

Regional Floodplain Database:

Hydrologic and Hydraulic Modelling - Brisbane Coastal Creeks (BCC)



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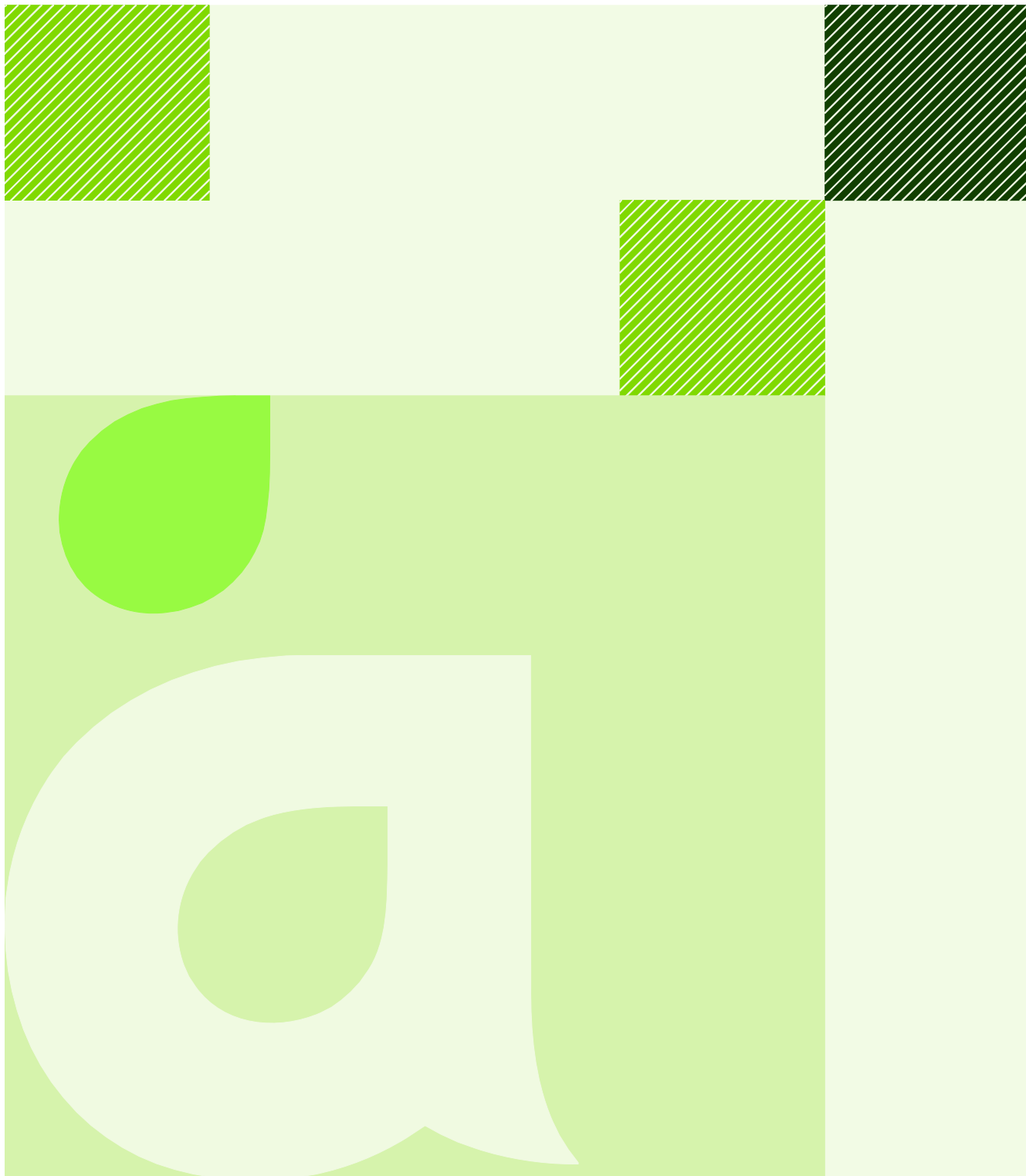
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1 Introduction

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 Brisbane Coastal Creeks (BCC) minor basin for the RFD.

This basin covers an area approximately 40 km² and incorporates the upper ends of the Kedron Brook and Cabbage Tree Creek catchments. Approximately 70% of the Kedron Brook catchment falls within the Brisbane City Council region. The basin is largely developed through the middle and lower reaches and includes the residential suburbs of Everton Hills, Arana Hills, Keperra, Ferny Hills, Ferny Grove and Upper Kedron.

1.1 Scope

The detailed modelling of the Brisbane Coastal Creeks 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.

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 '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 Brisbane Coastal Creeks 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 Brisbane City Council aerial imagery for the southern 60% of the Brisbane Coastal Creeks minor basin which falls in the Brisbane City Council 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 and only covered the MBRC part of the minor basin
- **Floodplain Topography** – A 2.5 m DEM and model z-points (on a 5 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 and modifiers (breaklines) developed by Aurecon
- **Woolshed Grove Development Topography** – a design surface for the Woolshed Grove development was provided by MBRC
- **Broadscale TUFLOW Model** – the broadscale Kedron Brook model was provided by MBRC. This model was developed by Cardno Lawson Treloar in 2008
- **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
- **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 and Brisbane City Council
 - Existing GIS database information for some existing culverts from MBRC and Brisbane City Council
 - 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 following historical flood study reports were provided by MBRC and Brisbane City Council
 - Kedron Brook Flood Study undertaken by Connell Wagner in 1995
 - Kedron Brook Design Events Flood Study DRAFT undertaken by Cardno Lawson Treloar in 2008
 - Kedron Brook Flood Assessment and Design and Extreme Flood Mapping undertaken by Cardno Lawson Treloar in 2008
 - Kedron Brook Flood Study undertaken by Cardno Lawson Treloar in 2009
 - Cabbage Tree Creek Flood Model Update Draft undertaken by JWP in 2006
 - Cabbage Tree Creek Extreme Event Report undertaken by JWP in 2007
 - **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 Brisbane Coastal Creeks 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. Within the BCC minor basin, although the creek invert levels may not be well represented in the LiDAR data, the channels themselves are well represented. The additional conveyance capacity which would be provided by accurate representation of the creek inverts is expected to be minimal; therefore it was not recommended that additional bathymetric data be captured for the BCC minor basin.

Table 1 | Infrastructure and bathymetric data

Data Item	Priority A	Priority B
Structures (culverts, bridges and trunk drains)	45	31
Bathymetric reaches	0km	0km

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 Brisbane Coastal Creek models was assessed. This was based on the availability of stream gauge, daily rainfall, pluviograph rainfall and historic flood mark data. It was determined that this data was available for four events, with stream gauges located near the downstream end of each creek. No rating curve data was available for the stream gauges; therefore this process would be limited to joint calibration of the hydrologic and hydraulic models at their downstream boundaries. Historic flood mark (Brisbane City Council Maximum Height Gauge) data was available for six locations within the Kedron Brook catchment and no historical flood mark data was available within the Cabbage Tree Creek catchment for the four events. Due to these data limitations, no calibration event was selected. The October 2010 event was selected as the validation event.

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 the Brisbane Coastal Creeks minor basin 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

A 5 m grid TUFLOW model was prepared 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
- Stream breakline modifiers, as developed by Aurecon, were used to create continuous stream paths for the following stream lengths:
 - 4.1 km of Cabbage Tree Creek
 - 7.1 km of Kedron Brook

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

- Z-points to represent the Woolshed Grove development, which was developed after the capture of the 2009 LiDAR
- 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 Brisbane Coastal Creeks 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
- Bridges were modelled as 2D structures using the 2d_flcsh approach

To solve stability issues, the culvert structure beneath Canvey Road in Upper Kedron was modelled using the 2D approach.

Table 2 | Number of modelled structures

Structure Type	Number of Modelled Structures
2D bridges	14
1D culverts	35
2D culverts	1

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 extended to cover the Brisbane City Council areas of the model. 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 m2)	0.300
Buildings	1.000
Roads	0.015
Footpaths	0.015
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.

Water level-discharge (QH) relationships were used as the downstream boundary conditions. Three separate conditions were used at the downstream end of Cabbage Tree Creek, the downstream end of Kedron Brook and the extreme event breakout to the south of Kedron Brook across Northmore Street. These conditions used the automatic QH relationship boundary calculation within TUFLOW and were based upon very flat slopes of 0.5%, 0.1% and 0.1% respectively.

3.4 Model calibration and validation

Calibration of the BCC models was not undertaken due to limitations with the available data. Validation of the models to the October 2010 event was carried out. The calibration and validation process which was undertaken for other minor basins provided model parameters for adoption in the BCC model validation, 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, 0090, 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 4 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 4 | Critical duration selection

Assessment Event	Selected Critical Durations	Adopted Events
10 year ARI	0060, 0120, 0180	1, 2, 5, 10 and 20 year ARI
100 year ARI	0060, 0120, 0180	50 and 100 year ARI
Probable Maximum Flood	0030, 0090, 0180	200, 500, 1000, 2000 year ARI and PMF

3.5.2 Design event simulations

The Brisbane Coastal Creeks model was simulated for the return periods, grid sizes and storm durations shown in Table 5.

Table 5 | Simulated design events

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

3.6 Sensitivity analysis

Table 6 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 6 Sensitivity runs

ID	Title	Description	Methodology Section
S1	EDS	MBRC EDS	
S2	Increase n	Increase manning's n values by 20%	3.6.2
S3	Blockage	Model blockage of culverts	3.6.3
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	N/A
S8	Storm Tide 2	Model rainfall with static storm tide boundary – 100 year ARI	N/A
S9	Storm Tide 3	Increased Rainfall (S4) + Increase in Sea level (S5) + Static ST level (100yr GHG)	N/A
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 BCC 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. No changes were made to the fraction impervious values within the Brisbane City Council area.

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

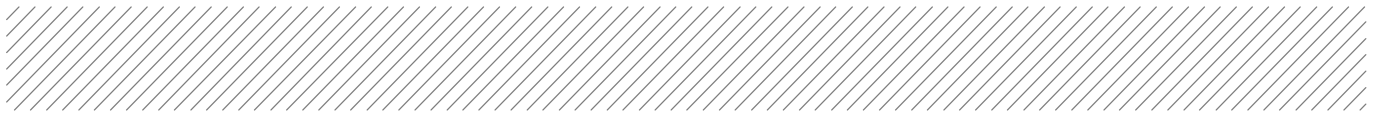
A blockage scenario (S3) was run to assess the effects of waterway crossings (culverts) becoming blocked during a flood event. The SKM Floodplain Parameterisation report (2012) provided recommendations for a moderate blockage scenario. The adopted blockage parameters were:

- 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

Three scenarios were simulated to assess the potential impacts of climate change in accordance with the SKM Boundary Conditions, Joint Probability & Climate Change (2012) recommendations. No analysis of storm tide events was required as the model does not have an oceanic downstream boundary and the area is not impacted by storm tide events. 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 and the PMF level was applied as a static tailwater level. Base Case rainfall was applied
- Increased rainfall and downstream boundary (S6) – S4 and S5 were combined
- Dynamic storm tide (S7) – N/A
- Static storm tide (S8) – N/A
- Increased rainfall, sea level rise and static storm tide (S9) – N/A

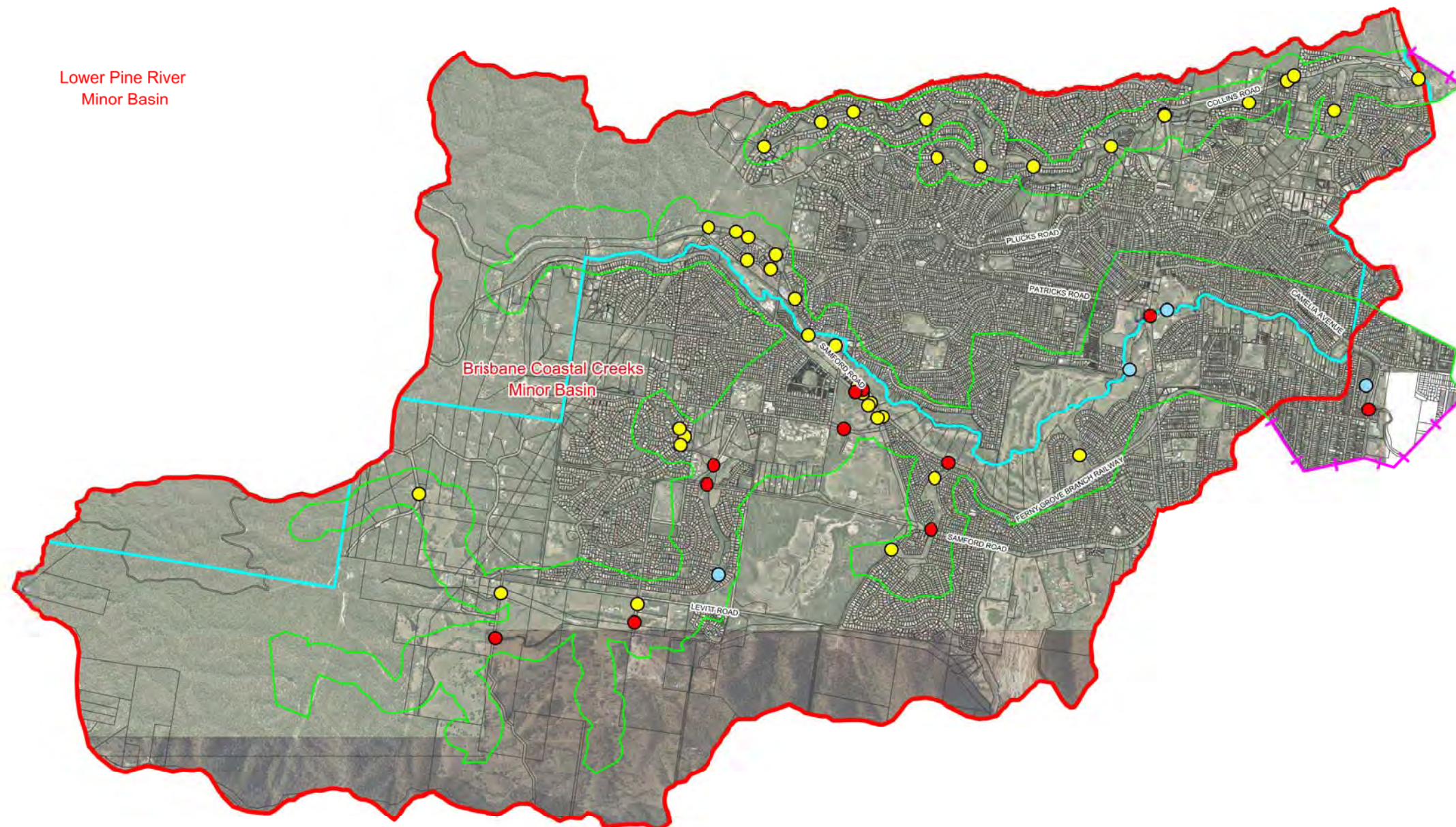


Legend

-  Cadastre
-  Minor Basin Boundaries
-  MBRC/BCC Boundary
-  Downstream Boundary
-  Hydraulic Model Boundary
-  Culvert
-  Bridge
-  Footbridge

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.



Lower Pine River
Minor Basin

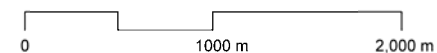
Brisbane Coastal Creeks
Minor Basin

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Map by: DJF



A3 scale 1:40,000



Date: 12/10/2012 Version: 0 Job No: 222767
Projection: MGA Zone 56

RFD Detailed Modelling (BCC)

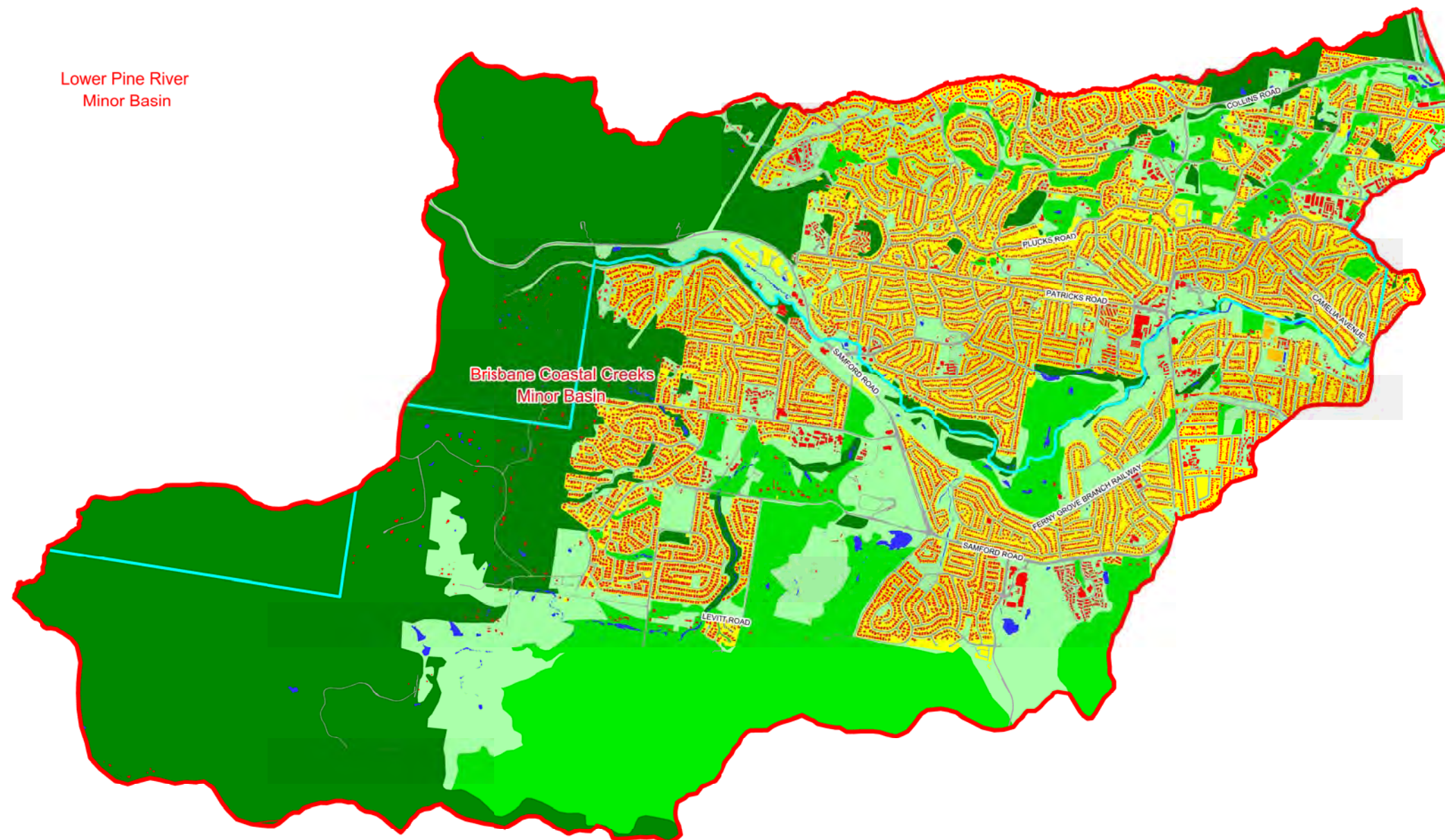
Figure 3-1: Hydraulic Model Layout

Legend

- Cadastre
- Minor Basin Boundaries
- MBRC/BCC Boundary
- Waterbody
- Roads/Footpaths
- Buildings
- Urban Blocks
- Crops
- Dense Vegetation
- Low Grass/ Grazing
- Medium Vegetation
- Reeds

Notes:

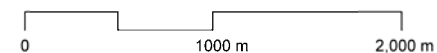
This figure is based on information provided to Aurecon by Moreton Bay Regional Council (MBRC) and other parties. Although the provider of the information has not warranted the accuracy of the data and has waived liability in respect of its use, Aurecon's study was undertaken strictly on the basis that 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.



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Projection: MGA Zone 56

RFD Detailed Modelling (BCC)

Figure 3-2: Landuse Mapping - Existing Conditions

Legend

- Cadastre
- Minor Basin Boundaries
- MBRC/BCC Boundary

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.

Lower Pine River
Minor Basin

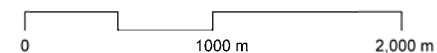
Brisbane Coastal Creeks
Minor Basin

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Map by: DJF



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RFD Detailed Modelling (BCC)

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

Map by: DJF
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Legend

- Cadastre
- Minor Basin Boundaries
- MBRC/BCC Boundary

Peak Flood Level Difference (m)

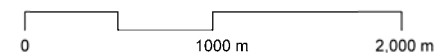
- < -0.50
- 0.50 to -0.10
- 0.10 to 0.10
- 0.10 to 0.50
- >0.5
- Was Dry Now Wet
- Was Wet Now Dry

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.



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Projection: MGA Zone 56

RFD Detailed Modelling (BCC)

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

Legend

- Cadastre
- Minor Basin Boundaries
- MBRC/BCC Boundary

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.

Lower Pine River
Minor Basin

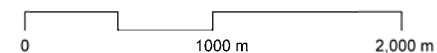
Brisbane Coastal Creeks
Minor Basin

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Map by: DJF



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Projection: MGA Zone 56

RFD Detailed Modelling (BCC)

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

4 Results and outcomes

4.1 Calibration and verification

The Brisbane Coastal Creeks model was verified to the October 2010 event. The peak water level comparisons for this event are presented in Table 7. This verification process showed that the model generally represents the timing and peak water levels of the October 2010 event well, with an overestimation of peak water levels in the lower reaches.

Table 7 | Comparison of modelled and recorded peak water levels

Stream gauge or maximum height gauge	Street	Recorded peak water level (m AHD)	Modelled peak water level (m AHD)	Difference (m)
Cabbage Tree Creek Stream Gauge	Old Northern Road	44.19	44.37	+0.18
Kedron Brook Stream Gauge	Osborne Road	33.30	34.18	+0.88
260	Osborne Road	32.71	33.93	+1.22
270	Dawson Parade	40.95*	41.56	+0.61
280	Pearse Street	45.21	45.48	+0.27
290	Kuringal Drive	48.59	48.51	-0.08
300	Samford Road	56.20	56.26	+0.06
310	Rangleigh Street	60.57*	61.04	+0.47

* Indicates debris-affected readings

The Brisbane Coastal Creeks model covers only one minor basin in the Moreton Bay Region. Under the direction of Council, the catchments in this region have been modelled with a uniform approach, using a standard set of modelling parameters. This holistic approach does not encourage use of minor basin or catchment specific modelling parameters. For this reason it is considered that the validation results obtained for the BCC model were within acceptable limits.

A copy of the Validation Report is included in Appendix C.

4.2 Design flood behaviour

The discussion in this section 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.

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. This figure shows that, the EDS model predictions are generally within ± 0.1 m of the 100 year ARI results.

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.

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 density causes increases in peak water levels within the Kedron Brook catchment by up to +1.0 m near Coles Street. Upstream of this location, water levels are typically increased by +0.3 m and downstream of this location typical increases are in the order of +0.5 m. In Cabbage Tree Creek water levels are increased approximately +0.1 to +0.15 m
- Increased residential development (S11, Figure F11)
 - The impacts of increased residential development are minor as this only occurs in areas which are already developed; therefore the ultimate percentage impervious values are only slightly higher than the existing values. The most noticeable impact occurs near the intersection of Yingally and Leonarda Drives where the roadway is shown as being inundated in the increased residential development case
- A combination of the above two (S12, Figure F12)
 - Increases in peak water levels are very similar to those which occur in the increased vegetation case

4.3.2 Hydraulic roughness analysis

The increased roughness impacts are presented in Figure F2. This figure shows that increased roughness primarily impacts upon water levels along the Cedar Creek tributary to Kedron Brook. Within the MBRC area, the greatest impacts occur in the Cabbage Tree Creek catchment where water levels are increased by up to +0.25 m on the northern side of Collins Road, near Peter Street North. Within the Keperra Country Golf Club water levels are increased by up to +0.2 m.

4.3.3 Structure blockage analysis

The impacts presented in Figure F3 show that structure blockage has very little impact within Kedron Brook. The greatest impact in this catchment occurs in the small tributary which runs through the Woolshed Grove development. Water levels in this tributary increase by up to +1.0 m upstream of Samford Road.

In Cabbage Tree Creek the following impacts occur:


- Increased in peak water levels of up to +3.5 m upstream of Linkwood Drive
- Impacts of up to +0.8 m upstream of Yingally Drive
- Increases in peak water levels of +0.2 to +0.3 m upstream of View Crescent, Bunya Road, Francis Road and Bennetts Road

4.3.4 Climate change and downstream boundary condition analysis

- Increased rainfall (S4, Figure F4)
 - Increased rainfall causes an average increase in water levels of +0.2 m in Kedron Brook, with impacts of up to +0.35 m near Galeola Street
 - Peak water levels in Cabbage Tree Creek are increased by up to +0.25 m upstream of Francis Road
- Increased downstream boundary (S5, Figure F5)
 - Peak water levels in Cabbage Tree Creek are increased by +0.8 m upstream of Old Northern Road. Approximately 300m upstream of Old Northern Road peak water levels are within ± 0.1 m of EDS peak water levels
- Increased rainfall and downstream boundary (S6, Figure F6)
 - The S6 results are a combination of S4 and S5 and show very similar impacts to these two scenarios. Water levels near Galeola Street are increased by up to +0.7 m
- Dynamic storm tide (S7, Figure F7)
 - N/A
- Static storm tide (S8, Figure F8)
 - N/A
- Increased rainfall, sea level rise and static storm tide (S9, Figure F9)
 - N/A

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 Brisbane Coastal Creeks 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 non-urban areas of the Brisbane Coastal Creeks 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.



5 Conclusions and recommendations

Hydrologic and hydraulic modelling has been undertaken to simulate the full range of design flood conditions in the Brisbane Coastal Creeks 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 and culvert blockage 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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