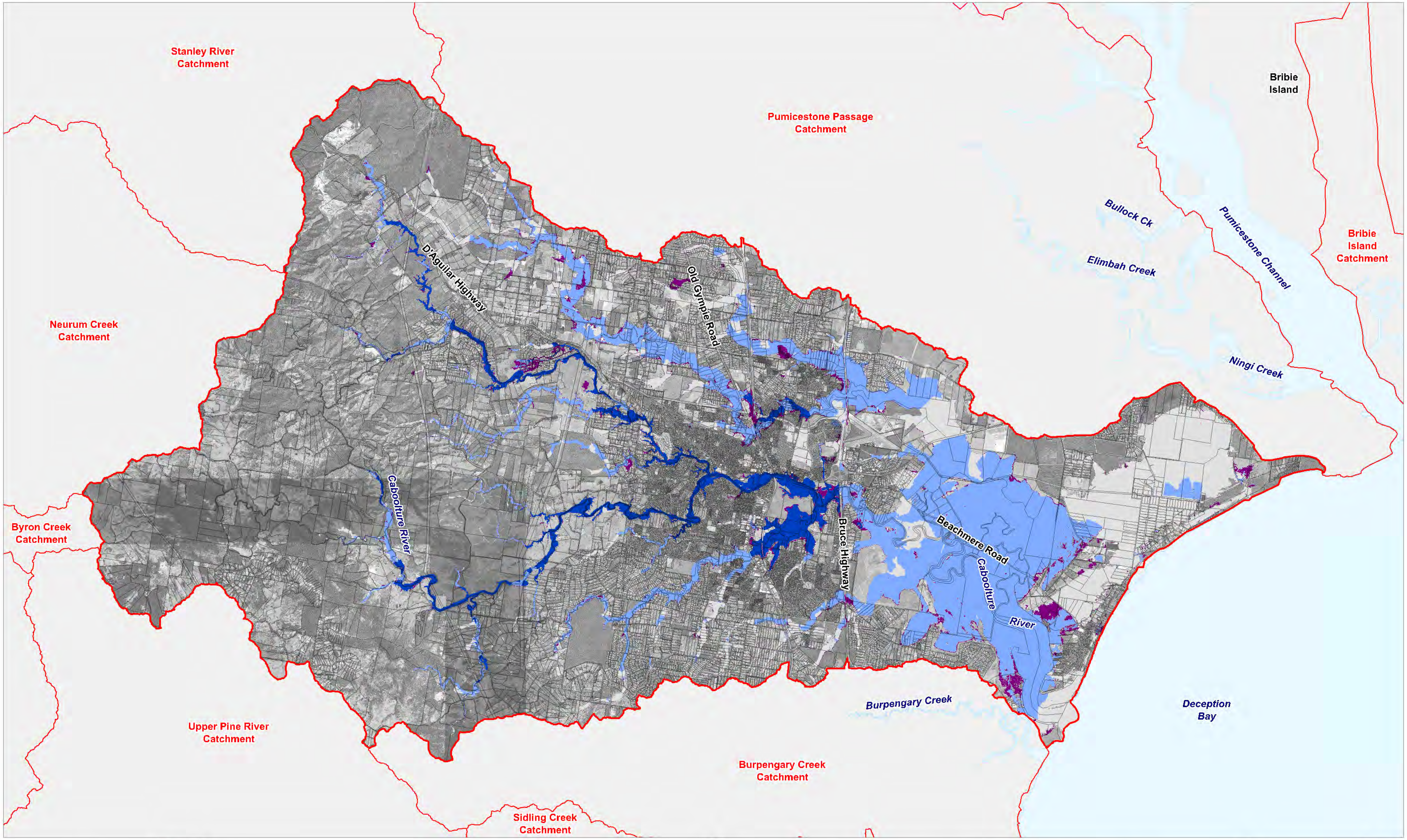
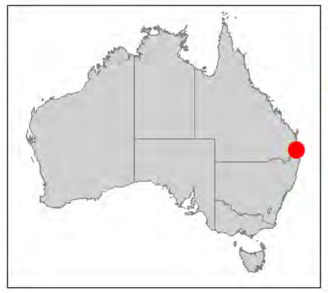
Filepath : I:\B18104_I_BRH Moreton Bay AK\DRG\Caboolture_Report\FLD_013_120523_Structure Blockage Flood Level Impact 100Year EDS.WOR





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
- Was dry now wet
- Was wet now dry

Title:

Increased Rainfall Scenario (S4) Minus 100 Year EDS

Figure: **F4**

Rev: **A**

N

0km 3 6

Approx. Scale

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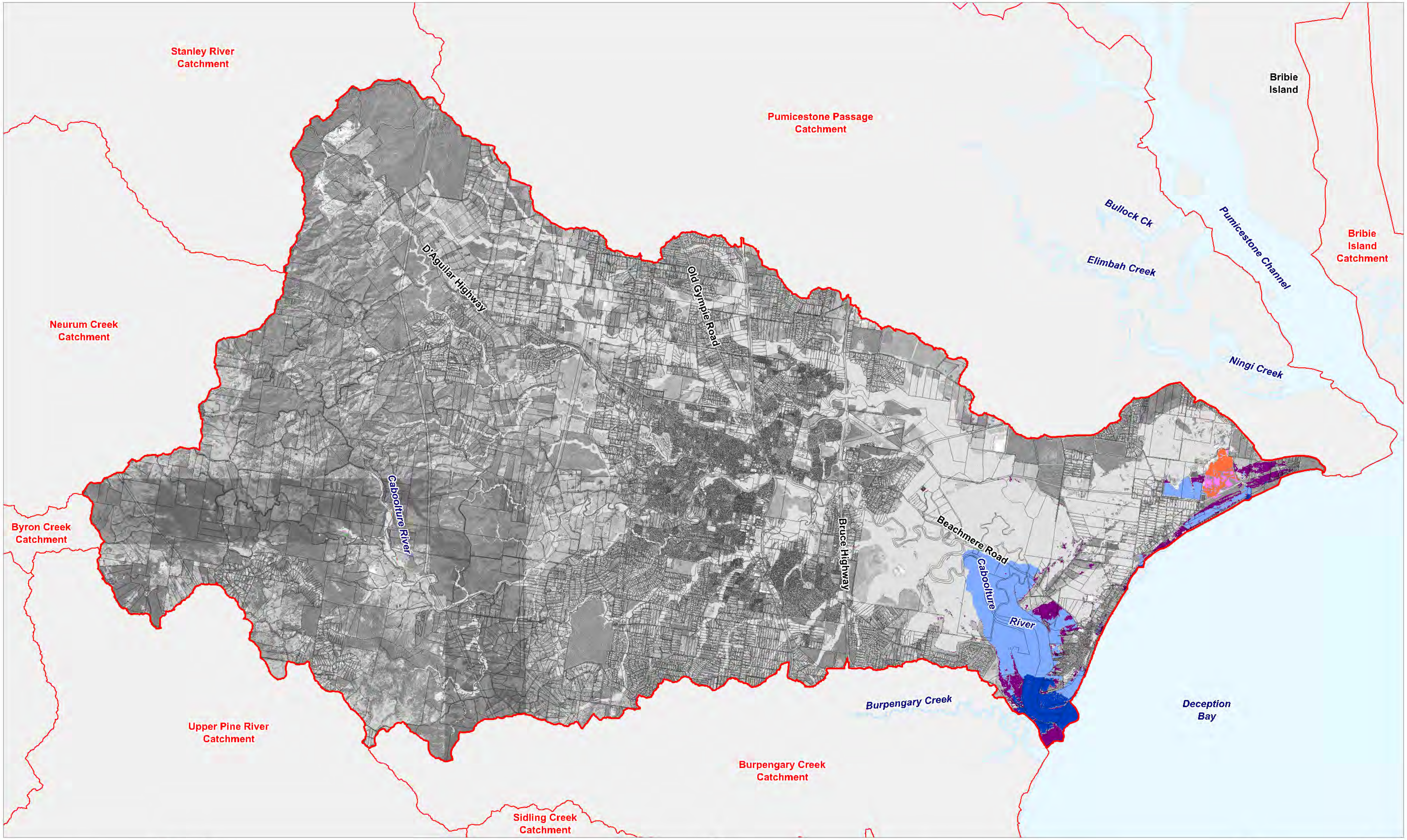
Filepath : I:\B18104_I_BRH Moreton Bay AK\DRG\Caboolture_Report\FLD_014_120523_Increase in Rainfall Flood Level Impact 100Year EDS.WOR



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
- Was dry now wet
- Was wet now dry

Title:

Increased Downstream Boundary Scenario (S5) Minus 100 Year EDS

Figure: **F5**

Rev: **A**

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Approx. Scale

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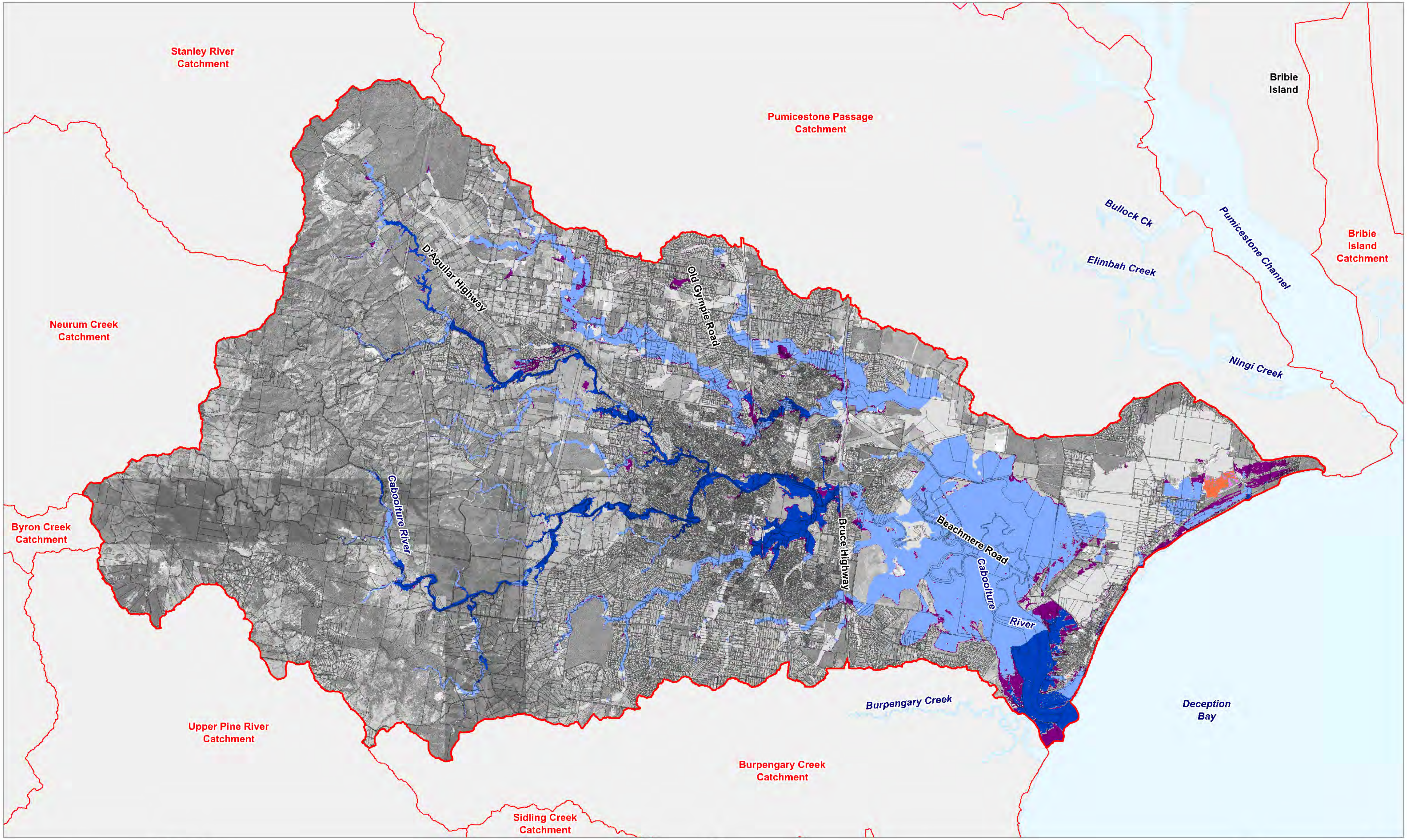

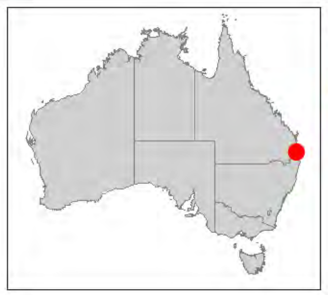

LEGEND

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
- Was dry now wet
- Was wet now dry

Title:

Increased Downstream Boundary and Rainfall Scenario (S6) Minus 100 Year EDS

Figure: **F6**

Rev: **A**

N

0km 3 6

Approx. Scale

BMT WBM

www.bmtwbm.com.au

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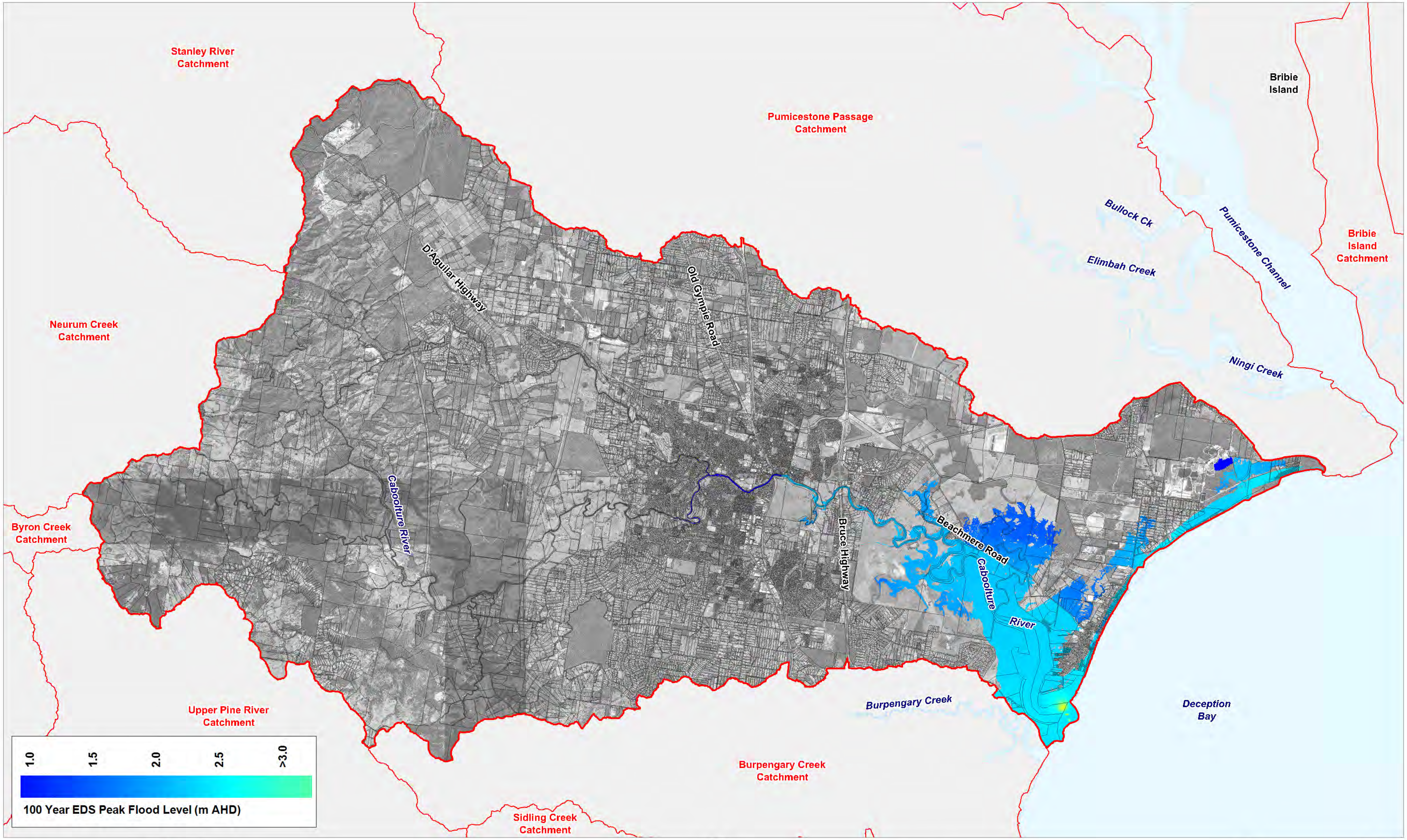


LEGEND

Caboolture Catchment Boundary

Cadastral Boundaries

Title:

Dynamic Storm Tide Peak Flood Level – 100 Year EDS (S7)

Figure: F7

Rev: A

N

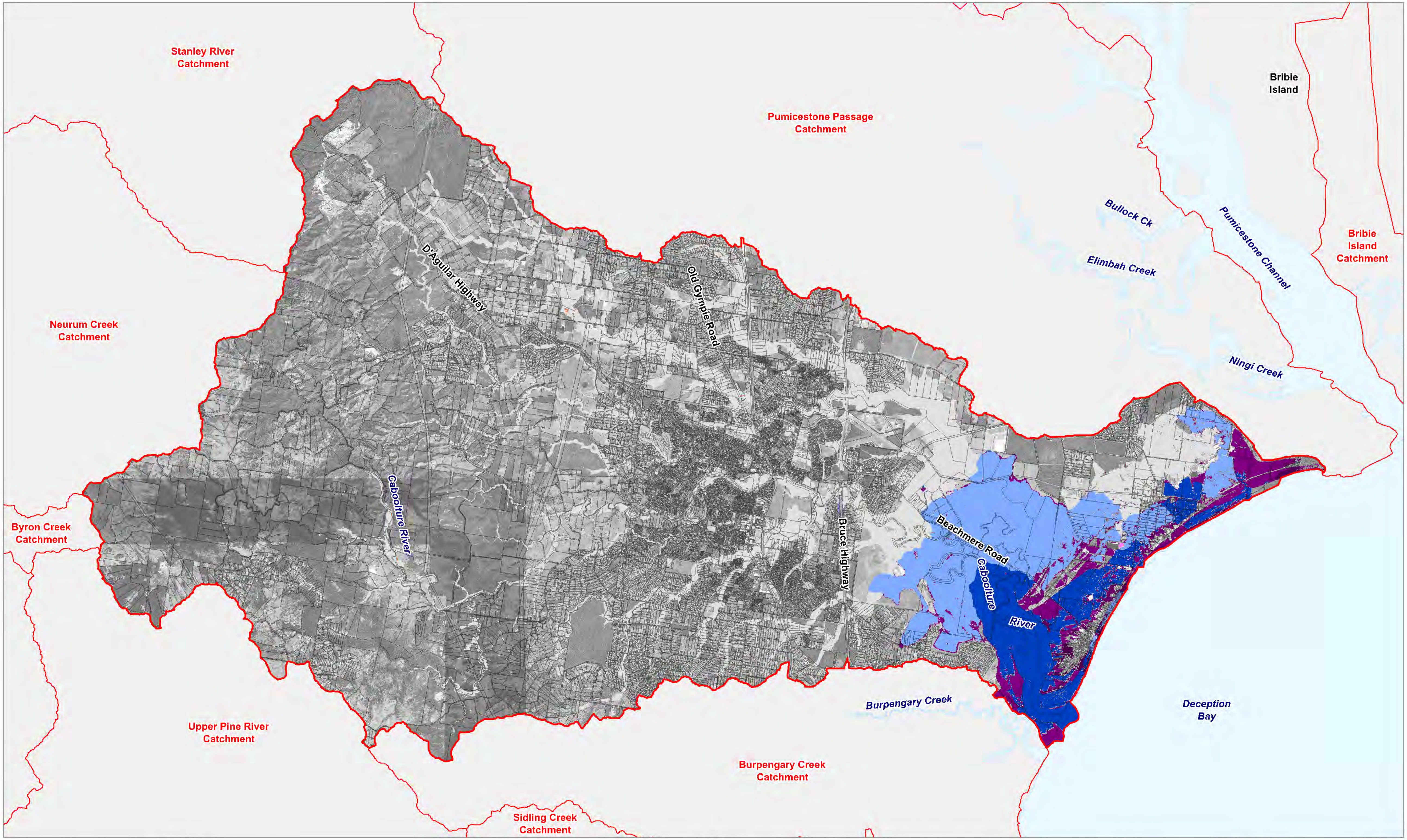
0km 3 6

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B18104_I_BRH Moreton Bay AK\DRG\Caboolture_Report\FLD_017_120523_Dynamic Storm Tide Peak Flood Level 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
- Was dry now wet
- Was wet now dry

Title:

Static Storm Tide Scenario (S8) Minus 100 Year EDS

Figure: **F8**

Rev: **A**

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N

0km 3 6

Approx. Scale

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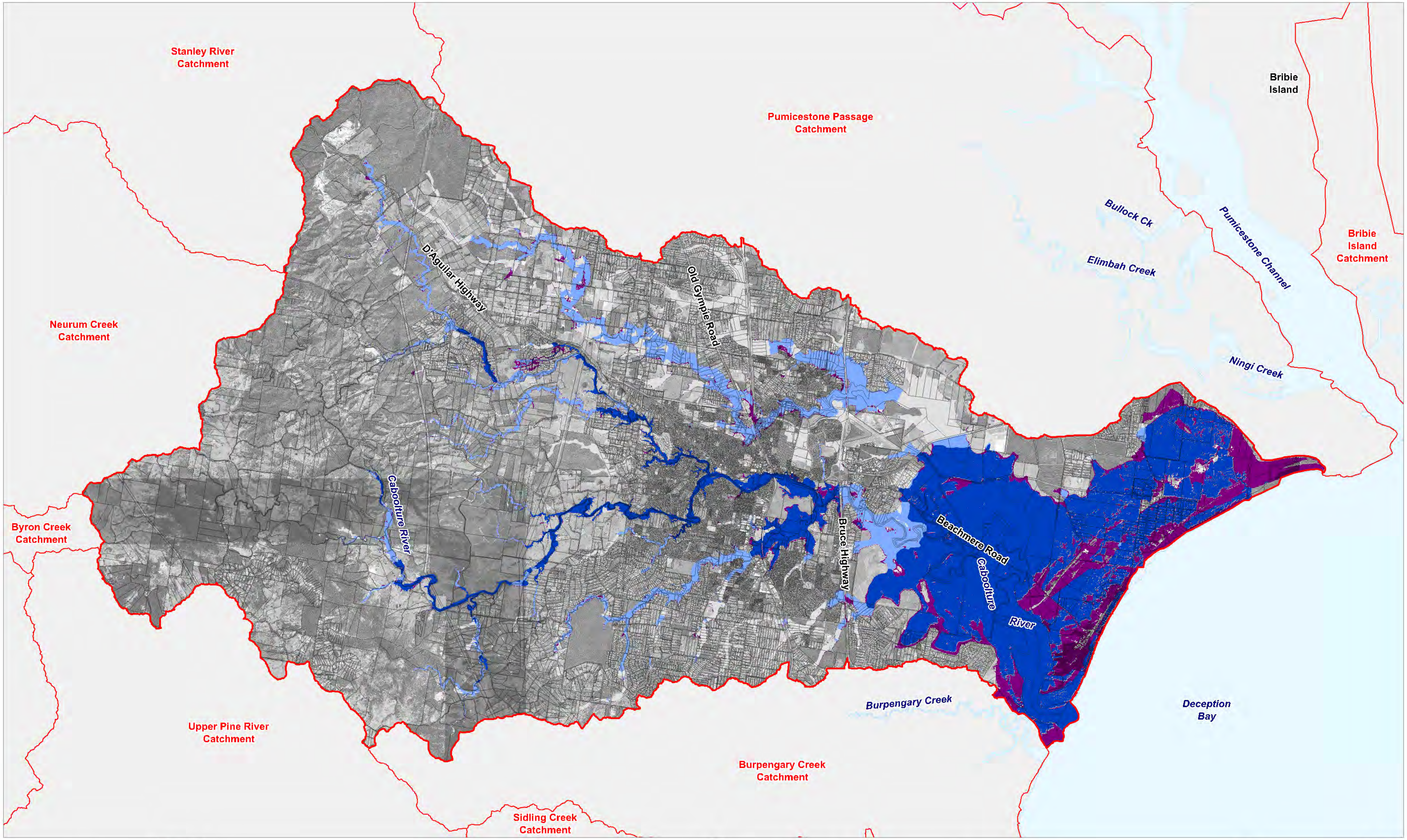
Filepath : I:\B18104_I_BRH Moreton Bay AK\DRG\Caboolture_Report\FLD_018_120523_Static Storm Tide Flood Level Impact 100Year EDS.WOR



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
- Was dry now wet
- Was wet now dry

Title:

Static Storm Tide, Increased Rainfall and Sea Level Rise Scenario (S9) Minus 100 Year EDS

Figure: **F9**

Rev: **A**

N

0km 3 6

Approx. Scale

BMT WBM

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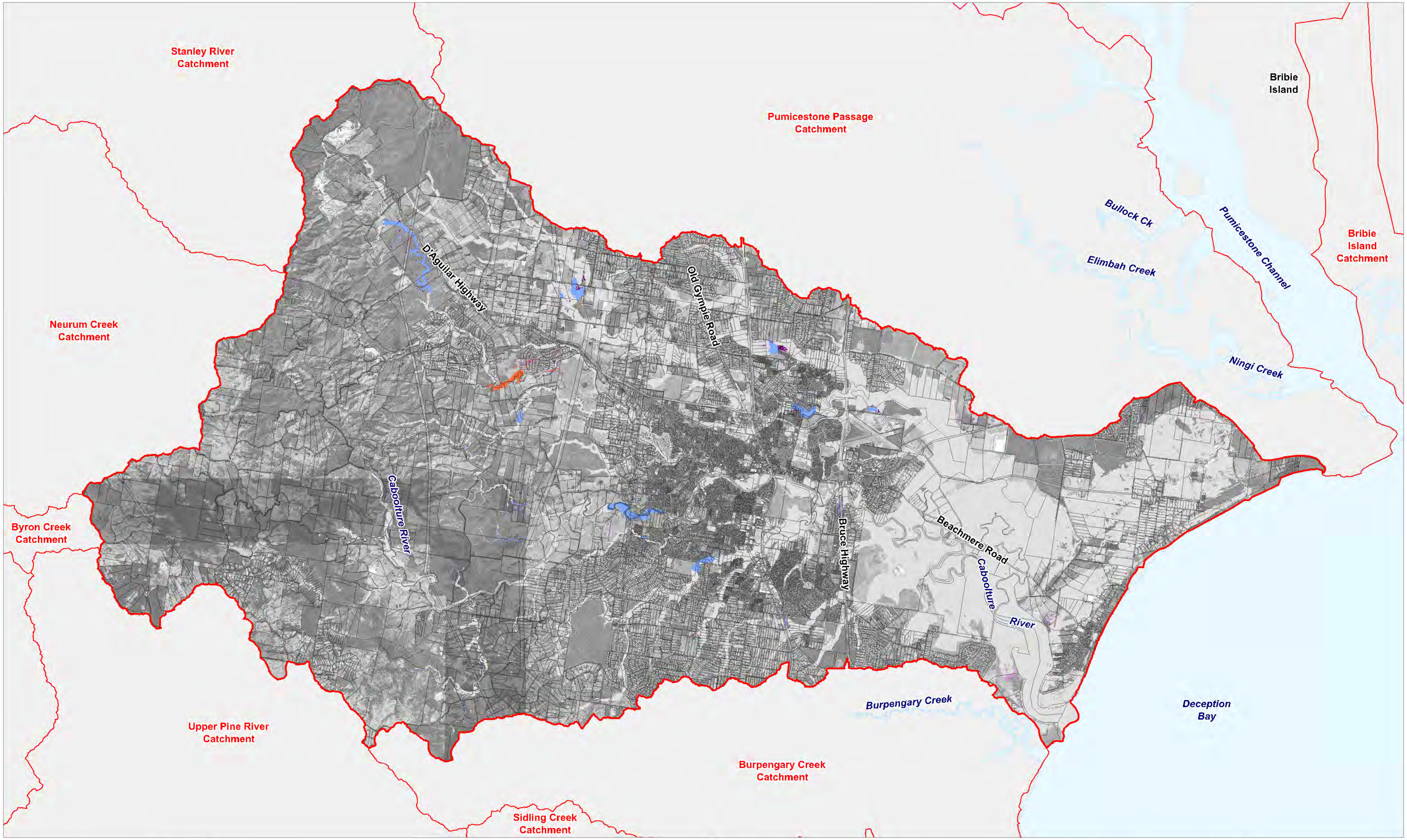
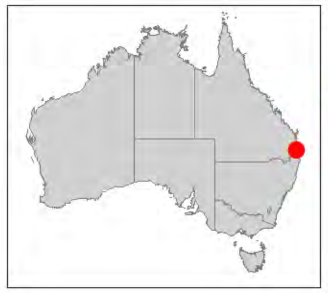
Filepath : I:\B18104_I_BRH Moreton Bay AK\DRG\Caboolture_Report\FLD_019_120523_Static Storm Tide and Climate Change Flood Level Impact 100Year EDS.WOR





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
- Was dry now wet
- Was wet now dry

Title:

Increased Vegetation Scenario (S10) Minus 100 Year EDS

Figure: **F10**

Rev: **A**

N

0km 3 6

Approx. Scale

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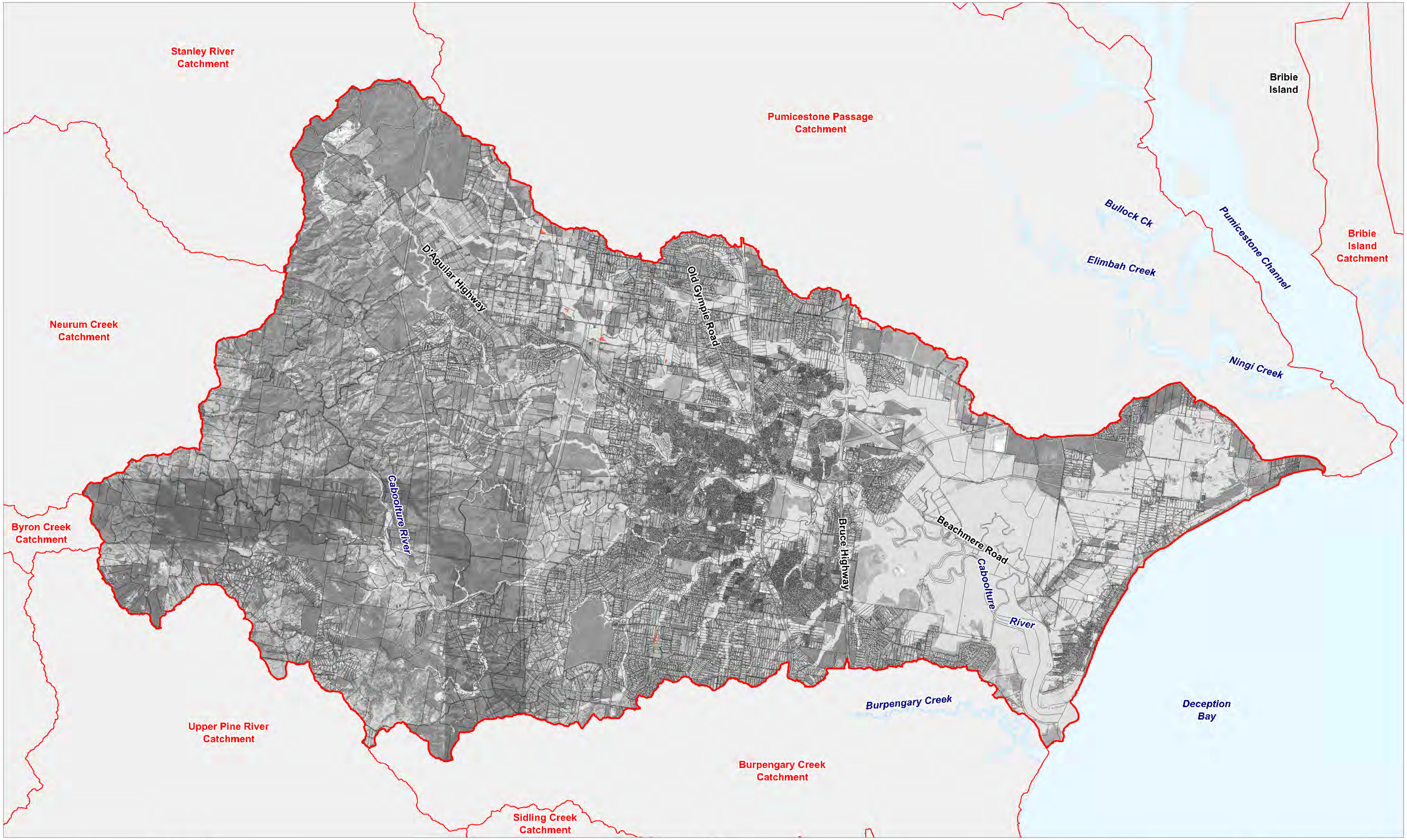
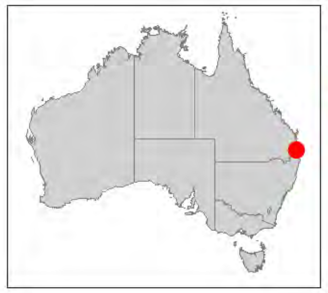
Filepath : I:\B18104_I_BRH Moreton Bay AK\DRG\Caboolture_Report\FLD_020_120523_Increase in Vegetation Flood Level Impact 100Year EDS.WOR





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
- Was dry now wet
- Was wet now dry

Title:

Increased Residential Development Scenario (S11) Minus 100 Year EDS

Figure: **F11**

Rev: **A**

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N

0km 3 6

Approx. Scale

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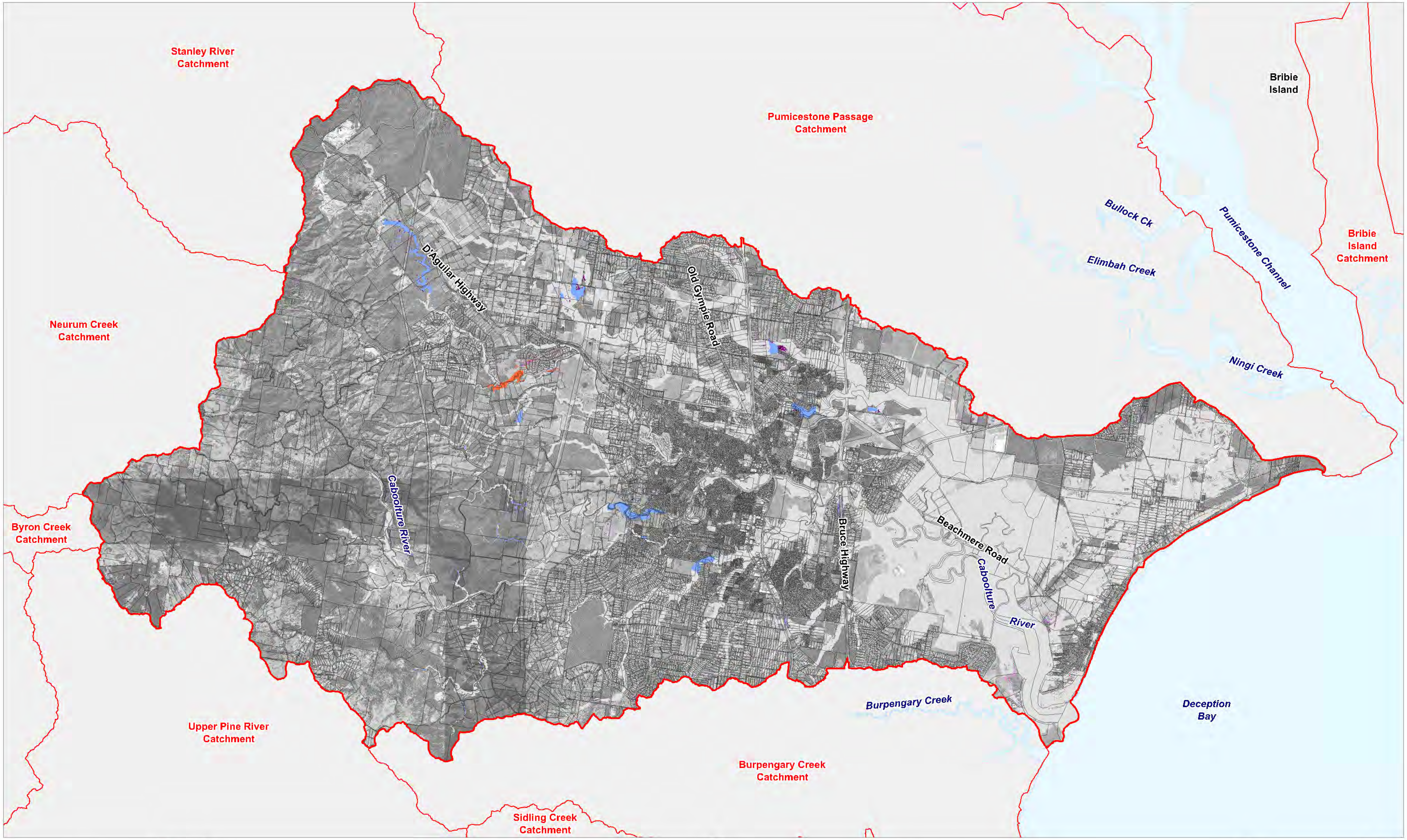

LEGEND

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
- Was dry now wet
- Was wet now dry

Title:

Increased Residential Development and Vegetation Scenario (S12) Minus 100 Year EDS

Figure: F12

Rev: A

N

0km 3 6

Approx. Scale

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Regional Council

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