Regional Floodplain Database:

Hydrologic and Hydraulic Modelling - Lower Pine River (LPR)

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Regional Floodplain Database Hydrologic and Hydraulic Modelling

Lower Pine River (LPR) April 2013

Moreton Bay Regional Council

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Regional Floodplain Database Hydrologic and Hydraulic Modelling Lower Pine River (LPR) Final Report

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Title :	Regional Floodplain Database, Hydrologic and Hydraulic Modelling: Lower Pine River (LPR)
Author :	Anne Kolega \ Richard Sharpe
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1 INTRODUCTION

Moreton Bay Regional Council (MBRC) is currently undertaking Stage 3 of developing the Regional Floodplain Database (RFD). The RFD includes the development of coupled hydrologic and hydraulic models for the entire local government area (LGA) that are capable of seamless interaction with a spatial database to deliver detailed information about flood behaviour across the region.

Stage 2 included the detailed hydrologic and hydraulic modelling of 5 packages, which cover 11 catchments in the MBRC LGA. Stage 3 includes the detailed hydrologic and hydraulic modelling of the two remaining catchments and the flood risk management study.

This report discusses the study data, methodology and results for Stage 3, Package 2 of the RFD, the detailed hydrologic and hydraulic modelling for the Lower Pine River catchment.

This study utilises the hydraulic model results from the Upper Pine River (UPR) and the Sideling Creek (SID) catchments (modelled as part of Stage 2), which form the upstream parts of the Pine River catchment.

1.1 Scope

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

- The model computational grid resolution was refined from 10m to 5m (for events smaller and up to the 100 Year ARI event);
- The latest 2009 LiDAR (**L**ight **D**etection **A**nd **R**anging) topographic data was used, incorporating terrain modifiers to enhance the capture of road embankments and stream lines in the Digital Elevation Model (DEM);
- Additional hydraulic structures were included in the model; and
- Utilisation of detailed land use delineation (developed as part of Stage 1, but not included in broadscale models).

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

1.2 Objectives

Key objectives of this study are as follows:

- Utilise the existing broadscale model to develop a detailed and dynamically linked two-dimensional and one-dimensional (2D/1D) hydrodynamic model of the Lower Pine River

Catchment using input data that were determined and provided by MBRC or other consultants; and

- Provision of all relevant flood information obtained from the modelling, which will form the base input data for the risk management study.

1.3 General Approach

The general approach for this study is summarised as follows:

- Review existing broadscale WBNM hydrologic model and results;
- Review existing broadscale TUFLOW modelling;
- Refine the TUFLOW modelling to include additional structures and topographical information, and refine the grid size to 5m for events smaller than the 100 Year ARI event;
- Investigate the feasibility of calibrating and/or verifying the combined WBNM and TUFLOW models. There was sufficient historical information available for this task, therefore model calibration was undertaken for the January 2011 event;
- Undertake a critical storm duration assessment for the 10 year ARI event, 100 year ARI event and the PMF, based on the 10m model;
- Simulate a large range of design flood events (1, 2, 5,10, 20, 50,100, 200, 500, 1000, 2000 year ARI events and PMF events) for three selected critical durations;
- Assess model sensitivity to future landuse patterns, Manning's 'n', structure blockage, climate change and downstream boundary conditions;
- Provide a concise report describing the adopted methodology, study data, model results and findings. The emphasis of the RFD project is on digital data management. Therefore only the 100 year ARI event and the sensitivity analysis results were mapped in this report; and
- Compilation of models and model outputs for provision to MBRC.

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

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

- **1D – Hydrologic and Hydraulic Modelling (Broadscale),** sub-project 1D defined model naming conventions and model protocols to be used in this sub-project (BMT WBM, 2010);
- **1E – Floodplain Topography (2009 LiDAR) including 1F, 2E, 2I,** sub-project 1E provided the topographic information, such as model Z points layer and digital elevation models (DEM). This was achieved using a bespoke DEM tool developed for the RFD (WorleyParsons, 2010a);
- **1G – Hydrography (MBRC),** sub-project 1G supplied the subcatchment delineation of the catchment including stream lines and junctions (used in the WBNM model);
- **1H – Floodplain Landuse,** sub-project 1H delivered the current percentage impervious cover (utilised in the hydrologic model) and the roughness Manning's 'n' values (utilised in the hydraulic model) (SKM, 2010);

- **1I – Rainfall and Stream Gauges Information Summary (MBRC),** sub-project 1I summarised available rainfall and stream gauge information for the study area;
- **2C – Floodplain Structures (Culverts),** sub-project 2C supplied the GIS layer of the culverts to be included in the model (Aurecon, 2010). A TUFLOW-specific MapInfo file was provided, however appropriate model linkages between the culvert data and the 2D domain had to be established;
- **2D - Floodplain Structures (Bridges),** sub-project 2D provided a GIS layer of the major bridges and foot bridges (Aurecon, 2010). A TUFLOW-specific MapInfo file was provided;
- **2F – Floodplain Structures (Trunk Underground Drainage),** sub-project 2F provided trunk underground drainage information;
- **2G - Floodplain Structures (Basins),** sub-project 2G consolidated and surveyed the existing basin information in the study area (Aurecon, 2010);
- **2I - Floodplain Structures (Channels),** sub-project 2I identified channels within the catchment (Aurecon, 2010);
- **2J – Floodplain Landuse (Historic and Future),** sub-project 2J defined the historic and future percentage impervious cover (utilised in the hydrologic model) and the roughness (Manning's 'n') values representing landuse for historical events (utilised in the hydraulic model) (SKM, 2010);
- **2K – Flood Information Historic Flooding,** sub-project 2K collected and surveyed flood levels for the historic May 2009 and February 1999 flood event (GHD, 2010);
- **2L – Design Rainfall and Infiltration Loss,** sub-project 2L developed the hydrologic models for the catchment and provided the design rainfall hydrographs for the pilot study (Burpengary Creek catchment) TUFLOW models (Worley Parsons, 2010b). A similar methodology was adopted for the Lower Pine River catchment;
- **2M – Boundary Conditions, Joint Probability and Climate Risk Scenarios,** sub-project 2M defined the boundary conditions and provided recommendations in regards to joint probability (i.e. occurrence of storm surge in combination with river flooding events, or river flooding in combination with local tributary flooding). This project also recommended certain sea level rise and rainfall intensity values to assess Climate Risk Scenarios (SKM, 2012a); and
- **2N – Floodplain Parameterisation,** sub-project 2N provided recommendations of the floodplain parameters, such as a range of values for various impervious percentages for various landuse types (i.e. residential or rural landuse, dense vegetation), a range of values for various roughness types (i.e. long grass, dense vegetation) and structure losses (SKM, 2012b).

2 AVAILABLE DATA

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

- **Floodplain Topography** – MBRC provided a DEM and Z points (for the 5m and the 10m models) that were generated using a tool that was developed and run by WorleyParsons. The DEM resolution was 2.5m and 5m (half the 2D computational grid resolution). The topography is based on LiDAR data collected in 2009 and provided by the Department of Environment and Resource Management (DERM);
- **Hydrography (MBCR)** – Catchment delineation and hydrology model dataset provided by MBRC;
- **Floodplain Landuse** (Current and Future) – Polygon data for 9 different landuse categories established as part of Stage 1;
- **Floodplain Structures (Culverts and Bridges)** – As-constructed bridge plans for selected minor or major roads in MBRC LGA (provided by MBRC where available). Additional structure survey data, as undertaken by MBRC when no structure data was available. State controlled roads and minor road GIS layers provided by MBRC;
- **Design Rainfall** – Amendment of WBNM models, development of design simulations and provision of design rainfall hydrographs (from the 1 year ARI to the PMF);
- **Boundary Conditions, Joint Probability and Climate Risk Scenarios** – Report with recommendations for boundary conditions, joint probability and climate change scenarios;
- **Floodplain Parameterisation** information, specifically about impervious percentages for various landuse types, roughness types and structure losses;
- **Upper Pine River (UPR) Model Results** provided for the upstream boundary conditions at the North Pine Dam. This data was derived from the final UPR model Stage 2; and
- **Sidling Creek (SID) Model Results** provided for the upstream boundary conditions at Lake Kurwongbah. This data was derived from the final SID model Stage 2.

3 METHODOLOGY

3.1 Data Review

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

- The infrastructure data within the catchment;
- The historical flooding information of the catchment; and
- The broadscale subcatchment delineation.

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

3.1.1 Infrastructure Data Assessment

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

The key findings from this report include:

- 366 culverts and structures prioritised as category A (260 and 86 and from the broadscale model and 20 from MBRC's review);
- 27 culverts and structures prioritised as category B (10 from the broadscale model and 17 from MBRC's review);
- 8 additional locations prioritised as category A were identified by BMT WBM; and
- 8 additional locations prioritised as category B were identified by BMT WBM.

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

3.1.2 Calibration and Validation

The available information on historical flooding was provided by MBRC and reviewed as part of the model calibration feasibility report (Appendix C) along with the collection of gauge data from the Bureau of Meteorology (BoM). The feasibility of using historic flood events for calibrating the Lower Pine River model was assessed. The model feasibility report concluded that there is sufficient data available in the catchment to perform calibration and validation to historical flood events. Model validation was undertaken for the following major and most recent flood event:

- The January 2011 flood event was used for the model calibration.

A full copy of the model calibration feasibility report is provided in Appendix C.

3.1.3 Hydrography Review

The subcatchment delineation completed as part of Stage 1 was reviewed; a copy of the report letter is provided in Appendix B. The review recommended subdivisions of the subcatchment delineation for 25 subcatchments to refine the resulting flood extent. MBRC appreciated the work undertaken and considered the recommendations for use in MBRC's internal overland flow mapping project. However, MBRC adopted the original subcatchment delineation to be used for the hydrologic and hydraulic modelling.

3.2 Hydrologic Model

The existing hydrological WBNM model for the Lower Pine River catchment was reviewed and updated using relevant data, utilising the WBNM 2010 beta version. The WBNM software was nominated by MBRC as the hydrologic software package for the RDF, and was used to model the design events (utilising existing landuse), the January 2011 calibration event (using existing landuse, and historic rainfall data) and a future landuse scenario.

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

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

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

3.3 Hydraulic Model

3.3.1 Model Software

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

- Accurately represent overland flow paths, including flow diversion and breakouts (2D modelling);
- Model the waterway structures of the entire catchment with a relatively high level of accuracy (1D or 2D modelling);
- Dynamically link components of the 1D models (i.e. culverts) to any point in the 2D model area; and

- Produce high quality flood map output (i.e. flood extent, flood levels, depths, velocities, hazard and stream power), which are fully compatible with Geographic Information Systems (GIS).

3.3.2 Model Geometry

The TUFLOW model was based on two sets of Z points provided by MBRC for two computational grid resolutions: 5m and 10m, as adopted by MBRC. These Z point layers were used to develop a 5m grid model and a 10m grid model. The 5m grid resolution model was used for events up to and including the 100 year ARI Event. The 10m model was used for events larger than and including the 100 year ARI event, the critical duration analysis and also for the sensitivity runs. The two grid resolutions were adopted due to the catchment size and the model run times; i.e. the 10 grid resolution model was used to expedite the model run times. The Lower Pine River model has extended model run times: the 5m model takes about 6 days to simulate a design event, whereas the 10m model takes about 14 hours to simulate a design event. These run times are provided as an indication, and depend on the storm magnitude, duration and computer specifications. The 5m model requires about 10.5GB of RAM and the 10m model about 2.3GB of RAM. The origin of the Z points was used to set the origin of the 2D domain, and 2D domain orientation was set to zero (or horizontal; i.e. no rotation).

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

Figure 3-1 illustrates the Lower Pine River model layout.

3.3.3 Model Structures

The Lower Pine River catchment is, in general, moderately urbanised. The mid part of the catchment along the North Pine and South Pine Rivers is densely developed and the upper South Pine River and Cedar Creek are less developed.

The LPR catchment includes about 400 structures in total. Culvert crossings were typically represented in the model as 1D structures, with flow over these structures modelled within the 2D domain. Bridges and footbridges were represented in the 2D domain (using TUFLOW layered flow constriction features). The hydraulic structure details were either provided by MBRC in TUFLOW ready format, or in the form of engineering drawings or digital data derived from a survey.

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

3.3.4 Landuse Mapping

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

Table 3-1 Hydraulic Model Landuse Categorisation

Landuse Type	Manning's 'n' Roughness Coefficient
Roads/Footpaths	0.015
Waterbodies	0.030
Estuarine Waterbodies	0.02
Low Grass/Grazing*	Ranging from 0.025 at 2 m depth to 0.25 a 0m depth
Crops	0.040
Medium Dense Vegetation*	Ranging from 0.075 up to a depth of 1.5m and 0.15 above 1.5m
Reeds	0.08
Dense Vegetation*	Ranging from 0.09 to 0.18 up to a depth of 1.5m and 0.18 above 1.5m
Urban Block (> 2000m^2)	0.300
Buildings	1.000
*Depth varying (linear) Manning's 'n' roughness was applied.	

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

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

3.3.5 Model Boundaries

The Upper Pine River catchment (UPR) and Sideling Creek catchment (SID) discharge into the Lower Pine River catchment. The UPR catchment includes Lake Samsonvale (also referred to as North Pine Dam) and the SID catchment includes the Sideling Creek Dam (Lake Kurwongbah). Therefore, the outflows from the Lake Samsonvale and Lake Kurwongbah form the major inflows to the North Pine River.

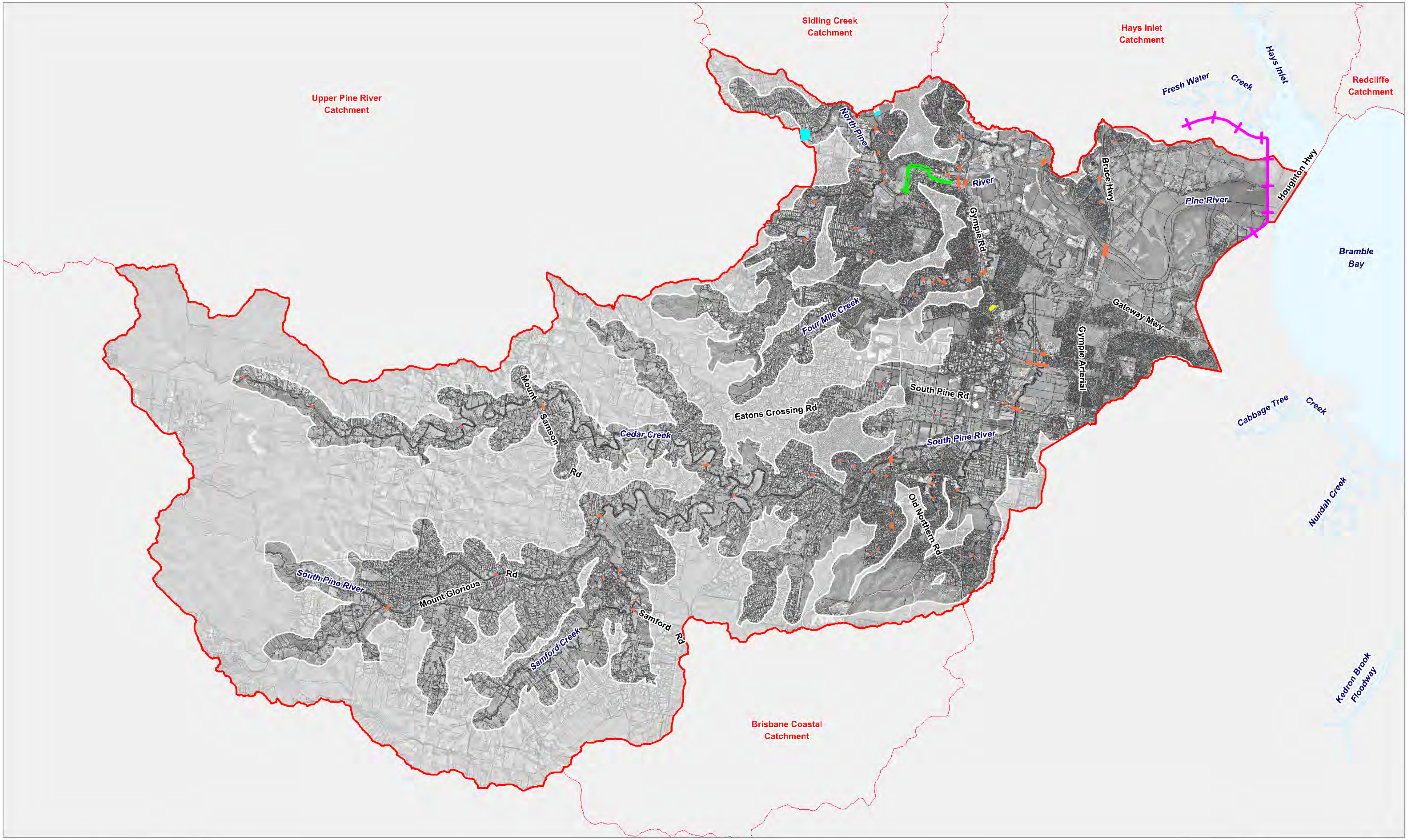
The results of the WBNM hydrologic model were used to generate runoff inflows within the LPR catchment for the hydraulic model for all design events, as discussed in Section 3.2. The inflows were applied to the 2D domain using a flow-time source boundary spread over each subcatchment. This technique applies the inflow at the lowest grid cell in a subcatchment initially and then subsequently to all wet cells in that subcatchment.

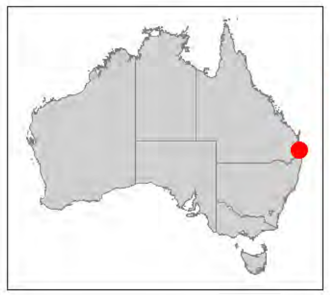
The downstream boundary conditions, joint probability and climate change scenarios were based on recommendations from the sub-project 2M report (SKM, 2012a). A static flood level was applied at the downstream boundary utilising the mean high water spring (MHWS) for all design events (see Table 3-2).

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

Table 3-2 Downstream Boundary Water Level

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





LEGEND

- Lower Pine River Catchment Boundary
- Hydraulic Model Boundary
- Cadastral Boundaries
- Extent of Bathymetry added by BMT WBM
- Downstream Boundary
- Inflows (Upper Pine River and Sidling Creek Catchments)
- Culvert
- Bridge

Title:
TUFLOW Model Layout

Figure: 3-1

Rev: A

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Approx. Scale

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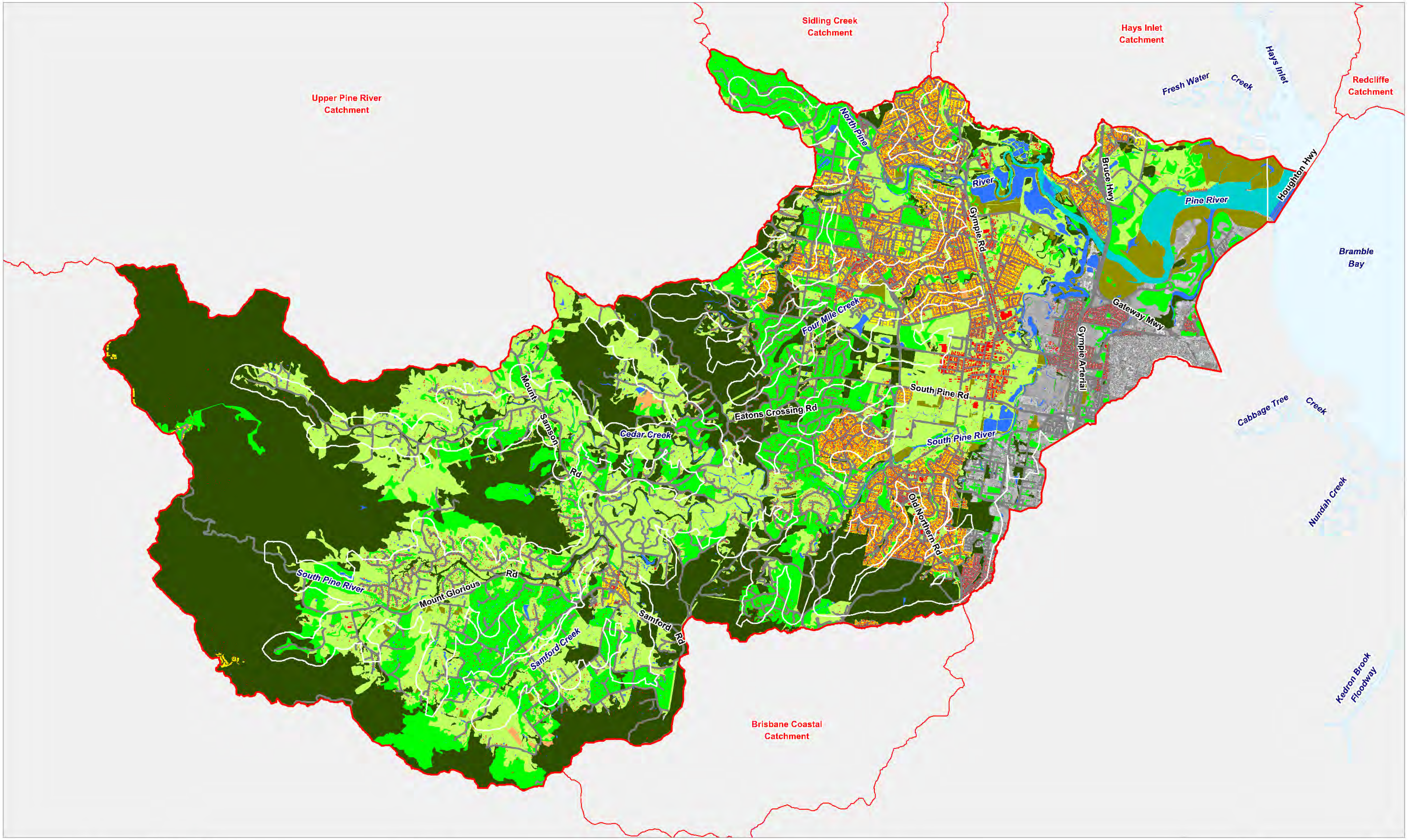

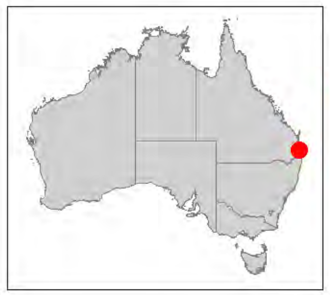

LEGEND

Lower Pine River Catchment Boundary

Hydraulic Model Boundary

Landuse

- Buildings
- Urban Blocks
- Roads / Footpaths
- Estuarine Waterbodies
- Waterbodies
- Crops
- Reeds
- Low Grass / Grazing
- Medium Vegetation
- Dense Vegetation

Title:

Landuse Existing Conditions

Figure: **3-2**

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3.4 Model Calibration and Verification

Where possible, MBRC have sought to calibrate and verify the models in their LGA to historical flood events. Model calibration and/or verification were undertaken for 6 other catchments, including the UPR catchment, as part of Stage 2. Therefore, the LPR model calibration had two objectives, firstly to calibrate the model to a historic event, and also to verify the model parameters adopted during the Stage 2 model calibration of 6 catchments within MBRC's LGA.

The Lower Pine River catchment hydraulic model was calibrated against the January 2011 event. This event was chosen because it was a large event that occurred most recently, and data from a large number of rainfall and stream gauges were available. Records from 17 rainfall gauges and 9 stream gauges were used for the January 2011 flood event. The gauge level data for these gauges were obtained from MBRC and the Bureau of Meteorology's website. These recorded water levels were compared to the modelled water levels, and the model was adjusted a number of times to improve the correlation between recorded and modelled flood levels. MBRC also provided 57 flood marks with surveyed peak flood levels. Histograms were provided to demonstrate the difference between the surveyed and the recorded peak flood levels versus the number of flood marks.

A good calibration was achieved without altering the Manning's roughness parameters adopted in Stage 2 of the RFD. A new landuse type was introduced, called estuaries. This landuse type represented the Lower Pine River where the alluvium bed is relatively smooth. Details of the simulations undertaken as part of the model calibration are documented in Appendix C.

3.5 Design Flood Events

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

3.5.1 Critical Storm Duration Assessment

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

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

To determine the critical storm durations for the Lower Pine River model, the following methodology was adopted:

1. Hydrologic and hydraulic modelling of a range of storm durations (1hr, 3hr, 6hr, 12hr and 24hr) for the 10 year, 100 year and PMF events; 5 hours and 48 hours storm durations were also

tested for the PMF event. The 10m grid model was used for this assessment.

2. Mapping of the peak flood level results for the 'maximum envelope' of all the storm durations for the three representative events.
3. Mapping of the peak flood level results for the 'maximum envelope' of selected storm durations for the three representative events.
4. Difference comparison between the mapped peak flood levels for selected critical durations and the results accounting for *all* storm durations.
5. The critical duration combination resulting in the lead difference compared with the mapping of the full envelope of durations was adopted. Selection of the critical durations was based on the storm durations generating the highest flood levels across the most widespread and developed areas.

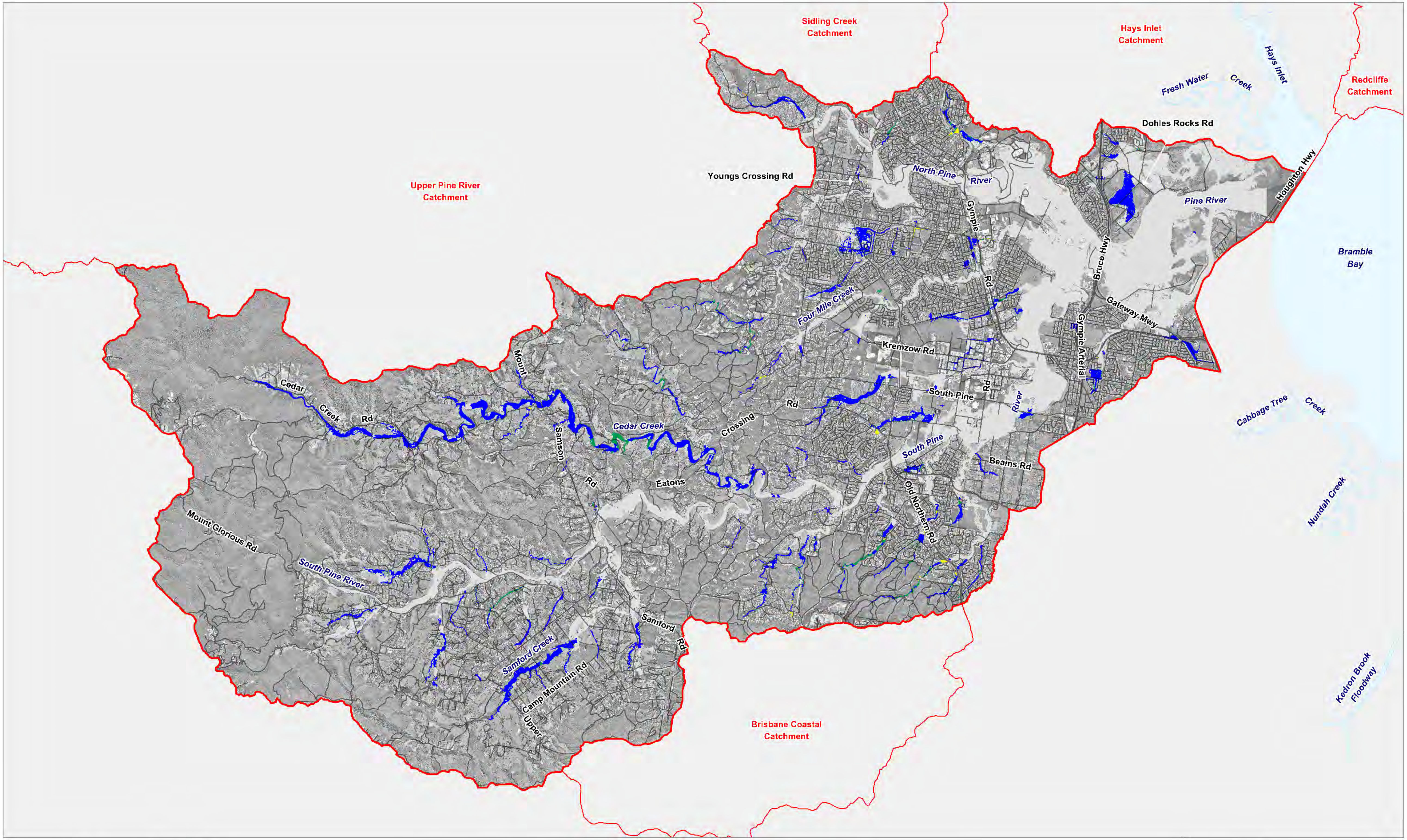
A summary of the selected critical storm durations for all events assessed is outlined in Table 3-3.

The difference comparison for the 10 and 100 year ARI and the PMF peak flood levels (as described in step 4 above) is shown in Figure 3-3 to Figure 3-5. The figures illustrate that the selected critical durations generally capture the peak flood levels across the site in developed areas. There are some localised areas, mainly in the upper parts of the catchment, where flood levels are under predicted. For the PMF event, the area downstream of Gympie Road is also under predicted by about 0.1m

Table 3-3 Critical Storm Duration Selection

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

This process was undertaken in consultation with MBRC, as their knowledge on local catchment and development issues was a factor in the decision-making and selection of the critical durations.



LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Peak Flood Level Difference (m)

- < -1.00
- -1.00 to -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.01
- No Change

Title:

Critical Duration Assessment
Peak Flood Level Difference - 10 Year ARI

Figure: **3-3**

Rev: **A**

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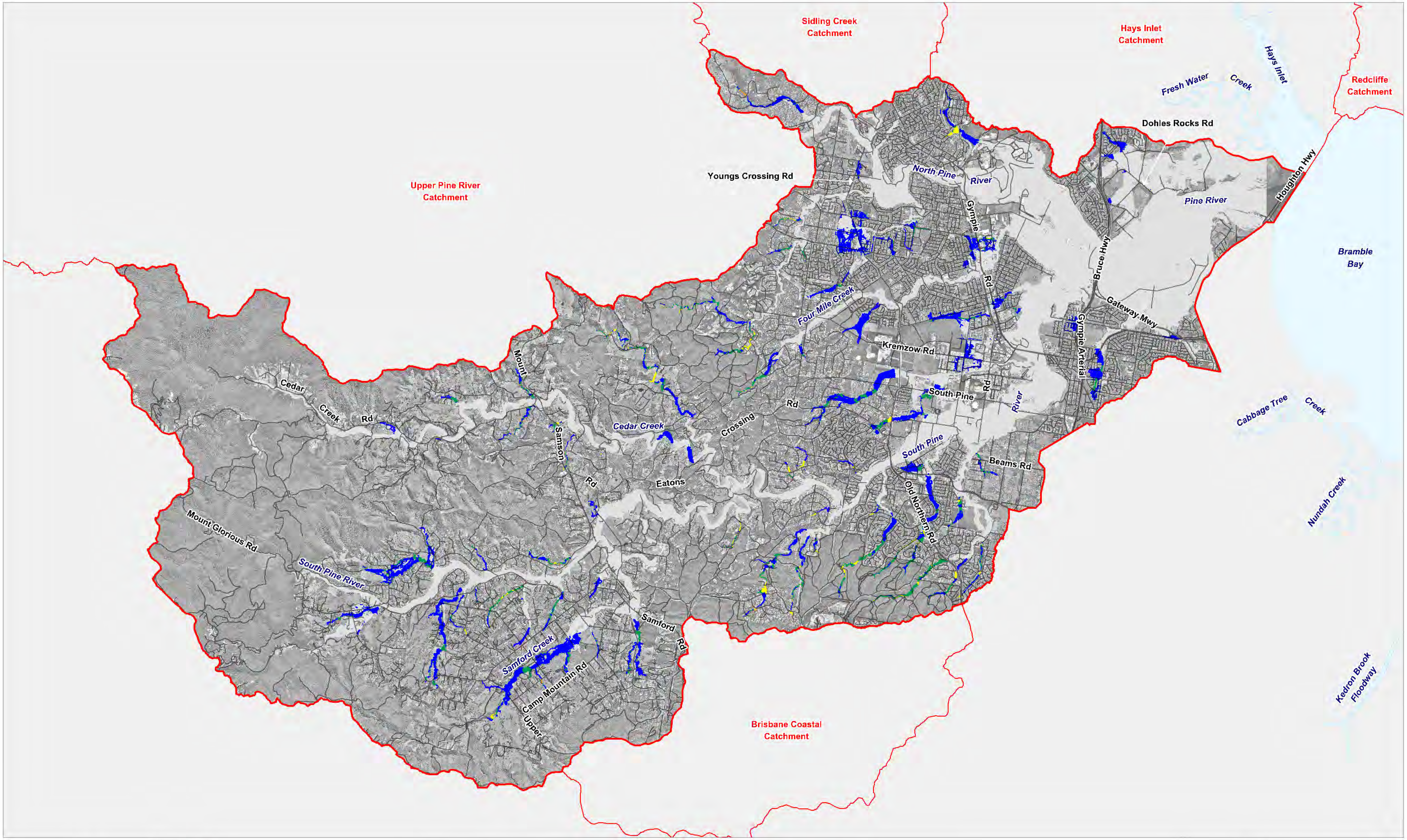

LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Peak Flood Level Difference (m)

- < -1.00
- -1.00 to -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.01
- No Change

Title:

Critical Duration Assessment
Peak Flood Level Difference - 100 Year ARI

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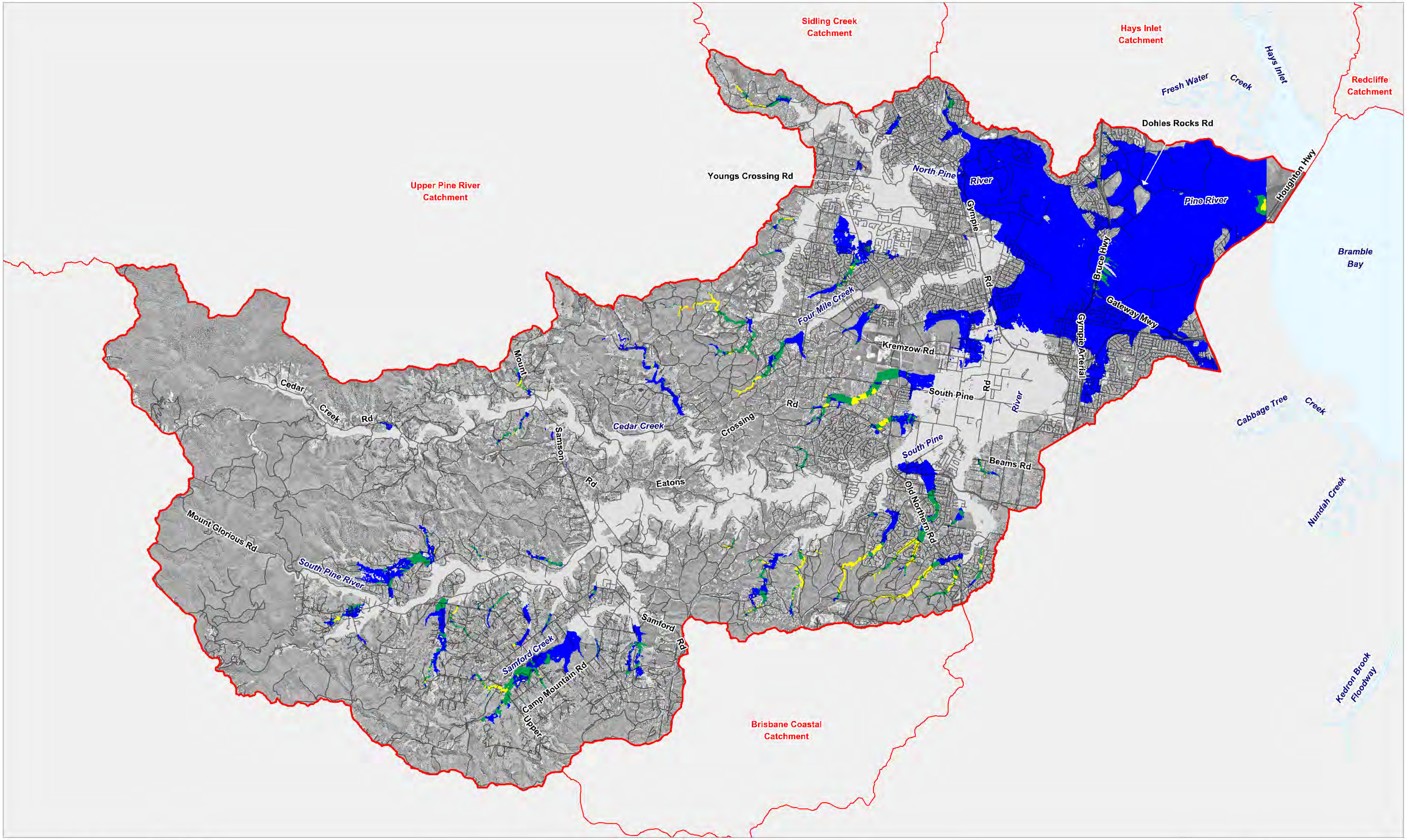

LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Peak Flood Level Difference (m)

- < -1.00
- -1.00 to -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.01
- No Change

Title:

Critical Duration Assessment
Peak Flood Level Difference - PMF

Figure: **3-5**

Rev: **A**

N

0km 2 4
Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\LPR_Report\FLD_005_130118_PMF Critical Storm Duration.WOR

3.5.2 Design Event Simulations

The Lower Pine River model was simulated for a range of ARI and storm durations and a 100 Year Embedded Design Storm (EDS). MBRC requested the use of a single EDS which synthesises a range of storm duration hyetographs into one representative design hyetograph. The EDS is useful for general investigations into changes in model parameters and catchment characteristics, as it reduces the number of model runs required (no need to run multiple storm durations).

MBRC advised that the100 year ARI 15 minute in 270 minute Embedded Design Storm was to be adopted. The adopted EDS storm was used as the base design storm for the sensitivity analyses.

In summary, the Lower Pine River model was simulated for the following design events:

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

3.6 Sensitivity Analysis

Twelve sensitivity simulations were undertaken as part of the Stage 2 and 3 detailed modelling projects. A summary of sensitivity analysis, the model identifier (ID), title and a description of the twelve sensitivity simulations are detailed in Table 3-4.

Table 3-4 Sensitivity Analysis Summary

ID	Title	Description
S1	Embedded Design Storm (EDS)	100 Year ARI 15 burst in 270min Embedded Design Storm
S2	Increase Roughness	Increase all Manning's 'n' by 20%
S3	Blockage	Model blockage of culverts (moderate blockage)
S4	Climate Change 1	Increase rainfall intensity by 20%
S5	Climate Change 2	Increase downstream boundary to MHWS +0.8m (Sea Level Rise)
S6	Climate Change 3	Increase rainfall intensity and downstream boundary (S4 + S5)
S7	Storm Tide 1	No rainfall, dynamic Storm Tide (100year current) from Storm Tide Hydrograph Calculator (peak at 2.3mAHD)
S8	Storm Tide 2	EDS rainfall with Static Storm Tide (100year current) (2.3mAHD)
S9	Storm Tide 3	Increase rainfall intensity (S4) + Increase downstream boundary (S5) + Static Storm Tide Level (100yr Greenhouse Gas +0.8m) (3.1mAHD)
S10	Future Landuse 1	Increase vegetation in floodplains
S11	Future Landuse 2	Increase residential development
S12	Future Landuse 3	Increase vegetation and residential development (S11 +S12)

3.6.1 Future Landuse Analysis

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

The hydrologic model utilises a 'fraction impervious' parameter which described the proportion of each subcatchment where water is not able to infiltrate, i.e. there are no rainfall losses on paved surfaces. If the fraction impervious increases, there will be more rainfall runoff and quicker concentration of flows. The fraction impervious in each subcatchment of the WBNM model was updated to reflect the future landuse scenario provided by MBRC.

Landuse is defined in the hydraulic model through the materials layer. This information covers the entire hydraulic model extent and describes landuse and the Manning's 'n' roughness values associated with each type of landuse. The materials layer was updated to reflect the future landuse scenario (change in vegetation density).

The landuse scenarios simulated included:

- **Future Landuse Scenario 1:** Investigated the impact of increased vegetation in the floodplains.

This involved changing the 'medium dense vegetation' material class to a 'high dense vegetation' class and changing the 'low grass/grazing' material class to a 'medium dense vegetation' class.

- **Future Landuse Scenario 2:** Investigated the impact of an increase in residential development. The hydrology model was updated with forecast future development (provided by MBRC) to estimate future inflows for the TUFLOW model.
- **Future Landuse Scenario 3:** Investigated the impact of an increase in residential area and increased vegetation in floodplains. This scenario combines future landuse scenarios 1 and 2.

3.6.2 Hydraulic Roughness Analysis

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

3.6.3 Structure Blockage Analysis

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

A moderate blockage scenario was adopted from the SKM *Floodplain Parameterisation* report (2012b), and includes:

- A full blockage is applied if the culvert diagonal is less than 2.4m; and
- A 15% blockage is applied if the culvert diagonal is greater than 2.4m.

3.6.4 Climate Change and Downstream Boundary Condition Analysis

A climate change and storm tide assessment investigated the possible impact of a storm tide and projected increases in sea level rise and rainfall intensity on flooding in the catchment. In total 6 scenarios were assessed:

- **Climate Change Scenario 1:** Investigated the impact of an increase in rainfall intensity of 20% (as per SKM (2012a) *Boundary Conditions, Joint Probability and Climate Change* Report);
- **Climate Change Scenario 2:** Investigated the impact of an increased downstream boundary of 0.8m due to predicted sea level rise;
- **Climate Change Scenario 3:** Investigated the impact of an increase in rainfall intensity and an increased downstream boundary. This scenario combines climate change scenarios 1 and 2;
- **Storm Tide Scenario 1:** Modelled a dynamic storm tide. No rainfall is applied and a dynamic storm tide (100 year current) boundary was applied (from the *Storm Tide Hydrograph Calculator* spreadsheet, developed by Cardno Lawson Treloar (2010). The MBC-009 reference point was used);
- **Storm Tide Scenario 2:** Investigated the impact of a 100 year static storm tide level (2.3mAHD) with concurrent 100 year EDS rainfall event; and

- S**torm Tide Scenario 3:** Investigated the impact of an increase in rainfall and an increase in sea level rise. An increase in rainfall of 20% was applied combined with a static storm tide level (100 year GHG) + 0.8m, resulting in a final static storm tide level of 3.1mAHD.

4 RESULTS AND OUTCOMES

4.1 Calibration and Verification

4.1.1 Overview

Calibration and verification of the modeling was undertaken for the January 2011 flood event. In total, eight simulations were undertaken as part of the calibration/verification process. Full details of each simulation can be found in the model calibration report in Appendix C.

Results from the adopted simulation are also represented in the following section.

4.1.2 January 2011 Results

Comparisons of the recorded and modelled water levels for the January 2011 flood are shown in Figure 4-1 to Figure 4-10.

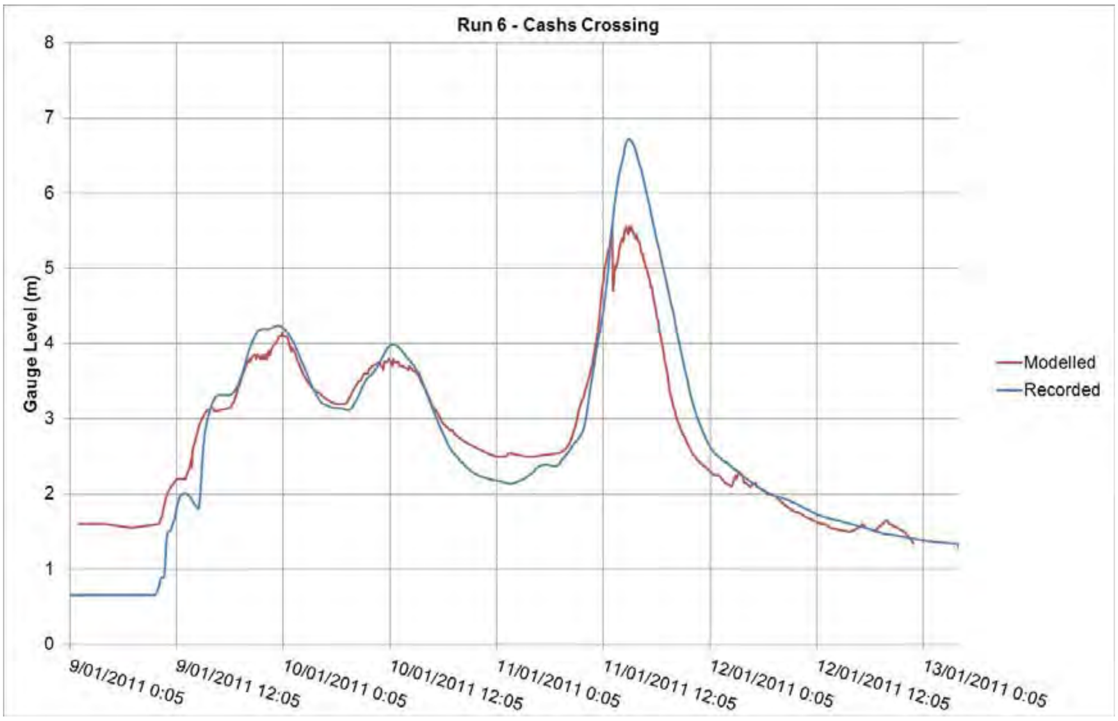

Figure 4-1 Flood Level Comparison at Cashes Crossing

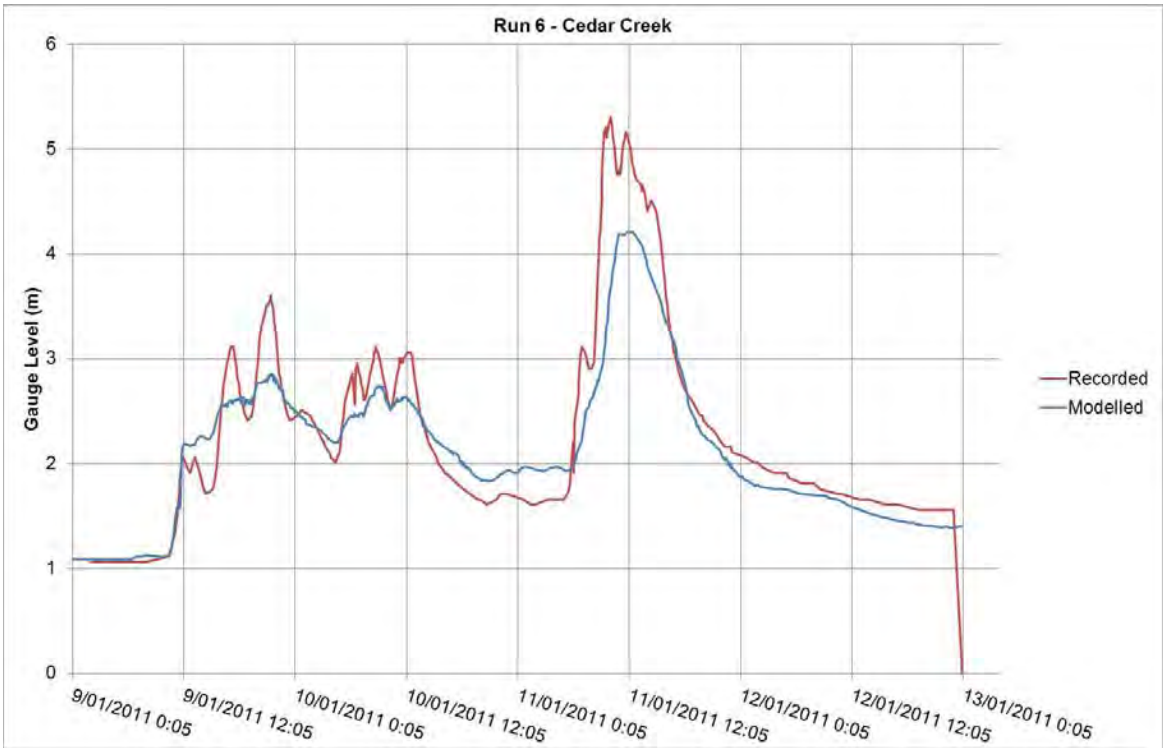

Figure 4-2 Flood Level Comparison at Cedar Creek

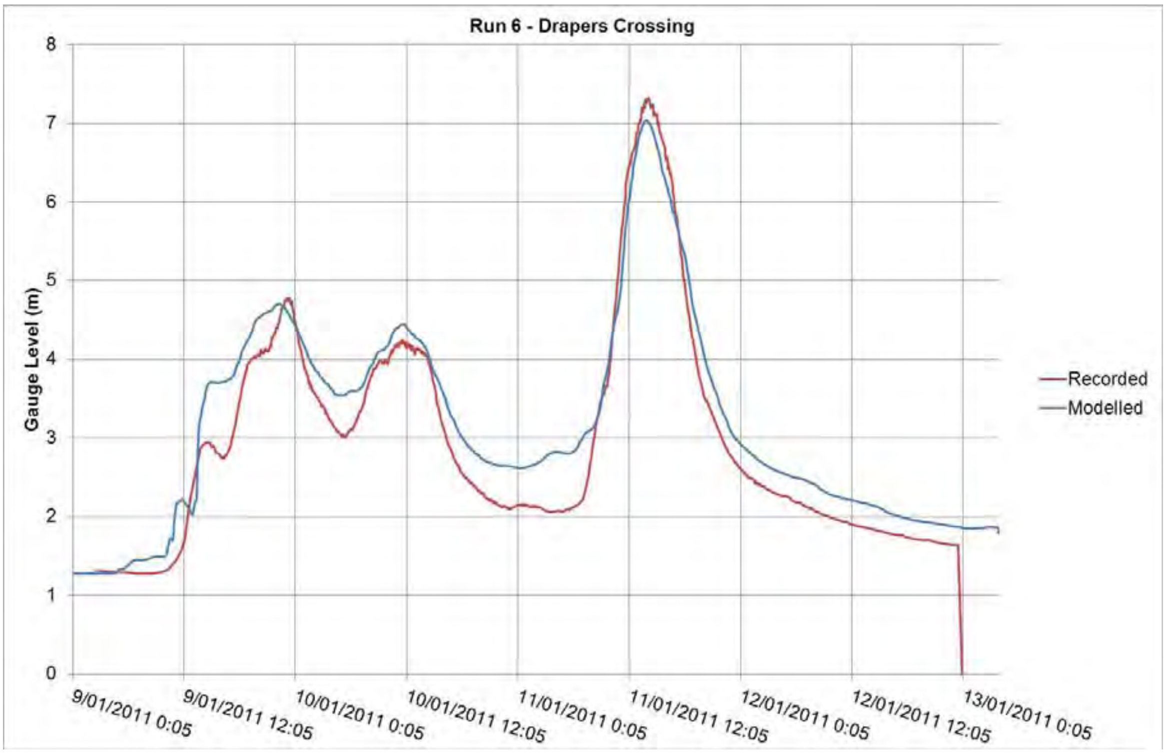

Figure 4-3 Flood Level Comparison at Drapers Crossing

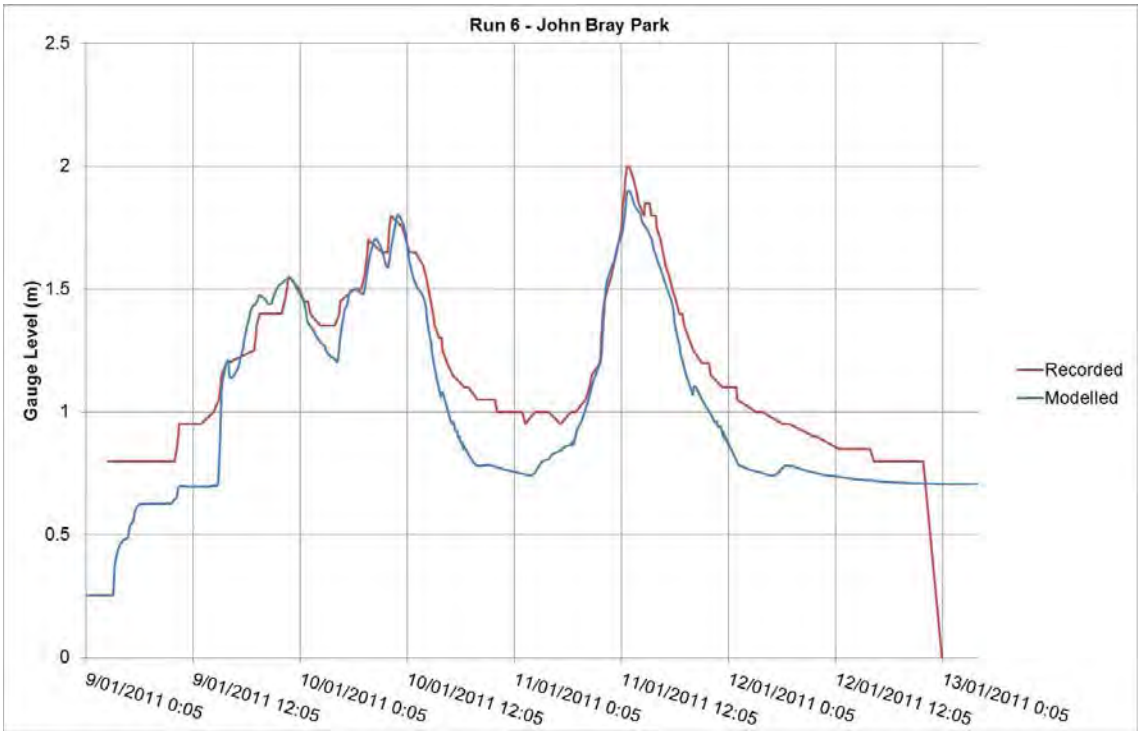

Figure 4-4 Flood Level Comparison at John Bray Park

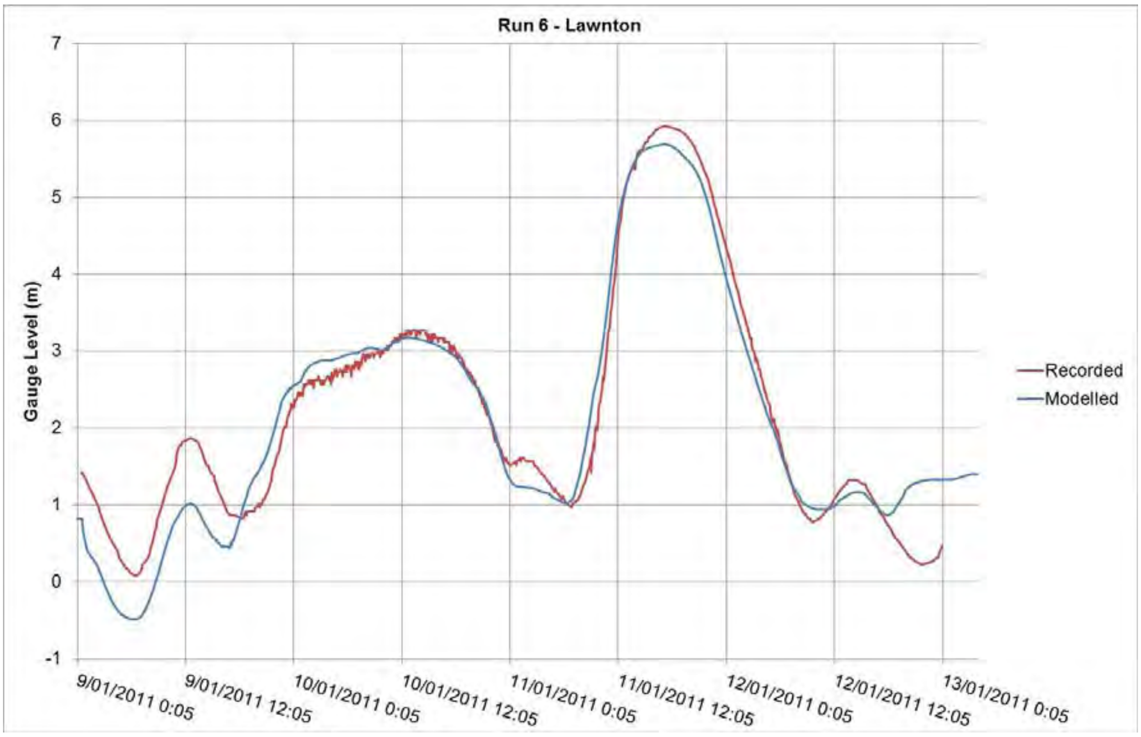

Figure 4-5 Flood Level Comparison at Lawnton

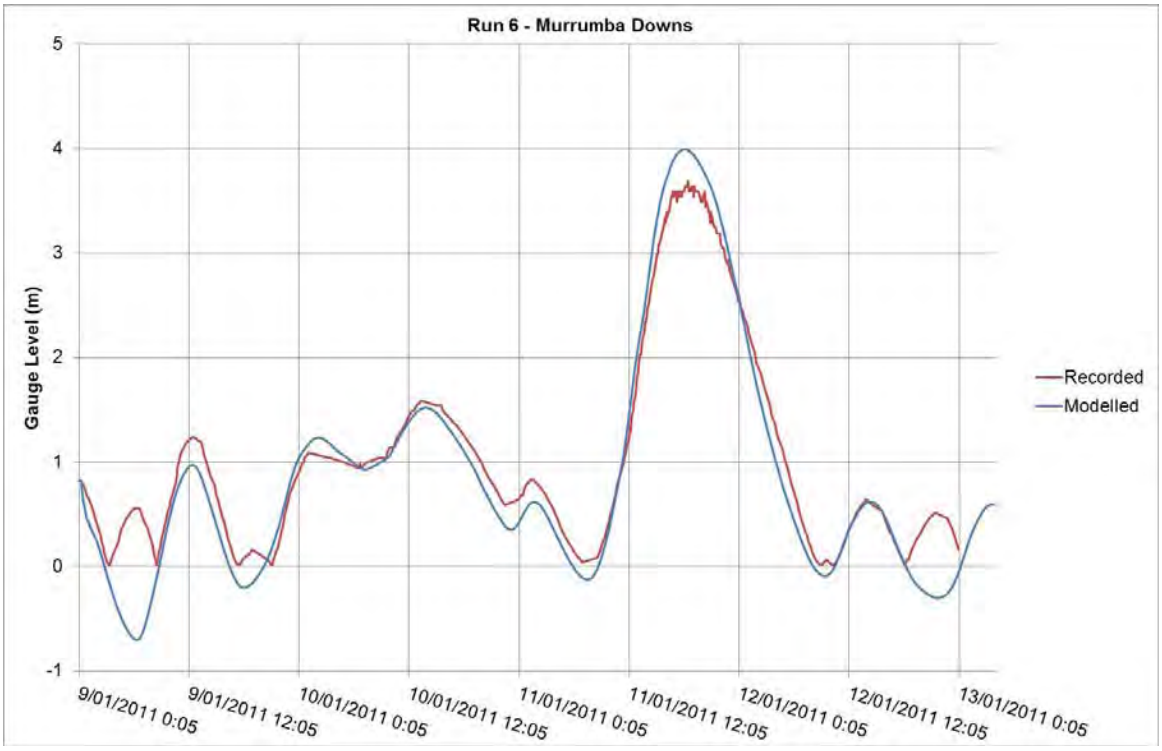

Figure 4-6 Flood Level Comparison at Murrumba Downs

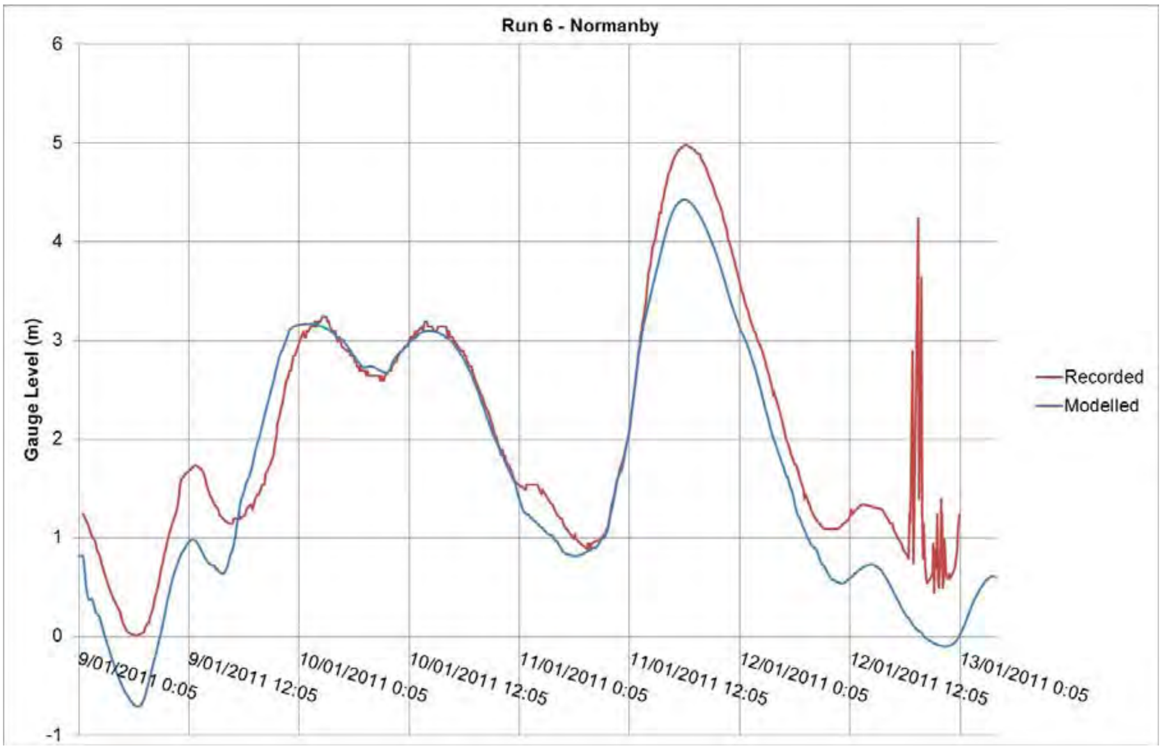

Figure 4-7 Flood Level Comparison at Normanby

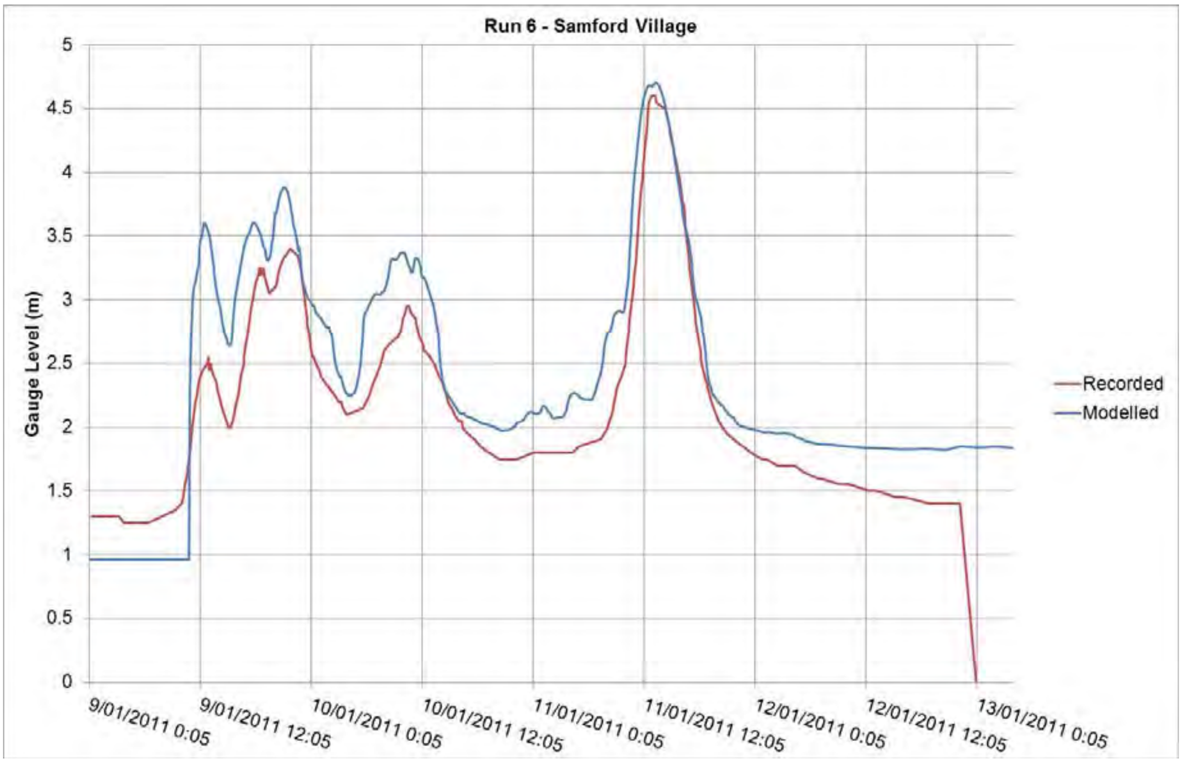

Figure 4-8 Flood Level Comparison at Samford Village

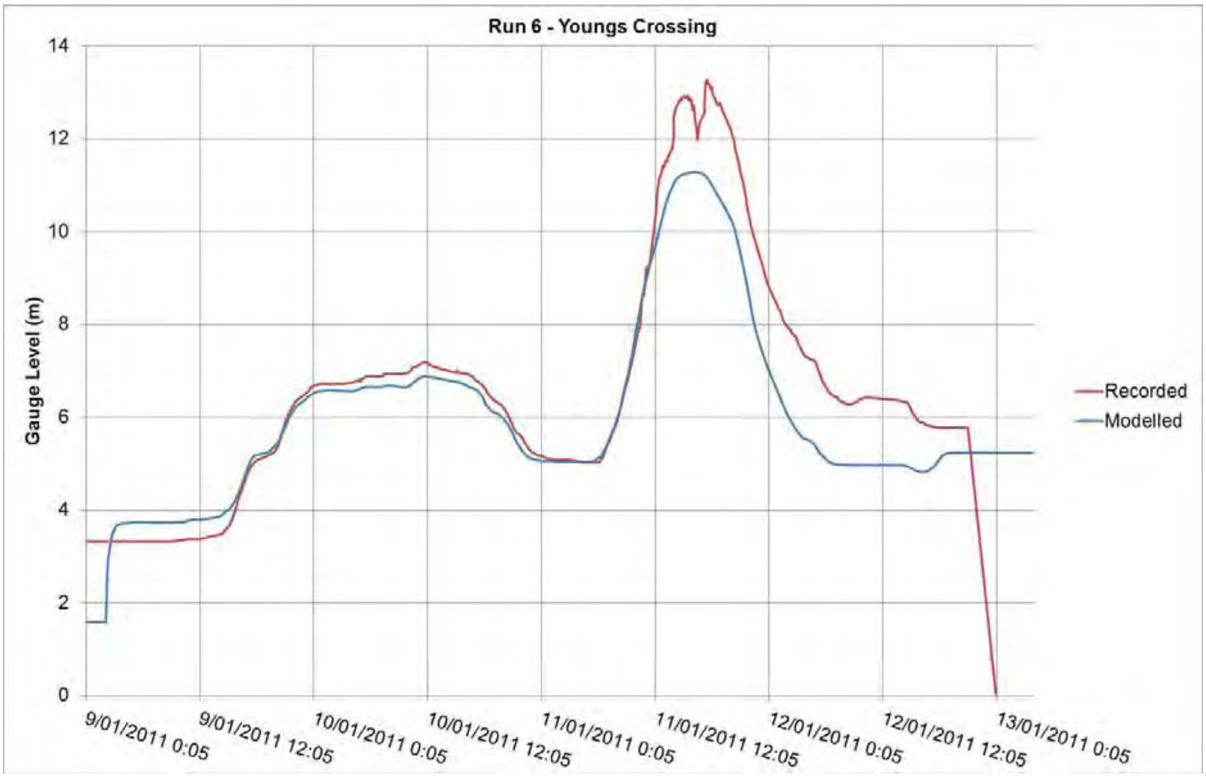

Figure 4-9 Flood Level Comparison at Youngs Crossing

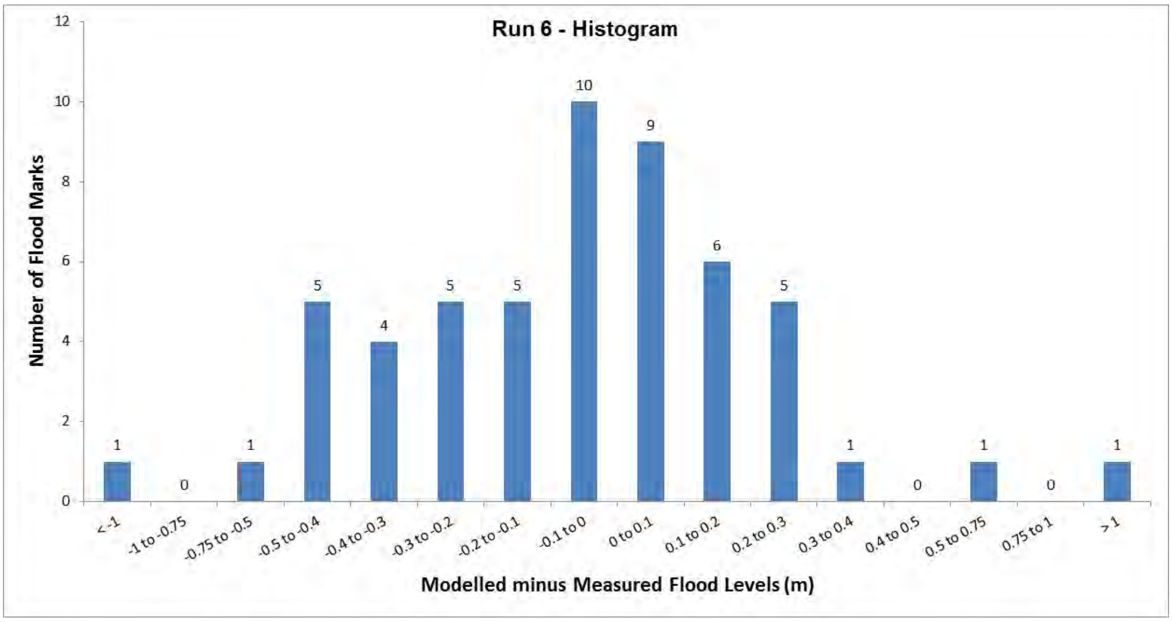

Figure 4-10 Flood Mark Histogram

4.1.3 Conclusion

The model calibration report demonstrates that reasonably good model calibration was achieved, in particular for the area between Young's Crossing and Gympie Road along North Pine River, where the majority of the flood marks were collected. The hydrograph comparison between the recorded and modelled flood levels at the river gauges indicate good timing of the peak levels and reasonable matching of the peak flood levels. The recorded and modelled peak flood levels were within 0.3m at Drapers Crossing, John Bray Park, Lawnton and Samford Village. The model was over predicting by up to 1m and 0.3m at the Cedar Creek and Murrumba Down gauges. An under prediction of the model by up to 1.1m and 0.5m occurred at the Cash's Crossing and Normanby gauges, along South Pine River.

It is known that the gauge at Youngs' Crossing malfunctioned at the peak of the flood. The under prediction at Cash's Crossing may be due to a spatial lack of rainfall data in the upper Cedar Creek catchment; i.e. the historical rainfall applied in the hydrological model in the upper Cedar Creek catchment, which has been interpolated from surrounding gauge data, may be less than what fell in reality.

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

4.2 Design Flood Behaviour

4.2.1 Model Results

The following data were output by the model at 30 minutes intervals as well as the peak values recorded during each simulation:

1. Flood Levels (H flag);
2. Flood Depth (D flag);
3. Flood Velocity (V flag);
4. Depth Velocity Product (Z0 flag);
5. Flood Hazard based on NSW Floodplain Development Manual (DIPNR, 2005) (Z1 flag);
6. Stream Power (SP flag); and
7. Inundation Times (no flag required).

The maximum velocity was used in combination with a 'Maximum Velocity Cutoff Depth' of 0.1m. Consequently, the model result files plot the maximum velocity for depths greater than 0.1m; for depths of less than 0.1m the velocity at the peak level is recorded in TUFLOW's output file. This approach is recommended so as to exclude any high velocities that can occur as an artefact of the modelling during the wetting and drying process.

TUFLOW can provide output relevant to the timing of inundation. In particular:

- The time that a cell first experiences a depth greater than the depth(s) specified; and
- The duration of time that a cell is inundated above the depth(s) specified.

A 'Time Output Cutoff Depths' of 0.1m, 0.3m and 1m, were selected. This selection provides further flood information in the catchment; e.g.:

- Establishing when areas are inundated with shallow depths of 0.1m;
- Considering pedestrian and vehicle safety (flood depth between 0.1 and 0.3m); and
- The duration and/or time of inundation for significant flood depths of 1m and more throughout the catchment.

This information can assist in emergency planning by highlighting which areas of the catchment are inundated early in the flood event and also highlighting which regions may be isolated for long durations.

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

4.2.2 Digital Data Provision

The Regional Floodplain Database is focused on structuring model input and output data in a GIS database. Therefore, all model input and output are being provided to MBRC at the completion of the study. The data includes all model files for the design events (for each storm duration) and sensitivity analyses.

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

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

4.3 Sensitivity Analysis

The 100 year Embedded Design Storm (100 year ARI 15 minute in 270 minute) was used as a base case for the sensitivity analysis. The results of the sensitivity analysis are mapped in Appendix F. A comparison of the EDS event with the 100 year design flood event with selected critical durations (3, 6 and 12 hours) is shown in Figure F1. The results indicate that peak flood levels for the EDS is up to 0.5m lower than the envelope of selected critical durations, predominantly in the downstream part of the catchment and along the North Pine River. Therefore, depending on the area of interest, for future sensitivity analyses use of the selected critical duration design events rather than the EDS event may be more appropriate.

4.3.1 Future Landuse Analysis

The Lower Pine River catchment is generally sensitive to changes in vegetation (Scenario S10) with increases in peak flood levels greater than 0.5m in the upper and middle part of the catchment, whereas the downstream part of the catchment has decreases in flood level, mostly up to 0.5m. This effect has also been assessed and presented for the Caboolture River catchment in a paper titled "*Back To Nature – Can Revegetation Of Riparian Zones Benefit Flood Risk Management*" (Sharpe, 2012).

Based on the model results, the difference in peak flood levels for the increased residential development (S11) compared to the Base Case is generally within 0.1m.

An increase in residential development has little impact on peak flood levels across the floodplain, whereas an increase in vegetation effects the catchment significantly.

4.3.2 Hydraulic Roughness Analysis

Increasing Manning's 'n' by 20% has resulted in increases in peak flood level by up to 0.5m across most of the catchment, in particular in the upstream areas along Cedar Creek and South Pine River, along North Pine River between Young's Crossing and Gympie Road and along the Pine River, downstream of the Bruce Highway. Increases in peak flood levels larger than 0.5m are limited to the area just downstream of the North Pine Dam. This finding is consistent with the results from the model calibration, where a change in landuse significantly affected this particular location.

4.3.3 Structure Blockage Analysis

As expected, the structure blockage analysis has shown that structure blockages cause an increase in peak flood levels in the vicinity of the blocked structures, and in some areas there has been a decrease in flood levels downstream of a structure. These changes in flood level are generally limited to 0.1m, however in some places the increases are significant, being over 0.5m. The decreases are up to 0.5m.

4.3.4 Climate Change and Downstream Boundary Conditions Analysis

The dynamic storm tide and climate change scenarios assessed various combinations of an increase in rainfall intensity by 20% and various sea levels (static and dynamic) as described in Section 3.6.4. As expected, the highest flood levels across the catchment result from the scenarios including an increase in rainfall intensity (scenarios 4, 6 and 9). Increases in peak flood levels larger than 0.5m occur in the middle parts of the North and South Pine River and in the downstream area of the catchment from approximately 2km upstream of the Bruce Highway.

The increased downstream boundary and static storm tide scenarios (100 year current) without increased rainfall intensity, scenarios 5 and 8, increases peak flood levels only at the most downstream part of the catchment, which is predominantly undeveloped.

The highest levels across the catchment are obtained from Scenario 9, which includes an increased rainfall, sea level rise and the Static Storm Tide Greenhouse Gas tailwater conditions. For this scenario peak flood levels increase by more than 0.5m for a large portion of the North Pine and Pine River catchment. Model results from this scenario also predict an increase in flood extent along the North Pine River and the Pine River.

Scenario 7 applied the dynamic 100 year storm tide hydrograph at the downstream boundary and does not include riverine flooding (model inflows). For this scenario, peak flood levels were mapped (Figure F-7) rather than the difference in peak flood levels and extents. This scenario results in higher flood levels in the undeveloped area near the downstream boundary.

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

4.4 Model Limitations and Quality

Watercourses within the Lower Pine River catchment were represented in the 2D domain, for which the grid resolution is limited to either 5m or 10m. This may not allow adequate representation of the channel conveyance, particularly for smaller, more frequent flood events. In some instances this limitation may lead to the model over or underestimating conveyance in the watercourses. The extent of this over or underestimation will vary according to local topographic factors.

The model was reviewed internally and the model quality report is provided in Appendix D. The model quality report highlights areas of uncertainty and model limitations. It is recommended that this report is reviewed prior to using the model and / or results files.

5 CONCLUSION

Two TUFLOW models of the Lower Pine River catchment were developed:

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

ii. A 10m grid resolution model for events larger than and including the 100 year ARI event as well as the sensitivity runs and calibration.

The model was set up in a manner prescribed by MBRC specifically for the RFD project to ensure a consistent approach across the whole LGA and to enable the model and model outputs to be integrated into MBRC's Regional Floodplain Database. The main focus of the project is delivery of the model and its outputs in digital format, therefore only a selection of results have been presented in this report. The outcomes of this work is being used in stage 3 of the RFD to analyse and assist with managing flood risk in the Lower Pine River catchment.

6 REFERENCES

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APPENDIX A

APPENDIX A: INFRASTRUCTURE DATA ASSESSMENT REPORT

A part of BMT in Energy and Environment

Infrastructure Data Assessment Report
Lower Pine River Catchment
Regional Floodplain Database Stage 3

R.B18521.001.01.LPR_Infrastructure_Data_Report.doc

January 2013

Infrastructure Data Assessment Report Lower Pine River Catchment Regional Floodplain Database Stage 3

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

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Project Manager :	Anne Kolega / Richard Sharpe
Client :	Moreton Bay Regional Council
Client Contact:	Hester van Zijl / Steve Roso
Client Reference	Regional Floodplain Database Stage 3

Title :	Infrastructure Data Assessment Report for the Lower River Catchment as part of Moreton Bay Regional Council's Regional Floodplain Database Stage 3
Author :	Anne Kolega / Richard Sharpe
Synopsis :	Infrastructure Data Assessment Report including the review and prioritisation of available and required infrastructure data for the detailed modelling of the Lower Pine River catchment for Moreton Bay Regional Councils RFD Stage 3.

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Moreton Bay Regional Council	PDF	PDF		
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CONTENTS

LIST OF FIGURES

1 INTRODUCTION

1.1 Background

Moreton Bay Regional Council (MBRC) is currently undertaking Stage 3 of developing a Regional Floodplain Database (RFD). The RFD includes the development of coupled hydrologic and hydraulic models for the entire local government area (LGA) that are capable of seamless interaction with a spatial database to deliver detailed information about flood behaviour across the region.

Stage 3 includes the detailed hydrologic and hydraulic modelling of 2 packages, which cover the Lower Pine River (LPR) catchment and the rivers and creeks that are also part of Brisbane City Council's (BCC) Local Government Area. This *Infrastructure Data Assessment report* forms part of the hydrologic and hydraulic modelling report of the Lower Pine River catchment.

1.2 Scope

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

- Review available information provided by MBRC and the Drainage Waterways Coastal Planning Unit (DWCP); this data included information from the Department of Environment and Resource Management (DERM);
- Undertake a gap analysis based on the broadscale model results and other data provided by MBRC (i.e. local roads, state controlled roads);
- Identify infrastructure data that need to be collected for the detailed modelling;
- Prioritise the additional infrastructure data required; and
- Document methodology and required infrastructure data in an Infrastructure Data Assessment report.

1.3 Objective

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

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

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

2 AVAILABLE DATA FOR GAP ANALYSIS

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

- Topographic data: The topography is based on LiDAR (**Li**ght **D**etection **A**nd **R**anging) data collected in 2009 and provided by Department of Environment and Resource Management (DERM);
- Hydrography dataset provided by MBRC in July 2011;
- State controlled roads and minor roads GIS layers provided by DERM in July 2011;
- As-constructed bridge plans for selected structures provided by MBRC where available;
- The structure information provided as part of the 1d_nwk_LPR and 2d_lfcsh_LPR layers from the broad-scale model developed by Worley Parsons. This structure data was based on plans, visual inspections and survey;
- The culvert survey information provided by MBRC, locating additional structures not included in the broadscale model, which have been surveyed by MBRC;
- The structure inspection information provided by MBRC, identifying additional structures, not included in the broadscale model that have been inspected by MBRC; the inspection will not be a detailed survey due to difficulties in the access, however it will provide photographs and measurements, which have proven to be helpful for modelling. MBRC has undertaken the site inspection on the 8th July 2011 and provided the collected data;
- The flood extents from the broad-scale model were utilised to locate potential structures; and
- A site visit undertaken by BMT WBM in the Lower Pine River catchment.

3 DATA CAPTURE METHODOLOGY

3.1 General Methodology

This section describes the methodology for the gap analysis and data prioritisation. All available data outlined in Section 2 were converted into GIS layers and reviewed. The roads layers were overlaid with the broadscale flood extent in the 1 in 100 year flood event to locate waterway structures. Each crossing was marked in locations where there was not already a previously modelled structure and where council had not already identified a structure as needing to be surveyed (gap analysis).

The data prioritisation was undertaken based on the following considerations and assumptions:

- Availability of accurate structure data from the broadscale model. These structures have been allocated priority A;
- Availability of additional structure data identified and already surveyed by MBRC. These have been allocated priority A;
- Culverts from the broadscale model with diameters of less than 0.6m have been allocated priority B; and
- Structures which were not included in the broadscale model but which council has identified for inspection (due to difficulty in access, not fully surveyed). These have been allocated priority B.

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

3.2 Data Prioritisation (A and B)

3.2.1 Bridges and Culverts

The gap analysis in the Lower Pine River catchment identified the following summary of available data and structure locations for potential additional data collection:

- 270 culverts were included in the broadscale model (1d_nwk_LPR layer). Of these, 10 have a diameter of less than 0.6m and have been prioritised as category B. The remaining 260 culverts have been prioritised as category A.
- 86 structures (bridges or culverts) were included in the broadscale model (2d_lfcsh_LPR layer). Of these, as-constructed bridge plans were provided for 6 structures. These have been reviewed and compared with the structures included in the broadscale model. Updates to the modelled structures will be undertaken as part of the detailed model development, where required. These 86 structures have been prioritised as category A.
- 20 culverts (not included in the broadscale model) were identified by the MBRC as critical structures to be surveyed were reviewed and have been prioritised as category A.
- 17 structures (not included in the broadscale model) were selected by the MBRC to be inspected were reviewed. Due to their location outside the broadscale flood extent or at the flood fringe, these structures were prioritised as category B. Of these 17 structures, photos and some measurements for 13 of the structures have been provided by MBRC, 3 structures could not be found or were not accessible and for one location dimensions were provided without a

photograph. For some of these inspected structure locations, MBRC also provided structure data from their existing stormwater asset database (LPR_GIS_Stormwater_pipes.TAB).

- 16 additional structure locations were identified by BMT WBM, where no available information was available from the broadscale model and from MBRC's review, based on the road and flood extent data available (LPR_gap_analysis_003.TAB). Out of these 16 locations, 8 were categorised with priority A and the remaining 8 were categorised with priority B. Figure A-1 in the Appendix provides a summary of the available and previously selected structures to be surveying or inspected by MBRC and the additional structures identified by BMT WBM from the gap analysis.

Based on the data review and gap analysis the bridges and culverts were prioritised as follows:

- a

The data prioritisation undertaken in category A and B are illustrated in Figure A-2 in the Appendix. The associated digital data are also being provided to MBRC.

3.2.2 Channels

A number of channels were identified in the Lower Pine River catchment. The locations have been digitised and are illustrated in Figure A-1. Channel information is currently being sourced from MBRC.

3.2.3 Detention Basins and Dams

The Sideling Creek Dam (Lake Kurwongbah) and Lake Samsonvale are part of the Sideling Creek and Upper Pine River catchments, respectively. These two catchments discharge into the Lower Pine River catchment.

No other major detention basins were identified in the Lower Pine River catchment; minor basins and/or wetlands have been identified based on the DEM. One of the larger minor basins is located between Kremzow Road and Old North Road in the Four Mile Creek catchment, discharging into South Pine River.

3.2.4 Bathymetry

Bathymetry was collected by MBRC in 2005. The bathymetry survey extends from Bramble Bay to Gympie Road on the North Pine and South Pine River. Therefore, no additional bathymetry data is required.

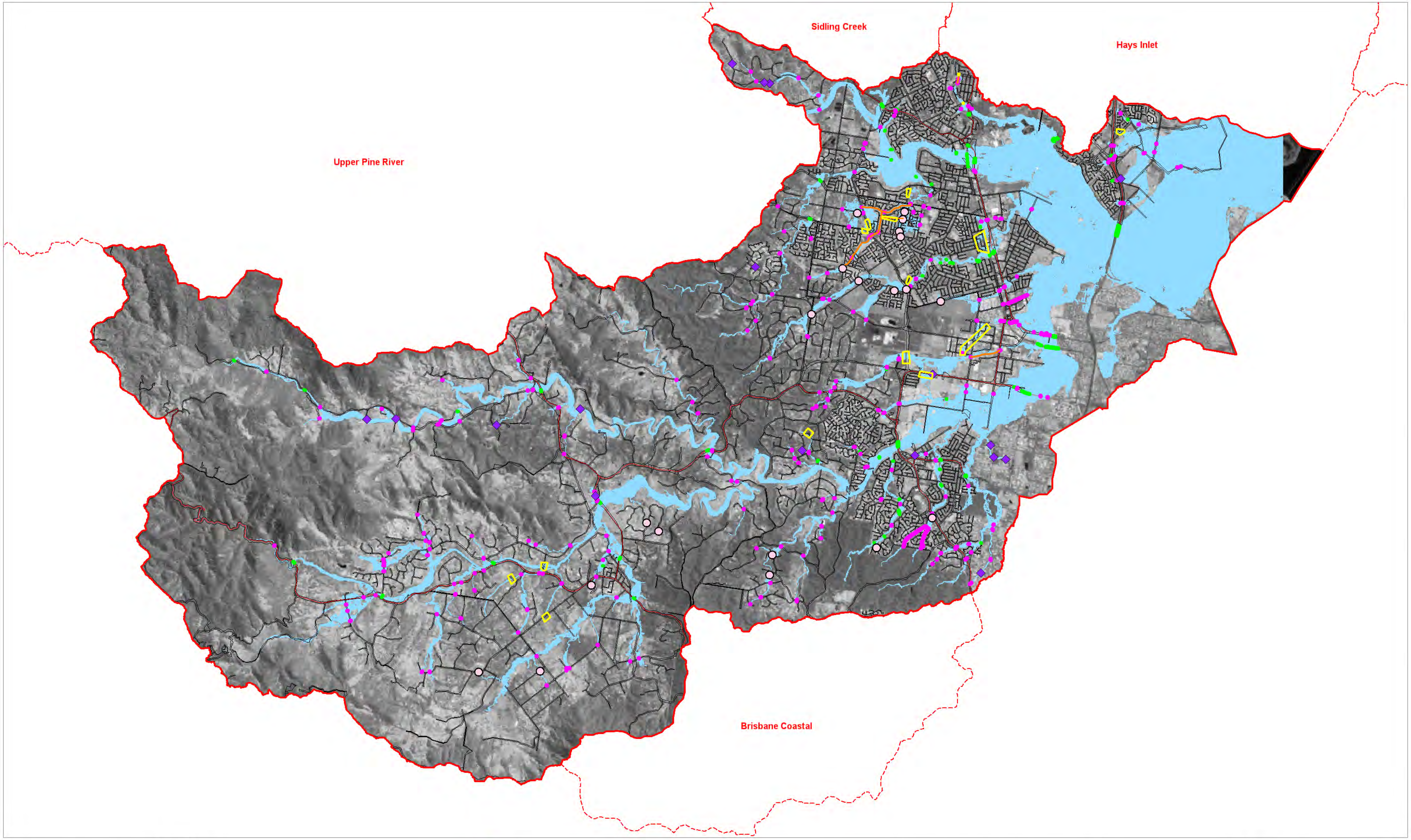
4 CONCLUSION AND RECOMMENDATION

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

Priority A data involves data that is critical for a high quality model; priority B data includes culverts with an opening smaller than 600mm and all remaining data for which assumptions, such as field inspection and desktop measurements, could be used to achieve a relatively high quality model.

The development of the Regional Floodplain Database (RFD) will also be used for other asset data management purposes by Moreton Bay Regional Council. Therefore this is a good opportunity for MBRC to collect additional data on waterway structures.

APPENDIX A: MAPS



LEGEND

- Lower Pine River Catchment
- Road Reserves
- Structures Inspected by MBRC
- Structures Surveyed by MBRC
- Channels Identified by BMT WBM
- 1D Structures provided by MBRC
- 2D Structures provided by MBRC
- State Controlled Roads
- Minor Roads and Road Reserves
- Additional Structure Locations Identified by BMT WBM
- Flood Extent (derived from the broadscale model)

Title:

Infrastructure Data Summary - Lower Pine River

Figure: **A-1**

Rev: **A**

N

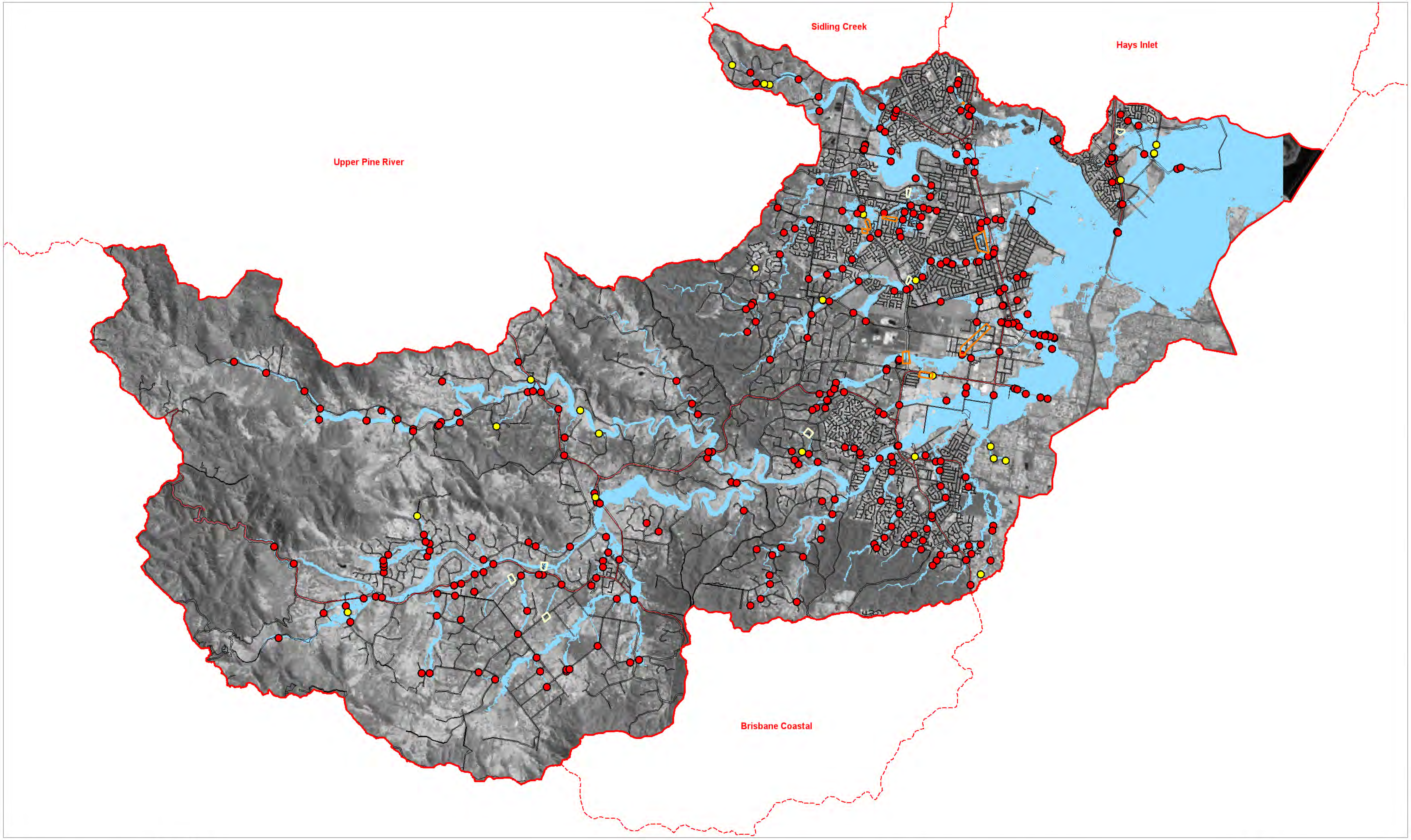
0 2.5 5km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\FLD_003_110803 Lower Pine Infrastructure Data.wor



LEGEND

- Lower Pine River Catchment
- Road Reserves
- Structure Priority A
- Structure Priority B
- State Controlled Roads
- Minor Roads and Road Reserves
- Additional Structures Priority A Identified by BMTWBM
- Additional Structures Priority B Identified by BMTWBM
- Flood Extent (derived from broadscale model)

Title:
Data Prioritisation Map - Lower Pine River

Figure: **A-2**

Rev: **A**

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Approx. Scale

BMT WBM
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Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\FLD_004_110803 Lower Pine Data Prioritisation.wor

APPENDIX B: SITE VISIT PHOTOS

Figure B- 1 Bruce Highway Bridge, Pine River

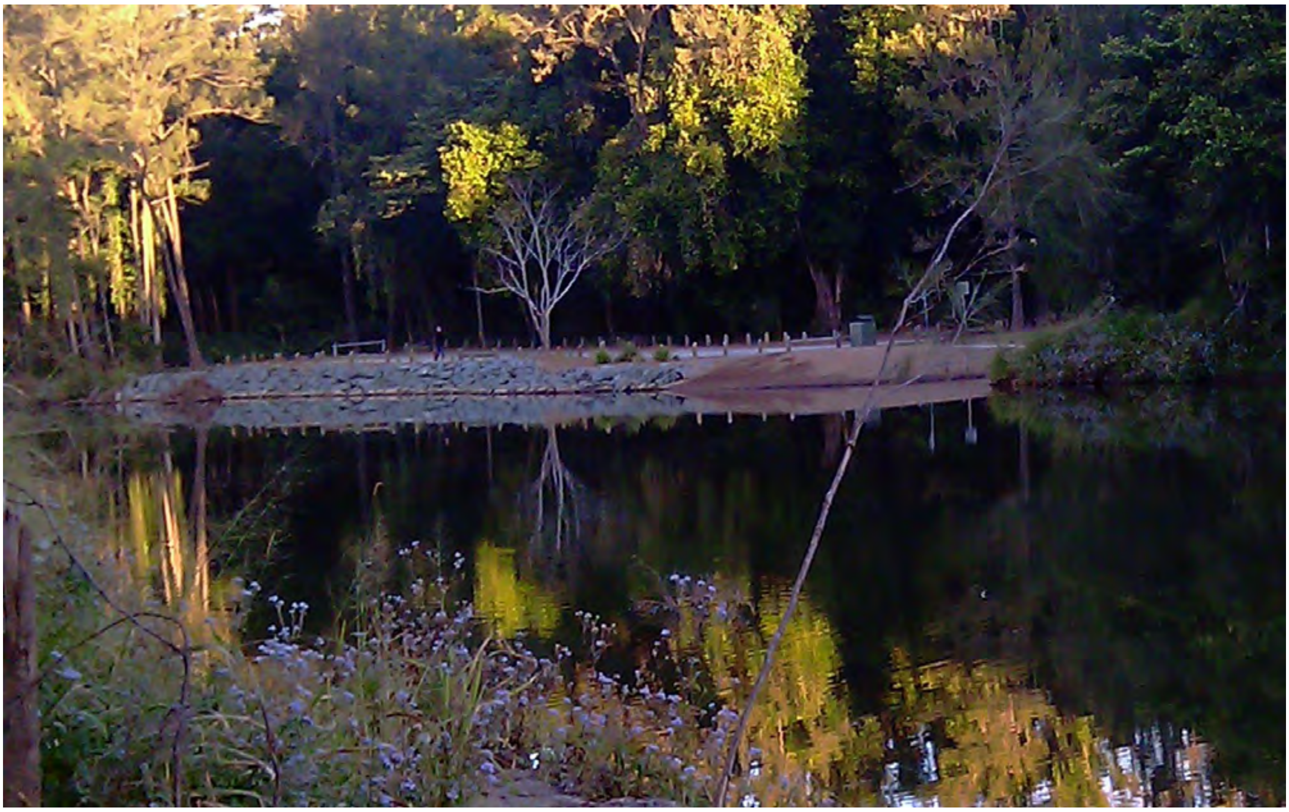

Figure B- 2 Bunya Crossing, South Pine River

Figure B- 3 Eatons Crossing Road Bridge, Cedar Creek

Figure B- 4 Cedar Creek, under Eatons Crossing Road Bridge

Figure B- 5 Eatons Crossing Road Bridge, Cedar Creek, Eastern Channel

Figure B- 6 Gympie Road Bridge, North Pine River

Figure B- 7 Gympie Road Railway Bridge, North Pine River

Figure B- 8 Youngs Crossing Road, North Pine River

Figure B- 9 Cedar Creek Road, Downstream (courtesy of MBRC)

Figure B- 10 Private Road close to Cedardell Ct, Upstream (courtesy of MBRC)

Figure B- 11 South Pine Road, Upstream (courtesy of MBRC)

Figure B- 12 Wagner Rd, Downstream (courtesy of MBRC)

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APPENDIX B

APPENDIX B: HYDROGRAPHY REVIEW REPORT

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Our Ref: AK: L.B18521.004.LPR_Hydrography_Review.doc

19 August 2011

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

Attention: Hester van Zijl

Dear Hester,

RE: Hydrography Review Report for the Lower Pine River Catchment
Regional Floodplain Database Stage 3

1 Background

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

Stage 3 of the RFD includes the detailed modelling of 2 catchments, namely the Lower Pine River (LPR) catchment and the rivers and creeks that are also part of Brisbane City Council's (BCC) Local Government Area.

This *Hydrography Review Report* forms part of the modelling of the LPR catchment, RFD, Stage 3.

2 Scope

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

- Review the subcatchment delineation as part of Stage 1 (broadscale modelling);
- Identify areas that are to be refined, taking the recommendations already made by MBRC into account; and
- Propose changes and provide a report and digital data to MBRC for review.

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

3 Objective

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

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

4 Hydrography Review Data

The following data was utilised for this assessment:

- Hydrography dataset (catchment delineation, reaches and junctions) provided by MBRC in July 2011;
- The 100y flood extents from the Stage 1 broad-scale model sub-project were utilised to locate potential structures;
- Overland flow layer provided by council;
- 7 locations identified by MBRC as possible sites for additional sub-catchment breakdowns; and
- Digital Elevation Model for the catchment provided by MBRC and based on LiDAR data collected in 2009 and derived from the Department of Environment and Resource Management (DERM).

5 Methodology

The original subcatchment delineation was reviewed utilising the data outlined above. In the 7 locations where MBRC recommended a sub-catchment breakdown, this was done. In the upper catchment there are a number of rural sub-catchments with little or no development. These subcatchments were not refined as the extra detail was not considered necessary. However in several more developed sub-catchments where it was observed that significant overland flow extended further than the 100y flood extent, these were broken down further.

6 Proposed Changes

Subcatchments that were considered too coarse were subdivided, thereby refining the subcatchment delineation and the associated future model output and flood information across the Lower Pine River catchment. The proposed changes to the subcatchments are illustrated in Figure 1. Figures 1 also show the original subcatchment delineation and the flood extent from the broadscale model.

Accompanying this report, a digital dataset has been provided to MBRC on 19 August 2011

- *LPR_Hydro_Catchments_Minor_revised_002.TAB*, comprising all sub-catchments including the proposed subcatchments; and
- *LPR_Hydro_Catchments_Minor_subdivided_002.TAB* including only the catchments that we propose to change within the catchment.

The following subcatchments are proposed to be subdivided:

Sub-catchment Identifier	Catchment	Minor Basin	Subdivision Recommended by:	Number of Divisions
FMC_01_13657	Four Mile Creek	Lower Pine River	MBRC	2
TOD_01_04496	Todds Gully	Lower Pine River	MBRC	2
KFC_02_00000	Kingfisher Creek	Lower Pine River	MBRC	4
SPR_26_00000	South Pine River	Lower Pine River	MBRC	4
BER_03_00000	Bergin Creek	Lower Pine River	MBRC	4
BER_01_02235	Bergin Creek	Lower Pine River	MBRC	2
YEB_04_00317	Yebri Creek	Lower Pine River	BMT WBM	4
YEB_04_00317	Yebri Creek	Lower Pine River	BMT WBM	4
NPR_49_00829	North Pine River	Lower Pine River	BMT WBM	5
FMC_07_00872	Four Mile Creek	Lower Pine River	BMT WBM	2
OMC_01_02640	One Mile Creek	Lower Pine River	BMT WBM	2
BHC_01_07934	Bald Hills Creek	Lower Pine River	BMT WBM	2
COU_02_00000	Coulthards Creek	Lower Pine River	BMT WBM	3
SPR_01_09076	South Pine River	Lower Pine River	BMT WBM	2
FMC_02_00566	Four Mile Creek	Lower Pine River	BMT WBM	2
CON_01_07374	Conflagaration Creek	Lower Pine River	BMT WBM	2
FMC_01_16828	Four Mile Creek	Lower Pine River	BMT WBM	2
SPR_35_00000	South Pine River	Lower Pine River	BMT WBM	2
SPR_33_05420	South Pine River	Lower Pine River	BMT WBM	4
KFC_03_00298	Kingfisher Creek	Lower Pine River	BMT WBM	2
SPR_23_00000	South Pine River	Lower Pine River	BMT WBM	3
SPR_01_16606	South Pine River	Lower Pine River	BMT WBM	3
CED_13_04708	Cedar Creek	Lower Pine River	BMT WBM	2
SPR_21_00336	South Pine River	Lower Pine River	BMT WBM	2
SAM_01_04779	Samford Creek	Lower Pine River	BMT WBM	3

7 Recommendation

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

8 Reference

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

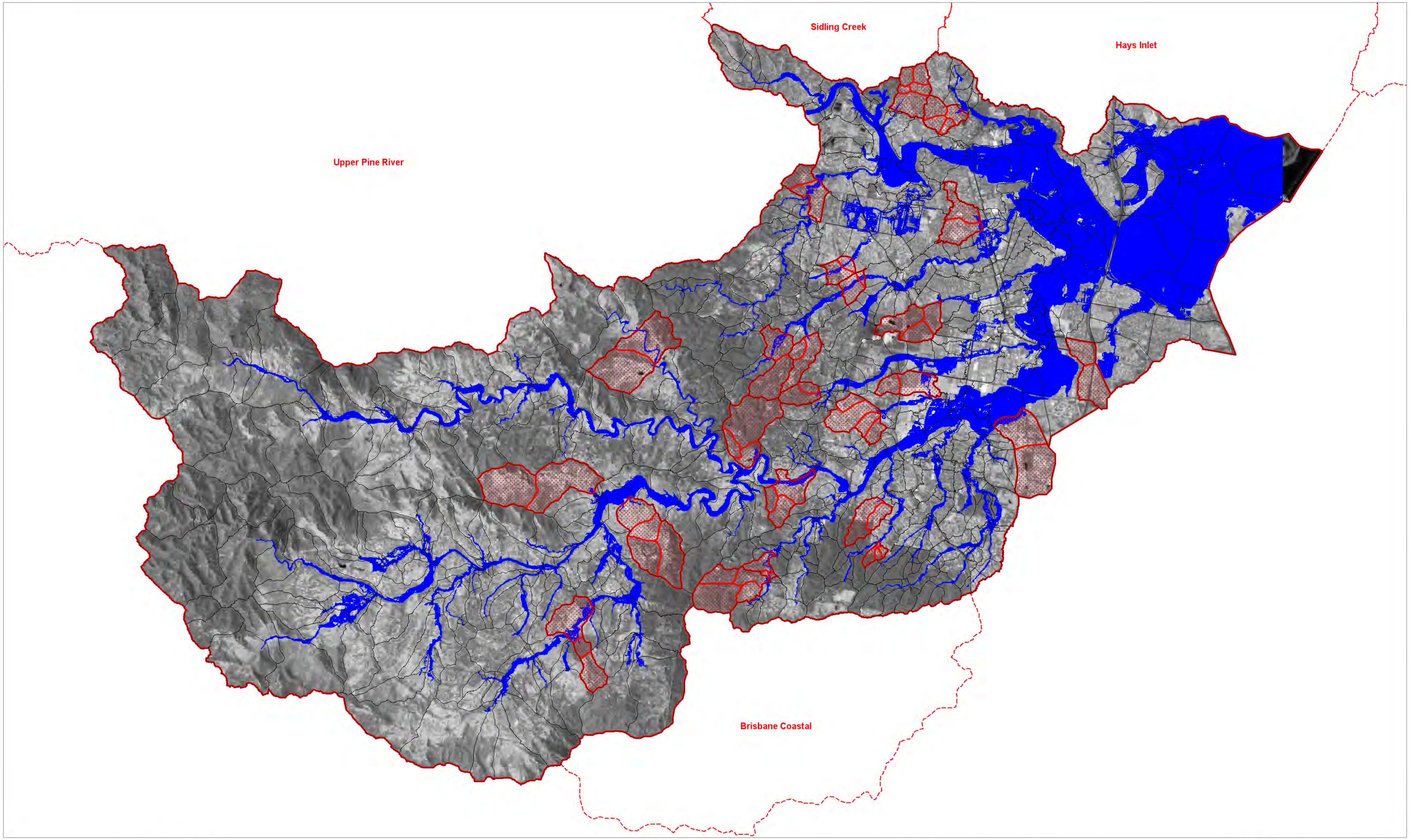
Please contact me should you wish to discuss the report.

Yours faithfully
BMT WBM Pty Ltd

Richard Sharpe
Senior Flood Engineer

Enclosed:

Figure 1: Hydrography Review and Proposed Changes Lower Pine River Catchment



LEGEND

- Lower Pine River Catchment
- Stage 1 Flood Extent (100 Year ARI)
- Original Catchment Delineation
- Proposed Catchment Delineation

Title:

Hydrography Review and Proposed Changes
Lower Pine River Catchment

Figure: **1**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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APPENDIX C

APPENDIX C: CALIBRATION AND VALIDATION REPORTS

A part of BMT in Energy and Environment

Calibration Feasibility Report Lower Pine River Catchment Regional Floodplain Database Stage 3

R.B18521.002.01.LPR_Calibration_Feasibility_Report

January 2013

Calibration Feasibility Report
Lower Pine River Catchment
Regional Floodplain Database
Stage 3

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Document :	R.B18521.002.01.LPR_Calibration_Feasibility_Report.doc
Project Manager :	Anne Kolega / Richard Sharpe
Client :	Moreton Bay Regional Council
Client Contact:	Steve Roso/ Hester van Zijl
Client Reference	Regional Floodplain Database

Title :	Calibration Feasibility Report for the Lower Pine River Catchment Regional Floodplain Database Stage 3
Author :	Anne Kolega / Richard Sharpe
Synopsis :	Calibration Feasibility Report including the review of available rainfall and river gauge data for the calibration of the combined hydrologic and hydraulic model developed for the Lower Pine River catchment for Moreton Bay Regional Councils RFD Stage 3.

REVISION/CHECKING HISTORY

REVISION NUMBER	DATE OF ISSUE	CHECKED BY		ISSUED BY	
0	08/09/2011	R Sharpe		A Kolega	
1	22/01/2013	R Sharpe		A Kolega	

DISTRIBUTION

DESTINATION	REVISION			
	0	1	2	3
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BMT WBM File	PDF	PDF		
BMT WBM Library	PDF	PDF		

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1 INTRODUCTION

1.1 Background

Moreton Bay Regional Council (MBRC) is currently undertaking Stage 3 of developing the Regional Floodplain Database (RFD). The RFD includes the development of coupled hydrologic and hydraulic models for the entire local government area (LGA) that are capable of seamless interaction with a spatial database to deliver detailed information about the existing flood behaviour across the region.

Stage 3 includes the detailed hydrologic and hydraulic modelling of 2 packages; the Lower Pine River (LPR) catchment and the rivers and creeks that are also part of Brisbane City Council's (BCC) Local Government Area. This *Calibration Feasibility Report* addresses the Lower Pine River catchment only and forms part of the hydrologic and hydraulic modelling for the LPR catchment.

The Lower Pine catchment includes the following Rivers and Creek:

- Parts of the North Pine River (from downstream of Lake Samsonvale, also called North Pine Dam) until it discharges into Pine River,
- Sideling Creek from downstream of Lake Kurwongbah where it discharges into North Pine River;
- The entire South Pine River catchment; and
- The entire Pine River, which is formed at the junction of the North Pine River and South Pine River (some 7 km upstream from the mouth), to the mouth, where the combined system forms an extensive coastal estuary.

The aim of this assessment is to investigate the feasibility of calibrating the Lower Pine River hydraulic model by considering the quantity and quality of rainfall gauge, river gauge and other information on flooding in the catchment.

1.2 Scope

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

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

2 HISTORIC FLOOD EVENTS

Based on the recorded flood levels in the South Pine River illustrated in Figure 2-1, significant flood events categorised as major floods by the Bureau of Meteorology (BoM) were reported in 1967, 1972, 1974, 1989, 1991, 2009, 2010 and, most recently, in January 2011. The three largest events on record are the 1974, 2011 and 1991 flood events.

The highest flood on record for the South Pine River at Drapers Crossing is the January 1974 flood with a height of 7.44mAHD, and the second highest record is in January 2011 with a flood height of 7.32mAHD.

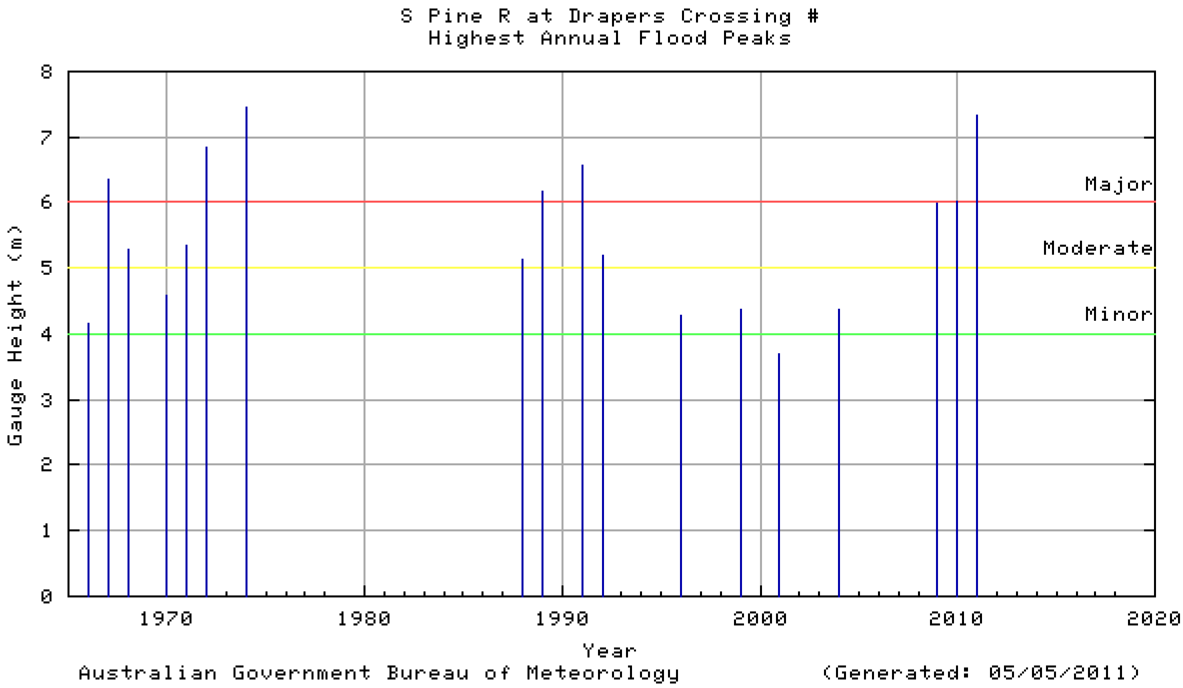


Figure 2-1 Historic Peak Flood Levels on the South Pine River at Draper Crossing

3 AVAILABLE DATA

3.1 Stream Gauge Data

A review of stream gauge data was undertaken based on data available from BoM and MBRC. Based on the water resource station catalogue provided by BoM, a total of 9 stream gauge stations were identified within the Lower Pine River catchment.

Table 3-1 summarises the available river gauge data obtained from MBRC, DERM and the BoM for the Lower Pine River catchment with the start and end date for the stream gauges. The information provided in Table 3-1 is based on the water resource station catalogue provided by BoM. Figure 3-1 illustrates the location of these gauges.

Table 3-1 Stream Gauge Summary[1]

ID	Stream Gauge	Station No	Owner	Start Date	End Date
1	Albany Ck	142201B	DERM	1/01/1917	1/01/1948
2	Cash's Crossing	142201A	DERM	1/01/1909	1/01/1917
	Cash's Crossing	142201D	DERM	1/01/1951	1/01/1964
3	Drapers Crossing	142202A	DERM	1/01/1965	
4	Drapers Crossing Alert	142804	BOM (Qld)	23/11/1994	
5	Fahey's Crossing	142201C	DERM	1/01/1947	1/01/1952
6	Petrie Alert	142802	BOM (Qld)	23/11/1994	
7	Samford Alert	142817	BOM (Qld)	12/04/1995	16/08/2004
8	The Y.M.C.A Camp	142102B	DERM	1/01/1969	1/01/1972
9	Young's Crossing	142101A	DERM	1/01/1915	1/01/1978

BoM also publishes information on their website on the *Flood Warning System for the Pine & Caboolture River Systems,* which is also provided in Appendix A. This information is somewhat contradictory to the water resource catalogue and information provided in Table 3-1. The stream gauge information has been requested and the availability of recorded data will be confirmed once this data is available.

The hydrograph for the Drapers Crossing gauge for the January 2011 and 1974 flood events are provided in Appendix B.

3.1.1 Flood Classification

Table 3-2 shows the flood classification levels of minor, moderate and major floods adopted by the BoM for selected river height stations in the Lower Pine River catchment[2].

[1] Source: http://www.bom.gov.au/hydro/wrsc
[2] Source: http://www.bom.gov.au/hydro/flood/qld/brochures/caboolture/caboolture.shtml

Table 3-2 Flood Level Classification of Selected Gauges

Stream Gauge	Minor Flood Level (m)	Moderate Flood Level (m)	Major Flood Level (m)
Cash's Crossing	6.3	6.7	8.1
Drapers Crossing	4.0	5.0	6.0
John Bray Park	3.4	3.7	4.3
Murrumba Downs	2.3	2.5	4.1
Petrie Alert	3.5	5.5	7.1
Samford Alert	4.8	5.3	5.8
Young's Crossing	6.0	7.5	9.5

Note: All heights are in metres relative to the stream gauge datum.

3.2 Rainfall Data

Rainfall gauge data was provided by MBRC, and comprised of the following three categories:

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

A review was undertaken to identify relevant rainfall data from stations that are located within the Lower Pine catchment and rainfall stations outside the Lower Pine catchment that can be utilised for the model calibration. Table 3-3 summarises the rainfall data for the Lower Pine River catchment and Figure 3-1 shows the gauge locations. In total, 18 rainfall alert gauges have been identified; 12 of these are located within the catchment, and the other 6 stations are nearby the catchment periphery, refer to Figure 3-1. MBRC has already consolidated and provided 5 minute interval data series for these 18 stations for the January 2011 event.

Figure 3-1 illustrates that these 18 gauge locations cover the catchment relatively well, except for the south-western portion of the catchment. Interpolation of rainfall depths across the south-west portion of the catchment will therefore be relatively coarse and uncertain. Radar data will be sourced from BoM to inspect rainfall intensity variations across the catchment, and thereby identify any inadequacies in the distribution of rainfall gauges.

Table 3-3 Rainfall Data Summary

ID	Sensor Name	Sensor Type	BoM Station	Easting	Northing
1	Cash's Crossing AL	Rainfall Alert	540415	496093	6975598
2	Cedar Creek AL	Rainfall Alert	540444	486608	6977170
3	Clear Mountain AL	Rainfall Alert	540418	488744	6979734
4	Deagon AL	Rainfall Alert	540124	505688	6976366
5	Drapers Crossing AL	Rainfall Alert	540205	492362	6974950
6	Ferny Hills AL	Rainfall Alert	540115	492997	6969719
7	John Bray Park AL	Rainfall Alert	540413	498524	6980705
8	Lake Kurwongbah AL	Rainfall Alert	540204	495050	6985873
9	Lawnton AL	Rainfall Alert	540439	499374	6982997
10	Mt Glorious Alert-P	Rainfall Alert	540138	474959	6978461
11	Murrumba Downs AL	Rainfall Alert	540417	501738	6981671
12	Normanby Way AL	Rainfall Alert	540414	499689	6979637
13	North Pine Dam AL-B	Rainfall Alert	540277	493401	6984027
14	Petrie AL	Rainfall Alert	540203	497526	6983659
15	Samford AL	Rainfall Alert	540060	488077	6973592
16	Samford Village AL	Rainfall Alert	540416	488991	6972560
17	Three Ways AL	Rainfall Alert	540110	482789	6964233
18	Youngs Crossing AL	Rainfall Alert	540412	495474	6984013
19	Amcor Cartonboard - Petrie Mill	Rainfall Daily	498406	6983748	498406
20	Highvale	Rainfall Daily	481845	6971617	481845
21	Strathpine Colonial Drive	Rainfall Daily	495873	6982208	495873
22	Bald Hills Post Office	Not Operational	500960	6977722	500960
23	Bracken Ridge Road Alert	Not Operational	502196	6979018	502196
24	Camp Mountain (Davison Road)	Not Operational	486792	6969685	486792
25	Clear Mountain Buranda Rd	Not Operational	490414	6977597	490414
26	Mt Glorious Fahey Rd	Not Operational	477416	6976527	477416
27	Samford CSIRO	Not Operational	488736	6973497	488736
28	Samford Kay Drive	Not Operational	487748	6972422	487748

3.3 Flood Marks Providing Historic Flood Levels

Historic flood level records were provided by MBRC. This data comprises in total 7 historic storm events ranging from 1966 through to 2011. The highest numbers of recorded levels were collected in 1974 and January 2011. A summary of the number of flood marks recorded for each year is provided in Table 3-4. The locations of the flood marks are shown in Figure 3-2.

It should be noted that most of the flood marks collected for the January 2011 flood event are located within the North Pine River catchment; only 4 flood marks were collected along Cedar Creek in the upper part of the South Pine River catchment. Therefore, the coverage of flood marks in this particular event is quite poor for the South Pine River.

Table 3-4 Flood Mark Summary

ID	Flood Mark Date	Number of Flood Marks
1	1974	73
2	January 2011	56
3	1967	46
4	1988	19
5	1989	13
6	1966	8
7	1976	3

3.4 Water Quality Event Monitoring and Maximum Height Indicators

Maximum height indicators were provided by MBRC. Ten maximum height indicators are located within the Lower Pine catchment; refer to Figure 3-1 for locations. These indicators are used for road safety and do not record levels. Therefore, these indicators are not suitable for model calibration and have been included in this report for documentation purposes only.

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

- South Pine River Site ID: South Pine River PRSC012;
- South Pine River Site ID: South Pine River - PRSC013;
- Cedar Creek Site ID: Cedar Creek - PRSC011;
- Four Mile Creek Site ID: Four Mile Creek - 2PRSC014; and
- One Mile Creek Site ID: Hayward Avenue Reserve.

These gauges record water levels, rainfall and turbidity and were installed between the years 2007 and 2009. The flood levels from these records may be used as additional information for model calibration for the January 2011 event. The gauge locations are illustrated in Figure 3-1.

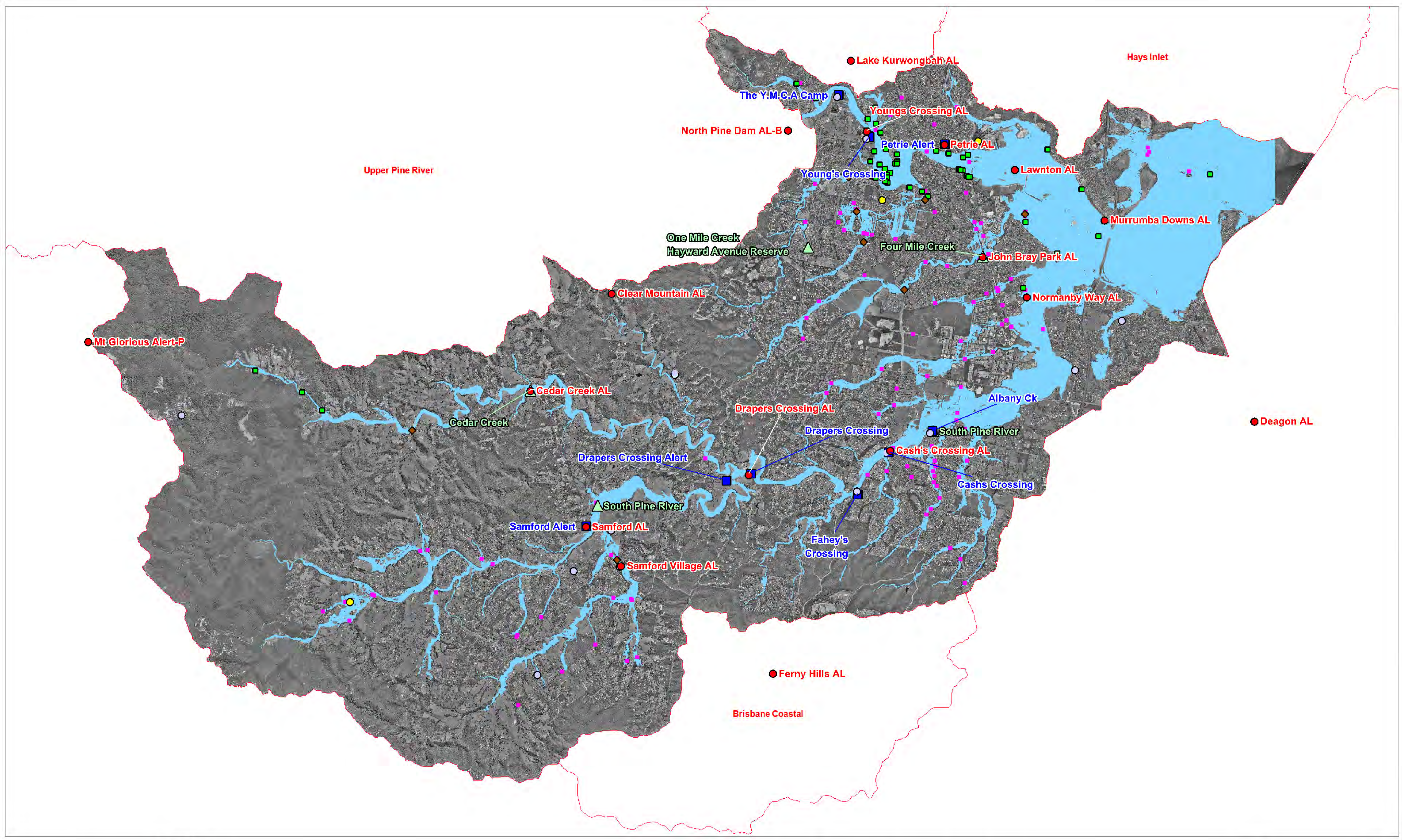
3.5 Resident Survey

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

Where the community provided feedback and flood marks, MBRC has surveyed these flood marks. These marks were included in the flood mark layer (Section 3.3) and will be utilised for the model calibration in the respective storm event.

3.6 Floodmark and Photo Collection January 2011 Event

The January 2011 flood event in the Lower Pine River Catchment provided an excellent opportunity to collate an expansive and reliable set of flood data. MBRC were active in capturing this flood information, which includes flood levels, and photographs, primarily on the North Pine River catchment. It is anticipated that the January 2011 flood information will be a good resource for model calibration in parts of the catchment where the data is available; mainly for the North Pine River. In the South Pine River part of the catchment there are only 4 flood marks and 1 definite stream gauge recorded level for the 2011 flood, however this gauge at Drapers Crossing was the second highest on record and classified as a major flood.



LEGEND

- Lower Pine River Catchment
- Stage 1 Flood Extent (100 Year ARI)
- Rainfall Alert Gauges and Pluviometers
- Rainfall Gauges - Not Operational (in 2011)
- Rainfall Gauges Daily
- River Gauges
- Water Quality Monitoring Event Gauges
- Flood Marks collected in January 2011
- Flood Marks collected prior to 2011
- Maximum Height Indicators

Title:

Rainfall and Stream Gauge Locations
Lower Pine River Catchment

Figure: **3-1**

Rev: **A**

N 0 2.5 5km
Approx. Scale

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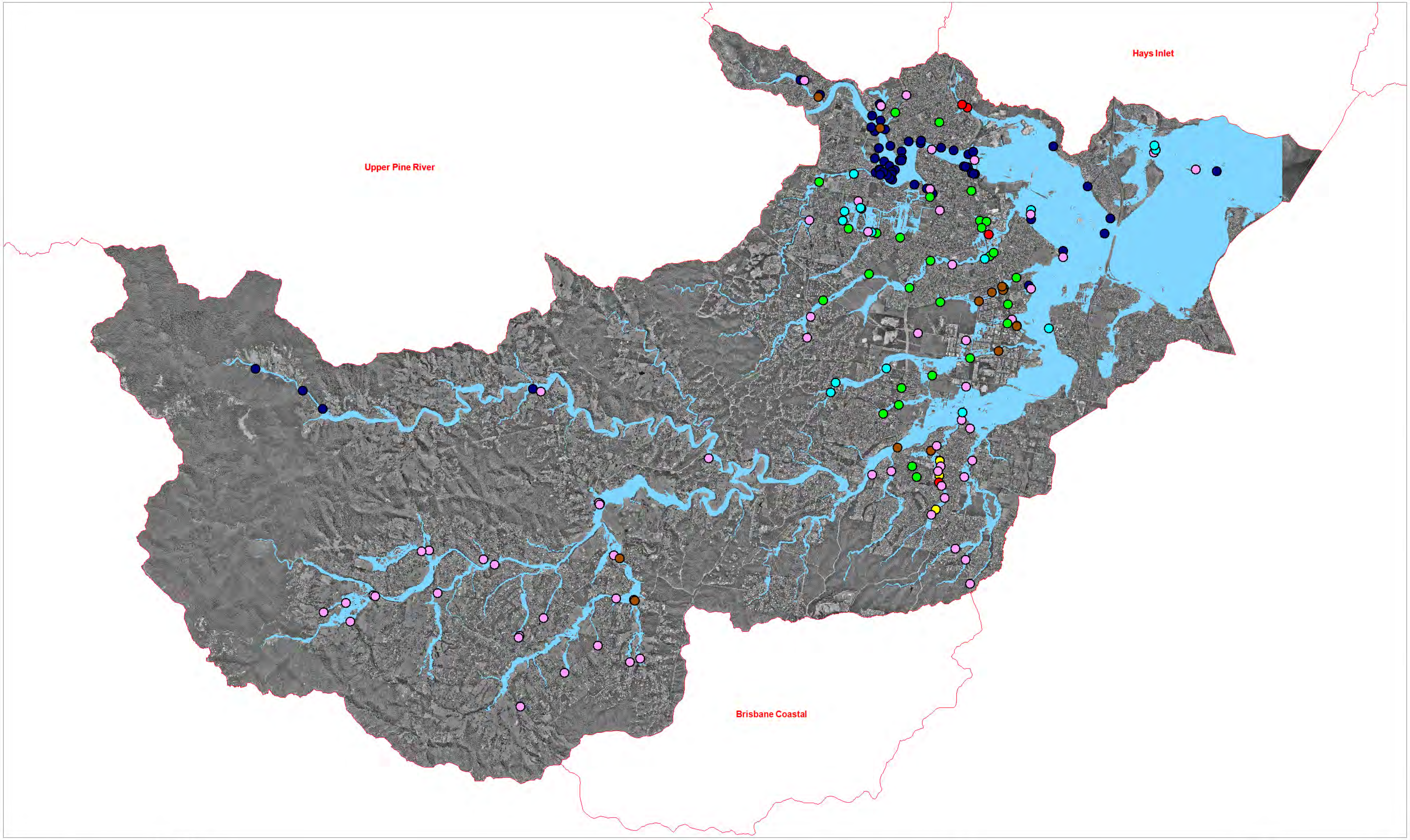


LEGEND

Lower Pine River Catchment

Stage 1 Flood Extent (100 Year ARI)

Historic Flood Marks

2011	1974
1989	1970
1988	1967
1976	1966

Title:

Flood Marks Categorised Per Year

Figure: **3-2**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N 0 2.5 5km Approx. Scale

BMT WBM www.bmtwbm.com.au

Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\FLD_007_110905_LPR_Flood_Marks.wor

4 CONCLUSION

Following on from the January 2011 event, MBRC has been active in collecting flood marks in a timely manner for the Lower Pine River and other catchments in the LGA. MBRC also invited the community to provide photos, flood marks and other relevant information via their RFD website. In total, 56 flood marks were collected in the LPR catchment. However, most of these are located within the North Pine River catchment (see Section 3.3). This recent January 2011 flood event is expected to improve flood awareness within the community, and may lead to improved acceptance of the RFD and, by calibrating the model to this flood event, the associated flood model results. However, since the coverage of the flood marks for the January 2011 flood event is limited, it is recommended that a second event is used to verify the model.

The 1974 flood was the largest on record and MBRC has recorded 73 flood marks for this event. The only negative aspect with use of this event for model verification is that it occurred nearly 40 years ago. During this time the catchment may have changed significantly in terms of its landuse, topography and number of structures within the creeks and rivers. All of these catchment characteristics will greatly affect the hydraulic behaviour and will have to be represented as best as possible in the model. Therefore, the suitability of the 1974 flood event for model verification will largely depend on whether information is available to replicate the LPR catchment in 1974.

River gauge data is crucial for a high quality model calibration due to the ability to not only calibrate to the peak flood level, but also to the flood volume and the timing. The number of available gauges across the catchment therefore influence the quality of the model calibration exercise; generally the more gauge data available the better, and a good spread of the gauges over various tributaries in the catchment is also advantageous. There will be at least one stream gauge on the South Pine River at Drapers Crossing that recorded flood levels for major storm events, including 1974 and 2011. The additional number of stream gauges data that recorded flood levels for the major storm events is yet to be confirmed, however it is likely that will be limited to a maximum of one more gauge at Petrie for the 1974 flood and two more gauges at Samford Village and Cashs' Crossing for the major event between 2009 and 2011 (based on information provided by BoM and provided in Appendix A).

More recent flood events are preferable for model calibration because it is less likely that the catchment's topography and landuse have changed significantly. The severity of the flood is also important. For this particular study a minor flood event (e.g. the 5 or 10 year ARI event) is less useful for calibration compared to larger flood events (e.g. 50 or 100 year ARI event). This is because the study includes modelling of large flood events, and calibrating to large flood events will test both in-bank and out-of-bank flow in the hydraulic model.

There are twelve alert rainfall and pluviometer gauges within the catchment and another 6 alert rainfall and pluviometer gauges outside but near the catchment. For model calibration the alert and pluviometer gauges are preferred compared to daily stations because the records are more detailed (5 to 6 minute interval data). The coverage of pluviometers is considered satisfactory, although it is also noted that there are certain areas, in particular in the south-west of the catchment, with a lack of rainfall data in the Lower Pine River. This will influence the accuracy and level of detail during the calibration process.

The January 2011 event had high rainfall at the western part of the Lower Pine catchment, but less rainfall was recorded towards the coast and Deception Bay. The neighbouring catchments to the north-east, Hays Inlet and Redcliffe, did not experience a major flood event in 2011.

The Lower Pine River model will receive inflows from two upstream catchments that have been modelled separately during Stage 2 of the RFD (the Upper Pine River (UPR) and Sideling Creek (SID)) for the design events. As such, inaccuracies in the upstream catchment models will be passed through into the Lower Pine River model. There are three approaches that could be used in the calibration modelling approach:

1. Utilise outflows from the UPR and SID models as upstream inflow boundary conditions in the UPR model. Model calibration has been undertaken for these two catchments for the January 2011 flood event, so the outflows are available for calibrating the LPR model.
2. Develop upstream inflow boundary conditions for the UPR calibration model based on recorded rain gauge data and the hydrology model. Again, this information is already available.
3. Use recorded stream gauge data at Young’s Crossing (including flows from the Upper Pine River and Sideling Creek catchment) to estimate an inflow into the model.

It is recommended that the first approach (point 1 above) is used, as this is consistent with the design flood event modelling approach. However, the other two approaches could be considered if the modelled and measured results are not comparing well.

Based on the severity of the flood events, the availability and frequency of rainfall and stream gauge data and flood mark information, model calibration is possible for the following events:

- January 2011;
- January 1974;
- February 1999; and
- May 2009.

5 RECOMMENDATIONS

As discussed in Section 4, there are sufficient historical flood records to undertake a calibration exercise on the LPR model; however, there are some limitations in the available data, so it is advisable that a second historical flood event is used to verify the model.

The most suitable flood event for calibration is the January 2011 flood event due to it being recent, large (second biggest flood on record) and having a sizeable and reliable data record relative to the other major flood events. However the quality of the calibration will be limited due to the following reason:

- Flood marks for the January 2011 flood event are concentrated around the Upper Pine River, and flows in this river will be largely controlled by the outflows of the UPR and SID models. As a result, the calibration will not cover much of the South Pine River catchment.

The most suitable flood event for the model verification is the 1974 flood event due to it being the largest flood on record and the availability of a large set of records relative to the other major floods. The quality of the verification will be limited due to the small number of stream gauges operational during the flood and because of potential changes to the catchment over the last 40 years.

In light of these limitations, it is still recommended to undertake a calibration and verification exercise on the LPR flood model, as this may provide a mechanism to improve and gain an understanding of the model performance.

6 REFERENCE

Bureau of Meteorology, 2011, *Water Resources Station Catalogue*, viewed 1 September 2011, <http://www.bom.gov.au/hydro/wrsc>

Bureau of Meteorology, 2011, *Flood Warning System of the Pine and Caboolture Rivers*, viewed 1 September 2011, <http://www.bom.gov.au/hydro/flood/qld/brochures/caboolture/caboolture.shtml>

Moreton Bay Regional Council, 2011, *Share your flood data*, viewed 1 September 2011, <http://www.moretonbay.qld.gov.au/general.aspx?ekfrm=74810&libID=77442>

APPENDIX A: FLOOD WARNING SYSTEM FOR THE PINE & CABOOLTURE RIVERS PROVIDED BY BOM

FLOOD WARNING SYSTEM for the PINE & CABOOLTURE RIVERS

This brochure describes the flood warning system operated by the Australian Government, Bureau of Meteorology for the Pine and Caboolture Rivers. It includes reference information which will be useful for understanding Flood Warnings and River Height Bulletins issued by the Bureau's Flood Warning Centre during periods of high rainfall and flooding.

Pine River at Murrumba Downs

Contained in this document is information about:
(Last updated May 2011)

Flood Risk

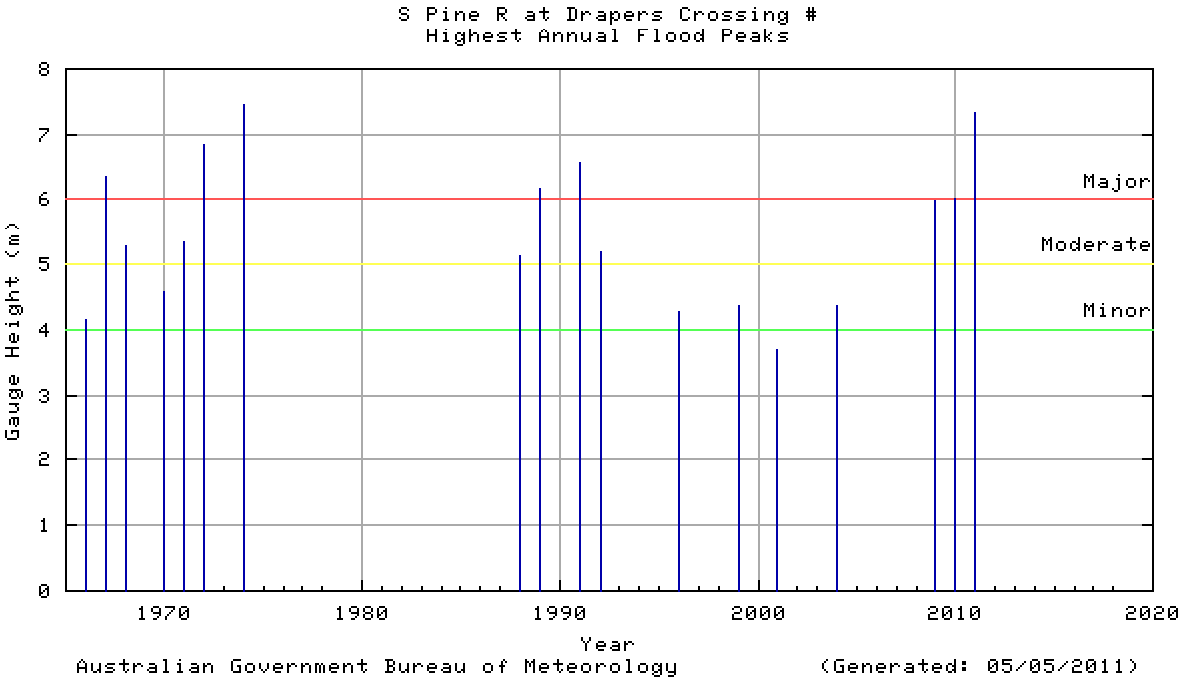
The Pine River catchment drains in a generally easterly direction from the relatively steep D'Aguilar Ranges towards the flat coastal plains of Bramble Bay between Sandgate and Redcliffe. The North Pine River and South Pine River join some 7 km upstream from the mouth,where the combined system forms an extensive coastal estuary. The North Pine Dam located in the middle of the catchment was completed in 1976. The Dam is operated by Seqwater.

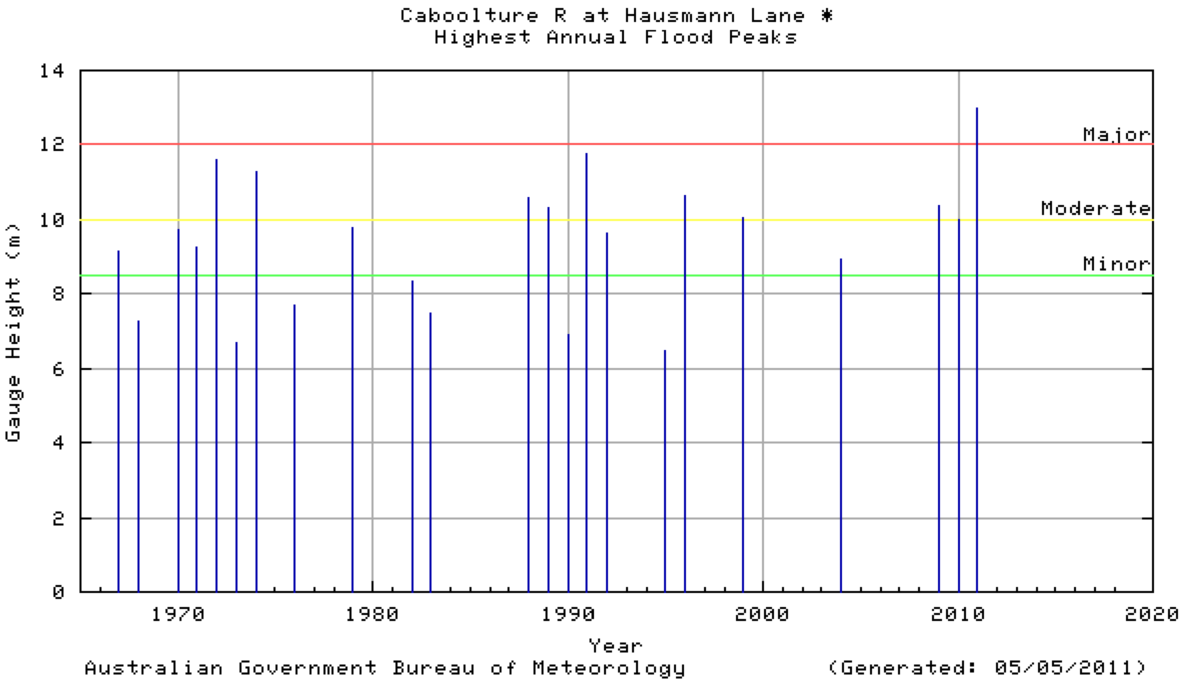
The Caboolture River is situated about 40 km north of Brisbane and has a total catchment area of 370 square kilometres. It rises in the D'Aguilar Ranges and flows in an easterly direction towards the coast, passing through Caboolture and entering Deception Bay (the northern part of Moreton Bay) near the township of Beachmere. Its major tributaries include Wararba, Sheep Station, King John and Lagoon Creeks.

The Pine and Caboolture system is susceptible to episodes of rapid flooding which can cause significant damage to public and private property throughout the catchment. Continuing increases in population have accentuated the potential flood risk to life and property, and this trend is unlikely to abate given the current growth in the area.

Previous Flooding

Records dating back to 1966 indicate a few major floods that have occurred in the Pine and Caboolture Rivers. Significant flood events with major flooding were reported in 1967, 1972, 1974, 1989, 1991, 2010 and 2011.





Flood Forecasting

In conjunction with the Moreton Bay Regional Council and Seqwater, the Bureau of Meteorology operates a flood warning system for the Pine and Caboolture Rivers, based on the network of rainfall and river height stations shown on the map.

The Bureau's Flood Warning Centre issues Flood Warnings and River Height Bulletins for the Pine and Caboolture River catchments during flood events.

Local Information

The Moreton Bay Regional Council is able to provide further information on flooding in your area of the Pine and Caboolture River catchments.

Flood ALERT System

Since the mid 1990's, an automated flood monitoring system in the Pine and Caboolture River catchments has been progressively developed by Seqwater and Councils.

The system is comprised of a network of rainfall and river height field stations located in the catchment which report via VHF radio to a base station computer located in the Moreton Bay Regional Council office at Strathpine and at Seqwater and Bureau offices. The field stations send reports for every 1 millimetre of rainfall and every 50 millimetre change in river height.

In consultation with the Moreton Bay Regional Council and Seqwater, the Bureau issues Flood Warnings for the Pine and Caboolture Rivers.

The base station computers located in the Moreton Bay Regional Council office collects the data and has software that displays it in graphical and tabular form. The data is also received by the Bureau's Flood Warning Centre where it is used in hydrologic models to produce river height predictions.

Flood Warnings and Bulletins

The Bureau of Meteorology issues Flood Warnings and River Height Bulletins for the Pine and Caboolture River catchment regularly during floods. They are sent to radio stations for broadcast, and to local Councils, emergency services and a large number of other agencies involved in managing flood response activities. Flood Warnings and River Height Bulletins are available via :

Radio
Radio stations, particularly the local ABC, and local commercial stations, broadcast Flood Warnings and River Height Bulletins soon after issue.

Local response organisations
These include the Councils, Police, and State Emergency Services in the local area.

Internet/World Wide Web
Flood Warnings, River Height Bulletins and other weather related data is available on the Bureau's Web page at http://www.bom.gov.au . The Queensland Flood Warning Centre website is http://www.bom.gov.au/qld/flood .

Telephone Weather
Flood Warnings are available through a recorded voice retrieval system, along with a wide range of other weather related and climate information.

Main Directory	Phone	1900 955 360
Flood Warnings	Phone	1300 659 219

Telephone Weather Services Call Charges:
1900 numbers: 77c per minute incl. GST; 1300 numbers: Low call cost - around 27.5c incl. GST.
(More from international, satellite, mobile or public phones)

Interpreting Flood Warnings and River Height Bulletins

Flood Warnings and River Height Bulletins contain observed river heights for a selection of the river height monitoring locations. The time at which the river reading has been taken is given together with its tendency (e.g. rising, falling, steady or at its peak). The Flood Warnings may also contain predictions in the form of minor, moderate or major flooding for a period in the future. River Height Bulletins also give the height above or below the road bridge or causeway for each river station located near a road crossing.

One of the simplest ways of understanding what the actual or predicted river height means is to compare the height given in the Warning or Bulletin with the height of previous floods at that location.

The table below summarises the flood history of the Pine and Caboolture River catchments - it contains the flood gauge heights of the more significant floods.

River height station	Feb 1972	Jan 1974	Apr 1989	Dec 1991	Apr 2009	May 2009	Oct 2010	Jan 2011
Baxters Creek	-	-	-	-	4.95	4.65	4.68	9.20
Dayboro	-	-	-	-	5.97	6.27	-	-
North Pine Dam	-	-	-	-	-	39.90	40.10	41.08
Lake Kurwongbah	-	-	-	-	21.84	22.19	21.16	-
Youngs Crossing	-	-	-	-	4.82	6.42	8.27	13.27
Petrie	-	5.10	-	-	3.04	4.79	-	-
Samford Village	-	-	-	-	2.40	4.70	5.00	4.60
Drapers Crossing	6.68	7.44	6.18	6.55	4.97	5.97	6.00	7.32
Cash's Crossing	-	-	-	-	4.00	4.80	5.10	5.60
Burpengary (Rowley Road)	20.30	20.00	20.00	20.20	20.15	20.02	18.25	-
Burpengary (Dale Street)	11.15	-	10.81	10.45	10.19	10.79	9.74	11.19
Upper Caboolture	11.58	11.30	10.29	11.76	10.64	10.29	9.44	13.01
Wamuran	30.61	-	30.11	30.26	29.37	29.02	28.67	30.67
Caboolture	9.91*	-	9.16*	9.54*	7.79	-	7.69	10.94

All heights are in metres on flood gauges. [*] These heights were obtained using surveyed flood marks.

Historical flood heights for all river stations in the Pine and Caboolture River Floodwarning networks, as shown on the map, are available from the Bureau of Meteorology upon request.

PINE AND CABOOLTURE CATCHMENTS - ASSESSMENT OF THE FLOOD POTENTIAL

Major flooding requires a large scale rainfall situation over the Pine and Caboolture River catchments. Once the North Pine Dam is at full capacity, overflowing occurs and inundation of the Petrie area begins. The following can be used as a rough guide to the likelihood of flooding in the catchment:

Average catchment rainfalls of in excess of 200mm in 12 hours causes minor to moderate flooding in both the Pine and Caboolture catchments. This flooding will cause minor traffic difficulties as well as inundation of low lying areas.

Average catchment rainfalls of in excess of 300mm in 12 hours causes serious major flooding to occur. Rises in stream height will serverly affect traffic capabilities and will affect houses and businesses on a widespread level. Releases from the North Pine Dam spillway during flood events causes the closure of Youngs Crossing Road.

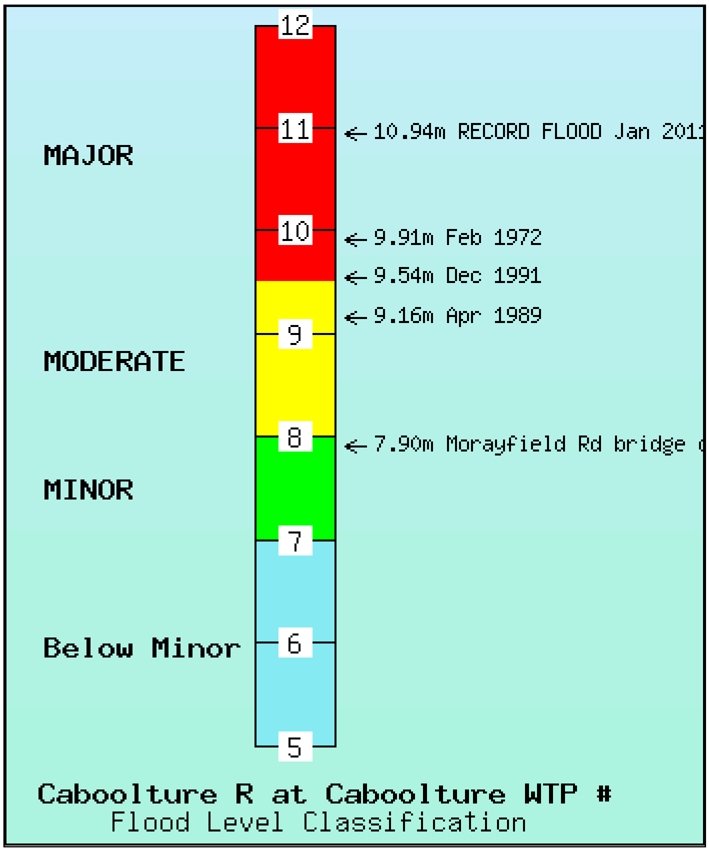
Flood Classifications

At each flood warning river height station, the severity of flooding is described as minor, moderate or major according to the effects caused in the local area or in nearby downstream areas. Terms used in Flood Warnings are based on the following definitions.

Major Flooding : This causes inundation of large areas, isolating towns and cities. Major disruptions occur to road and rail links. Evacuation of many houses and business premises may be required. In rural areas widespread flooding of farmland is likely.

Moderate Flooding : This causes the inundation of low lying areas requiring the removal of stock and/or the evacuation of some houses. Main traffic bridges may be closed by floodwaters.

Minor Flooding : This causes inconvenience such as closing of minor roads and the submergence of low level bridges and makes the removal of pumps located adjacent to the river necessary.



Each river height station has a pre-determined flood classification which details heights on gauges at which minor, moderate and major flooding commences. Other flood heights may also be defined which indicate at what height the local road crossing or town becomes affected by floodwaters.

The table below shows the flood classifications for selected river height stations in the Pine and Caboolture River catchments.

River Height Station	First Report Height	Crossing Height	Minor Flood Level	Crops & Grazing	Moderate Flood Level	Towns and Houses	Major Flood Level
North Pine Dam	-	39.6 (F)	-	-	-	-	-
Lake Kurwongbah	-	20.42 (S)	-	-	-	-	-
Youngs Crossing	-	3.49 (B)	6.0	-	7.5	-	9.5
Petrie	-	-	3.5	-	5.5	-	7.1
Samford Village	-	-	4.8	-	5.3	-	5.8
Drapers Crossing	-	-	4.0	-	5.0	-	6.0
Cash's Crossing	-	-	6.3	-	6.7	-	8.1
Normanby Way	-	-	3.7	-	3.9	-	4.6
John Bray Park	-	-	3.4	-	3.7	-	4.3
Murrumba Downs	-	-	2.3	-	2.5	-	4.1
Burpengary (Rowley Road)	-	20.0 (B)	15.0	-	20.0	-	20.5

Burpengary (Dale Sreet)	-	-	8.8	-	9.7	-	10.5
Upper Caboolture	-	-	8.5	-	10.0	-	12.0
Wamuran	-	30.60 (B)	29.0	-	30.0	-	30.5
Caboolture WTP	-	7.90 (B)	7.0	-	8.0	-	9.5

All heights are in metres on flood gauges. (B) = Bridge (F) = Full Supply Level (S) = Spillway

The above details are correct at the time of preparing this document. Up-to-date flood classifications and other details for all flood warning stations in the network are at:

http://www.bom.gov.au/hydro/flood/qld/networks/index.shtml

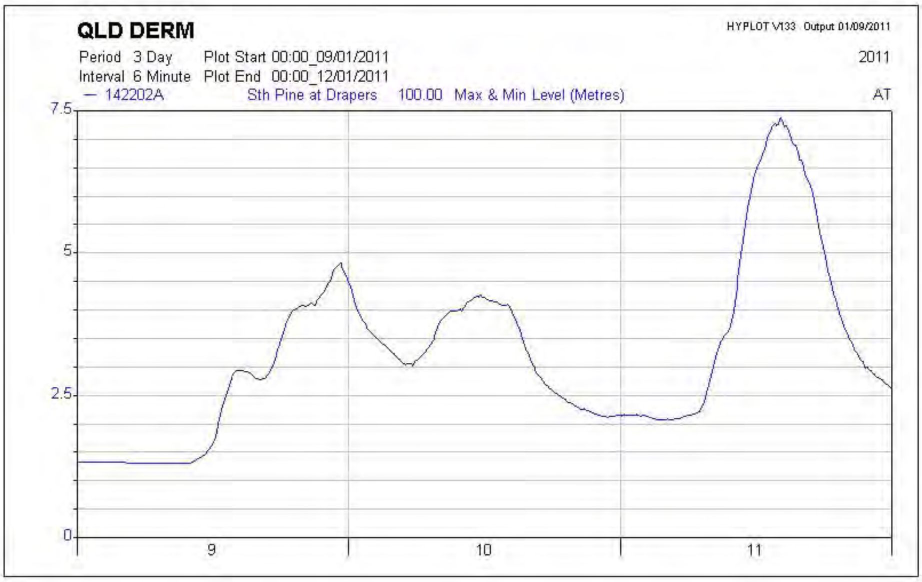
Catchment Map showing the Pine and Caboolture River flood warning network

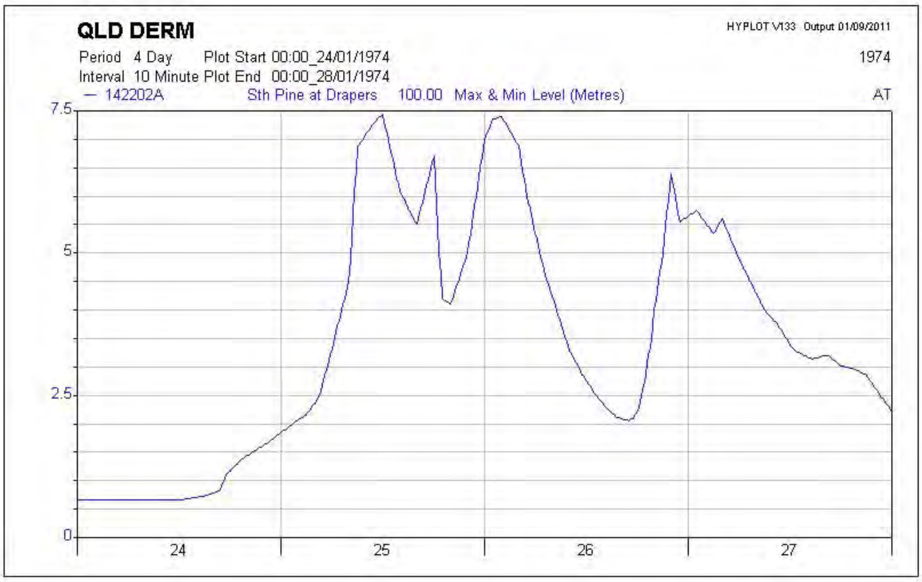
Click here to view map as: PNG PDF (308K bytes)

For further information, contact:
The Regional Director, Bureau of Meteorology, GPO Box 413, Brisbane Q 4001

APPENDIX B: RECORDED HYDROGRAPH JANUARY 2011 AND 1974 EVENT

B-2 Recorded Hydrograph January 2011 and 1974 Event





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Model Calibration Report
Lower Pine River Catchment
Regional Floodplain Database
Stage 3

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March 2013

Model Calibration Report
Lower Pine River Catchment
Regional Floodplain Database
Stage 3

Offices

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

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Title :	Model Calibration Report Lower Pine River Catchment Regional Floodplain Database Stage 3
Author :	Richard Sharpe
Synopsis :	This report includes the details and findings of the combined hydrologic and hydraulic model calibration of the Lower Pine River for the January 2011 flood event. This report is part of Council's Regional Floodplain Database, Stage 3.

REVISION/CHECKING HISTORY

REVISION NUMBER	DATE OF ISSUE	CHECKED BY		ISSUED BY	
0	20 December 2012	A Kolega		R Sharpe	
1	7 January 2013	A Kolega		R Sharpe	
2	1 March 2013	A Kolega		R Sharpe	

DISTRIBUTION

DESTINATION	REVISION			
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LIST OF FIGURES

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1 INTRODUCTION

As part of Stage 3 (Package 2) of the Regional Floodplain Database (RFD) project, Moreton Bay Regional Council (Council) has commissioned BMT WBM to develop a TUFLOW model of the Lower Pine River catchment. As part of the model development, the January 2011 flood event was simulated to calibrate the model to flood data that was recorded during this recent flood event. This report documents the calibration of the Lower Pine River TUFLOW model.

As recommended by Council and in the *Calibration Feasibility Report* (BMT WBM, 2011) the January 2011 event was utilised for the model calibration due it being both a recent event and the largest flood on record within the Lower Pine River catchment. The *Calibration Feasibility Report* also outlines limitations to the flood data collected for the January 2011 event and advantages of undertaking model calibration and verification to more than one historic event. It is recommended that the *Calibration Feasibility Report* is read in conjunction with this report.

Model calibration is an important part of developing a flood model, as it establishes confidence in the model performance and quantifies potential inaccuracies in the model results. Since the model results will ultimately be used to assess future development and for communication consultation, Council has promoted and been actively involved in the model calibration phase of the project.

Based on available rainfall, river gauge and flood mark data, model calibration was feasible and subsequently commissioned for the following six catchments as part of RFD:

- Burpengary Creek;
- Caboolture River;
- Sideling Creek;
- Upper Pine River;
- Lower Pine River; and
- Stanley River.

Council has an overarching understanding of calibration results for the models covering these catchments, with a view to adopting a consistent set of hydrologic and hydraulic parameters across the entire LGA.

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

2 AVAILABLE DATA

2.1 Rainfall Data

To represent the rainfall during the event, records from 17 rainfall gauges were utilised in the hydrologic model established for the January 2011 event. The recorded cumulative rainfall depths in millimetre (mm) for these rainfall gauges are illustrated in Figure 2-1. Note that the rainfall records from Ferny Hills gauge were not used as no rainfall was recorded during the event at this gauge.

These gauges provide a good spread of rainfall data across the catchment. Figure 2-2 presents the locations of the rainfall gauges used for the model calibration and the total rainfall depth over the four days from the 9th to the 12th of January 2011.

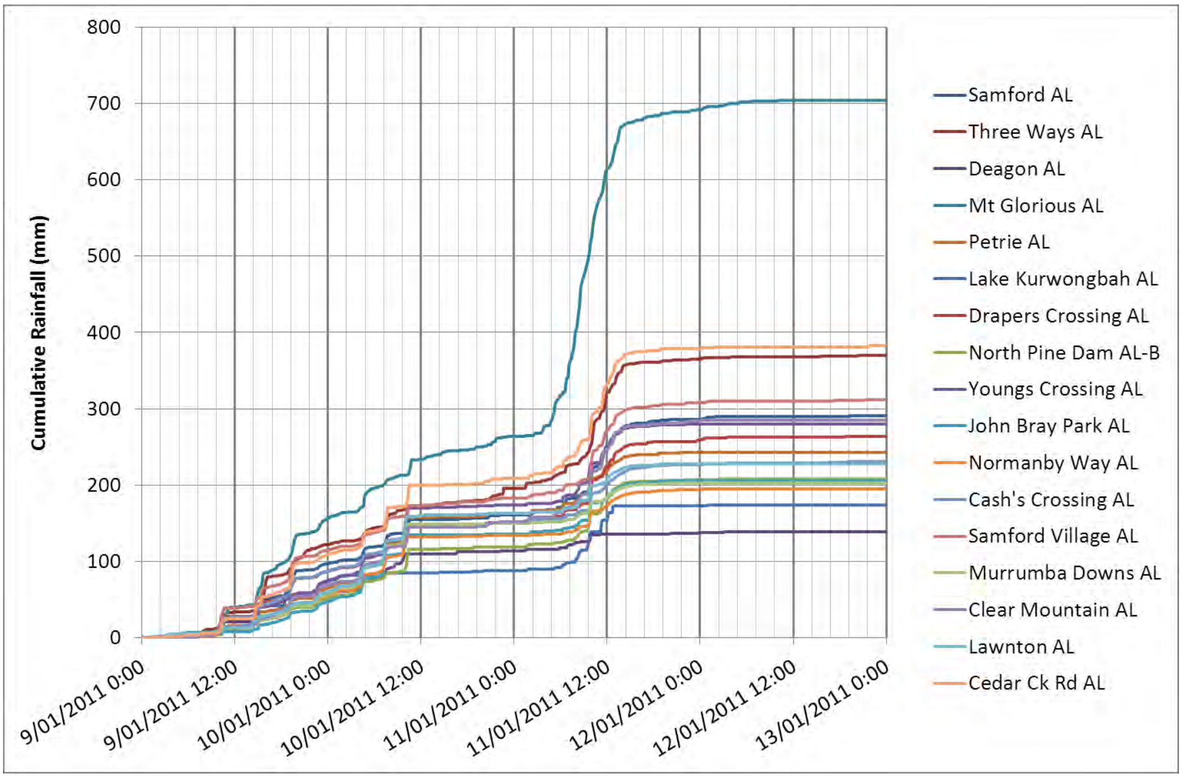


Figure 2-1 Cumulative Rainfall Depths (mm) for Lower Pine River Catchment during January 2011 Event

Analysis of the recorded rainfall data between the 9th and 12th of January 2011 suggest a similar trend in the timing of the rainfall bursts over the 4 day period. However, it is noted that the cumulative rainfall depth over 4 days results in significantly varied magnitudes across the Lower Pine River catchment. Cumulative rainfall depths range from approximately 140 to 280mm within the east of the catchment, whereas cumulative rainfall depths range from 280 to 700mm towards the west.

2.2 Stream Gauges

A number of stream gauges recorded water level data during the January 2011 flood event in the Lower Pine River catchment. The Gauge in Petrie did not record levels for this event. These gauges are spread throughout the catchment, as show in Figure 2-2.

The gauge level data for the gauges were obtained from Council and the Bureau of Meteorology's website. A list of the nine stream gauges and the gauge datum is provided in Table 2-1.

Table 2-1 List of Stream Gauges

Gauge Name	Gauge Datum (mAHD)
Cash's Crossing	6.525
Cedar Creek	62.248
Drapers Crossing	17.592
John Bray Park	9.006
Lawnton	0
Murrumba Downs	0
Normanby	-1.0
Samford Village	45.237
Young's Crossing	0

These gauges were used to compare time series water level results from the model with the recorded gauge data, enabling the performance of the model to be assessed in terms of both timing and magnitude of flooding. The Young's Crossing gauge malfunctioned during the peak of the flood event, so could only be used to compare water levels preceding the peak of the flood.

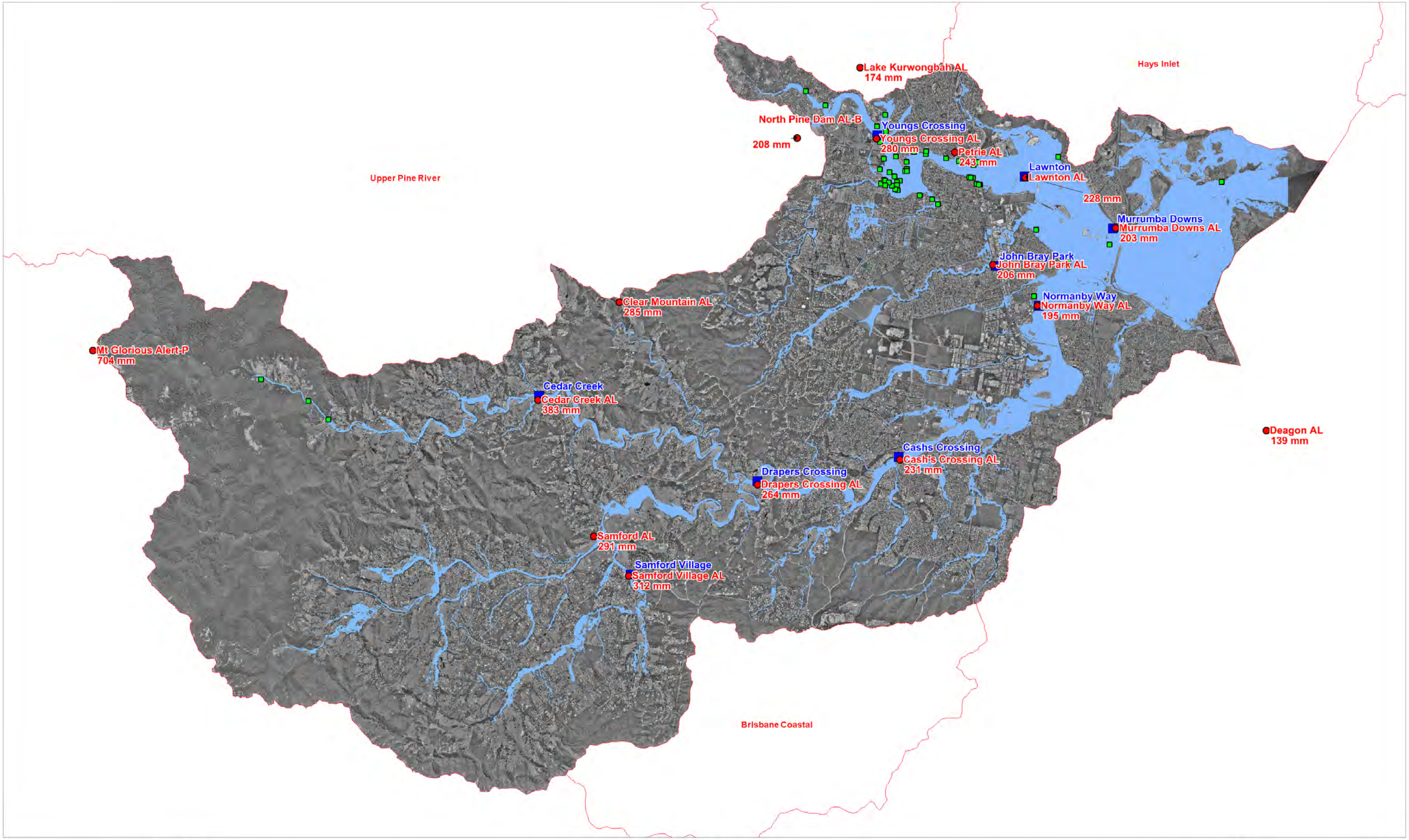
2.3 Surveyed Flood Marks

Council collected 57 surveyed flood marks for the January 2011 flood event; Figure 2-2 shows the locations. Of these flood marks:

- 49 were of medium quality derived from debris wrack marks; and
- 8 were of high quality derived from clearly defined wrack marks.

The majority of the flood marks were located on the North Pine River, and mostly between the Gympie Road and Young's Crossing bridges. There were only four flood marks in the South Pine catchment, with three in the upper reaches of Cedar Creek and one near the Normanby Way stream gauge.

These flood marks were compared against modelled peak flood level results during model calibration, thereby providing an indication of the model performance in terms of peak flood levels.



LEGEND

- Lower Pine River Catchment
- Modelled January 2011 Flood Extent (Adopted)
- Rainfall Gauges
  Total 4 day Rainfall Depth (mm) 9 to 12 January 2011
  (Except the Three Ways Gauge
  Located further outside the catchment)
- River Gauges
- Flood Marks January 2011 Event

Title:
Gauge Locations and Floodmarks utilised in the Model Calibration January 2011 Event Lower Pine River Catchment

Figure: **2-2**

Rev: **A**

N 0 2.5 5km
Approx. Scale

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Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\FLD_008_1212198_LPR_Rain_Stream_Gauges_Modelled.wor

3 HYDROLOGIC MODELLING

Council supplied a WBNM hydrologic model to BMT WBM, which was based on subcatchment delineation adopted by Council. The WBNM model was adapted to simulate the January 2011 flood event, by including 5 minute interval rainfall from the 17 rainfall gauges described in Section 2.1. The method used by WBNM to develop a hyetograph for each subcatchment is as follows:

i. For each subcatchment, the temporal pattern of the nearest rain gauge is adopted; and

ii. The total rainfall depth for each subcatchment is computed by applying a weighting to the depth of all surrounding rain gauges in the model. The weighting is based on the inverse square distance between each rain gauge and the centre of the subcatchment.

There is generally a reasonable spread of rainfall gauges around the catchment. However, there is a lack of rainfall data in the upper catchment of the South Pine River. This limitation in data availability is exacerbated in the upper Cedar Creek catchment, where rainfall depths change by 320mm over a gap of 11.5km (between the Mt Glorious and the Cedar Creek Gauges). The interpolation assumptions may produce modelled rainfall depths in the upper Cedar Creek catchment that deviate significantly from the actual rainfall that fell in the catchment.

The default values for the model setup were used for most of the WBNM parameters (i.e. nonlinearity exponent, stream routing). The adopted hydrological parameters are listed in Table 3-1.

Table 3-1 Hydrologic Model Parameters Calibration Event

Parameter	Value
Initial Loss	0mm
Continuing Loss	2.5mm/hr
Lag Factor	1.6

The WBNM model was simulated only once, with no further adjustment deemed necessary for calibration. The results of the WBNM model were then used as inflows in the hydraulic model.

4 HYDRAULIC MODELLING

A TUFLOW model was developed using various topographic, land use and structure data supplied by Council. The model was based on a 10m square computation grid. The AJ Wylie Bridge has undergone changes since the January 2011 flood event, so the dimensions of the bridge at the time of the flood event were used in the model.

The upstream boundary on the North Pine River is at the outflow of the North Pine Dam (Lake Samsonvale). The inflow for this boundary was extracted from the Seqwater report (Seqwater, 2011) on the North Pine Dam operation during the flood event.

Approximately 3km downstream of the North Pine Dam, outfalls from Lake Kurwongbah drain the Sidling Creek catchment into the North Pine River. Outflows from Council's Sidling Creek model for the January 2011 event were used as inflow boundaries in the model at the Lake Kurwongbah outfall.

For the remainder of the catchment, inflows for each subcatchment were derived from the Lower Pine River WBNM model. These inflows were applied at the lowest 2D grid cell (in terms of elevation) within each subcatchment at the first timestep in the simulation, and subsequently spread across all wet cells within the corresponding subcatchment (Source-Area approach in TUFLOW).

A head versus time downstream boundary was applied at the mouth of the Pine River. The downstream boundary conditions were based on predicted tide levels at the Brisbane Bar tidal gauge, which is 14km south of the Pine River mouth.

A number of alterations to the model setup were implemented to acquire a reasonable calibration. The model runs undertaken during the model calibration, the resolutions and remaining discrepancies are summarised in Table 4-1. Runs 4, 5, and 6 are the key runs with best model performance and detailed results of the flood marks and hydrograph comparisons for all gauges are provided in the Appendix D, E and F. These runs include the correct inflows to the South Pine River.

Runs 1, 2, 3, 7 and 8 were mainly undertaken to improve model calibration in the North Pine River. These model runs include incorrect (reduced) flows into the South Pine River, thus model results provided in the Appendices focus on the North Pine River area, the hydrograph comparison at the South Pine River gauges were not included in the Appendices.

There was no need to adjust the hydraulic roughness parameters that had previously been adopted by Council as part of Stage 2 of the RFD. A reasonable calibration was achieved by revising/updating topographic data, structure data and land use mapping.

Table 4-1 List of Hydraulic Model Runs

Adjustments	Resolutions	Residual Discrepancies/Issues
Run 1 – Results in Appendix A (LPR_002a_H _January_2011_047_10m.tcf)		
		• Considerable over prediction on the North Pine River between Young's Crossing and the Bruce Highway and on the lower reach of the South Pine River. This was primarily caused by too much backup of flow at the Bruce Highway Bridge. • Large head loss across some structures, such as the railway bridge on the North Pine River. This was attributed to incorrect bathymetry in the model under some structures, whereby the terrain modifiers in the model were creating small embankments under the structures. • Under prediction on Cedar Creek. At Cedar Creek gauge the river thalweg had a 'hump' of over 2m high controlling water levels. Council investigated this and did find some local silting up of the channel, but on a much smaller scale.
Run 2 – Results in Appendix B (LPR_002a_H _January_2011_048_10m.tcf)		
• Structure terrain modifiers were examined, and adjusted where necessary to ensure they did not inadvertently cause obstructions to flow. • The 2m high 'hump' in the Cedar Creek thalweg near Cedar Creek gauge was removed.	• Head loss across structures where terrain modifiers were adjusted had improved, but still looked too high in some instances. • Over prediction on the North Pine River reduced, but not enough.	• Considerable over prediction on the North Pine River between Young's Crossing and the Bruce Highway and on the lower reach of the South Pine River. This was primarily caused by too much backup of flow at the Bruce Highway Bridge. • Head loss across some structures, particularly the railway bridge on the North Pine River, were too large. • Large under prediction on Cedar Creek, leading to under prediction on the South Pine River at the confluence with Cedar Creek.

Adjustments	Resolutions	Residual Discrepancies/Issues
Run 3 – Results in Appendix C (LPR_002a_H _January_2011_050_10m.tcf)		
• Manning's n in the Pine River downstream of the confluence of the North and South Pine Rivers was reduced to 0.02. • Correction made to obvert level on Bruce Highway Bridge over the Pine River (raised by 0.88m). • Correction made at Gympie Road Bridge, the dimensions for the north and south bound lanes had been supplied the wrong way around. • Correction made to bridge form loss coefficients.	• Water levels upstream of the Bruce Highway Bridge on the Pine River dropped by over 2.5 meters, to within 70mm of recorded flood levels. Thus improving the calibration results along the North Pine River and lower South Pine River. • Head losses across the railway bridge on the North Pine River reduced to within realistic magnitudes. • Discrepancy on Cedar Creek was attributed to limitation in the rainfall data in the Cedar Creek catchment; discussed further in Section 5.2.	• Under prediction at Lawnton gauge. This could, in part, be attributed to crest levels of the river banks being 'missed' by the model resolution. A 0.5m head across the left bank into an adjacent lake was noted. • Peak flood levels upstream of a 'bottle neck' on the North Pine River near 122 Bray Road were over predicted in the model by up to 1m. The terrain in the 2D model in this area was based on LiDAR data. However, the river is relatively deep at the 'bottleneck'. Thus, the river bed levels inferred from the LiDAR data were too high, and the channel cross-sectional area significantly underestimated.
Run 4 – Results in Appendix D (LPR_002a_H _January_2011_072_10m.tcf)		
• Council supplied additional bathymetry data for the North Pine River to assist with resolving the issue raised in 'Run 3'. The bathymetry data includes elevations within the channel of -1 to -3mAHD (between Mungarra and Sweeney Reserves). • Breakline terrain modifiers representing riverbank crest levels near Lawnton gauge were added.	• Water levels in the vicinity of Mungarra Reserve and Ron Thomason Park reduced significantly, but were still over predicted. • Improved correlation between modelled and recorded levels at Lawnton gauge.	• Over prediction of peak flood levels of approximately 0.5m in the vicinity of Mungarra Reserve and Ron Thomason Park. This was believed to be attributed to morphological changes during the flood event. • Large over prediction of over 2m on a tributary to the North Pine River approximately 0.5km downstream of North Dine Dam (Floodmark LPR056).
Run 5 – Results in Appendix D (LPR_002a_H _January_2011_074_10m.tcf)		
• Council supplied an additional land use layer, to account for vegetation stripping during the flood event. This layer was exaggerated in order to gain an understanding of the sensitivity of the results to vegetation stripping.		• Rather than over predicting along the North Pine River, the model was now significantly under predicting flood levels on the North Pine River; by over 1m in the vicinity of Mungarra Reserve and Ron Thomason Park.

Adjustments	Resolutions	Residual Discrepancies/Issues
Run 6 – Results in Appendix E – *Adopted as the final calibration run* (LPR_002a_H _January_2011_075_10m.tcf)		
• Council supplied some revisions to the land use mapping. This included some slight changes to the creek waterbody extent, and conversion of dense vegetation to medium dense vegetation in some areas. • Manning's n reduced to 0.02 along the North Pine River downstream of the Gympie Road Bridge.	• Removed the over predictions of peak flood levels on the North Pine River in the vicinity of Mungarra Reserve and Ron Thomason Park. • Significantly reduced the over prediction of flood levels on a tributary to the North Pine River near Vores Road.	• 1.4m over prediction of flood levels on a tributary to the North Pine River approximately 0.5km downstream of North Dine Dam (Floodmark LPR056); discussed further in Section 5.3.
Run 7 – Results in Appendix F (LPR_002a_H _January_2011_056_10m.tcf)		
• Investigated sensitivity of results to 5m of vegetation stripping on each bank on the North Pine River, upstream of Murrumba Downs.	• Significantly reduced the over prediction of flood levels on a tributary to the North Pine River near North Dine Dam.	• 0.98m over prediction of flood levels on a tributary to the North Pine River approximately 0.5km downstream of North Dine Dam (Floodmark LPR056). • About 0.7m under prediction of flood levels in the Young's crossing area.
Run 8 – Results in Appendix G (LPR_002a_H _January_2011_057_10m.tcf)		
• Investigated sensitivity of results to 10m of vegetation stripping on each bank on the North Pine River, upstream of Murrumba Downs.	• Significantly reduced the over prediction of flood levels on a tributary to the North Pine River approximately 0.5km downstream of North Dine Dam.	• 0.46m over prediction of flood levels on a tributary to the North Pine River approximately 0.5km downstream of North Dine Dam (Floodmark LPR056). • About 1m under prediction of flood levels in the Young's crossing area.

5 DISCUSSION ON RESULTS

5.1 Overview

For each of the model runs listed in Table 4-1, the following result comparisons have been compiled:

1. Comparison of modelled water level hydrograph against recorded water level hydrograph at stream gauges in the catchment;
2. Histograms of the differences between the modelled peak flood level and surveyed flood marks; and
3. Maps of the flood marks showing differences between modelled peak flood levels and surveyed flood marks.

The results are included in the Appendices; Table 4-1 lists the Appendix number corresponding to each model run.

5.2 Stream Gauges

Young's Crossing – This gauge is located just 3km downstream of the North Pine Dam. The gauge malfunctioned at the peak of the flood. Therefore, it is not possible to infer the model performance in terms of peak levels at this gauge. Modelled levels match the recorded levels prior to the peak. This suggests that the model is accurately conveying flow in the upper reach of the North Pine River, and that the roughness parameters in the vicinity of the gauge are simulating flood levels well.

After the January 2011 event, Council had to move the location of the gauge, as it was relocated and buried in sedimentation. The changed location is of particular interest for any potential future flood events that may be used for calibration.

Lawnton – This gauge is located a further 6km downstream from Young's Crossing on the North Pine River. Initially the model was over predicting at this gauge, due to the issues at the Bruce Highway Bridge further downstream. After the bridge issues were resolved, water levels were under predicted at the Lawnton gauge. This under prediction was resolved in two ways:

i. Increasing the North Pine River conveyance upstream of Lawnton by including additional bathymetry; and

ii. A system of lakes lie on the right bank of the river in the vicinity of the gauge (north of Lawnton Pocket Road). The banks of the river control flows breaking out of bank and spilling into the lakes. A 0.5m head drop between the river and lake was noted during calibration. Due to the relatively coarse model resolution, the crest of the right bank was not consistently captured in the model topography. Thus, a breakline representing the bank crest levels was incorporated into the model.

After these modifications were included, the modelled peak flood level at the gauge was 0.23m below the recorded peak level. The general shapes of the modelled and recorded hydrographs also match well.

Murrumba Downs – This gauge is located upstream of the Bruce Highway Bridge across the Pine River, 4.5km downstream of Lawnton gauge. Initially, the obvert level and the way the form loss coefficients were being applied in the model were incorrect. As a result, the bridge was overly constrictive and the peak flood levels at the Murrumba Downs gauge was over predicted by more than 2.3m. After the bridge obvert was revised from 3.57mAHD to 4.45mAHD and the form loss coefficient application was corrected, the modelled peak flood level was similar to the recorded level. For the adopted calibration run, the modelled peak water level is 0.31m higher than recorded, and the general shapes of the modelled and recorded hydrographs match well.

John Bray Park – This gauge is located on a tributary of the South Pine River. Gympie Road and the Queensland railway cross this tributary immediately downstream of the gauge, and the tributary's confluence is 6.5km downstream of the gauge in close proximity to the North and South Pine River confluence and Bruce Highway Bridge. The flood behaviour at this gauge is driven by the local catchment conditions, and the modelled levels matched the recorded levels well throughout all model runs. For the final calibration run, the peak modelled flood level was 0.10m lower than recorded and the general shapes of the modelled and recorded hydrographs also match well.

Samford Village – This gauge is located at Samford Village in the upper South Pine River catchment. The peak flood level and timing of the peak is represented well in the model, with the model over predicting the peak flood level by 0.11m.

Cedar Creek – This gauge is located on Cedar Creek, a tributary of the South Pine River, approximately 200m upstream of the Mount Samson Road crossing. The model captures the lower water levels between peaks well, but the peak flood level is under predicted by 1.1m. This is believed to be due to insufficient rainfall being simulated in the hydrology model in the Cedar Creek catchment.

The total rainfall depth recorded (over the four days) at Cedar Creek gauge is 383mm. The next nearest gauge for the upper Cedar Creek catchment is 11.5km east, on the catchment divide at Mount Glorious, which recorded 704mm. Given this large change in rainfall depth, and the large under prediction in the peak flood levels, it appears that there is not enough rainfall in the upper Cedar Creek catchment in the hydrologic model. There is also a lack of rainfall gauges in the south-east of the catchment (no additional rainfall gauge to the east of the Samford gauge). It is likely that the interpolation procedure used by WBNM to assign rainfall depths to subcatchments between the rainfall gauges has significantly underestimated the rainfall that actually fell in the upper Cedar Creek catchment.

It is interesting to note that two of the three flood marks in the upper catchment, about halfway between the Cedar Creek and Mount Glorious gauges, indicate that the model is over predicting peak flood levels in the upper Cedar Creek catchment by 0.07m at floodmark LPR003 and 0.21m at floodmark LPR002, whereas the model is under predicting flood levels by about 0.41m at floodmark LPR001. This flood mark is located about 0.7km downstream of floodmark LPR002 and about 8.0km upstream of the Cedar Creek gauge. This demonstrates a discrepancy between the Cedar Creek gauge and the floodmarks.

It is concluded that the model calibration in the vicinity of Cedar Creek gauge is limited by a lack of rainfall data in the upper catchment. It is acknowledged that a better representation of rainfall could be developed by inspection of radar data. A similar approach was used for the Caboolture River model where a lack of rainfall data in the eastern part of the catchment occurred. For the Caboolture

River model radar data were obtained (from BoM) to further analyse the rainfall and model simulations were undertaken to “manually” increase the amount of rainfall in the eastern catchment; refer to the *Model Calibration Report Caboolture River Catchment* (BMT WBM, 2012). However, this process did not change the adopted calibration parameters; it focussed on a better representation of the rainfall during the flood event. Therefore, this approach was not repeated for the Lower Pine River model.

Drapers Crossing – This gauge is located at the confluence between Cedar Creek and the South Pine River. Apart from the peak flood level, the model simulates the recorded water levels well. The model under predicts the peak flood level by 0.28m. This under prediction during the peak of the flood (on 11^{th} of January 2011) is linked to the under prediction in flow in the Cedar Creek catchment, as discussed above.

Cash’s Crossing – This gauge is located immediately upstream of the South Pine Road Bridge on the South Pine River, 6km downstream of Drapers Crossing gauge and about 7km upstream of the Normanby gauge. The flood level comparison between the modelled and the recorded levels match very well at the start of the flood event and at the onset of the peak. However, the recorded peak flood levels are about 1.1m lower than the modelled peak flood levels from the adopted calibration model run. It is noticeable that the gauge records show a drop in levels just before the peak (at about 1pm on 11 January). It is possible that this gauge was malfunctioning during the peak of the event. This theory is supported by the fact that the model under predicts the peak flood levels only by about 0.3m at the Drapers Crossing gauge (upstream), and by about 0.56m at the Normanby gauge (downstream) .

Consideration was also given to the constriction of the flood extent at the South Pine Road Bridge as a result of the elevated South Pine Road levels (about 15.5m) to the south of the bridge. The model representation of the South Pine Road Bridge was compared to design drawings and was considered acceptable. However, it would be beneficial to undertaken additional survey of the South Pine Road Bridge configuration and the road levels to the south of the bridge to confirm the drawings and river bank elevations (potential scouring during the flood event).

Normanby Way – Located 3.5km upstream of the North and South Pine River confluence, water levels at this gauge are influenced by tail water conditions at the confluence. At this location, flood levels match very well at the start of the flood event and the onset of the peak, however the model under predicts peak flood levels by about 0.56m, which is a significant difference. However, at the nearby flood mark (LPR054), the model under predicts peak flood levels only by 0.19m. Unfortunately, there were no additional flood marks available nearby along South Pine River.

5.3 Flood Marks

The following statistics are drawn from the differences in modelled and measured flood marks for the adopted calibration run:

- Of the 57 flood marks, three were more than 10m from the flood extent and were excluded from the flood mark comparison analysis.
- The maximum difference is an over prediction of 1.4m on a tributary 0.5km downstream of the North Pine Dam.

- The minimum difference is an under prediction of 1.4m at Hampstead Outlook, Murrumba Downs (LPR035), 1km upstream of the Murrumba Downs gauge. This appears spurious, as the modelled peak levels at this gauge is within 0.31m of recorded levels (the model is over predicting).
- The median difference is an under prediction of 0.04, and the mean difference is an under prediction of 0.06m.
- 46% of the flood marks are within 0.1m, 56% within 0.2m and 76% within 0.3m of the modelled peak flood levels.

This is considered to be a reasonably good overall agreement between modelled and measured peak flood levels at the flood marks.

There is one flood mark (ID LPR056) on a small tributary to the North Pine River at Vores Road in **Whiteside**, 0.5km downstream of the outfall of the North Pine Dam. The model is significantly over predicting the flood level at this point, by 1.4m (for run 6). Flooding at this point is from North Pine River backwater. Therefore, this indicates that flood levels in the upper reach of the North Pine River in the model are over predicted. The river banks are lined with dense vegetation. With nearly 3,000m³/s released through this confined (150m wide) portion of the river, it is likely that significant vegetation stripping and morphological changes occurred during the flood. Run 8 considers modest bank vegetation stripped away by one grid cell (10m) on each bank. The results showed a large reduction in flood levels, with the flood level at the Vores Road flood mark reducing by 0.93m; resulting in an over prediction of 0.46m. Therefore, it considered that the over prediction at Vores Road in Whiteside is likely to be due to vegetation stripping (and possibly morphological changes) that occurred during the flood event.

Flood marks surrounding **Young's Crossing** gauge suggest that the model is under predicting peak flood levels in this area by approximately 0.4m to 0.5m. The gauged levels suggest that the model performs well subsequent to the flood peak. The under estimation at the peak of the flood may be due to a combination of an over estimate in upstream attenuation due to vegetation stripping and debris blockage at Young's Crossing.

There is a concentration of about 24 flood marks surrounding the **Mungarra Reserve and Ron Thomason Park area** up towards Young's Crossing. Initially the model was over predicting peak flood levels by approximately 1m in this area. Inspection of the results indicated that water levels in this area were controlled by a constriction in the floodplain near 122 Bray Road. Since the river channel and floodplain is incised at the constriction, Council provided additional bathymetry for this part of the North Pine River. Subsequent to including the bathymetry, the model was still over predicting levels by approximately 0.5m. This was attributed to some incorrect allocation of landuse types, whereby some areas of medium dense vegetation had been defined as dense vegetation. Correcting the land use definitions resulted in a good fit between modelled and measured flood levels, with the model over predicting by approximately 0.03m in average.

There are 10 flood marks surrounding **the Sweeney Reserve and Gympie Road Crossing area** on the North Pine River. At the western edge of Sweeney Reserve, one flood mark matched the modelled peak flood level to within 20mm. This flood mark is of high quality, and was provided by a local resident. A further 340m downstream another floodmark (medium quality) was 0.39m higher than the modelled peak flood level. And then a further 340m downstream, at the railway bridge, there are four flood marks where the model has under predicted flood levels by approximately 0.4m. At the Gympie Road Bridge (200m downstream of the railway bridge), the model is over predicting flood levels by 0.12m. The form loss coefficient at the railway bridge is relatively high (0.76), due to there being many piers spaced every 12m to 22m across the 300m span. It is likely that these piers trapped debris during the flood, and that the 0.4m under prediction is due to blockage at the structure.

In the vicinity of the Lawnton, Murrumba Downs and Normanby Way gauges (i.e. near the **confluence between the North and South Pine Rivers**) there are 8 flood marks. Some of these flood marks suggest that the model is significantly under predicting flood levels (by 0.1m to 1.4m), others indicate an over prediction of 0.1m to 0.6m. However, the more reliable gauged levels suggest the model is under predicting by 0.23m at Lawnton gauge, over predicting by 0.31m Murrumba Downs gauge and under predicting by 0.56m at Normanby Way gauge. Therefore, the quality of flood marks in this area is questionable, and discrepancies of more than 0.5m between modelled and measured levels at these flood marks have been disregarded.

6 CONCLUSION

The Lower Pine River WBNM hydrologic and TUFLOW hydraulic models were set up to simulate the January 2011 flood event. This historical event was used to calibrate the hydraulic model. Council provided historical flood data for the January 2011 flood event in the form of recorded water level hydrographs at nine stream gauges and 57 surveyed flood marks based on wrack marks identified shortly after the flood event. The availability of a large number of gauges, 17 rainfall and nine river gauges, and the location of these being well spread over the catchment provided a good data set for model calibration. The flood marks were mainly collected on the North Pine River, enabling a good calibration in this part of the model.

After making a number of revisions/adaptions to the TUFLOW model, a reasonable calibration has been achieved given the available data for the January 2011 flood event. Residual discrepancies between modelled and measured data do exist, but these have been justified as follows:

- Lack of rainfall data in the Upper Cedar Creek catchment;
- Vegetation stripping and possibly morphological changes on the upper North Pine River;
- Malfunctioning of the Young’s Crossing and possibly at the Cash’s Crossing gauge during the peak of the flood event; and
- Debris blockage at Young’s Crossing and the North Pine River Railway Bridge.

Based on this calibration assessment, the model is deemed suitable for determining design flood levels across the Lower Pine River catchment, in particular in the North Pine River. The model under predicts flood levels in particular in the vicinity of the Normanby Way gauge, along South Pine River .

It is recommended that additional rainfall gauges are installed in the western part of the catchment along Cedar Creek to improve rainfall data capture and potential future model calibration.

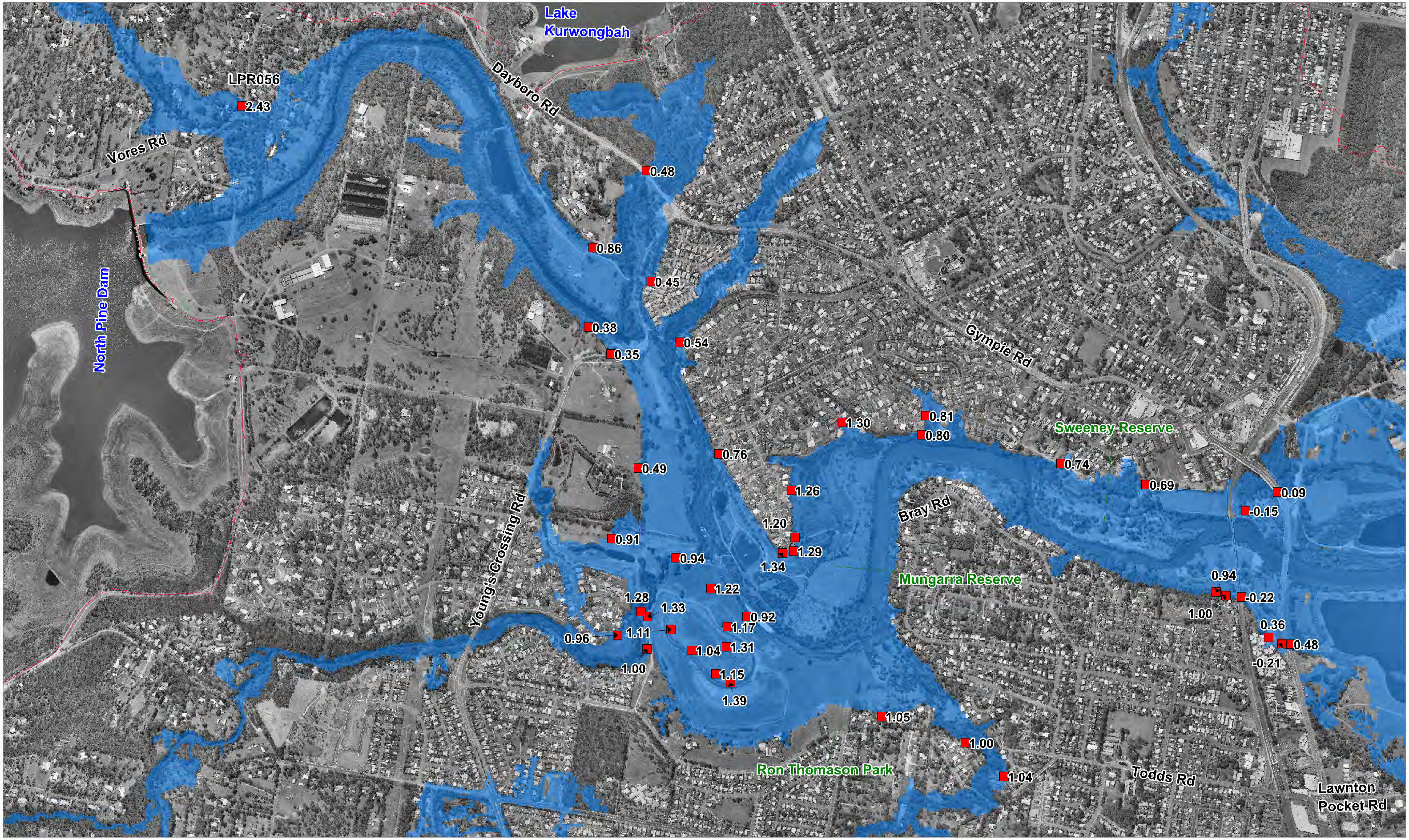
7 REFERENCES

BMT WBM (2011): *Calibration Feasibility Report, Lower Pine River Catchment, Regional Floodplain Database Stage 3, September 2011*

BMT WBM (2012): *Model Calibration Report Caboolture River Catchment, Regional Floodplain Database Stage 2, June 2012*

Seqwater (2011): *January 2011 Flood Event: Report on the operation of the North Pine Dam, 11 March 2011*

APPENDIX A: RUN 1 RESULTS



LEGEND

Lower Pine River Catchment

Modelled January 2011 Flood Extent

Flood Marks January 2011 Event
0.03 Difference in Peak Flood Levels in m (Modelled Minus Surveyed)

Title:
January 2011 Event Flood Mark Comparison
Run 1 Lower Pine River Catchment

Figure: **A-1**

Rev: **-**

N

0 250 500m
Approx. Scale

BMT WBM
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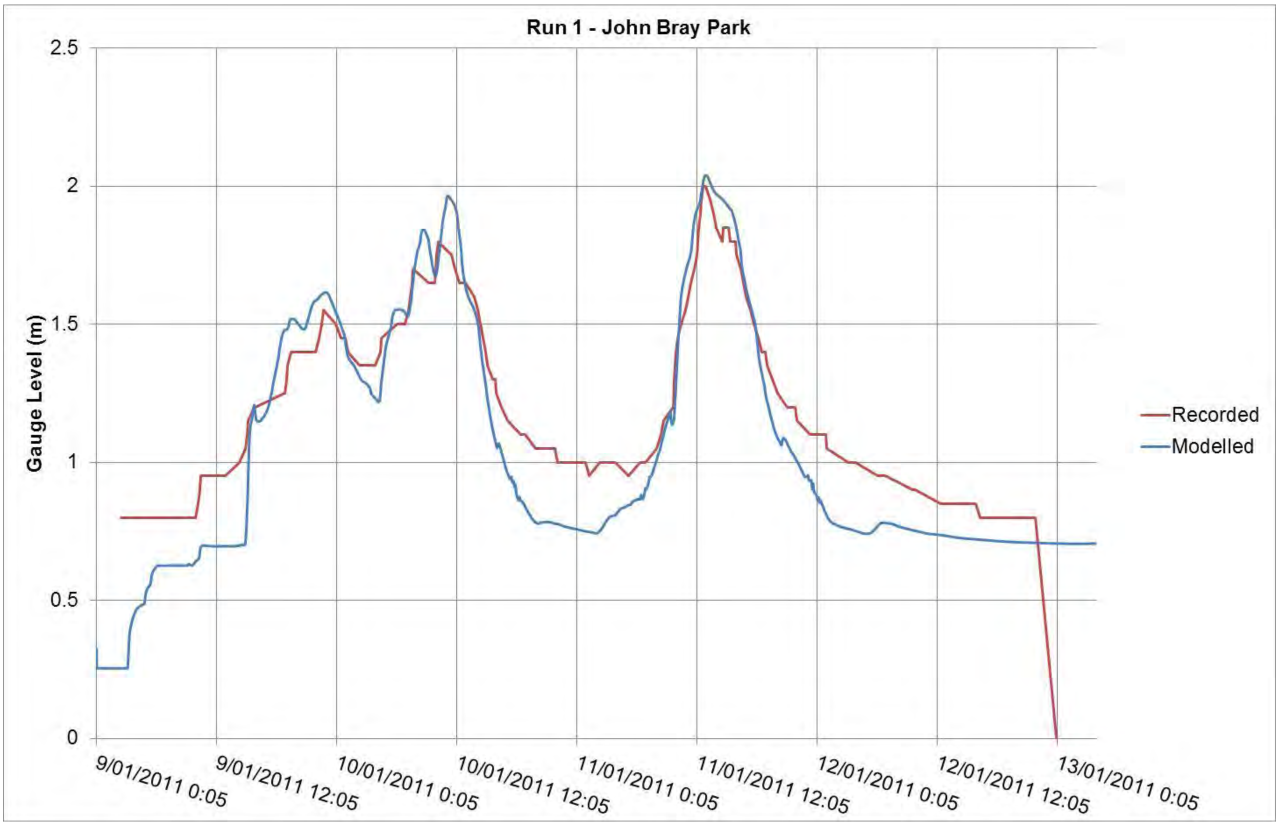
Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\Calibration\FLD_010_121219_LPR_Calibration_Results_F1.WOR


Run 1 - John Bray Park
Gauge Level (m)
2.5
2
1.5
1
0.5
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
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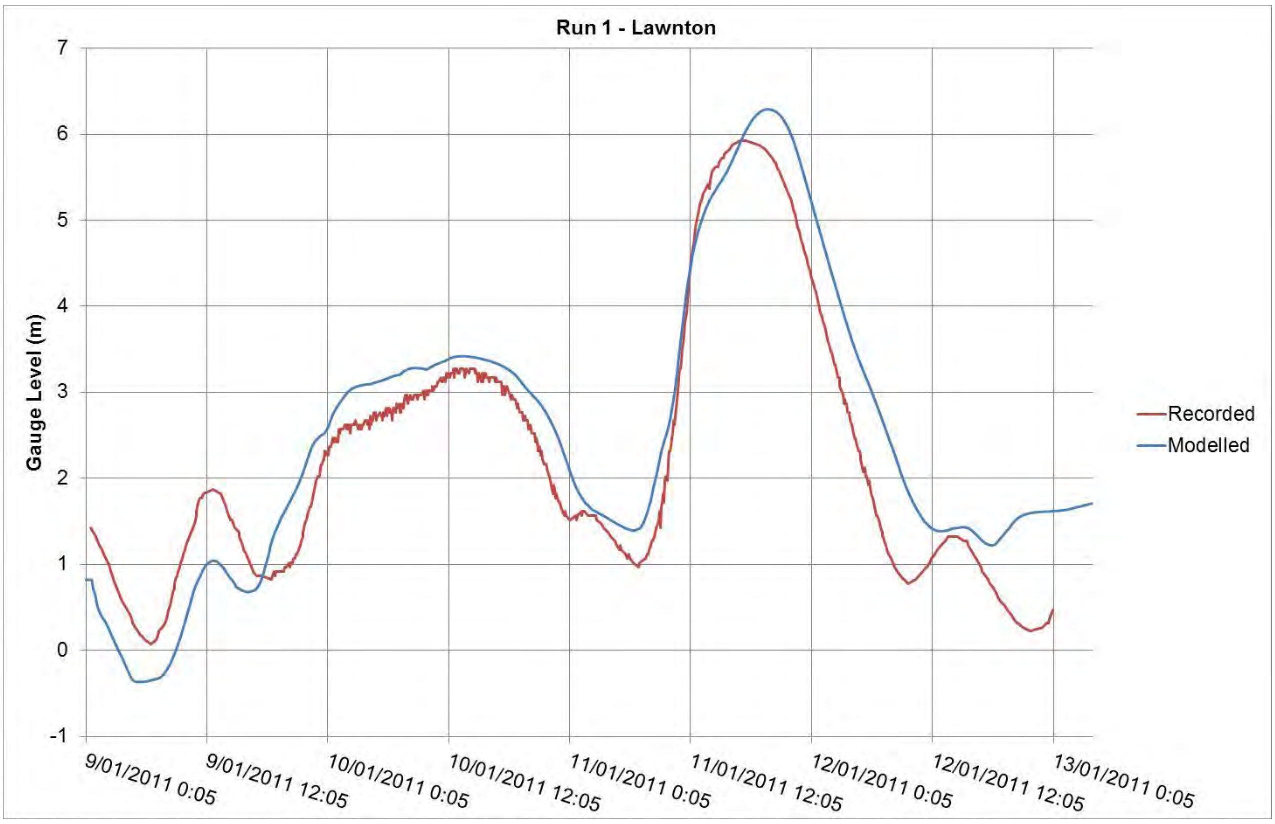
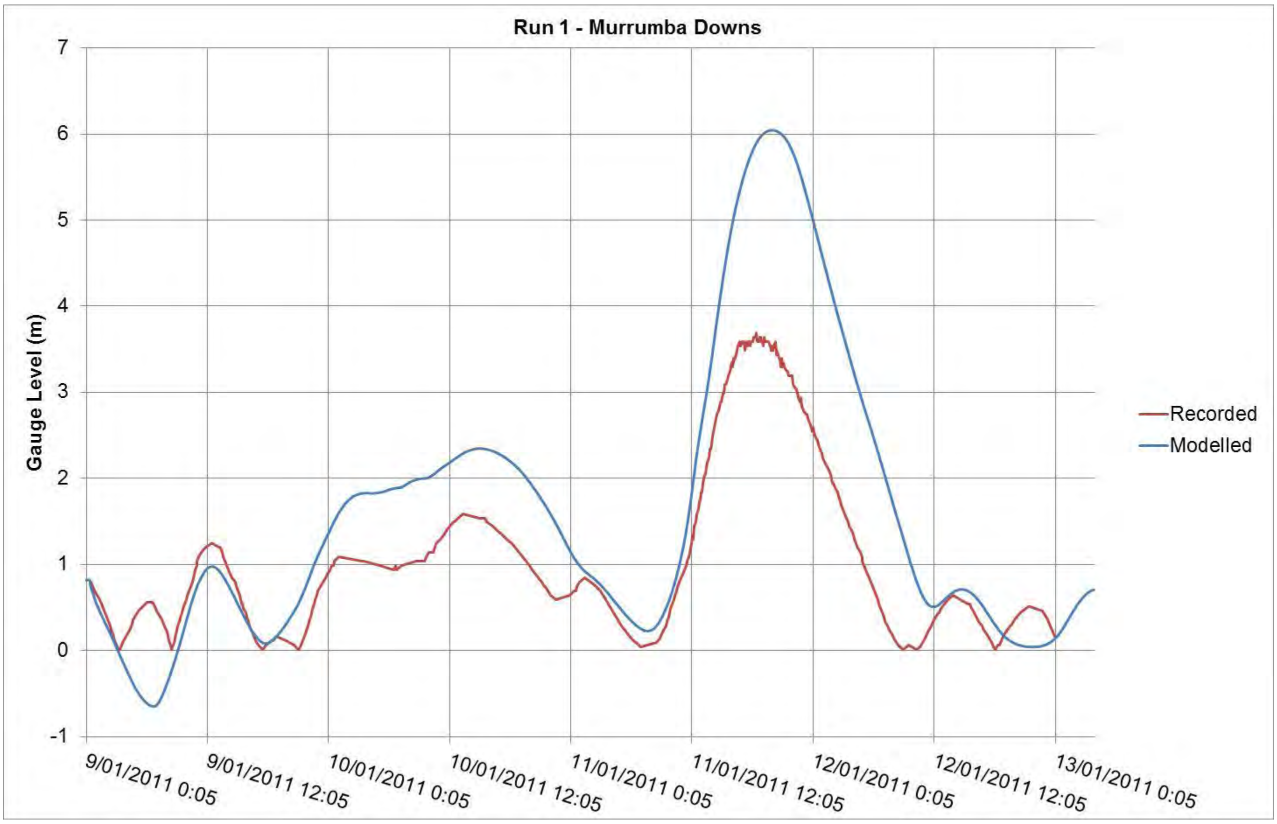
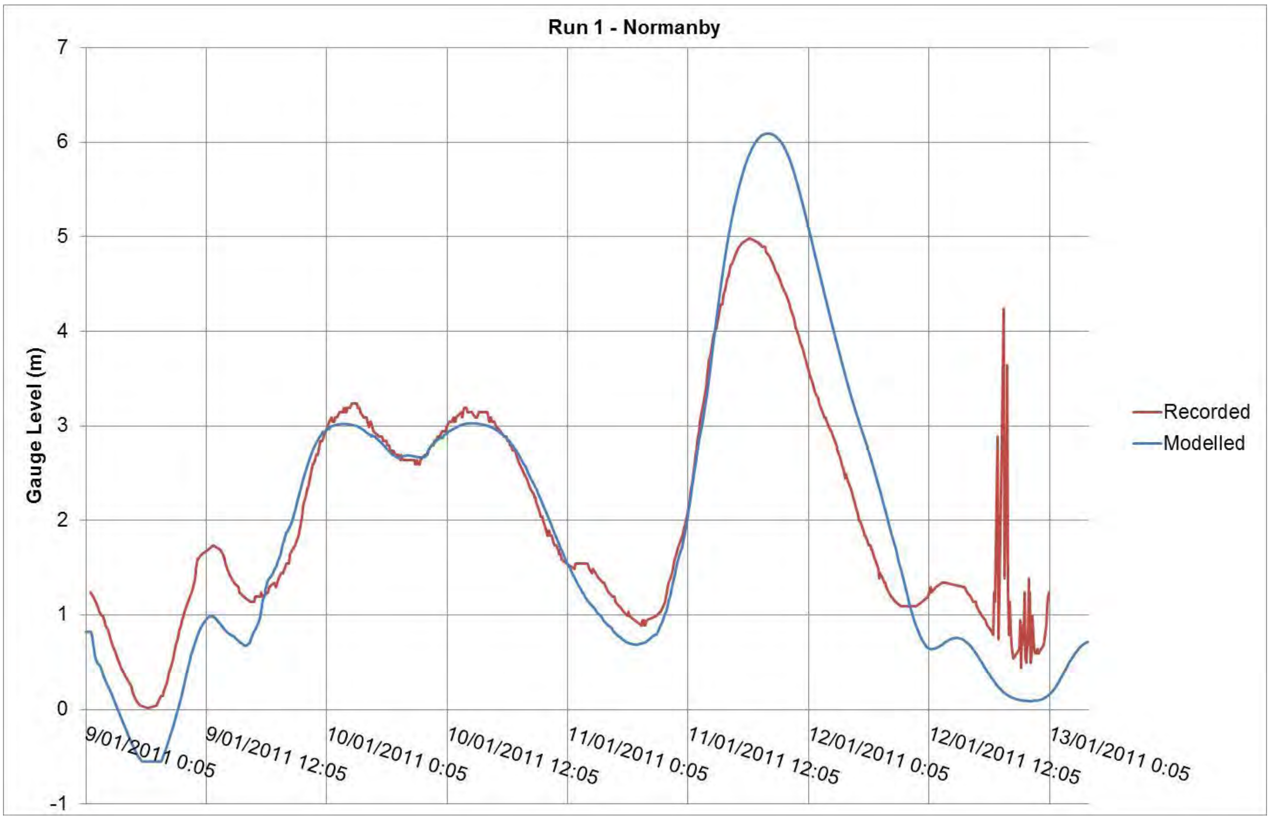
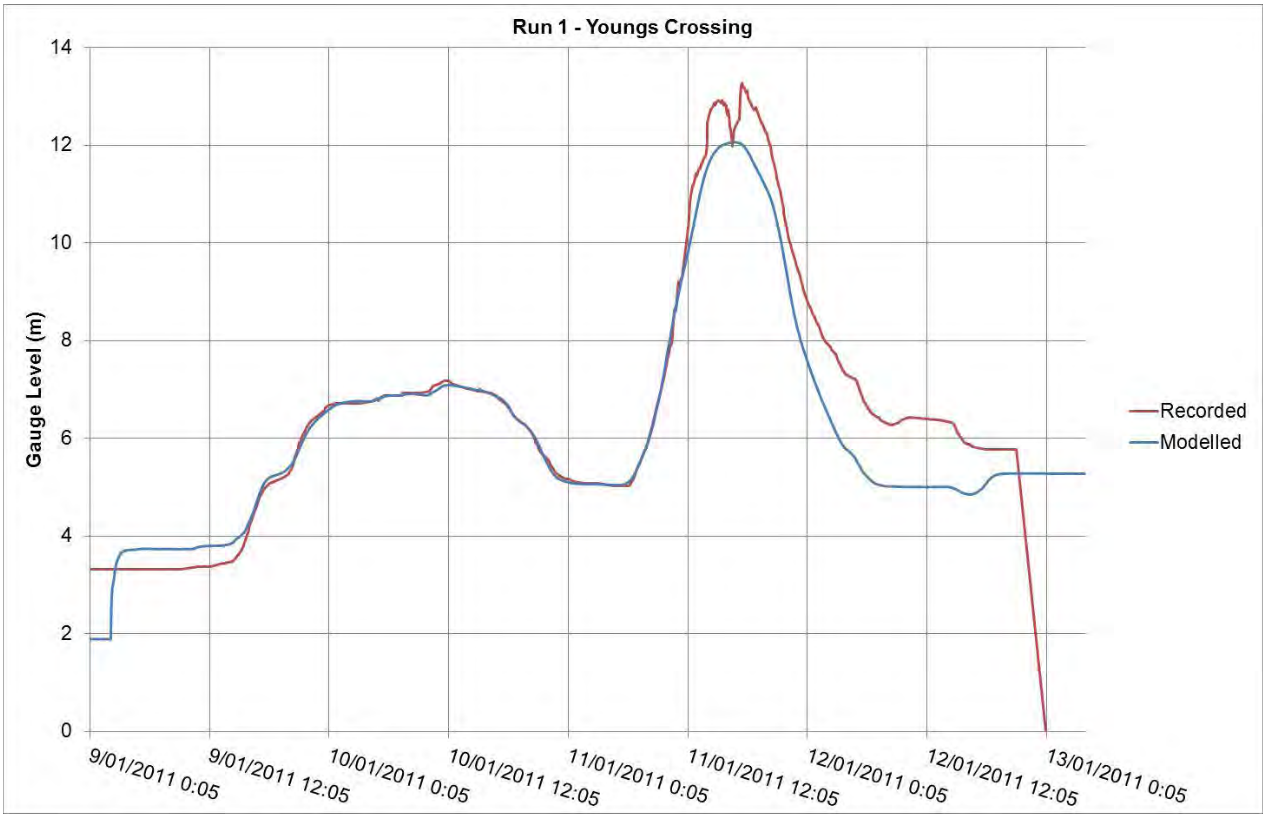
Recorded
Modelled

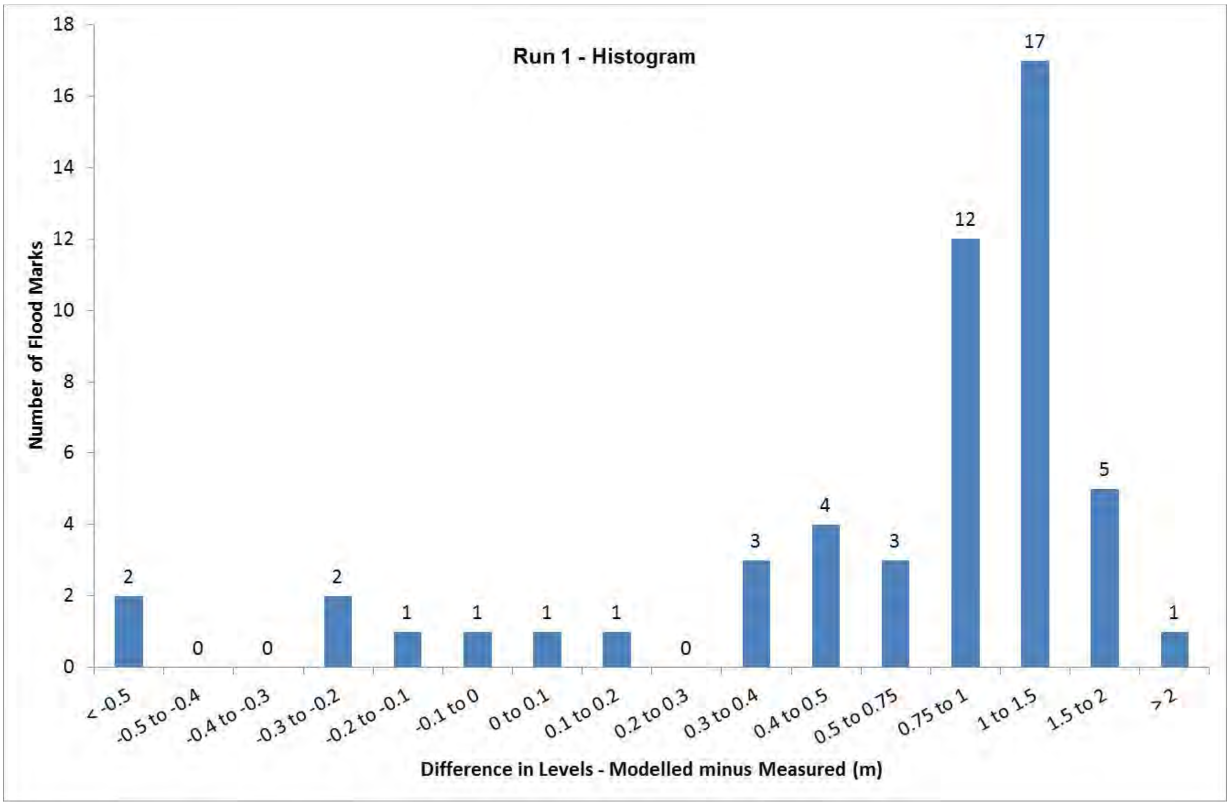

Run 1 - Lawnton
Gauge Level (m)
7
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

A-4 Run 1 Results

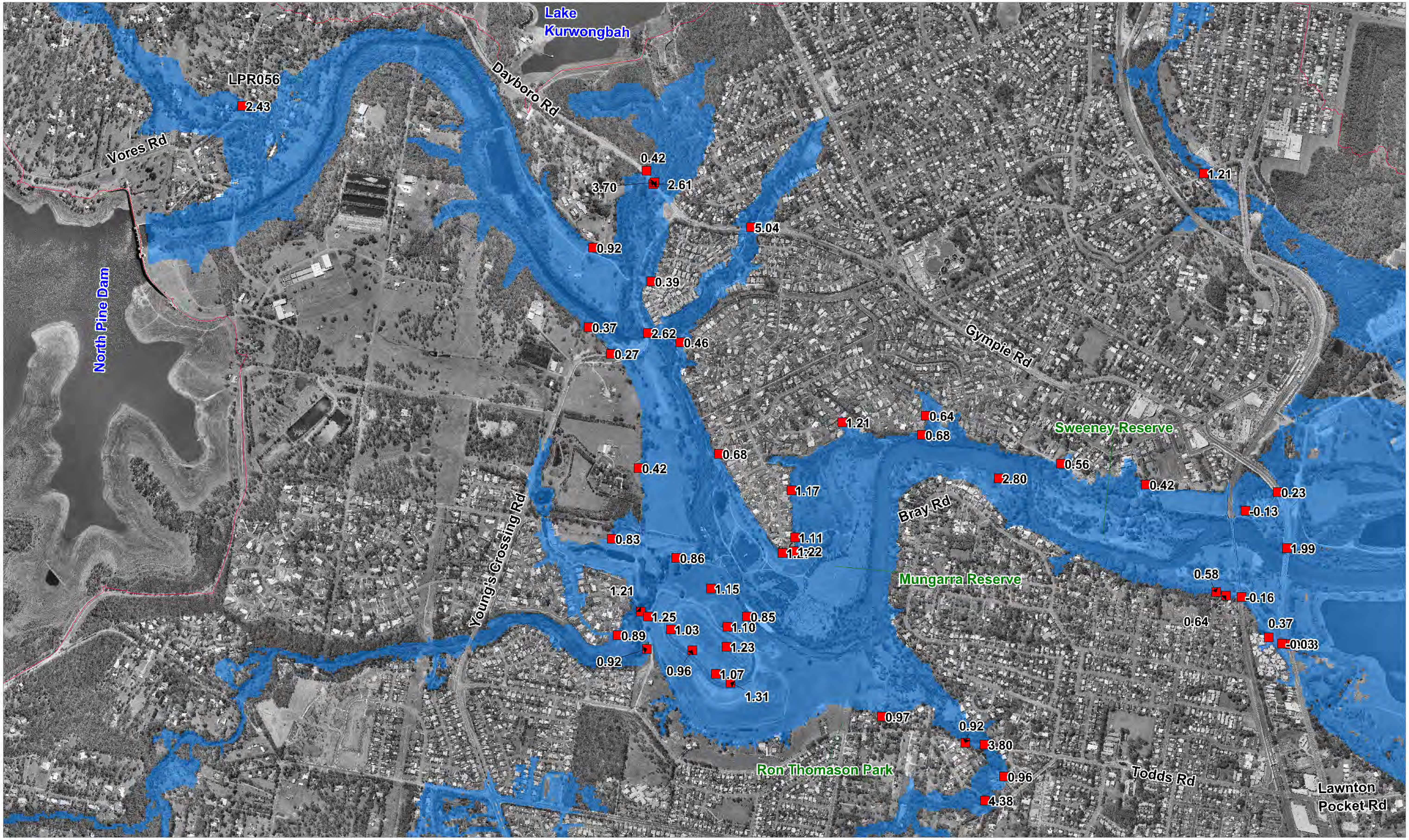





Run 1 - Youngs Crossing
Gauge Level (m)
14
12
10
8
6
4
2
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 1 - Histogram
Number of Flood Marks
18
16
14
12
10
8
6
4
2
0
2
0
0
2
1
1
1
1
0
3
4
3
12
17
5
1
< -0.5
-0.5 to -0.4
-0.4 to -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to 0
0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.75
0.75 to 1
1 to 1.5
1.5 to 2
> 2
Difference in Levels - Modelled minus Measured (m)

APPENDIX B: RUN 2 RESULTS



LEGEND

Lower Pine River Catchment

Modelled January 2011 Flood Extent

0.03 Flood Marks January 2011 Event Difference in Peak Flood Levels in m (Modelled Minus Surveyed)

Title:

January 2011 Event Flood Mark Comparison Run 2 Lower Pine River Catchment

N

0 250 500m

Approx. Scale

Figure: B-1

Rev: -

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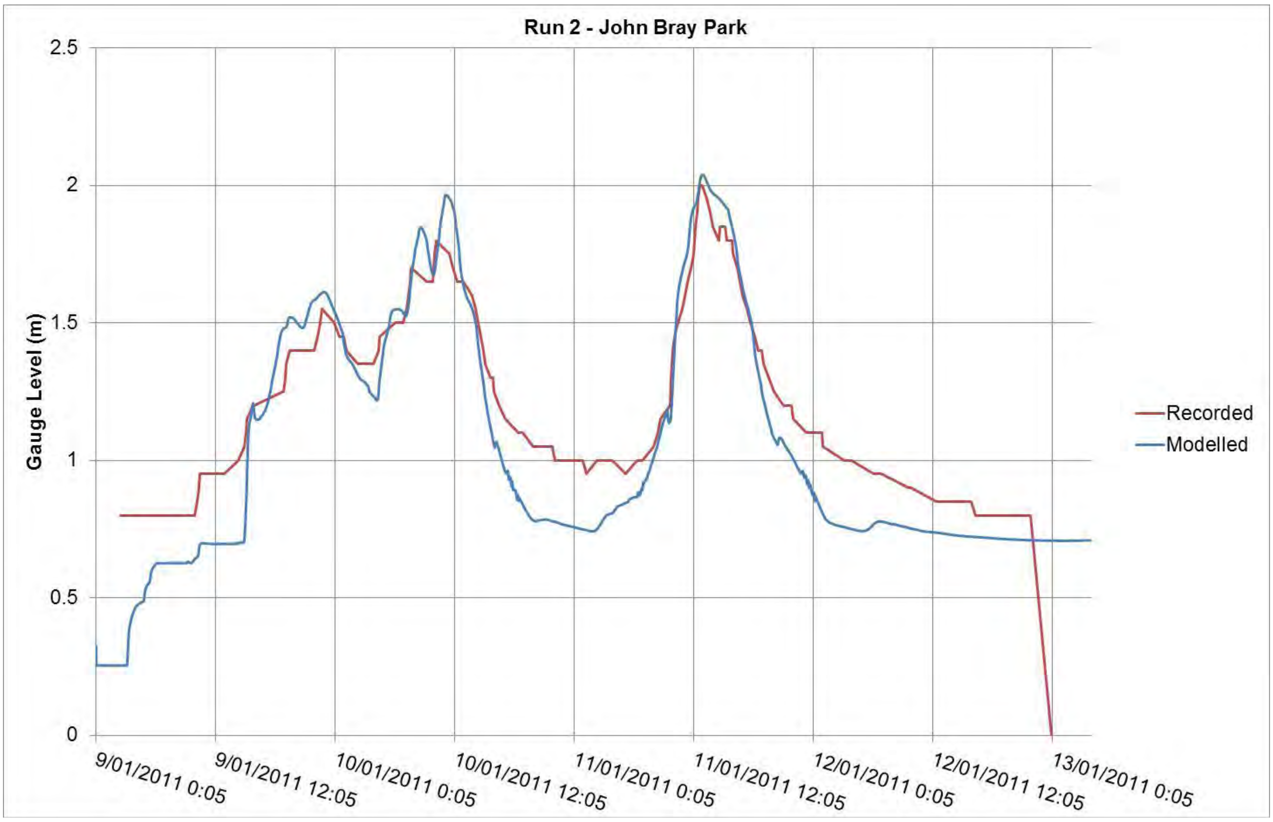
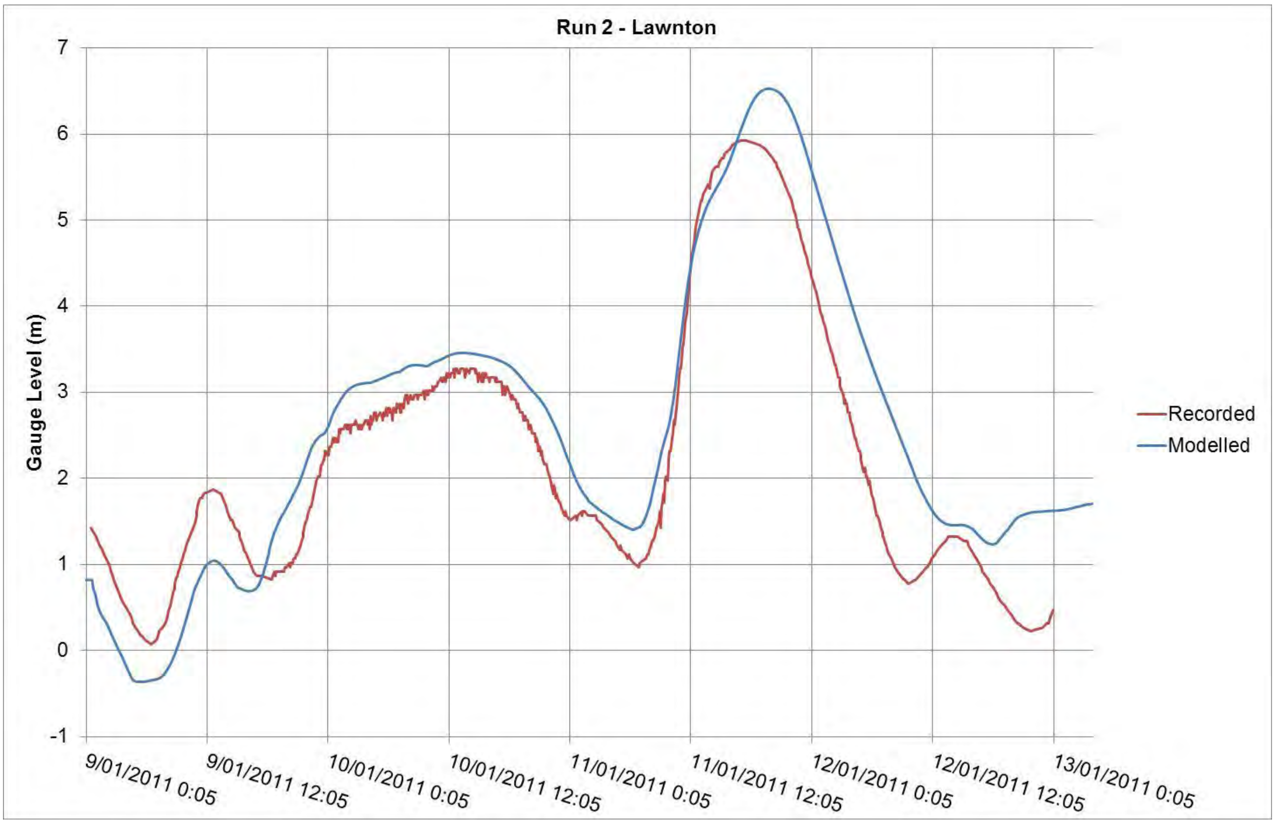
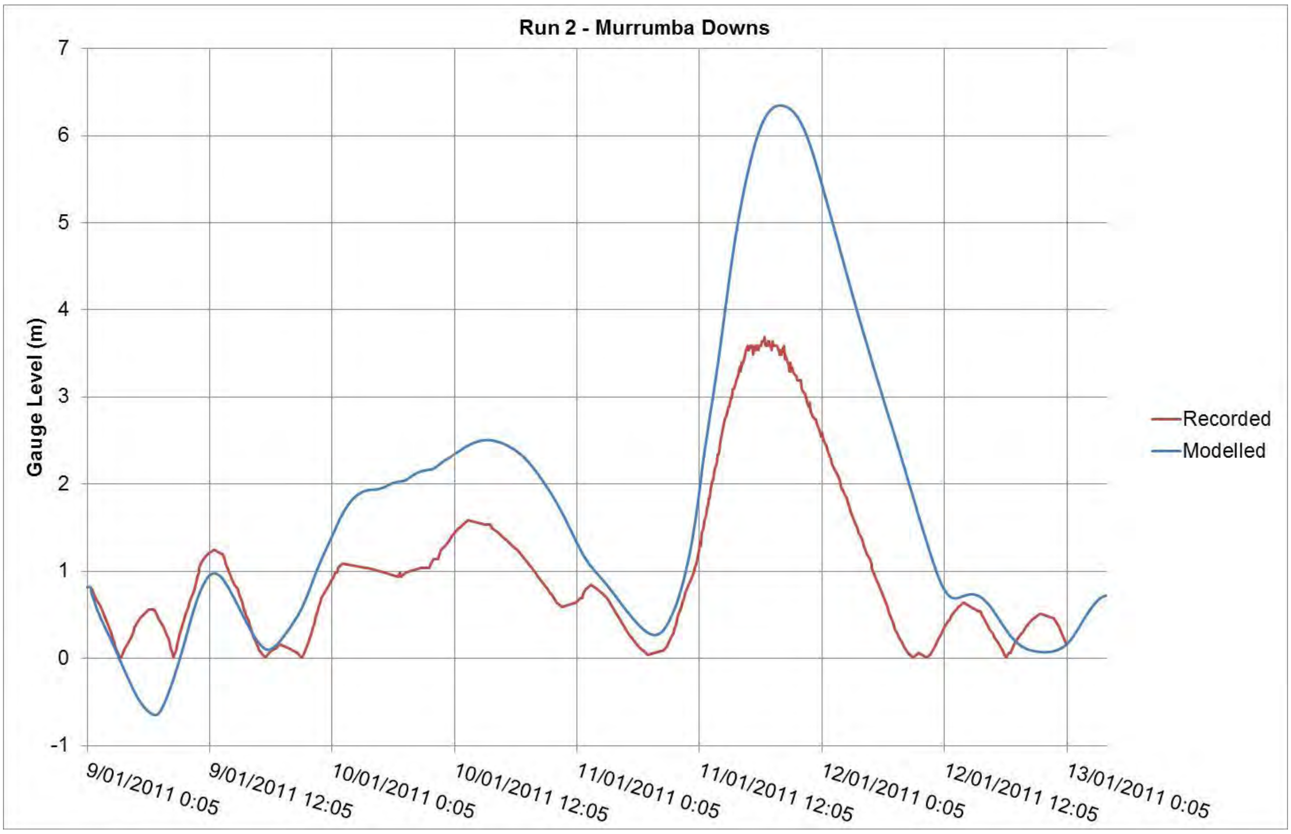
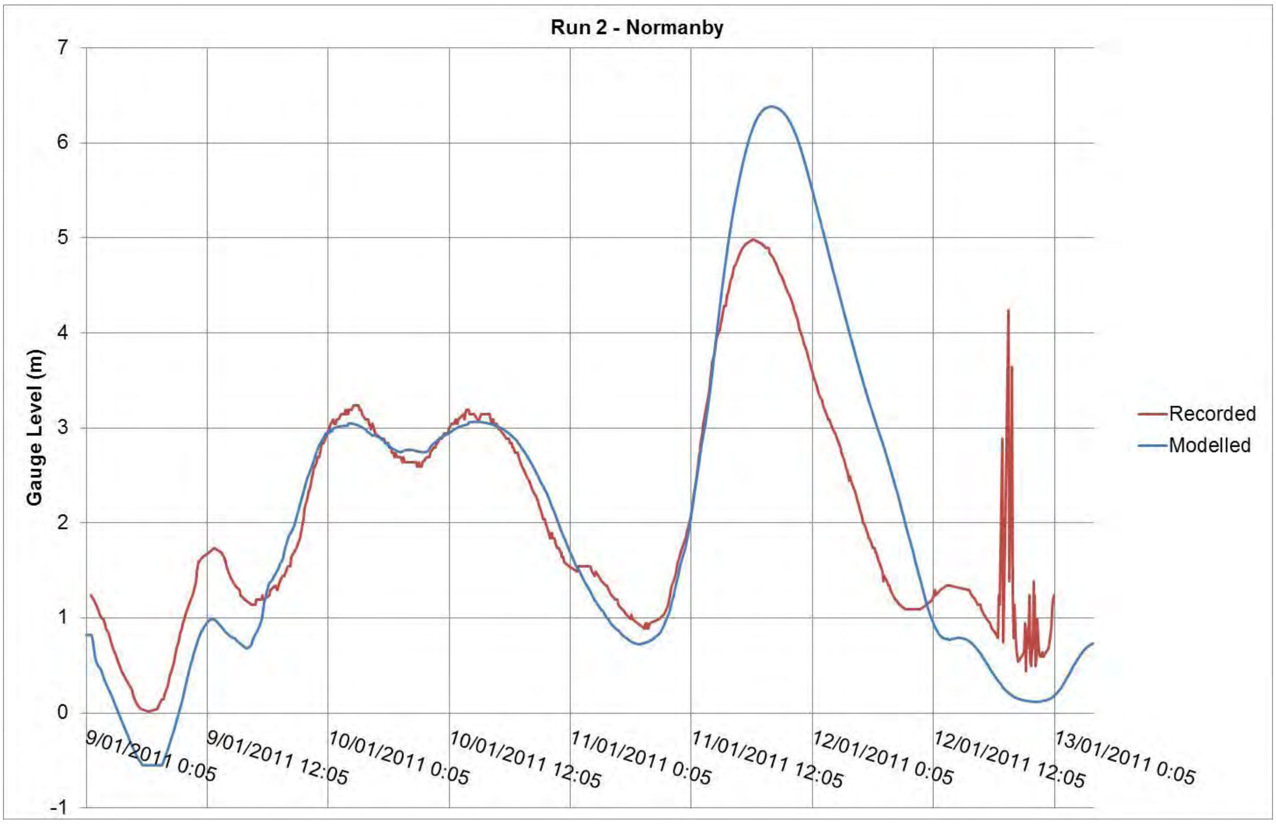
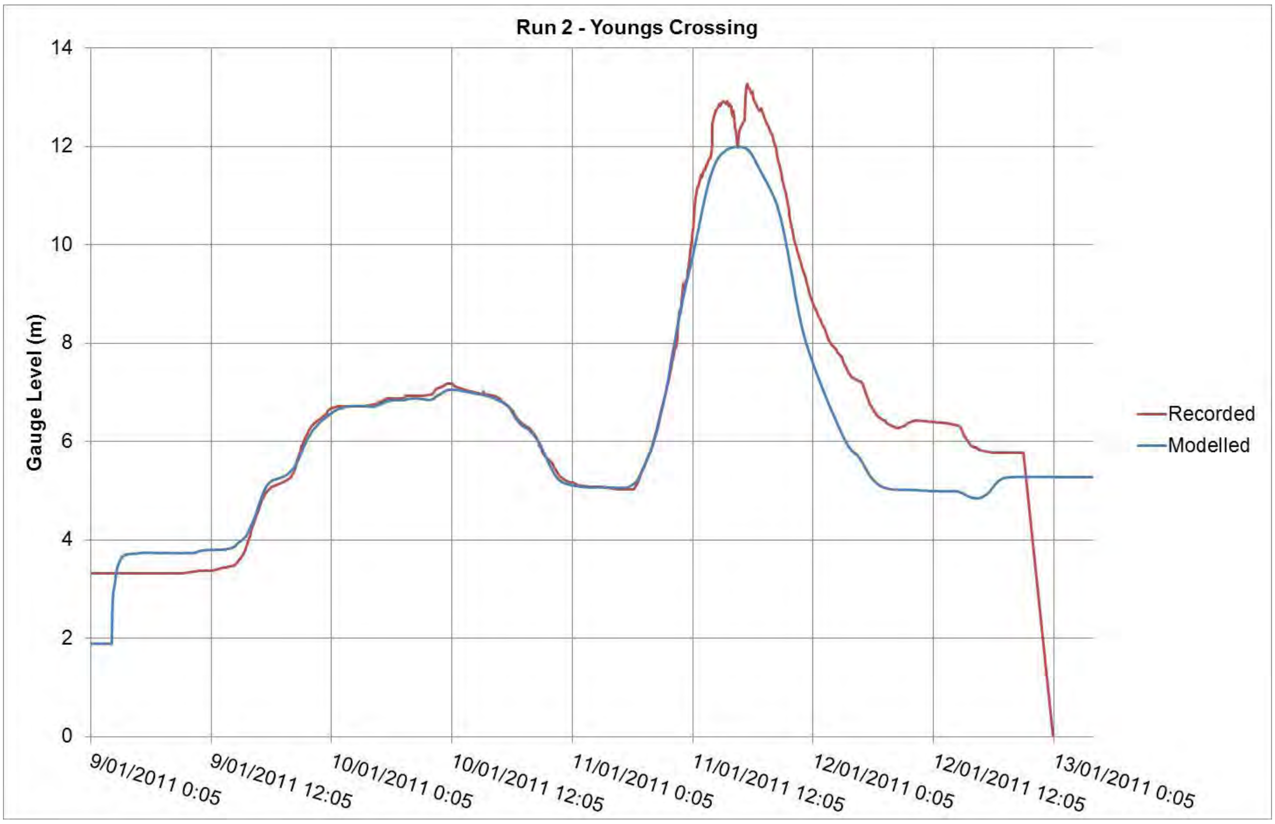
Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\Calibration\FLD_011_121219_LPR_Calibration_Results_F2.WOR


Run 2 - John Bray Park
Gauge Level (m)
2.5
2
1.5
1
0.5
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

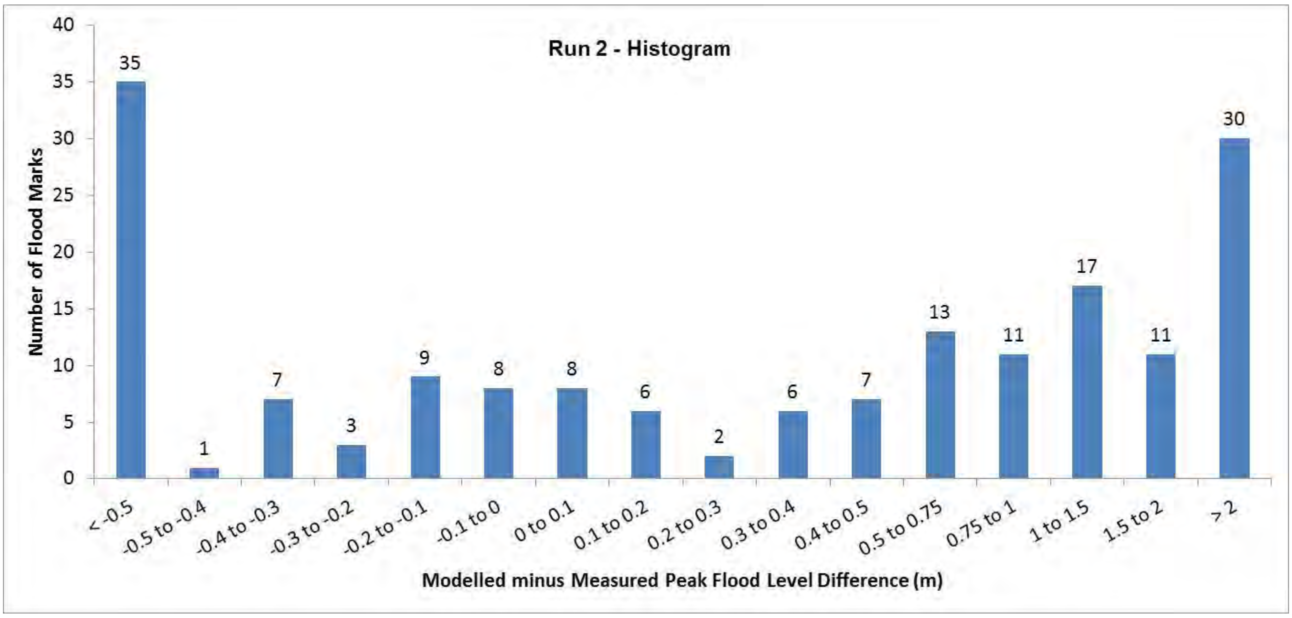

Run 2 - Lawnton
Gauge Level (m)
7
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 2 - Murrumba Downs
Gauge Level (m)
7
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 2 - Normanby
Gauge Level (m)
7
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

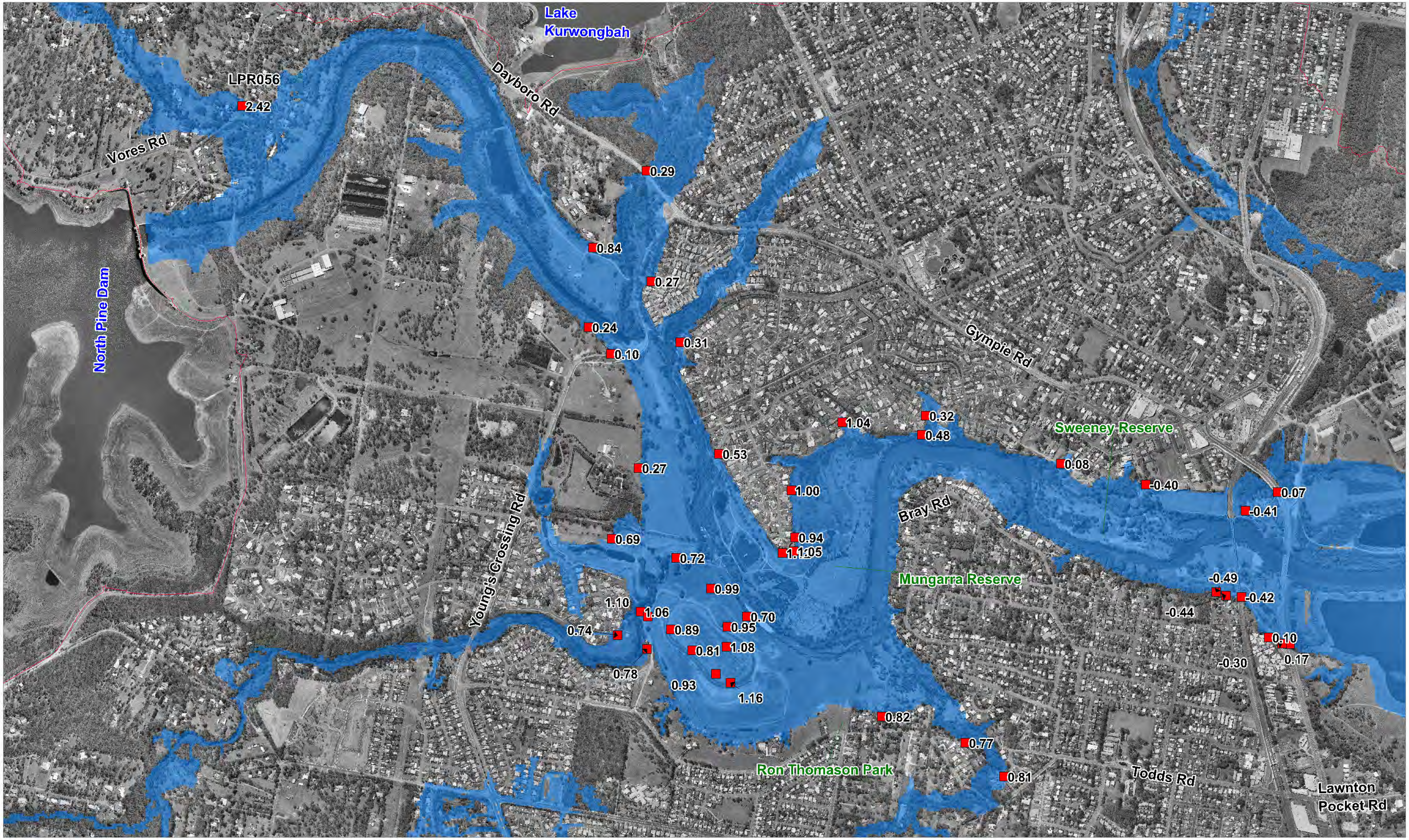


Run 2 - Youngs Crossing
Gauge Level (m)
14
12
10
8
6
4
2
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled



Run 2 - Histogram
Number of Flood Marks
40
35
30
25
20
15
10
5
0
35
1
7
3
9
8
8
6
2
6
7
13
11
17
11
30
< -0.5
-0.5 to -0.4
-0.4 to -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to 0
0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.75
0.75 to 1
1 to 1.5
1.5 to 2
> 2
Modelled minus Measured Peak Flood Level Difference (m)

APPENDIX C: RUN 3 RESULTS



LEGEND

Lower Pine River Catchment

Modelled January 2011 Flood Extent

Flood Marks January 2011 Event
0.03 Difference in Peak Flood Levels in m (Modelled Minus Surveyed)

Title:

January 2011 Event Flood Mark Comparison
Run 3 Lower Pine River Catchment

Figure: C-1

Rev: -

N

0 250 500m
Approx. Scale

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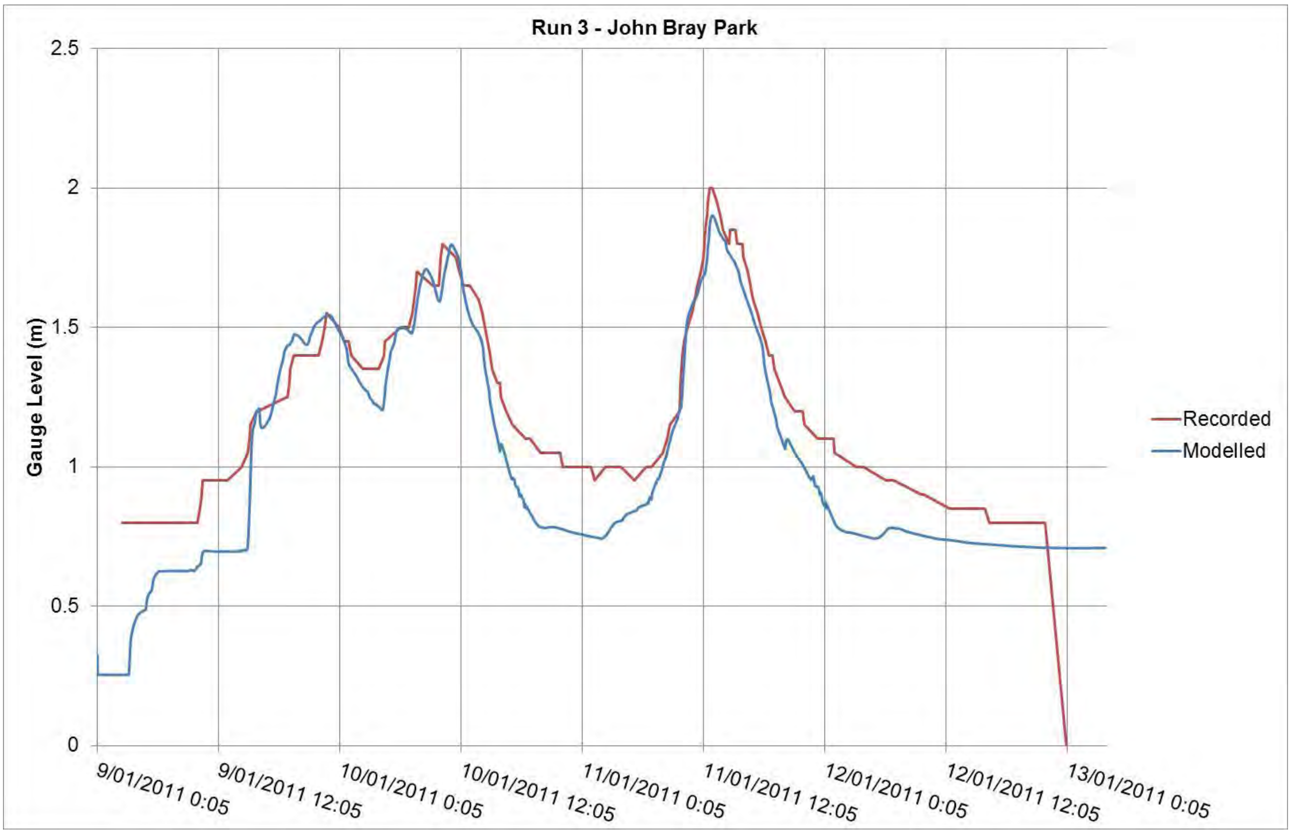
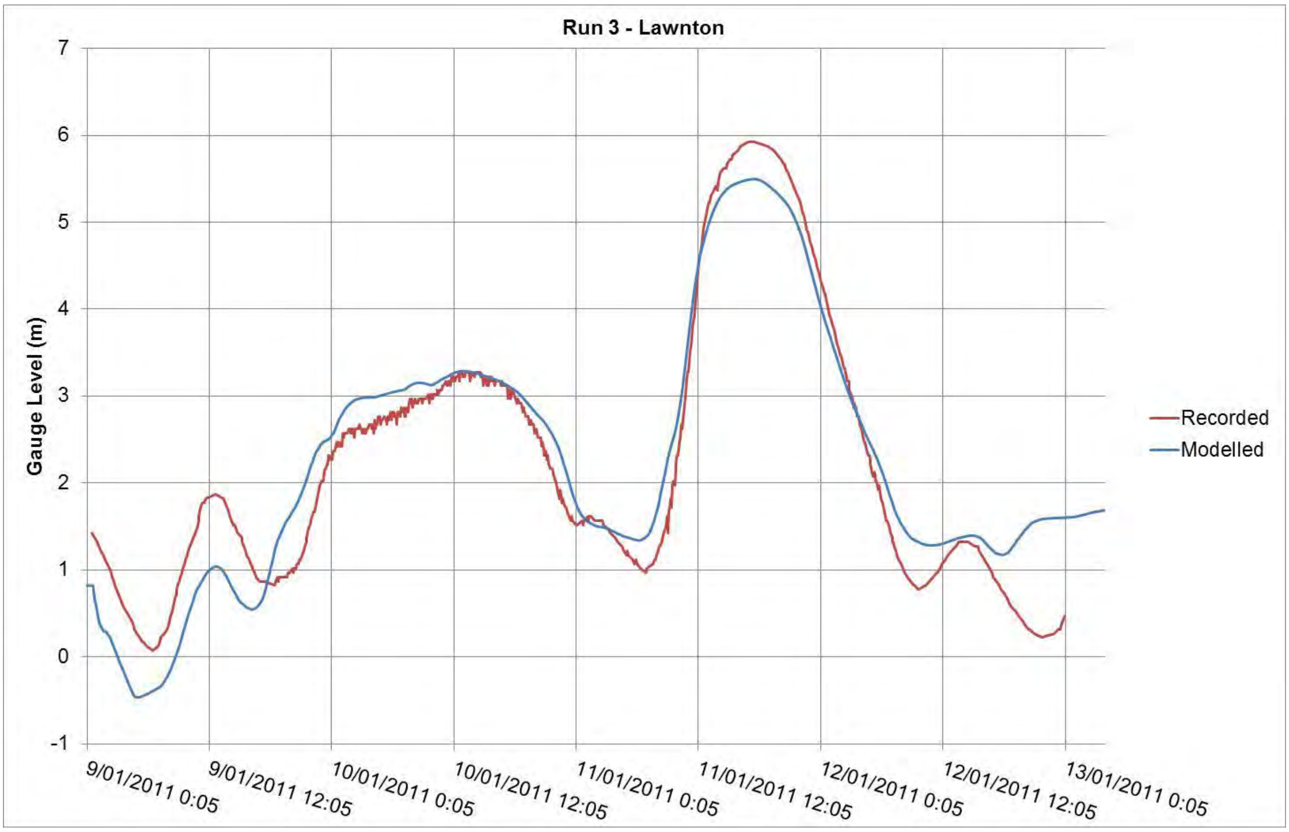
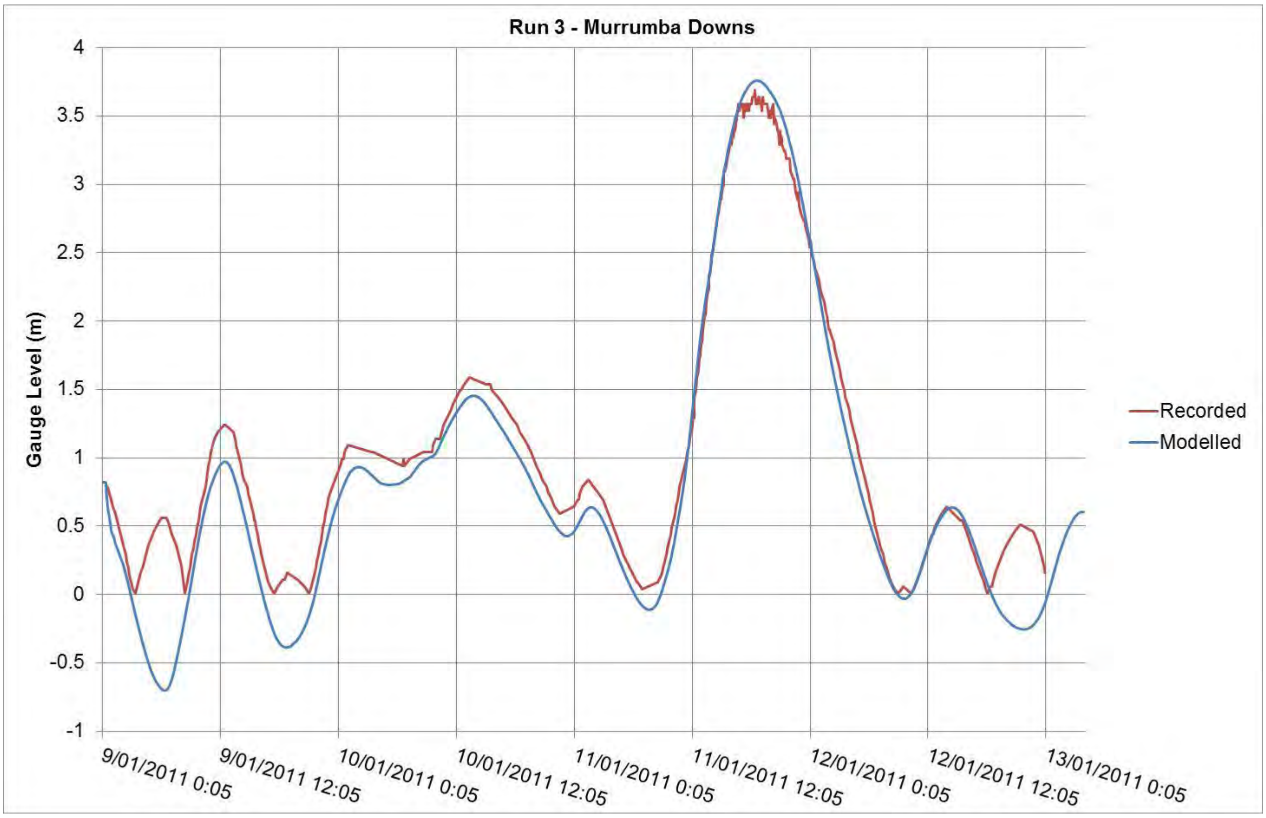
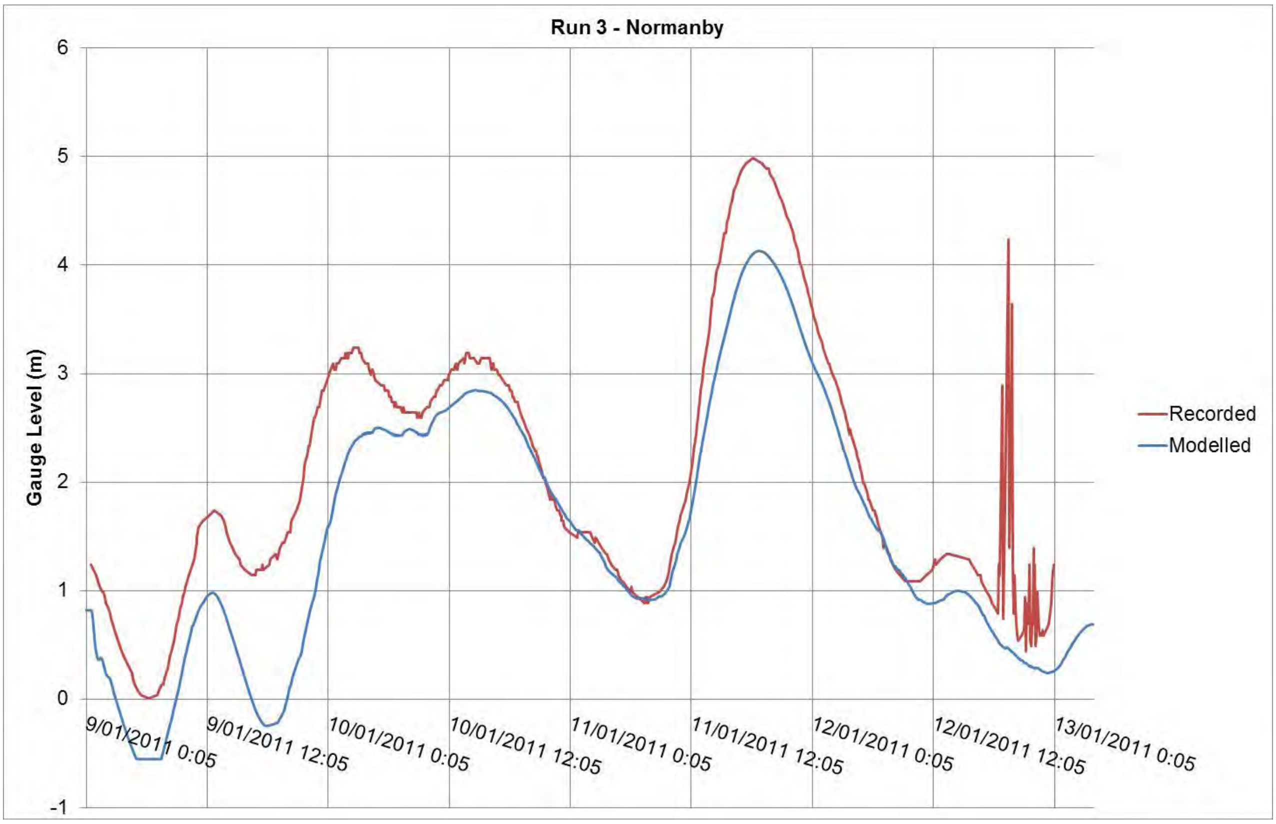
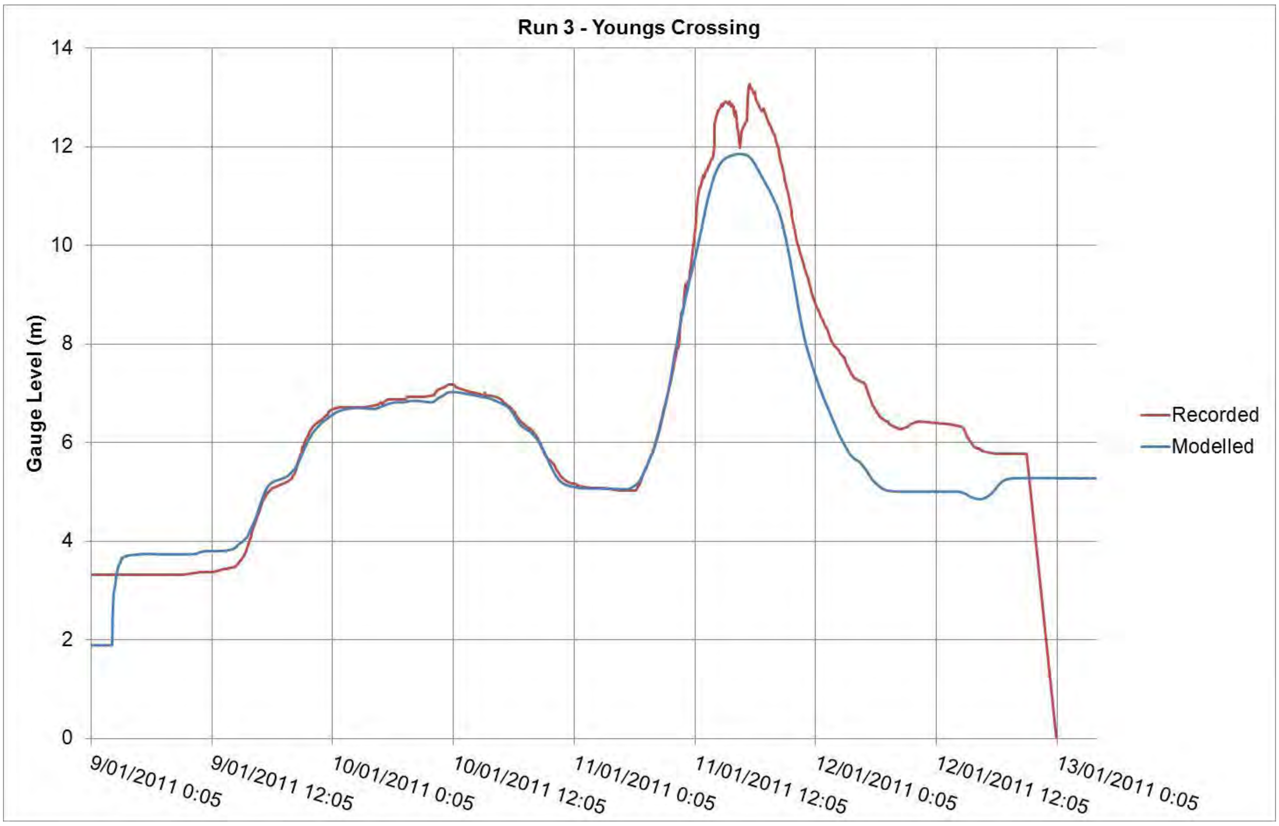
Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\Calibration\FLD_012_121219_LPR_Calibration_Results_F3.WOR

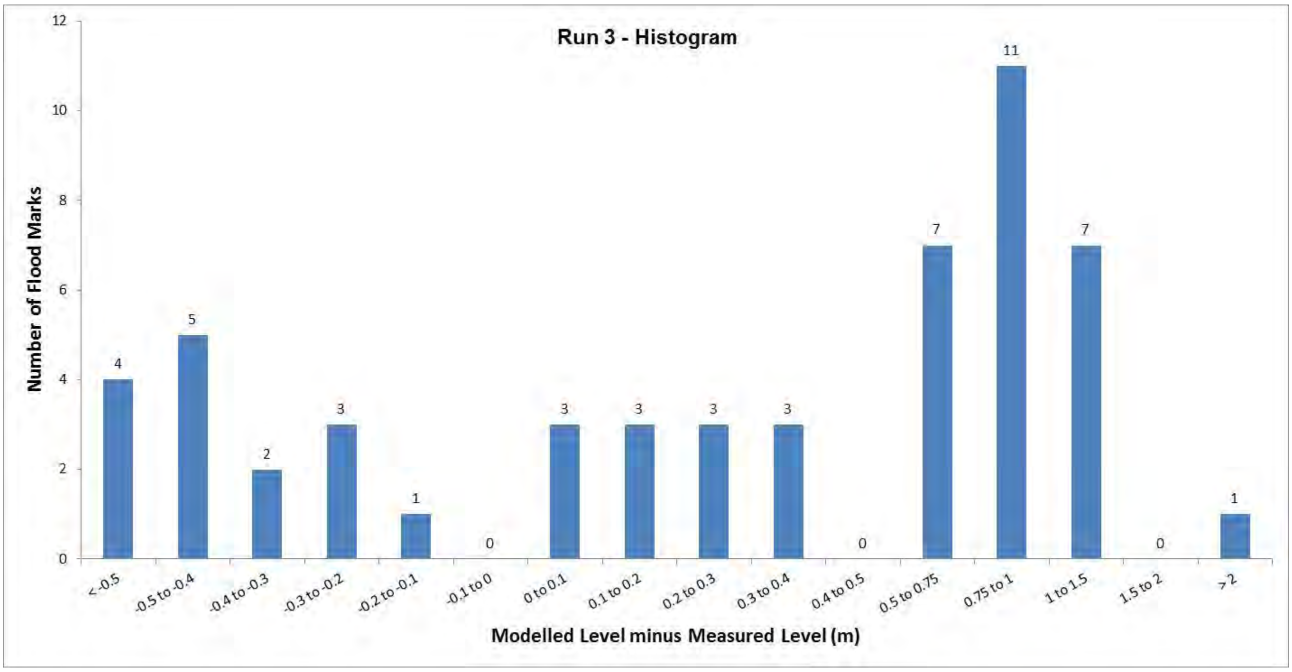

Run 3 - John Bray Park
Gauge Level (m)
2.5
2
1.5
1
0.5
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 3 - Lawnton
Gauge Level (m)
7
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

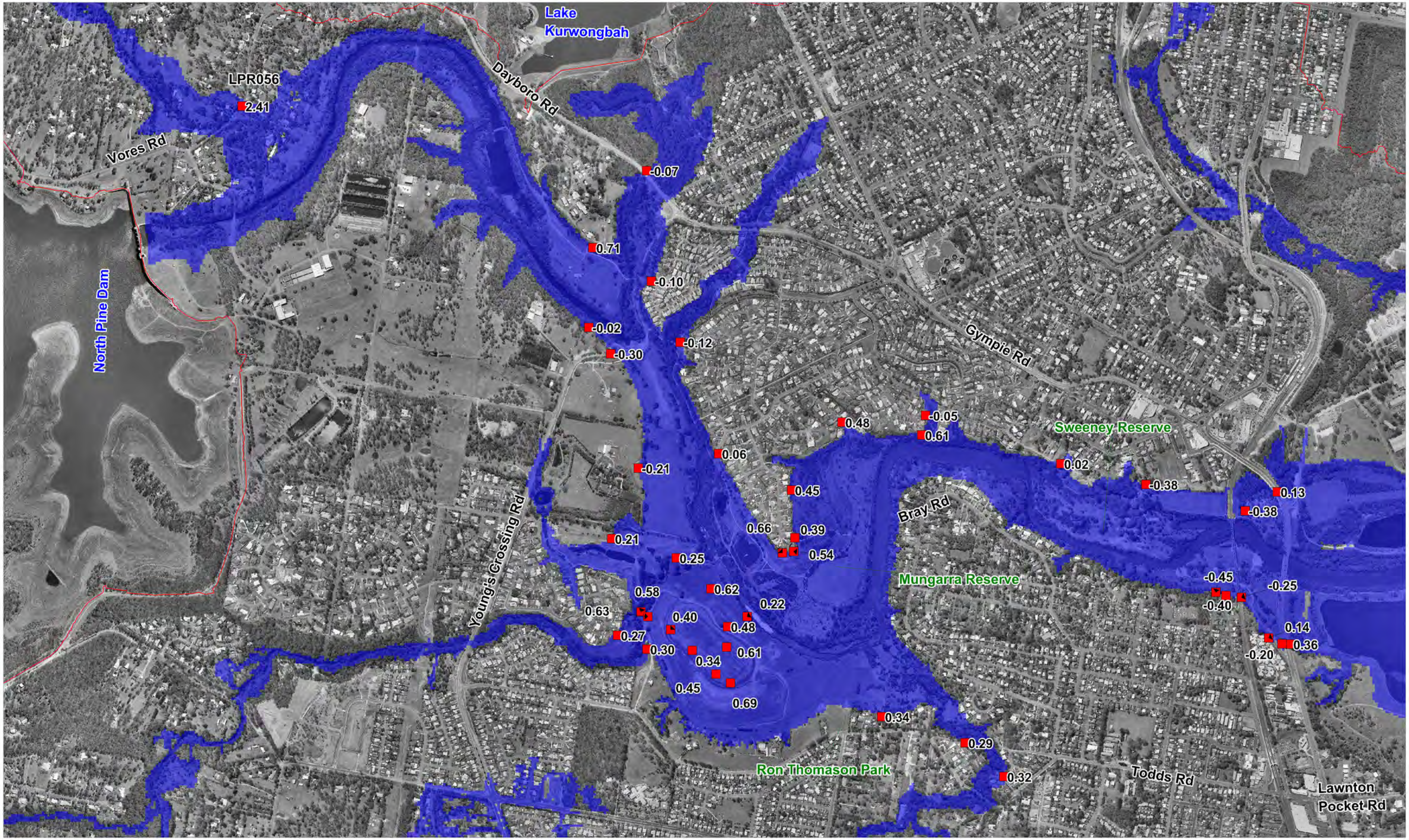

Run 3 - Murrumba Downs
Gauge Level (m)
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 3 - Normanby
Gauge Level (m)
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 3 - Youngs Crossing
Gauge Level (m)
14
12
10
8
6
4
2
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 3 - Histogram
Number of Flood Marks
Modelled Level minus Measured Level (m)
< -0.5
-0.5 to -0.4
-0.4 to -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to 0
0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.75
0.75 to 1
1 to 1.5
1.5 to 2
> 2
4
5
2
3
1
0
3
3
3
3
0
7
11
7
0
1

APPENDIX D: RUN 4 RESULTS



LEGEND

Lower Pine River Catchment

Modelled January 2011 Flood Extent

0.03 Flood Marks January 2011 Event Difference in Peak Flood Levels in m (Modelled Minus Surveyed)

Title:

January 2011 Event Flood Mark Comparison
Run 4 Lower Pine River Catchment

Figure: **D-1**

Rev: **-**

N

0 250 500m
Approx. Scale

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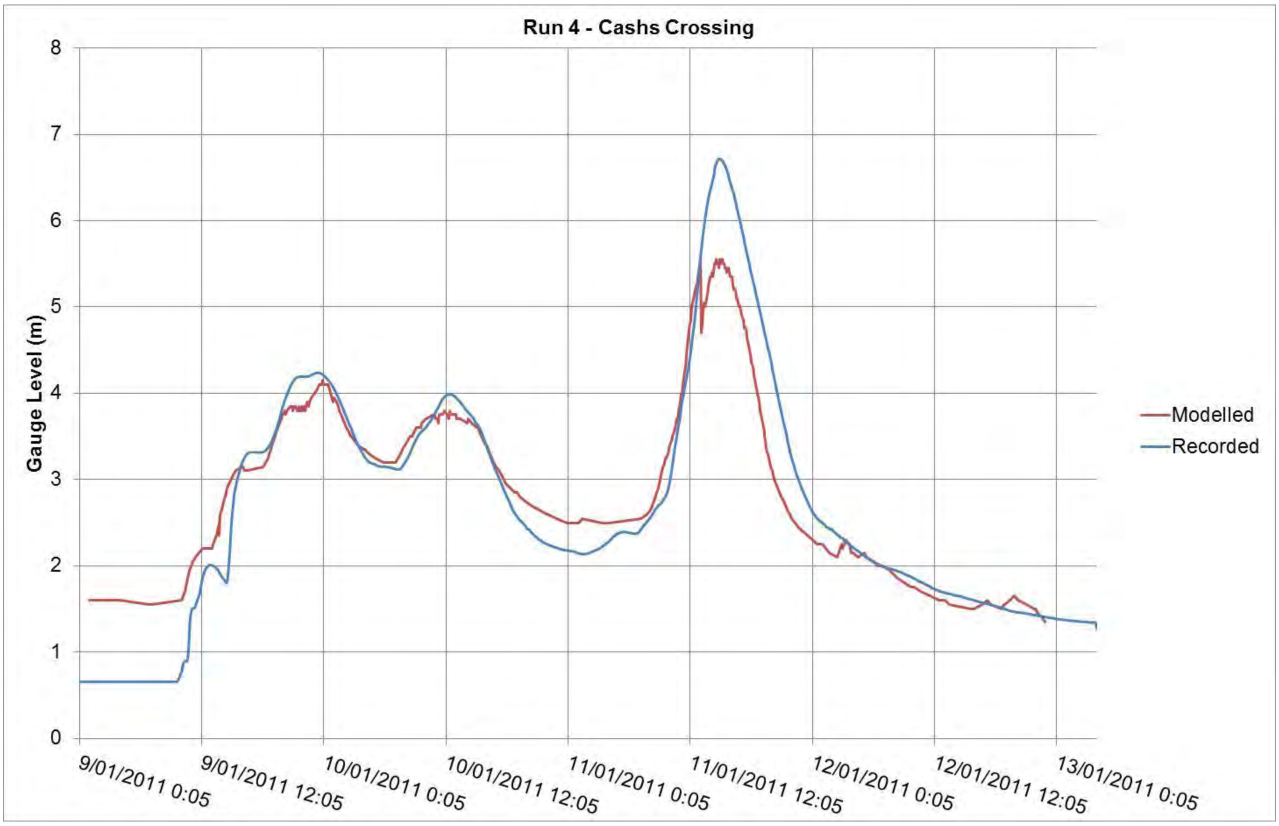
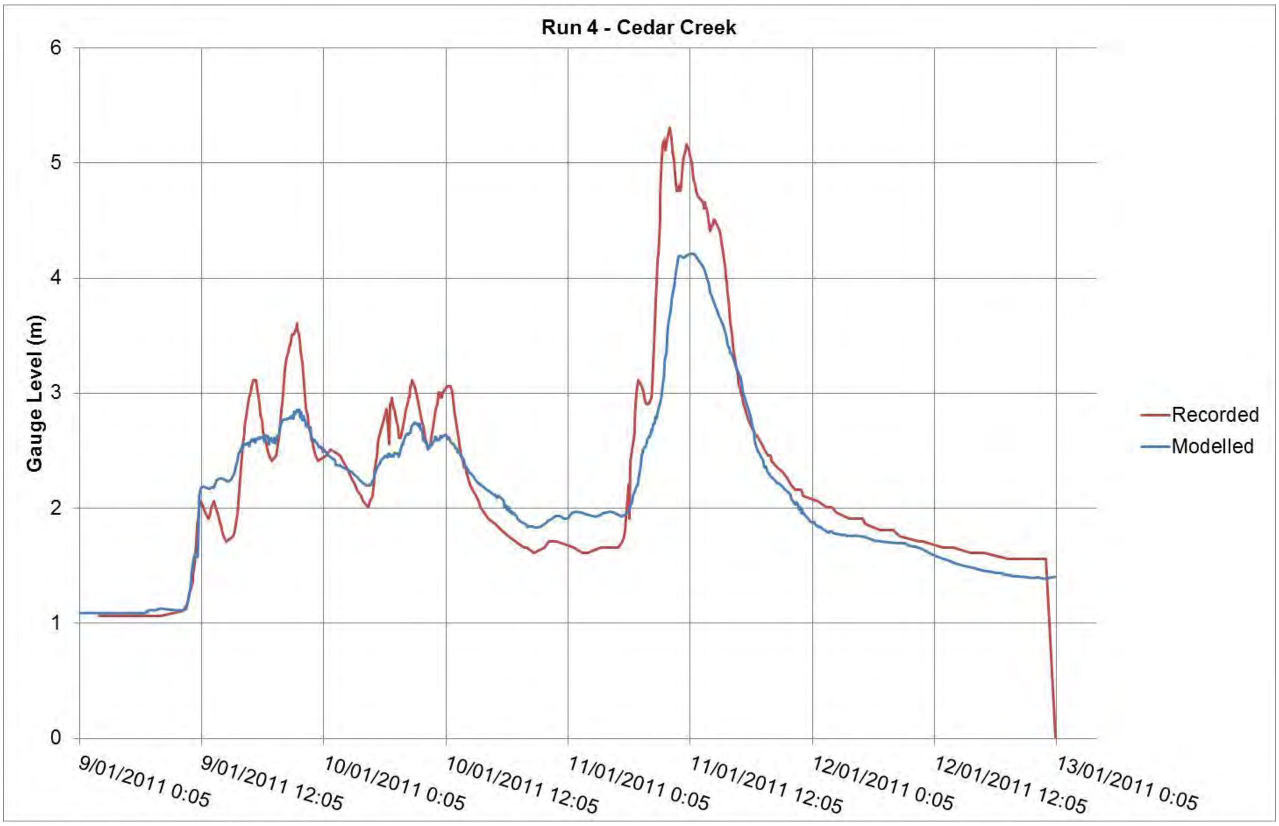
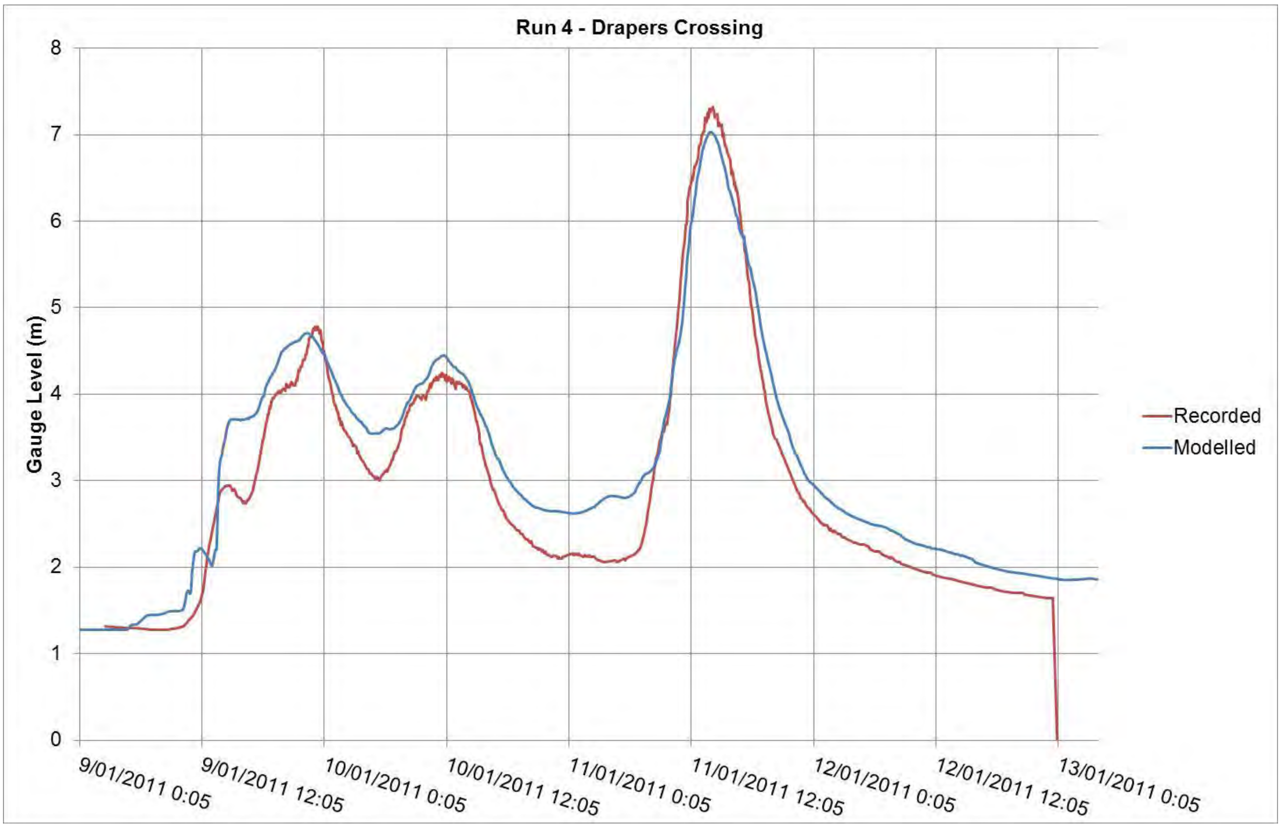
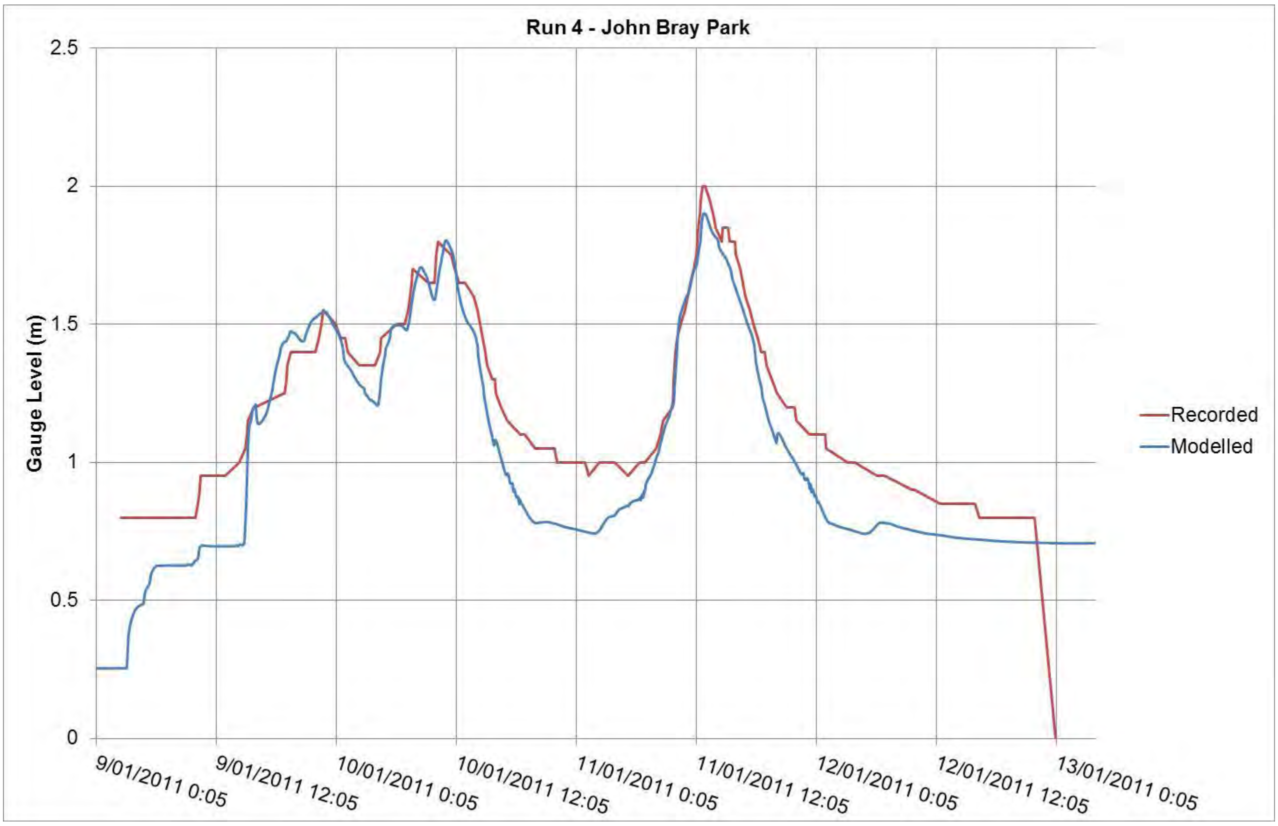
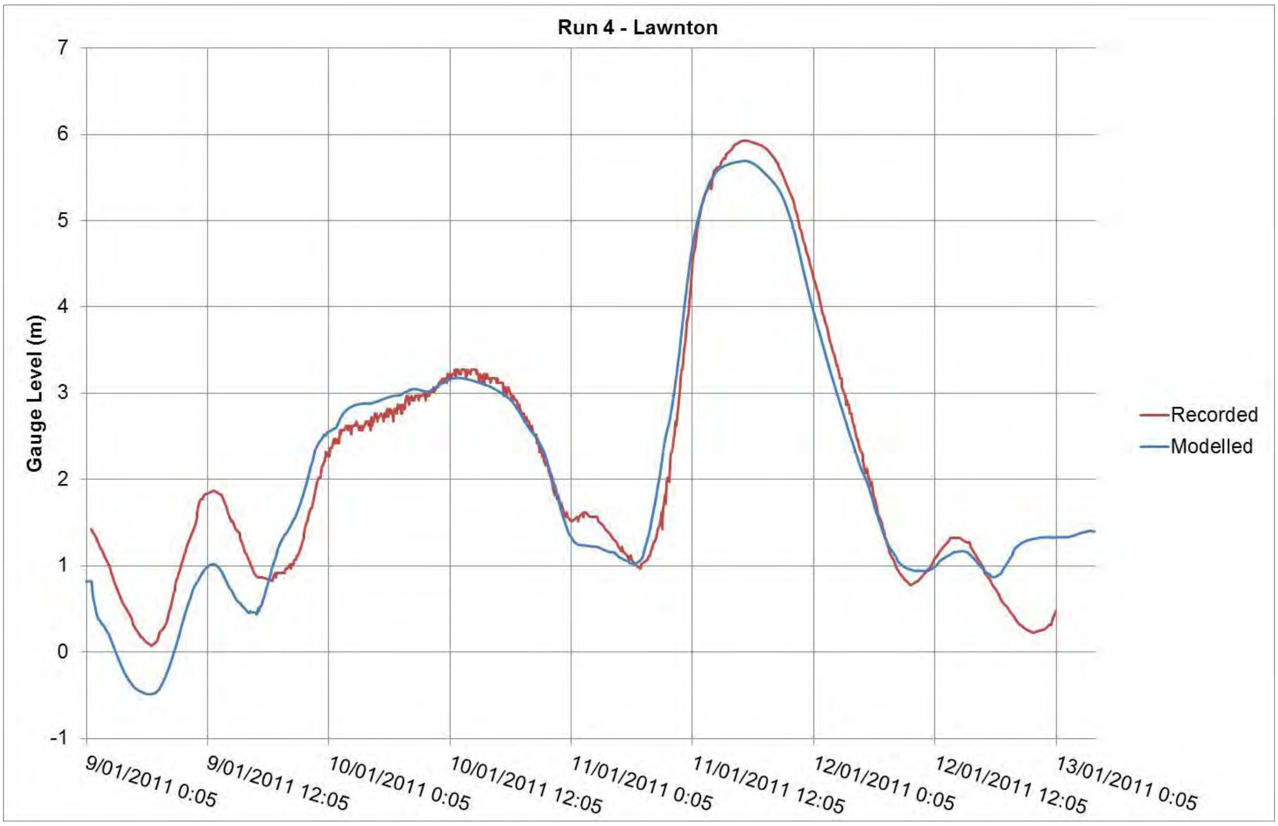
Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\Calibration\FLD_018_130129_LPR_Calibration_Results_F4_revised.WOR

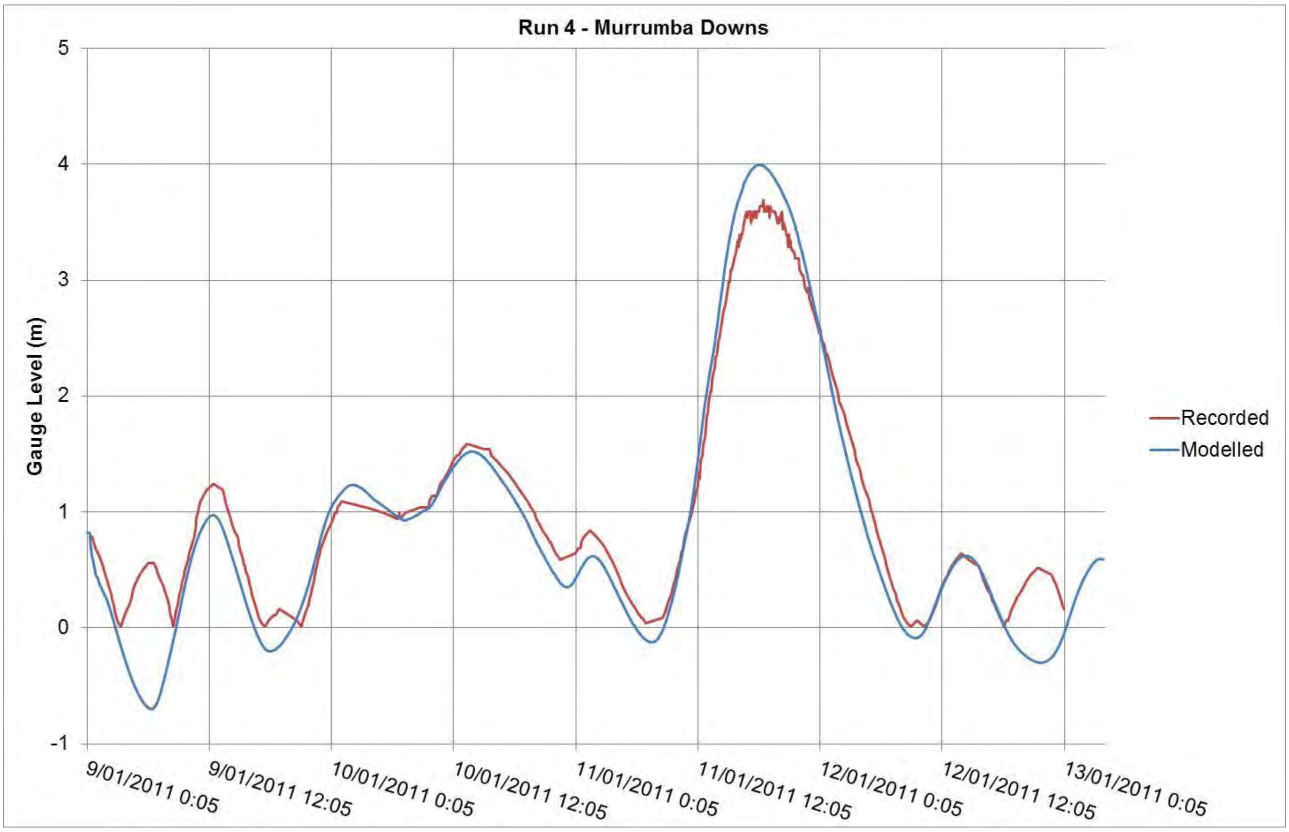

Run 4 - Cashs Crossing
Gauge Level (m)
0
1
2
3
4
5
6
7
8
Modelled
Recorded
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05

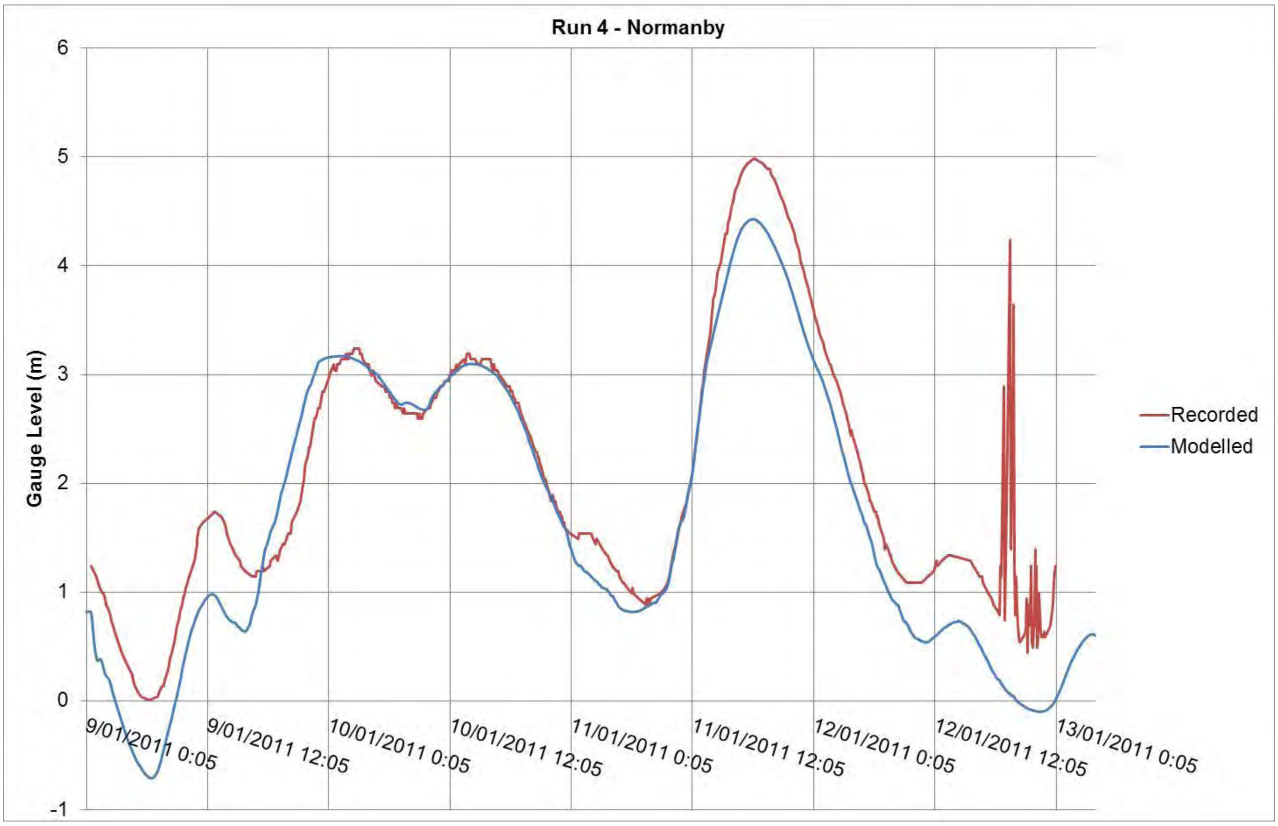

Run 4 - Cedar Creek
Gauge Level (m)
0
1
2
3
4
5
6
Recorded
Modelled
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05

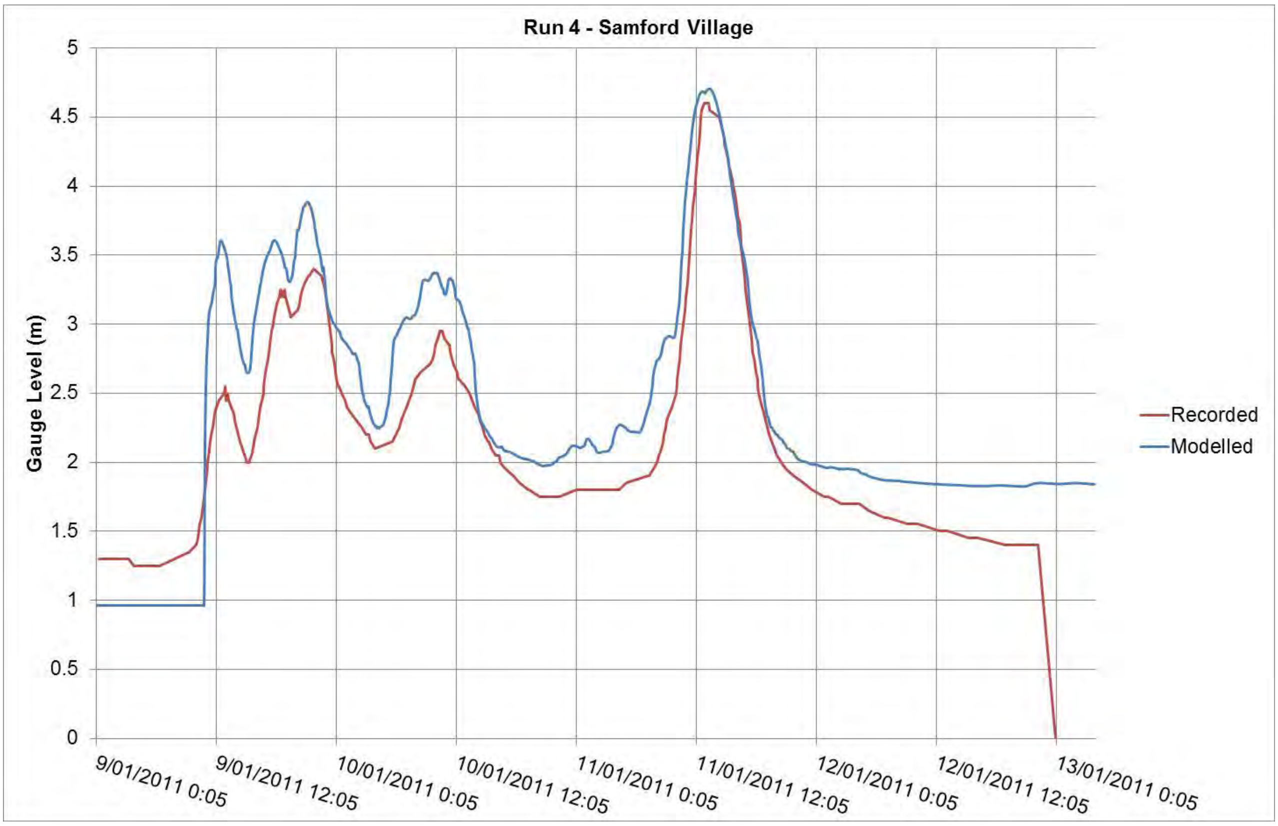

Run 4 - Drapers Crossing
Gauge Level (m)
0
1
2
3
4
5
6
7
8
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

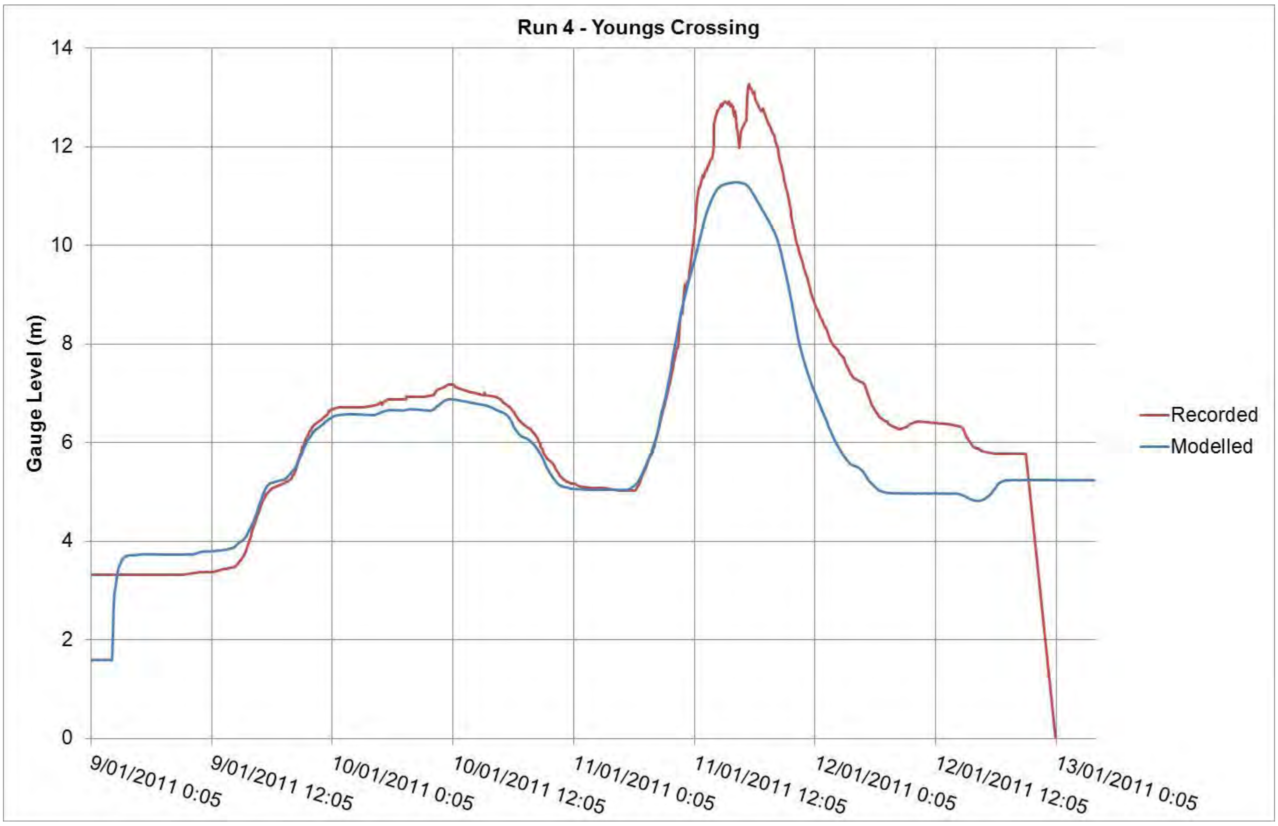

Run 4 - John Bray Park
Gauge Level (m)
0
0.5
1
1.5
2
2.5
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

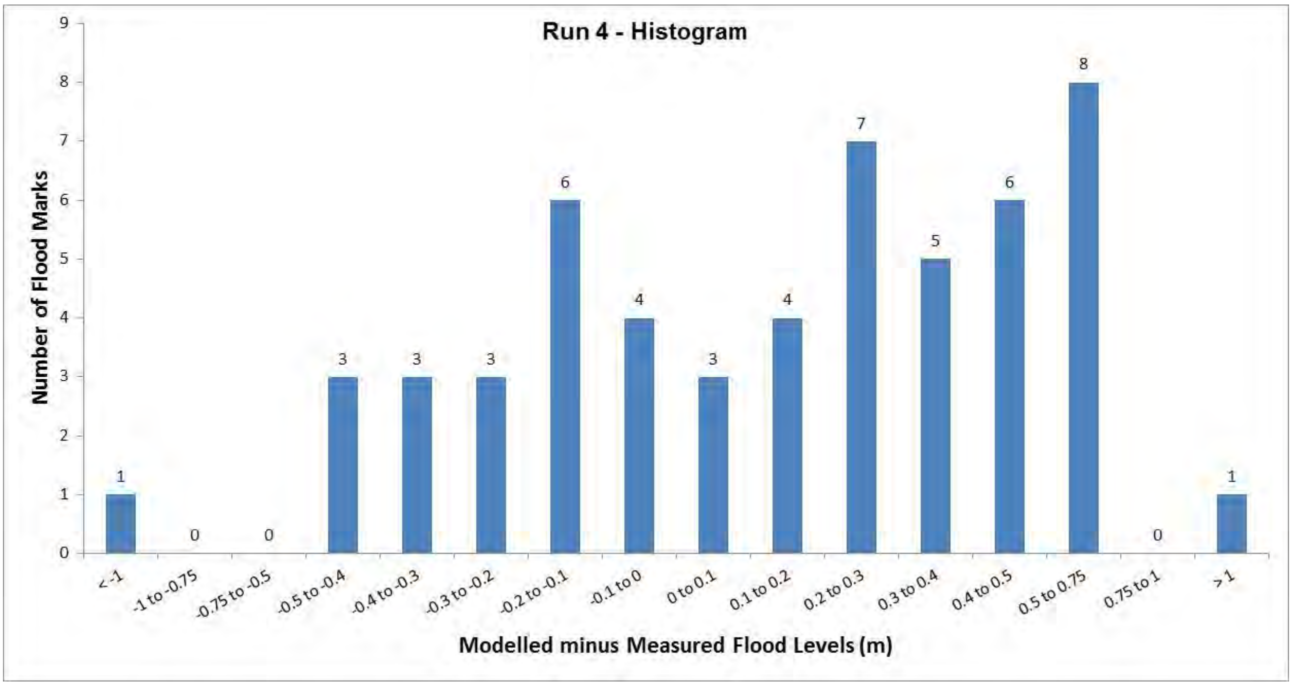

Run 4 - Lawnton
Gauge Level (m)
7
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 4 - Murrumba Downs
Gauge Level (m)
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

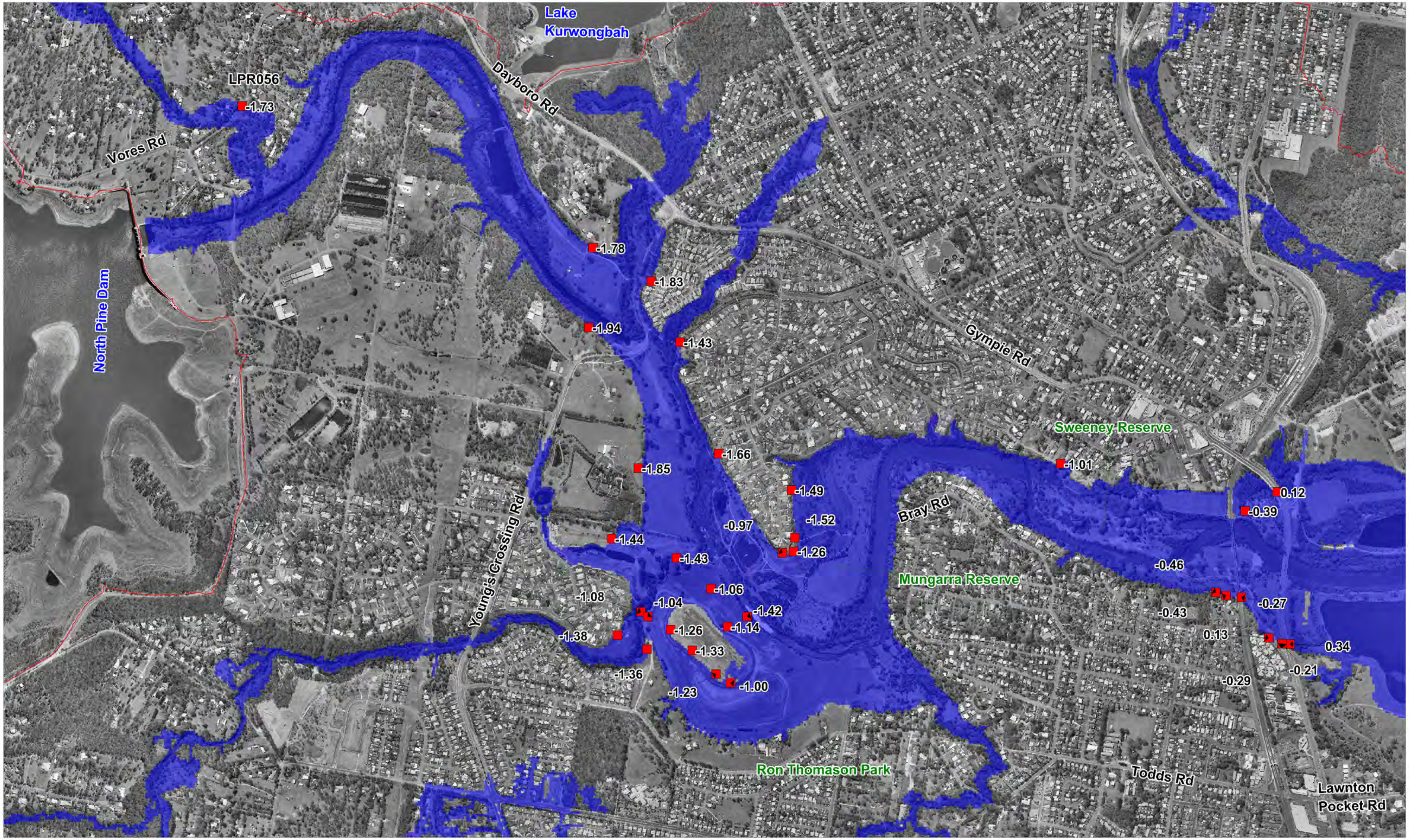

Run 4 - Normanby
Gauge Level (m)
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 4 - Samford Village
Gauge Level (m)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 4 - Youngs Crossing
Gauge Level (m)
14
12
10
8
6
4
2
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 4 - Histogram
Number of Flood Marks
Modelled minus Measured Flood Levels (m)
<-1
-1 to -0.75
-0.75 to -0.5
-0.5 to -0.4
-0.4 to -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to 0
0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.75
0.75 to 1
>1
1
0
0
3
3
3
6
4
3
4
7
5
6
8
0
1

APPENDIX E: RUN 5 RESULTS



LEGEND

- Lower Pine River Catchment
- Modelled January 2011 Flood Extent
- Flood Marks January 2011 Event Difference in Peak Flood Levels in m (Modelled Minus Surveyed) — 0.03

Title:
January 2011 Event Flood Mark Comparison
Run 5 Lower Pine River Catchment

Figure: **E-1**

Rev: **-**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m
Approx. Scale

BMT WBM
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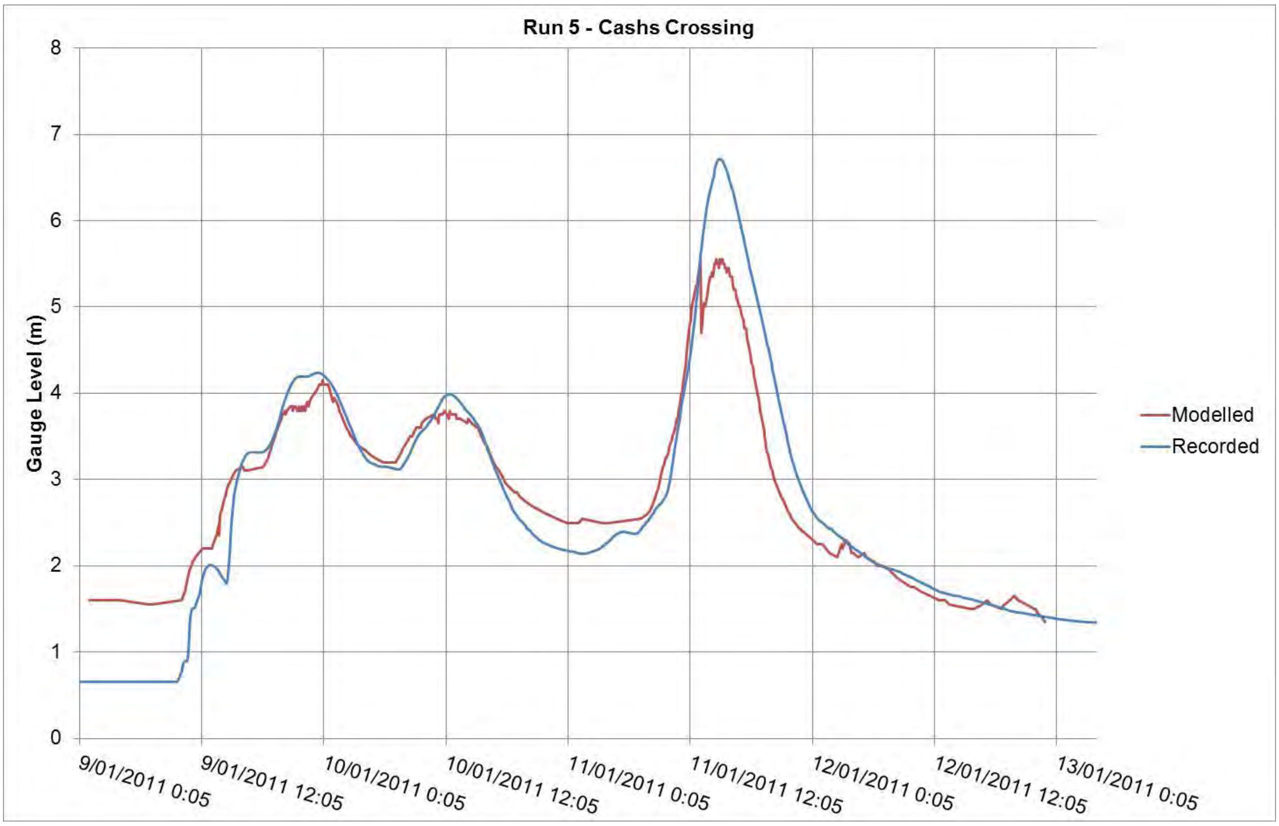
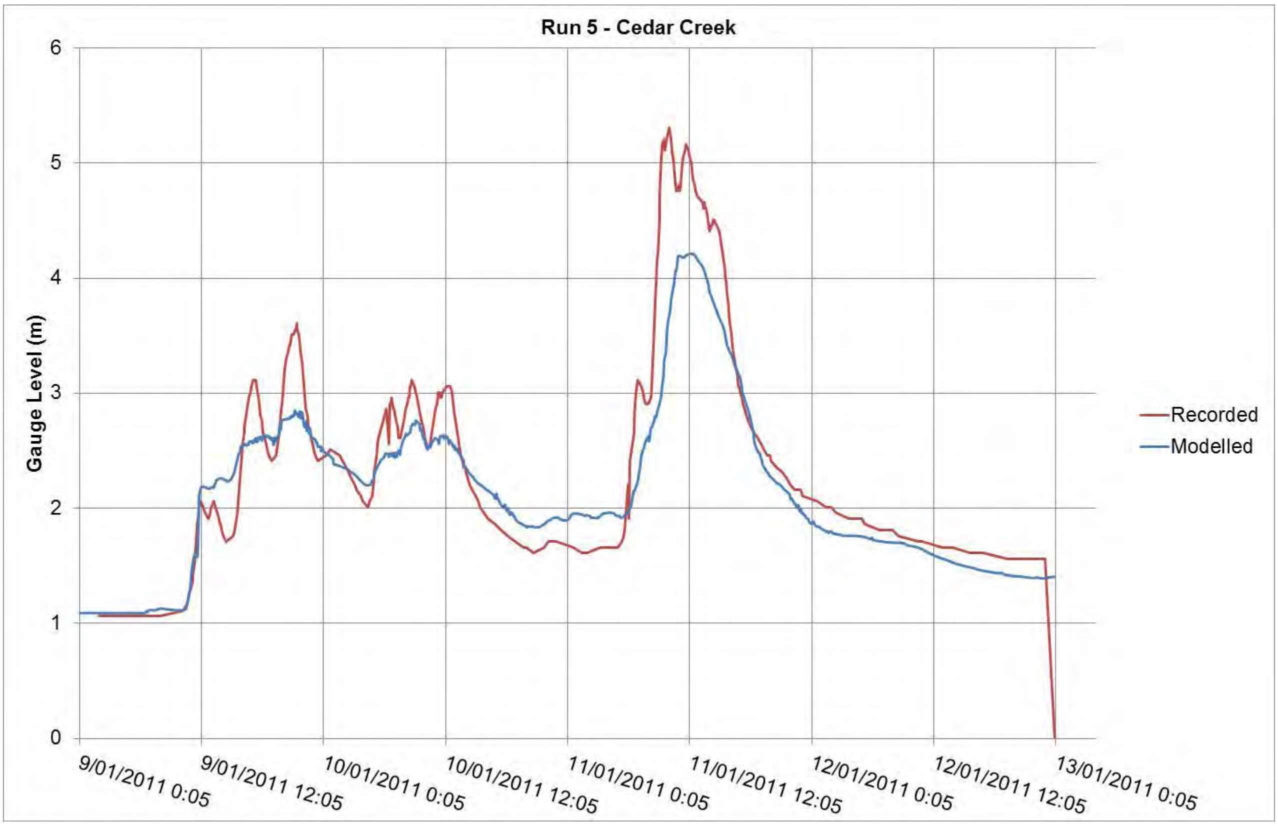
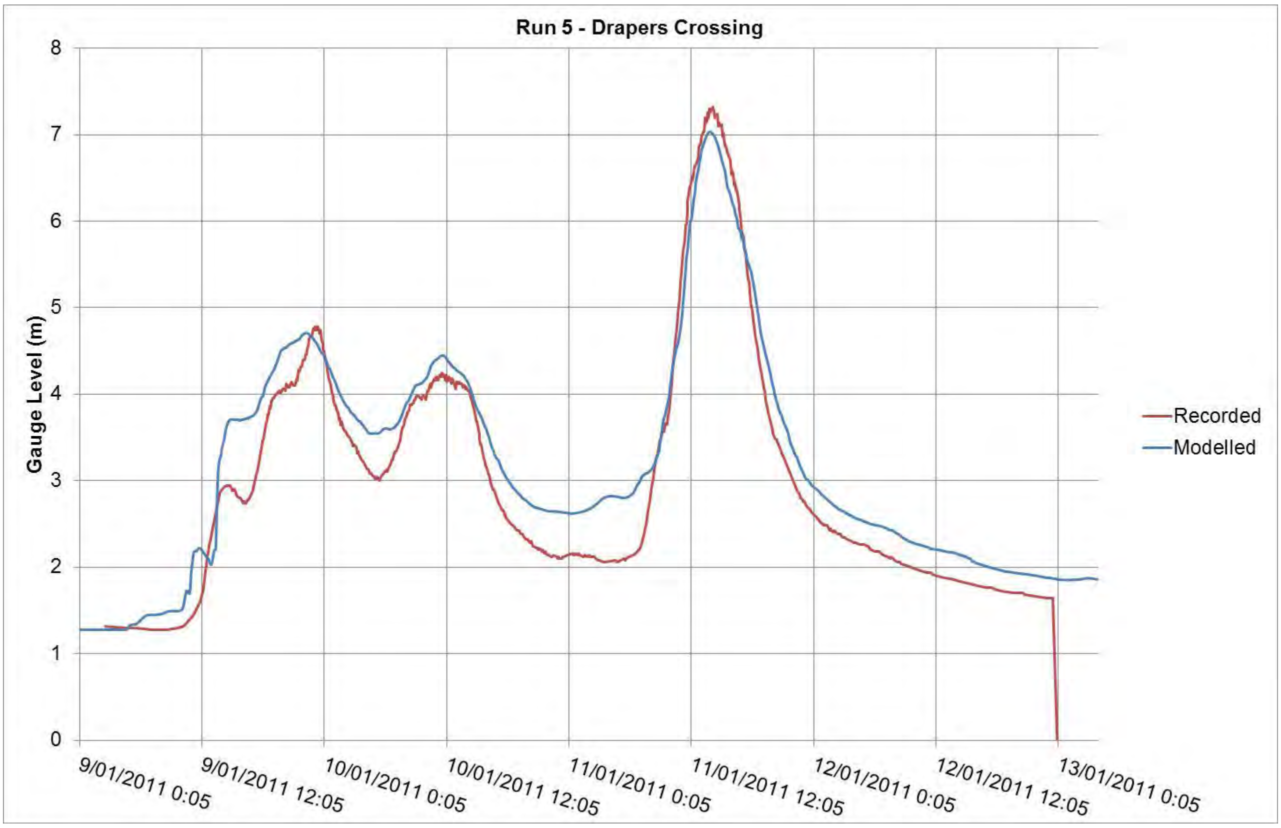
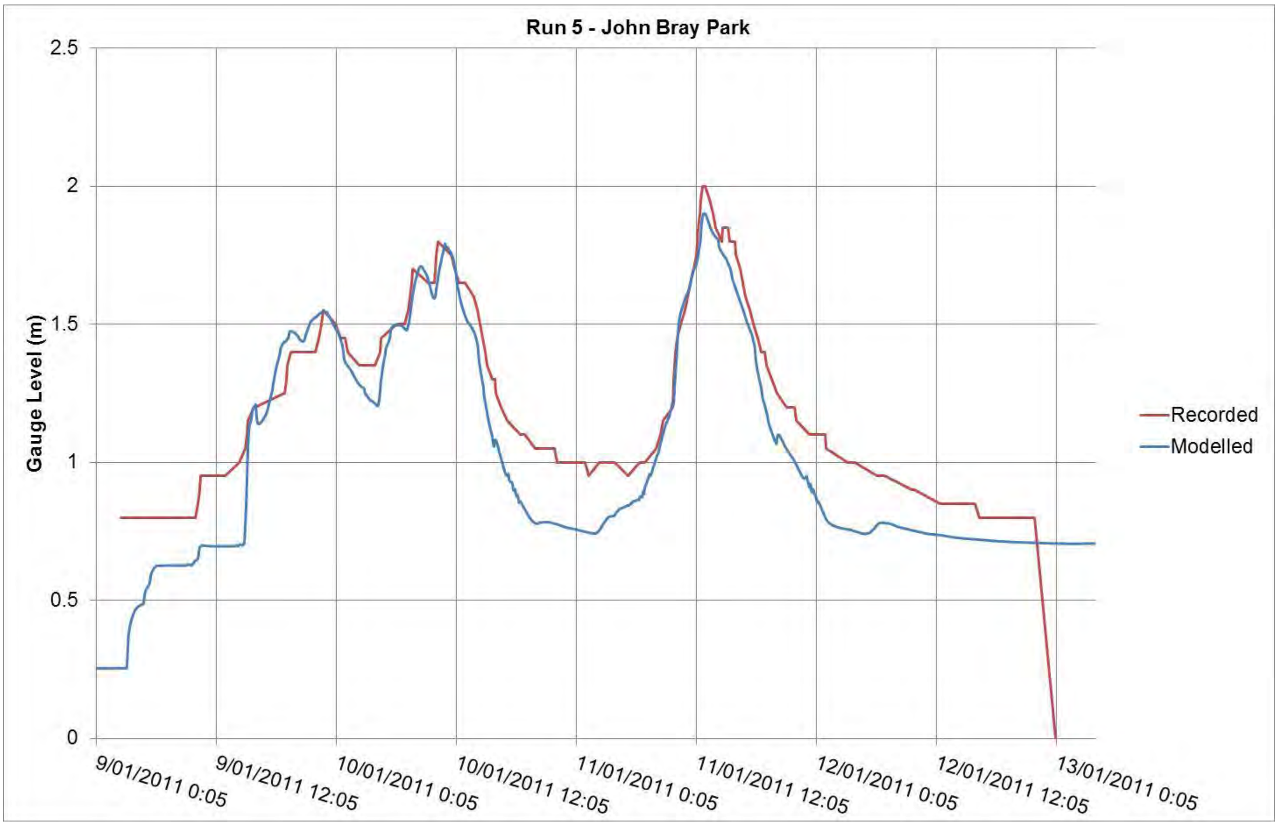
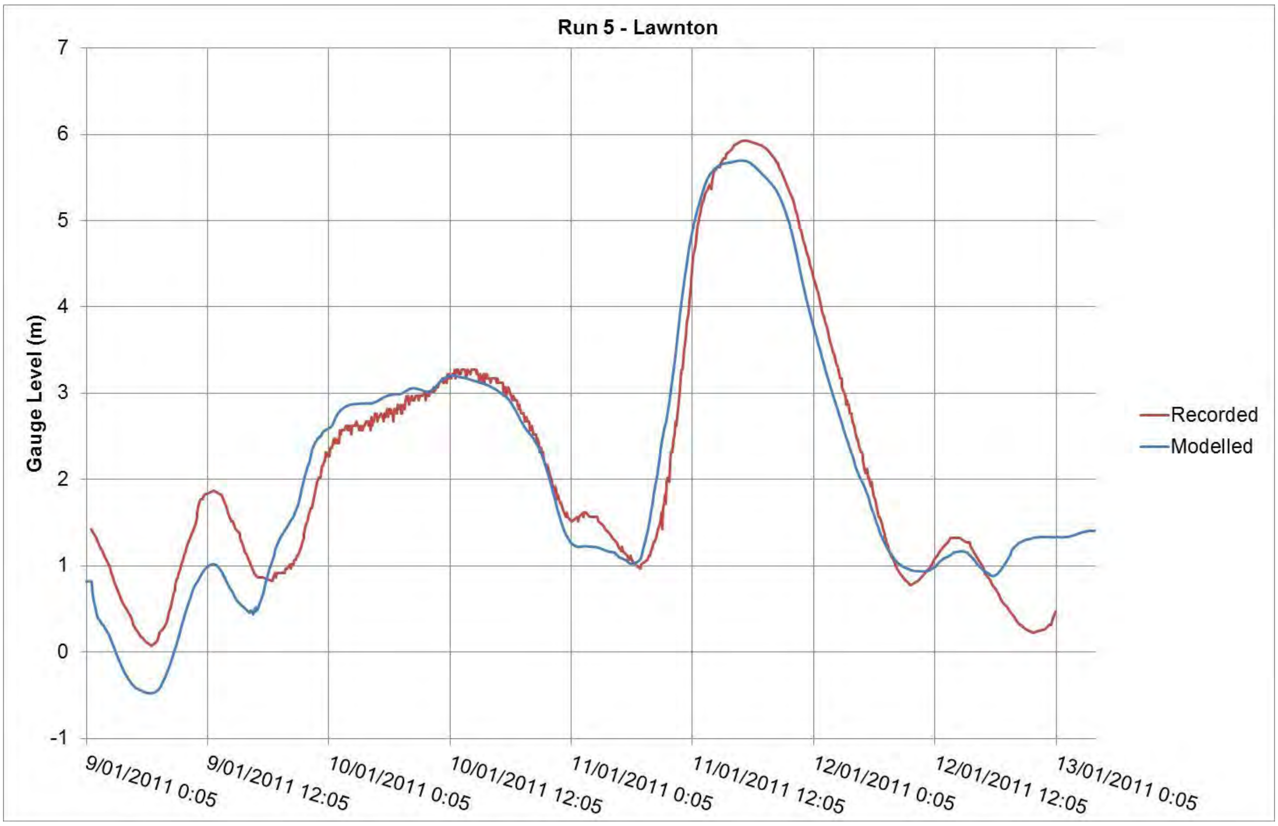
Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\Calibration\FLD_019_130129_LPR_Calibration_Results_F5_revised.WOR

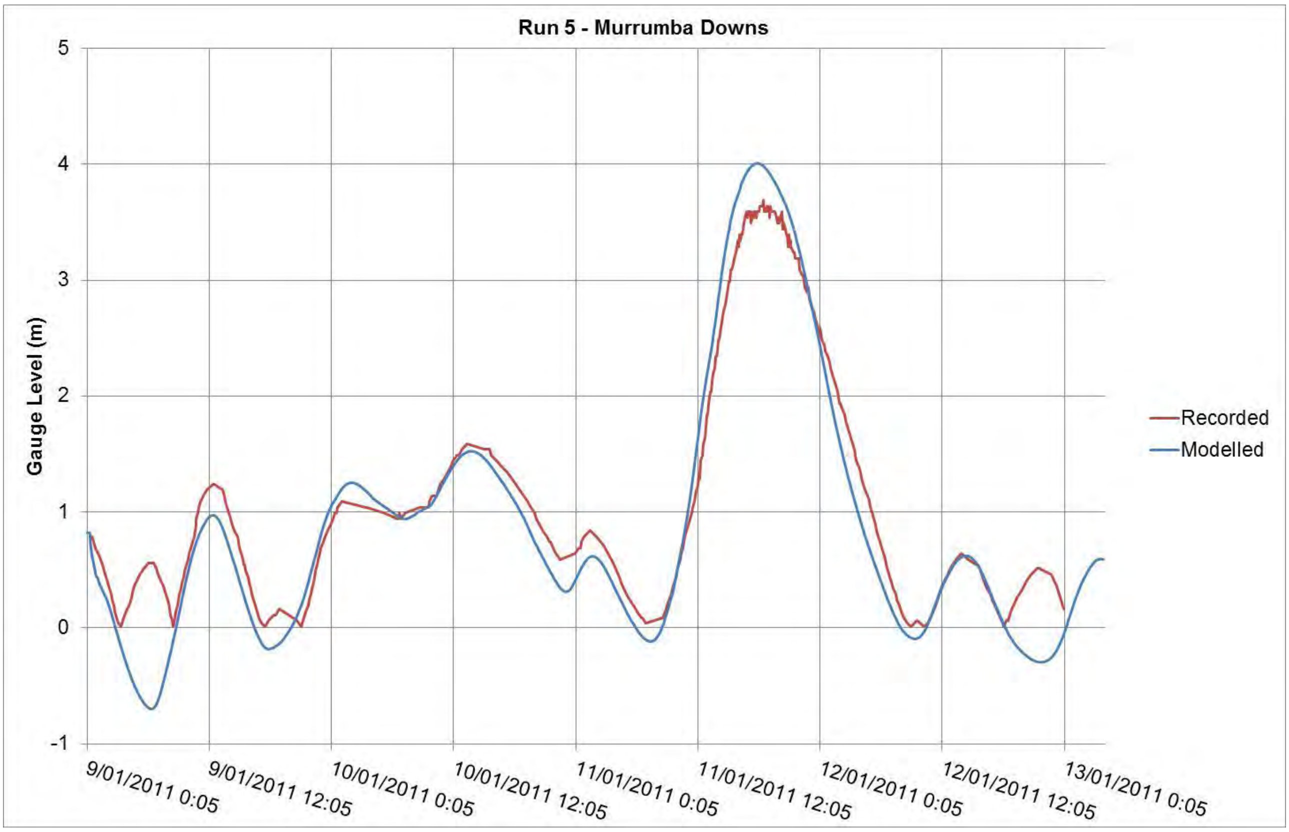

Run 5 - Cashs Crossing
Gauge Level (m)
8
7
6
5
4
3
2
1
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Modelled
Recorded

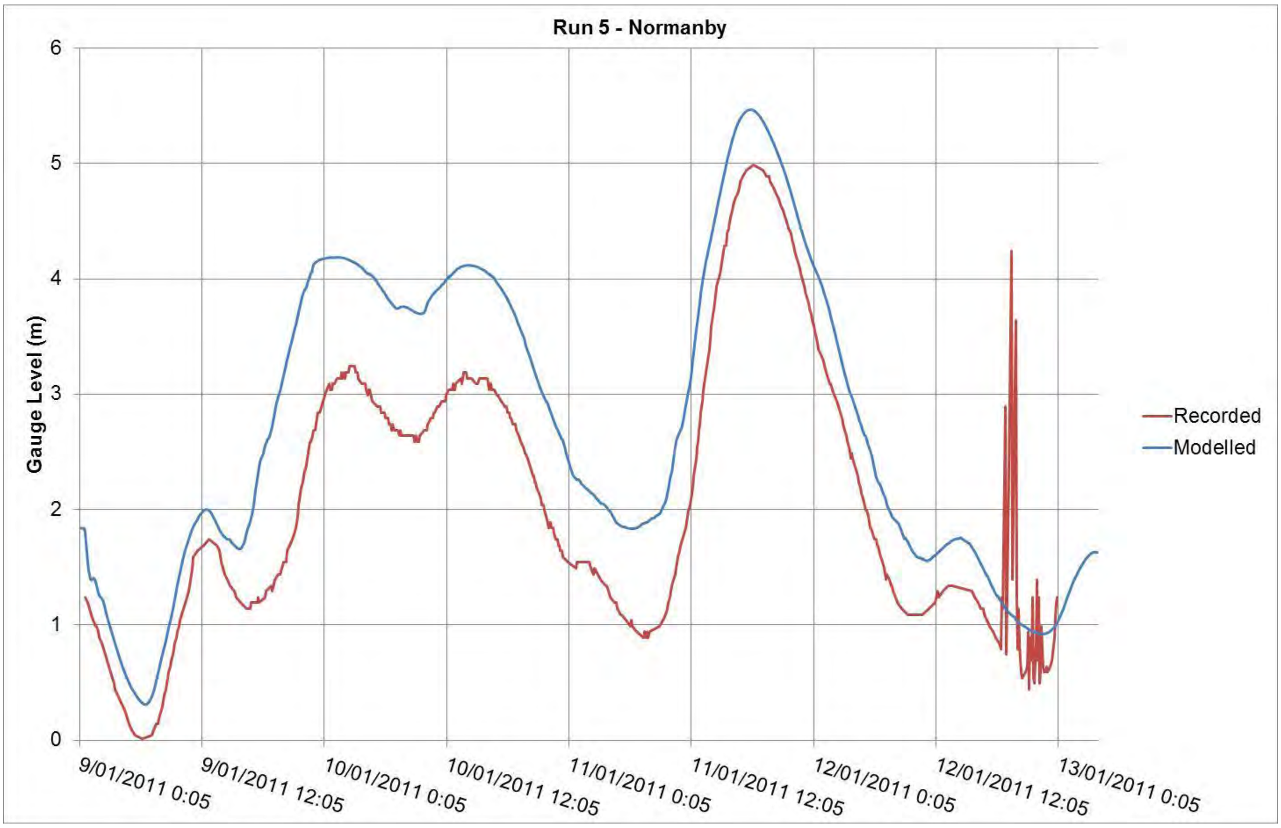

Run 5 - Cedar Creek
Gauge Level (m)
6
5
4
3
2
1
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

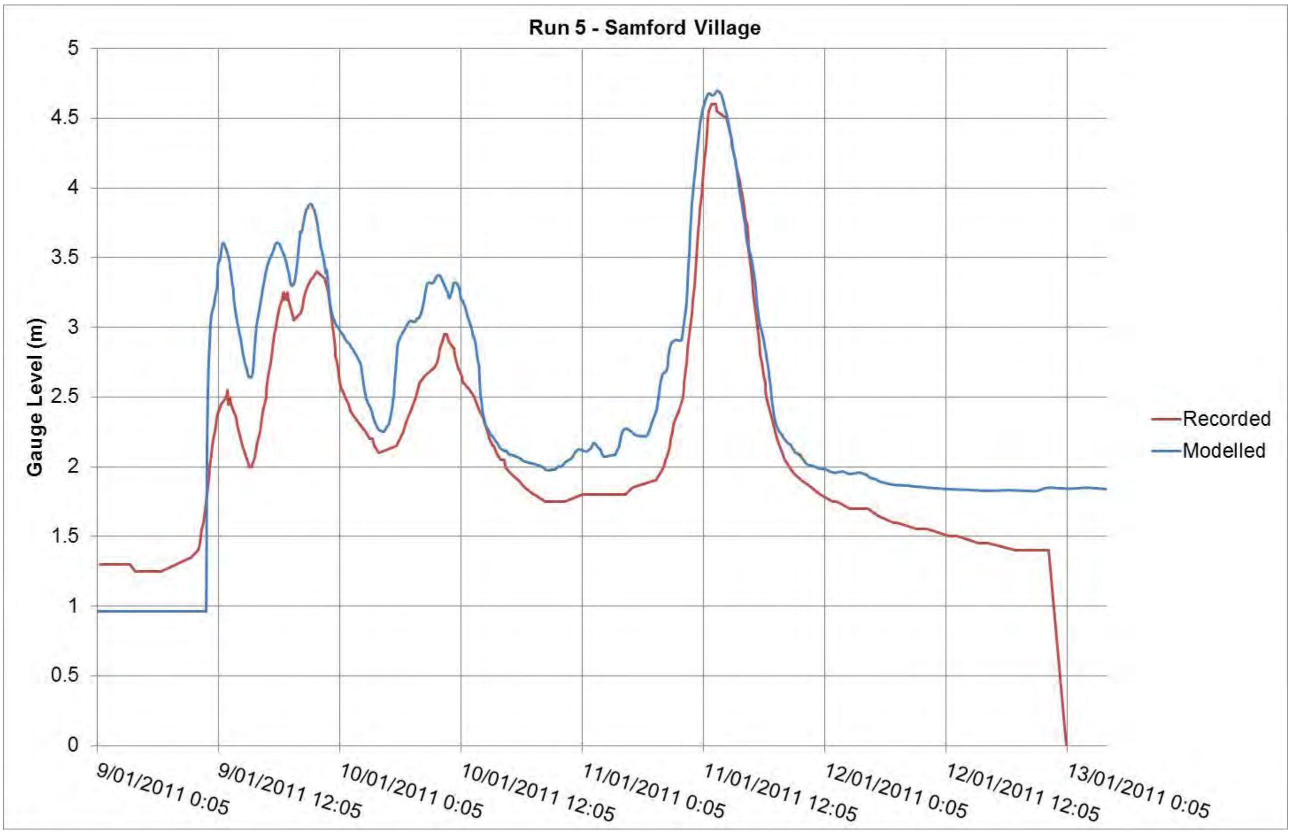

Run 5 - Drapers Crossing
Gauge Level (m)
0
1
2
3
4
5
6
7
8
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

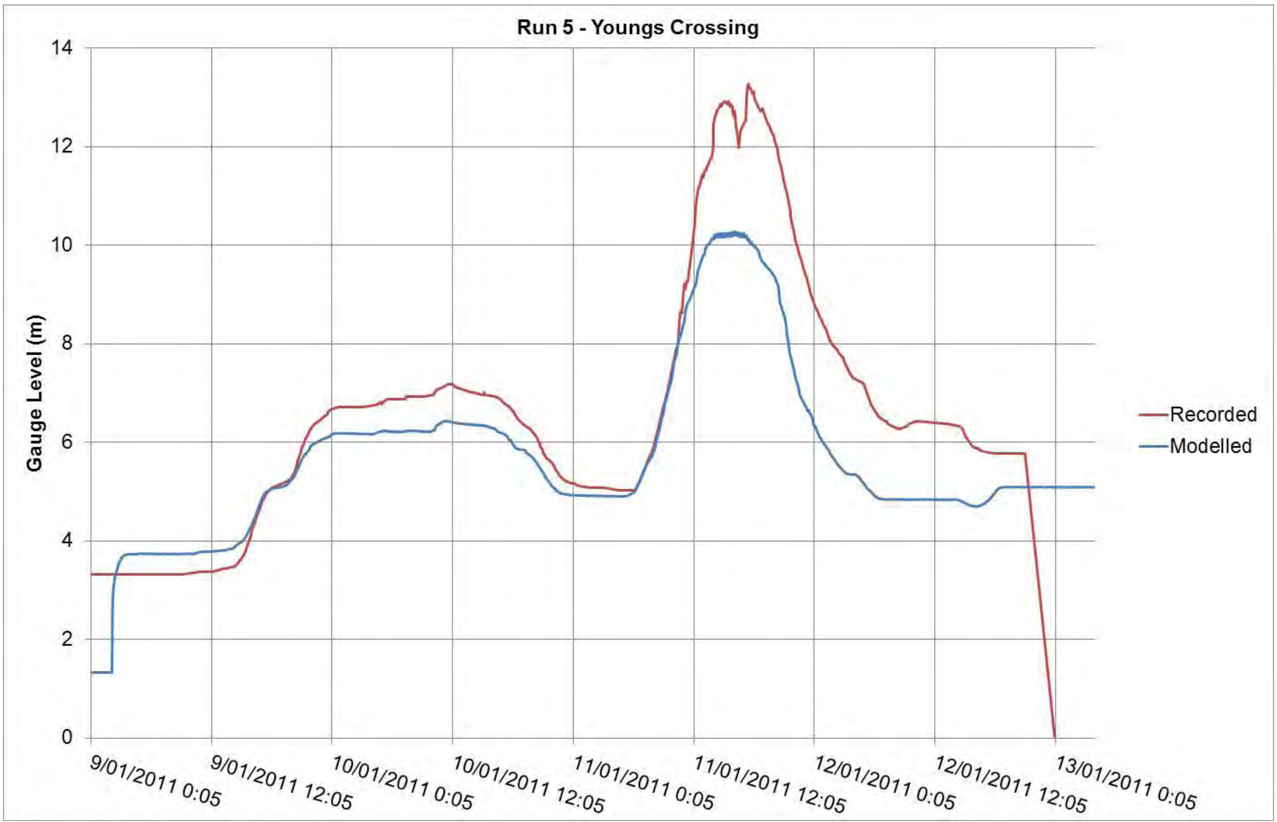

Run 5 - John Bray Park
Gauge Level (m)
0
0.5
1
1.5
2
2.5
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

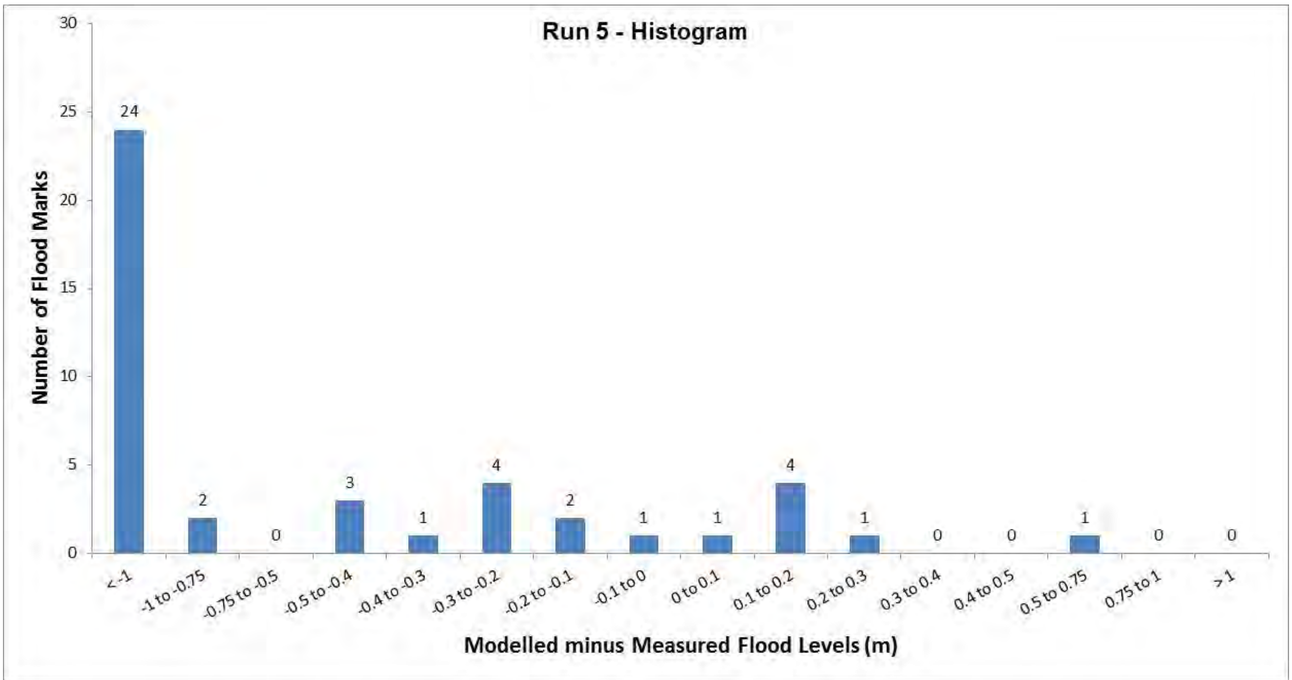

Run 5 - Lawnton
Gauge Level (m)
7
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 5 - Murrumba Downs
Gauge Level (m)
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

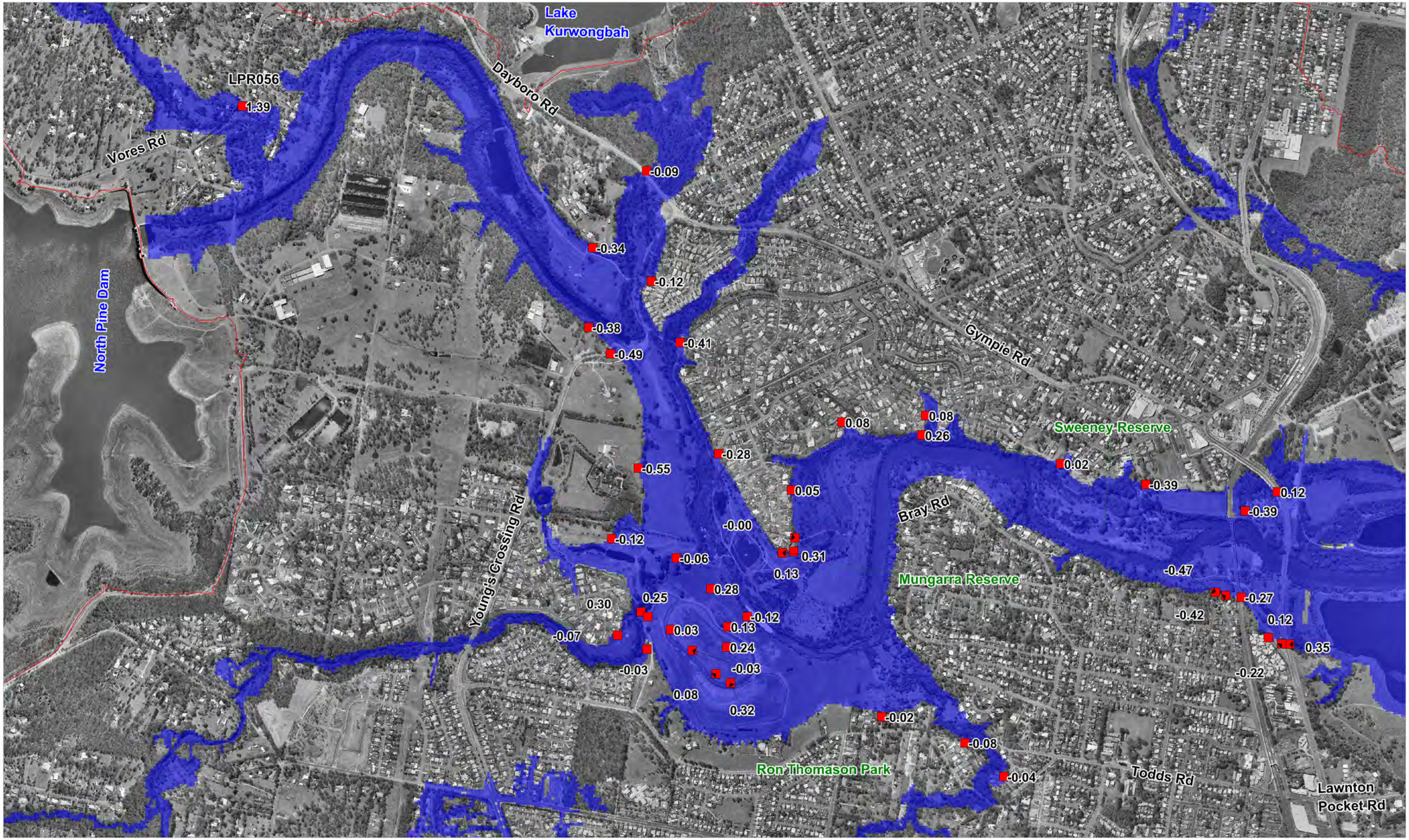

Run 5 - Normanby
Gauge Level (m)
6
5
4
3
2
1
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 5 - Samford Village
Gauge Level (m)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 5 - Youngs Crossing
Gauge Level (m)
14
12
10
8
6
4
2
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 5 - Histogram
Number of Flood Marks
30
25
20
15
10
5
0
24
2
0
3
1
4
2
1
1
4
1
0
0
1
0
0
<-1
-1 to -0.75
-0.75 to -0.5
-0.5 to -0.4
-0.4 to -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to 0
0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.75
0.75 to 1
>1
Modelled minus Measured Flood Levels (m)

APPENDIX F: RUN 6 RESULTS



LEGEND

Lower Pine River Catchment

Modelled January 2011 Flood Extent

0.03 Flood Marks January 2011 Event Difference in Peak Flood Levels in m (Modelled Minus Surveyed)

Title:

January 2011 Event Flood Mark Comparison
Run 6 Lower Pine River Catchment

N

0 250 500m
Approx. Scale

Figure: **F-1**

Rev: **-**

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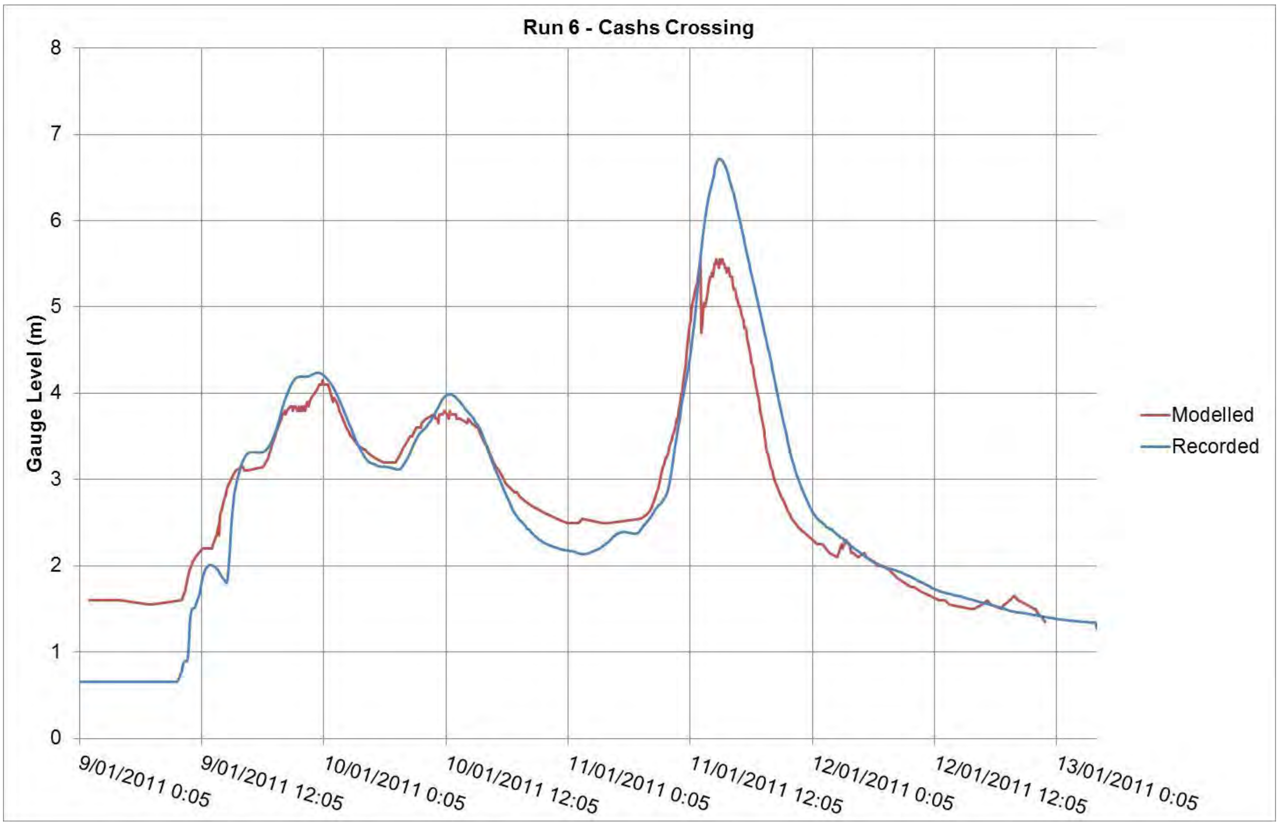
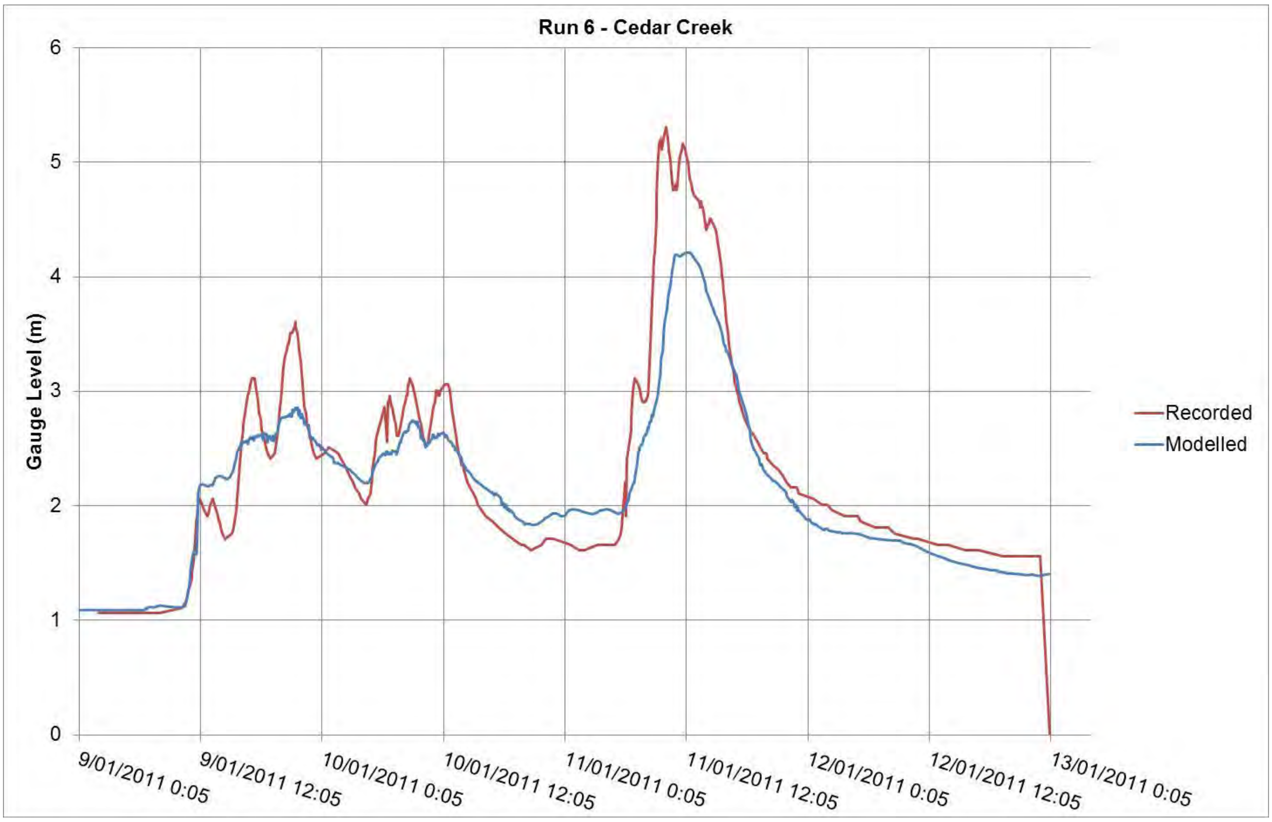
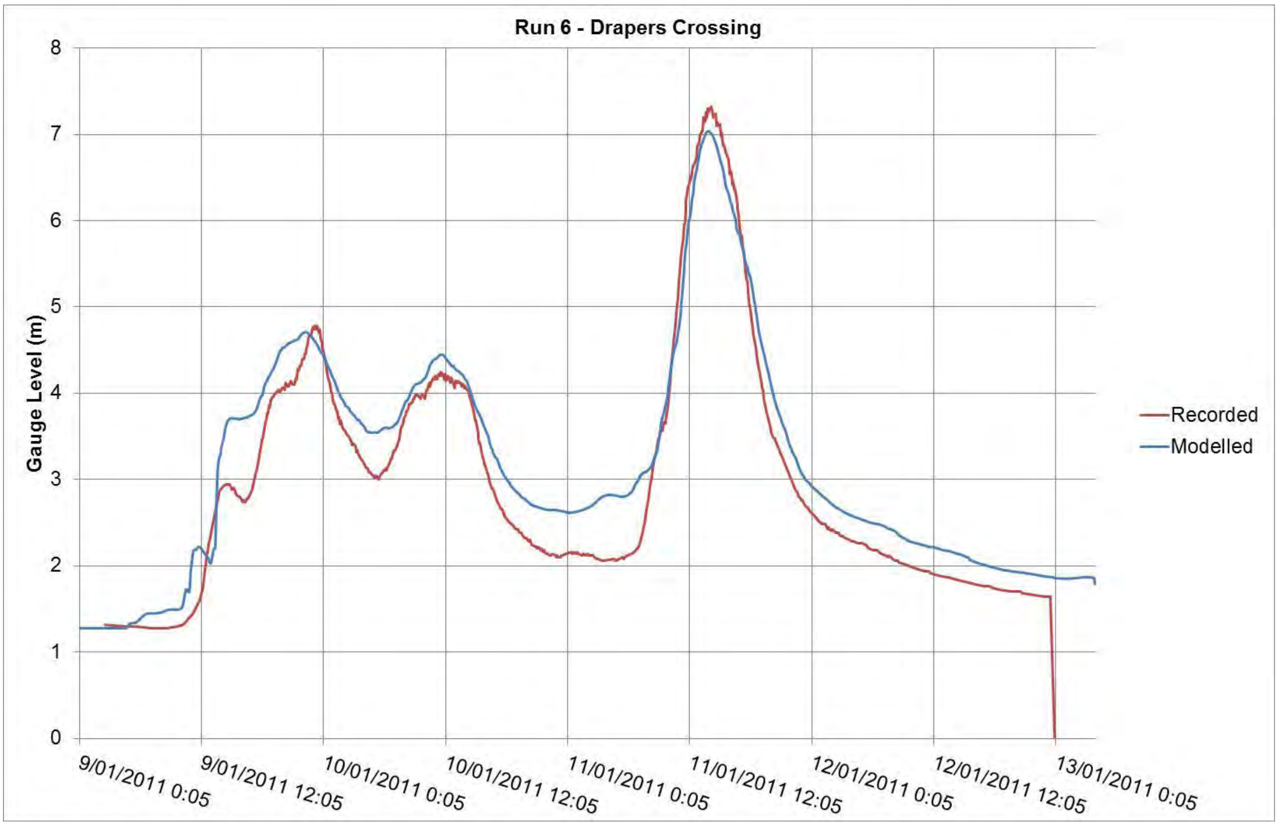
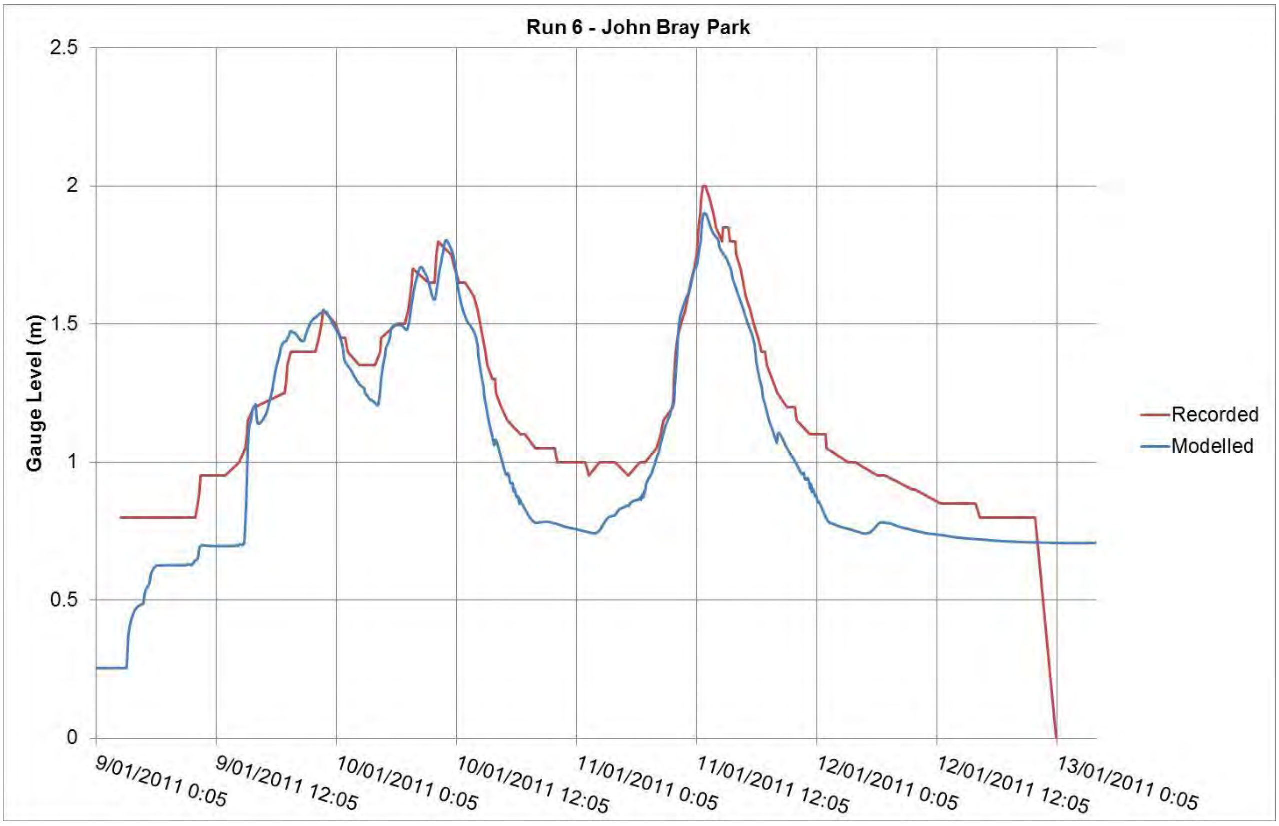
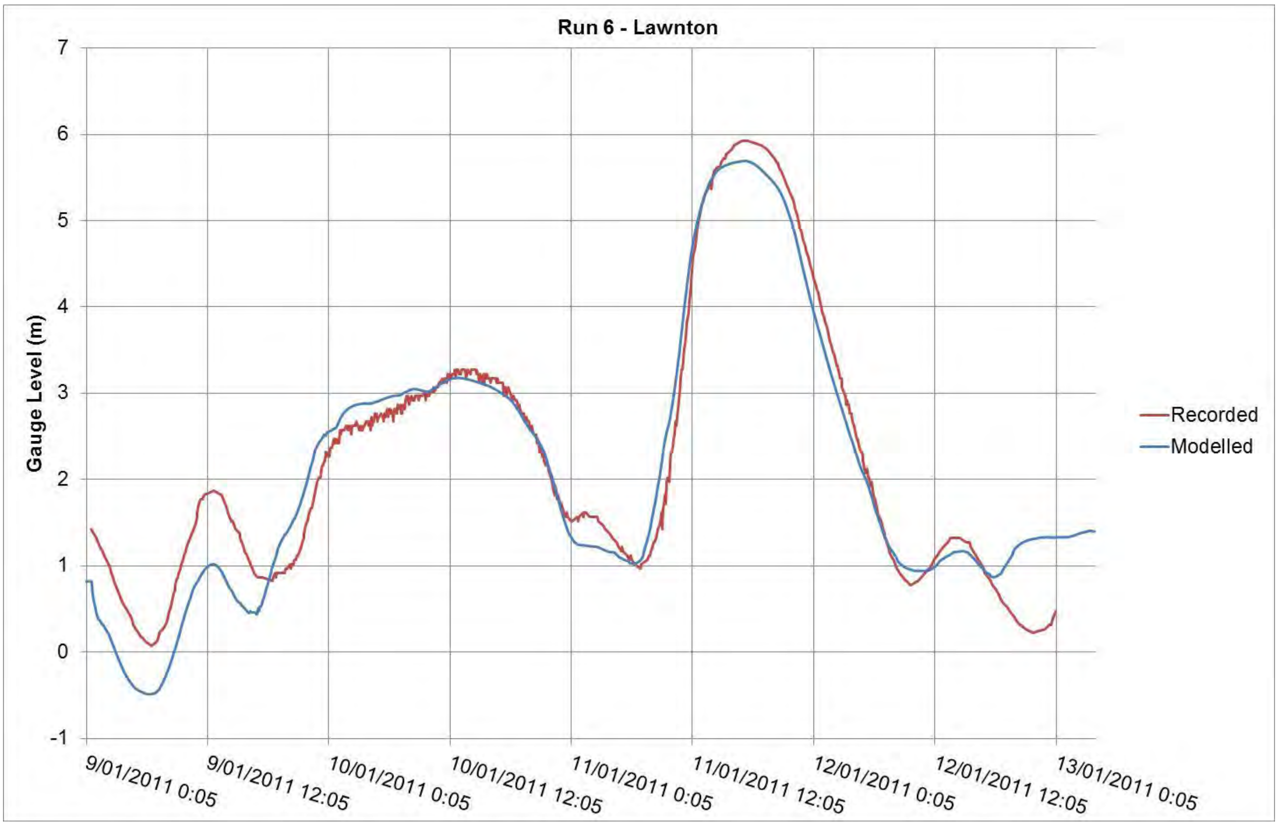
Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\Calibration\FLD_020_130129_LPR_Calibration_Results_F6_revised.WOR

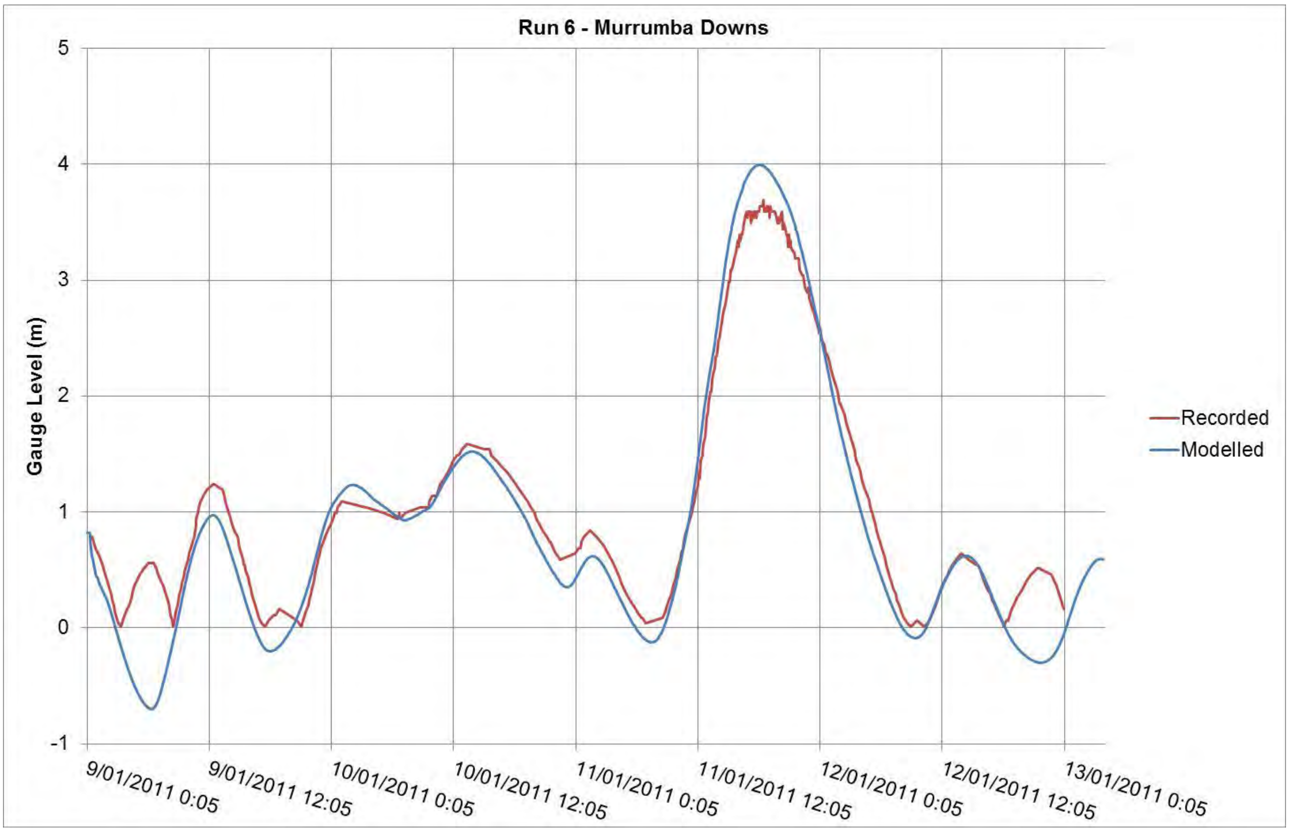

Run 6 - Cashs Crossing
Gauge Level (m)
0
1
2
3
4
5
6
7
8
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Modelled
Recorded

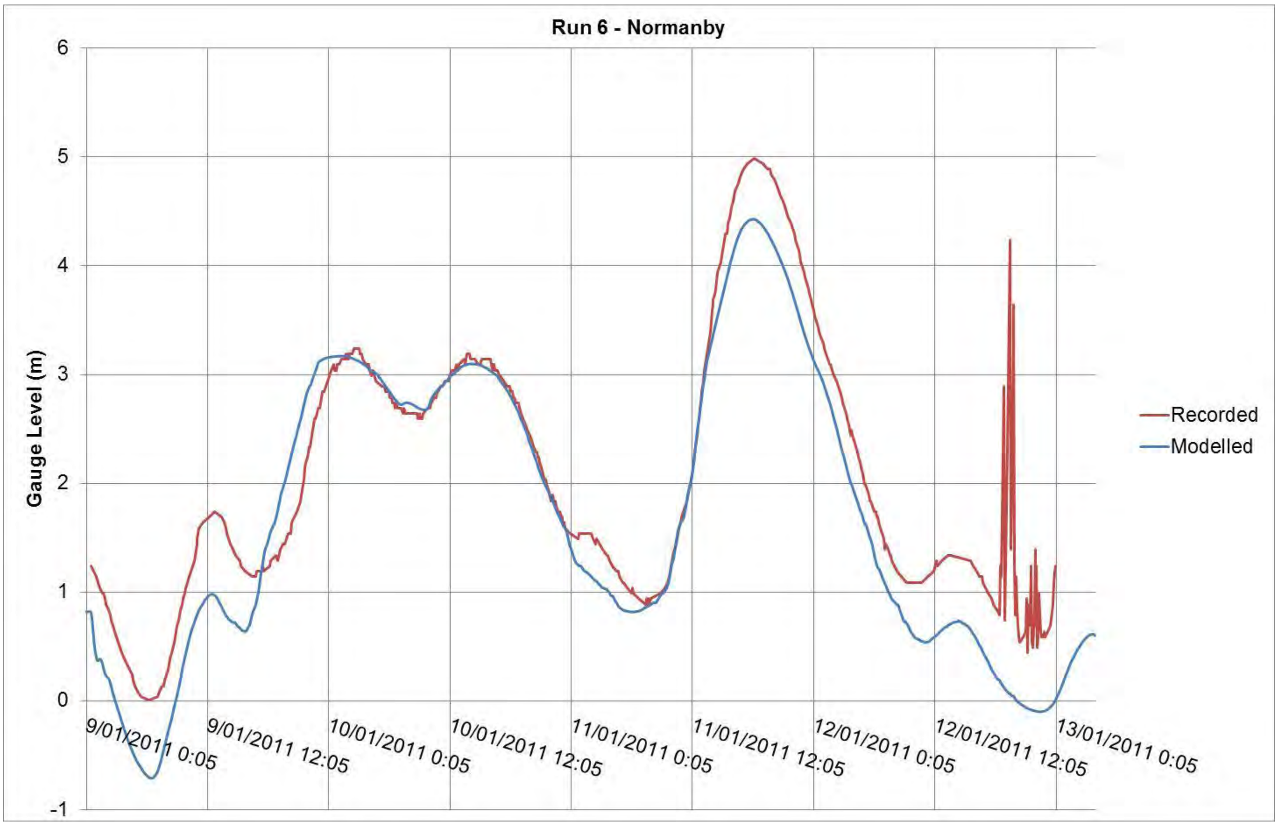

Run 6 - Cedar Creek
Gauge Level (m)
0
1
2
3
4
5
6
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 6 - Drapers Crossing
Gauge Level (m)
8
7
6
5
4
3
2
1
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

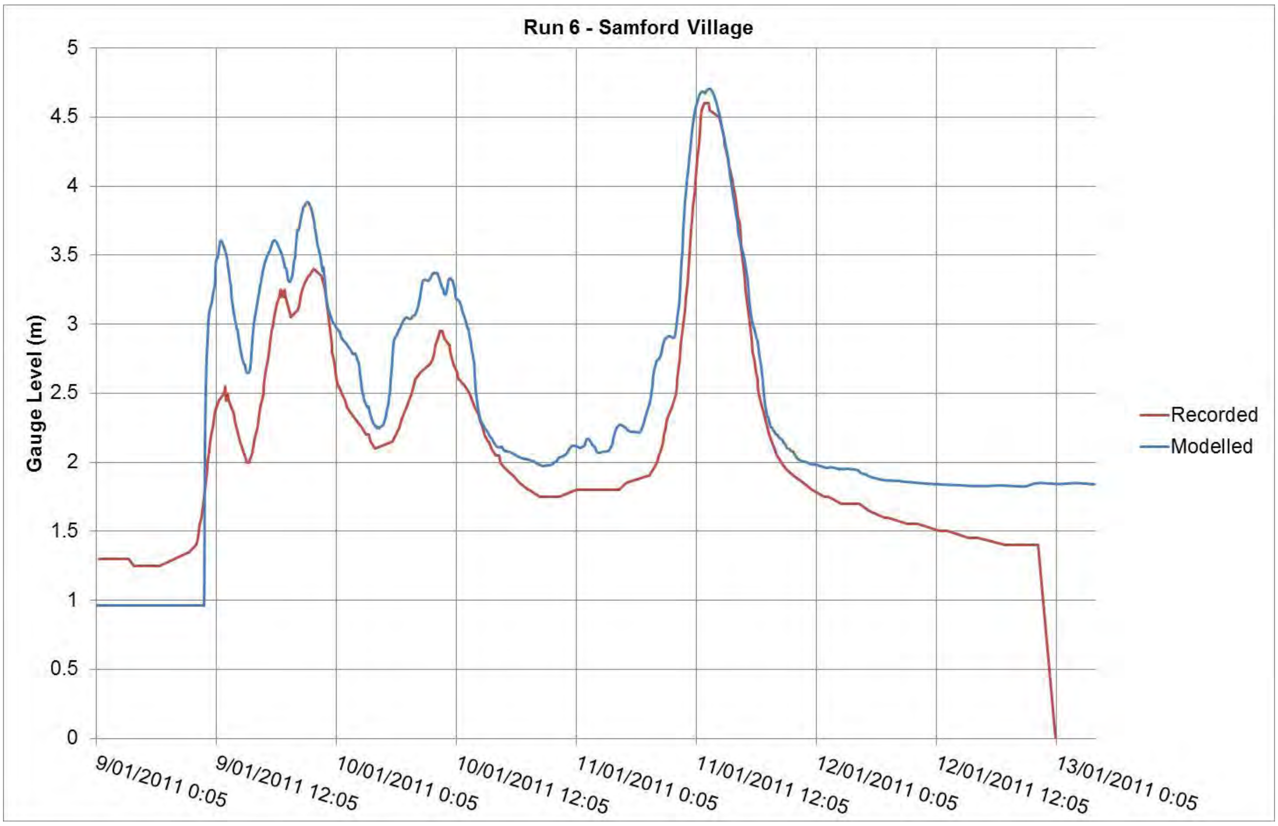

Run 6 - John Bray Park
Gauge Level (m)
2.5
2
1.5
1
0.5
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 6 - Lawnton
Gauge Level (m)
7
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 6 - Murrumba Downs
Gauge Level (m)
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

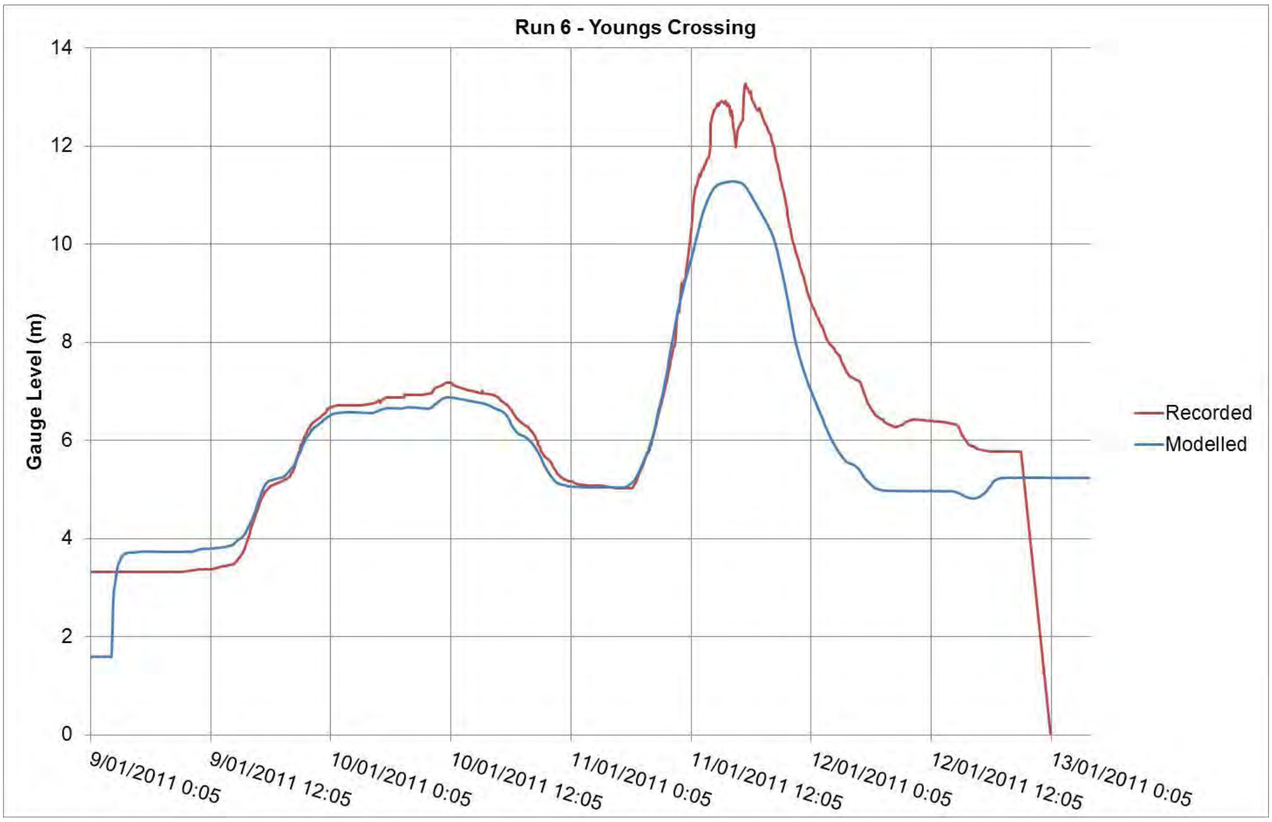


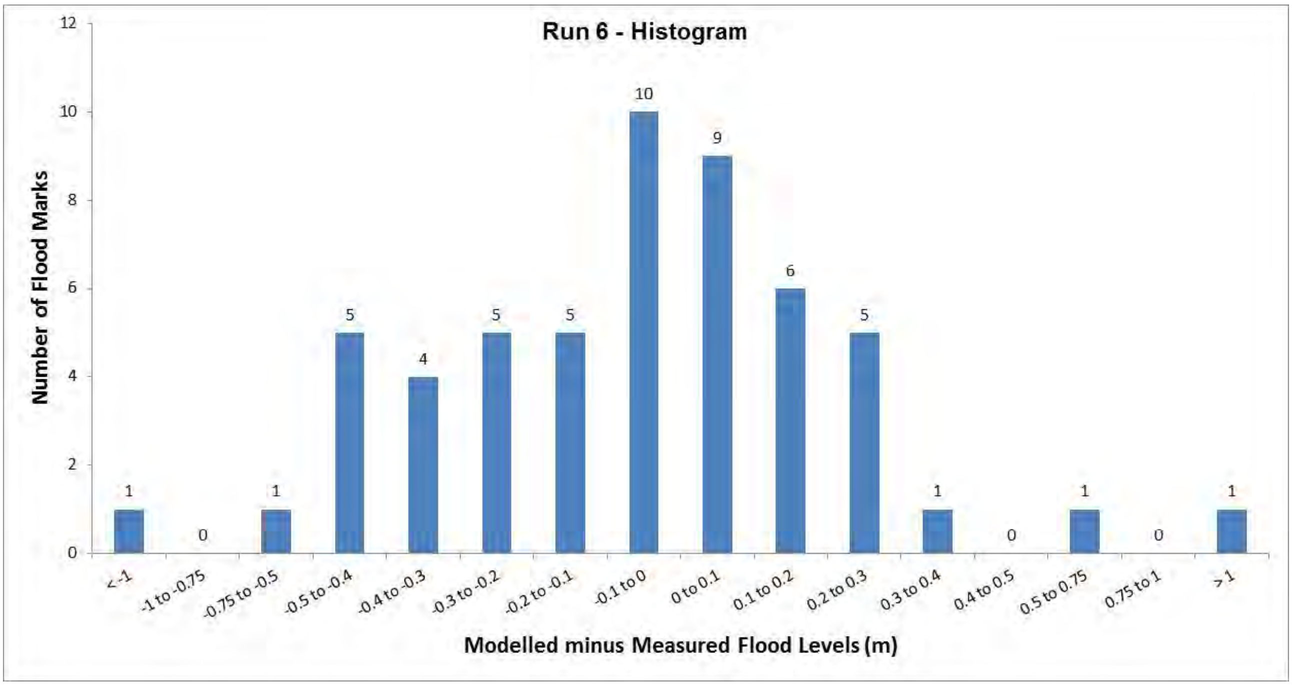
Run 6 - Normanby
Gauge Level (m)
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled



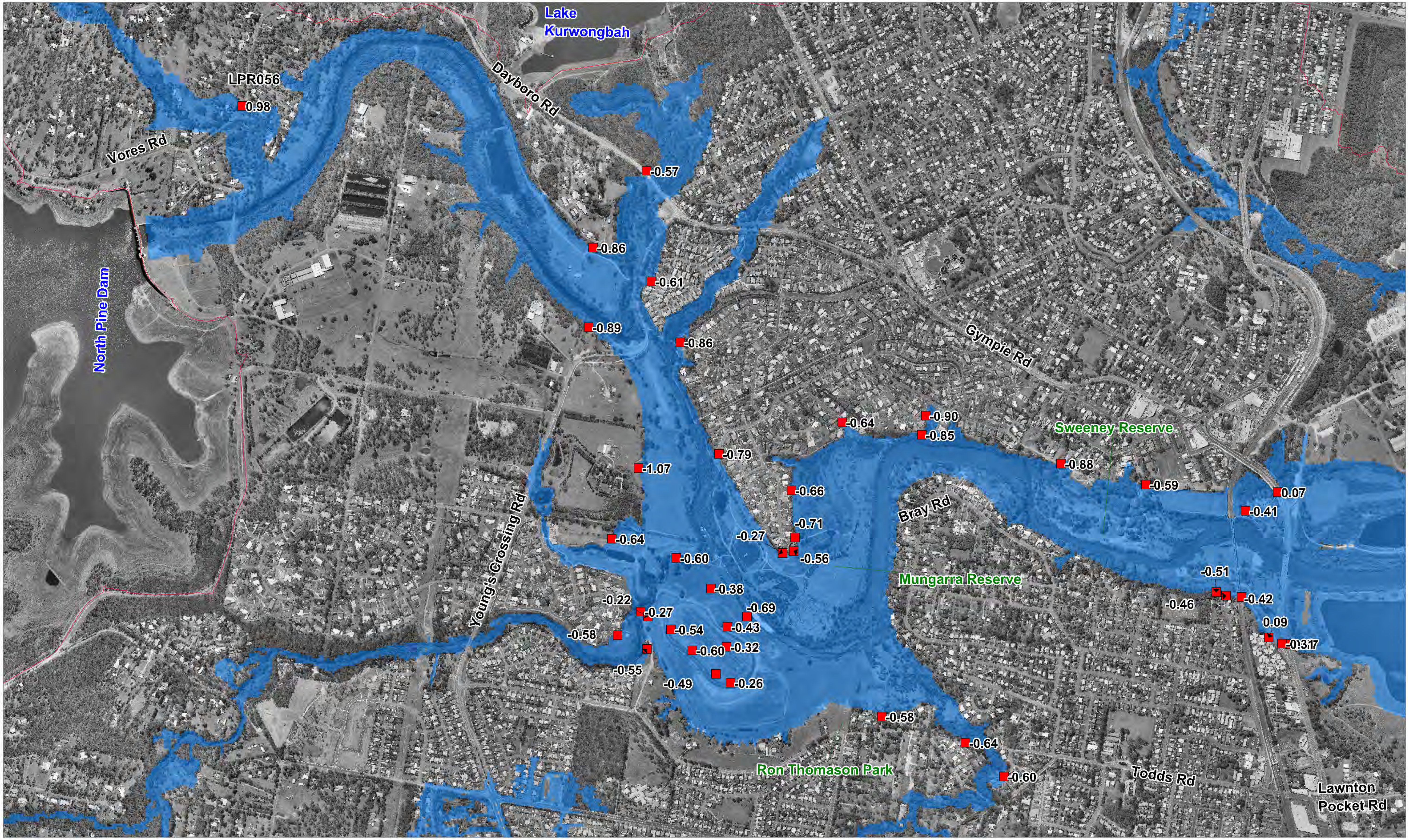
Run 6 - Samford Village
Gauge Level (m)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

F-7 RUN 6 RESULTS





APPENDIX G: RUN 7 RESULTS



LEGEND

Lower Pine River Catchment

Modelled January 2011 Flood Extent

0.03 Flood Marks January 2011 Event Difference in Peak Flood Levels in m (Modelled Minus Surveyed)

Title:

January 2011 Event Flood Mark Comparison
Run 7 Lower Pine River Catchment

Figure: **G-1**

Rev: **-**

N

0 250 500m
Approx. Scale

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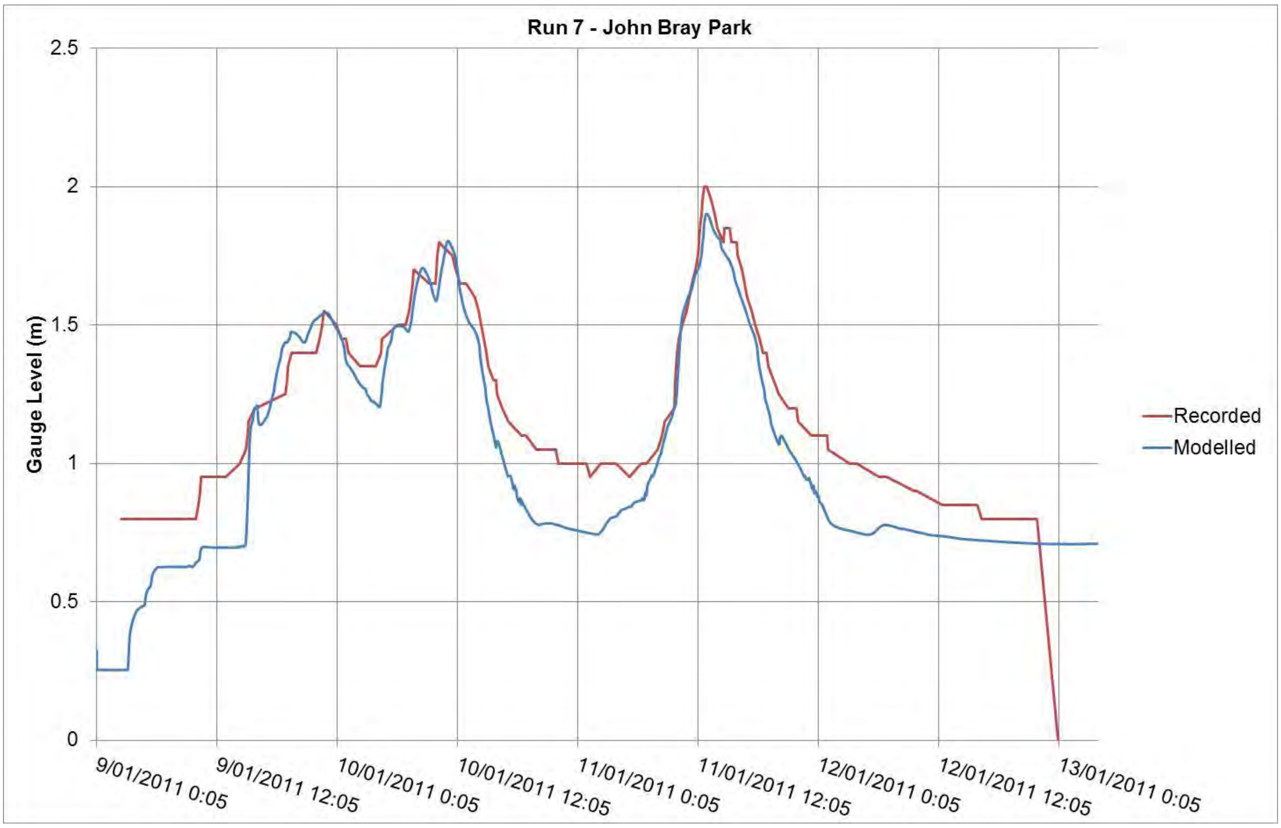
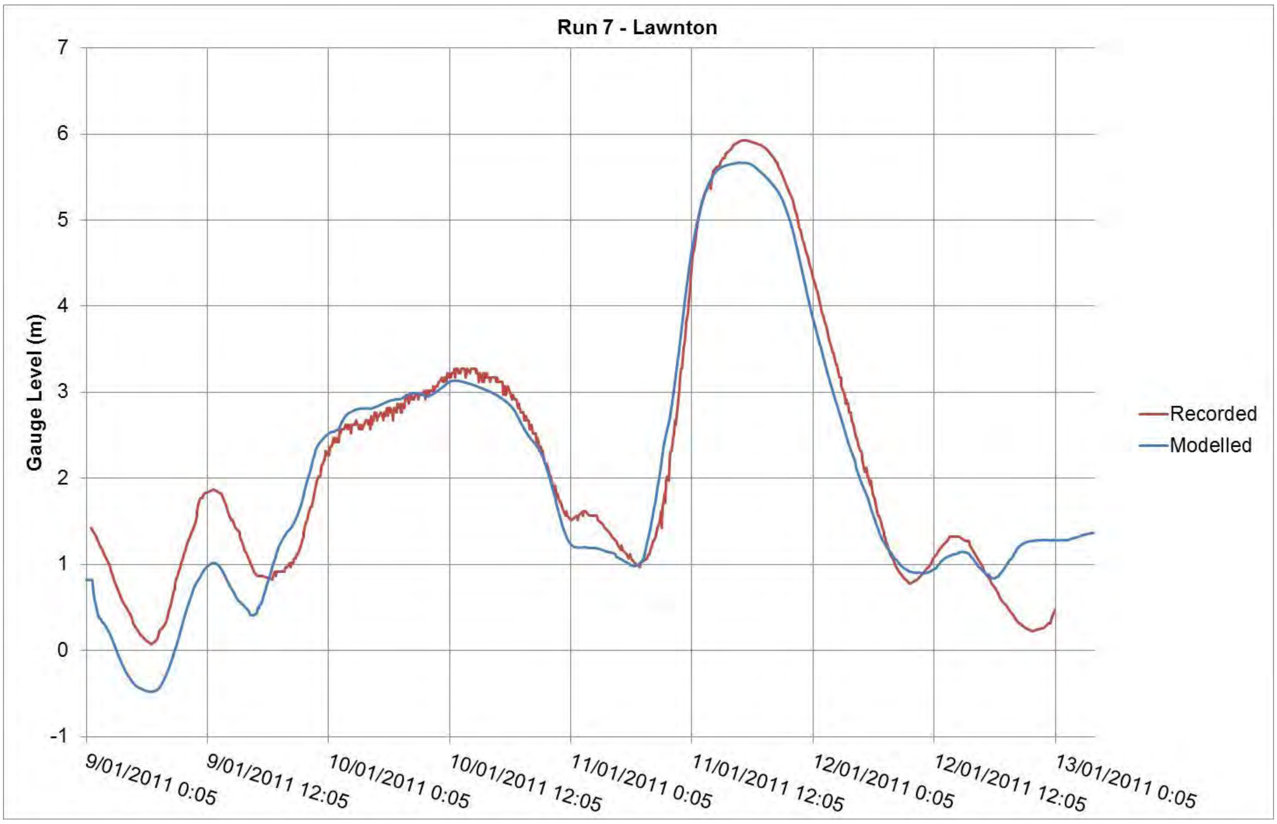
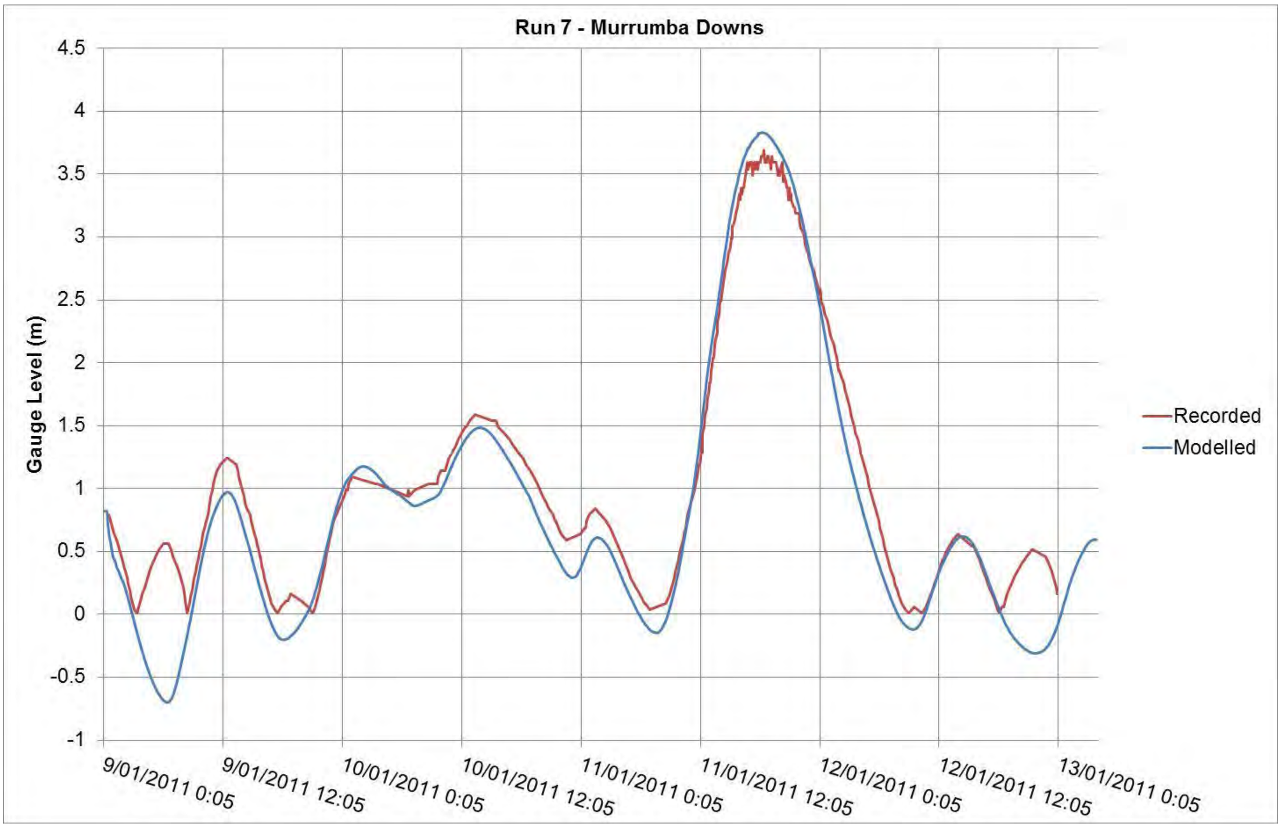
Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\Calibration\FLD_016_121219_LPR_Calibration_Results_F7.WOR



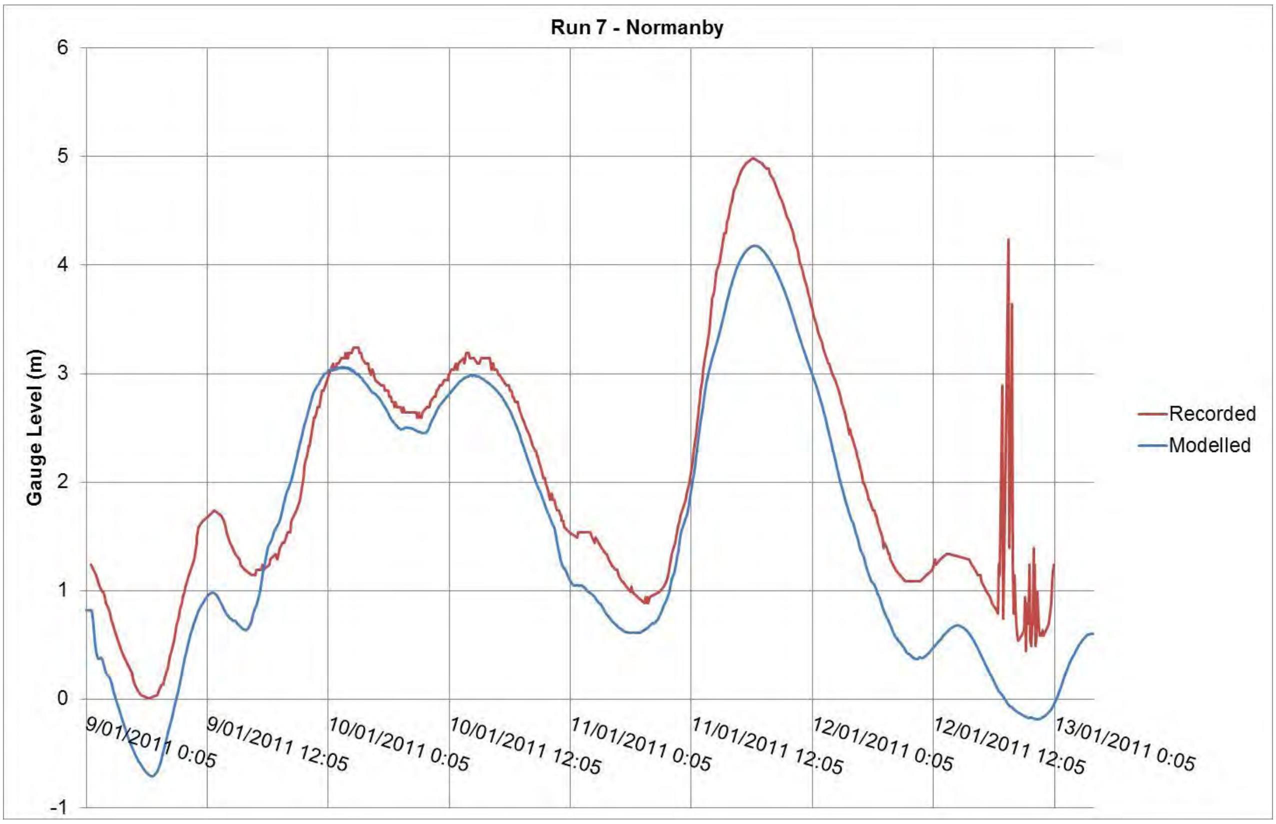
Run 7 - John Bray Park
Gauge Level (m)
2.5
2
1.5
1
0.5
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled



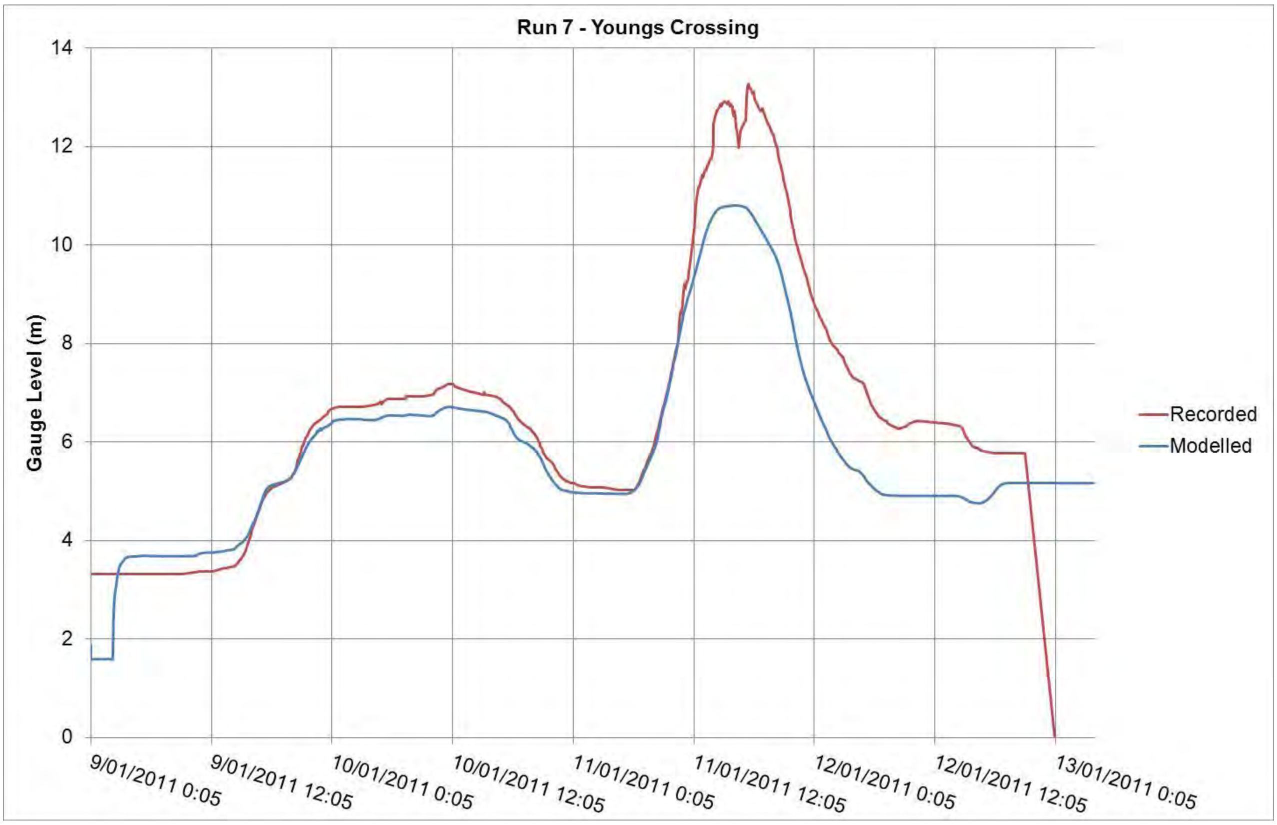
Run 7 - Lawnton
Gauge Level (m)
7
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

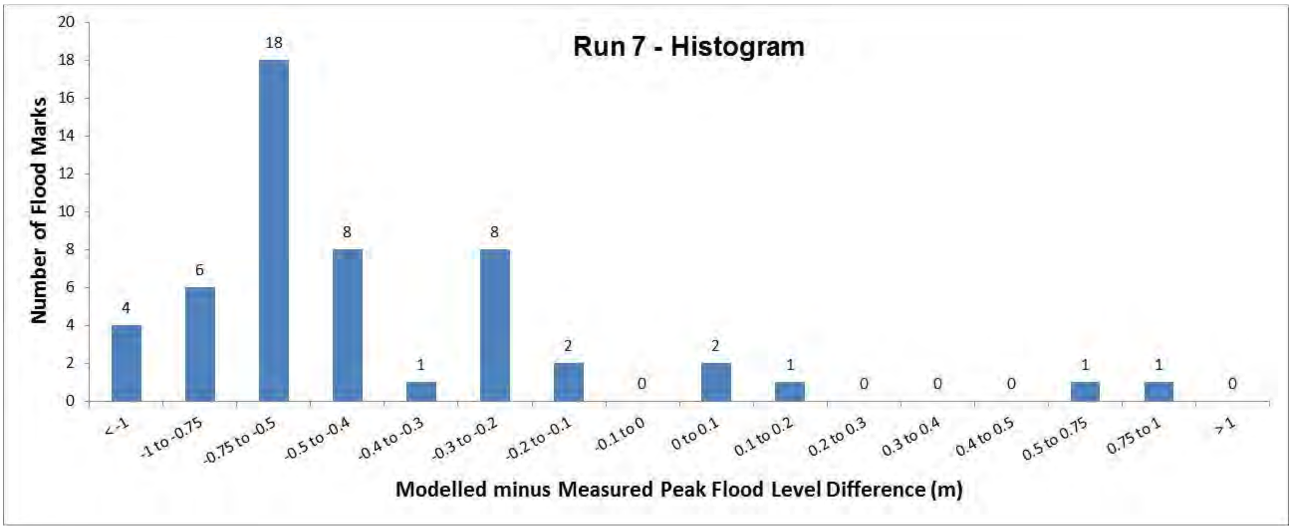


Run 7 - Murrumba Downs
Gauge Level (m)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled

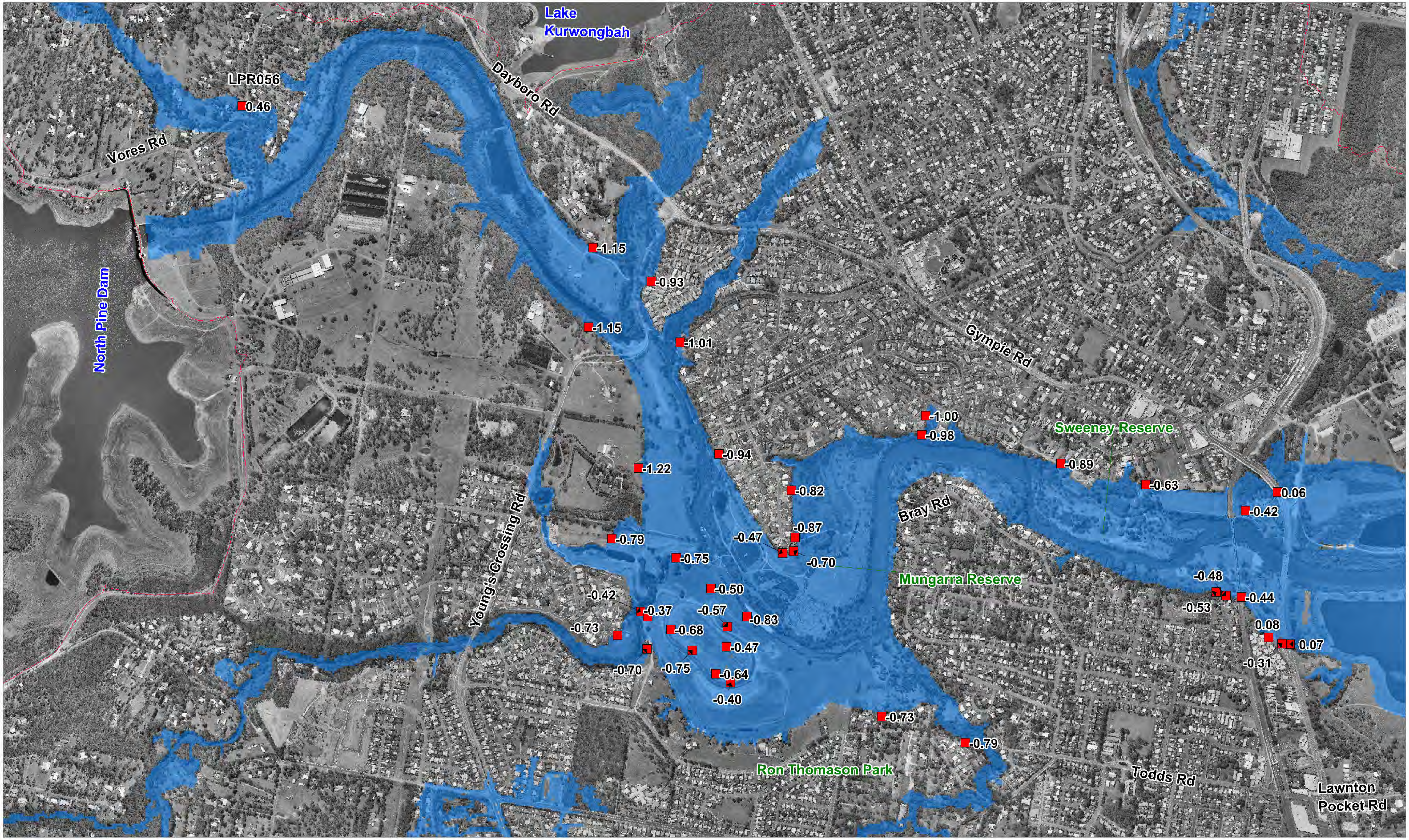


Run 7 - Normanby
Gauge Level (m)
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 7 - Youngs Crossing
Gauge Level (m)
14
12
10
8
6
4
2
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 7 - Histogram
Number of Flood Marks
Modelled minus Measured Peak Flood Level Difference (m)
< -1
-1 to -0.75
-0.75 to -0.5
-0.5 to -0.4
-0.4 to -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to 0
0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.75
0.75 to 1
> 1
4
6
18
8
1
8
2
0
2
1
0
0
0
1
1
0

APPENDIX H: RUN 8 RESULTS



LEGEND

Lower Pine River Catchment

Modelled January 2011 Flood Extent

0.03 Flood Marks January 2011 Event Difference in Peak Flood Levels in m (Modelled Minus Surveyed)

Title:

January 2011 Event Flood Mark Comparison
Run 8 Lower Pine River Catchment

Figure: **H-1**

Rev: **-**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m
Approx. Scale

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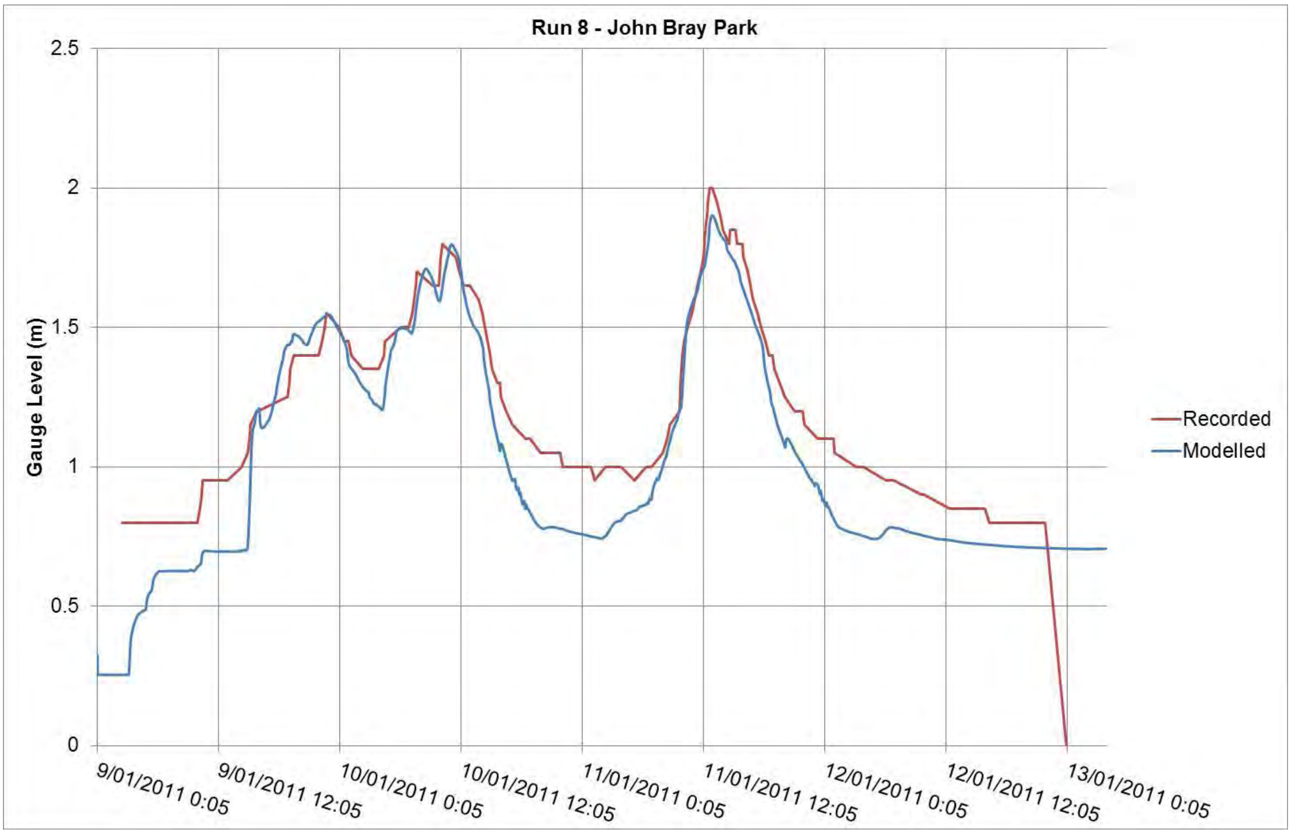
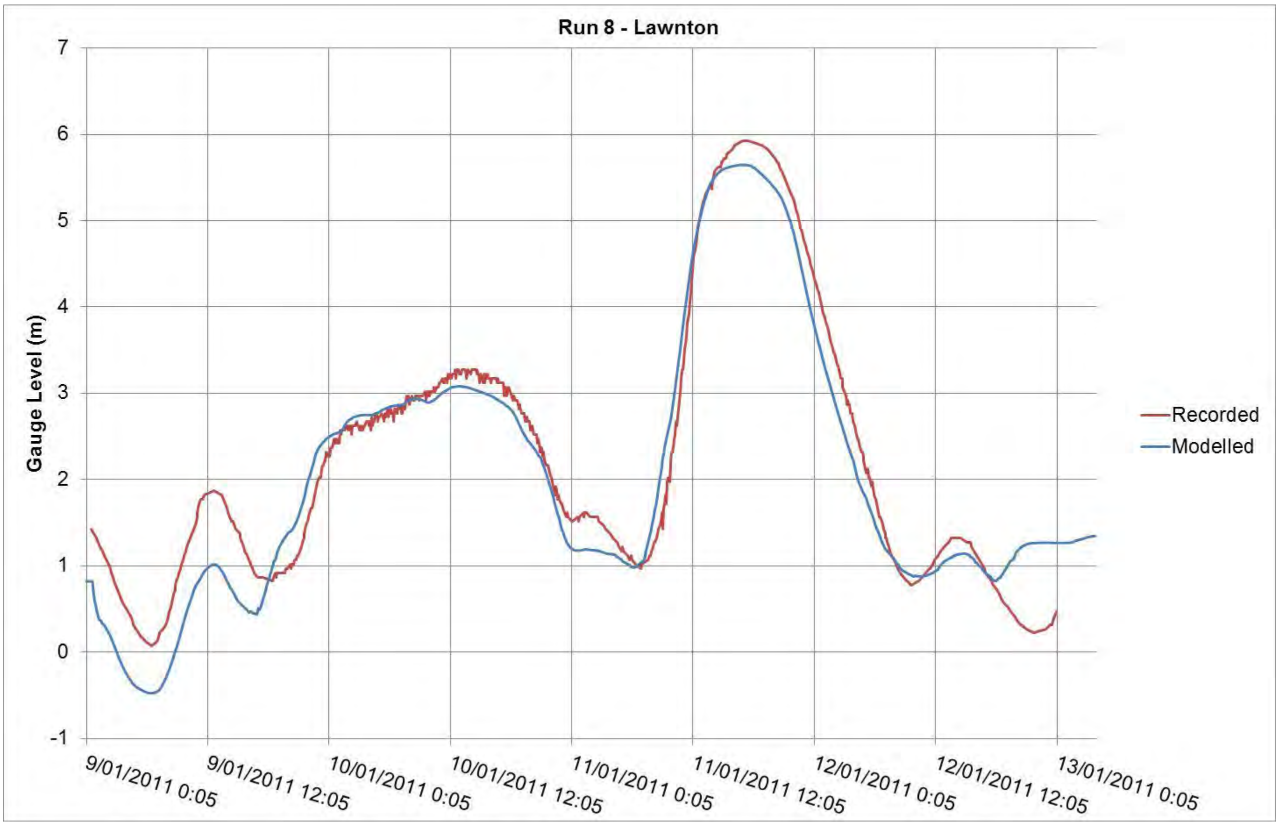
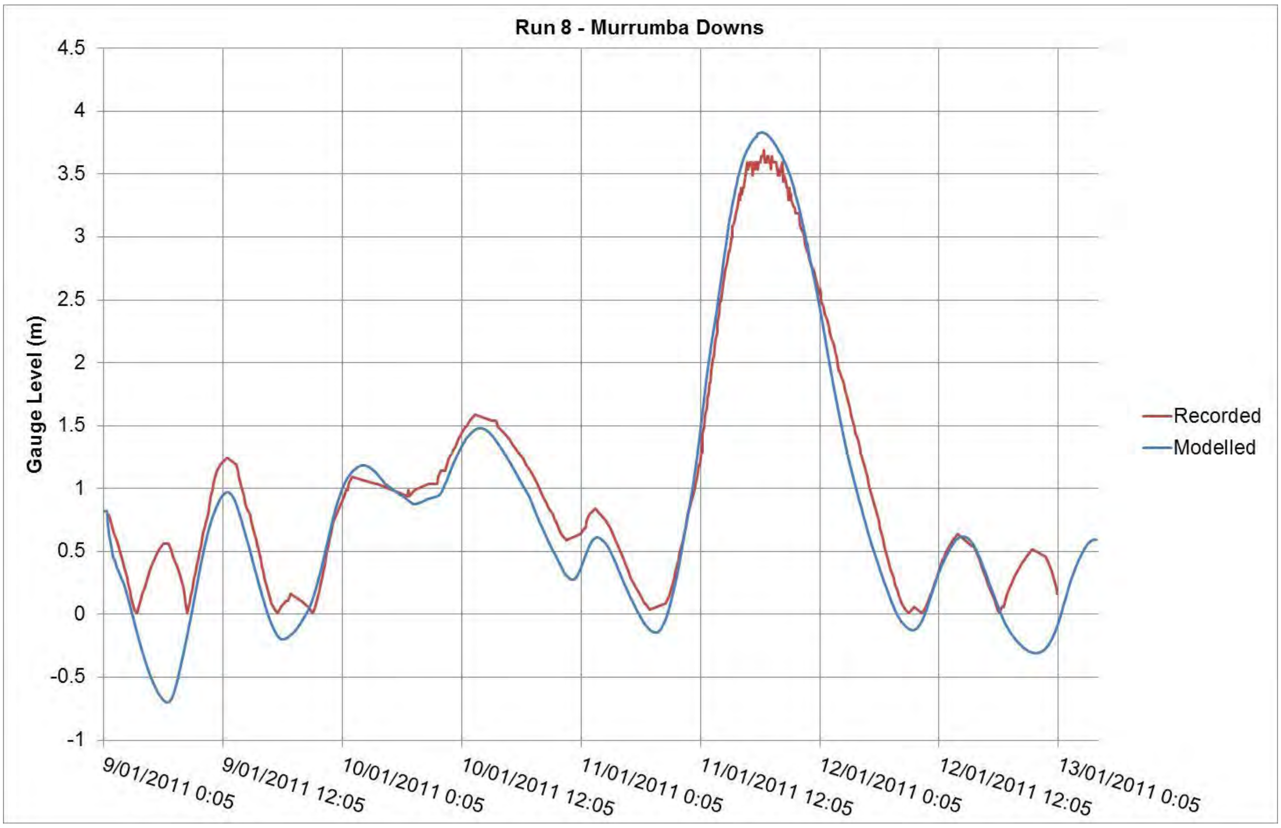
Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\Calibration\FLD_017_121219_LPR_Calibration_Results_F8.WOR

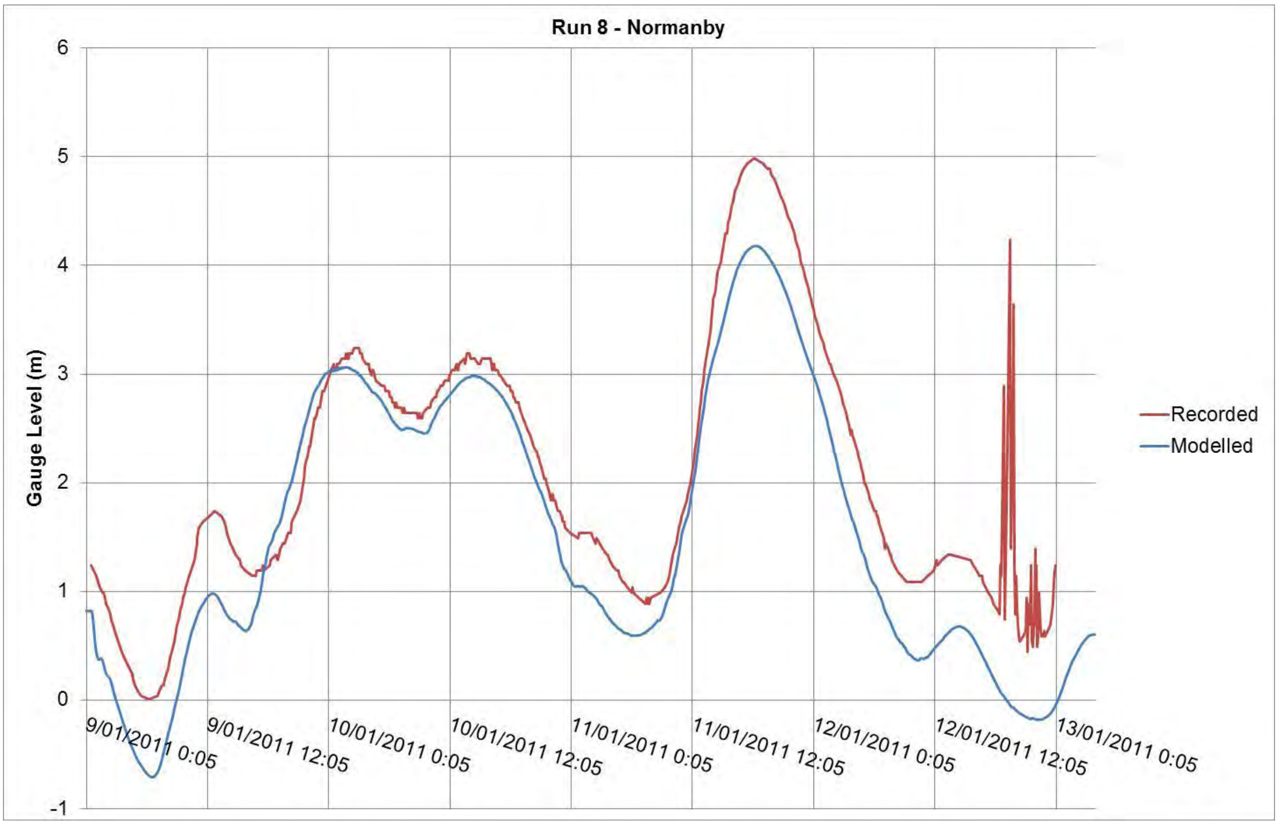
H-3 RUN 8 RESULTS



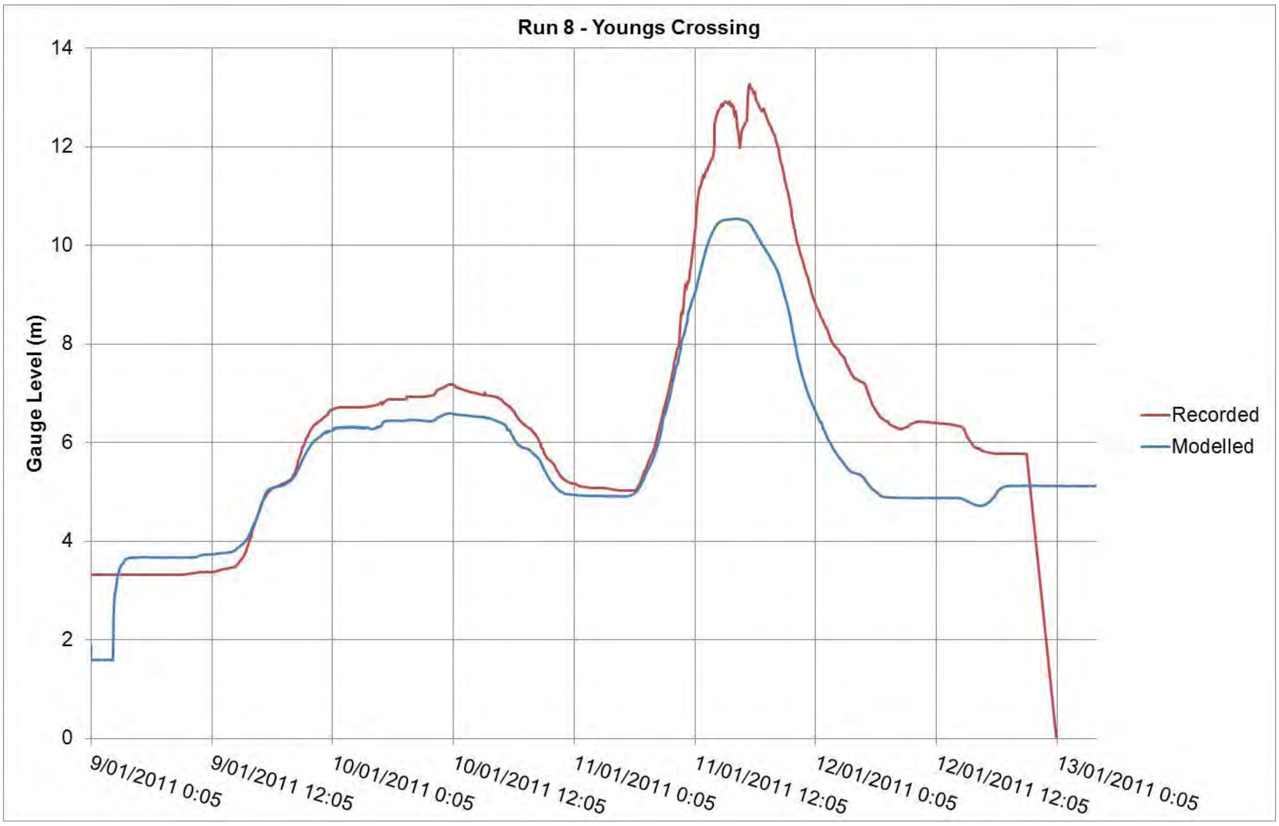


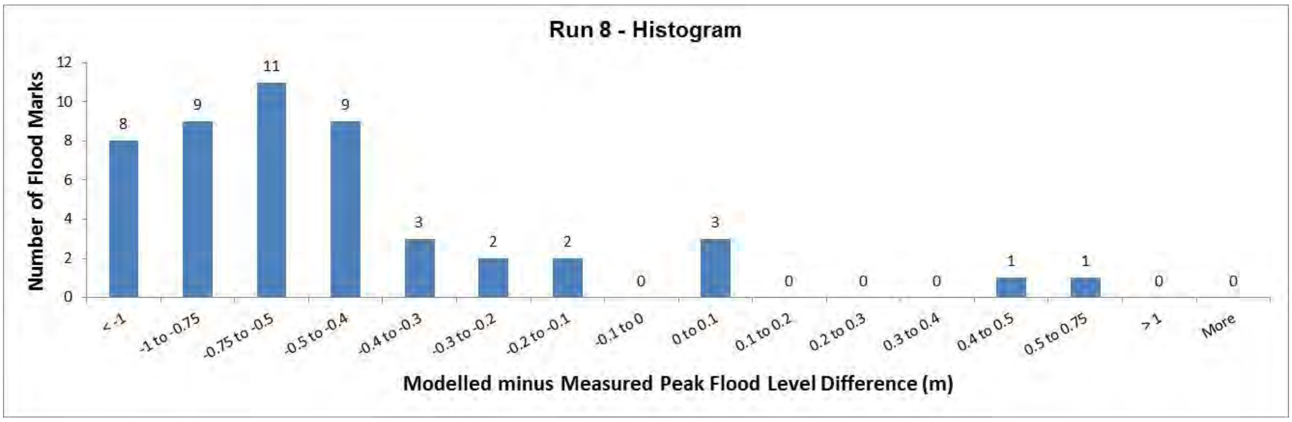


Run 8 - Murrumba Downs
Gauge Level (m)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled



Run 8 - Normanby
Gauge Level (m)
6
5
4
3
2
1
0
-1
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 8 - Youngs Crossing
Gauge Level (m)
14
12
10
8
6
4
2
0
9/01/2011 0:05
9/01/2011 12:05
10/01/2011 0:05
10/01/2011 12:05
11/01/2011 0:05
11/01/2011 12:05
12/01/2011 0:05
12/01/2011 12:05
13/01/2011 0:05
Recorded
Modelled


Run 8 - Histogram
Number of Flood Marks
12
10
8
6
4
2
0
8
9
11
9
3
2
2
0
3
0
0
0
1
1
0
0
< -1
-1 to -0.75
-0.75 to -0.5
-0.5 to -0.4
-0.4 to -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to 0
0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.75
> 1
More
Modelled minus Measured Peak Flood Level Difference (m)

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BMT WBM Denver	**8200 S. Akron Street, Unit 120** **Centennial Denver Colorado 80112 USA** **Tel +1 303 792 9814 Fax +1 303 792 9742** **Email denver@bmtwbm.com** **Web www.bmtwbm.com.au**
BMT WBM Mackay	**Suite 1, 138 Wood Street Mackay 4740** **PO Box 4447 Mackay QLD 4740** **Tel +61 7 4953 5144 Fax +61 7 4953 5132** **Email mackay@bmtwbm.com.au** **Web www.bmtwbm.com.au**
BMT WBM Melbourne	**Level 5, 99 King Street Melbourne 3000** **PO Box 604 Collins Street West VIC 8007** **Tel +61 3 8620 6100 Fax +61 3 8620 6105** **Email melbourne@bmtwbm.com.au** **Web www.bmtwbm.com.au**
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BMT WBM Perth	**Unit 6, 29 Hood Street, Subiaco 6008** **Tel +61 8 9322 1577 Fax +61 8 9226 0832** **Email perth@bmtwbm.com.au** **Web www.bmtwbm.com.au**
BMT WBM Sydney	**Level 1, 256-258 Norton Street Leichhardt 2040** **PO Box 194 Leichhardt NSW 2040** **Tel +61 2 9713 4836 Fax +61 2 9713 4890** **Email sydney@bmtwbm.com.au** **Web www.bmtwbm.com.au**
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APPENDIX D

APPENDIX D: MODELLING QUALITY REPORT

BMT WBM

Technical Note

From:	Anne Kolega	To:	Moreton Bay Regional Council
Date:	9 April 2013	CC:	
Subject:	Modelling Quality Report; Lower Pine River		

1 Background

As part of Moreton Bay Regional Council's (Council) Regional Floodplain Database (RFD) project, a detailed TUFLOW model of the Lower Pine River catchment has been developed. This technical note has been prepared to demonstrate that the Lower Pine River model has been reviewed, and that the model performance is suitable for the intended use and that the sensibility of the results has been checked. This report also documents areas of uncertainty, suggestions for future upgrades and local instability.

The extended model run times of approximately 6 days per run (for the 5m model) limited the number of iterations that could practicably be undertaken per event during model development. This particularly large model, and the long model run time, is due to the model extent and grid cell of 5m and 10m, which was chosen by MBRC. The main reason for the small grid size is for consistency within the RFD.

2 Model Development Process

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

1 A site visit was undertaken prior to commencing development of the model to gain an appreciation for the catchment;

2 An infrastructure assessment was undertaken. A report was produced from this assessment and submitted to MBRC for their consideration on structure data requirements. This approach ensured that sufficient data was captured for the level of accuracy required from the model;

3 The catchment delineation used in the hydrology was reviewed. This review indicated that the catchment delineation was suitable;

4 A draft TUFLOW model was developed, focussing on the January 2011 flood event, and submitted to MBRC for review (in October 2012);

5 MBRC provided feedback from their review of the TUFLOW model. Alterations following this review are discussed later in this note;

6 A final model was developed and used to simulate all the design and sensitivity events; and

7 Further checking was undertaken to ensure that the model was suitable for simulating the full range of flood events.

Throughout model development, model stability, warnings messages and mass errors were monitored to ensure that the model performance was acceptable.

3 Model Amendments

Various enhancements were recommended by BMT WBM during the model development. The following changes were implemented:

1 During calibration of the model it was found that the method used to apply form loss coefficients at the bridges was incorrect. The bridge layers were therefore corrected by analysing the bridge widths and

assigning the form loss coefficients as absolute values when the bridges were relatively narrow and as per meter width when the bridges were relatively wide (i.e. a bridge widths of 7.5m was chosen for the 5m model and 15m model was chosen for the 10m model).

2 A correction was made to the AJ Wylie Bridge (at Gympie Road), whereby the eastern and westerns crossings had been digitised the wrong way around in the original dataset. This bridge was severely damaged during the January 2011 event and is currently being rebuilt. The new AJ Wylie Bridge was also digitised and included in the model based on drawings provided by MBRC for the design event model.

3 MBRC supplied additional bathymetry data on the North Pine River to resolve discrepancies in modelled results versus recorded flood levels identified during calibration. This bathymetry data was converted to GIS format. Breaklines were drawn to generate a TUFLOW readable TIN (see Figure 3-1).

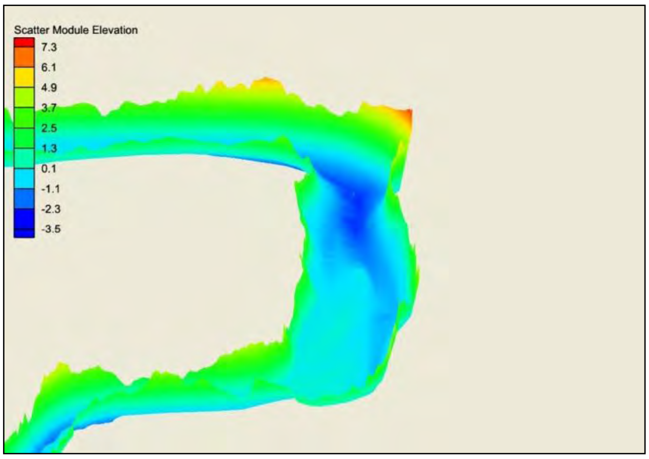


Figure 3-1: Additional Bathymetry Data for the North Pine River included in the TUFLOW Model

Following MBRC's review of the draft model, the following additional structures were incorporated/amended:

i. Plans were provided for the following three road crossings: BER_01_02037a, BER_01_02235a and BER_010331a.

ii. A plan was provided by MBRC for the channel under the Strathpine Courthouse (COU_01_02189a). This was included by developing a TIN from the survey marked on the plan (see Figure 3-2).

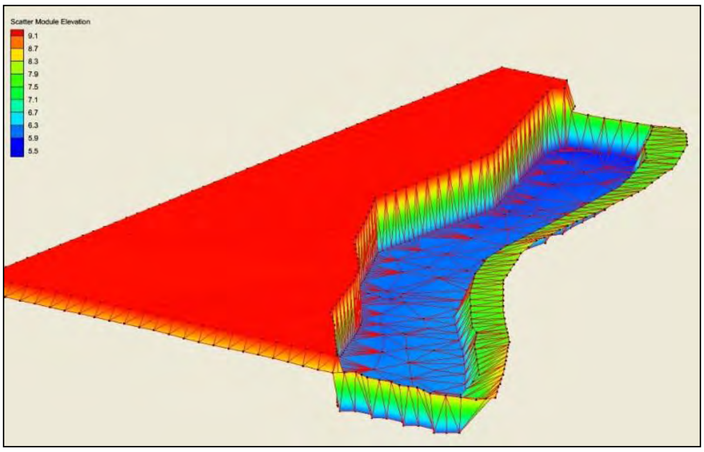


Figure 3-2: Channel Underneath the Strathpine Courthouse

iii. Plans of a culvert for new development next to Centre Link in Strathpine (SPR_43_00953a) were provided.

iv. A plan of an open channel drain at a new development in Petrie (NPR_49_00829a) was provided. The details of the drain were added to the model by developing a TIN.

v. A sound barrier adjacent to a railway line was incorporated using a GIS file that had been provided.

vi. The Railway Bridge on Four Mile Creek was amended. It appeared that the invert level of the creek for the western span had not been captured in the survey.

4 Additional Amendments

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

5 Model Performance

The following model performance checks have been undertaken:

- Stability of flow through key structures, represented in 2D, e.g. the Railway Bridge upstream of the Gympie Road at North Pine River (ID: NPR_01_06664) was checked during model development, refer to Figure 5-1.
- Stability of flow through key structures, represented in 1D, e.g. Anzac Avenue Culvert at Yebri Creek (ID: 01_02234) were checked during model development, refer to Figure 5-2.The arrangement of SX connections, structures and embankments has been edited to ensure that stable peak flows have been achieved where necessary.
- Stability of overland flow hydrographs were checked at several locations in the floodplain; e.g. downstream and to the north of Linkfield Road, ID: SPR_01_07887, refer to Figure 5-3.
- TUFLOW warning messages have been reviewed. Although some events include a large number of negative depth warning messages, these are spread over the model extent and are limited to small specific areas. This is discussed further in Section 6.
- Mass balance errors have been minimised. Mass balance errors range from -0.1% to 0.1% for most events up to the 1000 Year RI event. High mass balance errors occur in the PMF event with up to 1.6% for the 3 hours and 12 hours storm duration and 2.7% for the 24 hours storm duration.

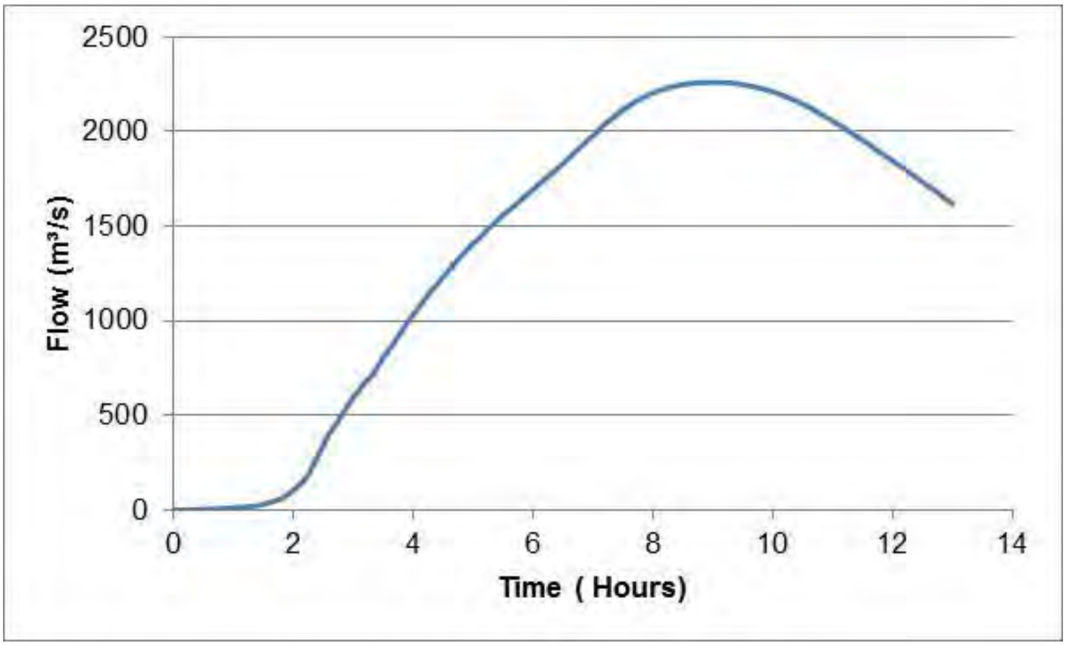


Figure 5-1: Flow through Railway Bridge Upstream of Gympie Road (100 Year ARI 12 Hours Storm Duration)

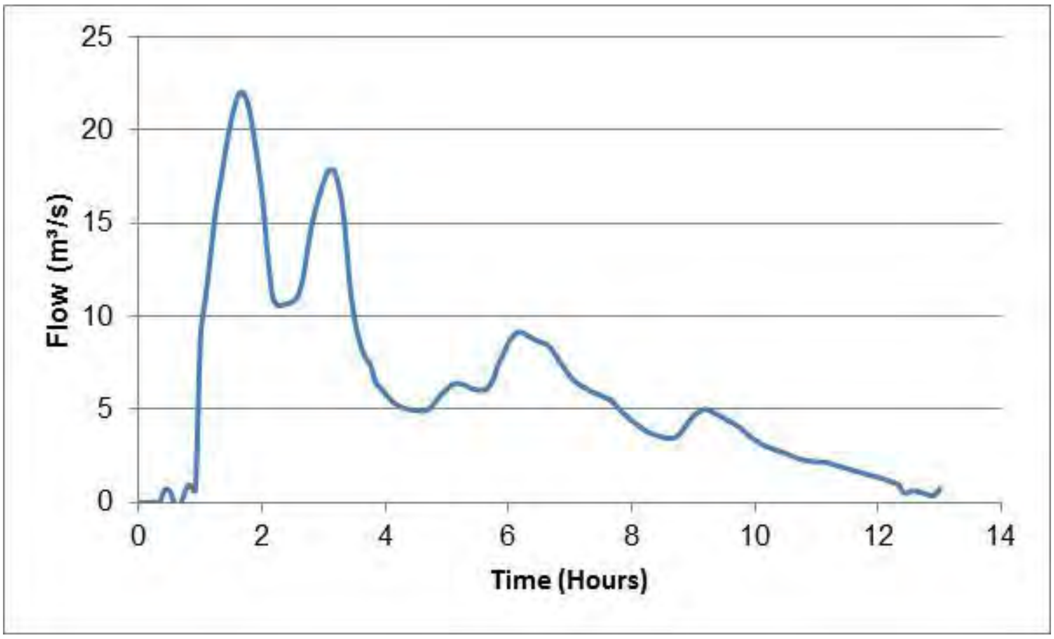


Figure 5-2: Flow through Railway Bridge Upstream of Gympie Road (100 Year ARI 12 Hours Storm Duration)

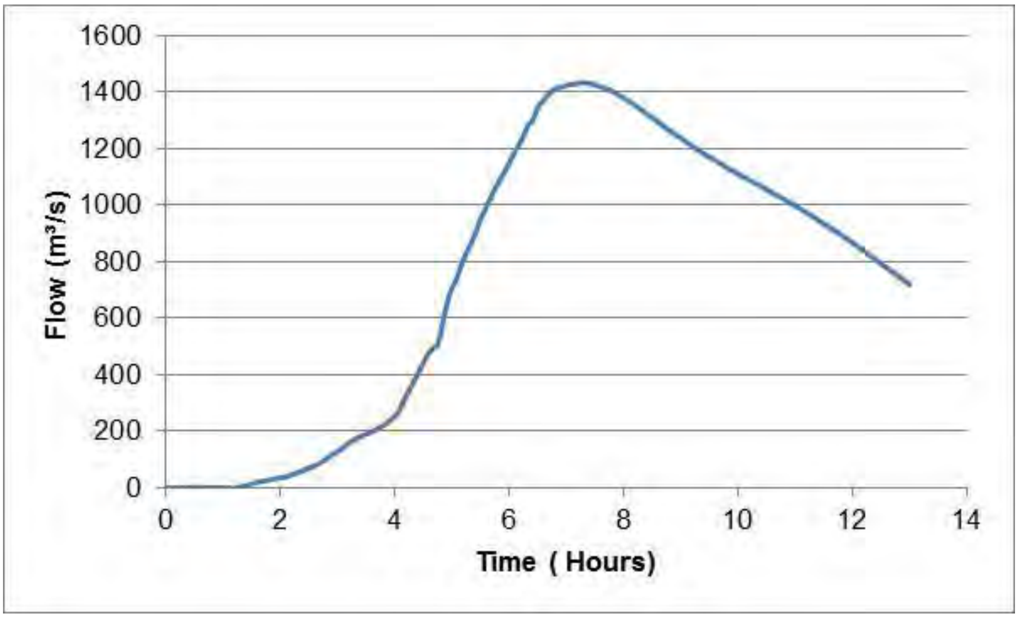


Figure 5-3: Flow South Pine River Floodplain Upstream of Linkfield Road (100 Year ARI 12 Hours Storm Duration)

6 Localised Instabilities

The Lower Pine River TUFLOW model includes a high number of warning messages for most design events as a result of localised instabilities. The locations of these messages vary significantly for various ARI events and storm durations.

For example, the 100 year 12 hours storm duration event has 1500 messages during the simulation. Most of these messages (1300) are located between the railway line and Railway Avenue at the inlet of the Strathpine Courthouse culvert. These warning messages are a result of model instability at this location for this particular event. This does not occur for events smaller than the 100 year ARI events, as the area where the instability occurs is not inundated in smaller events.
Similarly, there are different locations with localised instabilities for other design events. It is recommended that consideration is given to the warning messages and potential instability when interpreting the model

results. Furthermore, it is recommended that these instabilities be resolved as required, if the model is used for other analyses.

7 Model Run Times and Specification

A 5m and 10m model were developed for the Lower Pine River catchment, as adopted by MBRC. These models cover a catchment area of approximately 300km², which result in large model run times and specific requirements for the simulation, as listed in **Table 7-1**:

Table 7-1: Model Run Times and Specification

	5m Model	10m Model
RAM Requirement	10.3 GB (10315 MB)	2.5GB (2598 MB)
Number of Active Cells	6,800,000 cells	1,700,000 cells
Approximate Model Run Time	144 Hours (6 days)	15 Hours

8 Bathymetry Data

The model uses bathymetry data collected in 2005. The model calibration has shown that it is likely that the bathymetry has changed in some areas following the January 2011 flood event.

BMT WBM and MBRC recommend that the bathymetry survey is updated and possibly additional bathymetry data collected within the next 2 years.

The bathymetry data seems to have been poorly processed in some places. The Zpts and DEM (including the processed bathymetry data) for the LPR TUFLOW model were provided by WorleyParsons. One location is shown in Figure 8-1, where the provided DEM includes a 2m high weir feature within the South Pine River channel; presumably due to interpolation between the left and right bank.

The comparison between aerial photography and the DEM identified another two locations, where aerial photography showed high land, which was not represented in the DEM, as shown in Figure 8-2.

Figure 8-1: Anomaly in DEM Upstream of Gympie Road

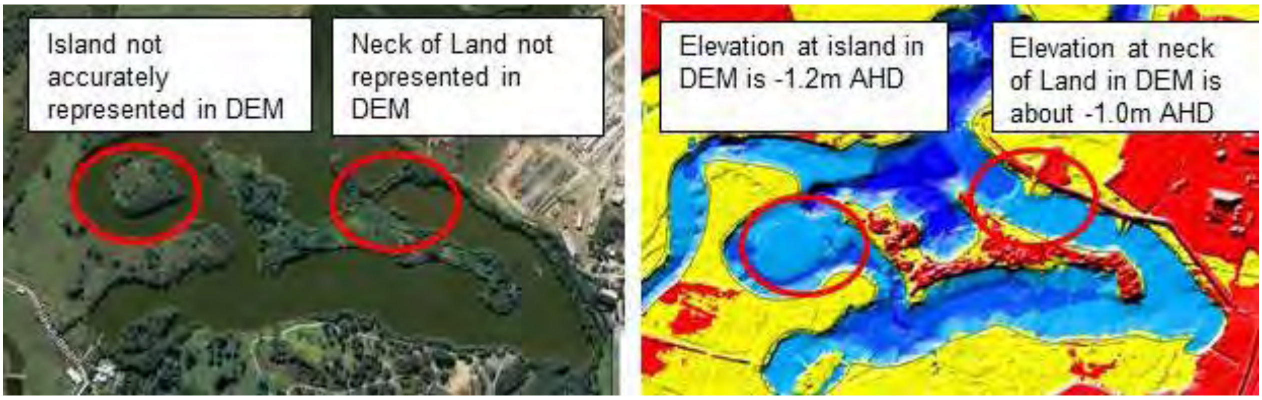


Figure 8-2: Anomaly in DEM in South Pine River Floodplain, East of Strathpine

A sensitivity test was undertaken using a DEM of the bathymetry for a portion of the South Pine River which had been interpolated more accurately by BMT WBM. This amended DEM extended from the railway line crossing to the Bruce Highway. The 100 year 6 hours storm duration (10m model) was used for the sensitivity test.

The results show that the adopted model over predicts peak flood levels by up to 0.12m in the area between Linkfield Road and approximately 350m downstream of Gympie Road on the South Pine River. This area is shown in dark blue with a black outline in Figure 8-3. For events smaller than the 100 Year ARI event, it is expected that the adopted DEM will further over predict peak flood levels. The light blue areas (shown in Figure 8-3) demonstrate that the adopted model over predicts by less than 0.1m.

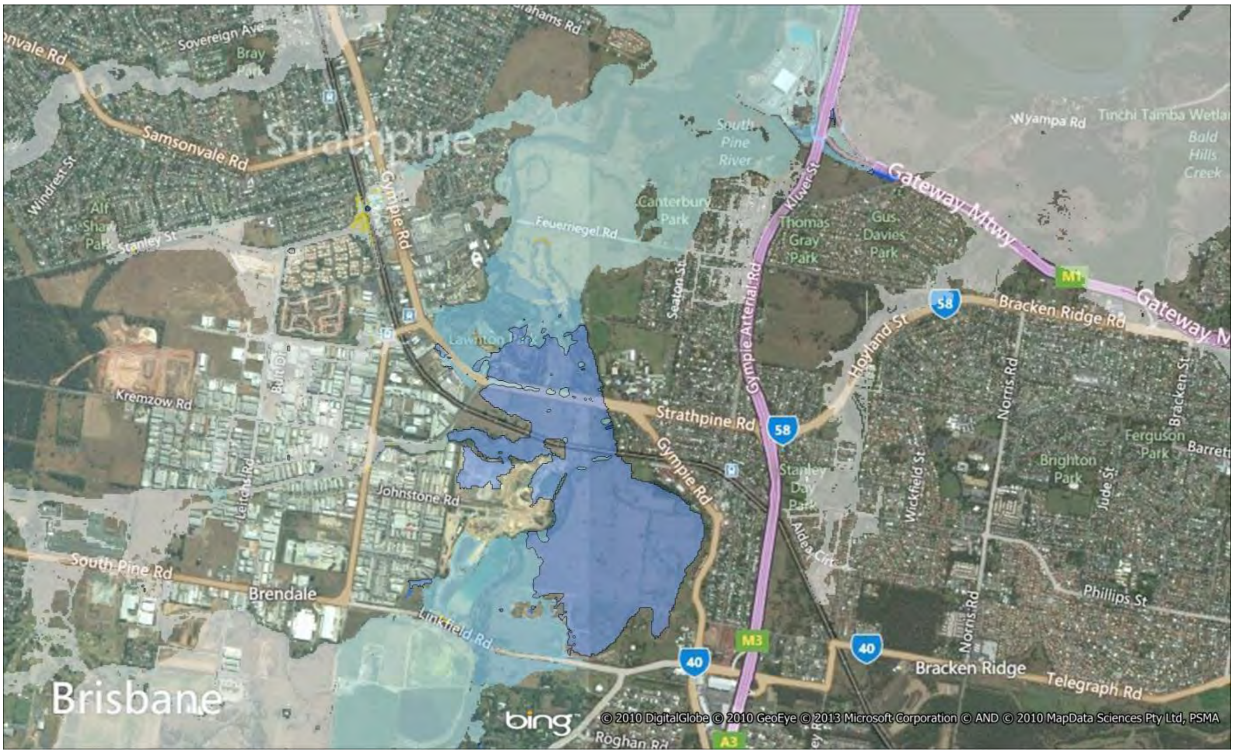


Figure 8-3: Results from Amended Bathymetry Data in South Pine River Floodplain (100 Year ARI 6 Hours Storm Duration)

Note: The dark blue area indicates that the adopted model over predicts peak flood levels by up to approximately 0.12m. The light blue areas show the adopted model over predicts by less than 0.1m.

9 Flood Depth Model Results

The 5m model includes approximately 10 grid cells (concentrated around four locations) that have an elevation lower than -50m AHD due to the corresponding Zpts erroneously attributed an elevation of -9999).

Two of these locations are located outside the flood extent and should be ignored (i.e. represented as dry areas). The other two locations are within the flood extent thus resulting in very high depths (and high depth x velocity product values) within 4 grid cells; these values should be ignored. This has occurred due to holes in the provided DEM; numerous holes in the DEM were identified and covered using Z shapes, but these few grid cells were missed. These remaining small holes in the DEM should be amended in future model upgrades.

10 Conclusion

The Lower Pine River model has been developed with due consideration given to ensuring the quality of the model; within the context of the size, large number of structures and practicality of running this large model. The Lower Pine River model has extended model run times and specific modelling requirements, as outlined in Section 7.

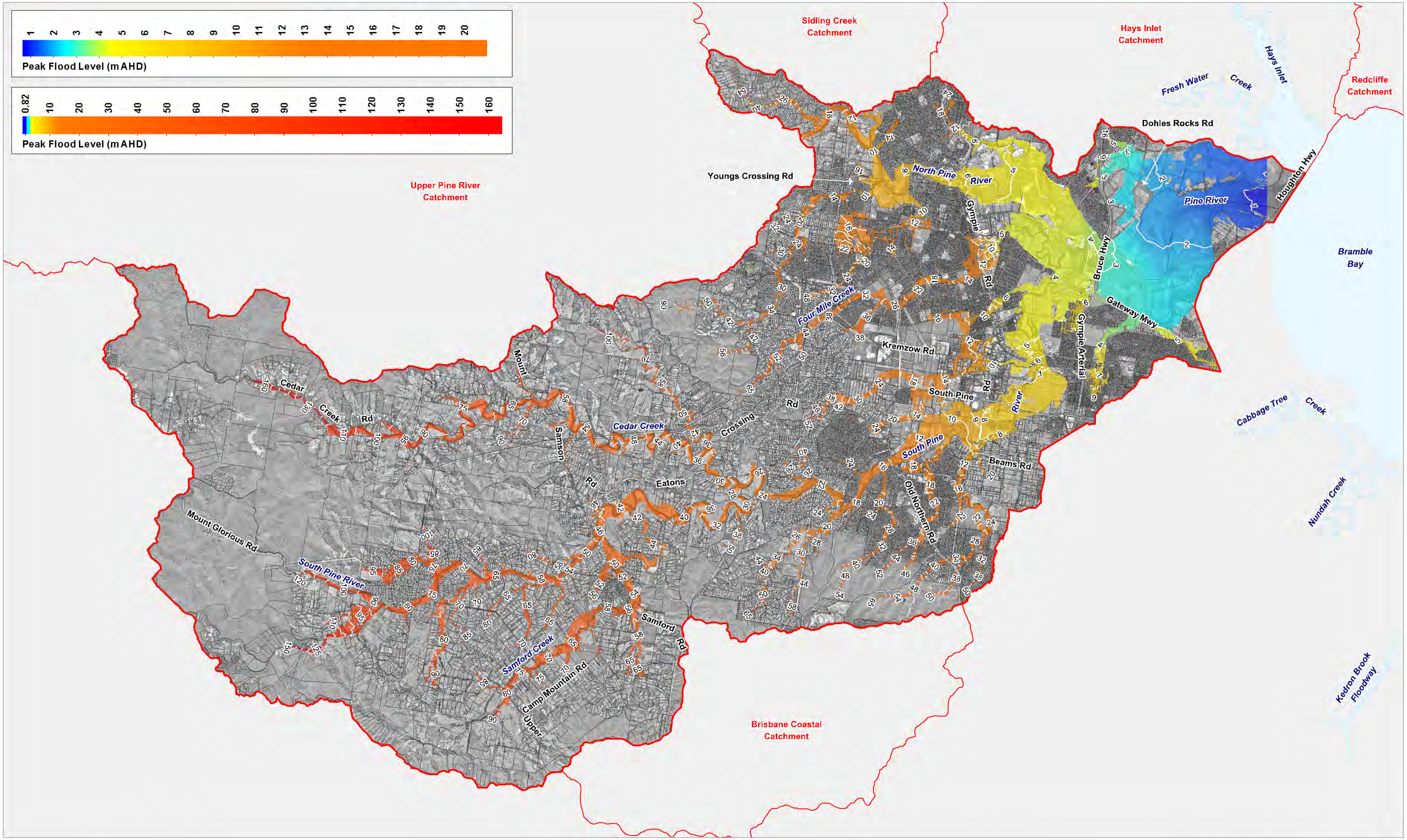
The model has been reviewed internally and externally by MBRC. Amendments have been made in light of these reviews. Some residual small errors were found subsequent to the reviews, which have been discussed in this report (Section 8 and Section 9). Also, isolated model instabilities exist (see Section 6). Despite these residual errors and instability, the overall model performance is suitable for the current intended use of the model.

For future use of the model, it is recommended that the following is considered:

1. Correction of the -9999 grid elevation errors;
2. Resolution of isolated model instabilities;
3. Resurveying of bathymetry data and extending the coverage of bathymetry data;
4. Improvement of the process used to interpolate the bathymetry data; and
5. Changes in the catchment, such as new development, that may have occurred subsequent to the model development.

APPENDIX E

APPENDIX E: FLOOD MAPS – 100 YEAR ARI



LEGEND

Lower Pine River Catchment Boundary

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

Cadastral Boundaries

Title:

Peak Flood Level Map - 100 Year ARI

Figure: E-1

Rev: A

N

0km 2 4
Approx. Scale

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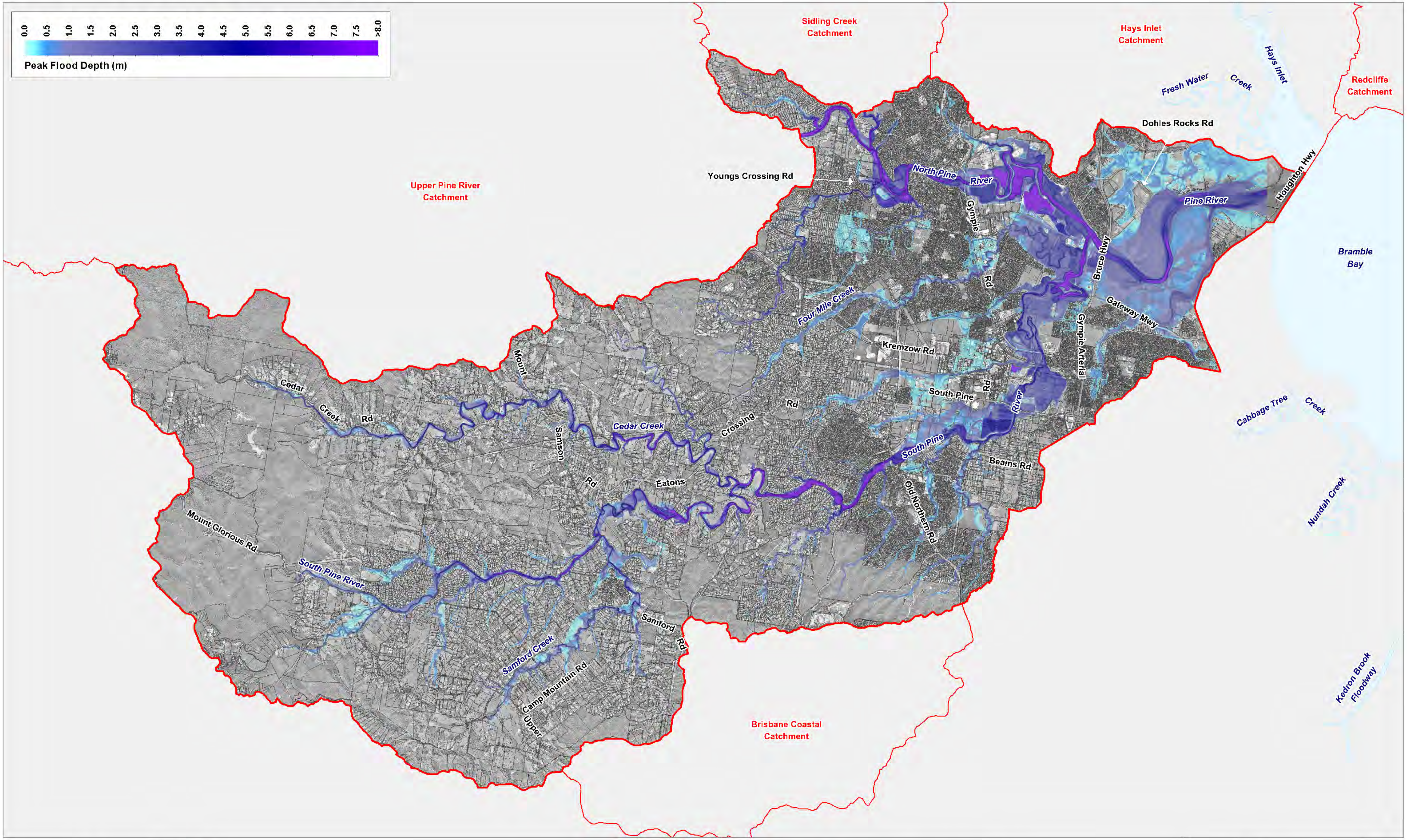
Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\LPR_Report\FLD_006_130118_100Y Peak Flood Level.WOR



LEGEND

Lower Pine River Catchment Boundary

Cadastral Boundaries

Title:

Peak Flood Depth Map - 100 Year ARI

Figure: E-2

Rev: A

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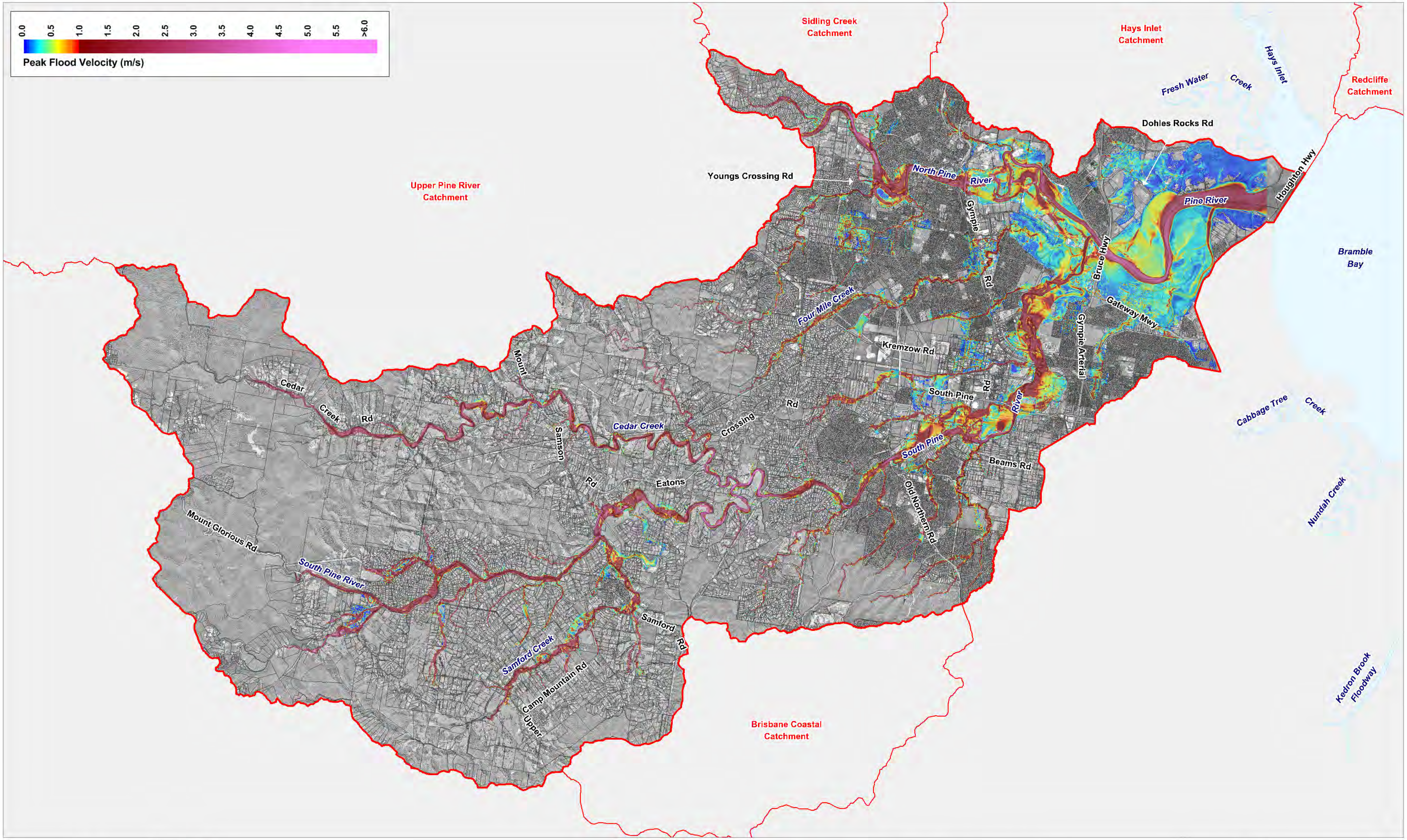

LEGEND

Lower Pine River Catchment Boundary

Cadastral Boundaries

Title:

Peak Flood Velocity Map - 100 Year ARI

Figure: **E-3**

Rev: **A**

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Approx. Scale

BMT WBM

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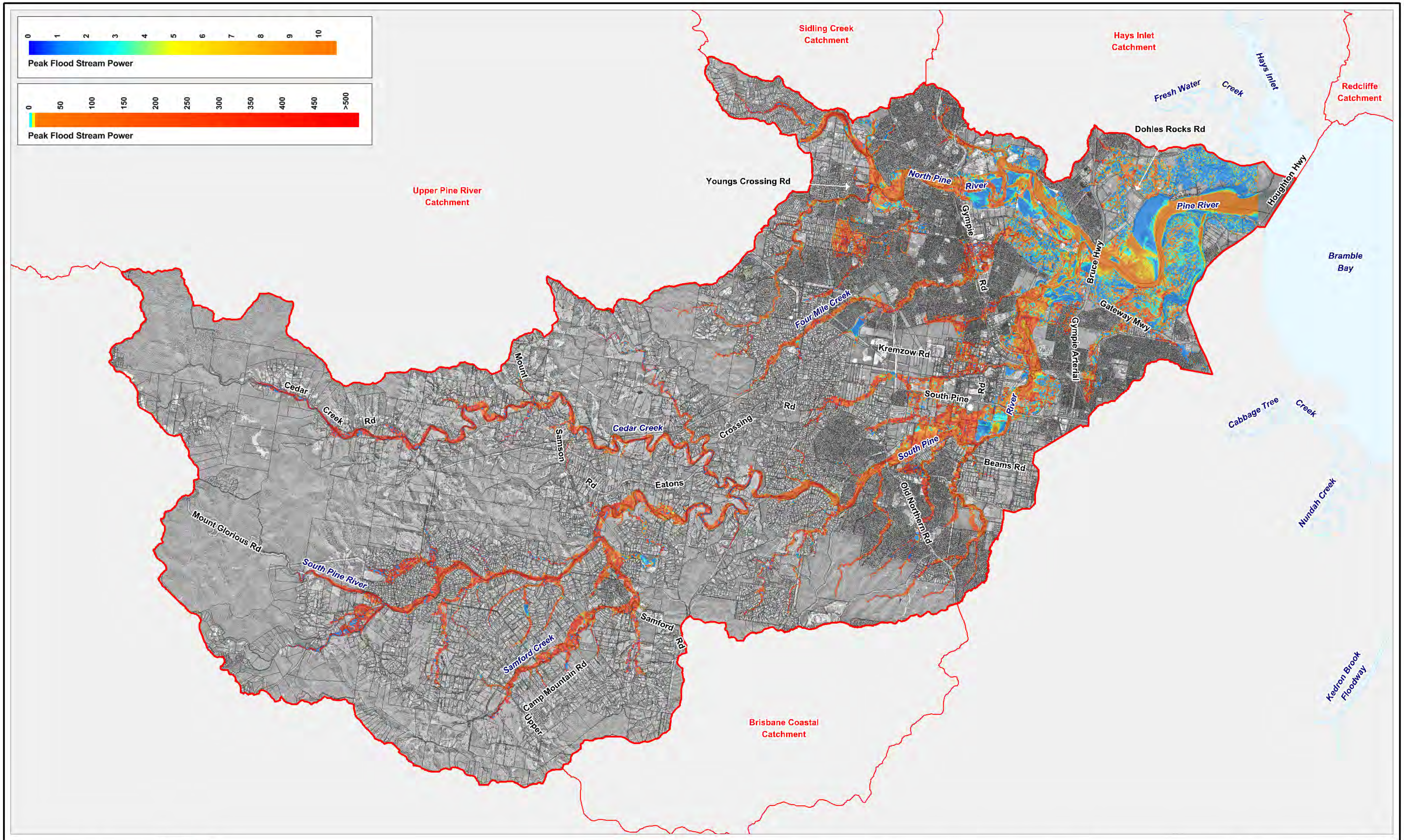

LEGEND

Lower Pine River Catchment Boundary

Cadastral Boundaries

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

Title:

Peak Flood Stream Power Map - 100 Year ARI

Figure: **E-4**

Rev: **A**

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Approx. Scale

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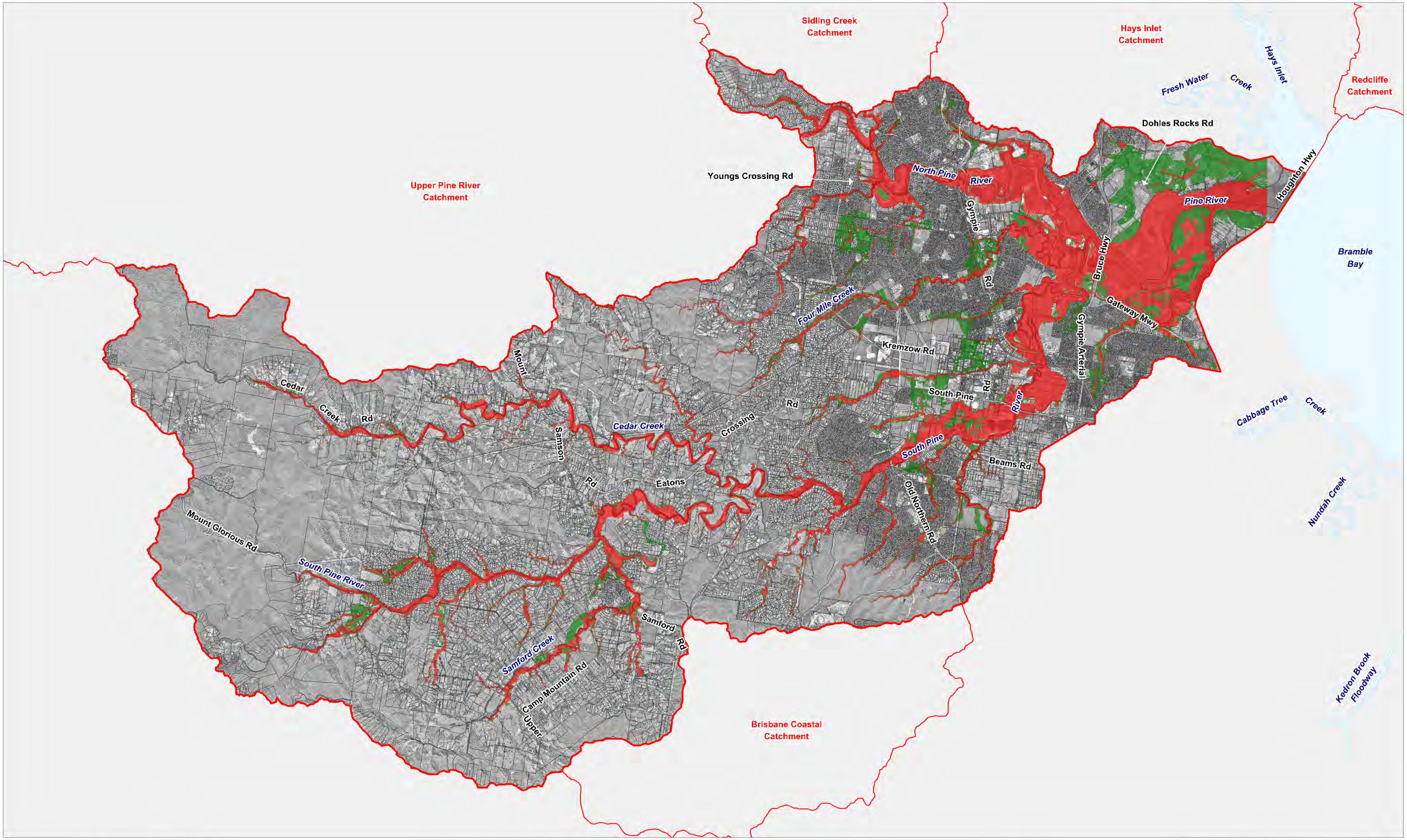

LEGEND

Lower Pine River Catchment Boundary

Cadastral Boundaries

NSW Floodplain Development Manual
Flood Hazard Category
100 Year ARI Event

Low Hazard
High Hazard

Title:
Peak Flood Hazard Map - 100 Year ARI

Figure: E-5

Rev: A

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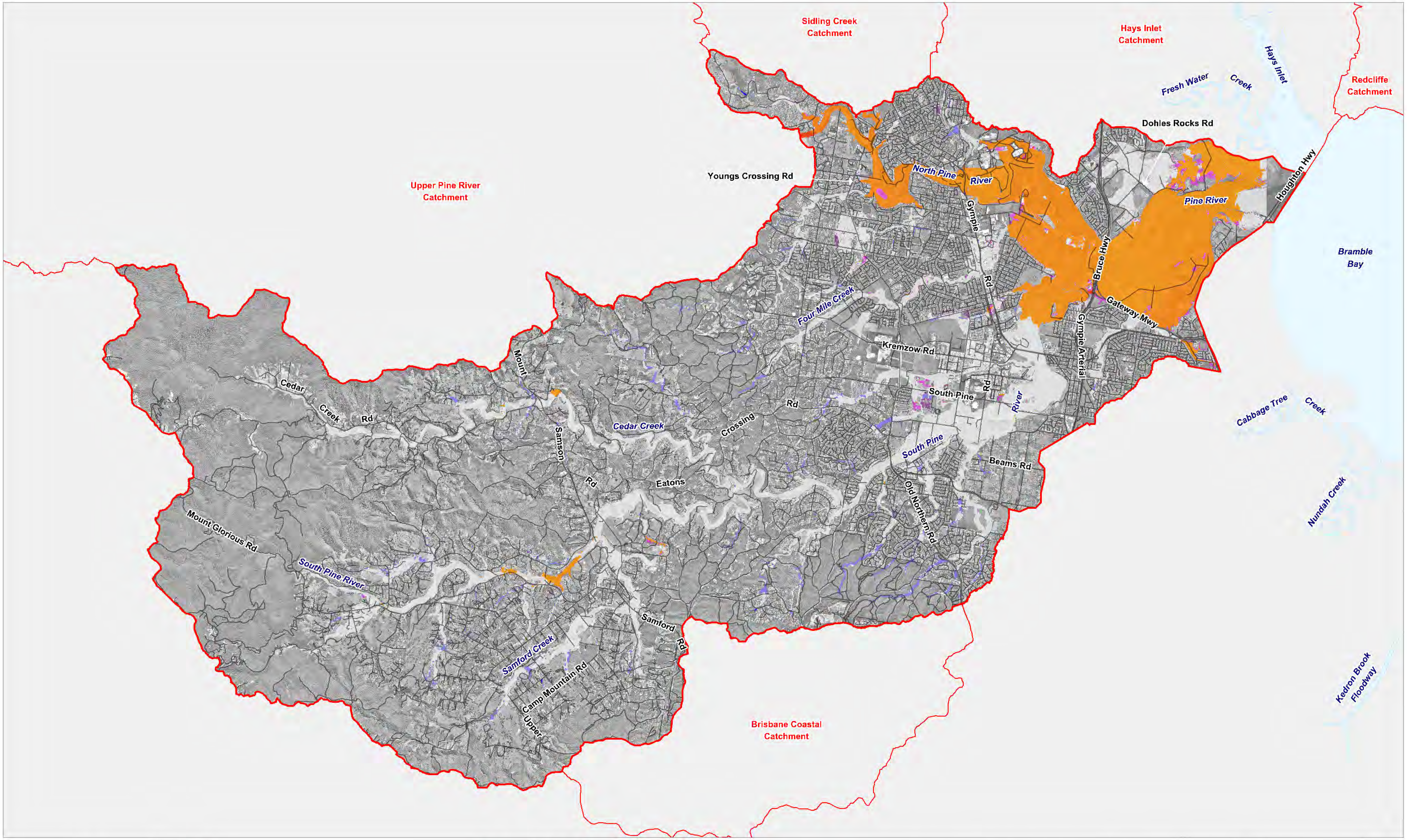
Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\LPR_Report\FLD_010_130121_100Y Peak Flood Hazard.WOR

APPENDIX F

APPENDIX F: MODEL SENSITIVITY ANALYSIS MAPS



LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Was dry now wet
- Was wet now dry

Title:

100 Year EDS Minus 100 Year ARI 3 Hours, 6 Hours and 12 Hours Storm (S1)

N

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Approx. Scale

Figure: F-1

Rev: A

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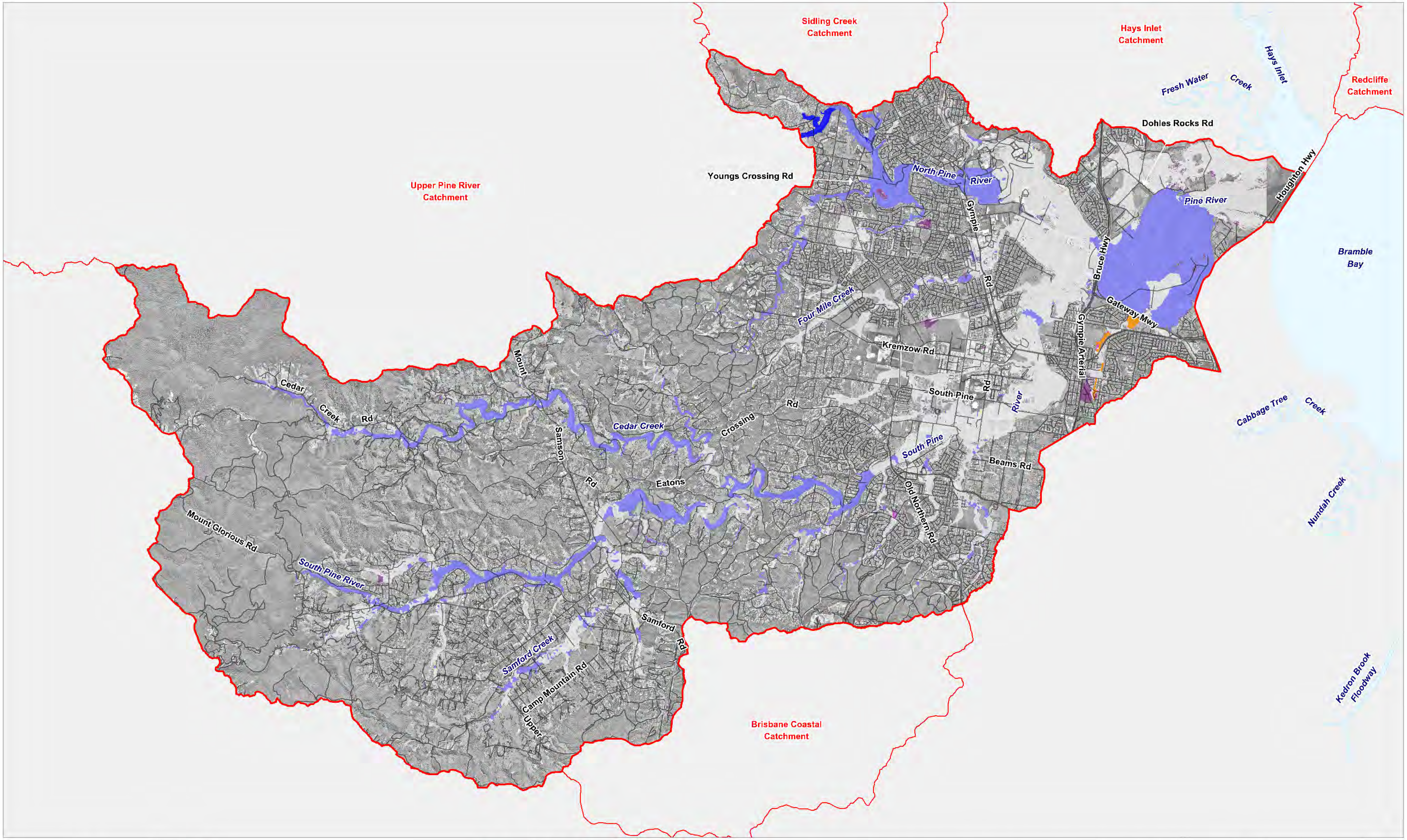

LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Was dry now wet
- Was wet now dry

Title:

Increased Roughness Scenario (S2) Minus 100 Year EDS

Figure: **F-2**

Rev: **A**

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Approx. Scale

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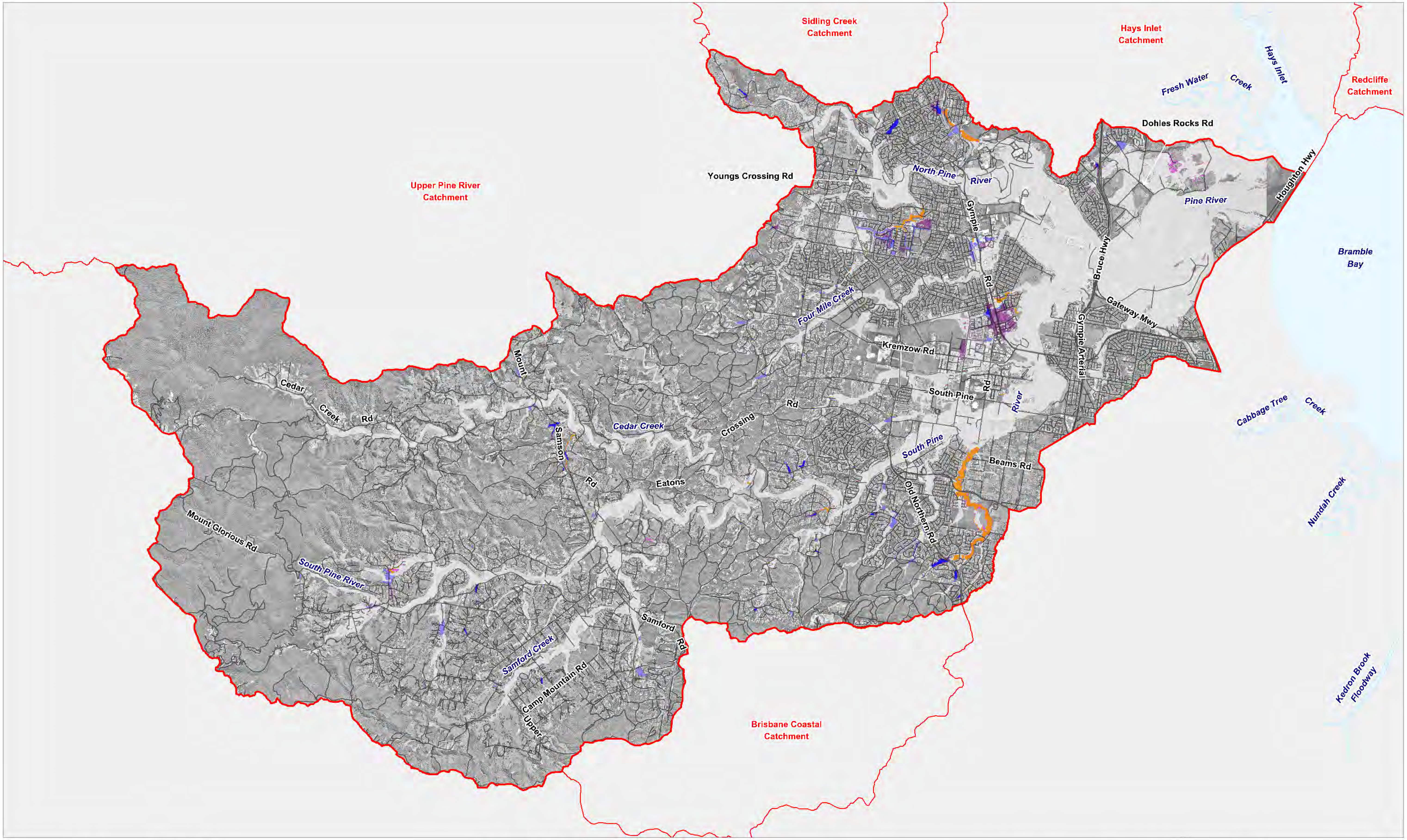

LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Was dry now wet
- Was wet now dry

Title:

Structure Blockage Scenario (S3) Minus 100 Year EDS

Figure: **F-3**

Rev: **A**

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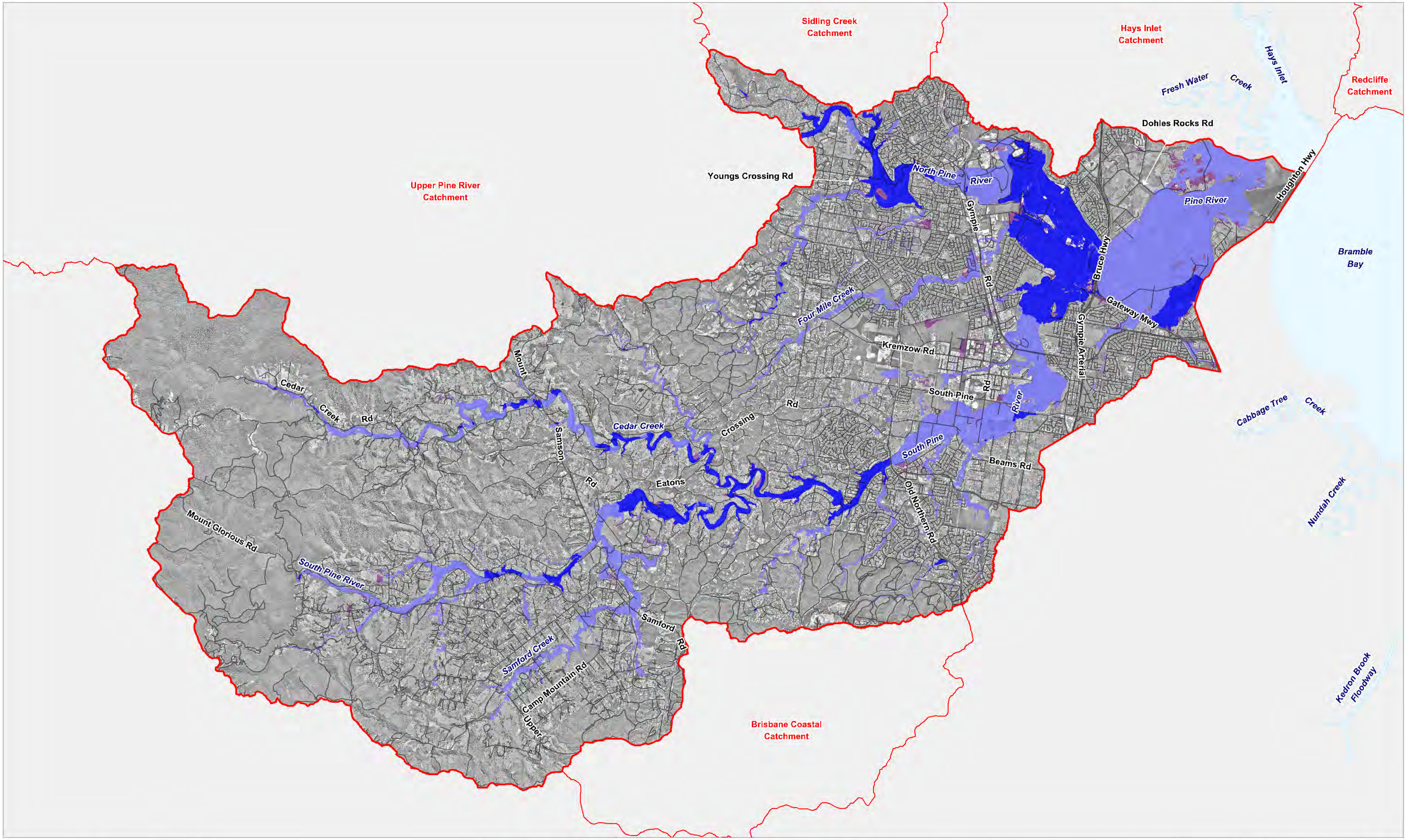

LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Was dry now wet
- Was wet now dry

Title:

Increased Rainfall Scenario (S4) Minus 100 Year EDS

Figure: **F-4**

Rev: **A**

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Approx. Scale

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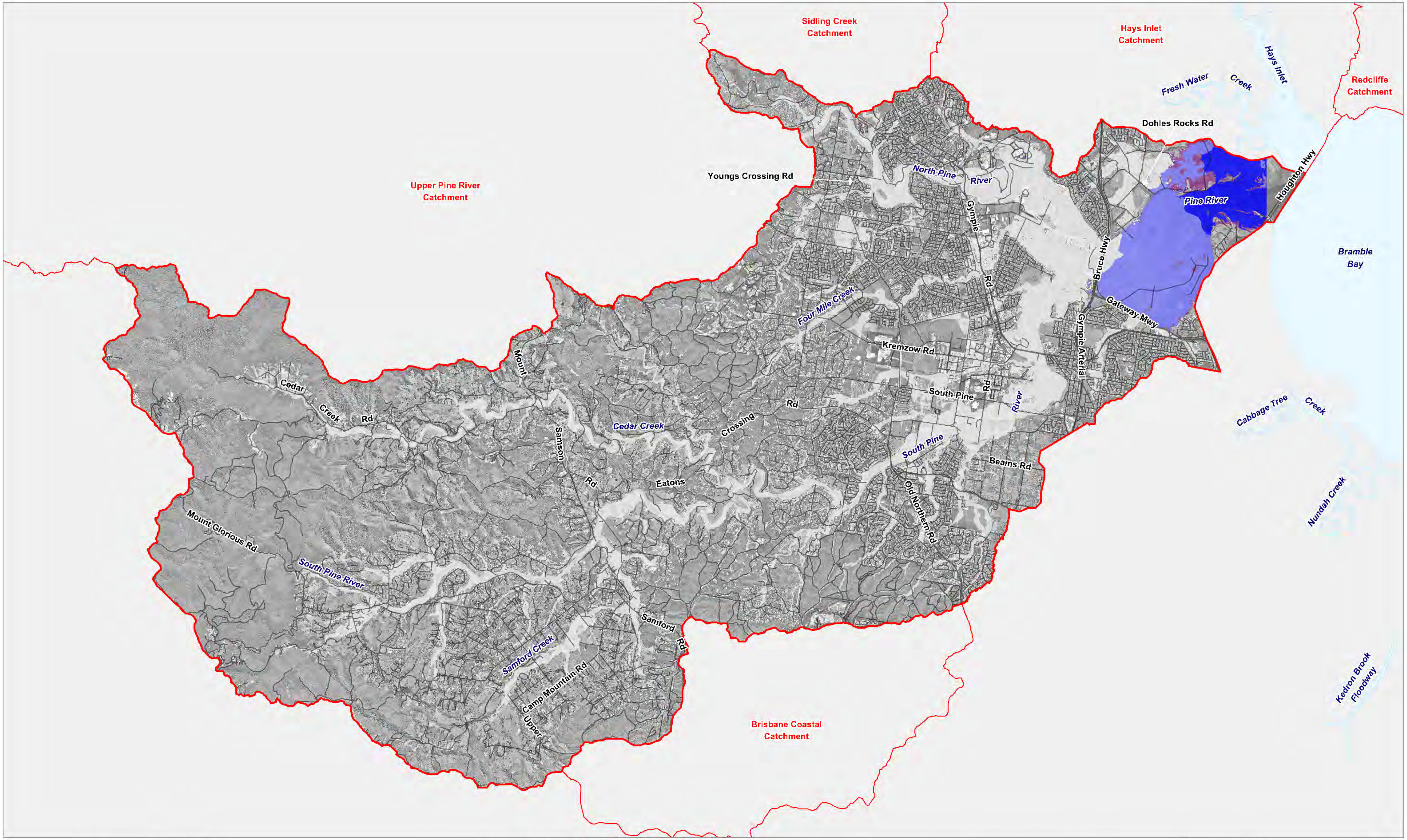
Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\LPR_Report\FLD_014_130201_Sensitivity_S4.WOR



LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Was dry now wet
- Was wet now dry

Title:

Increased Downstream Boundary Scenario (S5) Minus 100 Year EDS

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Figure: **F-5**

Rev: **A**

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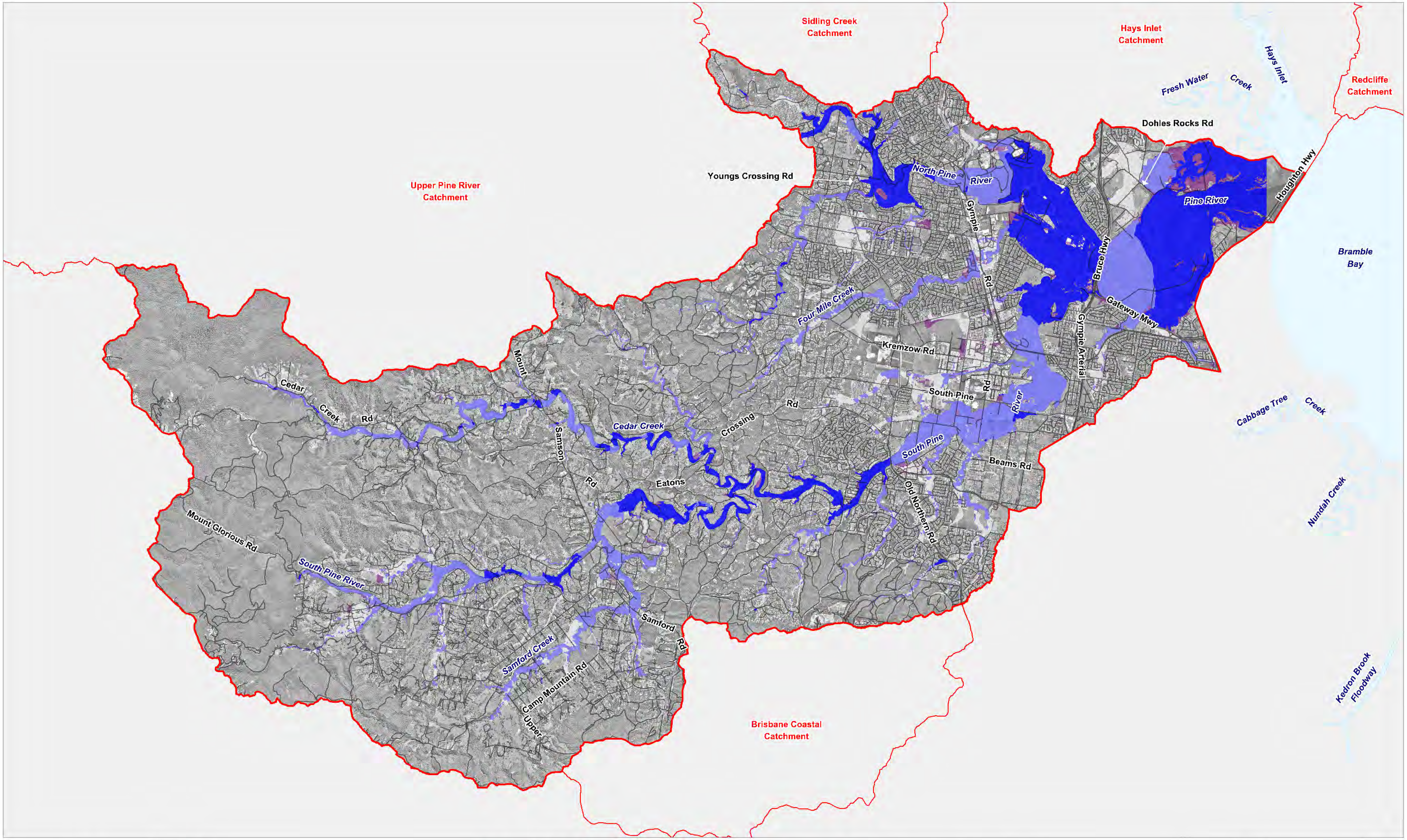

LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Was dry now wet
- Was wet now dry

Title:

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

Figure: **F-6**

Rev: **A**

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Approx. Scale

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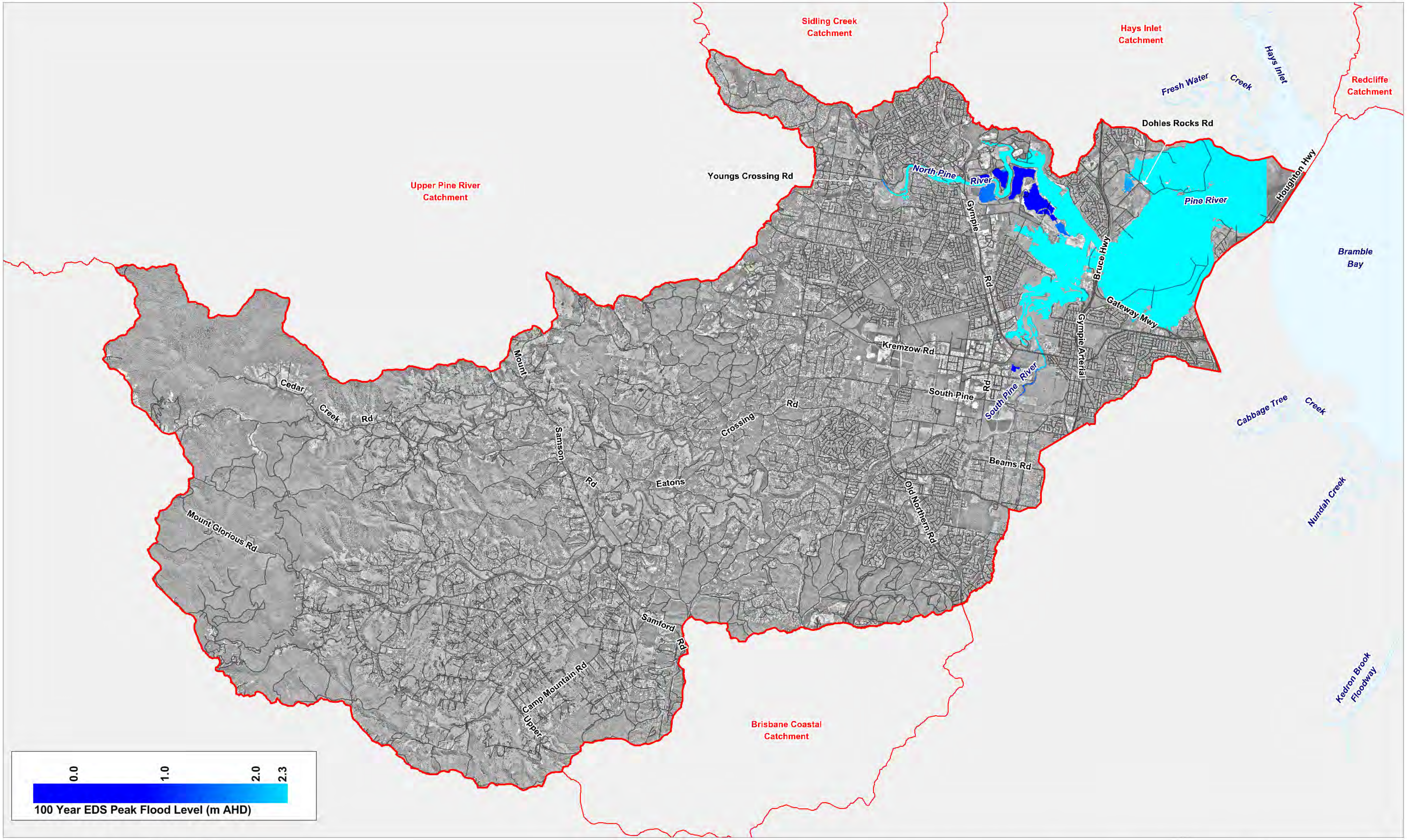

LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Title:

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

Figure: F-7

Rev: A

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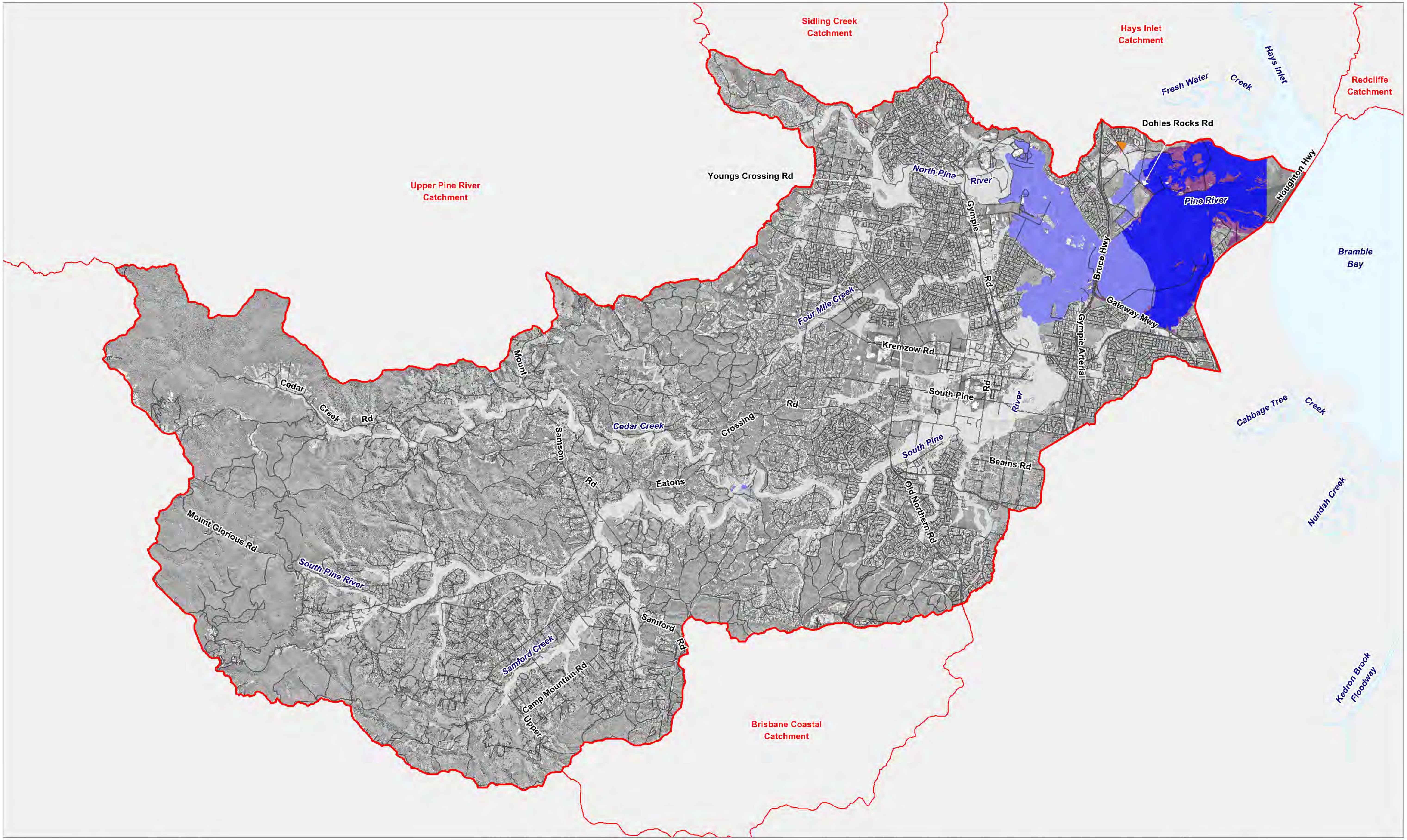

LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Was dry now wet
- Was wet now dry

Title:

Static Storm Tide Scenario (S8) Minus 100 Year EDS

Figure: **F-8**

Rev: **A**

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0km 2 4

Approx. Scale

BMT WBM

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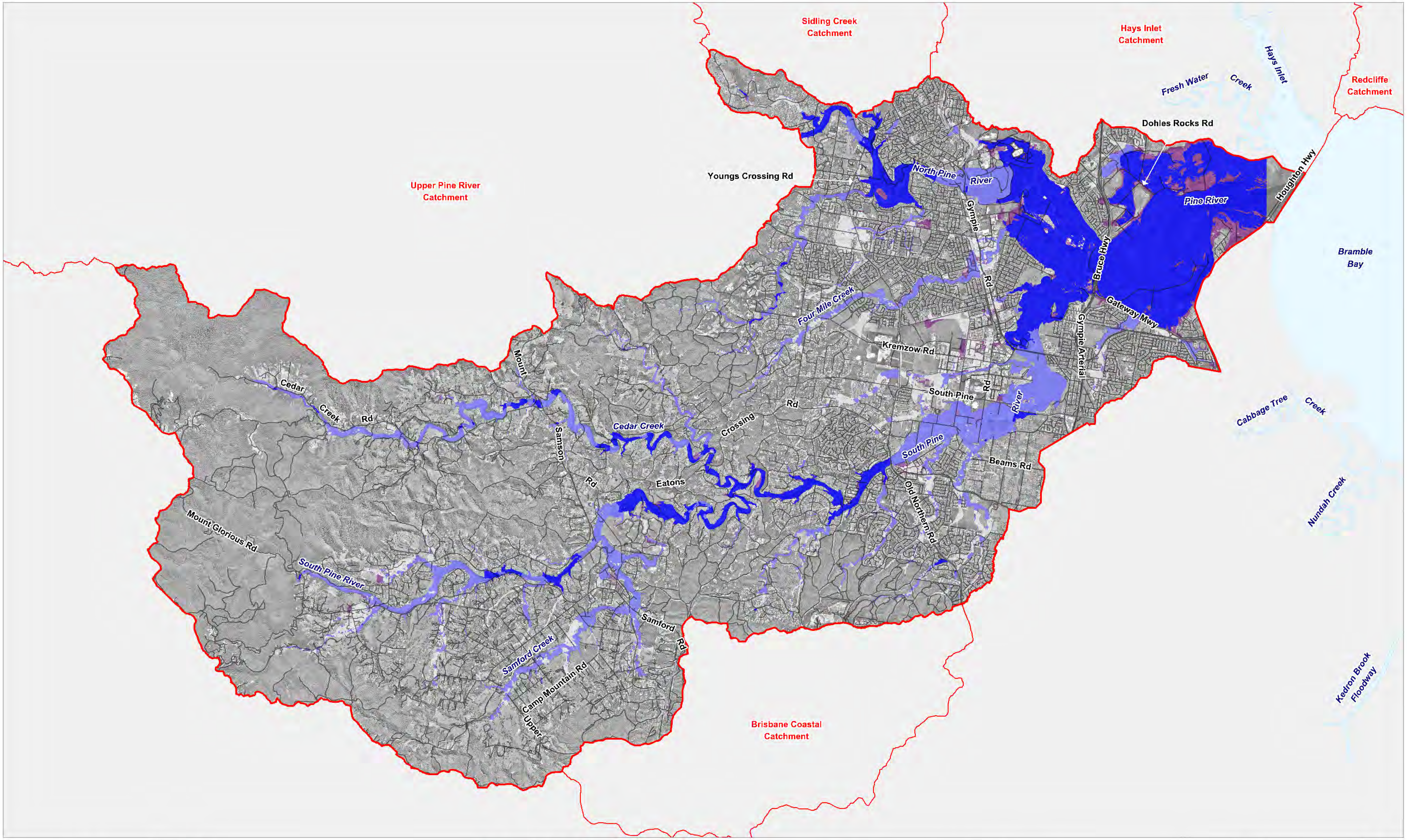

LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Was dry now wet
- Was wet now dry

Title:

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

Figure: **F-9**

Rev: **A**

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0km 2 4

Approx. Scale

BMT WBM

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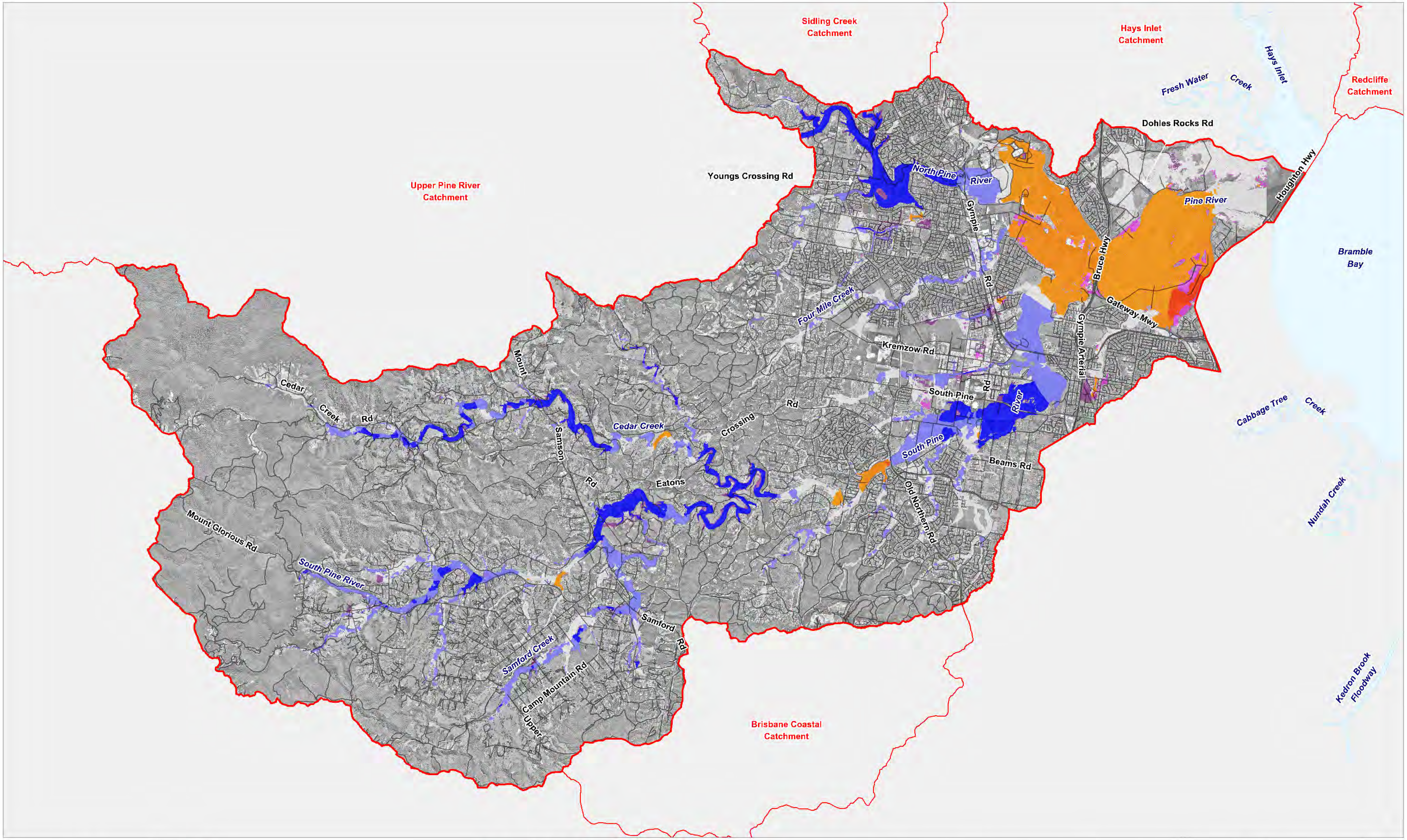

LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Was dry now wet
- Was wet now dry

Title:

Increased Vegetation Scenario (S10) Minus 100 Year EDS

Figure: **F-10**

Rev: **A**

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Approx. Scale

BMT WBM

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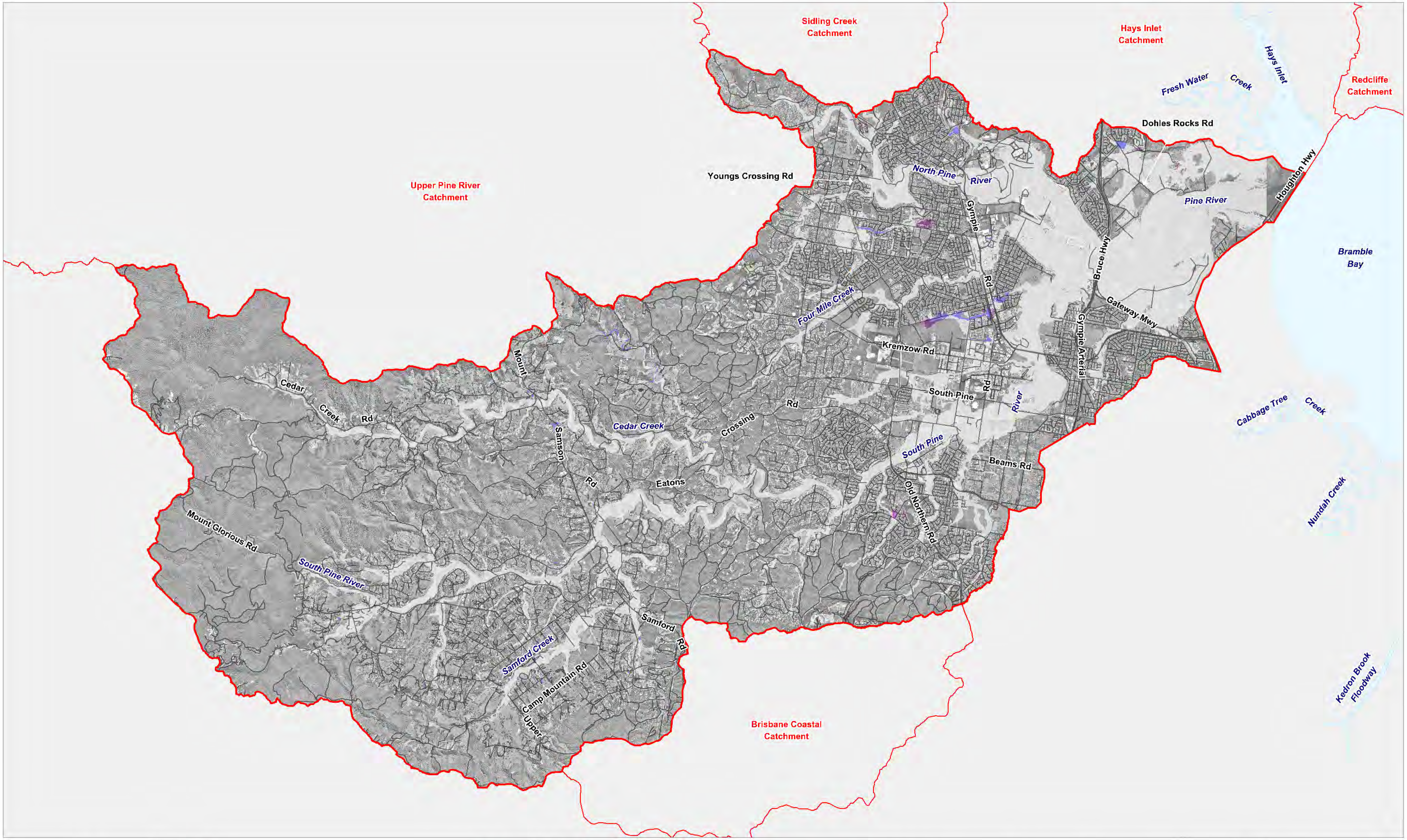

LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Was dry now wet
- Was wet now dry

Title:

Increased Residential Development Scenario (S11) Minus 100 Year EDS)

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0km 2 4

Approx. Scale

Figure: F-11

Rev: A

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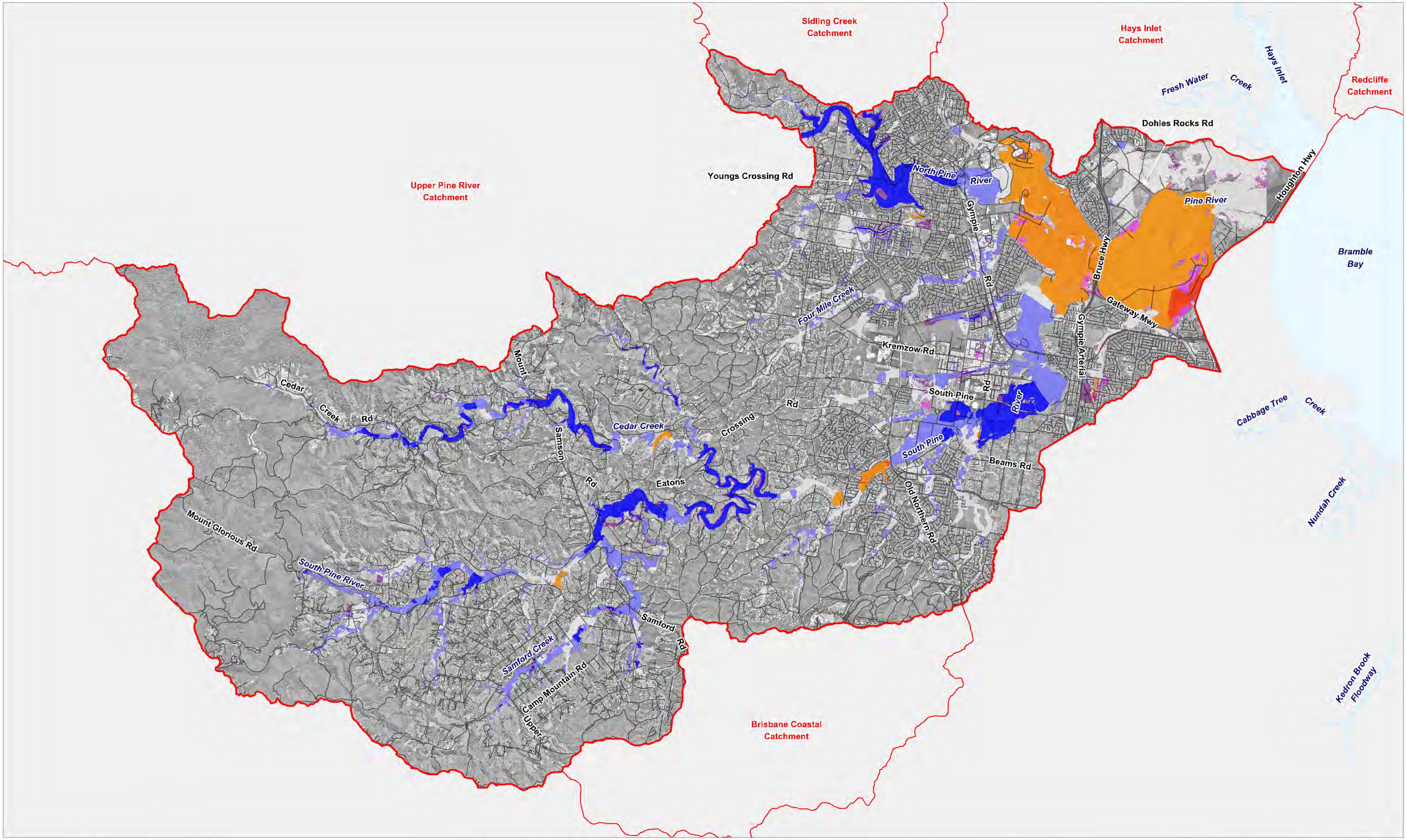
Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\LPR_Report\FLD_021_130201_Sensitivity_S11.WOR



LEGEND

Lower Pine River Catchment Boundary

Physical Road Network

Difference in Peak Levels (m)

- < -0.5
- -0.5 to -0.1
- -0.1 to 0.1
- 0.1 to 0.5
- > 0.5
- Was dry now wet
- Was wet now dry

Title:

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

Figure: **F-12**

Rev: **A**

N

0km 2 4

Approx. Scale

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Filepath : I:\B18521_I_AK_MBRC_RFD_Stage_3\DRG\LPR_Report\FLD_022_130201_Sensitivity_S12.WOR

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