Regional Floodplain Database:

Hydrologic and Hydraulic Modelling - Stanley River (STA)

Moreton Bay Regional Council

Emergency Management Queensland

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Regional Floodplain Database

Hydrologic and Hydraulic Modelling Report: Stanley River (STA)

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HYDROLOGIC AND HYDRAULIC MODELLING REPORT: STANLEY RIVER (STA)

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 Stanley River (STA) 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 Stanley River 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 STA 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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0	Issue for use	L Cheung	K Hegerty	M Shaw	10 Aug 2012		

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

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 Stanley River (STA) minor basin investigation.

1.1 Scope

The scope of this flood modelling investigation was to carry out detailed hydrologic and hydraulic modelling over the Stanley River minor basin. The results from the detailed modelling of Stanley River 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 Stanley River 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 Stanley River 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 STA minor basin has involved the following tasks:

- Refine the broadscale WBNM2010 hydrologic model established for STA minor basin in Stage 1 RFD project.
- Establish a detailed 1D/2D coupled TUFLOW model to investigate flood behaviour for the STA 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 STA 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

Sub-Project	Origin	Scope
2I - Floodplain Structures (Channels)	Aurecon (2010)	To identify channels within the minor basins
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-minor basin 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;
- 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.

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

Based on the recommendations from the feasibility study report, MBRC has decided to carry out model calibration to the January 2011 event and validation to the February 1999 event based on available data. Sections 3.4 and 4.1 provide a detailed description on the two calibration/validation modelling runs.

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 STA 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 STA 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

The Stanley River is located in the northeast of the Brisbane River Basin and has historically provided major contributions to floods in the Brisbane River System. Somerset Dam was constructed across the Stanley River just upstream of its confluence with the Brisbane River as a major water supply and flood mitigation storage for Southeast Queensland some 60 years ago.

The STA minor basin extends over the upper portion of the Stanley River catchment, upstream of Lake Somerset and includes a number of tributary streams. The town of Woodford is the major urban centre within the STA minor basin and is located just upstream of the Monkeybong Creek junction.

Neurum Creek and Delaney Creek, which are major tributaries of the Upper Stanley River, have been investigated in the NEU minor basin study. The total study area of STA minor basin is approximately 479 km^2.

Due to the large catchment size of the STA minor basin, the TUFLOW model has been constructed in two (2) chosen model cell sizes with a horizontal grid orientation (zero 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 two chosen model cell sizes are detailed below:

- 5m cell to carry out all the selected critical durations runs for the 1 year to 100 year ARI design events to ensure highest resolution design event flood results can be achieved for the STA minor catchment. However, the 5m cell model requires extensive model run time to complete one flood event run.
- 10m cell to carry out all the other event model runs including extreme design events, calibration/verification and model sensitivity analysis runs. Other than the cell size, all model input parameters are identical to the 5m cell model. The chosen 10m cell size is considered to be sufficiently detailed to determine flood behaviour for the extreme events, calibration and sensitivity analysis runs without extensive model run times.

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 STA minor basin. Figure 3-1 illustrates the STA model layout.

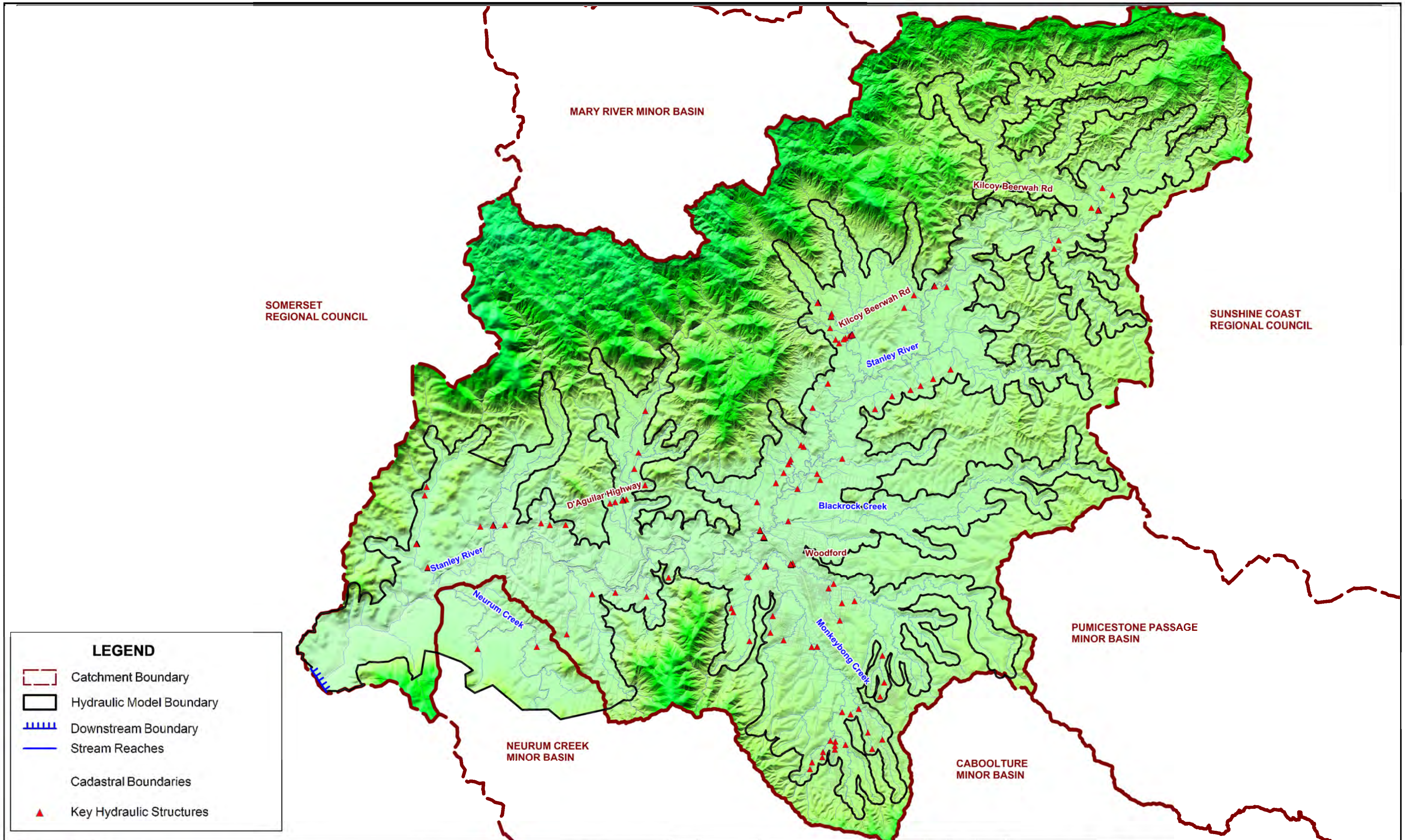

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FIGURE 3.1 - HYDRAULIC MODEL LAYOUT

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3.3.3 Model Structures

The entire STA TUFLOW model has been established in the 2D domain. A total number of some 98 culverts and 11 bridges have been included in the STA 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 Stanley River 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 model calibration and validation runs, 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’	
	Dense Vegetation	Medium Dense Vegetation
0	0.090	0.075
1.5	0.090	0.075
3.5	0.180	0.150
99.0	0.180	0.150

Depth y(m)	Manning’s ‘n’
	Low Grass Grazing
0	0.250
0.2	0.060
0.4	0.045
0.8	0.035
2.0	0.025
99.0	0.025

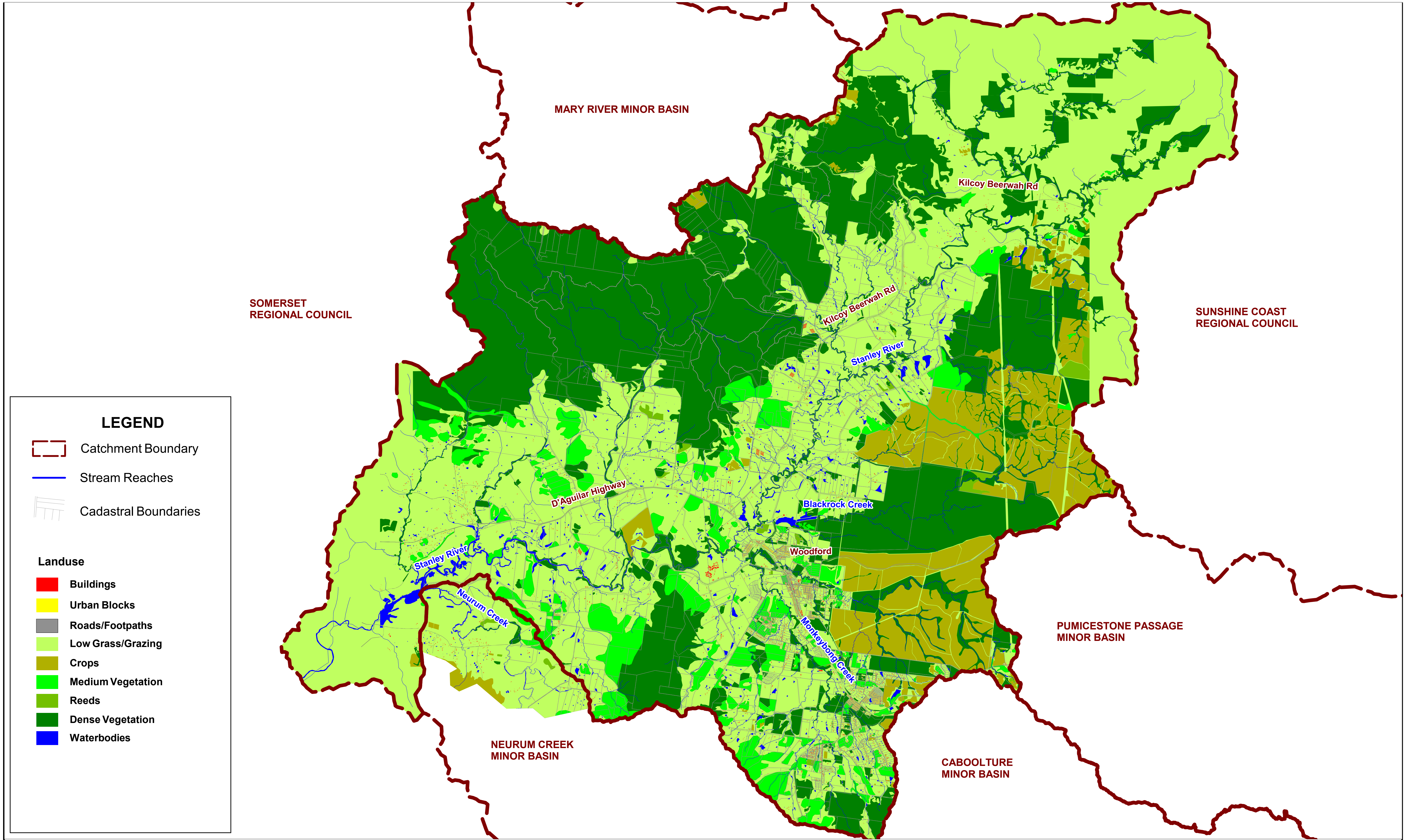

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FIGURE 3.2 - LANDUSE MAPPING - EXISTING CONDITIONS

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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 STA model is located 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 STA 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 STA model. The adopted peak downstream peak levels are presented in Table 3-4.

Table 3-4 STA 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 Validation

The STA TUFLOW model has been calibrated and validated against the following two historical events:

- January 2011 (calibration event); and
- February 1999 (validation event).

These events were chosen by MBRC due to the availability of rainfall, river stream gauge data and the availability of flood marks. Calibration and validation outcomes are provided and discussed in the Stanley River (STA) Model Calibration Report included in Appendix C of this report.

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 Stanley River 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 STA 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.

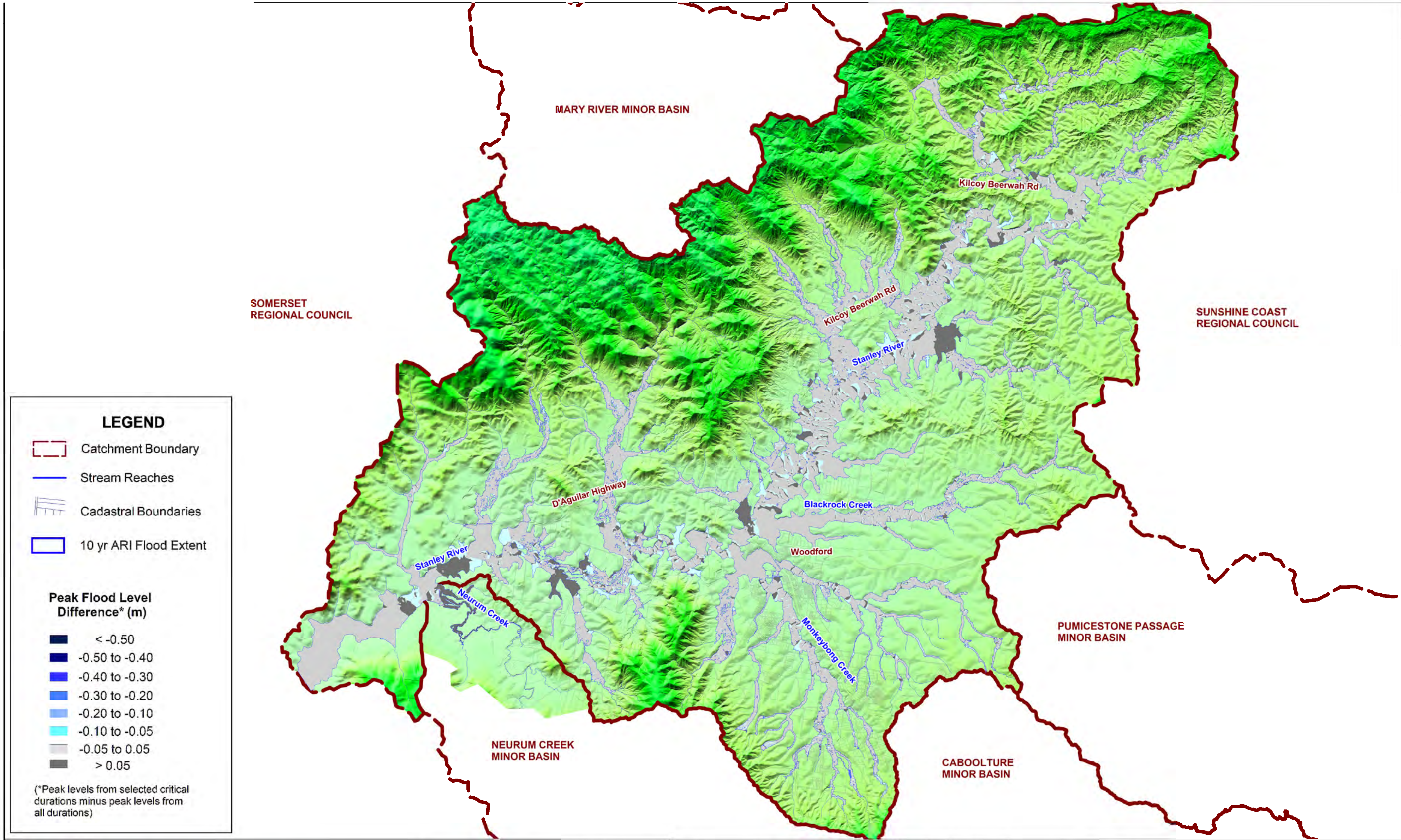
Table 3-5 Critical Duration Selection

Assessment Event	Selected Critical Durations	Adopted Event
10 year ARI	2hr, 12hr and 24hr	1, 2, 5 and 10 year ARI
100 year ARI	2hr, 12hr and 24hr	20, 50 and 100 year ARI
PMF	2hr, 6hr and 12hr	200, 500, 1000, 2000 year ARI and PMF

3.5.2 Design Event Simulations

As discussed in the previous section, the STA 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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STANLEY RIVER
FIGURE 3.3 - CRITICAL DURATION ASSESSMENT
PEAK FLOOD LEVEL DIFFERENCE - 10 YEAR ARI

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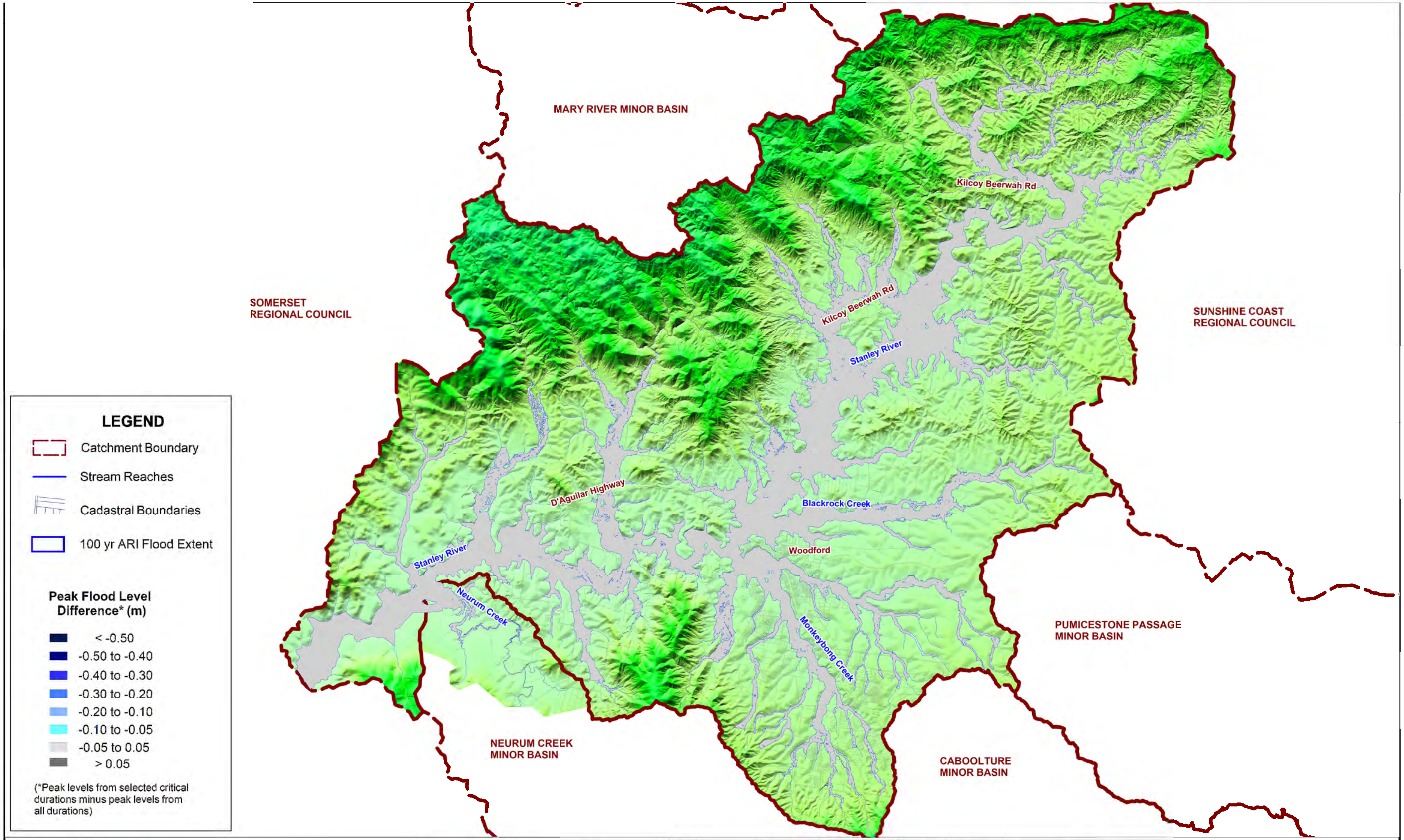

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FIGURE 3.4 - CRITICAL DURATION ASSESSMENT
PEAK FLOOD LEVEL DIFFERENCE - 100 YEAR ARI

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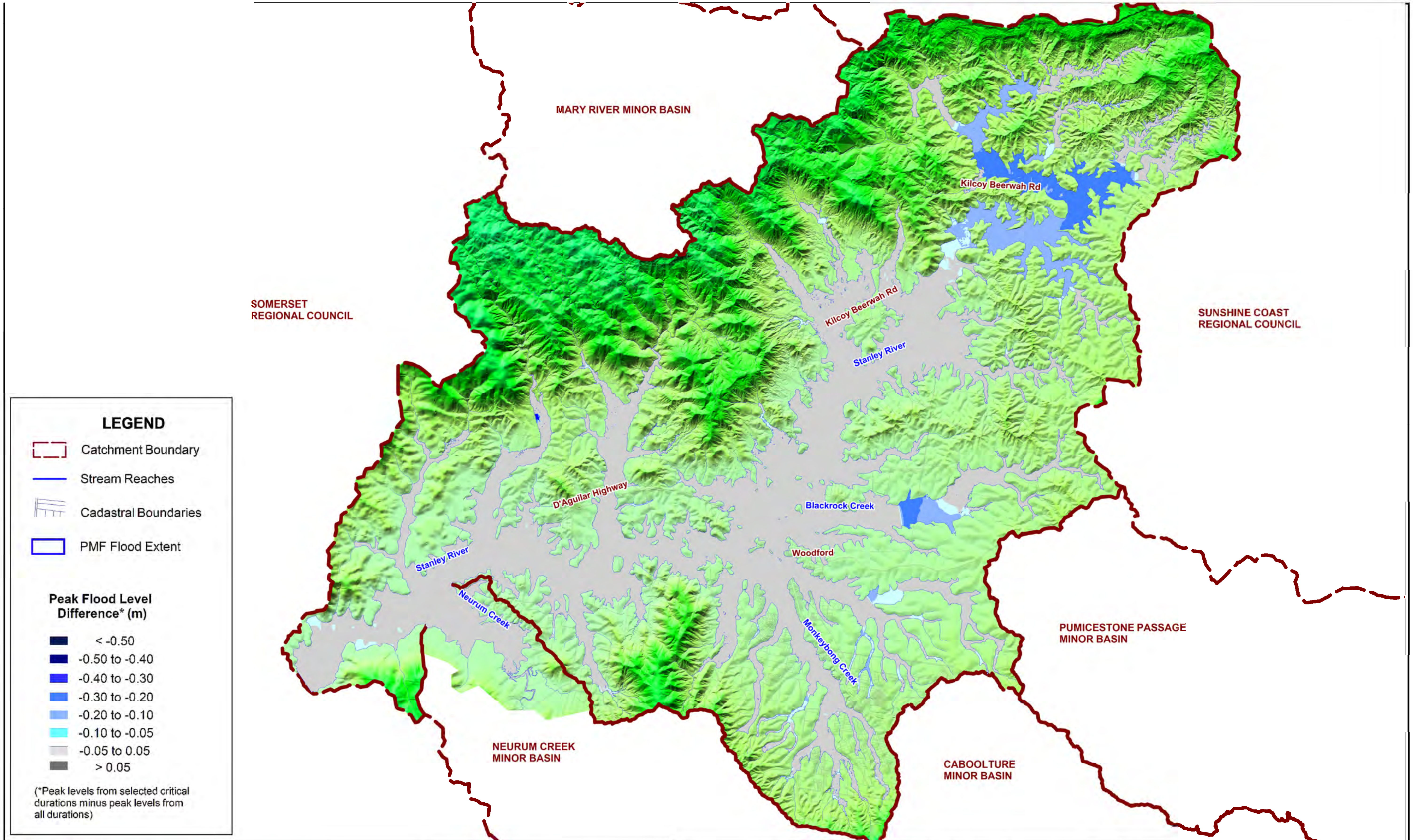

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Rev	Date	Revision Description	ORIG	CHK	ENG	QA	APPD
0	30/07/2012	Issue for use	LC	KH	LC		

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Moreton Bay Regional Council

MORETON BAY REGIONAL COUNCIL

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

Project No: 301001-01156	Figure:301001-01156-EN-DAL-0087	Rev: 0

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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 STA 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

Three (3) future landuse scenario model runs utilising the 100 year EDS event have been undertaken to assess the potential impact of flooding as a result of future development in the Stanley River floodplains. The three future landuse scenarios are:

- Assessment of the potential impact of increased vegetation in the Stanley River floodplains by
    - Changing medium dense vegetation to high dense vegetation; and
    - Changing low grass/grazing to medium dense vegetation through the materials layer.
- Assessment of the potential impact of increased residential development in the Stanley River floodplains by raising the impervious percentage in the WBNM hydrologic model at future residential development areas determined by MBRC to calculate inflow hydrographs for the TUFLOW model. The TUFLOW model was then run with the increased inflow hydrographs to assess the impact of future landuse as a result of increased residential development.
- A combination of increased vegetation and residential development in the Stanley River floodplains.

The results of the above scenario model runs were then compared to the 100 year EDS base case results to assess the potential flood impact to the STA minor basin as a result of future development 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 STA 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 STA 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 reports (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 increase 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 Validation

4.1.1 Overview

A model calibration and validation to two (2) historical flood events has been undertaken for the Stanley River (STA) minor basin. The calibration and validation outcomes are provided and discussed in the Stanley River (STA) Model Calibration Report included in Appendix C of this report.

Recorded rainfall data has been obtained from 11 gauging stations operated by MBRC or Bureau of Meteorology (BOM) for the period between 6th – 12th January 2011 and from 6 gauging stations for the period between 7th – 10th February 1999 for the purposes of model calibration and validation respectively.

Calibration and validation of the TUFLOW model was based on recorded flood level data collected from the January 2011 and February 1999 historical events. Surveyed levels were provided by MBRC for 37 flood marks for the January 2011 calibration event and for 34 flood marks for the February 1999 validation event. In addition, stage hydrographs were obtained from the Peachester ALERT flood warning station in the upper reach of the Stanley River for the January 2011 and February 1999 events and Woodford ALERT flood warning stations in the middle reach for the January 2011 event.

As stated in Section 3.3.3 above, the entry and exit loss coefficients at hydraulic structures adopted for the TUFLOW calibration/validation models have been based on recommendations from Sub-project 2N (SKM, 2012c). Initial runs for the February 1999 and January 2011 events were undertaken using the parameters for the Burpengary Pilot Project. Following a calibration and validation exercise for this and the adjacent minor basins, MBRC selected the final hydraulic roughness parameters as stated in Section 3.3.4. Therefore, the calibration and validation of the TUFLOW model was undertaken primarily to validate the adopted model parameters, as no refinement of parameters was required by Council. The results using the final adopted parameters are discussed below.

4.1.2 January 2011 Results

The modelled peak flood levels were compared to the recorded flood levels and the stage hydrographs obtained from the Peachester and Woodford ALERT flood warning stations.

The modelled peak flood levels were generally under-estimated with the median difference being -374mm and the range extending from -1,326mm to 1504mm. The differences distributions of the flood levels show that approximately 30% of modelled levels are within ±200mm and 40% of modelled levels are within ±300mm for the January 2011 event. The spatial results of the calibration run are presented on Figure 3 of the Model Calibration Report included in Appendix C of this report.

Comparisons of modelled and recorded stage hydrographs for the January 2011 event are presented on Figures 5 and 6 of the Model Calibration Report. The hydrograph plots show good agreement with timing at Peachester gauge, with the modelled at Woodford gauge being marginally early.

4.1.3 February 1999 Results

The modelled peak flood levels were compared to the recorded flood levels and stage hydrograph obtained from the Peachester gauge.

The modelled peak flood levels were generally under-estimated with the median difference being -207mm and the range extending from -1,207mm to 454mm. The differences distributions of the flood levels show that approximately 30% of modelled levels are within ±200mm and 40% of modelled levels are within ±300mm for the February 1999 event. The spatial results of the calibration run are presented on Figure 9 of the Model Calibration Report included in Appendix C of this report.

The stage hydrograph plots (Figure 10 of the Model Calibration Report) show that the modelled peak level is almost a meter lower than the Peachester gauge recorded level and the duration of modelled peak is about 12 hours longer than the recorded peak. The discrepancies may be due to the quality of the recorded data. The recorded hydrograph shows some discontinuity during the peak flood period.

4.1.4 Discussions and Conclusions

The January 2011 event used for model calibration was classified as a major event, based on BoM's classification system. The February 1999 event utilised for model validation was also classified as a major flood event at BoM's Woodford Flood ALERT flood gauge; for more details refer to the WorleyParsons (November 2010) *Calibration and Validation Feasibility Report Package 5*. These two events provide a good range of magnitude and in particular the January 2011 event occurred relatively recently, thus limiting the changes in the catchment of the landuse, additional waterway structures or change in topography.

The model calibration and validation model runs showed reasonable results, considering the two major factors of timing and peak flood levels; however it also highlighted that the peak flood levels in the middle reach were underestimated for both events. The anomalies are likely due to difference in the source of the levels (usage of the LiDAR versus ground survey undertaken to collect flood marks) and interpretation of flood marks/peak flood levels may have varied amongst the survey teams.

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

4.2 Design Flood Behaviour

Design flood event modelling of minor basin runoff events was undertaken using the STA 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 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 on the Stanley River floodplains to ensure the simulation extended well beyond the peak throughout the study area. A modelling quality report of the STA model has been included in Appendix D of this report.

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

- Flooding in the upper reaches of the tributary streams is generally confined to a corridor generally less than 500m wide.
- Extensive inundation is predicted upstream of the Monkeybong Creek junction with floodwaters extending approximately 1km over the floodplain.
- Flooding in the lower reaches of the Stanley River is affected by Lake Somerset water levels and runoff from the remainder of the Stanley River catchment into the Lake.
- Velocities of floodwaters are generally less than 2.5m/s within watercourse channels and less than 0.5m/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 STA 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 the predicted 100 year EDS flood levels are generally lowered than the 100 year ARI design storms. The EDS flood levels at the upper reaches of the tributaries are generally 100 to 200mm lower while the area over the floodplain around the Monkeybong Creek junction, the differences in flood levels are at the range of 500 to 1500mm. This is due to EDS is a 15minute burst in a 270 minute duration storm whereas the majority of the floodplains of Stanley River catchment are dominated by the 24 hour critical storm. Therefore, the flood volume of the EDS is much lesser than the ARI design storms resulting a lower flood level over the floodplains. It is recommended that future sensitivity analysis undertaken during model upgrades use the selected critical duration events rather than the EDS event in order to eliminate the under prediction of flooding for the STA minor basin

4.3.1 Future Landuse Analysis

The predicted difference in peak flood levels for the three (3) future landuse scenarios as described in Section 3.6.1 compared to the EDS Base Case are described as follows:

Increase of vegetation scenario

A general increase in flood levels by 100–500mm along the watercourses on the tributary streams with a maximum increase of some 700mm upstream of the Monkeybong Creek junction is observed due to significant change of vegetation profiles over these areas. Water levels have also increased in the range of 200–800mm in the lower Stanley River floodplain. However, the model has predicted a decrease in flood levels along a section of the water course immediately downstream of the Monkeybong Creek junction by 300 to 500mm due to the retardation of flood flow by the increased vegetation upstream. Figure F10 in Appendix F shows the difference in peak flood levels between the Base Case and the increase vegetation scenario.

Increase of residential development scenario

The proposed residential developments are located at Monkeybong Creek tributary. The model has predicted minimal impact on flood level as a result of increased residential development on the tributary catchment. This is due to most of the increased flow being attenuated during routing through the river channels. Figure F11 of Appendix F illustrates the difference in peak flood levels between the Base Case and the increase residential development scenario.

Combination of Increase Vegetation and Residential Development

The modelling results showed that the flood profile for the future landuse conditions is mainly affected by increase of vegetation over the STA minor basin. Cumulative impact due to increase of residential developments and increase of vegetation over the catchment is considered negligible in this future landuse scenario run. The difference in peak flood levels between the Base Case and a combination of increase vegetation and residential development conditions is shown on Figure F12 in Appendix F of this report.

4.3.2 Hydraulic Roughness Analysis

A hydraulic roughness sensitivity scenario has been simulated to assess an increase in roughness coefficients. Model results indicate that an increase in Manning's 'n' roughness coefficients by 20% generally results in a difference in peak levels of ±100mm. The difference in peak flood levels between the sensitivity run and the Base Case utilising the 100 year EDS is illustrated on Figures F2 in Appendix F.

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 STA minor basin as a result of blockage of culverts. The flood impact on the major waterways and floodplains of STA minor basin as a result of structure blockage is generally considered minimal. This is due to most of the culvert crossings already being overtopped during the flood event in the base case scenario. However, three culverts located along Kilcoy Beerwah Road with 100% culvert blockage have caused some local flood impacts. An increase in flood levels by approximately 700mm on the upstream side and a reduction in flood levels by 200mm on the downstream side of the culverts were observed. 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 STA minor basin. Figure F4 in Appendix F indicates 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 500mm along the upper reaches of the tributary streams across the STA minor basin. An increase of some 800mm flood levels is observed over the floodplain at the vicinity of the Monkeybong Creek junction. A 100 to 300mm increase in flood levels is also observed on the lower floodplains at the vicinity of the Neurum Creek junction.

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 STA EDS model. The PMF downstream level is 110.41m compared to the 100yr ARI level of 103.13m, an increase of 7.28m at the downstream boundary. The increased downstream boundary condition has caused significant expansion of the flood extent over the lower Stanley River floodplain up to a distance of some 15km from the downstream boundary. Figure F5 of Appendix F illustrates the difference in peak flood levels between the EDS Base Case and the increased downstream boundary condition scenario.

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 of rainfall and PMF downstream water levels were applied to the STA model. The modelling results showed that the downstream area of the STA minor basin is mainly controlled by the downstream boundary conditions. The cumulative effect of increased rainfall and downstream boundary is observed on a section of the Stanley River some 14km upstream from the downstream boundary. The cumulative effect of increased rainfall and raised downstream boundary water level was predicted to be an increase in peak flood levels up to a maximum of 500mm over and above the changes predicted for the individual change scenarios. The differences in peak flood levels between EDS Base Case and the combined increase of rainfall and downstream flood level conditions are shown on Figure F6 in Appendix F.

4.4 Model Limitations

The topography of creeks in the STA 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 up to major design event runs and 10m for the very large and extreme event runs. 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 STA 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 STA minor basin to run all the selected critical durations for the 1, 2, 5, 10, 20, 50 and 100 ARI design events to achieve the highest resolution design event flood results for the Stanley River minor basin.

A detailed 10m grid TUFLOW hydraulic model has also been developed for the STA minor basin to run the very large and extreme flood events including the 200, 500, 1000, 2000 year ARI and the PMF events as well as the calibration/validation and model sensitivity analysis runs. The chosen 10m cell size is considered to be sufficiently detailed to determine flood behaviour for the extreme large events, calibration/validation and sensitivity analysis runs without extensive model run times.

A model calibration and validation to two (2) historical flood events has been undertaken for the STA model. The January 2011 event was selected for model calibration due to the flood event being the largest flood on record within the Stanley River catchment. The February 1999 event was chosen for model validation for consistency with other catchments included in the RFD.

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 the probable maximum flood (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 STA minor basin.

Based on the critical duration assessments, the STA 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, 12hr and 24hr;
- Moderate and major events (20, 50 and 100 year ARI) - 2hr, 12hr and 24hr; and
- Very large and extreme events – 2hr, 6hr and 12hr.

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 STA 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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APPENDIX A: INFRASTRUCTURE DATA ASSESSMENT REPORT

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MORETON BAY REGIONAL COUNCIL

Infrastructure Data Assessment Report

Package 5

301001-01156 – EN-REP-0002

14 October 2010

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MORETON BAY REGIONAL COUNCIL
INFRASTRUCTURE DATA ASSESSMENT REPORT
PACKAGE 5

Disclaimer

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PROJECT 301001-01156 - INFRASTRUCTURE DATA ASSESSMENT REPORT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for Internal Review	R.Stewart	K.Hegerty		12-Oct-10	N/A	
0	For Issue	R.Stewart	K.Hegerty	E.Reid	14-Oct-10		

CONTENTS

1. INTRODUCTION

WorleyParsons Services Pty Ltd has been engaged by Moreton Bay Regional Council (MBRC) to carry out detailed surface water modelling over four of the regional catchments in their Local Government Area (LGA). The four catchments are Stanley River (STA), Neurum Creek (NEU), Mary River (MAR) and Byron Creek (BYR). These make up 'Package 5' of MBRC's Regional Floodplain Database Project (RFD Project) and are referred to as 'minor basins' in the GIS data provided by MBRC.

At the commencement of this project MBRC handed over an extensive data set including established 'broad scale' models and results. The purpose of this report is to identify and prioritise any additional floodplain infrastructure data which is necessary to complete the detailed modelling associated with the current project.

Due to the expansive catchment study areas of the project, it is difficult to convey the necessary level of data detail on Figures. For this reason an electronic copy of the GIS data associated with the findings of this report has been provided. The following electronic GIS data layers have been provided with this report:

1. "Existing Structure Junctions" (provided by MBRC). A data capture priority rating has been assigned to each of these structures;
2. "Identified Hydraulic Structures". This includes all additional structures identified by WorleyParsons including an associated data capture priority rating;
3. "Identified Basins/Dams". This includes all detention basins and dams significant enough to warrant incorporating into the modelling;
4. "Additional Buildings Identified in Floodplain". Includes buildings in the PMF flood extent that are not already included in MBRC's '"buildings" GIS layer.
5. "Miscellaneous Comments". Includes general comments relating data capture and modelling.

Figures provided with this report are for overview purposes only.

A fee proposal for WorleyParsons to carry out the data capture tasks identified in this report will be provided separately to MBRC for consideration.

2. AVAILABLE DATA AND GAP ANALYSIS

Floodplain Infrastructure Data provided by MBRC has been reviewed. Details of the available data and a gap analysis are provided below for each class of infrastructure data.

2.1 Bridges

Bridge design drawings have been supplied by MBRC for 11 locations within the Package 5 study area. These will be useful for defining geometry of the bridge however it is noted that generally these drawings do not have elevation data on AHD.

In addition to these bridges numerous road crossings have also been identified within the proposed hydraulic modelling area using aerial imagery, digital elevation modes (DEMs), and the supplied hydrography. Identifying road crossings in this manner makes it difficult to distinguish between culverts and bridges. Consequently, when reviewing the catchment data to identify additional waterway crossings we have not distinguished between bridges and culverts.

Each waterway crossing has been assigned a priority rating of A, B or C. This is discussed further in Section 3.1.

No bridge data is currently available in a TUFLOW compatible format.

2.2 Culverts

No culvert details have been provided for any of the Package 5 catchments.

Potential culvert crossings within the proposed hydraulic modelling area have been identified in the same manner as for bridge crossings, as discussed in the previous section. The location of these structures is shown generally on the figure provided in Appendix 1 and they are also included in the electronic GIS data provided with this report.

It is also noted that the location of some culverts may only become apparent with a field inspection. This is likely to be the case for high level floodplain crossings which do not tie in directly with a defined waterway.

2.3 Trunk Underground Drainage

A review of the supplied aerial imagery over the proposed hydraulic modelling area has found no evidence of underground trunk drainage. This is to be expected in these rural package 5 catchments.

2.4 Detention Basins / Farm Dams

No regional scale detention basins have been identified in any of the package 5 basins. There are numerous farm dams that are large enough to warrant incorporation into the modelling. . The location of these dams are shown generally on the Appendix figures and they are also included in the electronic GIS data provided with this report.

2.5 Terrain

Bathymetry

For the purpose of this report bathymetry is defined as ground elevation level data in areas beneath standing water.

No bathymetry data has been provided for any of the package 5 catchments however some localised sources of bathymetric data have been identified. These are discussed under the respective catchment headings below.

Topography

The topographic data sources which have been provided for use in this study include:

1. 2009 Aerial LiDAR survey. This has been provided as raw xyz data points and also as a 2.5m grid digital elevation model (DEM)
2. A 25m grid DEM has also been supplied by MBRC. It is understood that this is based on the 25m grid that is available through DERM.

The LiDAR survey has been filtered for ground elevation points and is considered to be of high quality and suitable for use in this study. Unfortunately the LiDAR does not provide complete coverage over each of the package 5 catchments. The LiDAR coverage area over each minor basin is shown in the respective catchment heading below.

Modelling outside of the LiDAR coverage areas is expected to be based on the 25m DEM. The accuracy of hydraulic modelling based on the 25m DEM is likely to be subject to errors resulting from inaccuracies in elevations in the DEM. The two grids have been compared and significant elevation differences have been found to be common. A typical floodplain section extracted from each of the grids is shown in the Figure below.

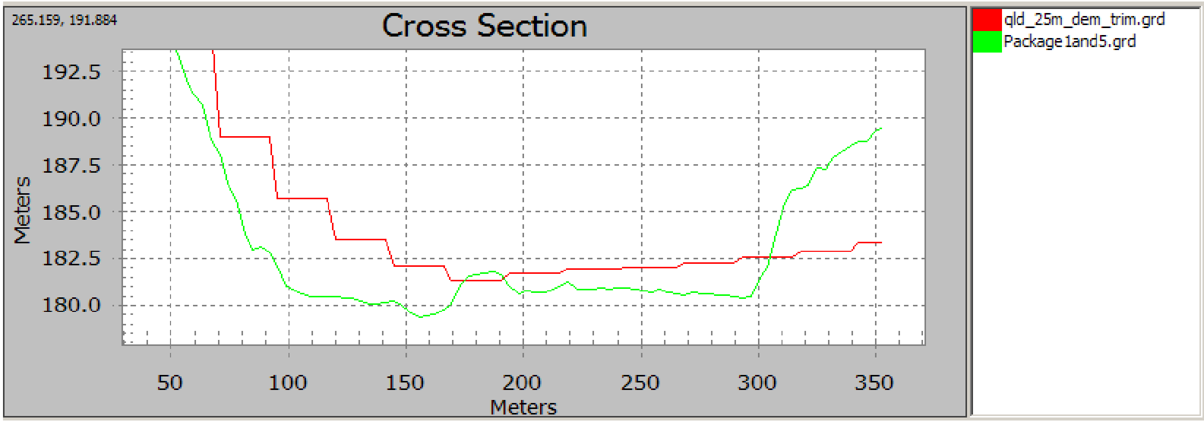


Figure 2.1 – Typical Floodplain Section: 2.5m DEM (Green) vs 25m DEM (Red)

2.5.1 Byron Creek

The coverage of the aerial LiDAR survey over the Byron Creek catchment is shown by the extent of the DEM in the figure below. No LiDAR is available in the south-west corner of the BYR catchment. The accuracy of modelling beyond the LiDAR extents will be significantly limited by the lack of good quality terrain data in this area.

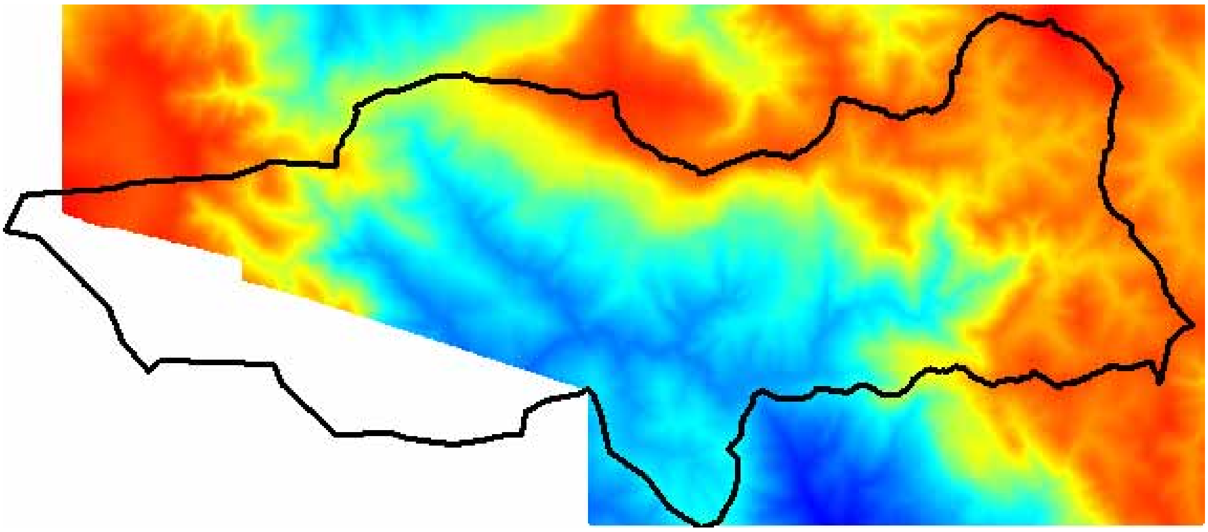


Figure 2.2 – Byron Creek 'Minor Basin' Overlaying LiDAR DEM.

2.5.2 Mary River

The LiDAR aerial survey covers the full extent of the Mary River 'Minor Basin'. It is noted however that an anomaly has been discovered in the supplied 2.5m DEM which appears to have been caused by a tile of data being excluded during the DEM creation. The anomaly, which is illustrated below, is located near MGAz56 coordinate 478,670, 7,035,579.

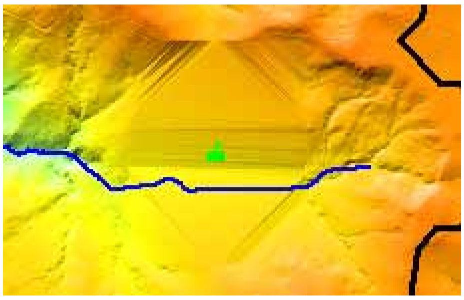


Figure 2.3 – 2.5m DEM anomaly in the MAR minor basin

This anomaly is included in the general comments GIS data layer provided with this report. Fortunately it is situated high enough in the catchment that hydraulic modelling will not be effected.

2.5.3 Neurum Creek

The coverage of the aerial LiDAR survey over the Neurum Creek catchment is shown by the extent of the DEM in the figure below. No LiDAR is available in the north-west corner of the NEU basin. The accuracy of modelling beyond the LiDAR extents will be significantly limited by the lack of good quality terrain data in this area.

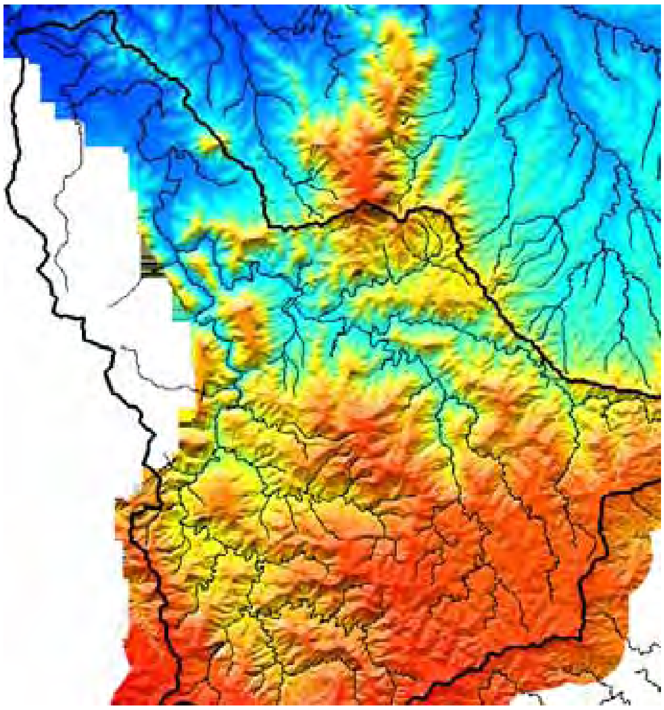


Figure 2.4 – Neurum Creek 'Minor Basin' Overlaying LiDAR DEM.

2.5.4 Stanley River

The coverage of the aerial LiDAR survey over the Stanley River catchment is shown by the extent of the *DEM* in the figure below. No LiDAR is available for the western, downstream portion of the Stanley River minor basin. The accuracy of modelling beyond the LiDAR extents will be significantly limited by the lack of good quality terrain data in this area.

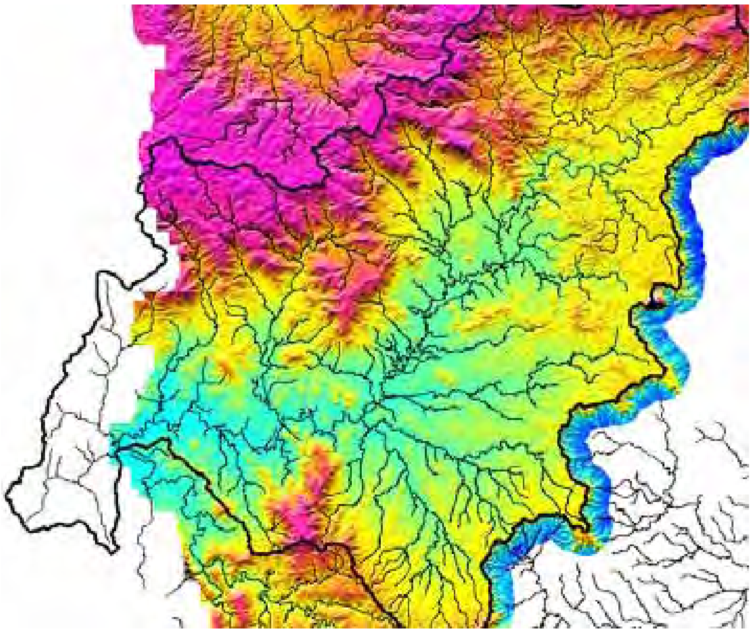


Figure 2.5 – Stanley River 'Minor Basin' Overlaying LiDAR DEM.

Cross-section ground survey was carried out during the 2003 Stanley River Flood Study (Sargent Consulting). This ground survey could be utilised to confirm the accuracy of the LiDAR data and also possibly to model the lower reaches of the Stanley River where LiDAR is not available. The cross-section survey data has not yet been supplied. The cross section survey is also a possible source of bathymetry.

The locations of the Stanley River Flood Study cross sections are shown in Appendix 2.

2.6 Miscellaneous

It is noted that some floodplain infrastructure is difficult to identify by studying aerial imagery and a *DEM*. One such example is in-stream weirs. No in-stream weirs were identified however it is worth confirming with the relevant authority as to whether any exist in these catchments.

Some buildings have also been identified in the floodplain that are not included in the MBRC supplied ‘buildings’ land-use layer. These additional buildings are also supplied in this report’s GIS data layers.

3. PROPOSED DATA CAPTURE

The key additional data capture required for this project is survey of the numerous hydraulic structures including bridges and culverts.

No regional scale detention basins or trunk drainage works were identified and hence no data capture is required for these structure classes.

The majority of the catchment area for each of the minor basins has been captured with high quality LiDAR survey. It would be ideal to obtain additional LiDAR survey over the remaining areas however MBRC may decide to accept a lower level of modelling accuracy in these areas to avoid the large cost of capturing this data.

Data capture tasks have been assigned a priority rating. Details are provided in the following sections.

3.1 Prioritisation Methodology

Hydraulic Structure Overall Priority

Each identified road crossing has been assigned a high, medium or low data capture priority. Prioritisation of the hydraulic structures has been based on the following criteria:

1. Likely impact on flooding characteristics;
2. Proximity to urban areas;
3. Class of road associated with the infrastructure; and
4. Catchment Size.

Based on these criteria each hydraulic structure that has been identified has been assigned a priority class or A (high), B (medium), or C (low). The priority has been assigned by reviewing aerial imagery, DEMS and the supplied hydrography.

By way of example, a dirt road with a minor causeway crossing and no significant road embankment would be assigned a 'C' priority. A significant road crossing in an urban area or on a major road would be assigned an 'A' priority. An example of a 'B' priority structure is a rural road crossing with no surrounding residential properties.

The priority rating of each structure is provided in the GIS data provided with this report ('priority' field).

Priority of Hydraulic Structure Elements

In addition to assigning each structure a priority, a further breakdown in priority has also been assigned to the various elements of data capture associated with each hydraulic structure. This relates to the priority High (or A) and Low (or B) data capture tasks referenced in the project brief whereby priority High tasks are considered critical for a high quality modelling outcome and priority Low tasks could potentially be incorporated with desktop techniques and assumptions.

3.2 Data Prioritisation

Culverts

Each structure has been assigned an overall priority as discussed in Section 3.1. The priority for each structure is provided in the GIS data provided with this report.

In addition to this, each element of data associated with capture of structures can further be prioritised as follows:

Priority High Elements of Culvert Data Capture

Capture of these elements is considered critical to a high quality modelling outcome:

1. Culvert Type (Box / Pipe);
2. Size and number of barrels;
3. Upstream and downstream invert levels;
4. Material (concrete/corrugated iron); and
5. Handrail type and extents.

Priority Low Elements of Culvert Data Capture:

The remaining elements associated with culvert data capture as detailed in the Culvert Data Standard by Aurecon, are considered to have type B Priority and could be incorporated into the modelling using desktop techniques and assumptions. These elements include

1. Wing walls:
2. Road elevation;
3. Handrail elevation;
4. Geo-referenced photos; and
5. Metadata.

Bridges

Each structure has been assigned an overall priority as discussed in Section 3.1.

In addition to this, each element of data associated with capture of structures can further be prioritised as follows:

Priority A Elements of Bridge Data Capture

1. Number / Length of spans;
2. Deck Thickness or soffit level;
3. Pier Configuration (width, shape, orientation etc);
4. Cross section of channel beneath the bridge; and
5. Handrail type and extents.

Priority B Elements of Bridge Data Capture:

The remaining elements associated with bridge data capture as detailed in the Bridge Data Standard by Aurecon, are considered to have type B Priority and could be incorporated into the modelling using desktop techniques and assumptions. These elements include

1. Road elevation;
2. Handrail elevation;
3. Deck levels points;
4. Geo-referenced photos; and
5. Metadata.

Most bridge details are able to be sourced from the supplied bridge drawings however levels on the drawings will need to be converted to AHD and it is noted that not all bridge drawings are complete.

Farm Dams

Priority B

It is proposed that the minor farm dams situated in the upper catchments upstream of the proposed hydraulic modelling extent will not be incorporated into the hydrologic or hydraulic modelling. While these small dams may have some impact on catchment hydrology (dependant on the level at the start of a rainfall event), the amount of work required to incorporate these dams into the modelling is not considered justified given that the impact of these dams is likely to be negligible if the dams are full at the start of a rainfall event.

While the farm dams in the upper catchments can justifiably be excluded from the modelling, there are several dams situated farther down in the catchments that are within the proposed hydraulic modelling area and are considered significant enough to warrant incorporation into the modelling. It is anticipated that the influence of the dam embankments on local hydraulic behaviour will be more significant that the storage effect of the impounded water.

It is proposed that these dams should be incorporated into the hydraulic model as follows:

1. Incorporate significant dams into the hydraulic modelling by creating a dam crest breakline. Ideally this should be based on Ground survey however a reasonable approximation should be possible in a lot of cases using aerial LiDAR survey; and
2. Defining initial water levels for the 2d grid within in each dam. It is recommended that a reasonable and conservative approach for this is to assume that the dams are full at the start of each simulation.

Terrain

Priority B: Stanley River Flood Study Survey

It is proposed to utilise the Stanley River Flood Study survey as follows:

1. Compare with cross section ground survey with the 2009 LiDAR survey to confirm accuracy of the LiDAR
2. Utilise the in-bank survey points to supplement the definition of the channel (including bathymetry.
3. It is also worth looking into what structure survey was carried out for the investigation

While having this data would be beneficial we suggest that it is not absolutely necessary because the LiDAR aerial survey is able to provide a reasonable representation of the major water course channels. This can be assisted by the use of stream gully breaklines.

Priority B: Stream Widths

It is noted that a stream width functionality has been included in the DEM processing utility developed for this project. A stream width field can be applied to the breakline strings that will be getting developed for the project. This is also considered to be a type of ‘data capture’ task in that it will improve the quality of the DEMs that will be generated for the project.

Miscellaneous

Priority A

It is proposed that relevant authorities should be contacted to confirm the existence of any instream weirs within the study area. If any are reported, then location and geometric details should be attained.

4. RECOMMENDATIONS

WorleyParsons recommends that MBRC should undertake or commission the undertaking of all data capture tasks detailed in this report. If budget and timing constraints limit the potential for this then, as a minimum, all data associated with priority "A" structures should be collected.

5. REFERENCES

Aurecon, July 2010, "Data Standard - Culverts, Regional Floodplain Database - Stage 2, Moreton Bay Regional Council"

Aurecon, July 2010, “Data Standard - Bridges, Regional Floodplain Database - Stage 2, Moreton Bay Regional Council”

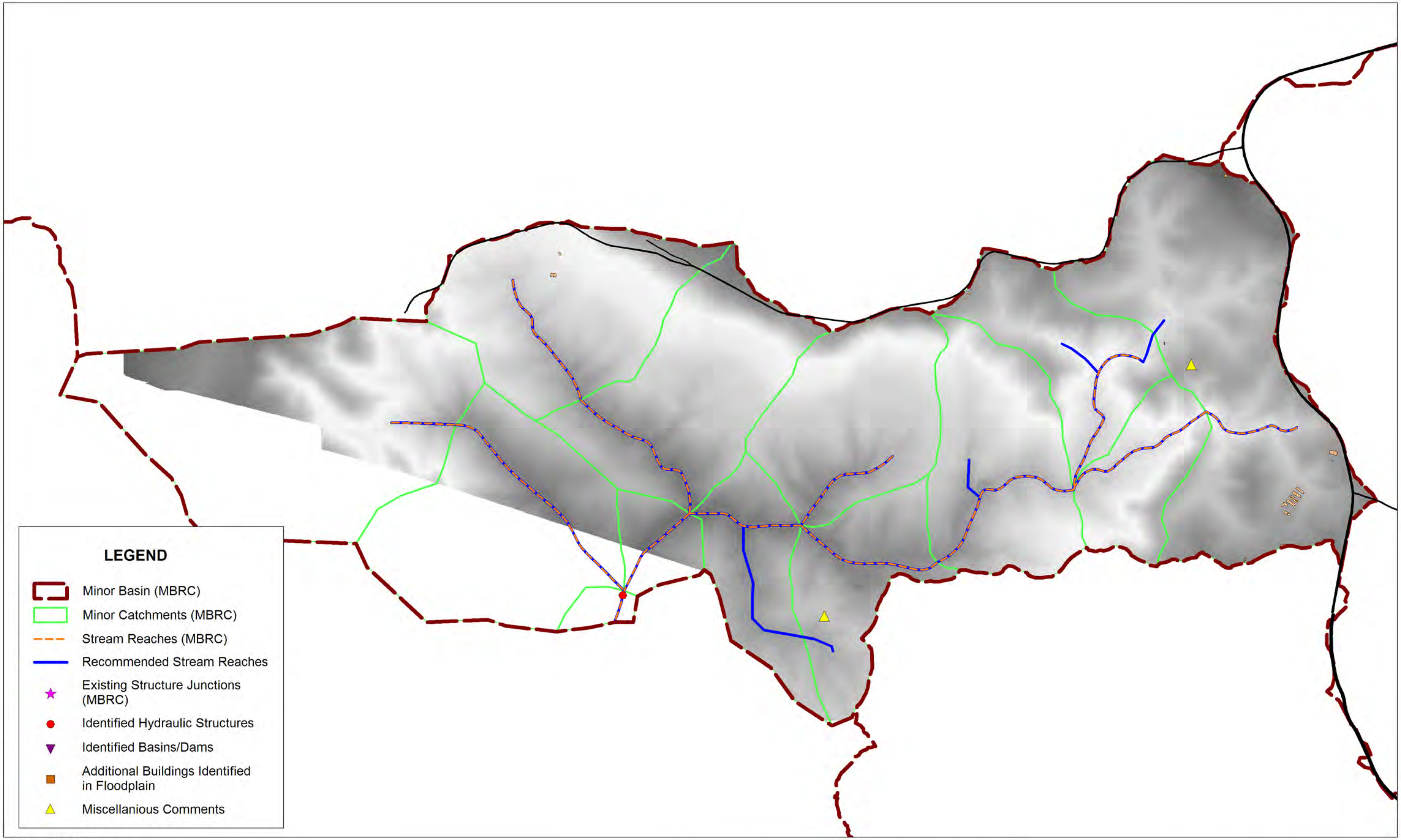
Aurecon, July 2010, “Data Standard - Detention Basins, Regional Floodplain Database - Stage 2, Moreton Bay Regional Council”

Aurecon, July 2010, “Data Standard – Trunk Underground Drainage, Regional Floodplain Database - Stage 2, Moreton Bay Regional Council”

Sargent Consulting (for the Caboolture Shire Council), March 2005, “Stanley River Flood Study Final Report”

WorleyParsons, September 2010 "Regional Floodplain Database - Floodplain Terrain"

Appendix 1 - Data Review Figures



All data supplied by MBRC.
Additional_Comments, Additional_Hydraulic_Structures, Additional_Bulidings, Additional_DamsBasins and MAR_Reach_Mod supplied by WorleyParsons on the 14/10/10

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Rev	Date	Revision Description	ORIG	CHK	ENG	APPD
0	14/10/2010	Issued for use	RS	JM	RS	KH

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REGIONAL FLOODPLAIN DATABASE PROJECT

FIGURE 1
BYRON CREEK DATA REVIEW

Project No: 301001-01156	Figure: 301001-01156-EN-DAL-0001	Rev: 0

Compiled by SUNSHINE COAST INFRASTRUCTURE GIS SECTION

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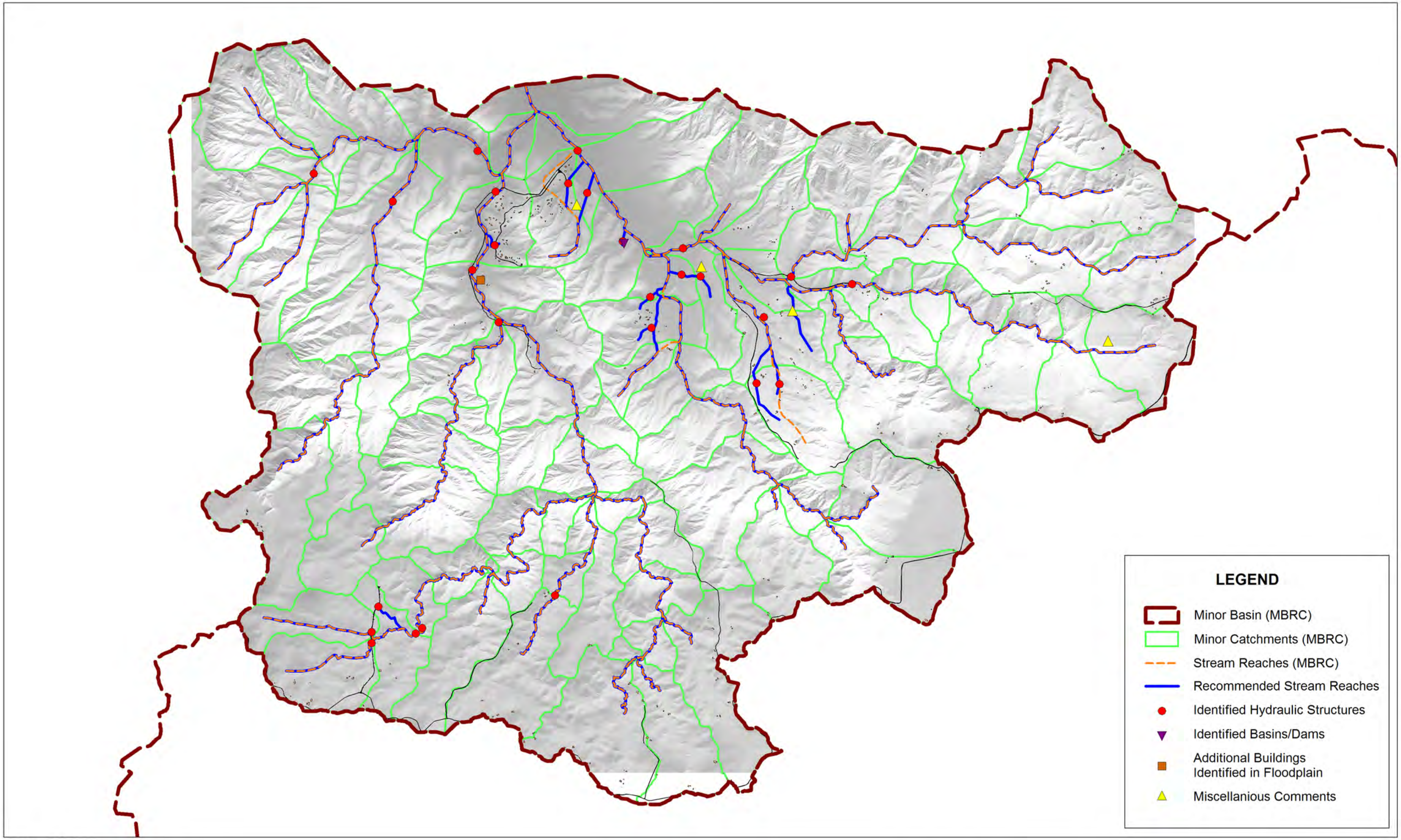

All data supplied by MBRC.
Additional_Comments, Additional_Hydraulic_Structures, Additional_Bulidings, Additional_DamsBasins and MAR_Reach_Mod supplied by WorleyParsons on the 5/10/10

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FIGURE 2
MARY RIVER DATA REVIEW

Project No: 301001-01156 | Figure: 301001-01156-EN-DAL-0002 | Rev: 0

Compiled by SUNSHINE COAST INFRASTRUCTURE GIS SECTION

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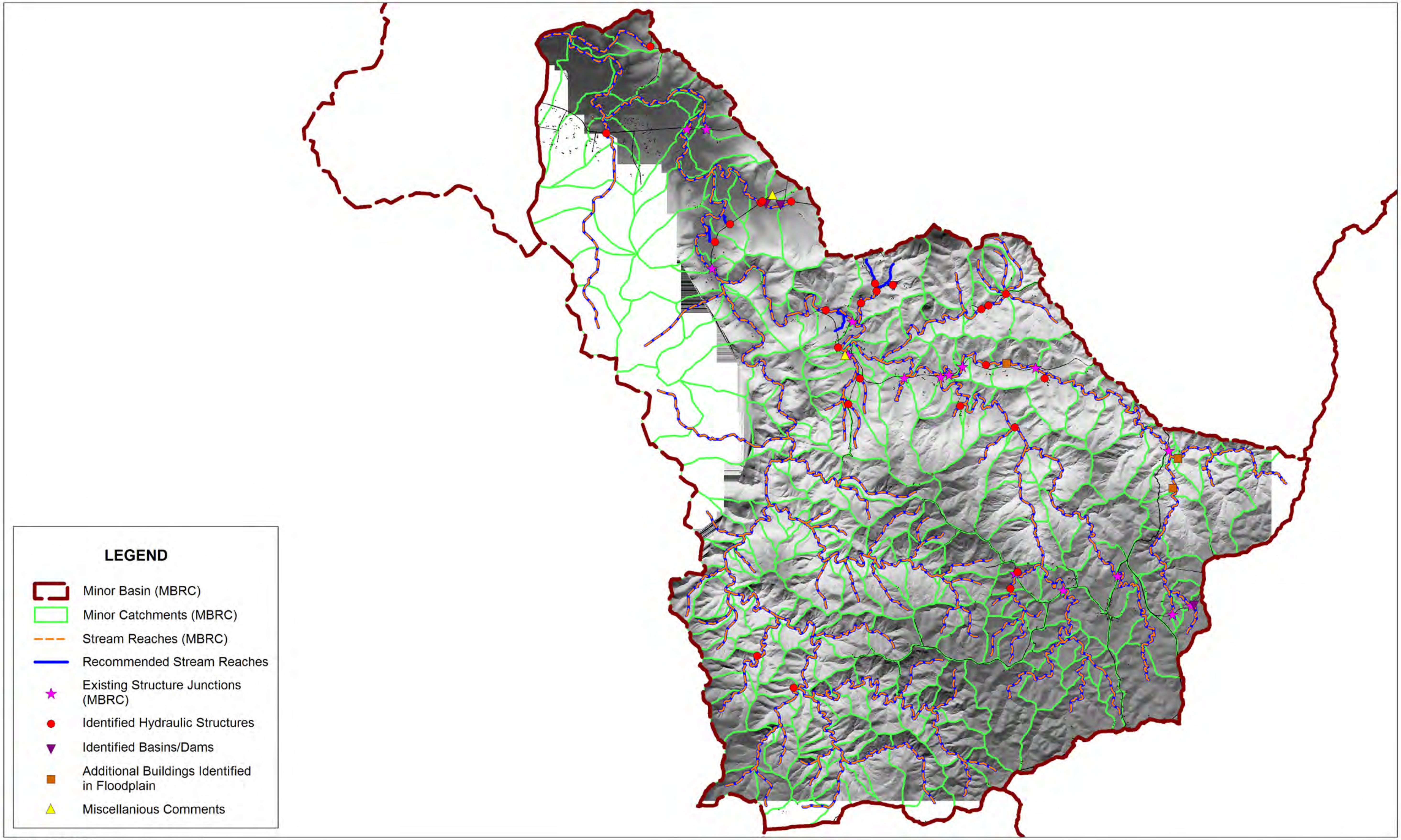

All data supplied by MBRC.
Additional_Comments, Additional_Hydraulic_Structures, Additional_Bulidings, Additional_DamsBasins and MAR_Reach_Mod supplied by WorleyParsons on the 14/10/10

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FIGURE 3
NEURUM CREEK DATA REVIEW

Project No: 301001-01156 | Figure: 301001-01156-EN-DAL-0003 | Rev: 0

Compiled by SUNSHINE COAST INFRASTRUCTURE GIS SECTION

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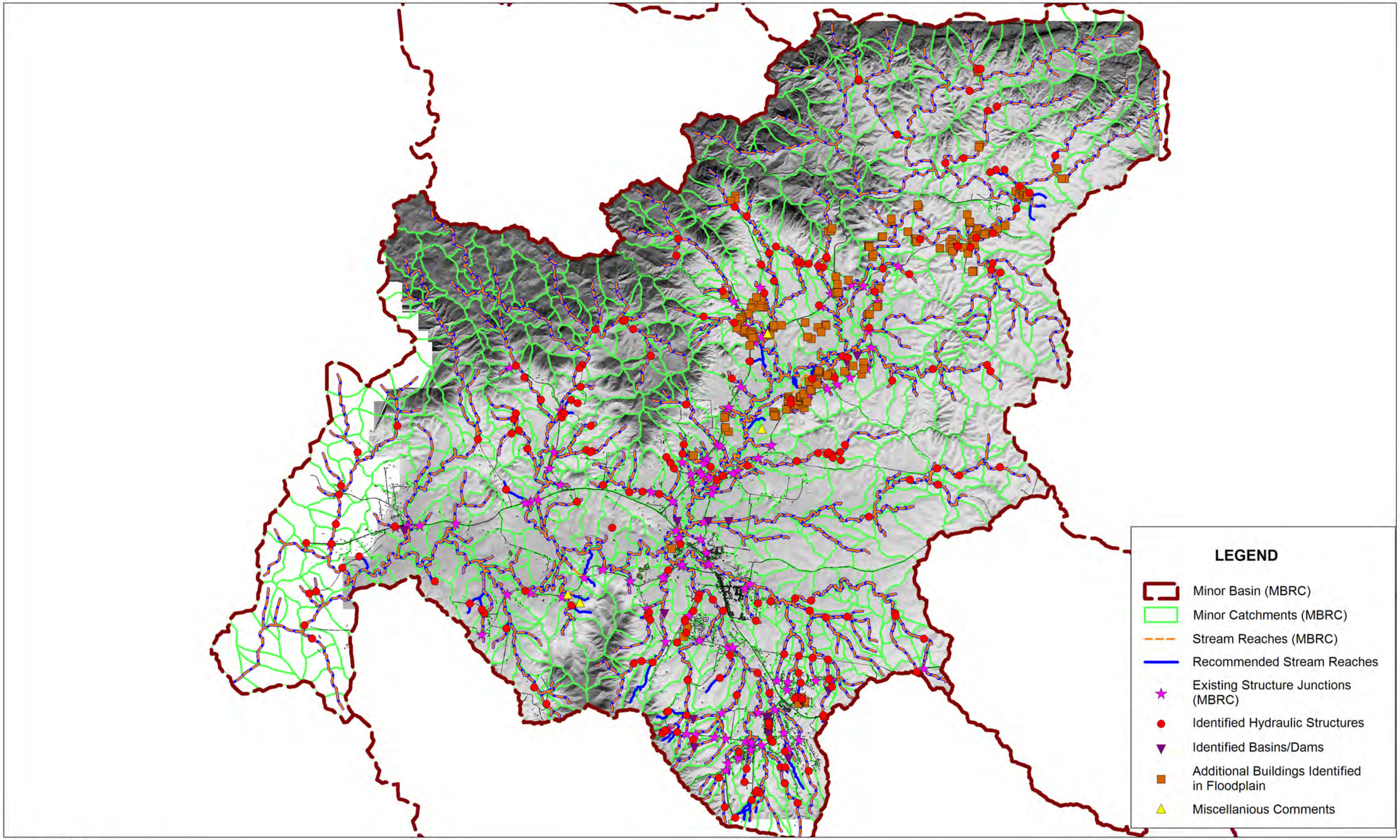

All data supplied by MBRC.
Additional_Comments, Additional_Hydraulic_Structures, Additional_Bulidings, Additional_DamsBasins and MAR_Reach_Mod supplied by WorleyParsons on the 14/10/10

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REGIONAL FLOODPLAIN DATABASE PROJECT

FIGURE 4
STANLEY RIVER DATA REVIEW

Project No: 301001-01156 | Figure: 301001-01156-EN-DAL-0004 | Rev: 0

Compiled by SUNSHINE COAST INFRASTRUCTURE GIS SECTION

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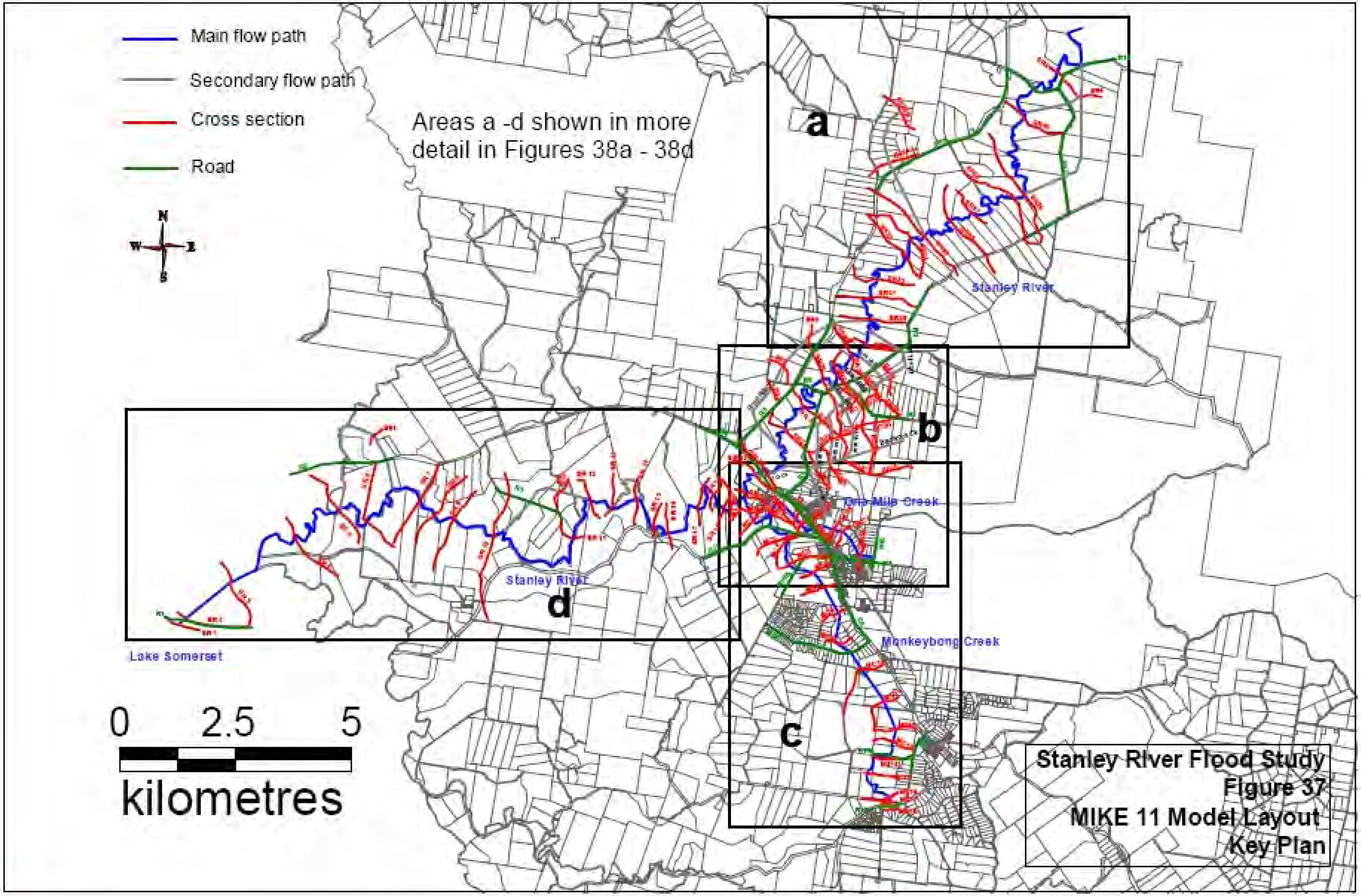
Appendix 2 - Stanley River 2003 MIKE 11 Model Layout


Main flow path
Secondary flow path
Cross section
Road
Areas a -d shown in more detail in Figures 38a - 38d
N
W
E
S
a
b
c
d
Stanley River
One Mile Creek
Monkeybong Creek
Stanley River
Lake Somerset
0
2.5
5
kilometres
Stanley River Flood Study
Figure 37
MIKE 11 Model Layout
Key Plan

APPENDIX B: HYDROGRAPHY REVIEW REPORT

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Hydrography Review Report

Package 5

301001-01156 – EN-REP-0006

16 November 2010

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MORETON BAY REGIONAL COUNCIL
HYDROGRAPHY REVIEW REPORT
PACKAGE 5

Disclaimer

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PROJECT 301001-01156 - HYDROGRAPHY REVIEW REPORT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for Internal Review	R.Stewart	K.Hegerty		16-Nov-10	N/A	
0	Issue for Use	R.Stewart	K.Hegerty	L.Stalley	16-Nov-10		

CONTENTS

1. INTRODUCTION

WorleyParsons Services Pty Ltd has been engaged by Moreton Bay Regional Council (MBRC) to carry out detailed surface water modelling over four of the regional catchments in their Local Government Area (LGA). The four catchments are Stanley River (STA), Neurum Creek (NEU), Mary River (MAR) and Byron Creek (BYR). These make up ‘Package 5’ of MBRC’s Regional Floodplain Database Project (RFD Project) and are referred to as ‘minor basins’ in the GIS data provided by MBRC.

At the commencement of this project MBRC handed over an extensive data set including established ‘broadscale’ models (including associated results and reporting) as well as their established hydrography layer. The hydrography data provided by MBRC includes their previously established stream reaches, stream junctions, major basins, minor basins, major catchments and minor catchments. An overland flowpath layer has also been provided for the Mary River catchment.

WorleyParsons has reviewed the supplied hydrography data against other data provided for the project including aerial imagery and a 2.5m grid aerial LiDAR digital elevation model. Based on this review, we have identified issues and where necessary we have made recommendations to improve the suitability of the hydrography for use in the current detailed modelling project.

2. HYDROGRAPHY REVIEW

2.1 Issues Identified During Stage 1

2.1.1 Byron Creek

Byron Creek was not included in the Stage 1 broadscale modelling hence no issues have previously been identified.

2.1.2 Mary River

Recommendations from Stage 1 are as follows:

'The upper sub-catchments are relatively elongated and due to the application of the inflows at the lowest or wet cells (within the 2d_sa polygon), accurate flood information may not be provided in the upper catchments. It is recommended that consideration be given to either subdividing the sub-catchments or applying portions of the sub-catchment inflows at a number of locations.'

2.1.3 Neurum Creek

Recommendations from Stage 1 are as follows:

'Due to the application of the inflows at the lowest or wet cells (within the 2d_sa polygon), accurate flood information may not be provided in the upper catchments. If Council requires more accurate flood information throughout the catchment, it is recommended that the sub-catchments be subdivided or portions of the sub-catchment inflows be applied at a number of locations.'

2.1.4 Stanley River

No hydrography issues where identified for the Stanley River catchment during Stage 1.

2.2 Stream Connectivity

Stream connectivity was generally found to be correct across the majority of the package 5 area. A few isolated instances have been identified where stream connectivity appears incorrect. A modified 'Stream Reaches' GIS layer has been provided reflecting WorleyParsons recommended stream connectivity.

2.3 Inclusion of Floodplain Structures

The majority of major floodplain structures have been picked up in the stream junction GIS layer provided by MBRC. Additional structures have been identified by WorleyParsons and it is recommended that these be incorporated into the MBRC hydrography stream junction layer.

2.4 Existing Resolution/Detail

The current resolution of the MBRC hydrography is considered suitable for use in the RFD project. This is on the basis that stream routing will generally be carried out hydraulically by TUFLOW as opposed to relying on WBNM hydrologic model's stream routing functionality which is calculated as a function of sub-catchment area.

The reason for this distinction is that flow attenuation occurring from channel routing may be incorrect in some instances when calculated using a function of sub-catchment area. This is due to a number of factors including sub-catchment shape, slope, and also by the hydrography including minor stream reaches (tributaries) which are located within a regional floodplain and which can artificially reduce the representative catchment size of the main channel.

3. PROPOSED CHANGES

WorleyParsons' recommended changes to the hydrography are detailed in the GIS data provided with this report. Figures 1 to 4 in Appendix A give an overview of this data for each minor basin however due to the large extent of the study areas it is recommended that this data be reviewed using a GIS software package rather than relying on these figures.

The following GIS layers have been provided to describe our recommended changes to the hydrography layer.

1. 'Recommended Stream Reaches': A complete updated set of stream reaches for each minor basin based on MBRC supplied data and incorporating WorleyParsons' suggested changes.
2. 'Recommended Stream Junctions': GIS layer including additional stream junctions which should be included. These stream junctions have been incorporated along the stream reaches layer at locations where additional sub-catchments should be delineated.
3. 'Identified Hydraulic Structure': This is a copy of the identified hydraulic structures that were identified in WorleyParsons previous package 5 Infrastructure Data Assessment Report (14/10/2010).
4. 'Miscellaneous Comments': Contains comments relating to the hydrography review. Comments are generally associated with highlighting issues with catchment delineation.

It is proposed that MBRC utilise WorleyParsons' GIS data layers to update the package 5 hydrography. Additional catchments should be delineated along the recommended stream reaches layer at points contained within the recommended stream junctions layer and also the identified hydraulic structure layer.

The location of the additional stream junctions have been chosen based on several factors including:

1. To provide additional catchment break down in the upper catchments to reduce potential inaccuracies identified in the previous stage 1 broadscale modelling.
2. To provide increased sub-catchment resolution where appropriate.
3. To improve sub-catchment shape and length.
4. Stream junctions have also been put at new stream confluences in the recommended stream reaches layer.

4. RECOMMENDATIONS

It is recommended that MBRC update the package 5 hydrography based on the proposed changes discussed in this report and detailed in the supplied GIS data.

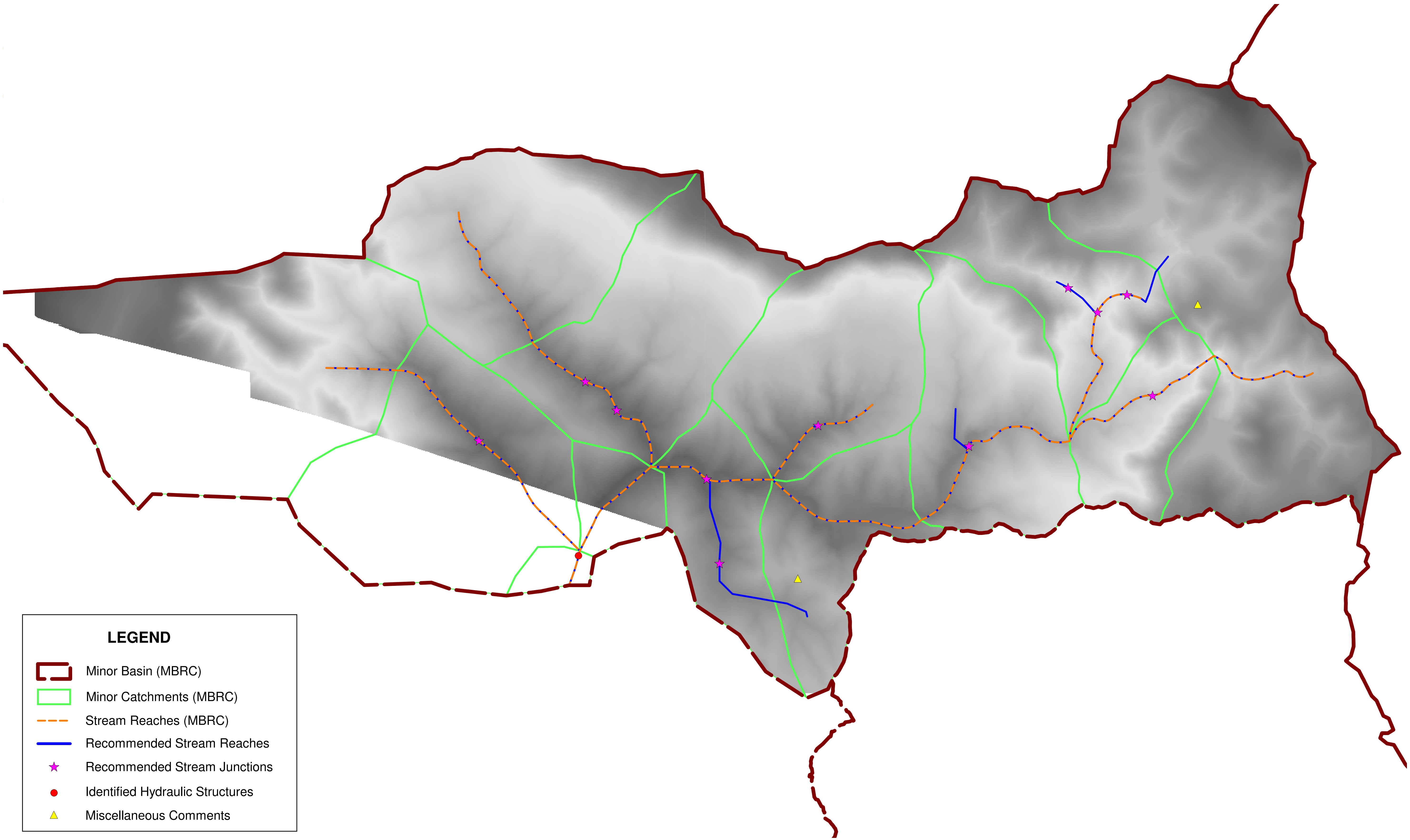
5. REFERENCES

BMT WBM, July 2010, *"Hydraulic Modelling (Broadscale) Regional Floodplain Database Stage 1 Sub-Project 1D"*

WorleyParsons, September 2010 *"Regional Floodplain Database - Floodplain Terrain"*

WorleyParsons, September 2010 *"Regional Floodplain Database, Design Rainfall - Burpengary Pilot Project"*

Appendix 1 - Hydrography Review Figures



LEGEND

- Minor Basin (MBRC)
- Minor Catchments (MBRC)
- Stream Reaches (MBRC)
- Recommended Stream Reaches
- Recommended Stream Junctions
- Identified Hydraulic Structures
- Miscellaneous Comments

Existing hydrographic data supplied by MBRC. Miscellaneous_Comments, Identified Hydraulic Structures, Recommended Stream Reaches, Recommended Stream Junctions supplied by WorleyParsons on the 11/11/10

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0	11/11/2010	Issued for use	RS	JM	RS	ER

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REGIONAL FLOODPLAIN DATABASE PROJECT

FIGURE 1
BYRON CREEK HYDROGRAPHY REVIEW

Project No: 301001-01156	Figure: 301001-01156-EN-DAL-0008	Rev: A

Compiled by SUNSHINE COAST INFRASTRUCTURE GIS SECTION

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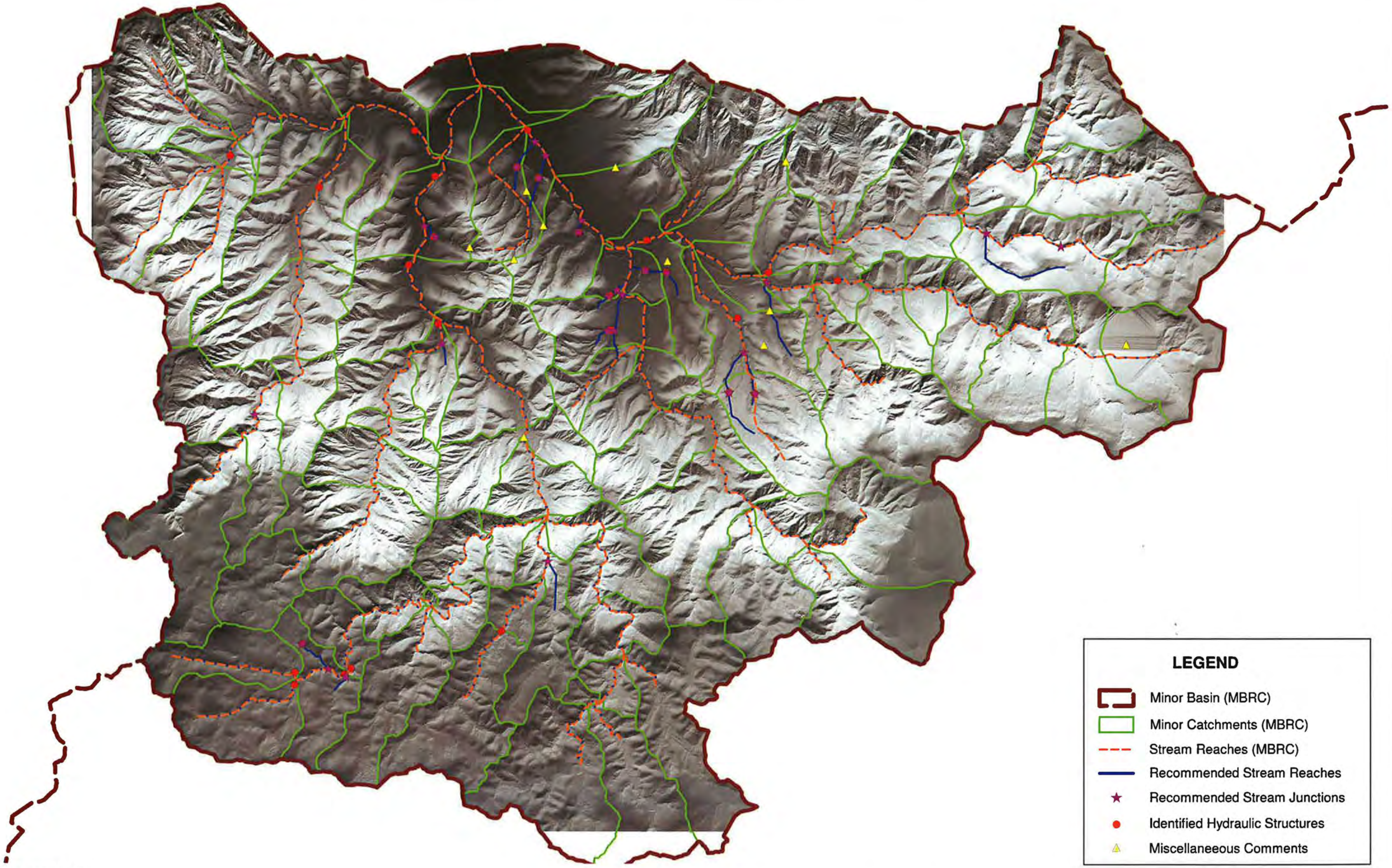

Existing hydrographic data supplied by MBRC. Miscellaneous_Comments, Identified Hydraulic Structures, Recommended Stream Reaches, Recommended Stream Junctions supplied by WorleyParsons on the 11/11/10

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A	11/11/2010	Issued for use	RS	JM	RS	ER
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FIGURE 2
MARY RIVER HYDROGRAPHY REVIEW

Project No: 301001-01156	Figure: 301001-01156-EN-DAL-0009	Rev: A

Compiled by SUNSHINE COAST INFRASTRUCTURE GIS SECTION

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Existing hydrographic data supplied by MBRC. Miscellaneous_Comments, Identified Hydraulic Structures, Recommended Stream Reaches, Recommended Stream Junctions supplied by WorleyParsons on the 11/11/10

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REGIONAL FLOODPLAIN DATABASE PROJECT

FIGURE 3
NEURUM CREEK HYDROGRAPHY REVIEW

Project No: 301001-01156	Figure: 301001-01156-EN-DAL-0010	Rev: A

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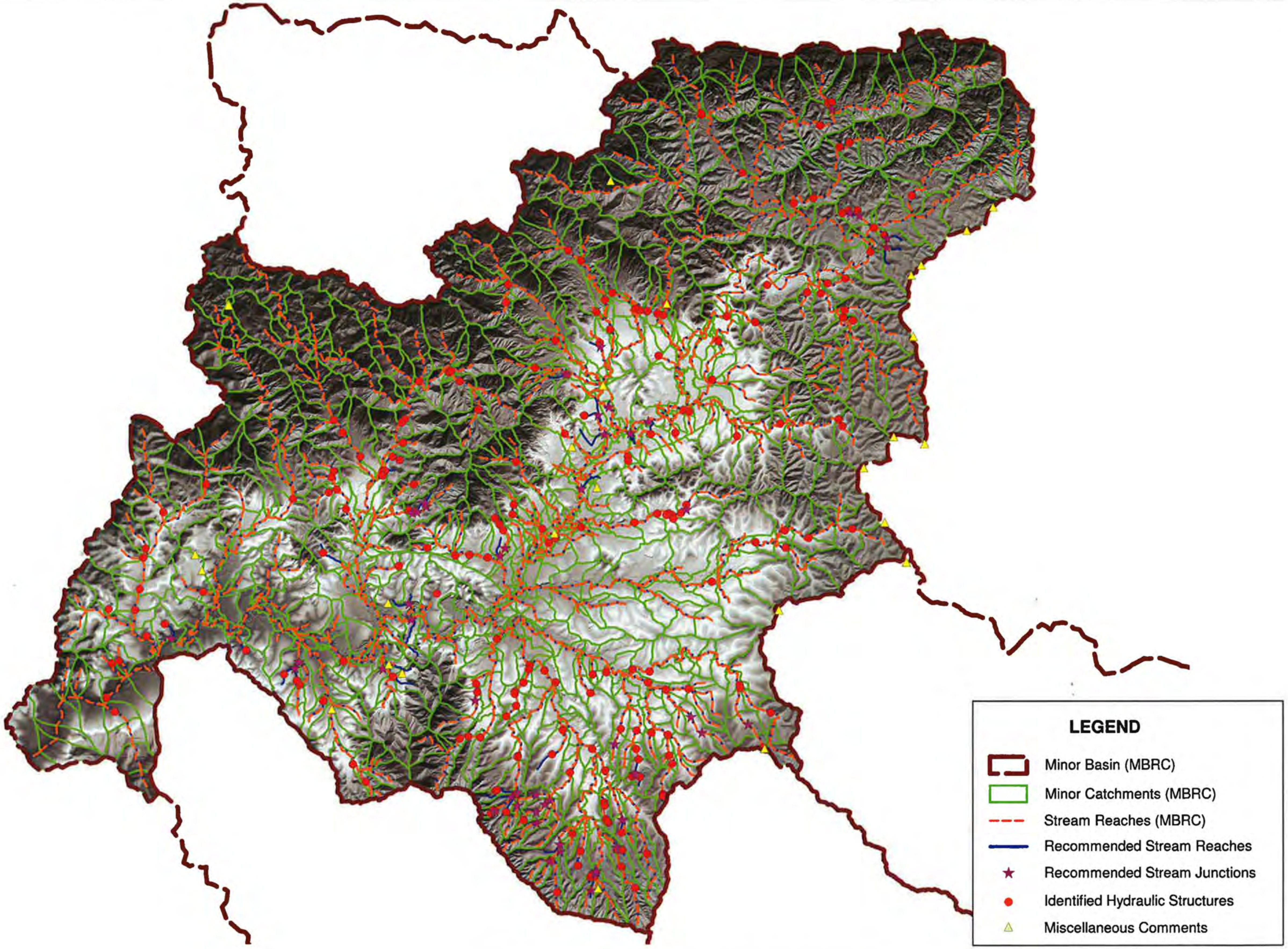

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FIGURE 4
STANLEY RIVER HYDROGRAPHY REVIEW

Project No: 301001-01156 | Figure: 301001-01156-EN-DAL-0011 | Rev: A

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APPENDIX C: CALIBRATION AND VALIDATION REPORTS

MORETON BAY REGIONAL COUNCIL

Regional Floodplain Database

Stanley River (STA) Model Calibration Report

301001-01156 – 00-EN-REP-0007

9 Aug 2012

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REGIONAL FLOODPLAIN DATABASE
STANLEY RIVER (STA) MODEL CALIBRATION REPORT

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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	9 Aug 2012		

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

As part of the Moreton Bay Regional Council (MBRC) Regional Flood Database (RFD) Stage 2, a model calibration and validation to two (2) historical flood events has been undertaken for the Stanley River (STA) minor basin.

The January 2011and February 1999 historic flood events were selected by MBRC for this purpose. The January 2011 event was selected for the model calibration due to the flood event being the largest flood on record within the Stanley River catchment. The February 1999 event was chosen for model validation for consistency with other catchments included in the RFD.

Model calibration is an important process of developing a flood model. Model calibration also helps to understand the resolution, accuracy and potential limitations of the model. The model calibration is therefore an important step in the development of the RFD. MBRC is aware of the importance of model calibration, in particular when utilising the models to assess future development and for community consultation. Council has therefore paid great attention to the model calibration phase of the project. Based on available rainfall, river gauge and flood mark data, model calibration was considered to be feasible and subsequently commissioned in the following four (4) minor basins as part of the RFD:

- Burpengary Creek (pilot study);
- Caboolture River (CAB);
- Stanley River (STA); and
- Upper Pine River (UPR).

This report outlines the data used, results and discussion of the model calibration for the STA minor basin.

2 JANUARY 2011 CALIBRATION EVENT

2.1 Rainfall Data

Recorded rainfall data has been obtained from 11 gauging stations operated by MBRC or Bureau of Meteorology (BOM) for the period between 6th – 12th January 2011 for the purposes of model calibration. Details of the rainfall gauges are summarised in Table 1. Location of the rainfall gauges are presented on Figure 1.

Table 1 January 2011 Event Rainfall Gauge Details

Gauge ID	Easting	Northing	Total Rainfall Depth (mm)	Source
Hume Lane AL	489568	7031071	748	MBRC Data
Kilcoy AL	458707	7019245	424	MBRC Data
Mt Mee Alert-P	478186	7005826	682	MBRC Data
Wamuran AL	486116	7008263	754	MBRC Data
Woodford Alert-P	476175	7020376	592	MBRC Data
Maleny	484838	7039794	827	BoM Data
Bald Knob	491580	7038050	644	BoM Data
Landsborough	495806	7035228	713	BoM Data
Harper Creek	477352	7039661	667	BoM Data
West Bellthorpe	468003	7033095	695	BoM Data
Ferris Knob	481820	7029700	711	BoM Data

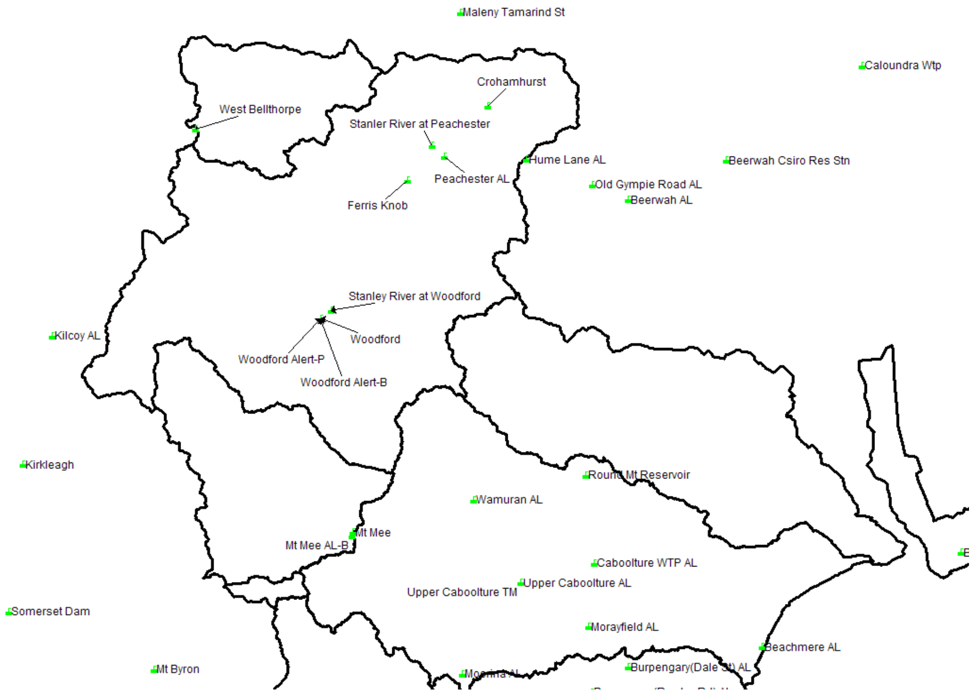

Figure 1 Rainfall Gauge Locations

Analysis of the recorded rainfall data between the 6th and 12th of January 2011 suggest a similar trend in the timing of rainfall bursts over the Stanley River catchment during the 6 day rainfall recorded period. It is noted that the magnitude of the total rainfall depths over the north-eastern part of the catchment is higher than the south-western part during the model calibration period. Cumulative rainfall depths range from approximately 600 to 800mm over the north-eastern part of the catchment and gradually decrease to the range from 400 to 600mm towards the southwest. The recorded cumulative rainfall depths for these rainfall gauges are illustrated on Figure 2.

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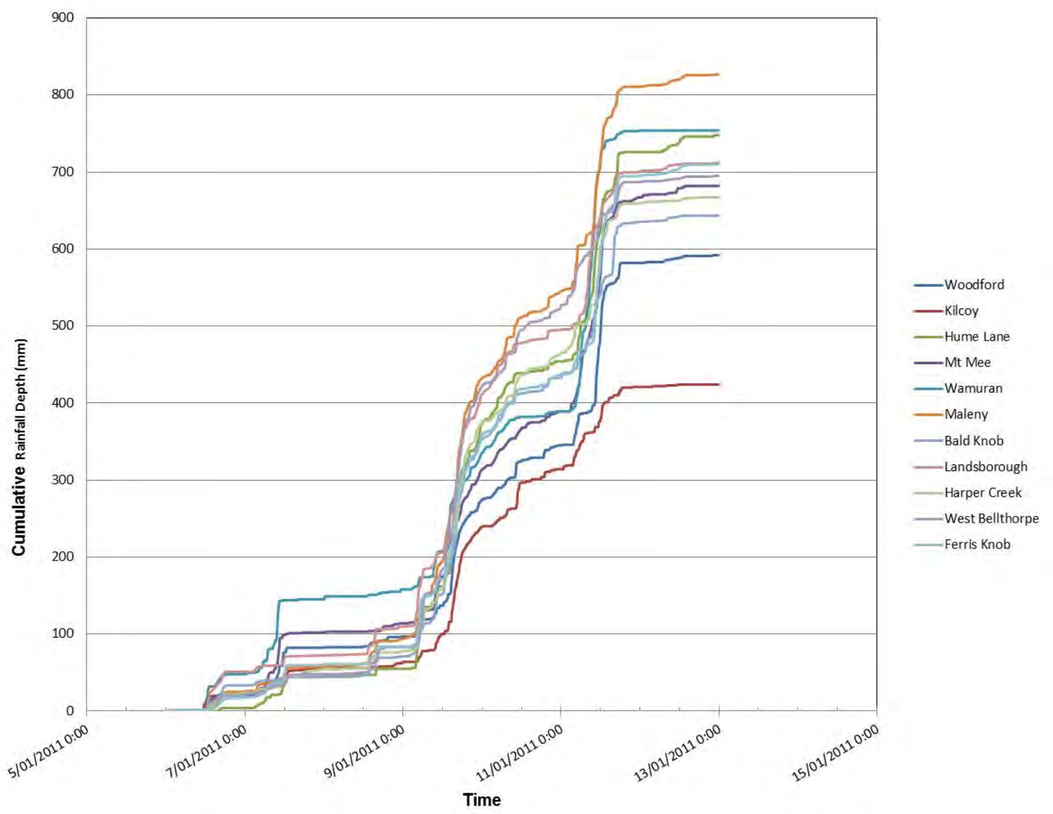


Figure 2 Cumulative Rainfall Depths – January 2011 Event

2.2 Modelling

2.2.1 Hydrologic Model

The hydrologic WBNM model was developed using 5 minute interval rainfall from the 11 rainfall gauges described in Section 2.1. Sub-catchment information was based on the hydrography (sub-catchment delineation) adopted by Council. The default values for the setup were used for most of the WBNM parameters (i.e. nonlinearity exponent, stream routing). The ultimate rainfall loss and model lag parameters adopted for the STA WBNM calibration model are summarised in Table 2 .

Table 2 Rainfall Loss and Model Lag Parameters

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

2.2.2 Hydraulic model

The hydraulic model used for this assessment has a cell size of 10m grid resolution, compared to the 5m grid model developed for modelling the minor to large design events. The increase in cell size from 5m to 10m grid was to avoid the excessive model run times for simulation of the 6 day rainfall for the January 2011 event.

As part of the model calibration assessment various hydraulic models were setup and simulated utilising the inflows derived from the WBNM hydrologic modelling. The downstream boundary of STA model is located 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 STA model. The peak Lake Somerset level at 105 mAHD during the January 2011 event has been adopted for the STA calibration model run.

The initial run of the January 2011 event was undertaken using the parameters obtained from the Burpengary Pilot Project. A number of iteration runs for various model scenarios following the initial run has been undertaken for the determination of the final model input parameters including a set of depth varying Manning's 'n' values to represent the hydraulic roughness for the dense, medium dense and low grass grazing vegetation landuse profiles for the STA minor basin.

The results of the January 2011 calibration run using the final adopted parameters are discussed below.

2.2.3 January 2011 Results

MBRC has provided surveyed flood mark levels collected from 37 locations for the January 2011 events. In addition, stage hydrographs were obtained from the Peachester and Woodford ALERT flood warning stations in the upper and middle reaches of the Stanley River for the January 2011 event.

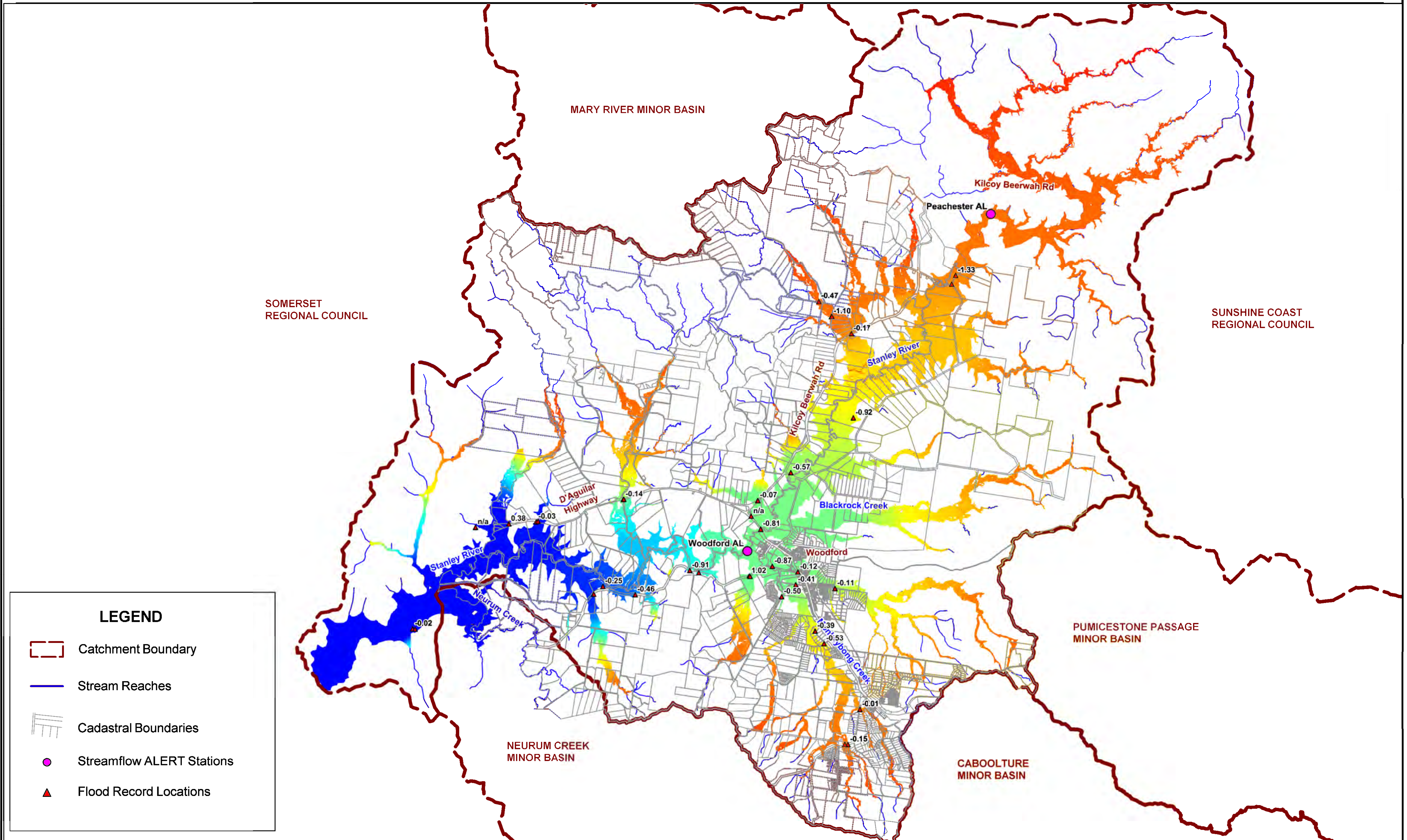
2.2.3.1 Flood Mark Comparison

Among the 37 flood marks for within the STA minor basin; 4 of them were categorised as being of high quality, 32 being of medium quality and the remaining 1 being low quality. The flood level heights at the flood mark locations were surveyed by Council following the January 2011 event. Two of the 37 flood marks were located outside the modelled flood extent.

The surveyed flood levels at the flood marks were compared to the modelled peak flood levels derived from the calibration model. The distributions of modelled differences are summarised in Table 3. The table shows that the modelled peak flood levels were generally under-estimated with the median difference being -374mm and the range extending from -1,326mm to 1,504mm. The differences distributions are approximately 30% of modelled levels are within ±200mm and 40% of modelled levels are within ±300mm for the January 2011 event. The spatial results of the January 2011 calibration run are presented on Figure 3. A histogram showing the difference in flood levels versus the number of flood marks is presented in Figure 4.

Table 3 Summary of Modelled Differences in Peak Flood Levels

Parameter	January 2011
Average (mm)	-321
Median (mm)	-374
Maximum (mm)	1504
Minimum (mm)	-1326
No. within Range >1.0m	2
No. within Range 0.5m, 1.0m	-
No. within Range 0.4m, 0.5m	-
No. within Range 0.3m, 0.4m	1
No. within Range 0.2m, 0.3m	-
No. within Range 0.1m, 0.2m	-
No. within Range 0.0m, 0.1m	-
No. within Range -0.1m, 0.0m	4
No. within Range -0.2m, -0.1m	7
No. within Range -0.3m, -0.2m	3
No. within Range -0.4m, -0.3m	2
No. within Range -0.5m, -0.4m	5
No. within Range -1.0m, -0.5m	9
No. within Range <-1.0m	2



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Latitude / Longitude
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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER MODEL CALIBRATION
FIGURE 3 - FLOOD LEVEL COMPARISON
(MODELLED - MEASURED)
JANUARY 2011 EVENT

Project No: 301001-01156	Figure:301001-01156-EN-DAL-0048	Rev: 0

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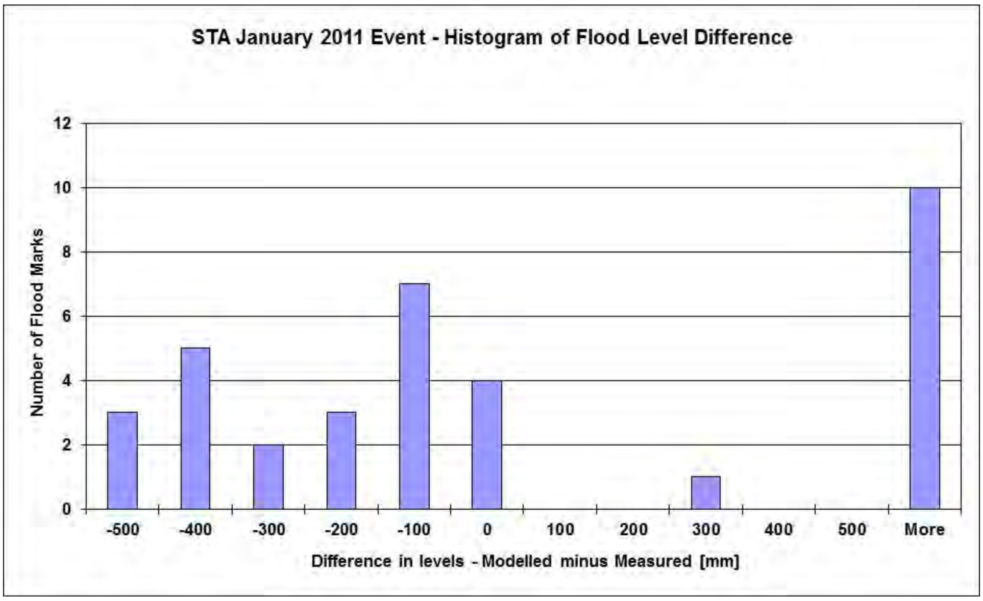


Figure 4 Flood Level Comparison Histogram

As discussed above, the modelled results are generally lower than the recorded levels, especially over the floodplain in the middle reach of the Stanley River. Some flood marks differ significantly between the surveyed and the modelled level (between +/- 1m). The anomalies are likely due to:

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

2.2.3.2 Stage Hydrograph Comparison

Comparisons of modelled and recorded stage hydrographs for the January 2011 event are presented on Figure 5 and Figure 6. The hydrograph plots show good agreement with timing at Peachester gauge, with the modelled at Woodford gauge being marginally early.

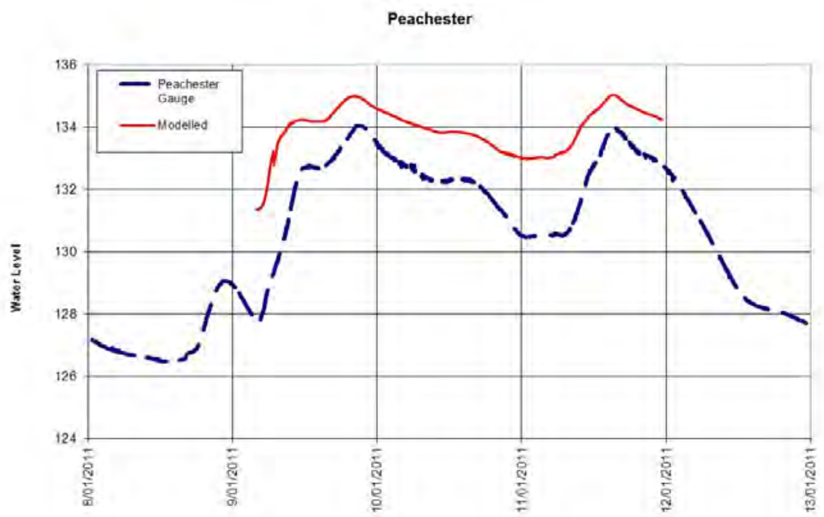


Figure 5 Comparison of Stage Hydrographs – Peachester Gauge January 2011 Event

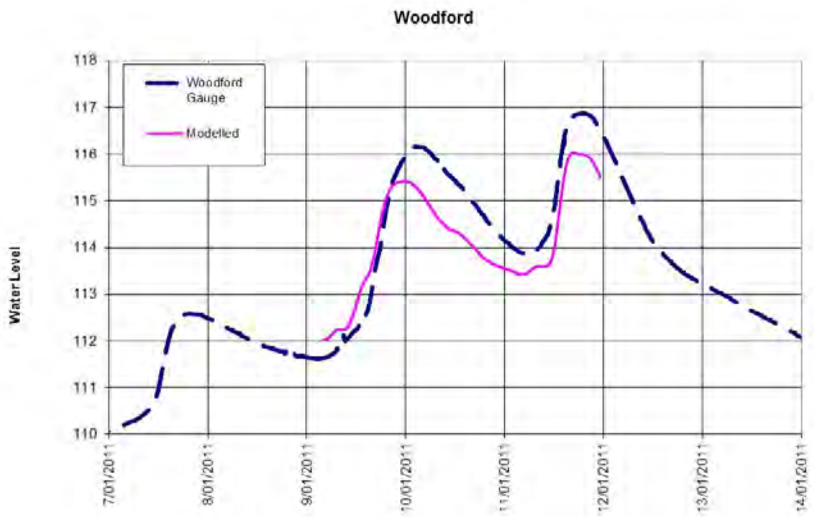


Figure 6 Comparison of Stage Hydrographs – Woodford Gauge January 2011 Event

3 FEBRUARY 1999 VALIDATION EVENT

3.1 Rainfall Data

Recorded rainfall data has been obtained from 6 gauging stations operated by MBRC or Bureau of Meteorology (BOM) for the period between 7th – 10th February 1999 for the purposes of model validation. Details of the rainfall gauges are summarised in Table 4. Location of the rainfall gauges are presented on Figure 1.

Table 4 February 1999 Event Rainfall Gauge Details

Gauge ID	Easting	Northing	Total Rainfall Depth (mm)	Source
Kilcoy AL	458707	7019245	332	MBRC Data
Mt Mee Alert-P	478186	7005826	513	MBRC Data
Woodford Alert-P	476175	7020376	382	MBRC Data
Bald Knob	491580	7038050	450	BoM Data
West Bellthorpe	468003	7033095	497	BoM Data
Ferris Knob	481820	7029700	505	BoM Data

Analysis of the recorded rainfall data between the 7th and 10th of February 1999 suggest a similar trend in the timing of rainfall bursts over the Stanley River catchment during the 3 day rainfall recorded period. Cumulative rainfall depths range from approximately 330 to 500mm and is distributed evenly across the STA minor basin. The recorded cumulative rainfall depths for these rainfall gauges are illustrated on Figure 7.

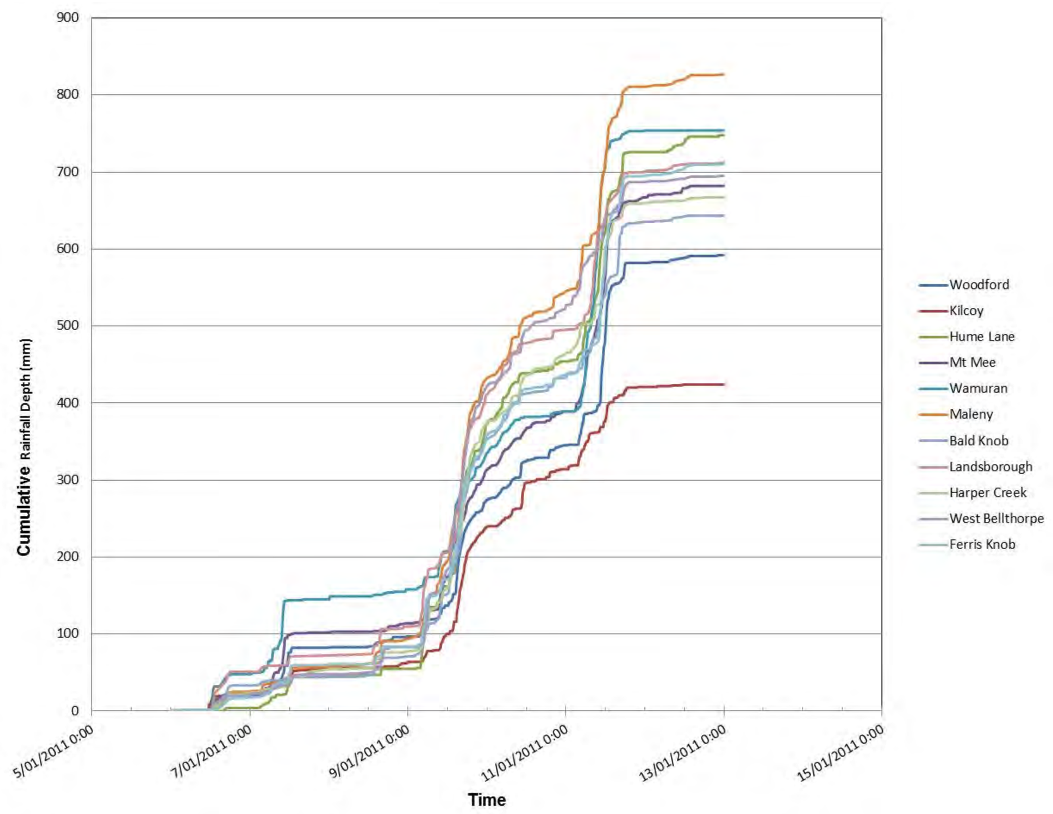


Figure 7 Cumulative Rainfall Depths – February 1999 Event

3.2 Modelling

3.2.1 Hydrologic Model

The adopted model calibration parameters from the January 2011 event have been applied to the WBNM hydrologic model to calculate inflow hydrographs for the February 1999 model validation run.

3.2.2 Hydraulic model

The adopted model parameters from the January 2011 event have been applied to the February 1999 model validation run.

The peak Lake Somerset level at 103.3 mAHD was adopted as the downstream boundary of STA model for the February 1999 run.

3.2.3 February 1999 Results

MBRC provided surveyed flood mark levels collected from 34 locations for the February 1999 event. In addition, stage hydrographs were obtained from the Peachester flood warning station in the upper reach of the Stanley River for the February 1999 event.

3.2.3.1 Flood Mark Comparison

All 34 flood marks were categorised as being medium quality. The flood level height at these flood mark locations were surveyed by Council following the February 1999 event.

The surveyed flood levels at the flood marks were compared to the modelled peak flood levels derived from the validation model. The distributions of modelled differences are summarised in Table 5. The table shows that the modelled peak flood levels were generally under-estimated with the median difference being -374mm and the range extending from -1,207mm to 454mm. The differences distributions are approximately 30% of modelled levels are within ±200mm and 40% of modelled levels are within ±300mm for the February 1999 event. A histogram showing the difference in flood levels versus the number of flood marks is presented in Figure 8. The spatial results of the February 1999 validation run are presented on .

Table 5 Summary of Modelled Differences in Peak Flood Levels

Parameter	February 1999
Average (mm)	-269
Median (mm)	-207
Maximum (mm)	454
Minimum (mm)	-1207
No. within Range >1.0m	-
No. within Range 0.5m, 1.0m	-
No. within Range 0.4m, 0.5m	1
No. within Range 0.3m, 0.4m	2
No. within Range 0.2m, 0.3m	1
No. within Range 0.1m, 0.2m	2
No. within Range 0.0m, 0.1m	4
No. within Range -0.1m, 0.0m	2
No. within Range -0.2m, -0.1m	3

Parameter	February 1999
No. within Range -0.3m, -0.2m	2
No. within Range -0.4m, -0.3m	3
No. within Range -0.5m, -0.4m	3
No. within Range -1.0m, -0.5m	5
No. within Range <-1.0m	5

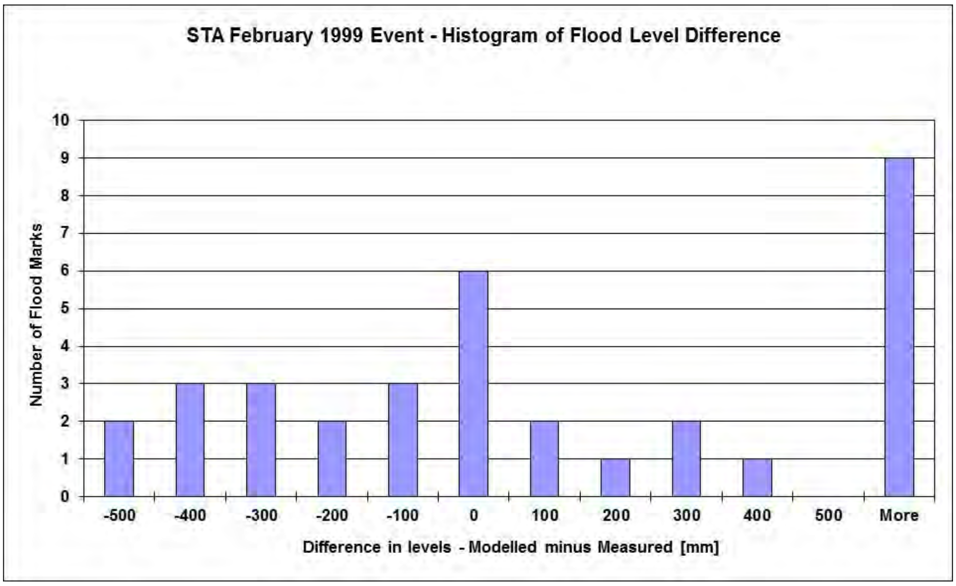
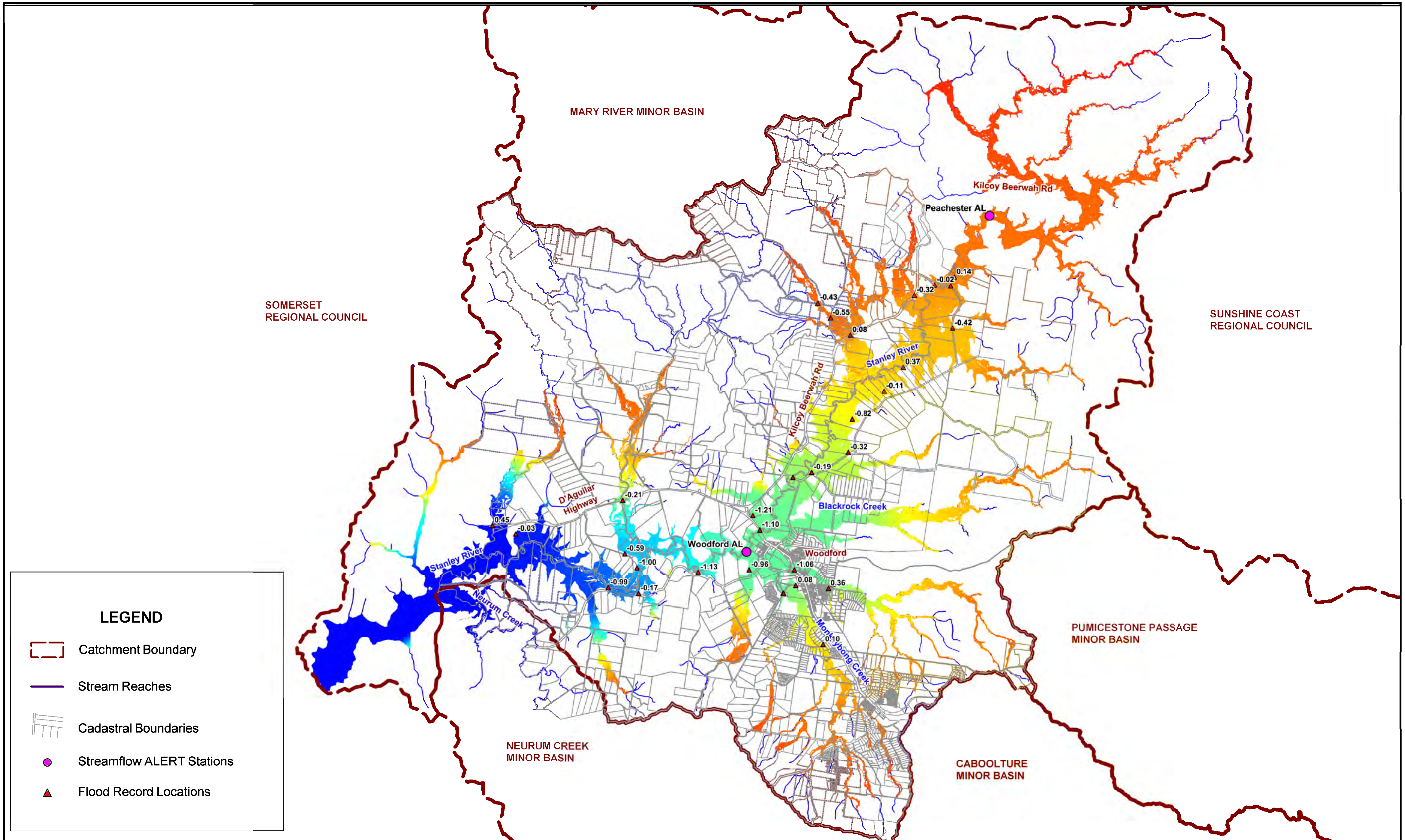


Figure 8 Flood Level Comparison Histogram

As discussed above, the modelled results are generally lower than the recorded levels, especially over the floodplain at the middle reach of Stanley River, similar to the January 2011 calibration event. Some flood marks differ significantly between the surveyed and the modelled level (between +/- 1m). As discussed above, the causes of the anomalies are likely the same as the January 2011 event due to:

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



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Latitude / Longitude
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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER MODEL VALIDATION
FIGURE 9 - FLOOD LEVEL COMPARISON
(MODELLED - MEASURED)
FEBRUARY 1999 EVENT

Project No: 301001-01156	Figure:301001-01156-EN-DAL-0049	Rev: 0

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3.2.3.2 STAGE HYDROGRAPH COMPARISON

Comparisons of modelled and recorded stage hydrographs for the February 1999 event are presented on Figure 10. The hydrograph plots show the modelled peak level is almost a meter lower than the recorded level and the duration of modelled peak is about 12 hours longer than the recorded peak. The discrepancies may be due to the quality of the recorded data. The recorded hydrograph shows some discontinuity during the peak flood period.

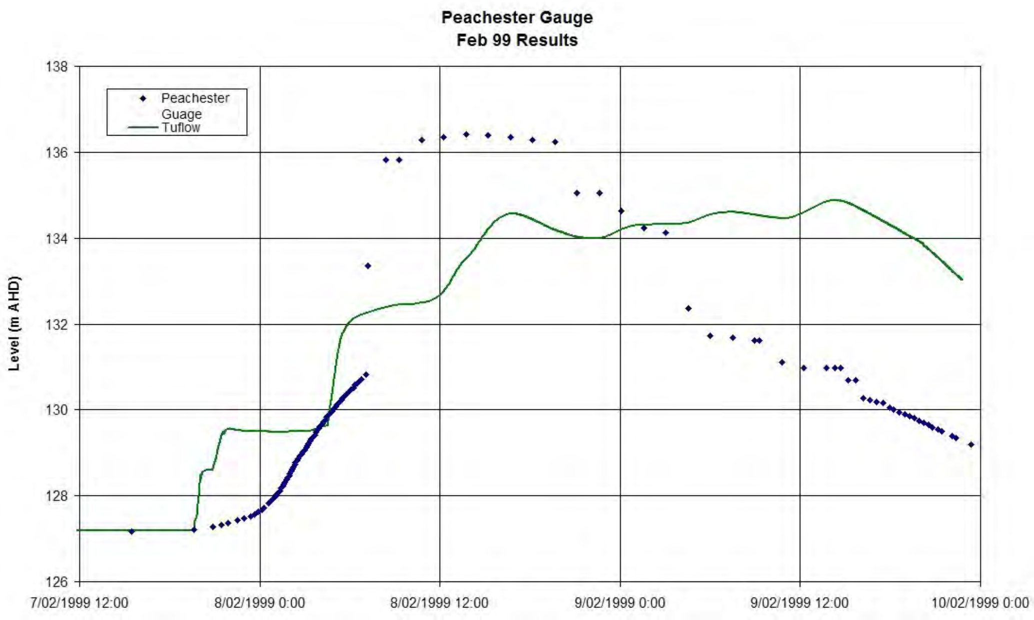

Figure 10 Comparison of Stage Hydrographs – Peachester Gauge February 1999 Event

4 DISCUSSIONS AND CONCLUSIONS

The January 2011 event used for model calibration was classified as a major event, based on BoM's classification system. The February 1999 event utilised for model validation was also classified as a major flood event at BoM's Woodford Flood ALERT flood gauge; for more details refer to the WorleyParsons (November 2010) *Calibration and Validation Feasibility Report Package 5*. These two events provide a good range of magnitude and in particular the January 2011 event occurred relatively recently, thus limiting the changes in the catchment of the landuse, additional waterway structures or change in topography.

The model calibration and validation model runs showed reasonable results, considering the two major factors of timing and peak flood levels; however it also highlighted that the peak flood levels in the middle reach were underestimated for both events. The anomalies are likely due to difference in the source of the levels (usage of the LiDAR versus ground survey undertaken to collect flood marks) and interpretation of flood marks/peak flood levels may have varied amongst the survey teams.

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

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Calibration and Validation Feasibility Report

Package 5

301001-01156 – EN-REP-0004

4 November 2010

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MORETON BAY REGIONAL COUNCIL
CALIBRATION AND VALIDATION FEASIBILITY REPORT
PACKAGE 5

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PROJECT 301001-01156 - CALIBRATION AND VALIDATION FEASIBILITY REPORT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issue for Internal Review	R.Stewart	K.Hegerty		3-Nov-10	N/A	
0	Issue for Use	R.Stewart	K.Hegerty	E.Reid	4-Nov-10		

CONTENTS

1. INTRODUCTION

WorleyParsons Services Pty Ltd has been engaged by Moreton Bay Regional Council (MBRC) to carry out detailed surface water modelling over four of the regional catchments in their Local Government Area (LGA). The four catchments are Stanley River (STA), Neurum Creek (NEU), Mary River (MAR) and Byron Creek (BYR). These catchments make up 'Package 5' of MBRC's Regional Floodplain Database Project (RFD Project) and are referred to as 'minor basins' in the GIS data provided by MBRC.

At the commencement of this project MBRC handed over an extensive data set comprising established 'broad scale' models (including associated results and reporting) as well as several sources of historic flooding information. The purpose of this report is to assess the feasibility of carrying out historic event calibration and validation for the current detailed modelling project. This assessment is based on a review of the data set provided by MBRC.

2. AVAILABLE DATA

Details of the data available for calibration and validation modelling are provided in this section. This includes data provided by MBRC as well as information obtained from websites of the Bureau of Meteorology (BoM).

The BoM operate a flood warning alert network for the upper Brisbane River which incorporates several gauges within the Package 5 area. Details of the network, including location of alert flood and rainfall gauges are provided in Appendix A for reference purposes.

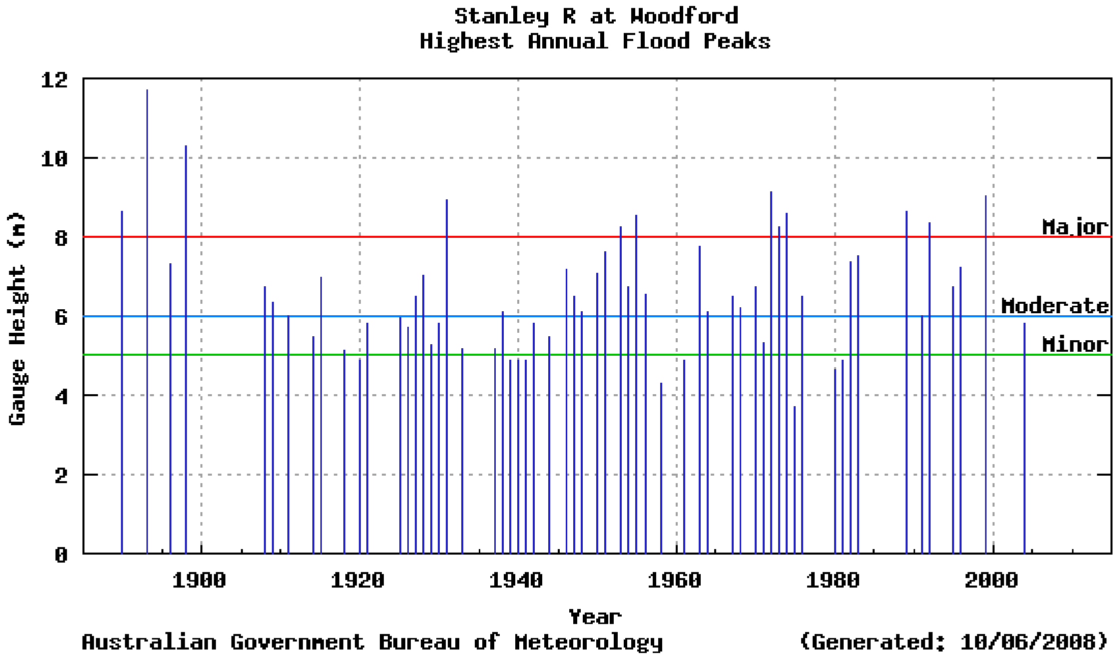
2.1 Stream Gauge Data

Stanley River has long term historic stream gauge data at Peachester and Woodford. Both of these stream gauges now incorporate telemetry and form part of the BoM's flood warning system. Details of the BoM's flood warning system are provided in Appendix A.

Hourly flow rate data has been provided for the Stanley River Peachester gauge for the period ranging from June 1927 up to April 2009.

Hourly flow rate data has been provided for the Stanley River Woodford gauge for the period ranging from February 2002 up to April 2009. This is not the complete range of data for the Stanley River which is known to extend back over 100 years. Historic flood heights at this stream gauge are shown on Figure 2.1 below. This figure is taken from the BoM's website "FLOOD WARNING SYSTEM for the UPPER BRISBANE RIVER ABOVE WIVENHOE DAM".

Figure 2.1 Stanley River Annual Flood Peaks (Source BoM)



There is no stream gauge data available for Byron Creek, Mary River or Neurum Creek (within the vicinity of the study area).

2.2 Rainfall Data

There are several historic rainfall stations with both continuous ('pluvio' or 'ALERT' data) and daily data situated in and around the package 5 minor basins. The spatial coverage of these rain gauges should allow a sufficient representation of historic rainfall patterns associated with the large weather systems which have historically generated regional flooding in the larger package 5 minor basins.

It is noted that due to the relatively small size of the Byron Creek minor basin (approx 6.8km^2), peak flooding in this catchment will be dominated by relatively short duration intense rainfall events. The inherent nature of these weather events is that they are not widespread and consequently historic flooding in Byron Creek is not likely to be well picked up by the nearest continuous rain gauge stations nearly 5km away.

We note that the MBRC supplied rainfall database does not include the pluvio data which is understood to be available from BoM for the Woodford Bcc rain gauge (dating back to 1964). The MBRC data provided is for the Woodford ALERT rain gauge only which dates back to November 1994.

We also note that only daily rainfall data is available for the Somerset Dam and the Hume Lane ALERT rain gauges in the supplied MBRC database. It is expected that some form of continuous record should also be available for these gauges from BoM.

2.3 Historic Flood Marks

A GIS layer called "OLD CAB Dist Historic Flood Levels' has been provided by MBRC. This contains recorded flood heights for 15 separate historic flood events.

There are over 110 recorded historic flood levels within the Stanley River minor basin. The two historic events populated with the most historic flood level data points are the February 1999 event and the April 1989 event. There are only two historic flood marks in the STA catchment for the May 2009 event (near Woodford).

No recorded flood level data has been provided for Byron Creek, Mary River or Neurum Creek.

2.4 Other Data

A GIS layer called "Maximum Height Indicators' has been provided by MBRC, however this data layer doesn't contain any information relevant to the Package 5 minor basins.

A GIS layer called "WQ Event Monitoring Program' has been provided by MBRC, however this data layer also doesn't contain any information relevant to the Package 5 minor basins.

It is recommended that data associated with design and historic flood levels in Somerset Dam be sourced. The reason for this is that the water level in the dam will influence flood levels in the lower Stanley River Catchment.

3. FLOOD EVENTS

3.1 Possible Events for Calibration/Validation

3.1.1 Stanley River

The following historic floods are considered the most appropriate for calibration and validation of the Stanley River catchment.

- February 1999: 373mm rainfall at Woodford over 94 hours. This flood was classified as a major flood at BoM's Woodford Flood ALERT flood gauge. There are also numerous peak flood level historic marks available for this event
- April 1989: 609mm rainfall at Crohamhurst over 8 days. This flood was classified as a major flood at BoM's Woodford Flood ALERT flood gauge. There are also numerous peak flood level historic marks available for this event. In the rainfall data provided by MBRC this event has only been picked up in the Crohamhurst pluvio data. It is expected that additional pluvio data could also be sourced from the BoM Woodford rain gauge.

3.1.2 Mary River

If sufficient peak water level flood marks can be obtained, the following historic floods are considered the most appropriate for calibration and validation of the Mary River catchment.

- March 2003: 519mm rainfall at West Bellthorpe rain gauge over 41 hours (peak 6 hour intensity of 54mm/hr);
- February 1999: 489mm rainfall at West Bellthorpe rain gauge over 4 days (peak 6 hour intensity of 19mm/hr).

3.1.3 Neurum Creek

If sufficient peak water level flood marks can be obtained, the following historic floods are considered the most appropriate for calibration and validation of the Neurum Creek catchment.

- February 1999: 502mm rainfall at Mount Mee rain gauge over 93 hours (peak 6 hour intensity of 21mm/hr).
- March 2009: 350mm rainfall at Mount Mee rain gauge over 76 hours (peak 6 hour intensity of 15mm/hr).

3.1.4 Byron Creek

Calibration of the Byron Creek catchment is not considered feasible due to the lack of both suitable rainfall data and also the expected lack of flood marks that will be available in this bushland dominated catchment.

3.2 Feasibility of Calibration/Validation

3.2.1 Stanley River

Calibration and validation of the Stanley River catchment is considered feasible based on the data provided by MBRC. There are sufficient historic flood level marks and rainfall data to carry out these tasks for the events described in Section 3.1.1.

It is however recommended that additional pluvio data be sourced from the BoM Woodford rain gauge for the April 1989 event.

3.2.2 Mary River & Neurum Creek

There is sufficient rainfall data for both the Mary River and the Neurum Creek catchments for the events described in Section 3.1.2 and Section 3.1.3. Unfortunately no historic water level data is currently available in either of these catchments. Consequently, historic flood level data would need to be collected to undertake calibration and validation.

3.2.3 Byron Creek

Calibration of the Byron Creek catchment is not considered feasible due to the lack of both suitable rainfall data and also the expected lack of flood marks that will be available in this bushland dominated catchment.

4. RECOMMENDATIONS

4.1.1 Stanley River

It is recommended that calibration and validation of the Stanley River models be carried out for the events detailed in Section 3.1.1.

It is recommended that additional pluvio data be sourced from the BoM Woodford rain gauge for the April 1989 event.

It is also recommended that the complete historic record be sourced for the Woodford Stanley River flood gauge.

It is recommended that data associated with design and historic flood levels in Somerset Dam be sourced. The reason for this is that the water level in the dam will influence flood levels in the lower Stanley River Catchment.

4.1.2 Mary River & Neurum Creek

It is recommended that MBRC collect historic flood level data for these catchments for the events detailed in Section 3.1.2 and 3.1.3.

4.1.3 Byron Creek

It is considered that no historic calibration can be carried out for the Byron Creek catchment and that calibration parameters for the Byron Creek models be based on the calibrated values of the remaining package 5 minor basins.

5. REFERENCES

Bureau of Meteorology, September 2009 (last website update), “FLOOD WARNING SYSTEM for the UPPER BRISBANE RIVER ABOVE WIVENHOE DAM” (http://www.bom.gov.au/hydro/flood/qld /brochures/brisbane_upper/brisbane_upper_above_wivenhoe_dam.shtml)

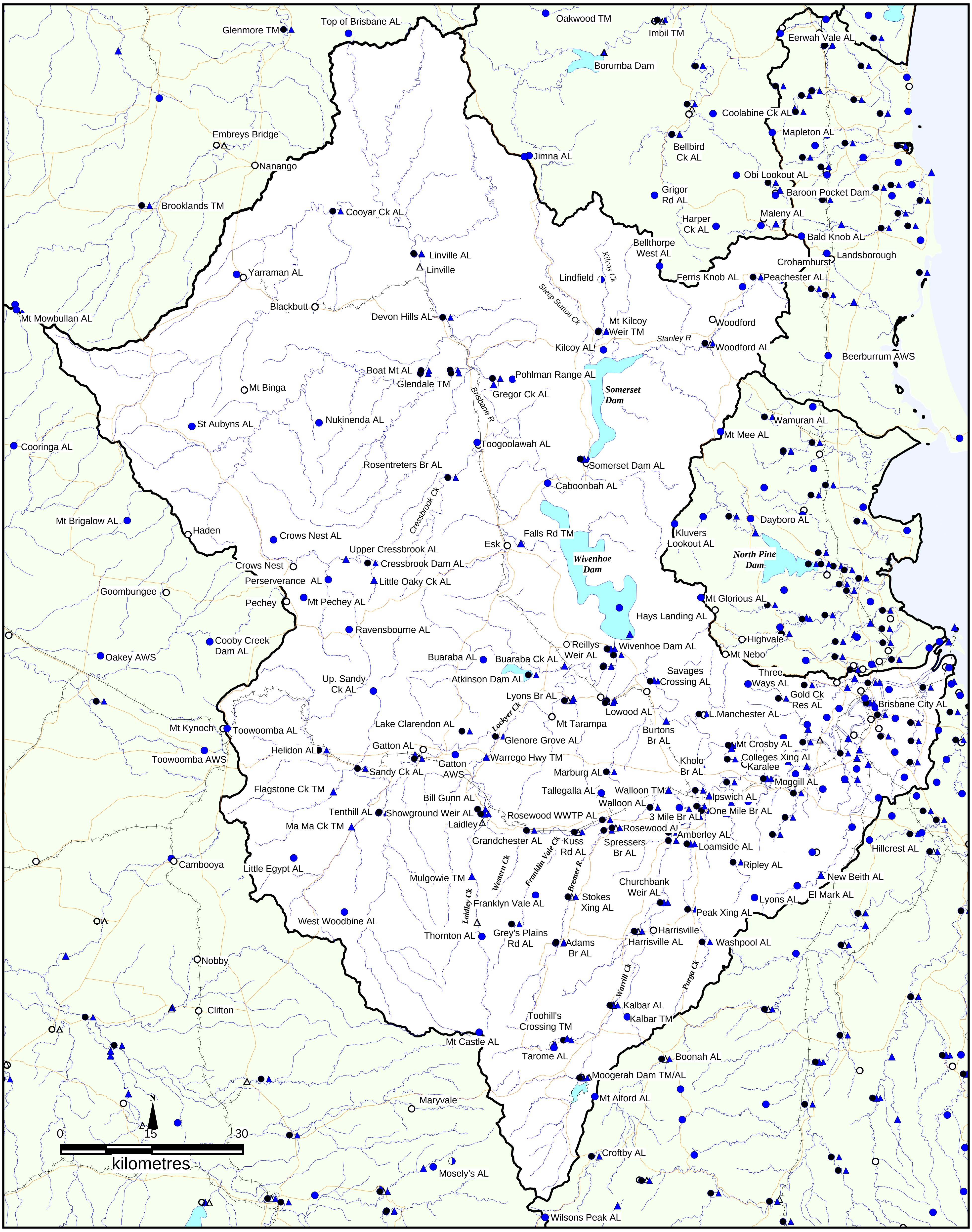
GHD (for MBRC), June 2010, “Regional Floodplain Database, Sub-project 2K Historic Flood Information”

Sargent Consulting (for the Caboolture Shire Council), March 2005, “Stanley River Flood Study Final Report”

Appendix 1 - BoM Brisbane, Bremer, Stanley Rivers Flood Warning Network

Australian Government
Bureau of Meteorology

MAP 143.1



◑	Manual Heavy Rainfall Station
○	Daily Reporting Rainfall Station
△	Manual River Station
●	Telemetry Rainfall Station
▲	Telemetry River Station

BRISBANE, BREMER & STANLEY RIVERS

FLOOD WARNING NETWORK

Major Roads

Railway

Revised: Nov 2009

r:/pub/maps/map03/map143_1.wor

APPENDIX D: MODELLING QUALITY REPORT

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TECHNICAL NOTE

DATE	10 July 2010
TO	Moreton Bay Regional Council
FROM	Leonard Cheung
COPY	
PROJECT	301001-01156
SUBJECT	Stanley River Modelling Quality Report
DOC NO	
FILE LOC	

INTRODUCTION

A detailed TUFLOW model of the Stanley River (STA) minor basin has been developed as part of Moreton Bay Regional Council's (MBRC) Regional Floodplain Database (RFD) Stage 2 project.

This technical note is prepared to demonstrate that the performance of the STA model is suitable for the intended use and the associated model outputs can be adopted by MBRC for the RFD to deliver reliable flood information across the Stanley River minor basin.

MODEL PERFORMANCE

Model stability, warning messages and mass errors were monitored throughout model simulation periods to ensure that the model performance was acceptable. Careful attention has been paid to ensure that flood water flowing through the 1D structure elements in the model as well as flowing across the floodplain in the 2D domain were stable during model simulation period.

Overland flow hydrographs were checked at key locations in the floodplain (PO lines) to ensure the simulation extended well beyond the peak throughout the STA study area, especially around the downstream boundary.

To demonstrate there are no significant loss or gain of flood volumes during model runs, a check of the mass balance of the flood volumes for the three selected critical durations of the 10Yr, 100Yr ARI and PMF flood events has been undertaken and presented in the following Table 1.

Table 1: Mass Balance Check

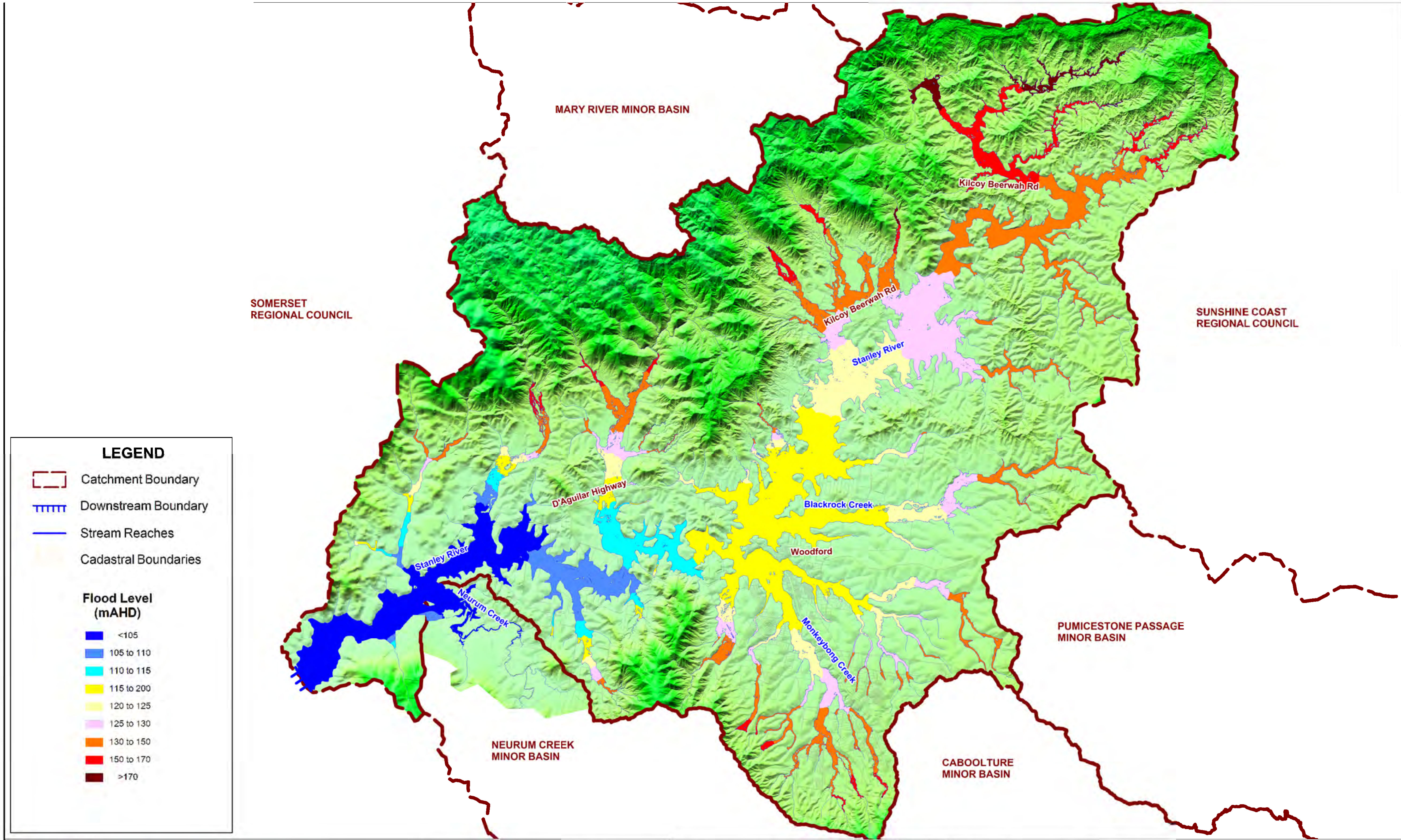
Event	10Yr ARI			100Yr ARI			PMF		
Critical Duration	**120M**	**720M**	**1440M**	**120M**	**720M**	**1440M**	**120M**	**360M**	**720M**
Volume at Start (m3)	30835642	30835642	30835642	41039327	41039327	41039327	173122879	173122879	173122879
Volume at End (m3)	44286143	64861081	65197048	66316378	111718655	103610471	289682264	347759616	397735319
Total Volume In (m3)	49607805	94081952	116520167	78552237	160378434	209437282	390109448	623430087	694581802
Total Volume Out (m3)	35771033	59946928	81245568	52805260	89051077	145418870	273416440	448613502	469694679
Volume Error (m3)	-386270	-109585	-913193	-469926	-648029	-1447269.00	-133624	-179848	-274684
Final Cummulative ME (%)	-0.45%	-0.07%	-0.46%	-0.36%	-0.26%	-0.41%	-0.02%	-0.02%	-0.02%

The above table shows that there are no significant loss and gain of flood volume during the modelling and the mass balance errors are within the range of -0.46% to -0.02% for the critical duration runs of the three design events.

CONCLUSIONS

The quality of the STA model run has been reviewed. It is considered that the overall model performance is suitable for the intended use and the associated model outputs can be adopted for the MBRC RFD to deliver reliable flood information across the Stanley River minor basin.

APPENDIX E: FLOOD MAPS – 100 YEAR ARI



0 3000 6000m

SCALE - 1:120,000 (at A3)

Latitude / Longitude
Geocentric Datum of Australia 1994

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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER
FIGURE E1 PEAK FLOOD LEVEL MAP - 100 YEAR ARI

Project No: 301001-01156	Figure:301001-01156-EN-DAL-0090	Rev: 0

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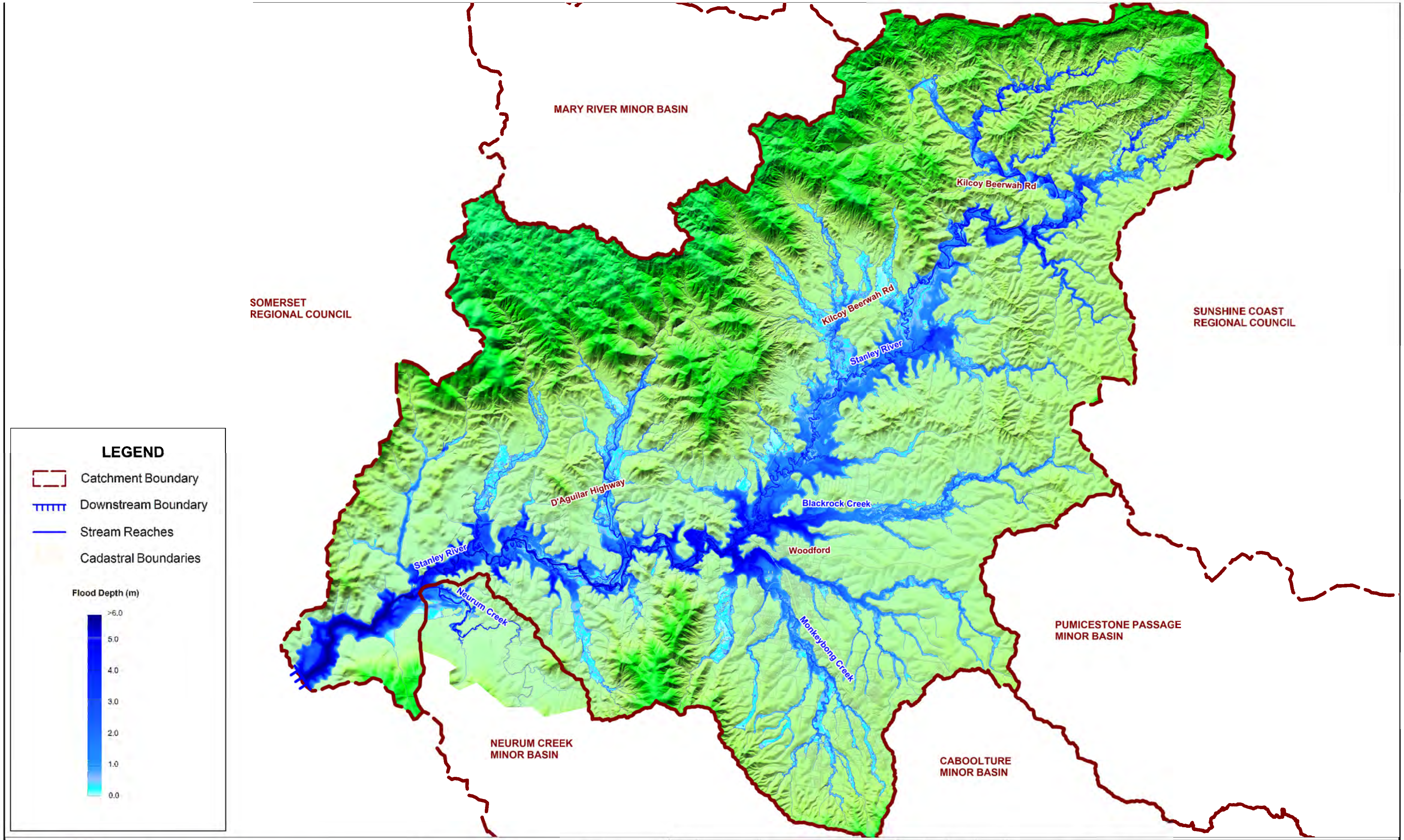

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SCALE - 1:120,000 (at A3)

Latitude / Longitude
Geocentric Datum of Australia 1994

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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER
FIGURE E2 PEAK FLOOD DEPTH MAP - 100 YEAR ARI

Project No: 301001-01156 | Figure:301001-01156-EN-DAL-0091 | Rev: 0

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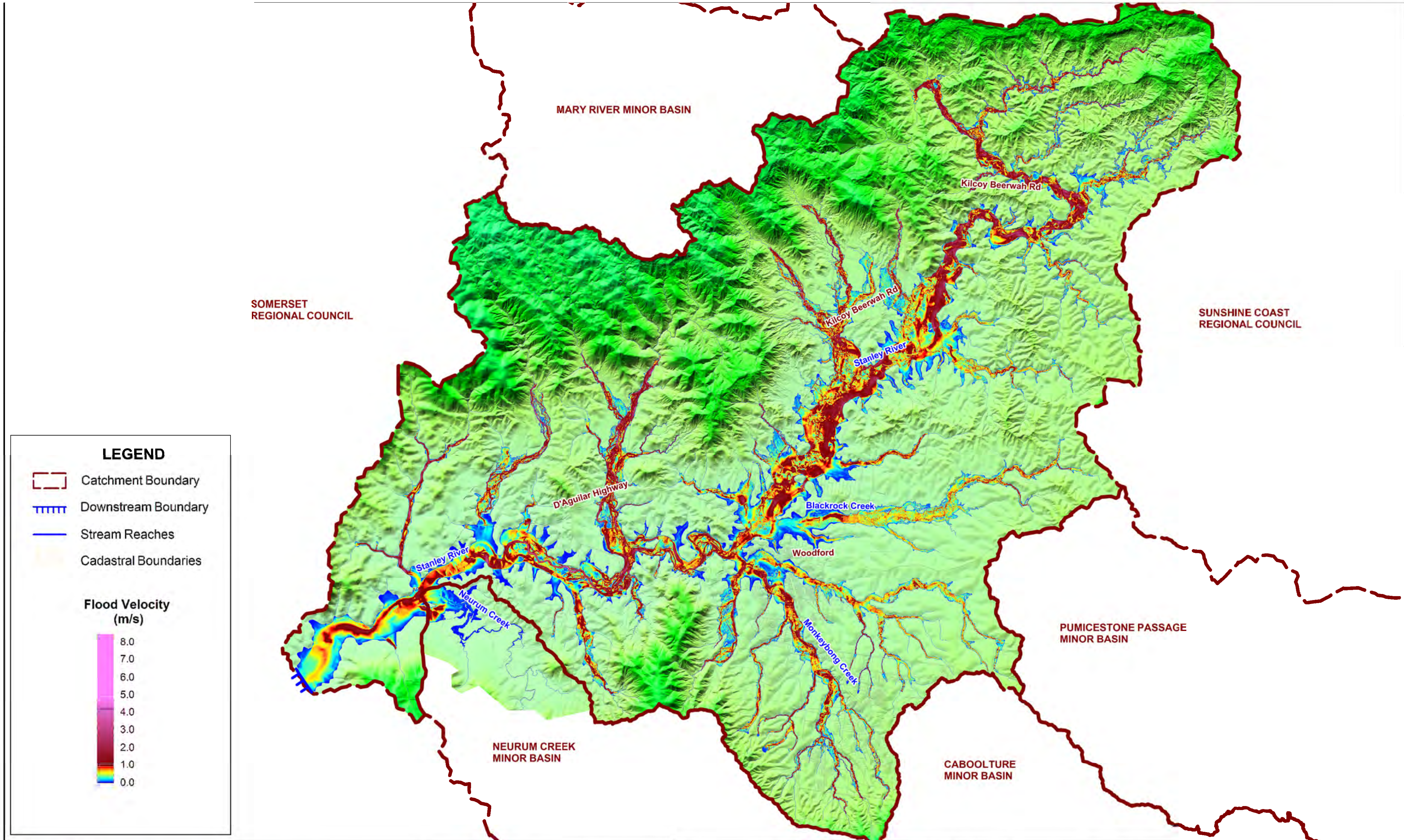

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Geocentric Datum of Australia 1994

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STANLEY RIVER
FIGURE E3 PEAK FLOOD VELOCITY MAP - 100 YEAR ARI

Project No: 301001-01156 | Figure:301001-01156-EN-DAL-0092 | Rev: 0

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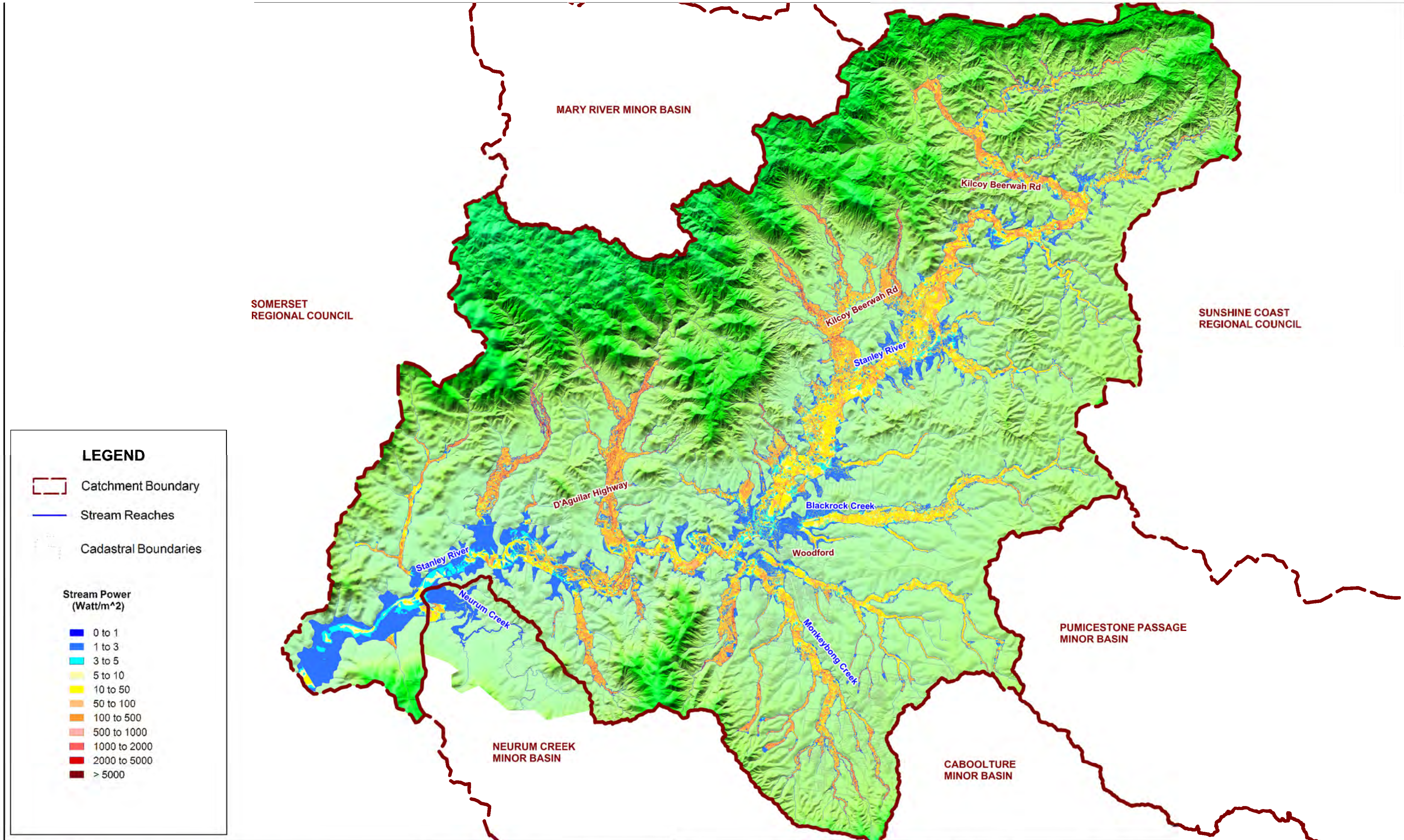

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Latitude / Longitude
Geocentric Datum of Australia 1994

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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER
FIGURE E4 PEAK STREAM POWER MAP - 100 YEAR ARI

Project No: 301001-01156	Figure:301001-01156-EN-DAL-0093	Rev: 0

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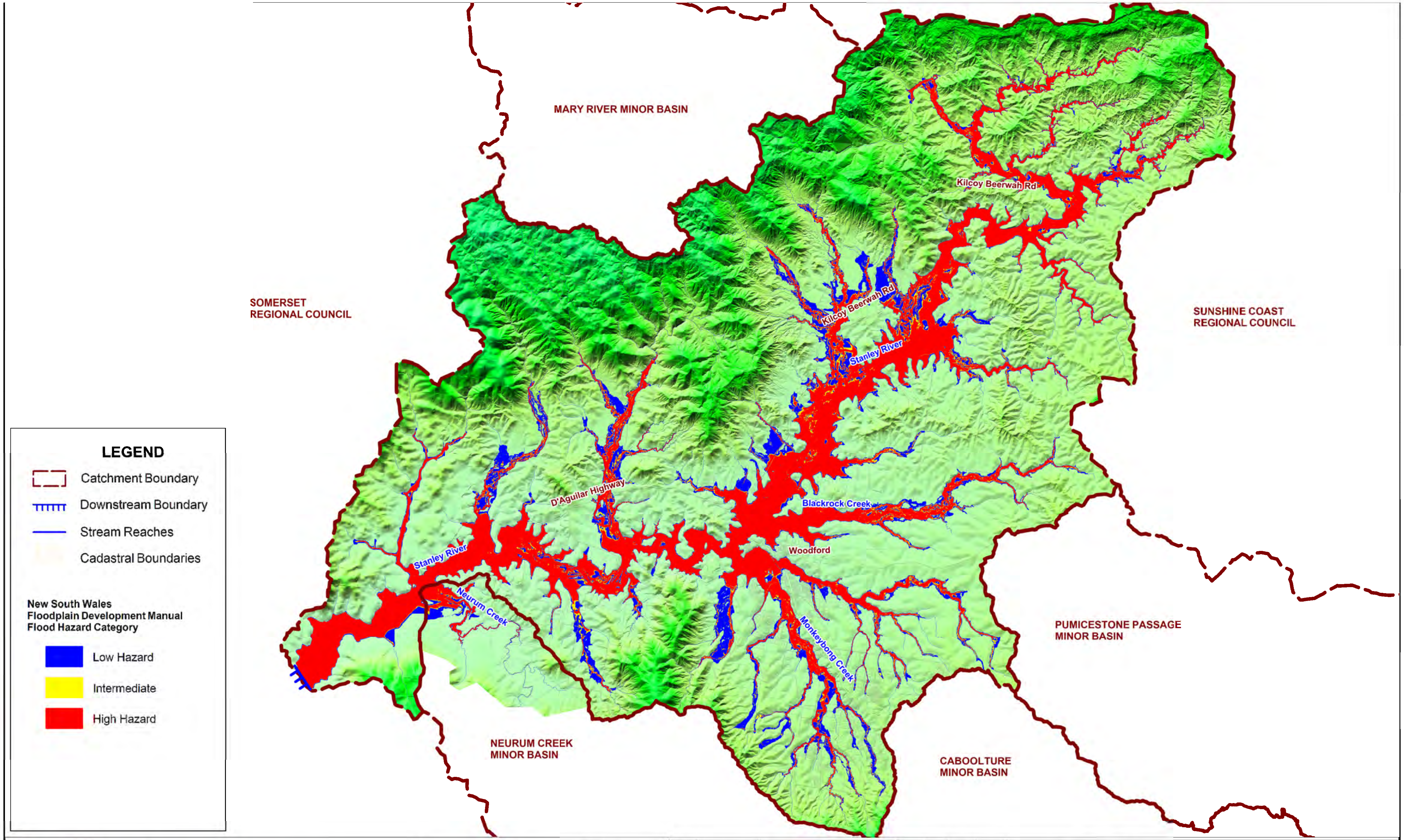

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Latitude / Longitude
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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER
FIGURE E5 PEAK FLOOD HAZARD MAP - 100 YEAR ARI

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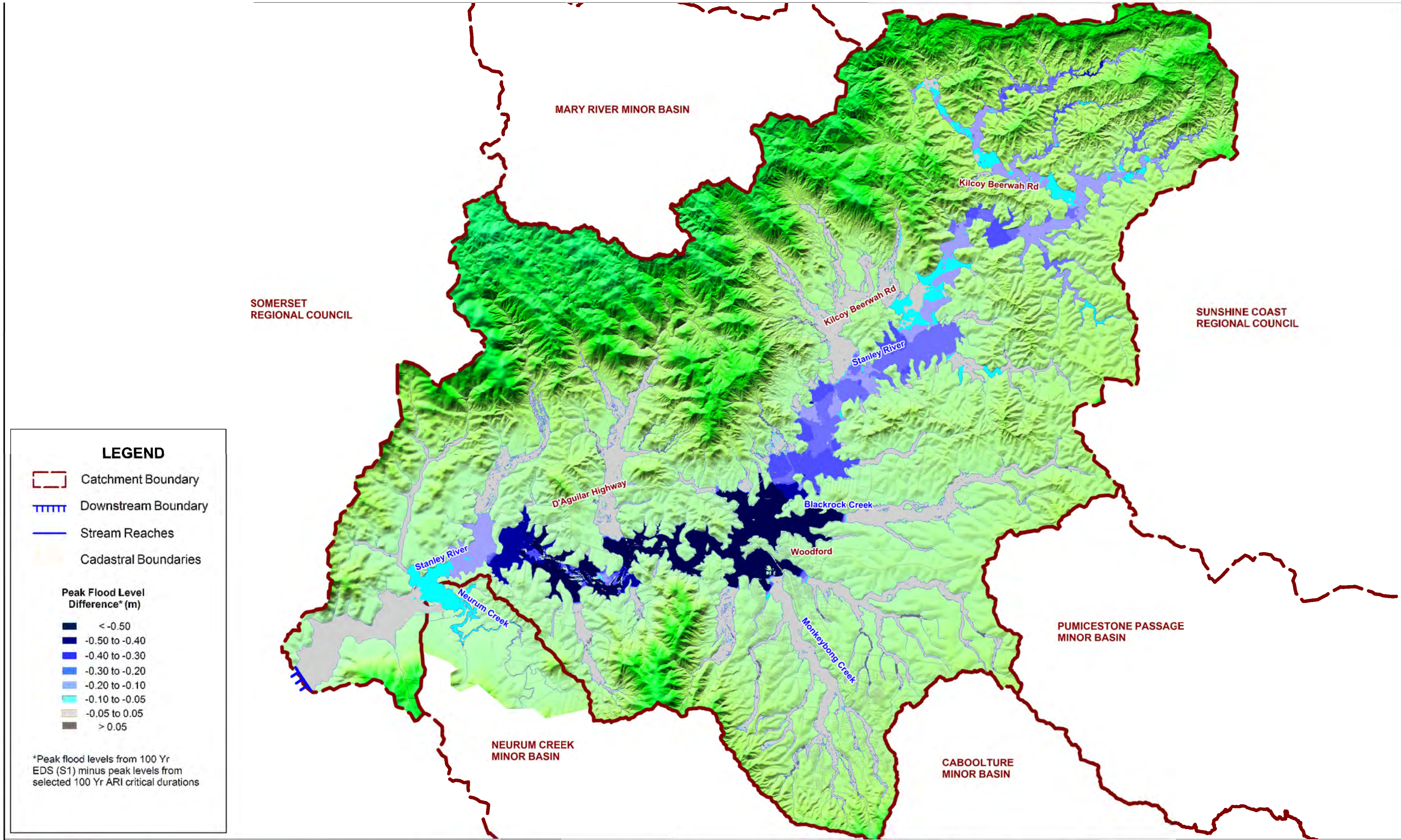
APPENDIX F: MODEL SENSITIVITY ANALYSIS MAPS



0 3000 6000m

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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER
FIGURE F1 FLOOD LEVEL DIFFERENCE BETWEEN EDS AND SELECTED CRITICAL STORM DURATIONS - 100 YR ARI (S1)

Project No: 301001-01156	Figure:301001-01156-EN-DAL-0095	Rev: 0

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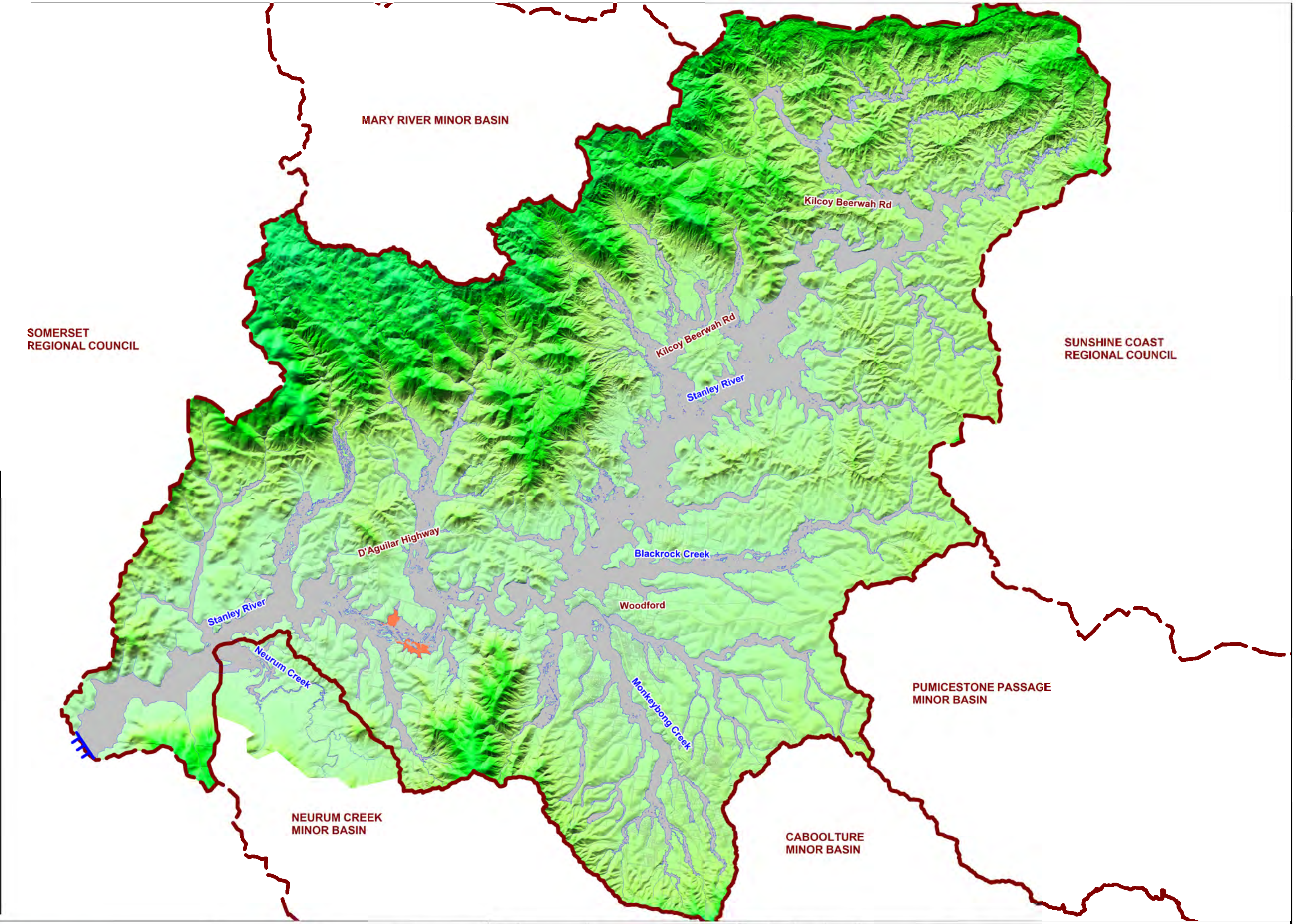

LEGEND

- Catchment Boundary
- Downstream Boundary
- Stream Reaches
- Cadastral Boundaries

Peak Flood Level Difference* (m)

- < -0.50
- -0.50 to -0.10
- -0.10 to 0.10
- 0.10 to 0.50
- > 0.50
- Was dry now wet
- Was wet now dry

*Peak flood levels from increase in roughness (S2) minus peak flood levels from 100 Yr EDS (S1)

0 3000 6000m

SCALE - 1:120,000 (at A3)

Latitude / Longitude
Geocentric Datum of Australia 1994

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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER
FIGURE F2 INCREASE IN ROUGHNESS FLOOD LEVEL IMPACT - 100 YEAR EDS (S2)

Project No: 301001-01156 | Figure:301001-01156-EN-DAL-0096 | Rev: 0

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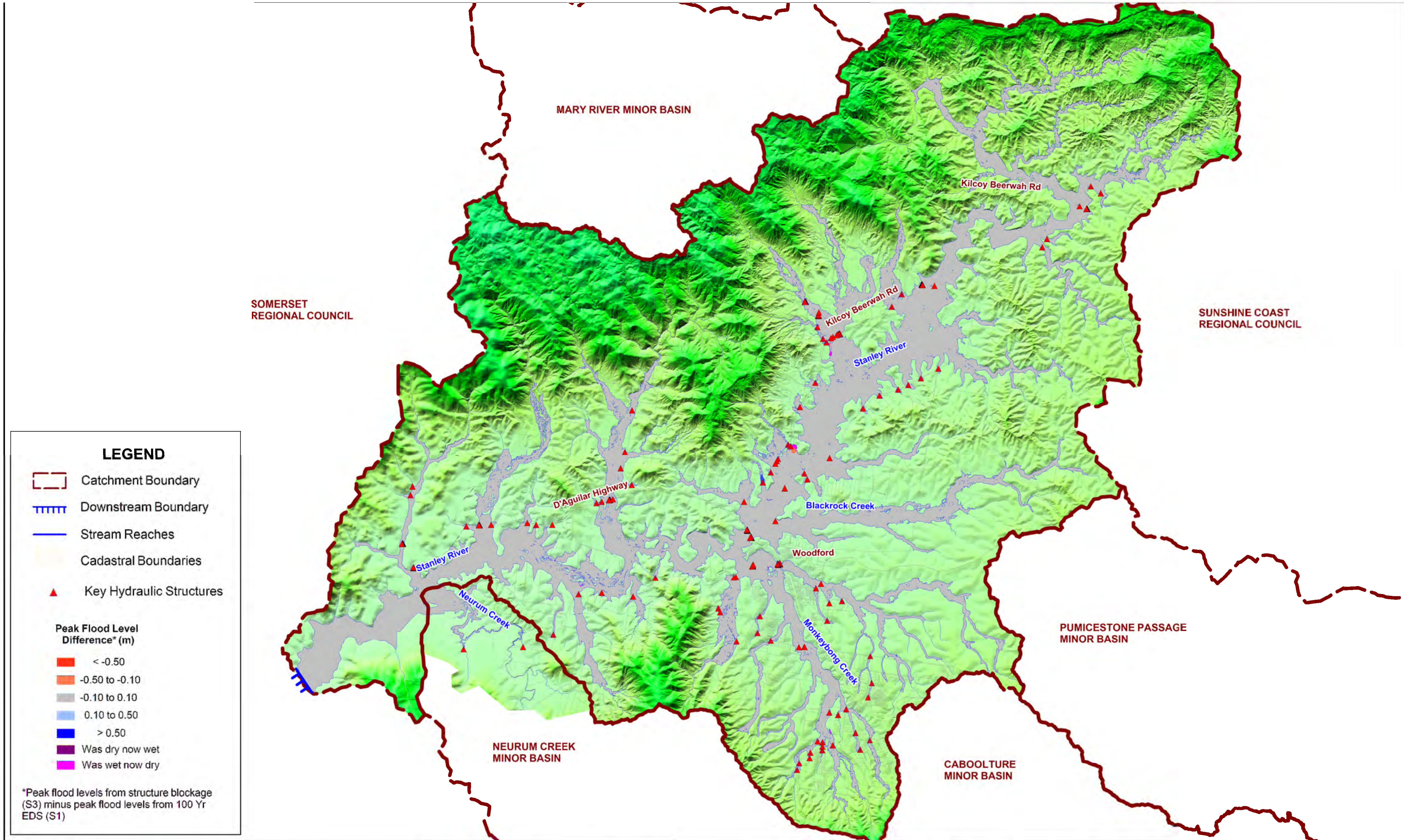

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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER
FIGURE F3 STRUCTURE BLOCKAGE FLOOD LEVEL IMPACT - 100 YEAR EDS (S3)

Project No: 301001-01156 | Figure:301001-01156-EN-DAL-0097 | Rev: 0

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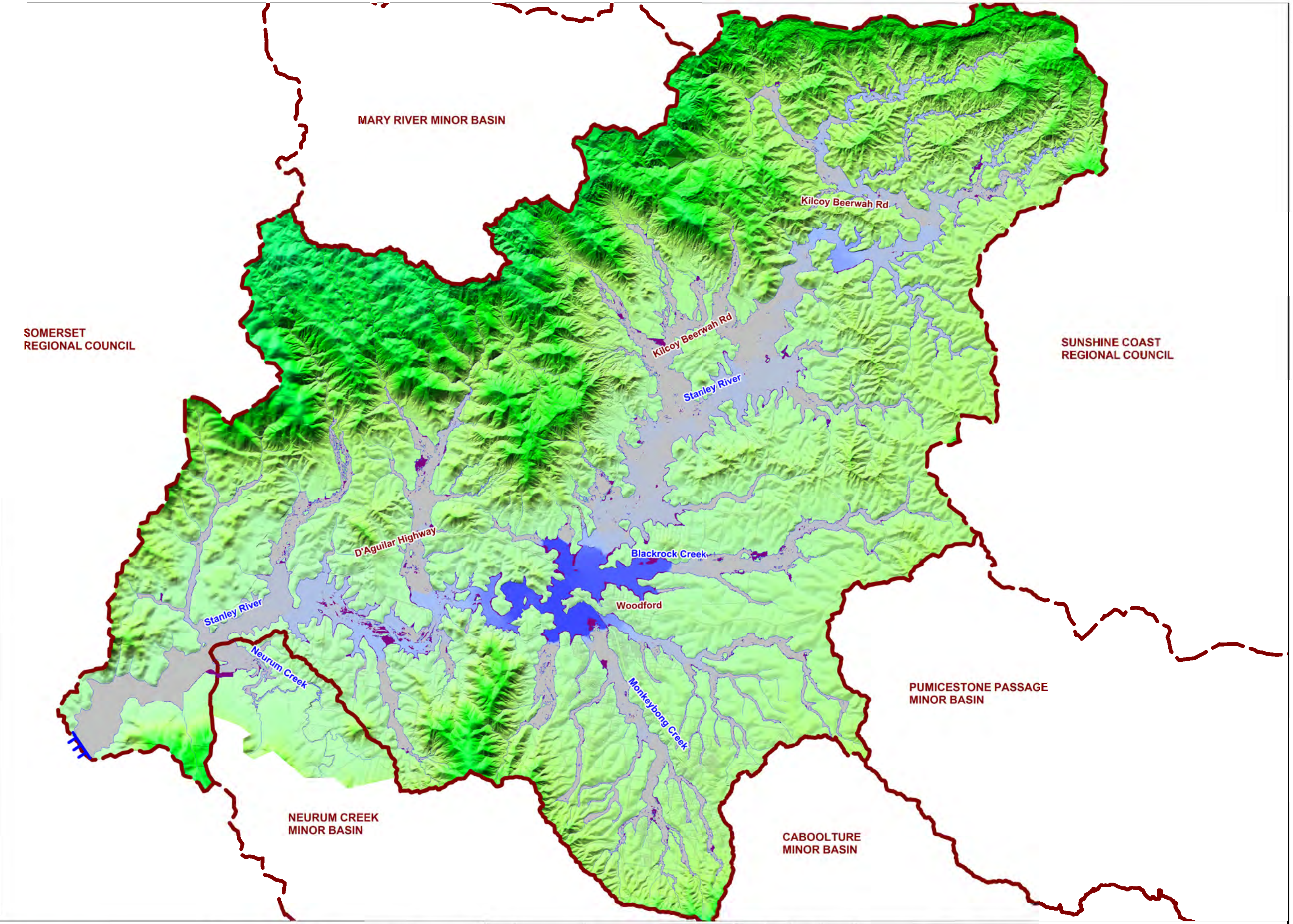

LEGEND

Catchment Boundary
Downstream Boundary
Stream Reaches
Cadastral Boundaries

Peak Flood Level Difference* (m)

- < -0.50
- -0.50 to -0.10
- -0.10 to 0.10
- 0.10 to 0.50
- 0.50 to 1.00
- > 1.00
- Was dry now wet
- Was wet now dry

*Peak flood levels from increase in rainfall (S4) minus peak flood levels from 100 Yr EDS (S1)

0 3000 6000m

SCALE - 1:120,000 (at A3)

Latitude / Longitude
Geocentric Datum of Australia 1994

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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER
FIGURE F4 INCREASE IN RAINFALL FLOOD LEVEL IMPACT - 100 EDS (S4)

Project No: 301001-01156	Figure:301001-01156-EN-DAL-0098	Rev: 0

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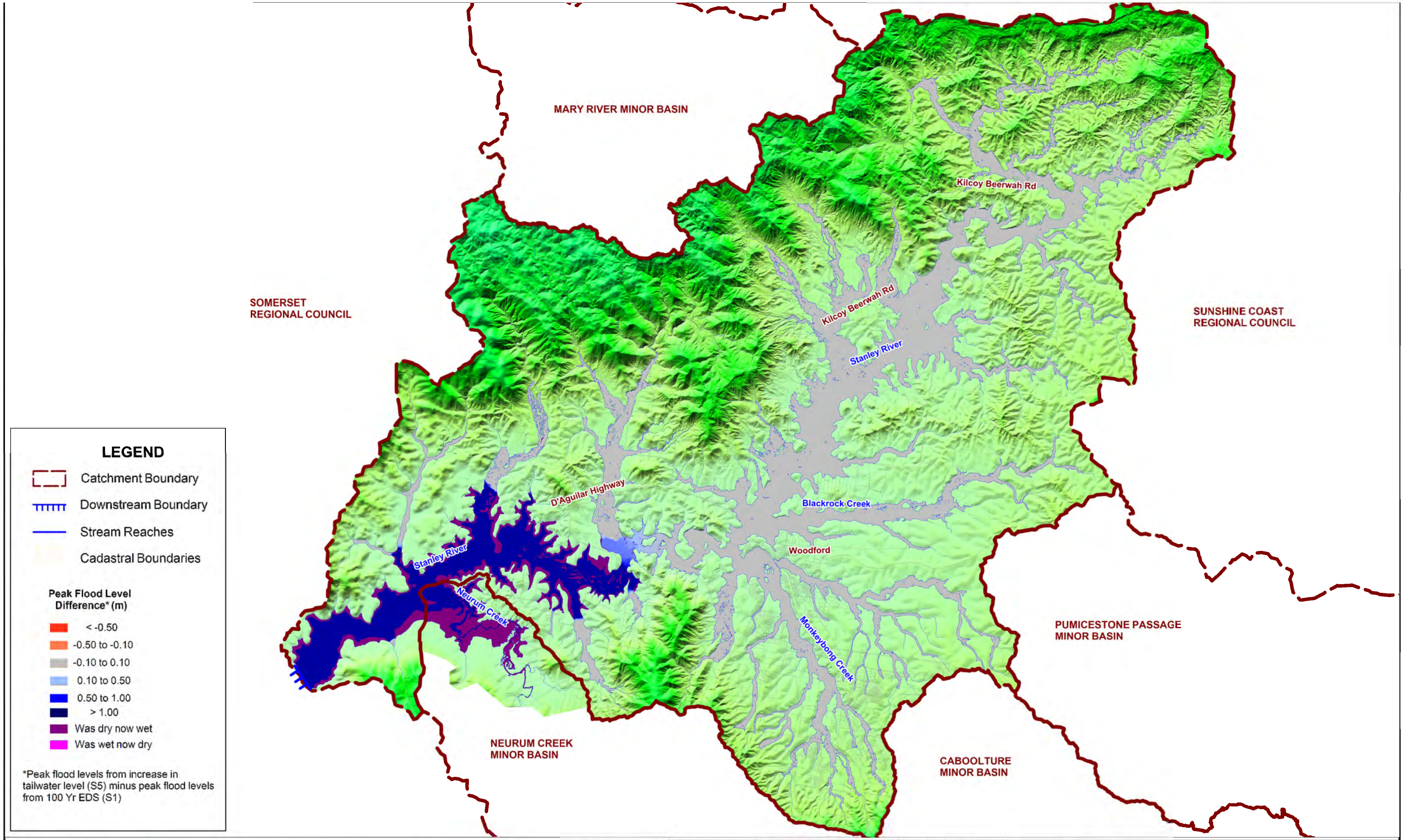

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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER
FIGURE F5 INCREASE IN TAILWATER LEVEL
FLOOD LEVEL IMPACT - 100 EDS (S5)

Project No: 301001-01156 | Figure:301001-01156-EN-DAL-0099 | Rev: 0

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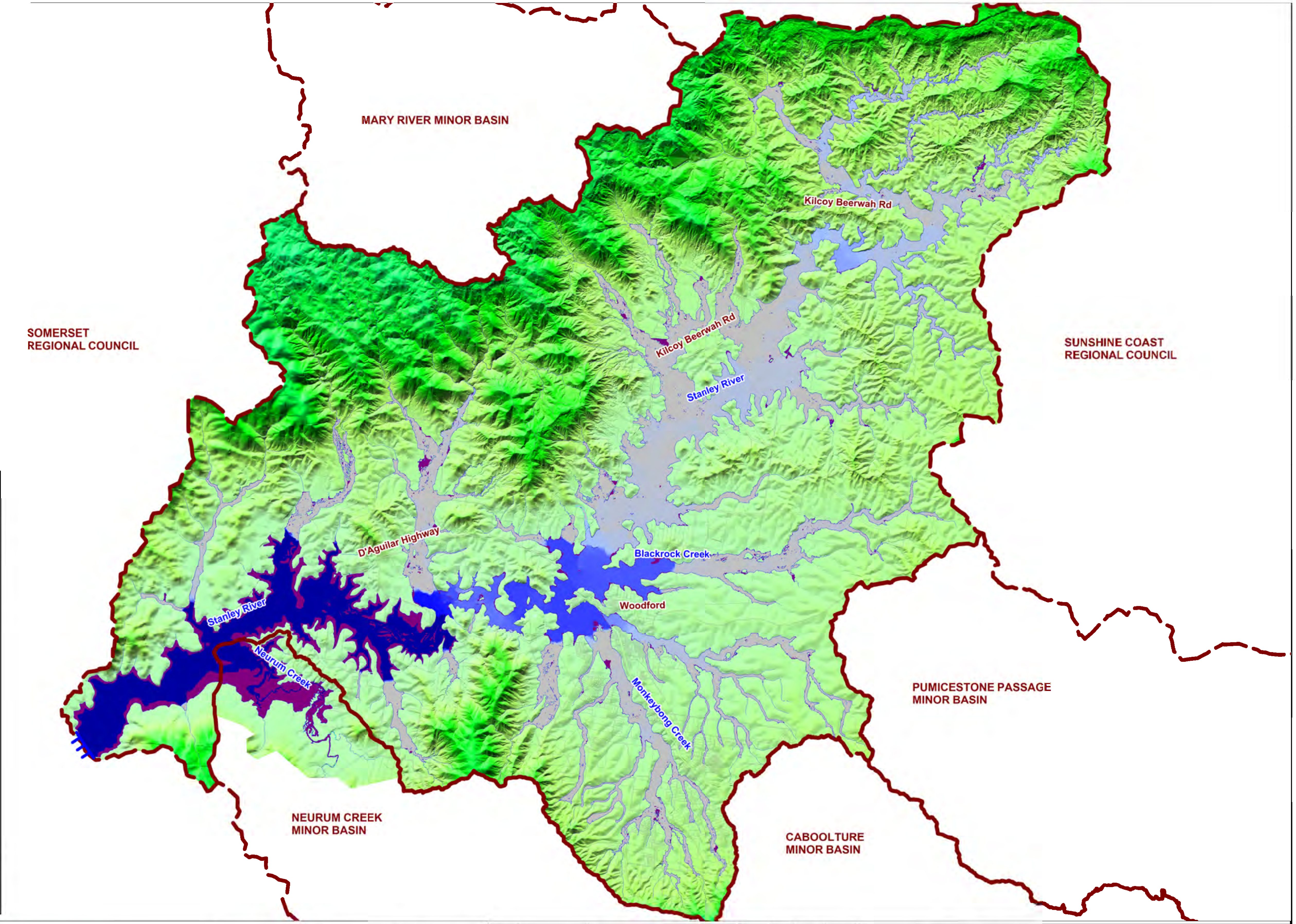

LEGEND

- Catchment Boundary
- Downstream Boundary
- Stream Reaches
- Cadastral Boundaries

Peak Flood Level Difference* (m)

- < -0.50
- -0.50 to -0.10
- -0.10 to 0.10
- 0.10 to 0.50
- 0.50 to 1.00
- > 1.00
- Was dry now wet
- Was wet now dry

*Peak flood levels from increase in rainfall & tailwater level (S6) minus peak flood levels from 100 Yr EDS (S1)

SCALE - 1:120,000 (at A3)

Latitude / Longitude
Geocentric Datum of Australia 1994

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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER
FIGURE F6 INCREASE IN RAINFALL & TAILWATER LEVEL
FLOOD LEVEL IMPACT - 100 EDS (S6)

Project No: 301001-01156	Figure:301001-01156-EN-DAL-0100	Rev: 0

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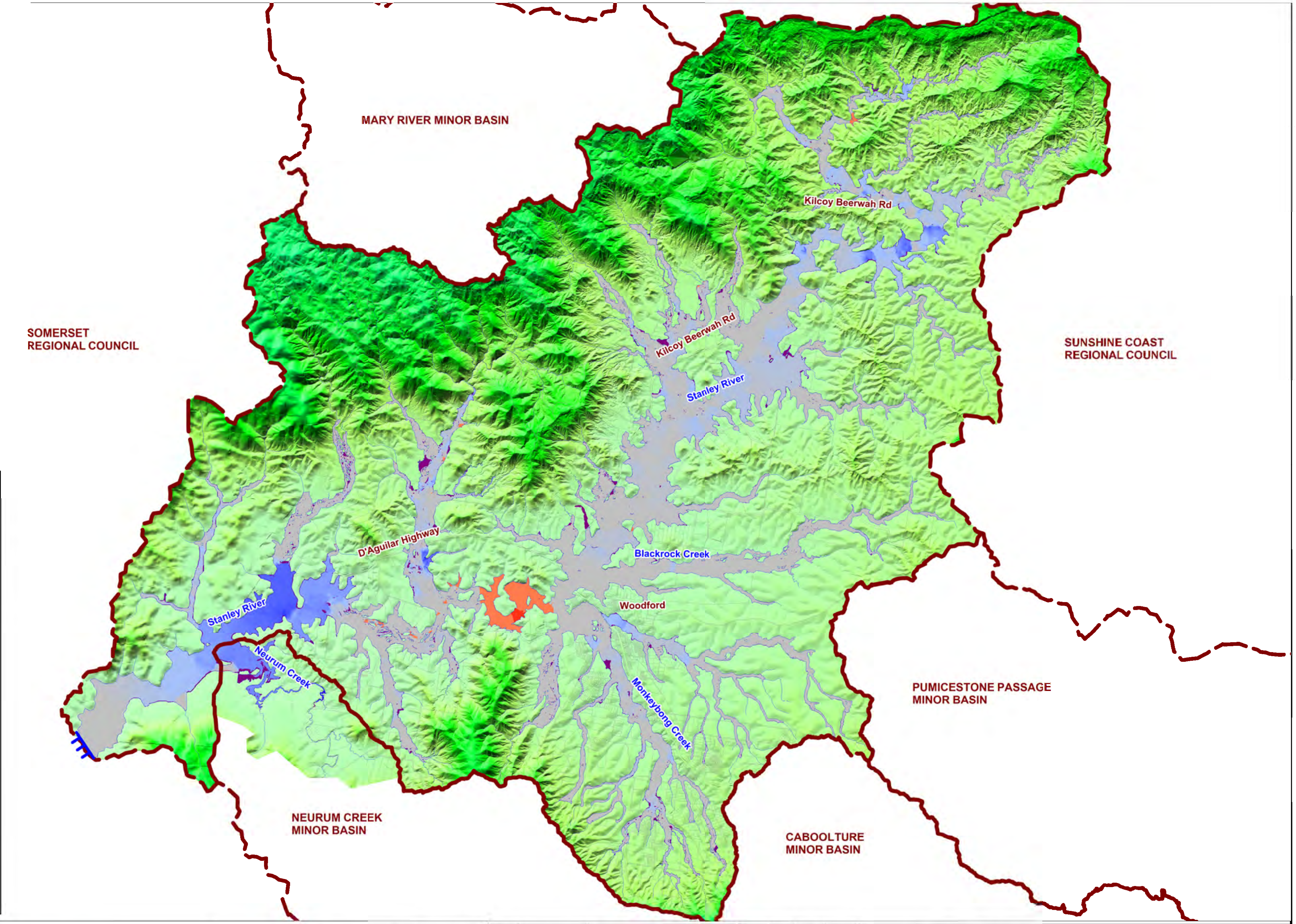

LEGEND

- Catchment Boundary
- Downstream Boundary
- Stream Reaches
- Cadastral Boundaries

Peak Flood Level Difference* (m)

- < -0.50
- -0.50 to -0.10
- -0.10 to 0.10
- 0.10 to 0.50
- > 0.50
- Was dry now wet
- Was wet now dry

*Peak flood levels from increase in vegetation (S10) minus peak flood levels from 100 Yr EDS (S1)

0 3000 6000m

SCALE - 1:120,000 (at A3)

Latitude / Longitude
Geocentric Datum of Australia 1994

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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER
FIGURE F10 INCREASE IN VEGETATION FLOOD LEVEL IMPACT - 100 EDS (S10)

Project No: 301001-01156	Figure:301001-01156-EN-DAL-0101	Rev: 0

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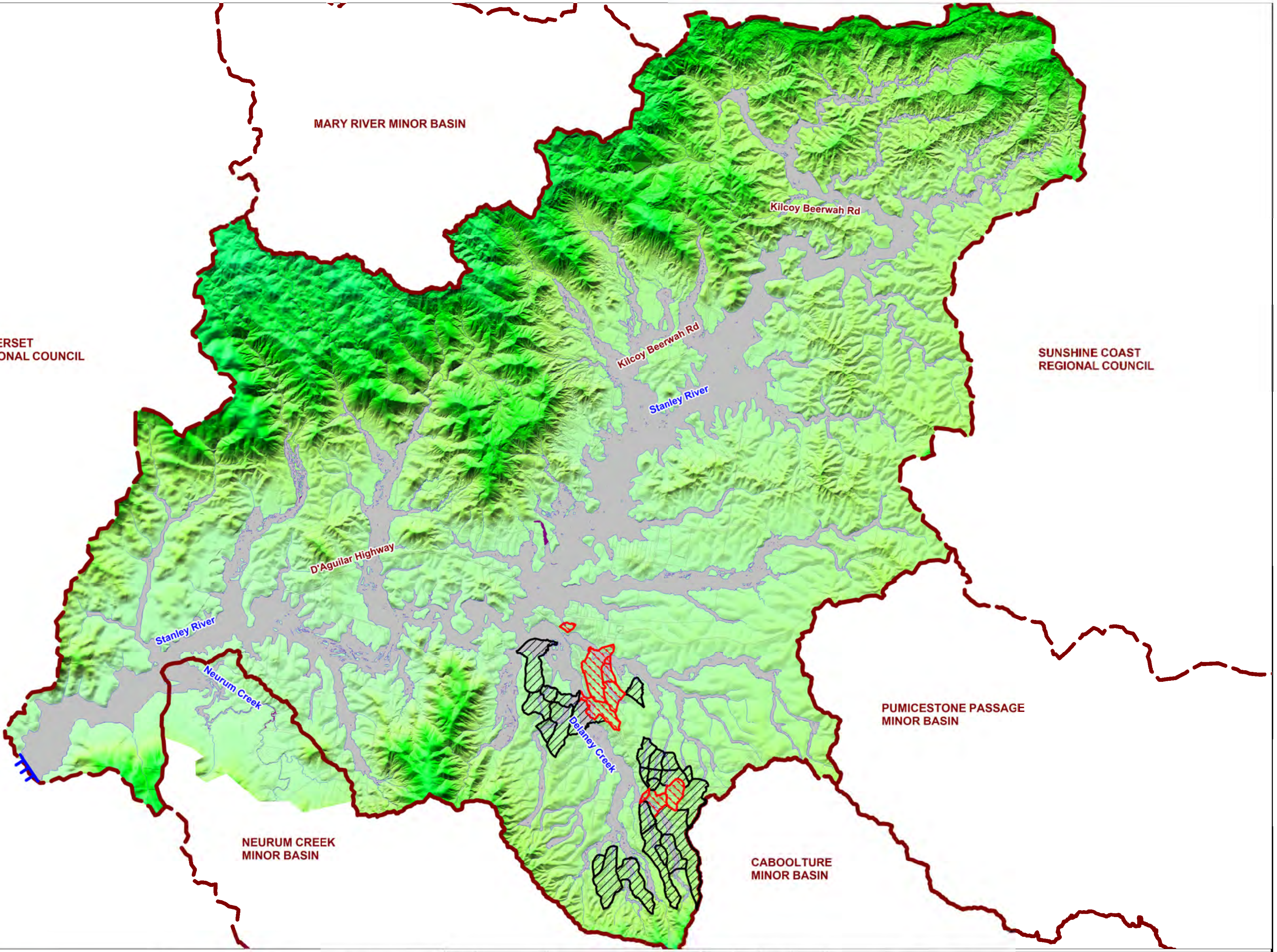

LEGEND

- Catchment Boundary
- Downstream Boundary
- Stream Reaches
- Cadastral Boundaries
- 10% Impervious Area
- 40% Impervious Area

Peak Flood Level Difference* (m)

- < -0.50
- -0.50 to -0.10
- -0.10 to 0.10
- 0.10 to 0.50
- > 0.50
- Was dry now wet
- Was wet now dry

*Peak flood levels from increase in residential development (S11) minus peak flood levels from 100 Yr EDS (S1)

0 3000 6000m

SCALE - 1:120,000 (at A3)

Latitude / Longitude
Geocentric Datum of Australia 1994

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0	30/07/2012	Issue for use	LC	KH	LC		

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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER
FIGURE F11 INCREASE IN RESIDENTIAL DEVELOPMENT FLOOD LEVEL IMPACT - 100 EDS (S11)

Project No: 301001-01156 | Figure:301001-01156-EN-DAL-0102 | Rev: 0

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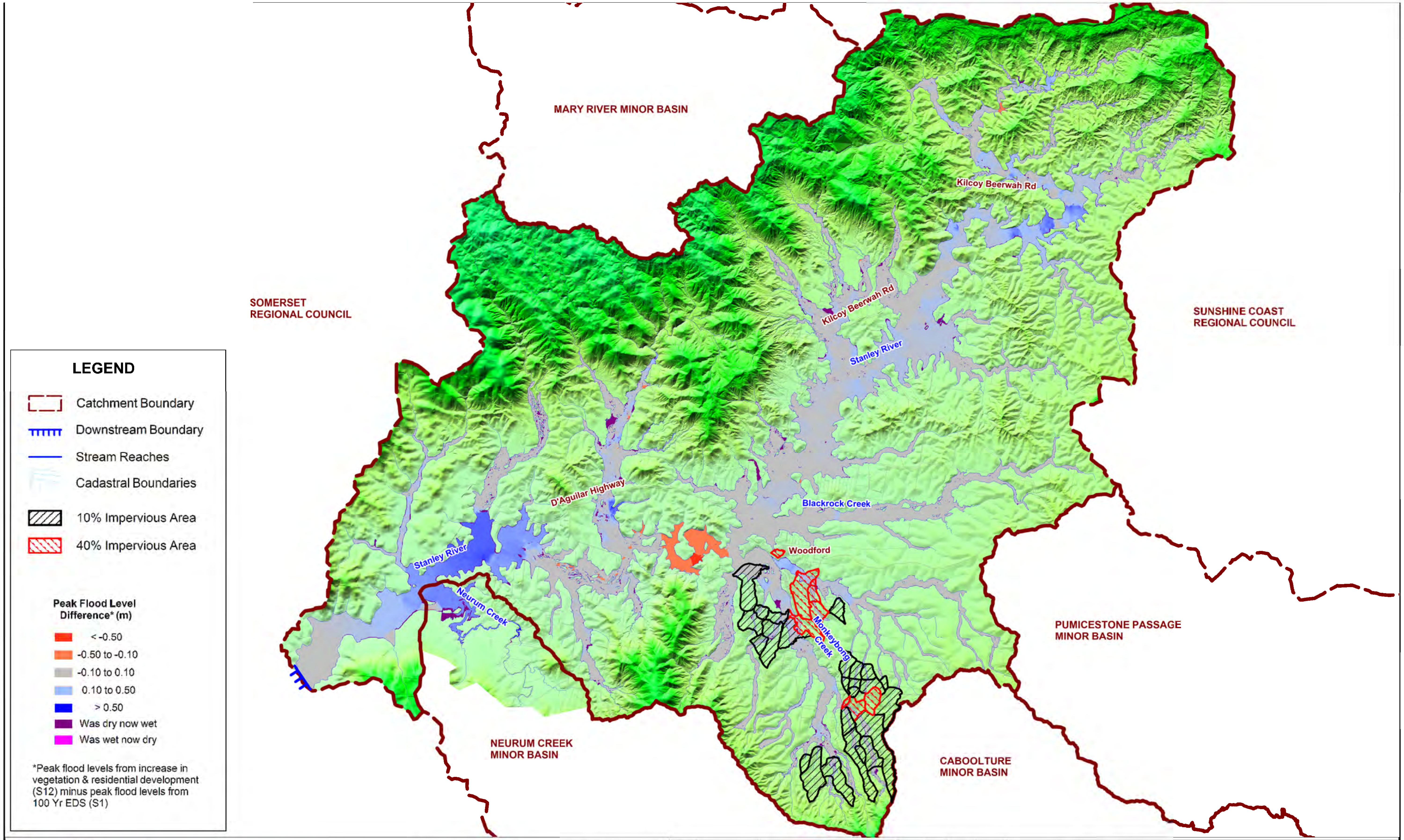

0 3000 6000m

SCALE - 1:120,000 (at A3)

Latitude / Longitude
Geocentric Datum of Australia 1994

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REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)
STANLEY RIVER
FIGURE F12 INCREASE IN VEGETATION & RESIDENTIAL DEVELOPMENT FLOOD LEVEL IMPACT - 100 EDS (S12)

Project No: 301001-01156	Figure:301001-01156-EN-DAL-0103	Rev: 0

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