Regional Floodplain Database:

Hydrologic and Hydraulic Modelling - Neurum Creek (NEU)

Moreton Bay Regional Council

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Regional Floodplain Database

Hydrologic and Hydraulic Modelling Report: Neurum Creek (NEU)

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REGIONAL FLOODPLAIN DATABASE
HYDROLOGIC AND HYDRAULIC MODELLING REPORT: NEURUM CREEK (NEU)

SYNOPSIS

This flood study report has been prepared by WorleyParsons for Moreton Bay Regional Council for the purposes of documenting the methodology, approach and outcomes associated with the comprehensive flood assessment works undertaken for the Neurum Creek (NEU) minor basin as part of the MBRC Regional Floodplain Database (RFD) Stage 2 project. The study has included detailed hydrologic and hydraulic modelling to assess the flood behaviour of Neurum Creek for a range of design storm events from the 1 year Average Recurrence Interval (ARI) event to the Probable Maximum Flood (PMF).

Modelling software packages used in this flood study are the WBNM (Watershed Bounded Network Model) as the hydrologic modelling software and TUFLOW as the hydraulic modelling software.

The flood assessment undertaken for the NEU minor basin as documented in this report has been successful in addressing the overall objectives of the study. It is considered that the associated model outputs can be adopted by MBRC for the Regional Floodplain Database to deliver seamless information about flood behaviour across the entire Moreton Bay Regional Council area.

Disclaimer

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PROJECT 301001-01156 - REGIONAL FLOODPLAIN DATABASE

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
0	Issue for use	L Cheung	K Hegerty	M Shaw	30 Jul 2012		

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1 INTRODUCTION

WorleyParsons Services Pty Ltd has been commissioned by Moreton Bay Regional Council (MBRC) to carry out detailed surface water flood modelling over six (6) regional minor basins located within the MBRC Local Government Area (LGA). The six minor basins are Upper Pine River (UPR), Sideling Creek (SID), Stanley River (STA), Neurum Creek (NEU), Mary River (MAR) and Byron Creek (BYR). This flood modelling study has been carried out as part of Stage 2 of the Regional Floodplain Database (RFD) Project. Stage 1 of the RFD Project involved a pilot study and various sub-projects that have provided the basis for the overall project methodology.

UPR and SID make up ‘Package 1’ and STA, NEU, MAR and BYR make up ‘Package 5’ of MBRC’s Stage 2 RFD Project.

This report details the project methodology, results and outcomes associated with the Neurum Creek (NEU) minor basin investigation.

1.1 Scope

The scope of this flood modelling investigation was to carry out detailed hydrologic and hydraulic modelling over the Neurum Creek minor basin. The results from the detailed modelling of Neurum Creek will provide Council with an enhanced understanding of the flood behaviour in the minor basin for a large range of flood events from the 1 year Average Recurrence Interval (ARI) event to the Probable Maximum Flood (PMF).

1.2 Objectives

The objectives of this study are:

- Development of computer based hydrologic and hydraulic modelling suite for the Neurum Creek minor basin based on standardised modelling procedures and modelling input parameters specific for the RFD study minor basins.
- Use of the developed models to predict where and how flooding may occur in the Neurum Creek minor basin.

The associated model outputs are to be included in the RFD for delivering seamless information about flood behaviour across the entire MBRC LGA.

1.3 General Approach

The detailed hydrologic and hydraulic modelling undertaking for the NEU minor basin has involved the following tasks:

- Refine the broadscale WBNM2010 hydrologic model established for NEU minor basin in Stage 1 RFD project;
- Establish a detailed 1D/2D coupled TUFLOW model to investigate flood behaviour for the NEU minor basin utilising the topographic information, roughness values, inflow and other boundary condition information determined in previous sub-projects as detailed in Table 1-1;
- Undertake separate critical duration assessments for simulation of a range of storm durations for the 10 and 100 year ARI design events and the Probable Maximum Flood (PMF) event;
- Select three (3) critical durations for each design event from the above separate critical duration assessments as follows:
  - 1 to 10 year ARI events, determined by the 10 year ARI critical duration assessment;
  - 20 to 100 year ARI events, determined by the 100 year ARI critical duration assessment; and
  - 200 year ARI to PMF events, determined by the PMF critical duration assessment;
- Simulate 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000 year ARI and PMF events for the three (3) selected critical durations for each design event;
- Simulate the 100 year ARI 15 minutes Burst in 270 minutes envelope Embedded Design Storm (EDS);
- Assess model sensitivity to Manning's 'n' and blockage of culverts;
- Assess climate change scenarios including 20% increase of rainfall intensity and rise of tailwater boundary conditions over the NEU minor basin;
- Assess future landuse scenarios by increased vegetation coverage and residential development on the floodplain; and
- Provide a concise report describing the adopted methodology, study data, model results and findings.

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

Table 1-1 summarises the previous related sub-projects (as part of the RFD Stage 1) for the purposes of providing input data and or methodologies to this RFD Stage 2 project:

Table 1-1 Related Previous Sub-Projects

Sub-Project	Origin	Scope
1D – Hydrologic and Hydraulic modelling (Broadscale)	BMT WBM (2010)	To define model naming conventions and model protocols to be used in the RFD project
1E – Floodplain Topography (2009 LiDAR)	WorleyParsons (2010a)	To provide the topographic information, such as model z-pts layer and digital elevation models (DEM) utilising a DEM tool developed specifically for the RFD
1G – Hydrography	MBRC	To supply the sub-catchment delineation of Burpengary minor basin including a stream line and junctions (used in the WBNM model)
1H – Floodplain Landuse	SKM (2010a)	To deliver the current percentage impervious cover (utilised in the hydrologic model) and the roughness Manning's 'n' values (utilised in the hydraulic model)
1I – Rainfall and Stream Gauges Information Summary	MBRC	To summarise available rainfall and stream gauge information for the study area
2B – Detailed modelling of the Burpengary Creek minor basin	BMT WBM (2010)	The pilot study for the RFD Stage 2. One of the key outputs of this sub project was to develop a general modelling methodology and structure as an overall guideline for all detailed modelling being undertaken in Stage 2 of the RFD
2C – Floodplain Structures (Culverts)	Aurecon (2010)	To supply a GIS layer of the culverts to be included in the hydraulic model for the RFD project
2D - Floodplain Structures (Bridges)	Aurecon (2010)	To provide a GIS layer of the major road bridges and foot bridges to be included in the hydraulic model for the RFD project
2F – Floodplain Structures (Trunk Underground Drainage)	Aurecon (2010)	To provide trunk underground drainage information for the RFD project
2G - Floodplain Structures (Basins)	Aurecon (2010)	To consolidate and survey the existing basin information for the RFD project
2I - Floodplain Structures (Channels)	Aurecon (2010)	To identify channels within the minor basins

Sub-Project	Origin	Scope
2J – Floodplain Landuse (Historic and Future)	SKM (2010a)	To define 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)
2K – Flood Information Historic Flooding	GHD (2010)	To locate and survey flood levels for the May 2009 and February 1999 historic flood events
2L – Design Rainfall and Infiltration Loss	WorleyParsons (2010b)	To develop the hydrologic models for the Burpengary Creek minor basin and provide the design rainfall hydrographs for the TUFLOW models
2M – Boundary Conditions, Joint Probability and Climate Risk Scenarios	SKM (2012b)	To define the boundary conditions and provide recommendations in regards to joint probability (i.e. occurrence of storm surge in combination with river flooding events, or river flooding in combination with local tributary flooding). This project also recommended certain sea level rise and rainfall intensity values to assess Climate Risk Scenarios
2N – Floodplain Parameterisation	SKM (2012c)	To provide recommendations of the floodplain parameters, such as a range of values for various impervious percentages for various landuse types (i.e. residential or rural landuse, dense vegetation), a range of values for various roughness types (i.e. long grass, dense vegetation) and structure losses

2 AVAILABLE DATA

The following list summarises the data available for the study:

- Floodplain Topography - DEM Tool to create 2.5m DEM and model Z-pts (model topography) The topography is based on LiDAR (Light Detection And Ranging) data collected in 2009 and provided by Department of Environment and Resource Management (DERM);
- Hydrography - hydrography dataset (sub-catchment delineation) supplied by MBRC;
- Floodplain Landuse – polygons for nine (9) different landuse categories provided by MBRC and developed by SKM (2010a) as part of RFD Stage 1;
- Floodplain Structures – DTMR and QT structures prepared by Aurecon (2010) and provided by MBRC in TUFLOW readable format. Other structure provided by MBRC in the form of as constructed drawings and detail survey;
- Design Rainfall – amendment of WBNM models, development of design simulations and provision of design rainfall hydrographs;
- Boundary Conditions, Joint Probability and Climate Risk Scenarios – report with recommendations for boundary conditions, joint probability and climate change scenarios; and
- Floodplain Parameterisation – recommendations for impervious percentages for various landuse types, roughness types and structure losses.

2.1 Qualification to Report Findings

It is important to appreciate that the accuracy of the information presented in this report is entirely dependent on the accuracy of these available data. Therefore, the interpretation of information presented in this report should be done so with an understanding of any limitations in their accuracy.

Factors for consideration:

- All data listed above have been provided by Moreton Bay Regional Council for the purpose of developing this model. WorleyParsons have assumed the accuracy of this data and suitability of use for this study, and have not critically reviewed this information. In particular, topographic information has been provided by MBRC, and the flood assessment predictions are based on the accuracy of this data;
- Due to unavailability of suitable historical data there has not been the opportunity to undertake calibration of model results. Therefore, models have been derived based on regionally verified parameters;
- Recognition that no two floods behave in exactly the same manner and the data provided for use cannot represent conditions for all possible flood scenarios. Therefore, the results presented may not exactly replicate the flooding behaviour of an actual flood event;

- Design floods are considered a best estimate of an “average” flood for their probability of occurrence. It is assumed that these data provide the best estimate of the average;
- Over time further information may become available that could impact on the outcomes of the study as presented in this report. Council should be mindful of new information that may impact the outcomes as presented in this study and consider appropriate actions to address possible changes to findings;
- Flood study analysis relies on the requirement to have a freeboard between the predicted average recurrence interval flood event and land levels used for development purposes. The freeboard accounts for variation in modelling assumptions and impacts not accounted in the analysis such as wave action. Accordingly flood levels from this study will need to be used with freeboard allowances contained in the applicable MBRC Town Planning Scheme; and
- This analysis has been carried out using industry standard software and methods considered industry best practice at the time of the study.

3 METHODOLOGY

3.1 Data Review

3.1.1 Infrastructure Data Assessment

WorleyParsons completed a report entitled "*Infrastructure Data Assessment Report Package 5*" in October 2010. The purpose of the report was to review, identify and prioritise any additional floodplain infrastructures as well as the existing data for the Stanley River (STA), Upper Mary River (MAR), Neurum Creek (NEU) and Byron Creek (BYR) minor basins that is necessary to complete the detailed modelling for the Stage 2 RFD project. The infrastructures assessed within the minor basins included:

- Structure junctions
- Hydraulic structures
- Basins and dams
- Buildings in the floodplains

A copy of the "*Infrastructure Data Assessment Report Package 5*" is included in Appendix A.

3.1.2 Calibration and Validation

WorleyParsons completed a report entitled "*Calibration and Validation Feasibility Report Package 5*" in November 2010. The purpose of the report was to assess the feasibility of carrying out historical event model calibration and validation for the Stanley River (STA), Upper Mary River (MAR), Neurum Creek (NEU) and Byron Creek (BYR) minor basins as part of the Stage 2 RFD project. The report identified two (2) river gauges within the Stanley River minor basin with potential historical data for the purpose of model calibration/ validation. There is however no stream gauge data available within the vicinity study area of Neurum Creek, Upper Mary River or Byron Creek.

A copy of the "*Calibration and Validation Feasibility Report Package 5*" is included in Appendix C.

Due to insufficient reliable historical flow data, MBRC has decided not to carry out model calibration/validation for NEU model. Selection of key modelling parameters for the NEU model is discussed further in Section 3.4.

3.1.3 Hydrography

WorleyParsons completed a report entitled "*Hydrography Review Report Package 5*" in November 2010. The purpose of the report was to review the supplied hydrography data against other data provided for the Stage 2 RFD project including aerial imagery and a 2.5m grid aerial LiDAR digital elevation model and identify issues in the supplied data as well as make recommendations to improve the suitability of the hydrography for use in the Stage 2 RFD project. Most of the recommendations in the report have been adopted by MBRC and the sub-catchment delineation for NEU minor basin was updated and re-issued.

A copy of the "*Hydrography Review Report Package 5*" is included in Appendix B of this report.

3.2 Hydrologic Model

The WBNM (Watershed Bounded Network Model) software was nominated by MBRC as the hydrologic software package to be used for the RFD to calculate inflow hydrographs for the hydraulic model described in Section 3.3 of this report.

WBNM is an event based hydrologic model that was developed at the University of Woolongong and is widely used throughout Australia. The model calculates flood flow hydrographs from storm rainfall hyetographs and can simulate the behaviour of hydraulic structures including weirs, culverts and diversion works. The model routes runoff from upstream sub-areas through the current sub-area and adds the routed flow to the excess rainfall that is routed separately through the sub-area. The model can be used for natural, partly urban and fully urbanized minor basin using different lag factors for pervious and impervious areas.

Detailed hydrologic model parameters, such as adopted losses, design gauge locations and Intensity Frequency Duration (IFD) data are described in the Regional Floodplain Database Design Rainfall - Burpengary Pilot Project Report (WorleyParsons, 2010b). Other model input data, such as landuse and minor basin delineation, was provided through other sub-projects outlined in Section 1.4 of this report. Table 3-1 below summarises the ultimate rainfall loss and model lag parameters adopted for the current NEU WBNM model.

Table 3-1 Rainfall Loss and Model Lag Parameters

Loss Parameters		Sub-area Lag Parameter
Initial	Continuing	
0mm	2.5mm/hour	1.6

3.3 Hydraulic Model

3.3.1 Model Selection

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

- Accurately represent overland flow paths, including flow diversion and breakouts (2D modelling);
- Model the waterway structures of the entire minor basin 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).

A brief description of TUFLOW is provided in the following sections.

3.3.2 Model Geometry

Neurum Creek discharges in a northerly direction into the lower reach of Stanley River at a location near the top of Lake Somerset. Delaney Creek is the major tributary of Neurum Creek. The total study area of NEU minor basin is approximately 132 km^2.

A TUFLOW model was developed for the Neurum Creek with the model resolution pre-defined by MBRC at 5m cell size across the entire 2D model domain with a horizontal grid orientation (i.e. no rotation). The horizontal grid orientation approach was selected as part of the development of the RFD to ensure consistency of model parameters across the entire RFD study area.

The model topography was derived from the DEM tool (WorleyParsons, 2010) including the DEM modifiers utilising the 2009 ALS data developed for the RFD project. During Stage 1 RFD studies, stream and road modifiers were used in the DEM tool to ‘carve out’ streams and define road embankments in the Z-pts layer. However, in the current RFD Stage 2 studies, the DEM tool has been updated so that roads are modified after the streams, avoiding the need to further modify the topography in TUFLOW.

The combination of the above features has allowed for the development of catchment-wide flood models, providing detailed flood information across the entire NEU minor basin. Figure 3-1 illustrates the NEU model layout.

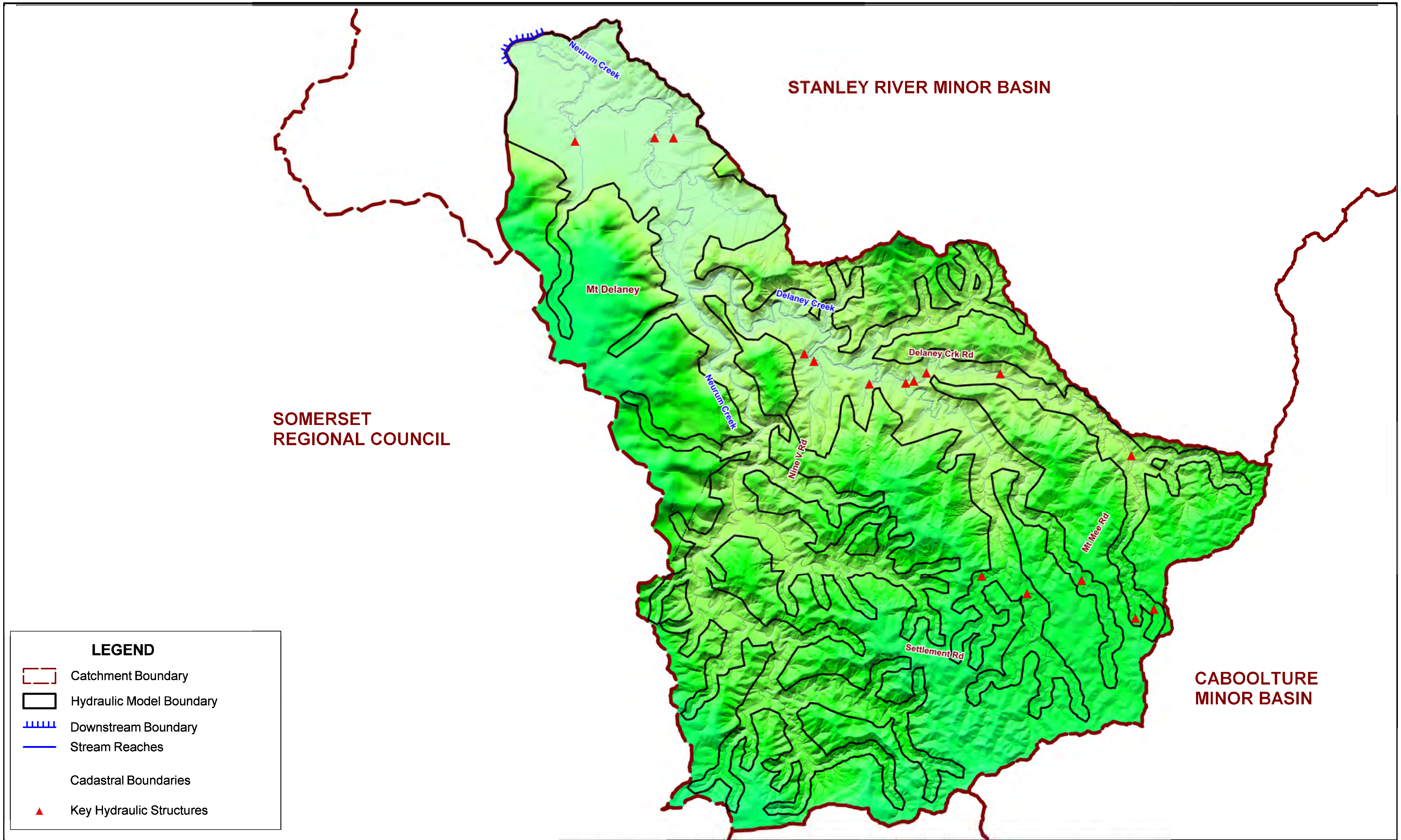

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FIGURE 3.1 - HYDRAULIC MODEL LAYOUT

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3.3.3 Model Structures

The entire NEU TUFLOW model has been established in the 2D domain. A total number of 10 culverts and 6 bridges have been included in the NEU TUFLOW model. Culvert crossings were typically modelled as 1D elements. Flow over culverts was modelled within the 2D domain. Bridges and footbridges were represented in the 2D domain. Structure details were provided by MBRC in the form of as constructed drawings and detail survey.

The adopted exit and entry loss coefficients, applied to the hydraulic structures, have been based on recommendations from Sub-project 2N (SKM, 2012c).

3.3.4 Landuse Mapping

Landuse mapping was used to define the spatially varying hydraulic roughness within the hydraulic model. In total, nine (9) different types of landuse based on recommendations from Sub-project 2N (SKM, 2012c) were mapped across Neurum Creek minor basin, together with associated Manning's 'n' values as presented in Table 3-2 and Figure 3-2.

Table 3-2 Hydraulic Model Roughness and Landuse Categorisation

Landuse Type	Manning's 'n' Roughness Coefficient
Dense vegetation	Depth varying Mannings 'n'
Medium dense vegetation	Depth varying Mannings 'n'
Low Grass/Grazing	Depth varying Mannings 'n'
Reeds	0.080
Crops	0.040
Roads/Footpaths	0.015
Buildings	1.000
Waterbodies	0.030
Urban block	0.300

Footpaths within open space areas were excluded from the model, as these features are typically finer than the model grid resolution. In some locations where there were sudden changes in roughness across one or a few cells (e.g. narrow roads crossing dense vegetation), roughness was locally modified to resolve associated modelling instabilities.

In highly developed blocks larger than 2000m², the urban block category was used (Manning's 'n' of 0.3). In addition, an individual buildings layer (building footprint) was used for areas outside the high residential development (Manning's 'n' of 1.0).

Based on the results from the calibration runs for other adjacent models, MBRC has adopted a depth varying Manning's ‘n’ approach to globally represent the hydraulic roughness for the dense, medium dense and low grass grazing vegetation landuse profiles.

The change in roughness factors with increasing depth of water represents the increased obstruction to flow caused by branches and foliage of trees, compared to individual tree trunks at lower depths and the reduction in vegetation retardance due to flattening of grasses with increasing depth of flow.

The depth varying Manning’s ‘n’ relationships for the above vegetation profiles are summarised in Table 3-3.

Table 3-3 Depth Varying Manning’s ‘n’

Depth y(m)	Manning’s ‘n’			Depth y(m)	Manning’s ‘n’
	Dense Vegetation	Medium Dense Vegetation			Low Grass Grazing
0	0.090	0.075		0	0.250
1.5	0.090	0.075		0.2	0.060
3.5	0.180	0.150		0.4	0.045
99.0	0.180	0.150		0.8	0.035
				2.0	0.025
				99.0	0.025

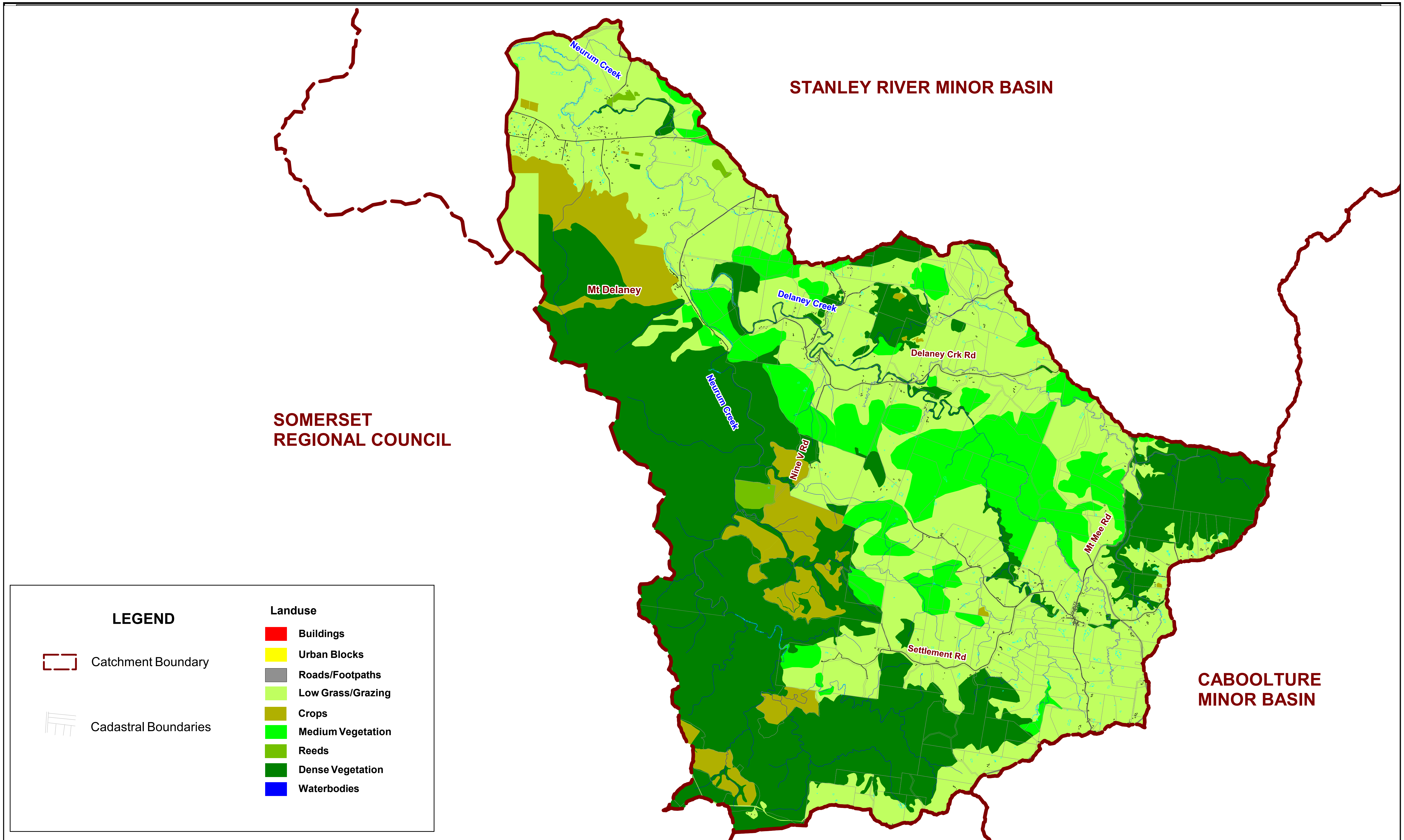

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FIGURE 3.2 - LANDUSE MAPPING - EXISTING CONDITIONS

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3.3.5 Model Boundaries

The results of the WBNM hydrologic model were used to generate inflow hydrographs for the hydraulic model for all design events, as discussed in Section 3.1. The inflows were applied to the 2D domain using a flow-time source boundary for each sub-catchment. This technique applies the inflow at the lowest grid cell in a sub-catchment initially and then subsequently to all wet cells in that sub-catchment.

The downstream boundary of NEU model is located at the floodplain of Stanley River near the top of Lake Somerset; therefore, the gate operations at the dam will control water levels in the lake and the outflow of the NEU model. In 2003, Sargent Consulting completed the Stanley River Flood Study for the former Caboolture Shire Council and has provided the peak dam levels for a range of design events (sourced from SEQWater) in the study report (Sargent Consulting, 2003).

Based on the Stanley River flood study report, WorleyParsons utilised the frequency relationship approach to derive a range of design event downstream water levels for the NEU model. The adopted peak downstream peak levels are presented in Table 3-4.

Table 3-4 NEU Downstream Water Levels

ARI Events	Design Peak Level (mAHD)
1	100.50
2	101.70
5	102.00
10	102.12
20	102.24
50	102.68
100	103.13
200	103.62
500	104.49
1000	105.19
2000	105.80
PMF	110.41

3.4 Model Calibration and Verification

No model calibration has been specifically carried out for the NEU hydraulic model. However, the key modelling parameters (such as landuse, floodplain roughness) adopted in the model have been validated through the model calibration and model verification processes undertaken for other adjacent minor basins modelled during Stage 2.

3.5 Design Flood Events

Design storm events are hypothetical events that are used to estimate design flood conditions. They are based on a probability of occurrence, frequently specified as an Average Recurrence Interval (ARI).

3.5.1 Critical Storm Duration Assessment

Critical storm durations were selected based on the hydraulic models results, rather than hydrologic model results. This means that the critical duration was selected based upon the maximum flood levels rather than flows. Separate assessments were undertaken for the minor events (1, 2, 5 and 10 year ARI event), moderate and major events (20, 50 and 100 year ARI), very large and extreme events (200, 500, 1000, 2000 year ARI and the probable maximum flood (PMF) event).

The following methodology was adopted to determine the critical storm durations for the NEU model:

- WBNM hydrologic modelling of a range of 10, 100 year ARI and PMF standard storm durations (from 30 minutes to 72 hours) to calculate inflow hydrographs for the TUFLOW hydraulic model.
- TUFLOW hydraulic modelling of 10, 100 year ARI and PMF to calculate peak flood levels for all the studied storm durations.
- Mapping of the peak flood level results for the 'maximum envelope' of all the 10, 100 year ARI and PMF standard storm durations.
- Selection of three critical durations for each ARI storm event based on the storm durations generating the highest flood levels across the most widespread and developed areas.
- Mapping of the peak flood level results for the 'maximum envelope' of the selected three storm durations for each storm event.
- Difference comparison between the mapped peak flood levels for the three selected critical durations and the results accounting for all storm durations for each of the storm event.
- The critical duration storms resulting in the least difference, compared with the mapping of the full envelope of durations, were then adopted throughout the studied storm events ranging from 1 year to PMF events.

A summary of the three selected critical storm durations for NEU model for all events assessed is outlined in Table 3-5. A comparison of the 10, 100 year ARI and PMF peak flood levels is illustrated in Figure 3-3 to Figure 3-5 respectively. The figures demonstrate that the three selected critical storm durations have dominated the 10, 100 year ARI and PMF peak flood levels across the study area.

Table 3-5 Critical Duration Selection

Assessment Event	Selected Critical Durations	Adopted Event
10 year ARI	2hr, 3hr and 24hr	1, 2, 5 and 10 year ARI
100 year ARI	2hr, 3hr and 24hr	20, 50 and 100 year ARI
PMF	1hr, 2hr and 3hr	200, 500, 1000, 2000 year ARI and PMF

3.5.2 Design Event Simulations

As discussed in the previous section, the NEU model was simulated for a range of Average Recurrence Intervals (ARI) and storm durations which has included:

- Minor events – 1, 2, 5 and 10 year ARI events;
- Moderate and major events – 20, 50 and 100 year ARI events; and
- Very large and extreme events – 200, 500, 1000, 2000 year ARI and PMF events.

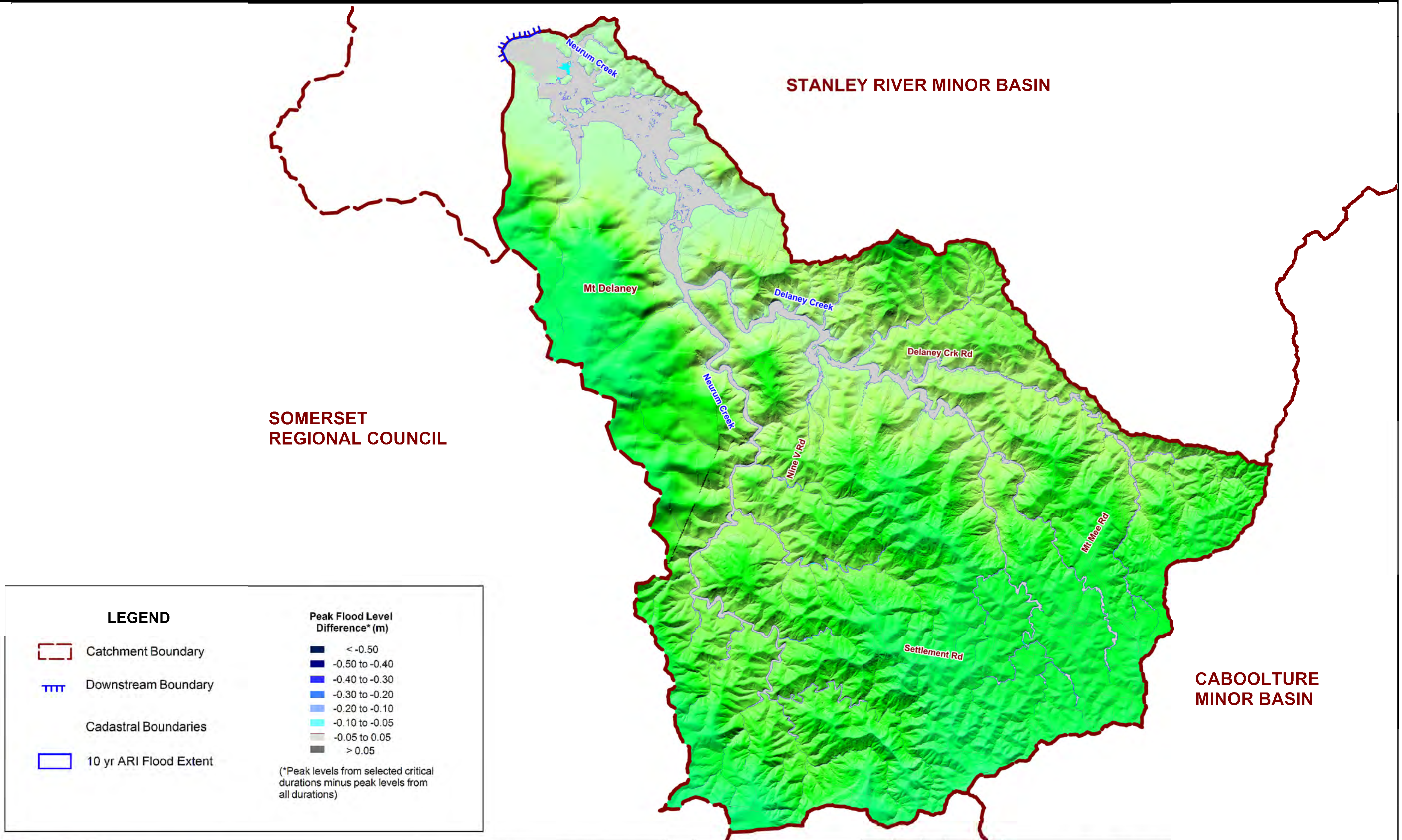

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FIGURE 3.3 - CRITICAL DURATION ASSESSMENT
PEAK FLOOD LEVEL DIFFERENCE - 10 YEAR ARI

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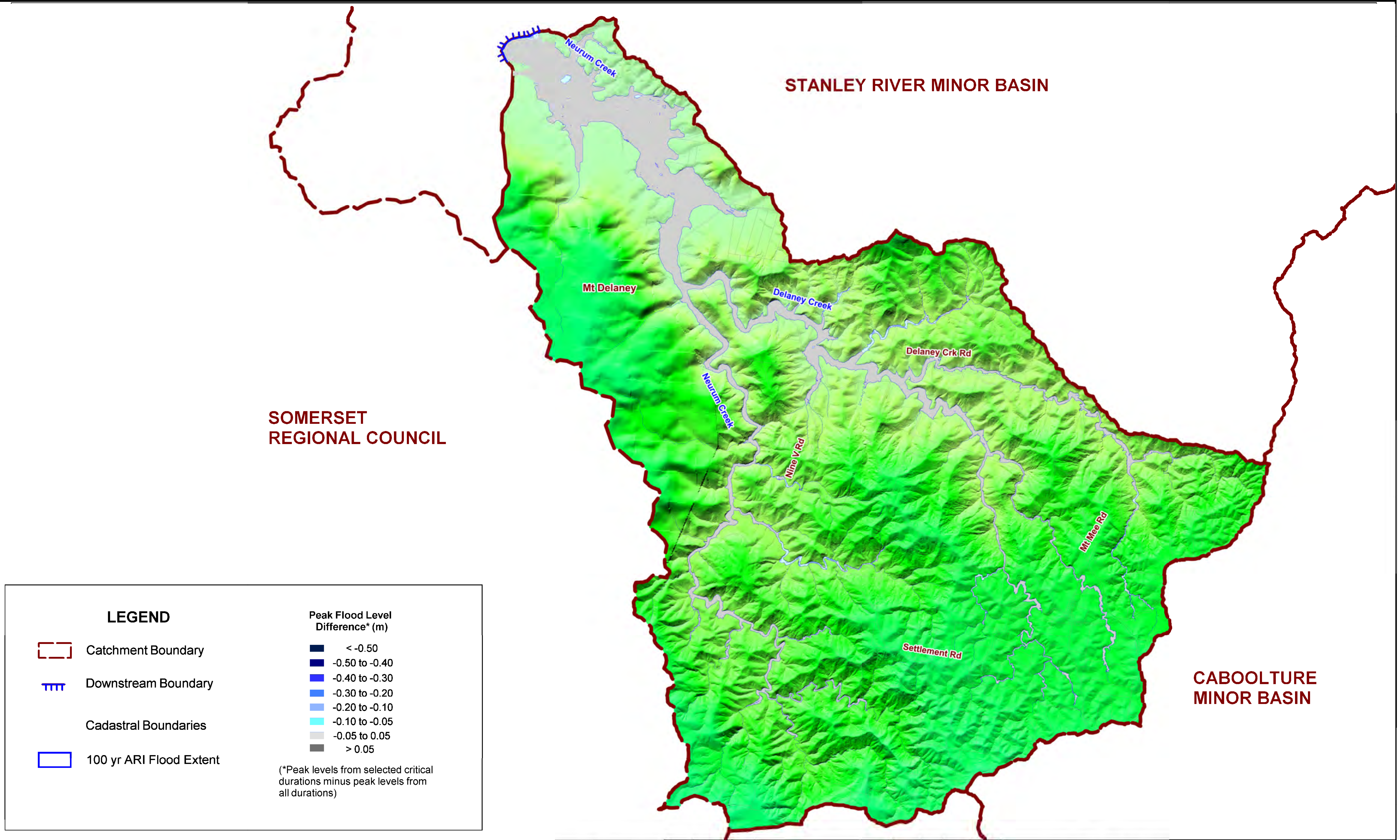

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FIGURE 3.4 - CRITICAL DURATION ASSESSMENT
PEAK FLOOD LEVEL DIFFERENCE - 100 YEAR ARI

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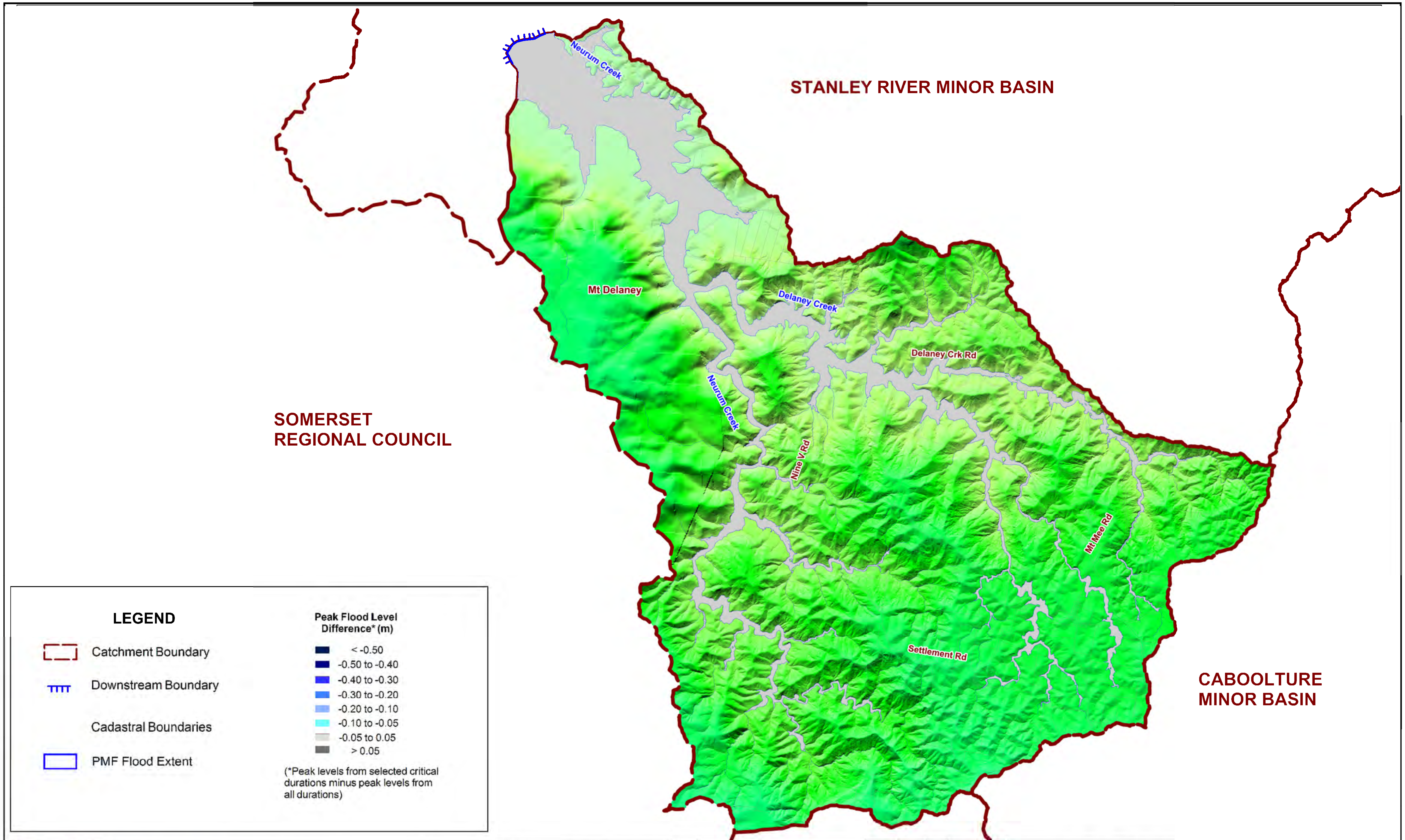

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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
NEURUM CREEK
FIGURE 3.5 - CRITICAL DURATION ASSESSMENT
PEAK FLOOD LEVEL DIFFERENCE - PMF

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3.6 Sensitivity Analysis

MBRC adopted the use of a single EDS which approximates the flood levels and behaviour of the 100 year ARI 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 15 minutes burst in a 270 minutes storm envelope duration provides the best representation across all minor basins within the MBRC LGA. Therefore, the 100 Year 15 minutes burst in a 270 minutes envelope EDS has been adopted for the NEU model.

The adopted EDS storm was utilised as a base case for the assessment of model sensitivity, climate change and future landuse scenarios as discussed in the following sections below.

3.6.1 Future Landuse Analysis

A future landuse scenario model run utilising the 100 year EDS event has been undertaken to assess the potential impact of increased vegetation in the Neurum Creek floodplains as part of the RFD Stage 2 project. This has been achieved by

- Changing medium dense vegetation to high dense vegetation; and
- Changing low grass/grazing to medium dense vegetation through the materials layer.

The results of this scenario model run were then compared to the 100 year EDS base case results to assess the potential flood impact to the NEU minor basin as a result of increased vegetation on the floodplains.

3.6.2 Hydraulic Roughness Analysis

To check the sensitivity of the adopted model roughness values, all Manning's 'n' values were uniformly increased by 20% and applied to the 100 year EDS model. Results of the increased Manning's "n" values run were then compared to the base case run results to check how sensitive the model is to the initial selection of the roughness values.

3.6.3 Structure Blockage Analysis

A structure blockage scenario in the 100 year EDS event was run to simulate the effects of waterway crossings (culverts) becoming blocked during a flood event. This is a reasonably common occurrence and may be the result of debris being washed into the waterways during a flood. Recent storm events have shown that the blockage is generally caused by accumulated debris, or larger items such as tree stems, wood planks, shopping trolleys or even cars. Blockages reduce the capacity for water to flow through stormwater infrastructure and force the water out of the channel, often increasing overland flooding.

The sub-project 2N report provided by SKM (SKM, 2012c) compared three potential debris risk categories to the culvert opening size, to determine culvert blockage factors.

Table **3-6** summarises the blockage factors as presented in of the SKM report (Table 8-3 SKM, 2012c).

Based on the SKM blockage factors, MBRC has adopted the moderate blockage category to assess the culvert blockage sensitivity scenario in the NEU model with the following blockage factors:

- 100% blockage for all culverts/pipes with culvert diameter/width less than 2.4m; and
- 15% blockage for culverts/pipes with culvert diameter/width larger than 2.4m.

Table 3-6 Blockage Categories and Factors (SKM 2012c)

Blockage Category/ Debris Potential	Culvert Blockage Condition	
	Full Blockage	Partial Blockage
High	If culvert < 6.0m diagonal	If culvert > 6.0m diagonal, apply 25%
Moderate	If culvert < 2.4m diagonal	If culvert > 2.4m diagonal, apply 15%
Low	If culvert < 1.2m diagonal	If culvert > 1.2m diagonal, apply 10%

3.6.4 Climate Change and Downstream Boundary Condition Analysis

As determined by MBRC, three (3) climate change scenario model runs have been undertaken to investigate the potential impact on flooding for the NEU minor basin as a result of climate change.

These climate change scenarios are:

- Increase in rainfall intensity -The rainfall intensity increase assessment used for this study is based on the Sub-project 2M report (SKM, 2012b). A 20% increase of rainfall to the 100 year EDS event was applied to the WBNM hydrologic model to calculate inflow hydrographs for the TUFLOW model. The TUFLOW model was then run with the increased inflow hydrographs to assess the impact of climate change as a result of increased rainfall;
- Increase of downstream boundary condition - To assess the potential impact of an increased downstream boundary, the peak flood level obtained from the PMF run was applied as the downstream boundary condition; and
- A combination of increased rainfall intensity and downstream boundary condition.

4 RESULTS AND OUTCOMES

4.1 Calibration and Verification

As discussed previously, no model calibration has been specifically carried out for the NEU model due to insufficient historical data available for the NEU minor basin. Calibration and validation undertaken for other minor basins provided the model parameters adopted for the NEU model.

4.2 Design Flood Behaviour

Design flood event modelling of minor basin runoff events was undertaken using the NEU TUFLOW model for the 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000 year ARI design events and the Probable Maximum Flood (PMF) event. For each design flood magnitude, the model was run for the three nominated storm durations (refer to Section 3.5.1).

The performance of the model was monitored throughout the simulation. Careful attention was paid to ensure that flows through the 1D elements in the model as well as flows over the floodplain in the 2D domain were stable. Overland flow hydrographs were checked at key locations and especially at the floodplain near the downstream boundary to ensure the simulation extended well beyond the peak throughout the study area. A modelling quality report of the NEU model has been included in Appendix D of this report.

General patterns of flood behaviour that can be observed from the NEU design run results include:

- Flooding in the upper reaches of the tributary streams is confined to a corridor generally less than 200m wide.
- Extensive inundation is predicted downstream of the confluence of Neurum and Delaney Creeks with floodwaters extending approximately 1.2km over the floodplain.
- Flooding in the lower reaches of the Neurum Creek is affected by Lake Somerset water levels and runoff from the Stanley River catchment into the Lake.
- Velocities of floodwaters are generally ranged from 2 to 5m/s within watercourse channels and less than 1m/s on the floodplain.

4.2.1 Model Results

The following output types were used in the model to produce modelling results:

- Flood Levels (H flag);
- Flood Depth (D flag);
- Flood Velocity (V flag);
- Flood Velocity x Depth (Z0 flag);
- Flood Hazard based on NSW Floodplain Development Manual (DIPNR, 2005) (Z1 flag);

- Stream Power (SP flag);
- Unit Flow (q flag); and
- Inundation times (Times flag).

The model results were used to prepare a set of design flood map database, including inundation, peak flow velocity, hazard and stream power. The flood conditions for these flood map database were derived using the envelope (maximum) of the three critical storm durations for all studied events. Typical flood maps presented in Appendix E are the 100 year ARI design event as the focus of this project is on digital data, rather than provision of hardcopy flood maps. A description of the digital data provided to MBRC for incorporation into their RFD is summarised in Section 4.2.2.

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 in digital format will be provided to MBRC at the completion of the study. The digital data includes all model files and result files for all the design events, sensitivity analysis, climate change assessment and future landuse scenarios.

4.3 Sensitivity Analysis

The 100 Year Embedded Design Storm (EDS) with a 15 minutes burst and a 270 minutes envelope storm duration was simulated to form the base case for model sensitivity runs as described previously. The sensitivity runs undertaken for the NEU minor basin have included future landuse, hydraulic roughness, structure blockage and climate change scenarios.

A plot for comparing flood levels of the 100 year EDS base case run against the 100 year ARI design storm is provided in Figure F1 of Appendix F. The plot demonstrates that differences in flood levels between the 100 year EDS and ARI design storm is generally within ±100mm across the study area.

4.3.1 Future Landuse Analysis

The predicted difference in peak flood levels for the future landuse (increase vegetation) scenario as described in Section 3.6.1 compared to the EDS Base Case are summarised as follows:

- Minimal change was observed along Neurum Creek and tributary streams located on the western side of the NEU minor basin, upstream of the Neurum and Delaney Creek confluence. This is because most of the land over the western side of the basin is already covered by high density vegetation.
- Flood levels in the middle reach of Delaney Creek and its side branches have been increased by 500-1000mm along the watercourses with a maximum increase of 1350mm at some local reach sections.
- Water levels at the downstream floodplain have increased by 100mm to 500mm.

The differences in peak flood levels between existing and the future landuse (increase vegetation) conditions are shown on Figure F10 in Appendix F.

4.3.2 Hydraulic Roughness Analysis

A hydraulic roughness sensitivity scenario has been simulated to assess an increase in roughness coefficients. Figure F2 in Appendix F illustrates the difference in peak flood levels between the sensitivity run and the Base Case utilising the 100 year EDS.

Model results indicate that an increase in Manning's 'n' roughness coefficients by 20% generally results in an increase of peak levels approximately by 150mm. Upper reach waterways over the NEU minor basin shows an increase of peak flood levels of up to 200mm. Flood level differences at the lower reach waterways are generally within the range of ±100mm.

4.3.3 Structure Blockage Analysis

A structure blockage analysis has been simulated utilising the 100 year EDS model as described in Section 3.6.3 to assess impact to the NEU minor basin as a result of blockage of culverts. The difference in peak flood levels for the structure blockage modelling compared to the EDS Base Case is generally within the range of ±20mm. This is due to all the culvert crossings within the study area already being overtopped during the flood event in the base case scenario. As such, blockage of the culverts will only have minimal impact on the flood levels across the NEU minor basin. Figures F3 in Appendix F illustrates the difference in peak flood levels between the Structure Blockage run and the Base Case utilising the 100 year EDS.

4.3.4 Climate Change and Downstream Boundary Condition Analysis

The predicted differences in peak flood levels for the three (3) climate change and downstream boundary condition analysis scenarios as described in Section 3.6.4 compared to the EDS Base Case are described as follows:

Increase of rainfall intensities by 20%

A global increase of the 100 year EDS event rainfall intensities by 20% was applied to the WBNM hydrologic model to calculate inflow hydrographs for the TUFLOW model. An increase of rainfall results in higher flood levels throughout the NEU minor basin. Figure F4 in Appendix F indicates that the difference in peak flood levels for the increased rainfall scenario compared to the EDS Base Case is generally an increase within the range of 200 to 700mm along the middle and upper reaches of the tributary streams. An increase of 200 to 300mm in flood levels is observed in the downstream floodplain. The smaller flood level increase over the downstream floodplain areas is due in part to the increased flow being attenuated by the floodplain storage.

Increase of downstream boundary condition

To assess the impact of an increased downstream boundary, the peak flood level obtained from the PMF run was applied to the downstream boundary condition of the NEU EDS model. The PMF downstream level is 110.41m compared to the 100yr ARI level of 103.13m, an increase of 7.28m. The increased downstream boundary condition has caused significant expansion of the flood extent over the lower Neurum Creek floodplain up to a distance of some 3km from the downstream boundary. Figure F5 of Appendix F illustrates the difference in peak flood levels between the EDS base case and the increase downstream boundary condition scenario. The increase in the flood levels range from 0 to 7275mm.

Combination of increase rainfall and downstream boundary condition

To assess the cumulative impact of the increased rainfall and downstream boundary scenarios, the inflow hydrographs with 20% increased rainfall and PMF downstream water level were applied to the NEU model. The modelling results showed that the downstream area of the NEU minor basin is mainly controlled by the downstream boundary condition and that the cumulative effect (increase rainfall and downstream boundary) on the NEU minor basin is considered minimal. The differences in peak flood levels between the EDS base case and the combined increase of rainfall and downstream boundary conditions are shown on Figure F6 in Appendix F.

4.4 Model Limitations

The topography of creeks in the NEU minor basin is defined using LiDAR data due to the absence of surveyed cross-sections or bathymetry. LiDAR data are unable to pick up ground levels below the water surface, and therefore the bed levels of creeks are not precisely 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 within bank (e.g. the 1 to 10 year ARI), may be overestimated. The extent of this over-estimation will vary according to local topographic factors.

Watercourses have also been represented in the 2D domain, for which the grid resolution is limited to 5m. 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 for small flood events.

5 CONCLUSIONS AND RECOMMENDATIONS

The hydrologic modelling works undertaken in this study have utilised the WBNM (Watershed Bounded Network Model) software to calculate flood flow hydrographs for a range of design storm events to be used as inflows to the hydraulic model developed for the NEU minor basin.

The hydraulic assessment under this project has included the development of a detailed 5m grid TUFLOW hydraulic model, a dynamically-linked 2D/1D hydrodynamic numerical model for the NEU minor basin. The TUFLOW model has been used to run the 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000 year ARI design events and the Probable Maximum Flood (PMF) event.

Separate critical storm duration assessments have been undertaken for the minor events (1, 2, 5 and 10 year ARI event), moderate and major events (20, 50 and 100 year ARI), very large and extreme events (200, 500, 1000, 2000 year ARI and PMF event) to determine three (3) critical storm durations for each design flood event for the purpose of predicting the peak flood behaviour of the NEU minor basin.

Based on the critical duration assessments, the NEU TUFLOW model has been utilised to run for the following three (3) nominated storm durations for each design flood event:

- Minor events (1, 2, 5 and 10 year ARI) - 2hr, 3hr and 24hr;
- Moderate and major events (20, 50 and 100 year ARI) - 2hr, 3hr and 24hr; and
- Very large and extreme events – 1hr, 2hr and 3hr.

The 15 minutes burst in a 270 minutes 100 year Embedded Design Storm (EDS) has been adopted and applied to the TUFLOW model. The EDS is useful for initial investigations into changes in model parameters and minor basin characteristics, as it reduces the number of model runs required. The adopted EDS storm was utilised as a base case for the comparison to model sensitivity, climate change and future landuse scenarios.

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 in digital format will be provided to MBRC at the completion of the study. The data includes all model files for all the design events, sensitivity analysis, climate change assessment and future landuse scenarios.

The flood assessment undertaken for the NEU minor basin as documented in this report has been successful in addressing the overall objectives of the study. It is recommended that this study report be accepted by MBRC and the associated model outputs be included in RFD for delivering seamless information about flood behaviour across the entire Moreton Bay Regional Council area.

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