Regional Floodplain Database:

Hydrologic and Hydraulic Modelling - Pumicestone Passage (PUM)

Moreton Bay Regional Council

Emergency Management Queensland

Australian Government
Attorney-General's Department
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Queensland Government

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Pumicestone Passage (PUM)

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1 Introduction

Moreton Bay Regional Council (MBRC) is delivering a Regional Floodplain Database (RFD) in support of their flood risk management, considering emergency response, development control, strategic landuse and infrastructure planning. The MBRC was recently formed under local government amalgamations and is responsible for Caboolture, Pine Rivers, Redcliffe and Bribie Island. The RFD project focuses on the northern sector as a key growth area for South-East Queensland.

The project is being funded by MBRC, Emergency Management Queensland (EMQ) and Emergency Management Australia (EMA) as part of the Disaster Resilience Program and will provide:

- A comprehensive and consistent description of flood behaviour across the region
- Strategies for management of any flooding problems identified
- A system/process to store and manage this information and keep it up-to-date

Stage 1 of the project was completed in July 2010 and involved a number of sub-projects. These projects delivered consistent processes and protocols for the detailed hydrologic and hydraulic model development. A key sub-project involved the development of broadscale hydrodynamic models for each minor basin to provide general understanding of flooding mechanisms and allow prioritisation of data capture.

Stage 2 (current stage) of the project involves the development of detailed hydrologic and hydraulic models for each minor basin.

Stage 3 will build on the detailed models and “add value” through assessment of flood damages and community resilience measures.

This report discusses the study data, methodology and results for the Stage 2 detailed modelling of the Pumicestone Passage (PUM) minor basin for the RFD.

This basin covers an area approximately 240 km^2 and incorporates Glass Mountain Creek, Ningi Creek, Elimbah Creek, Six Mile Creek and Beerburrum Creek. It is largely rural in nature, with residential areas occurring at Elimbah, Donnybrook, Toorbul, Ningi and Sandstone Point. The basin falls primarily in the MBRC region, with approximately 43 km^2 of the northern basin area falling within the Sunshine Coast Regional Council (SCRC) area.

1.1 Scope

The detailed modelling of the Pumicestone Passage minor basin will provide Council with an understanding of flood behaviour for the range of flood events between the 1 year Average Recurrence Interval (ARI) and the Probable Maximum Flood (PMF) event.

The detailed modelling converts broadscale hydrologic and hydraulic models developed as part of Stage 1 into detailed models. This conversion is done using the approaches and methodologies developed during Stage 1 and through inclusion of the latest topographic/bathymetric data and key hydraulic features, such as culverts, bridges and footbridges.

The detailed models are then used to undertake detailed catchment analysis, calibration (where possible) and flood scenario modelling. The scenario modelling includes sensitivity analysis to a range of catchment changes. The results provide detailed flood information such as levels, depths, velocities, hazard, flood extents and flood timing.

Given the large size of the Pumicestone Passage minor basin, the hydraulic model was developed on both a 5 m grid and a 10 m grid. In order to reduce model run times, the 10 m grid was used to model the less frequent and larger events, including those between the 100 year ARI event and the PMF event. The 5 m grid was used to model the smaller, more frequent events between the 1 and 100 year ARI.

1.2 Objectives

Key objectives of this study are as follows:

- Convert the broadscale hydrologic and hydraulic models into detailed models
- Undertake detailed catchment analysis for the 1 year ARI to PMF events for current catchment conditions
- Assess a range of scenarios including climate change, land use change, vegetation change, culvert blockage and storm tide events
- Provide Council with flood mapping to be incorporated into their GIS system

1.3 General approach

The general approach for this study is summarised as follows:

- Familiarisation with background materials and models
- Review of floodplain infrastructure and bathymetric data and identification of additional data required
- Review of broadscale catchment and stream definition (hydrography) and recommendation of changes
- Review of historic flood studies, rainfall, stream gauge, flood mark and catchment data; assessment of calibration and validation feasibility; and recommendation of suitable calibration/validation events
- Review of broadscale land use and topographic data and recommendation of modifications
- Review and update of the WBNM hydrologic models for existing, historic and future scenarios
- Updating broadscale TUFLOW hydraulic models to include:
  - Boundary conditions reflective of changes in hydrography and/or downstream boundary
  - Smaller grid resolution and review of active model area
  - Existing, historic and future hydraulic landuse scenarios
  - Floodplain infrastructure and bathymetry
  - Topographic modifiers for stability and key floodplain features
- Calibration and validation of the models to a single calibration and a single validation event (if possible)
- Modelling of the 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000 and PMF design events for the existing catchment
- Assessment of the MBRC Design Storm (a 100 yr ARI 15 min in 270 min hour ‘Embedded Design Storm’)

- Undertaking sensitivity testing for:
  - Varied discharges, manning's n, tailwater and culvert blockages
  - Climate change scenarios for rainfall intensity and sea level rise
  - Storm tide without any riverine flooding
  - Future landuse
- Checking of model quality for all model runs
- Preparation of a report to describe the model establishment, methodology, limitations and input data including mapping
- Collation of GIS data and model outputs for handover to Council

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 Pumicestone Passage Stage 2 models:

- 1D – Hydrologic and Hydraulic Modelling (Broadscale), sub-project 1D developed the broadscale TUFLOW models used as the basis for the detailed modelling (BMT WBM, 2010)
- 1E – Floodplain Topography (2009 LiDAR) including 1F, 2E, 2I, sub-project 1E provided the topographic information, such as model z-pts layer and digital elevation models (DEM) utilising a DEM tool developed specifically for the RFD (WorleyParsons, 2010)
- 1G – Hydrography (MBRC), sub-project 1G supplied the subcatchment delineation including streamlines and junctions (used in the WBNM model)
- 1H – Floodplain Landuse, sub-project 1H delivered the percentage impervious raster (utilised in the hydrologic model) and the roughness Manning's 'n' values and spatial definitions (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. Based on the assessment undertaken in this sub-project, the historical flood events (May 2009 and February 1999) were selected for model calibration and/or verification
- 2B – Hydrologic and Hydraulic Modelling (Detail), sub-project 2B defined model naming conventions and model protocols to be used in the detailed modelling (BMT WBM, 2010)
- 2C – Floodplain Structures (Culverts), sub-project 2C defined the process to be used for modelling of culverts on the floodplain (Aurecon, 2010)
- 2D – Floodplain Structures (Bridges), sub-project 2D defined the process to be used for modelling of bridges on the floodplain (Aurecon, 2010)
- 2F – Floodplain Structures (Trunk Underground Drainage), sub-project 2F defined the process to be used for modelling of trunk underground drainage on the floodplain (Aurecon, 2010)
- 2G – Floodplain Structures (Basins), sub-project 2G consolidated defined the process to be used for modelling of detention basins on the floodplain (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 the February 1999 event (utilised in the hydraulic model) (SKM, 2010)
- 2K – Flood Information Historic Flooding, sub-project 2K collected flood levels for the historic May 2009 and February 1999 flood events (GHD, 2010)
- 2L – Design Rainfall and Infiltration Loss, sub-project 2L defined the rainfall parameters to be adopted in the WBNM modelling (WorleyParsons, 2010)
- 2M – Boundary Conditions, Joint Probability and Climate Risk Scenarios, sub-project 2M defined the boundary conditions and provided recommendations in regards to joint probability (ie 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, 2012)

- 2N – Floodplain Parameterisation, sub-project 2N provided recommendations for the floodplain parameters to adopt, such as a range of values for various impervious percentages for various landuse types (ie residential or rural landuse, dense vegetation), a range of values for various roughness types (ie long grass, dense vegetation) and structure losses (SKM, 2012)

2 Available data

The following list summarises the data available for the study:

- **Aerial imagery** – imagery across the entire catchment was supplied by MBRC. This included SCRC aerial imagery from the northern portion of the Pumicestone Passage minor basin which falls in the SCRC area
- **Hydrography** – delineation of major basins, minor basins, major catchments, minor sub-catchments, reaches and junctions were provided by MBRC
- **Floodplain Landuse** – polygons for buildings, footpaths, roads, urban blocks, vegetation and waterbodies were provided by MBRC. These were developed by SKM as part of RFD Stage 1
- **Floodplain Topography** – A 2.5m DEM and model z-points (both 5 m grid and 10 m grid) were provided by Worley Parsons. The DEM Tool developed during Stage 1 was used to prepare these datasets based on LiDAR data collected in 2009, bathymetric data collected for this study and modifiers (breaklines) developed by Aurecon. A copy of the thinned LiDAR data was also provided
- **Broadscale TUFLOW Model** – the broadscale PUM model was provided by MBRC. This model was developed by BMT WBM as part of RFD Stage 1
- **Detailed BUR Model** – the detailed model of the Burpengary (BUR) minor basin was provided by MBRC. This model was developed by BMT WBM as part of RFD Stage 1
- **WBNM Model** – the WBNM model of the minor basin was provided by MBRC. This was developed by Andrew Wiersma
- **Materials values** – materials values for the Stage 2 models were provided by MBRC
- **Rainfall, Stream Gauge and Historic Flood Information** – rainfall and stream gauge data was provided by MBRC. Historical flood information was also provided by MBRC
- **Floodplain Structures** – floodplain structure information was provided from a range of sources including:
  - Completed 1d_nwk and 2d_lfcsh files for QR and TMR bridges (as developed by Aurecon under a separate commission)
  - Details (plans) of a number of Council owned bridges from MBRC
  - Existing GIS database information for some existing culverts from MBRC
  - Detailed survey undertaken by MBRC surveyors as part of this study

- Photos of various structures captured during site visits

- **Storm Tide Tool** – the storm tide hydrograph generator developed by Cardno Lawson Treloar as part of Council's storm tide study was provided by MBRC
- **Historical Flood Study Information** – the Six Mile Creek Flood Study Report was provided by MBRC. This study was undertaken by Australian Water Engineering in 1994
- **Stage 1 Reports** – reports from the various consultants involved in Stage 1 of the RFD project were provided by MBRC
- **Example folder structure and run files** – these were provided by MBRC based on the outputs developed by BMT WBM for the RFD Stage 1
- **Mapping colour profiles** – these were developed by BMT WBM in Stage 1 of the RFD and provided by MBRC
- **Future landuse scenario** – hydrography (sub-catchments) files for the future landuse scenario were provided by MBRC
- **Impervious area raster files** – these were provided by MBRC and were developed by SKM during RFD Stage 1

3 Methodology

3.1 Data review

3.1.1 Infrastructure data assessment

At the outset of the project, the infrastructure and bathymetric data requirements for modelling of the Pumicestone Passage minor basin were assessed. This included a data gap analysis for bridges, culverts, detention basins and trunk drainage infrastructure and also for below-water bathymetric details. Infrastructure and bathymetric details were then assigned a priority (A or B) based upon their likelihood of impacting upon the model predictions.

The infrastructure was prioritised according to the significance of location and potential impacts on the hydraulic model results. Key factors which were taken into account were proximity to broadscale flood extents, surrounding land use and whether the structure was beneath a major road or a railway. The creek bathymetry was prioritised according to the size (width) of the reach, the size of the contributing catchment and proximity to urban areas.

Table 1 presents a summary of the structures and bathymetric reaches which were identified and prioritised.

Table 1 Infrastructure and bathymetric data

Data Item	Priority A	Priority B
Structures (culverts, bridges and trunk drains)	49	82
Bathymetric reaches	23.2km	45.5km

Following the gap analysis and the data prioritisation, a composite assessment of survey requirements was undertaken and provided to Council. A copy of the Data Infrastructure Assessment Report is included in Appendix A.

3.1.2 Calibration and validation

The feasibility of carrying out calibration and validation for the Pumicestone Passage models was assessed. This was based on the availability of stream gauge, daily rainfall, pluviograph rainfall and historic flood mark data.

Stream gauge data (recorded water level with respect to time) is essential to calibrating a hydrologic model. Recorded water levels are converted to discharges and compared with hydrologic model predictions. Stream gauge data is also useful in calibrating a hydraulic model through comparisons of recorded and predicted water levels with time at the gauge location. No stream gauges exist in the Pumicestone Passage minor basin.

When no stream gauge data is available and historic flood mark data available, it is possible to undertake a joint calibration process in which both hydrologic and hydraulic parameters are modified until calibration of the hydraulic model is achieved. Unfortunately, no historic flood mark data was available in the PUM minor basin.

Given that no stream gauge data and no historic flood mark data was available in the PUM minor basin it was recommended that calibration and validation of the models was not feasible. A copy of the Calibration and Validation Feasibility Report is included in Appendix C.

3.1.3 Hydrography

The hydrography provided by MBRC was reviewed to ensure the following two key objectives were supported:

- Catchments were sufficiently defined to ensure accurate representation of contributing areas at key points of interest (urbanised areas, drainage control points, areas marked for future development)
- Hydraulic model objectives were supported through appropriate flow reporting locations, noting the following:
  - The hydraulic model applies inflow distributed across the sub-catchment, effectively “filling” the sub-catchment from the lowest point
  - The hydraulic model will advise on flood immunity of major roads accessing key urban areas

A number of recommendations were made, including:

- Junctions be included at structures where no junction had previously been defined
- Sub-catchments which cover only a section of road should be modified so the inflow is not applied to the road surface in the hydraulic model, which would in turn show the road to be inundated

A copy of the Hydrography Review Report for Package 3: Pumicestone Passage and Bribie Island is included in Appendix B.

Upon receipt of the final updated hydrography from MBRC, the sub-catchment fraction impervious values were updated using the process defined by SKM (2010) in their *Existing, Historic and Future Floodplain Land Use* report. This final hydrographic dataset was used to develop the WBNM model.

3.2 Hydrologic model

The WBNM model supplied by MBRC was adopted for use in the hydrologic modelling. The hydrologic model setup process is described in Appendix G.

Hydrologic modelling was undertaken for the following events:

- **Design events**: 1, 2, 5, 10, 20, 50 and 100 year ARI
  The 0010, 0015, 0030, 0045, 0060, 0090, 0120, 0180, 0270, 0360, 0540, 0720, 1080, 1440, 1800, 2160, 2880, 4320 minute durations were run for each event
- **Embedded design storm (EDS)**: the 0015 minute burst in a 0270 minute duration event was run for the 1, 2, 5, 10, 20, 50 and 100 year ARI events
- **Extreme events**: 200, 500, 1000 and 2000 year ARI
  The 0015, 0030, 0045, 0060, 0090, 0120, 0180, 0360 0720, 1440, 2160, 2880 and 4320 minute durations were run for each event

- **PMP event**: The 0015, 0030, 0045, 0060, 0090, 0120, 0150, 0180, 0240, 0300, 0360, 0720, 1440, 2160, 2880 and 4320 minute durations were analysed
- **Climate change event** (S4): The EDS was run with IFD rainfall intensities increased by 12%
- **Future landuse scenario** (S11): The EDS was run with percentage impervious changed to represent the future landuse scenario

The local catchment flows derived from the hydrologic model were used as inputs to the hydraulic model. No total catchment flows were used as input to the hydraulic model.

3.3 Hydraulic model

3.3.1 Model software

The following text describes the TUFLOW modelling package. This text has been copied from Section 3.2.1 of the *Hydraulic Modelling (Detail) Regional Floodplain Database Sub-Project 2B Report* (BMT WBM, 2010).

"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 a catchment. 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

Two separate TUFLOW models of the PUM basin were developed, one on a 5 m grid and one on a 10 m grid, in accordance with the requirements of MBRC. The model topography was developed by Worley Parsons using the DEM tool (Worley Parsons, 2010) and provided for use in this study, in both DEM and z-point format. The following information was included in the DEM tool:

- 2009 ALS data used as the base information across the entire MBRC area
- LiDAR data sourced from SCRC was used as the base information across the northern portion of the basin
- Bathymetric survey data for the downstream reaches of Elimbah Creek (10.55 km) and Ningi Creek (3.43 km) as captured for this study
- Stream breakline modifiers, as developed by Aurecon, were used to create continuous stream paths for the following stream lengths:
  - 8.9 km at the downstream end of Glass Mountain Creek
  - 7.6 km of Elimbah Creek, upstream of the bathymetric survey extents
  - 6.8 km of Ningi Creek, upstream of the bathymetric survey extents

In addition to the z-points provided by the DEM tool, a number of modifiers were incorporated directly into the model, including:

- Z-shapes for the road and rail embankments in a number of locations where these were not included in the 2009 ALS data
- Stability modifiers, primarily at culvert inlet and outlets

Figure 3-1 illustrates the Pumicestone Passage model layout. Additional details on the model setup are provided in Appendix D.

3.3.3 Model structures

Structures were represented using three different approaches, as recommended in the Floodplain Structures report (Aurecon, 2010):

- Culverts were modelled as 1D structures using the 1d_nwk approach
- Trunk drains were modelled as 1D elements using the 1d_nwk approach
- Bridges were modelled as 2D structures using the 2d_flcsh approach

To solve stability issues, two culvert structures beneath Sandheath Place and Redondo Street (on branch NIN_28) were modelled using the 2D approach.

Table 2 | Number of modelled structures

Structure Type	Number of Modelled Structures
2D bridges	13
1D culverts	80
2D culverts	2 in Ningi (on branch NIN_28)
Trunk drains	1 system located in Toorbul, consists of 4 pipes

Culvert exit and entry loss coefficients were applied as per the recommendations of the SKM Floodplain Parameterisation report (2012).

3.3.4 Landuse mapping

Landuse polygons were used to define the spatially varying hydraulic roughness within the hydraulic model. In total, eleven different types of landuse were mapped and provided by SKM as part of the Floodplain Parameterisation project (2012). These polygons were reviewed and modified in a number of locations (see Appendix H for more information). They were also extended to cover the SCRC portion of the catchment, which was not covered in SKM's work. The final adopted landuse map is presented in Figure 3-2.

Manning's n roughness parameters were determined during the calibration and verification process. The adopted values are presented in Table 3.

Table 3 Hydraulic model landuse categorisation

Landuse Type	Manning's n Roughness Coefficient
Dense vegetation	Depth varying: 0.090 – 0.180
Medium dense vegetation	Depth varying: 0.075 – 0.150
Low grass/grazing	Depth varying: 0.025 – 0.250
Reeds/swamp	0.080
Crops	0.040
Urban Blocks (> 2000 m^2)	0.300
Buildings	1.000
Roads	0.015
Footpaths	0.015

Landuse Type	Manning's n Roughness Coefficient
Waterbodies – Creeks	0.030
Waterbodies – Rivers	0.030

3.3.5 Model boundaries

The WBNM hydrologic model results were used to provide inflows to the hydraulic model for all design, extreme, PMF and sensitivity events, as discussed in Section 3.2. The inflows were applied to the 2D domain using a flow-time source boundary for 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.

A static Mean High Water Springs (MHWS) oceanic condition was applied as the downstream boundary condition, based on recommendations from SKM's Boundary Conditions, Joint Probability & Climate Change Report (2012). MHWS values were sourced from the Maritime Safety Queensland (MSQ) semi-diurnal tidal planes (2010). Different values were applied for Toorbul and Donnybrook as shown in Table 4.

Table 4 | Downstream boundary water levels

Location	Mean High Water Springs Level (m AHD)
Toorbul	0.85
Donnybrook	0.76

3.4 Model calibration and verification

Calibration and verification of the PUM models was not undertaken due to the lack of available data. The calibration and verification process which was undertaken for other minor basins provided model parameters for adoption in the PUM model, including:

- WBNM C value = 1.6
- Manning's n values as described in Table 3

3.5 Design flood events

This section describes the design event conditions (including design, extreme and PMF events as identified in Section 3.2) which were analysed using the hydraulic models. Design storm events are hypothetical events that are used to estimate design flood conditions. They are based on a probability of occurrence, usually specified as an Average Recurrence Interval (ARI).

3.5.1 Critical storm duration assessment

A detailed assessment of the hydraulic model critical storm durations for the 10 year ARI, 100 year ARI and PMF events was undertaken using the following process:

- Hydrologic modelling of the 0010, 0015, 0030, 0045, 0060, 0090, 0120, 0180, 0270, 0360, 0540, 0720, 1080, 1440, 1800, 2160, 2880 and 4320 minute durations for the 10 and 100 year ARI events and the 0015, 0030, 0045, 0060, 090, 0120, 0150, 0180, 0240, 0300, 0360, 0720, 1440, 2160, 2880 and 4320 minute durations for the PMP event
- Hydraulic modelling of the above events using the 5 m model for the 10 year ARI and the 10 m model for the 100 year ARI and PMF events

- Processing of the model results to create an overall peak water level envelope from all durations and a map showing the spatial extents of the critical durations
- Selection of durations (two or three) which cover the most widespread and developed areas
- Calculation of the peak water level from the selected durations
- Comparison and mapping of peak water level differences between the overall peak and the peak from the selected durations
- An iterative process covering the above three steps was undertaken to select the critical durations producing the least differences over the largest area
- The remainder of the events (ARIs) were then modelled for the selected critical durations

Table 5 presents the selected critical durations and the events to which they were applied. Figure 3-3, Figure 3-4 and Figure 3-5 show the comparisons between the overall peak water levels and the selected duration peak water levels for the 10 year ARI, 100 year ARI and PMF events respectively.

Table 5 | Critical duration selection

Assessment Event	Selected Critical Durations	Adopted Events
10 year ARI	0180, 0360, 0720	1, 2, 5, 10 and 20 year ARI
100 year ARI	0180, 0360, 0720	50 and 100 year ARI
Probable Maximum Flood	0120, 0180, 0360	200, 500, 1000, 2000 year ARI and PMF

3.5.2 Design event simulations

The Pumicestone Passage model was simulated for the return periods, grid sizes and storm durations shown in Table 6.

Table 6 | Simulated design events

Return Period (years)	Model Grid Size (m)	Modelled Durations (mins)
1, 2, 5	5	0180, 0360, 0720
10	5	0010, 0015, 0030, 0045, 0060, 0090, 0120, 0180, 0270, 0360, 0540, 0720, 1080, 1440, 1800, 2160, 2880, 4320
20, 50	5	0180, 0360, 0720
100	5	0180, 0360, 0720
100	10	0010, 0015, 0030, 0045, 0060, 0090, 0120, 0180, 0270, 0360, 0540, 0720, 1080, 1440, 1800, 2160, 2880, 4320
200, 500, 1000, 2000	10	0120, 0180, 0360
PMF	10	0015, 0030, 0045, 0060, 0090, 0120, 0150, 0180, 0240, 0300, 0360, 0720, 1440, 2160, 2880, 4320

3.6 Sensitivity analysis

Table 7 below provides a summary of the sensitivity runs which were undertaken based on specifications by MBRC. The methodology for each of these is described further in Sections 3.6.1 to 3.6.4.

Table 7 | Sensitivity runs

ID	Title	Description	Methodology Section
S1	EDS	MBRC EDS	
S2	Increase n	Increase manning's n values by 20%	0
S3	Blockage	Model blockage of culverts	0
S4	Climate Change 1	Model impact of increased rainfall	3.6.4
S5	Climate Change 2	Model impact of increased downstream boundary	3.6.4
S6	Climate Change 3	Model impact of increased rainfall (S4) and sea level (S5)	3.6.4
S7	Storm Tide 1	Model dynamic storm tide boundary – 100 year ARI storm tide event, no rainfall	3.6.4
S8	Storm Tide 2	Model rainfall with static storm tide boundary – 100 year ARI	3.6.4
S9	Storm Tide 3	Increased Rainfall (S4) + Increase in Sea level (S5) + Static ST level (100yr GHG)	3.6.4
S10	Future Landuse 1	Model impact of increased vegetation in floodplains	3.6.1
S11	Future Landuse 2	Model impact of increased residential development – hydrology changes only	3.6.1
S12	Future Landuse 3	Model impact of increased residential development (S11) and increased vegetation in floodplains (S12)	3.6.1

The EDS was simulated for the PUM model. The EDS is a single storm event which approximates the flood levels and behaviour of the critical duration design events. The EDS is useful for initial investigations into changes in model parameters and catchment characteristics, as it reduces the number of model runs required. The adopted EDS event was utilised as a base case for the comparison to future landuse, sensitivity and climate change scenarios.

3.6.1 Future landuse analysis

Three future landuse scenarios were assessed:

- Increased vegetation (S10)
- Increased residential development (S11)
- A combination of the above two (S12)

For the increased vegetation case (S10), two modifications were made to the Manning's n values applied to the model. For the landuse types defined in Figure 3-2 and Table 3 the following changes were made:

- Medium Dense Vegetation was changed to Dense Vegetation
- Low Grass/Grazing was changed to Medium Dense Vegetation

For the increased residential development case (S11), the fraction impervious values in the WBNM model were increased. The sub-catchments in which development may occur were identified by MBRC and increased fraction impervious values were provided for these sub-catchments. The WBNM model was then run with these increased values for the EDS event and the resulting inflows were applied to the TUFLOW model.

3.6.2 Hydraulic roughness analysis

To test the sensitivity of the model to selection of landuse roughness values (S2), a scenario was run whereby Manning's n values were uniformly increased by 20%.

3.6.3 Structure blockage analysis

A blockage scenario (S3) was run to assess the effects of waterway crossings (culverts) becoming blocked during a flood event. The SKM Floodplain Parameterisation report (2012) provided recommendations for a moderate blockage scenario. The adopted blockage parameters were:

- Full blockage for culverts/pipes with width ≤ 2.4 m
- Partial (15%) blockage for culverts/pipes with width > 2.4 m

3.6.4 Climate change and downstream boundary condition analysis

Six scenarios were simulated to assess the potential impacts of climate change and storm tide in accordance with the SKM Boundary Conditions, Joint Probability & Climate Change (2012) recommendations. The horizon for climate change events was selected as 2050. Details of the changes made in each of these simulations are provided below.

- Increased rainfall (S4) – the IFD parameters for the WBNM model were increased by 12%, then the increased inflows were applied to the TUFLOW model
- Increased downstream boundary (S5) – the downstream boundary was increased to represent a sea level rise of 0.8 m to 2050. Base Case rainfall was applied
- Increased rainfall and downstream boundary (S6) – S4 and S5 were combined
- Dynamic storm tide (S7) – the Storm Tide Hydrograph Calculator (Cardno Lawson Treloar, 2010) was used to determine the dynamic storm tide conditions (no rainfall), for the 100 year ARI event with wave setup included. Three locations were adopted for application to the model boundary locations:
  - MBC-064 was applied downstream of Ningi Creek
  - MBC-075 was applied downstream of Elimbah Creek
  - MBC-083 was applied downstream of Glass Mountain Creek
- Static storm tide (S8) – the downstream boundaries were increased to 2.1 m AHD at the Toorbul boundary location and 2.2 m AHD at the Donnybrook boundary location as per information supplied by MBRC. Base Case rainfall was applied
  Increased rainfall, sea level rise and static storm tide (S9) – Inflows from S4 were applied. Downstream boundary conditions were raised to 3.1 m AHD (2.3 + 0.8) at the Ningi and Elimbah Creek boundaries and 3.6 m AHD (2.8 + 0.8) at the Glass Mountain Creek boundary in accordance with information supplied by MBRC

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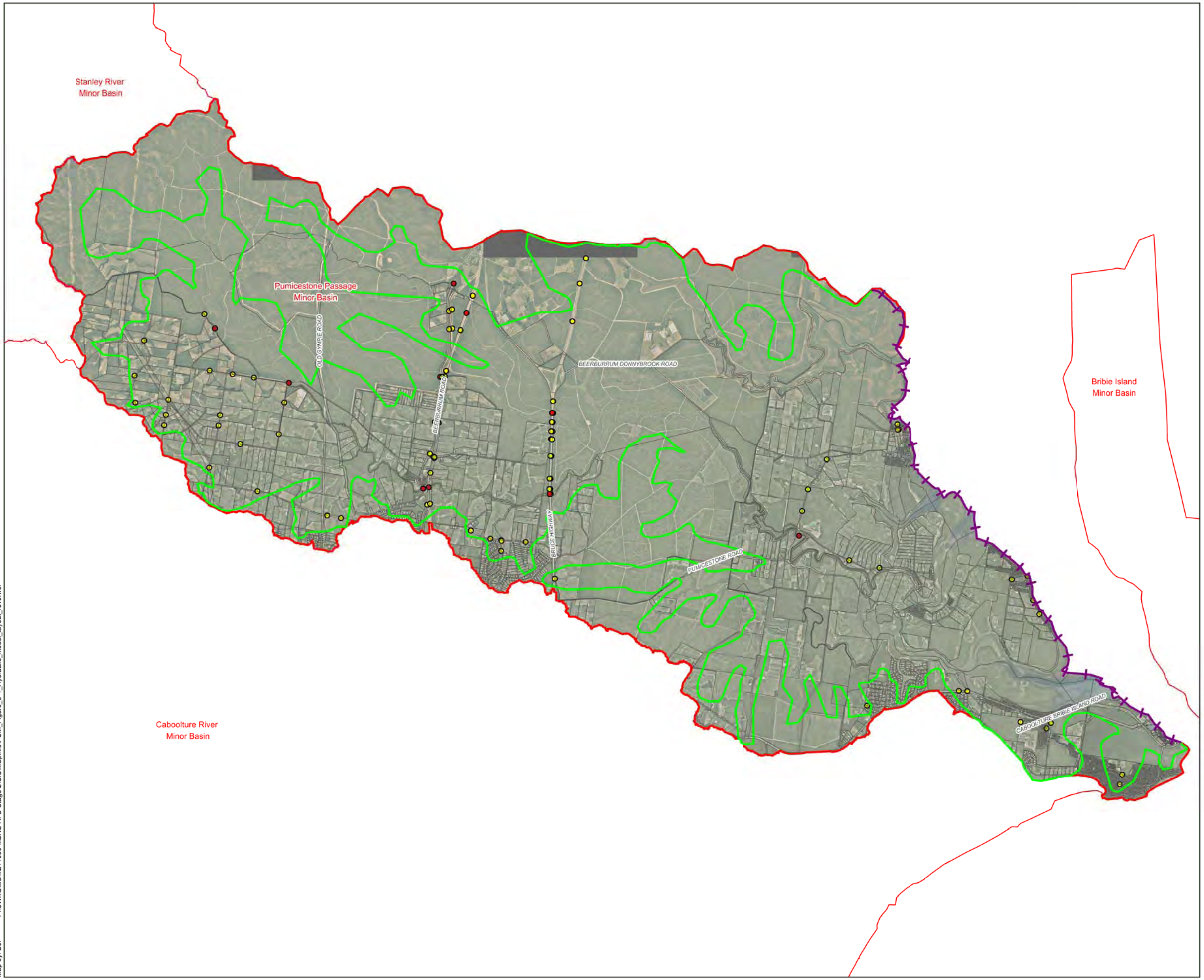

Map by: DJF

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Legend

- Cadastre
- Minor Basin Boundaries
- Downstream Boundary
- Hydraulic Model Boundary
- Culvert
- Bridge

Notes:

This figure is based on information provided to Aurecon by Moreton Bay Regional Council (MBRC) and other parties. Although the provider of the information has not warranted the accuracy of the data and has waived liability in respect of its use, Aurecon's study was undertaken strictly on the basis that the information that has been provided is accurate, complete and adequate. Aurecon takes no responsibility and disclaims all liability whatsoever for any loss or damage that MBRC may suffer resulting from any conclusions based on information provided to Aurecon, except to the extent that Aurecon expressly indicates in the associated report that it has verified the information to its satisfaction.

Date: 31/05/2012 **Version: 0**

A3 scale 1:100,000

0 2,500 m 5,000 m

Projection: MGA Zone 56

RFD Detailed Modelling (PUM)

Figure 3-1:Hydraulic Model Layout

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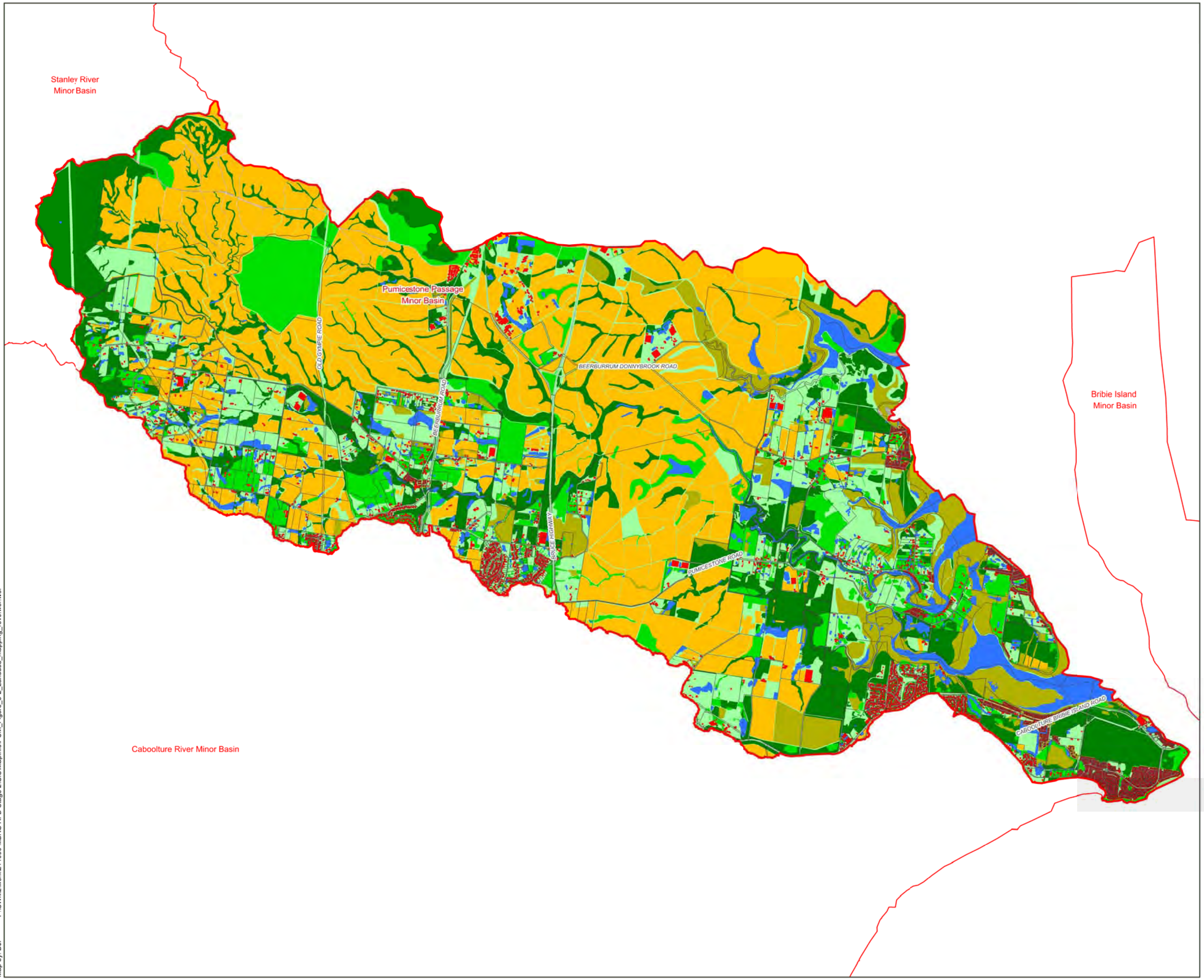

Legend

- Cadastre
- Minor Basin Boundaries
- Low Grass/Grazing
- Medium Vegetation
- Dense Vegetation
- Swamp
- Crops
- Roads/Footpahs
- Buildings
- Urban Blocks
- Waterbodies

Notes:

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Map by: DJF P:\SWM2\work\211090 MBRC RFD Stage 2\GIS\MapInfo\PUM_Figure_3-2_Landuse_mapping_rev0.wor.wor

A3 scale 1:100,000

0 2,500 m 5,000 m

Projection: MGA Zone 56

RFD Detailed Modelling (PUM)

Figure 3-2: Landuse Mapping - Existing Conditions

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Legend

Cadastre

Minor Basin Boundaries

Peak Flood Level Difference (m)

- < -0.50
- -0.50 to -0.10
- -0.10 to 0.10
- 0.10 to 0.50
- >0.5
- Was Dry Now Wet
- Was Wet Now Dry

Notes:

This figure is based on information provided to Aurecon by Moreton Bay Regional Council (MBRC) and other parties. Although the provider of the information has not warranted the accuracy of the data and has waived liability in respect of its use, Aurecon's study was undertaken strictly on the basis that the information that has been provided is accurate, complete and adequate. Aurecon takes no responsibility and disclaims all liability whatsoever for any loss or damage that MBRC may suffer resulting from any conclusions based on information provided to Aurecon, except to the extent that Aurecon expressly indicates in the associated report that it has verified the information to its satisfaction.

Date: 31/05/2012 **Version: 0**

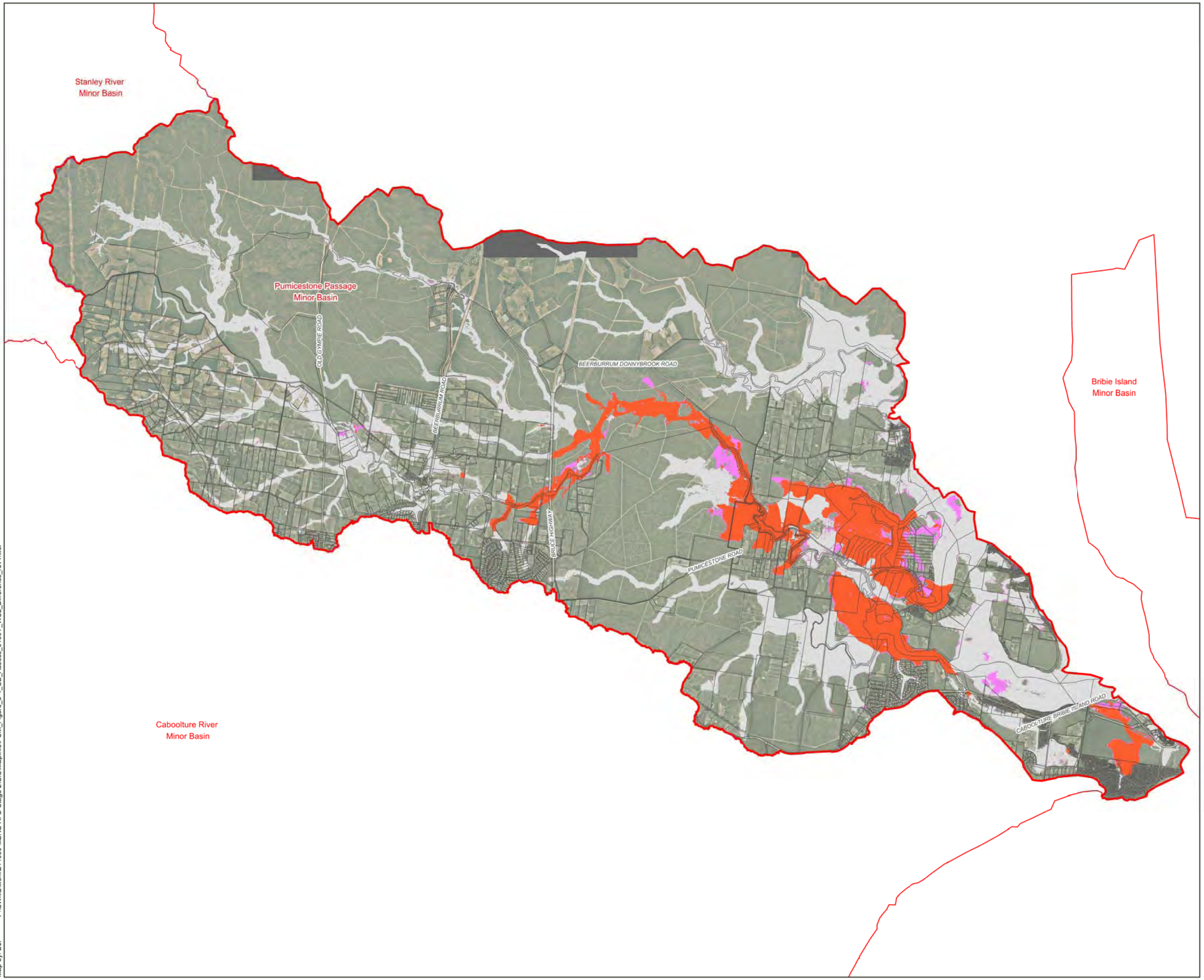
A3 scale 1:100,000

0 2,500 m 5,000 m

Projection: MGA Zone 56

RFD Detailed Modelling (PUM)

Figure 3-3:Critical Duration Assessment Peak Flood Difference 10 Year ARI



Map by: DJF P:\SWM2\work\211090 MBRC RFD Stage 2\GIS\MapInfo\PUM_Figure_3-4_CD_Assess_0100Y_WSL_Difference_rev1.wor

aurecon

Legend

- Cadastre
- Minor Basin Boundaries

Peak Flood Level Difference (m)

- < -0.50
- -0.50 to -0.10
- -0.10 to 0.10
- 0.10 to 0.50
- >0.5
- Was Dry Now Wet
- Was Wet Now Dry

Notes:

This figure is based on information provided to Aurecon by Moreton Bay Regional Council (MBRC) and other parties. Although the provider of the information has not warranted the accuracy of the data and has waived liability in respect of its use, Aurecon's study was undertaken strictly on the basis that the information that has been provided is accurate, complete and adequate. Aurecon takes no responsibility and disclaims all liability whatsoever for any loss or damage that MBRC may suffer resulting from any conclusions based on information provided to Aurecon, except to the extent that Aurecon expressly indicates in the associated report that it has verified the information to its satisfaction.

Date: 31/05/2012 Version: 0

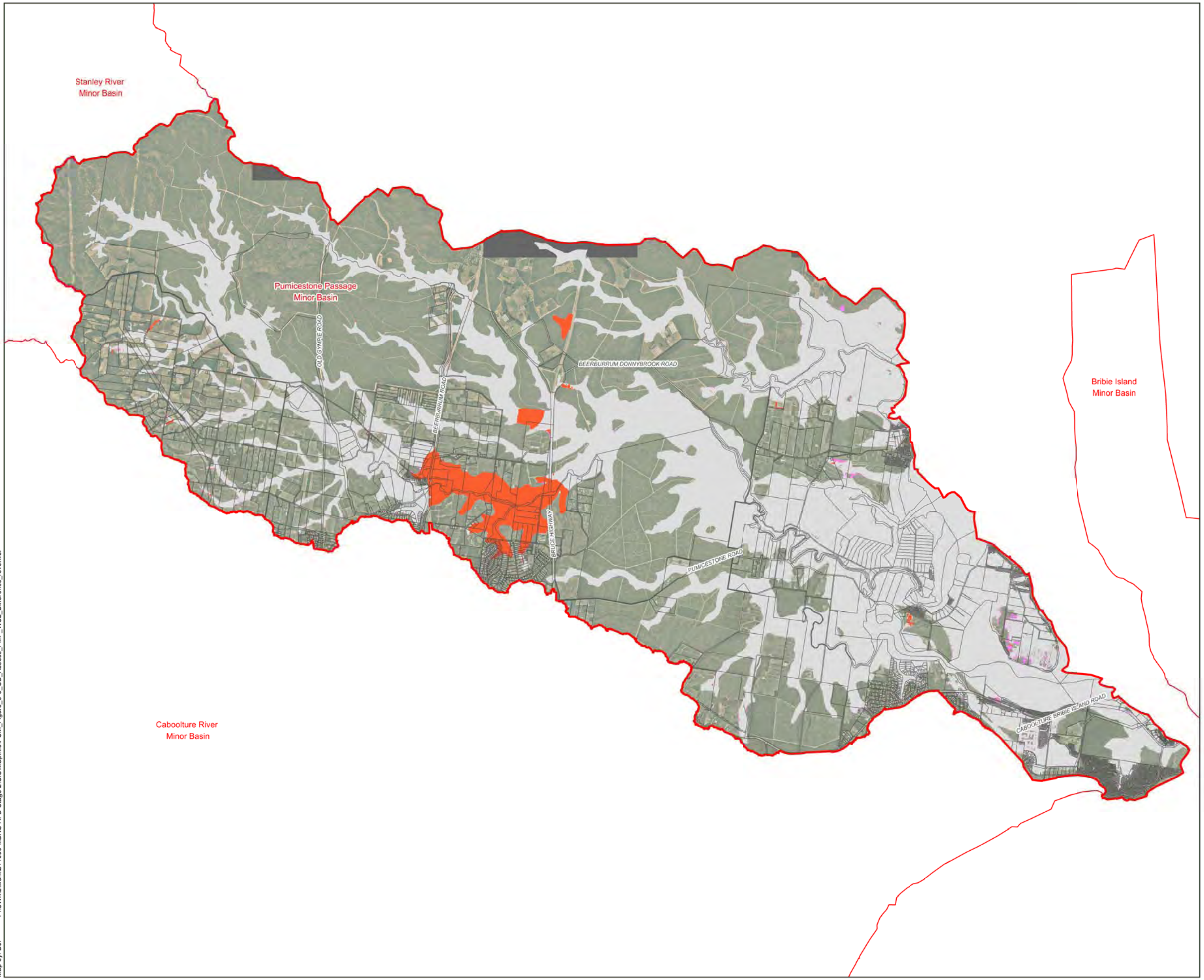
A3 scale 1:100,000

0 2,500 m 5,000 m

Projection: MGA Zone 56

RFD Detailed Modelling (PUM)

Figure 3-4: Critical Duration Assessment Peak Flood Difference 100 Year ARI



aurecon

Legend

Cadastre

Minor Basin Boundaries

Peak Flood Level Difference (m)

- < -0.50
- -0.50 to -0.10
- -0.10 to 0.10
- 0.10 to 0.50
- >0.5
- Was Dry Now Wet
- Was Wet Now Dry

Notes:

This figure is based on information provided to Aurecon by Moreton Bay Regional Council (MBRC) and other parties. Although the provider of the information has not warranted the accuracy of the data and has waived liability in respect of its use, Aurecon's study was undertaken strictly on the basis that the information that has been provided is accurate, complete and adequate. Aurecon takes no responsibility and disclaims all liability whatsoever for any loss or damage that MBRC may suffer resulting from any conclusions based on information provided to Aurecon, except to the extent that Aurecon expressly indicates in the associated report that it has verified the information to its satisfaction.

Date: 31/05/2012

Version: 0

Map by: DJF

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A3 scale 1:100,000

0 2,500 m 5,000 m

Projection: MGA Zone 56

RFD Detailed Modelling (PUM)

Figure 3-5: Critical Duration Assessment Peak Flood Difference PMF

4 Results and outcomes

4.1 Calibration and verification

Calibration and verification of the PUM models was not undertaken due to the lack of available data. The calibration and verification process which was undertaken for other minor basins provided model parameters for adoption in the PUM model (refer to SKM's Floodplain Parameterisation report, 2012).

4.2 Design flood behaviour

The discussion below is copied from Sections 4.3.3 and 4.3.4 of BMT WBM's Hydraulic Modelling (Detail) Sub-Project 2B Report (2010). Very few changes have been made to the text from BMT WBM's report.

Further to that below, the model quality was reviewed in detail and is described in the Model Quality Report provided in Appendix D. In summary:

- The hydrologic model is performing well
- The hydraulic model is generally performing well, with the following issues being of note
  - Water level oscillations occur in the Pacific Harbour canals – these intuitively do not seem correct, however the situation has been reviewed in detail and the model is performing correctly
  - Structure stability – the stability of the structures has been problematic and whilst stability has been significantly improved, minor instabilities are still occurring at some structures, particularly in low flow conditions

4.2.1 Model results

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. The flood conditions presented in these maps were derived using the envelope (maximum) of all modelled storm durations. Flood maps are only provided for the 100 year ARI design event as the focus of this project is on digital data, rather than provision of flood maps. A description of the digital data provided to Council for incorporation into their RFD is summarised in Section 4.2.2. The flood maps for 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* held by MBRC. Therefore, all model input and output data is being provided upon completion of the study. The data includes all model files for the design events (for each duration), future scenarios, sensitivity analysis and climate change assessment.

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

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

4.3 Sensitivity analysis

The 100 Year EDS (with a 15 minute burst in a 270 minute storm duration) was simulated. The results were compared to the 100 year ARI results and are provided in Figure F1 of Appendix F. These results show that peak water levels are within ±0.1 m of the 100 year ARI peak water levels across much of the basin. In Elimbah Creek and Six Mile Creek between Quinn Road North and Old Gympie Road water levels are approximately 0.2 m lower than the 100 year levels. In the upper end of Bullock Creek (branch ELI_11) water levels are approximately 0.1 m lower than the 100 year levels.

The 100 Year EDS was utilised for sensitivity, future landuse conditions and climate change scenarios and is therefore the Base Case for these sensitivity runs.

The use of SA boundaries for the application of rainfall to the model has impacted upon the location in which inflows are applied in some of the sensitivity runs. For this reason some of the runs show a reduction in flood levels and inundation extents in areas where this would not be expected to occur. Results in these areas should be treated with caution.

4.3.1 Future landuse analysis

For each of the future landuse cases, the peak flood levels were compared to those of the Base Case EDS. The results are presented in Figure F10, Figure F11 and Figure F12 in Appendix F. A summary of the model results are presented below.

- Increased vegetation (S10, Figure F10)
  - Increased vegetation has only minor impacts across the basin. Water levels are predicted to increase by up to 0.3 m in Elimbah Creek upstream of Quinn Road North. Increases of +0.1 to +0.2 m are also predicted in parts of Six Mile Creek. These increases occur in rural areas
- Increased residential development (S11, Figure F11)
  - The impacts of increased residential development are minor (±0.1 m) as this only occurs in areas which are already developed, therefore the ultimate percentage impervious values are only slightly higher than the existing values
- A combination of the above two (S12, Figure F12)
  - Impacts across the basin are minor and are almost identical to those in sensitivity run S10

4.3.2 Hydraulic roughness analysis

The increased roughness impacts are presented in Figure F2. This figure shows that increased roughness has very little impact in the lower reaches of the model and increases peak water levels by +0.1 to +0.2 m throughout Beerburrum and Six Mile Creeks.

4.3.3 Structure blockage analysis

Figure F3 presents the impacts of structure blockage across the PUM basin. Blockage of structures beneath Beerburrum Road increases peak water levels upstream in Beerburrum Creek and its tributaries by 2.4 to 3.2 m. Blockage of the Bruce Highway culverts increases water levels in Glass Mountain Creek and its tributaries by 1.1 to 2.0 m on the upstream side of the highway. Peak water levels are significantly reduced (up to -1.3 m) downstream of the blocked culverts.

4.3.4 Climate change and downstream boundary condition analysis

- Increased rainfall (S4, Figure F4)
  - Increased rainfall creates impacts of +0.1 to +0.5 m throughout much of Elimbah, Six Mile and Beerburrum Creeks and parts of Ningi Creek. Water levels are predicted to increase by approximately +0.55 m in Six Mile Creek near Beerburrum Road
- Increased downstream boundary (S5, Figure F5)
  - As expected, an increase in tailwater level results in increased water levels (+0.8 m) at the downstream end of the model. The greatest impact in residential areas occurs in Toorbul, where water levels are predicted to increase by up to +0.55 m and inundation is predicted to extend through much of the township
- Increased rainfall and downstream boundary (S6, Figure F6)
  - The results for this case show a combination of the above two cases, with water levels being increased by at least +0.1 m across most of the basin. The impacts described above for S4 and S5 occur for this case as well
- Dynamic storm tide (S7, Figure F7)
  - The inundation extents for the dynamic storm tide case are significantly increased in the coastal areas. The storm tide is predicted to travel at least 5.0 km inland from the coast and inundate Toorbul, Meldale and the northern parts of Donnybrook
- Static storm tide (S8, Figure F8)
  - The inundation extents for the static storm tide are similar to those of the dynamic storm tide in the coastal areas and water level increases occur up to 5 km inland from the coast. Peak water levels are predicted to increase by up to +1.0 m in Toorbul and +1.1m in Meldale
- Increased rainfall, sea level rise and static storm tide (S9, Figure F9)
  - S9 is predicted to have the most significant impacts upon peak water levels. In the upper catchment, impacts are similar to those in S4 and in the lower catchment inundation extends across most of the catchment between Ningi, Elimbah and Bullock Creeks. Peak water levels increase by up to +2.0 m in Toorbul and Donnybrook and +2.1m in Meldale

4.4 Model limitations

This section is reproduced from Section 4.7 of BMT WBM's Hydraulic Modelling (Detail) Sub-Project 2B Report (2010) and revised to be specific to the Bribie Island minor basin. Given that the same approach has been used across all the Stage 2 hydraulic models, the limitations will be similar.

The topography of creeks in the upper Pumicestone Passage basin is defined using LiDAR data due to the absence of surveyed cross-sections or bathymetry. LiDAR is unable to pick up ground levels below the water surface, and therefore the bed levels of creeks are not represented in detail. This approach means that the flood levels, particularly for small flood events where a greater proportion of the flow is typically conveyed in bank (eg the 1 to 10 year ARI), may be overestimated. This approach has been adopted by MBRC due to budget constraints and the consideration of cost versus benefit. The use of LiDAR data in the creeks will generally be conservative (ie overestimate flood levels).

Watercourses have also been represented in the 2D domain, for which the grid resolution is limited to 5 m. In addition, for the narrower upstream reaches, a waterway landuse layer has not been incorporated. This may not allow adequate representation of the channel conveyance, particularly for the narrower upper reaches. 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 Conclusions and recommendations

Hydrologic and hydraulic modelling has been undertaken to simulate the full range of design flood conditions in the Pumicestone Passage minor basin, from the 1 year ARI event to the Probable Maximum Flood. This modelling was undertaken using the standards and approaches developed during Stage 1 of the Regional Floodplain Database project.

Assessment of a range of scenarios including climate change, land use change, vegetation change, culvert blockage and storm tide events was also undertaken.

A comprehensive set of GIS results has been prepared for incorporation into Council's GIS systems. This includes peak water surface levels, depths, velocities, stream power and hazard. Mapping of the 100 year ARI results has also been prepared.

We recommend that the outcomes of the Model Quality Report in Appendix D should be taken into account when using the models and/or their results.

6 References

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