Regional Floodplain Database:

Hydrologic and Hydraulic Modelling - Redcliffe (RED)

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Regional Floodplain Database Hydrologic and Hydraulic Modelling

Redcliffe (RED) **June 2012**

Moreton Bay Regional Council

Emergency Management EMQ Queensland

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Synopsis :	Report outlining the study data, methodology and delivery of the detailed modelling of the Redcliffe catchment, as part of Moreton Bay Regional Council's Regional Floodplain Database (Stage 2, Package 2) project.

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1 INTRODUCTION

Moreton Bay Regional Council (MBRC) is currently undertaking Stage 2 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 includes the detailed hydrologic and hydraulic modelling of 5 packages, which cover 11 catchments in the MBRC LGA. This report discusses the study data, methodology and results for Stage 2, Package 2 of the RFD (i.e the detailed hydrologic and hydraulic modelling) for the Redcliffe catchment. Furthermore, this stage will form the basis of Stage 3 of the RFD, which aims to analyse the results of the detailed modelling for the purposes of understanding and managing flood risk in the MBRC LGA.

1.1 Scope

The detailed models of the Redcliffe 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 broad scale model that was developed by MBRC as part of the RFD. The following primary alterations were made to convert the broad scale model to a detailed model:

- The model computational grid resolution was refined from 10m to 5m;
- 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 Redcliffe 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 Stage 3 of the RFD.

1.3 General Approach

The general approach for this study is summarised as follows:

- Review existing broad scale WBNM hydrologic model and results;
- Review existing broad scale TUFLOW modelling;
- Refine the TUFLOW modelling to include a refined grid size and any additional structure and topographical information;
- Investigate the feasibility of calibrating and/or verifying the combined WBNM and TUFLOW models using two historical events. There was insufficient historical information available for this task, therefore calibration was not undertaken;
- Undertake a critical storm duration assessment for the 10 year ARI event, 100 year ARI event and the PMF;
- 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 up to 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 was 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 Redcliffe 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 (Worley Parsons, 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 Redcliffe 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 that were generated using a tool that was developed and run by Worley Parsons. The DEM resolution was 2.5m (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 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); and
- **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.

3 METHODOLOGY

3.1 Data Review

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

- The infrastructure data within the catchments;
- The historical flooding information of the catchments; and
- The broadscale subcatchment delineations.

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 Redcliffe 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:

- 2 DTMR bridge and culvert structures were prioritised as category A, along with 17 additional crossings;
- 2 additional crossings were prioritised as category B;
- 1 MBRC bridge plan; and
- 9 channel information to be provided by MBRC.

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 this report, along with the collection of gauge data from the Bureau of Meteorology (BoM). The feasibility of using historic flood events for calibrating the Redcliffe model was assessed. The assessment concluded that there is insufficient data available in the catchment to perform calibration and validation to historical flood events. A full copy of this report is provided in Appendix C.

3.1.3 Hydrography Review

The subcatchment delineation completed as part of Stage 1 was reviewed. The review recommended that the subcatchment delineation was sufficient for the purposes of the detailed modelling at that no refinement of the subcatchment delineation was necessary. A full copy of the report is provided in Appendix B.

3.2 Hydrologic Model

The existing hydrological WBNM model for the Redcliffe 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) 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, was 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 a set of Z points provided by MBRC, with a computational grid resolution of 5m. 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 Worley Parsons). 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 Redcliffe model layout.

3.3.3 Model Structures

The Redcliffe catchment is highly urbanised, and contains a number of engineered open drains and canals. These waterways were represented in the 2D domain using break line terrain modifiers, with invert levels inspected from a combination of the supplied DEM and engineering drawings. 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 provided by MBRC 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 Figure 3-2 and Table 3-1.

Table 3-1 Hydraulic Model Landuse Categorisation

Landuse Type	Manning's ‘n’ Roughness Coefficient
Roads/Footpaths	0.015
Waterbodies	0.030
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 up to a depth of 1.5m to 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).

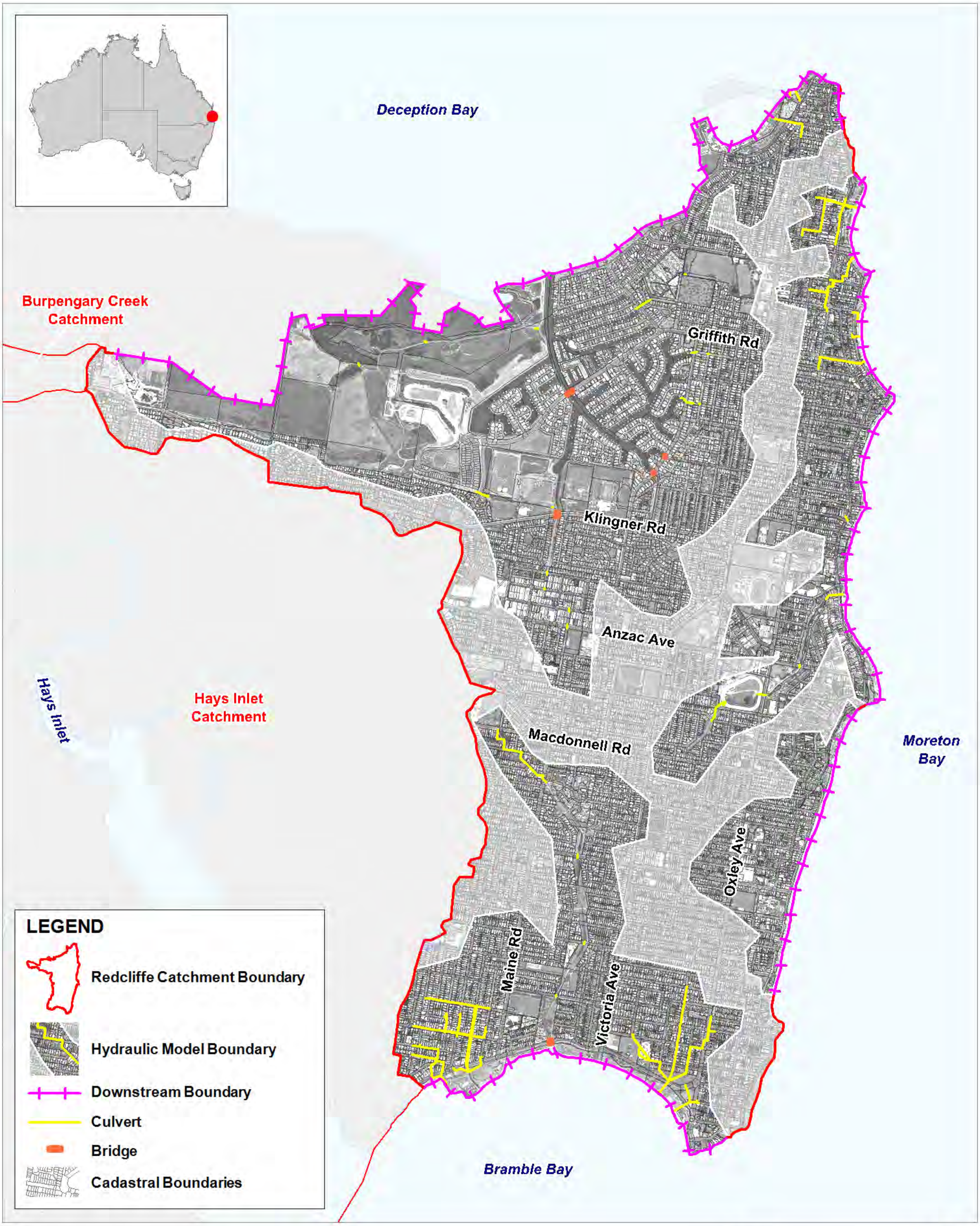
3.3.5 Model Boundaries

The results of the WBNM hydrologic model were used to generate rainfall inflows 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 in 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



Title:
Hydraulic Model Layout

Figure: 3-1

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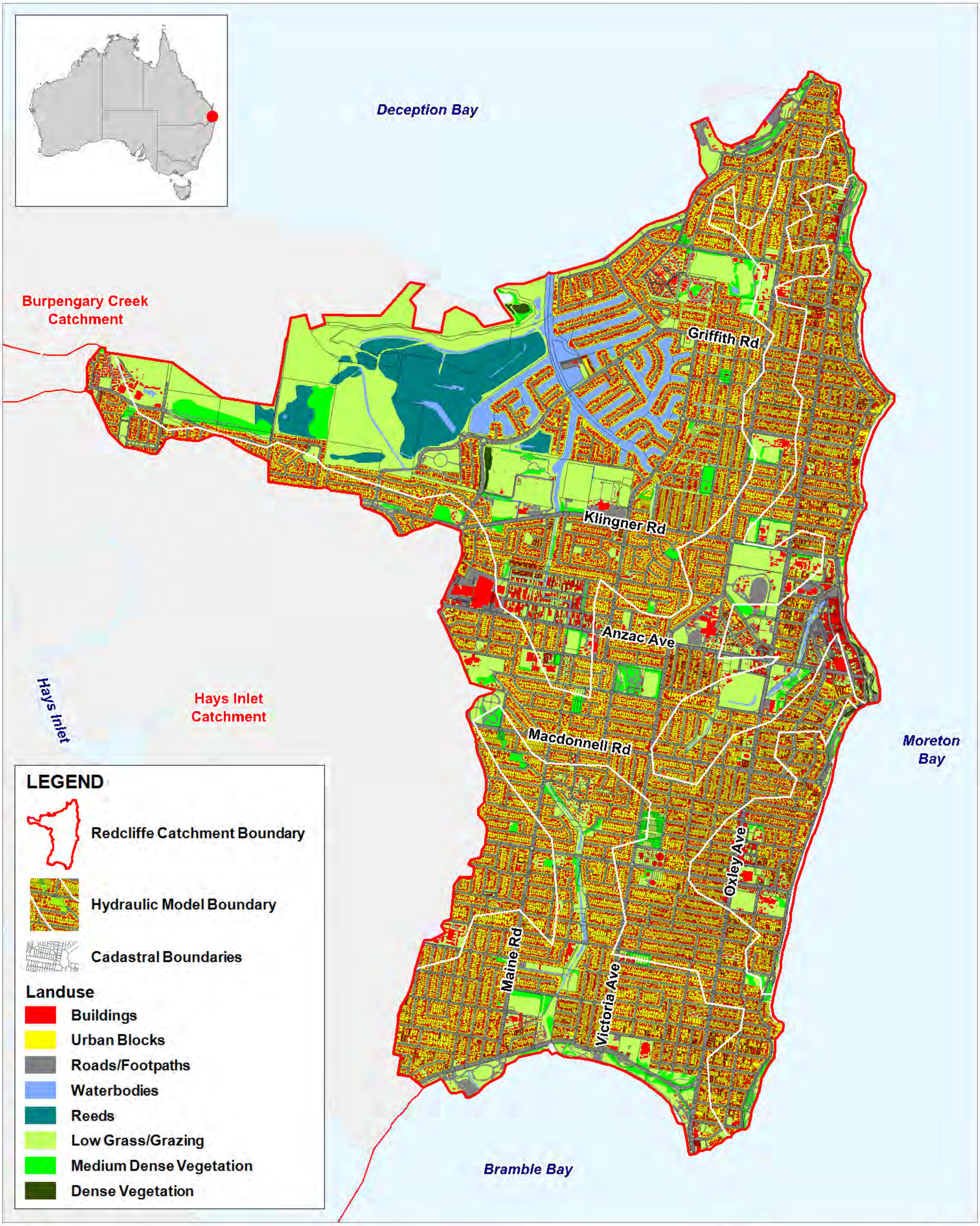

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Landuse Mapping – Existing Conditions

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. No calibration or verification was undertaken on the Redcliffe catchment due to insufficient historical records on flood levels, as outlined in Section 3.1.2. However the adopted model parameters are based on a consistent set of model parameters that were applied over the entire MBRC LGA. This consistent parameter set was determined in view of the calibration of a number of other models in the region. Therefore the model parameters that were applied are effectively verified through surrogate model calibration and verification.

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 and 10 year ARI events);
- 100 year ARI event, to represent larger events (20, 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 Redcliffe model, the following methodology was adopted:

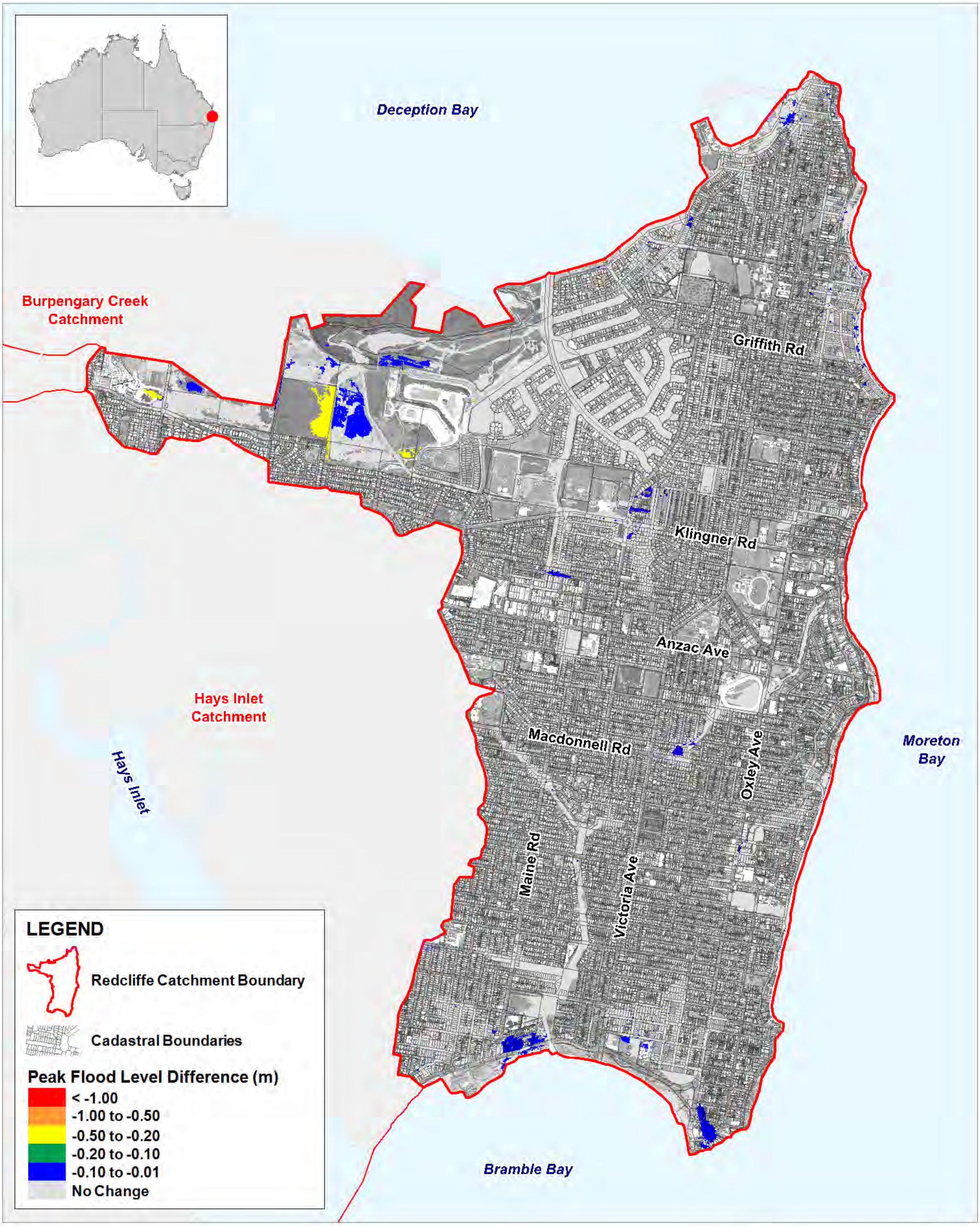
1. Hydrologic and hydraulic modelling of a range of storm durations (0.5hr, 1hr, 3hr, 6hr, 12hr, 24hr and 48hr) for the 10 year, 100 year and PMF events; 5 hour storm duration was also tested for the PMF event.
2. Mapping of the peak flood level results for the ‘maximum envelope’ of all the storm durations 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 100 year ARI 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 where flood levels are under predicted.

Table 3-3 Critical Storm Duration Selection

Assessment Event	Selected Critical Durations	Adopted Event
10 year ARI	1 and 3 hour storm	1, 2, 5 and 10 year ARI
100 year ARI	1 and 3 hour storm	20, 50 and 100 year ARI
Probable Maximum Flood	0.5, 1 and 3 hour storm	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.



Title:

Critical Duration Assessment
Peak Flood Level Difference – 10 Year ARI

Figure: 3-3

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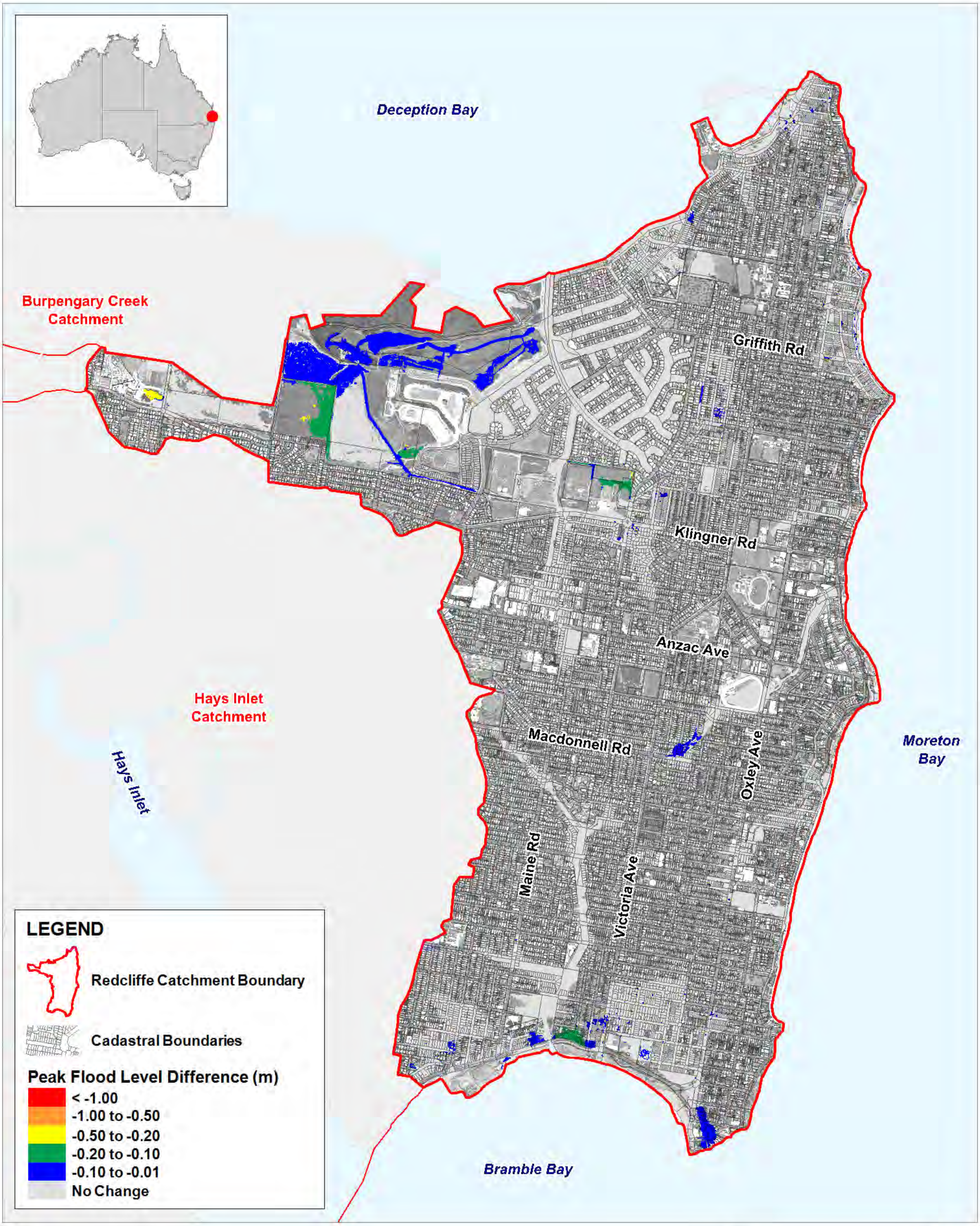

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Critical Duration Assessment
Peak Flood Level Difference – 100 Year ARI

Figure: 3-4

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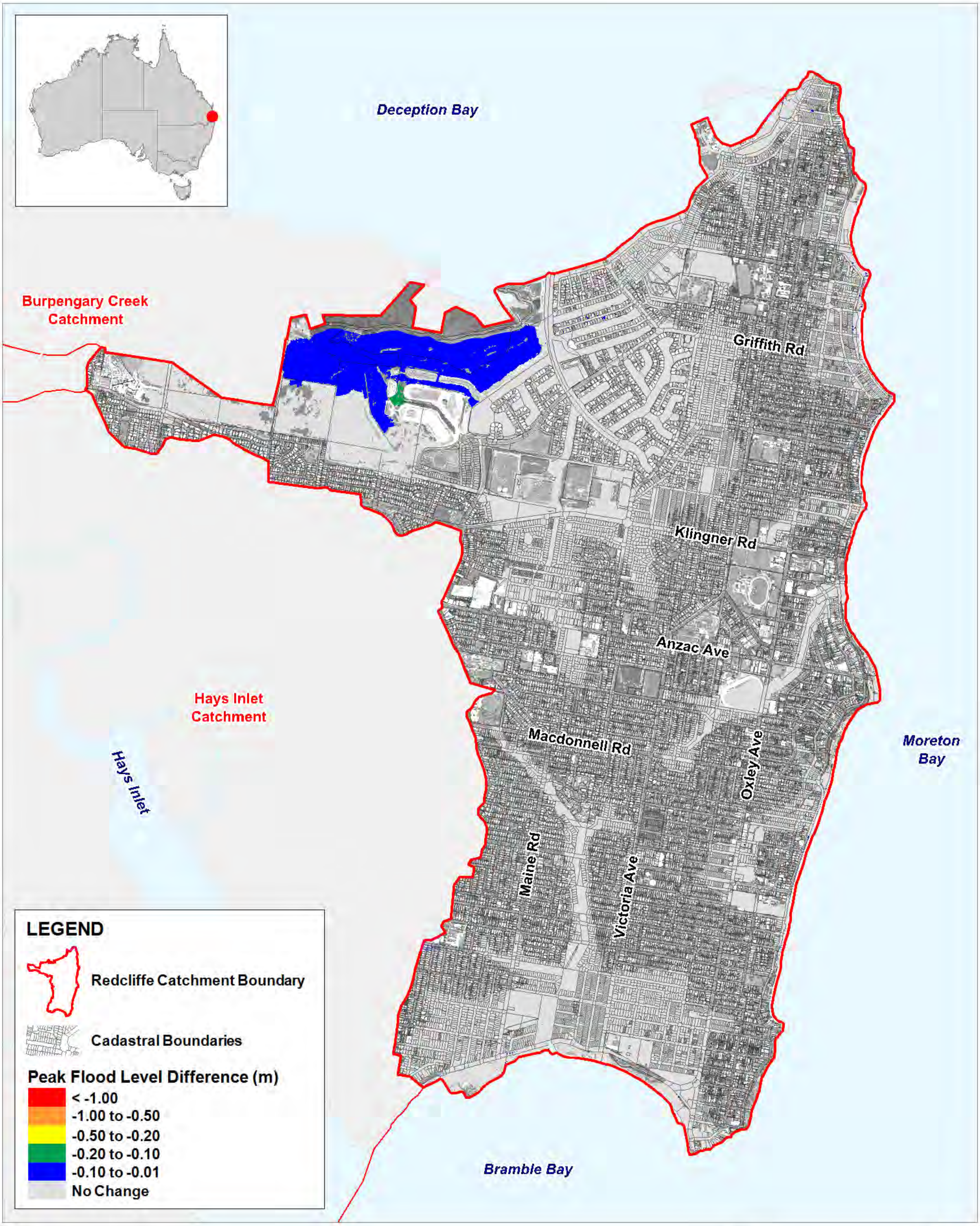

Title:

Critical Duration Assessment
Peak Flood Level Difference – PMF

Figure: **3-5**

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3.5.2 Design Event Simulations

The Redcliffe 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 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 Redcliffe 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

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 following reference points were used: eastern coast – MBC-093; northern coast – MBC-106; and southern coast – MBC-086);
- **Storm Tide Scenario 2:** Investigated the impact of a 100 year static storm tide level 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.

A summary of the static tide levels used is shown in Table 3-4.

Table 3-4 Static Storm Tide Levels

Static Storm Tide Scenario	Tide Level (mAHD)
Scenario 2 (100 year Current)	Eastern and northern coast = 2 Southern coast = 2.1
Scenario 3 (100 year GHG + 0.8m)	Eastern coast = 3 (2.2 static + 0.8) Northern coast = 2.9 (2.1 static + 0.8) Southern coast = 3.1 (2.3 static + 0.8)

4 RESULTS AND OUTCOMES

4.1 Calibration and Verification

As discussed in Section 3.4, there were insufficient historical records of flood levels to calibrate the model. As such, there are no calibration results for this catchment. However the adopted parameters have undergone substantial calibration in adjoining catchments and are therefore considered suitable (SKM, 2012b).

4.2 Design Flood Behaviour

4.2.1 Model Results

The following data were output by the model at 5 minute 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. A comparison of this event with the 100 year design flood event with selected critical durations (1 hour and 3 hour) is provided in Appendix F. The results indicate that there is less than 100mm difference in flood levels between these two design events.

4.3.1 Future Landuse Analysis

Since the catchment is highly urbanised, with only small pockets of vegetation, the peak flood levels are generally insensitive to increased vegetation roughness, with changes in peak flood levels being less than 100mm. However, flood levels in some vegetated areas, such as HA Dalton Park, KR Benson Park and MJ Brown Park are more sensitive to increased vegetation density, with flood levels increasing by more than 100mm.

4.3.2 Hydraulic Roughness Analysis

Apart from a few small isolated areas, increasing Manning's 'n' by 20% has resulted in no changes in peak flood level of more than 100mm.

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 flood level increases are significant in some places, being over 0.5m.

4.3.4 Climate Change and Downstream Boundary Conditions Analysis

Neither increased sea levels due to climate change or high tidal surges have a significant effect on flood levels in Redcliffe. This is because the peninsular rises steeply along the coastal edges. Increases in flood levels due to sea level rise or tidal surges are therefore only occurring along the outer fringe of the peninsular.

Increases in rainfall intensity mostly result in changes in flood levels of no more than 100mm. However, in some locations where there is a significant accumulation of runoff, such as along some of the main gullies, there has been an increase in flood level of more than 100mm.

These increases in flood level due to increased rainfall intensity are further exacerbated when combined with a tidal surge and sea level rise altogether. In this case, there are significant increases in flood levels throughout the catchment. However, upper reaches of the catchment remain unaffected.

4.4 Model Limitations

Watercourses within the Redcliffe catchments were represented in the 2D domain, for which the grid resolution is limited to 5m. 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.

5 CONCLUSION

A 5m grid resolution TUFLOW model of the Redcliffe catchment was developed for MBRC. 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 will be used in stage 3 of the RFD to analyse and assist with managing flood risk in the Redcliffe catchment.

6 REFERENCES

Aurecon (2010): *Floodplain Structures Regional Floodplain Database Moreton Bay Regional Council*

BMT WBM, 2010: H*ydraulic Modelling (Broadscale) Regional Floodplain Database Stage 1 Sub-project 1D*

Cardno Lawson Treloar (2010): *Moreton Bay Regional Council – Storm Tide Hydrograph Calculator*

Department of Infrastructure, Planning and Natural Resources - New South Wales (DIPNR), 2005: *Floodplain Development Manual the management of food liable land*

GHD (2010): *Moreton Bay Regional Council Regional Floodplain Database Sub-project 2K Historic Flood Information*

SKM (2010): *MBRC Regional Floodplain Database Existing, Historic and Future Floodplain Land Use*

SKM (2012a): *MBRC Regional Floodplain Database Boundary Conditions, Joint Probability & Climate Change*

SKM (2012b): *MBRC Regional Floodplain Database Floodplain Parameterisation*

The Institution of Engineers Australia (2001): *Australian Rainfall and Runoff*

Worley Parsons (2010a): *Regional Floodplain Database Floodplain Terrain*

Worley Parsons (2010b): *Design Rainfall - Burpengary Pilot Project*

.

APPENDIX A

APPENDIX A: INFRASTRUCTURE DATA ASSESSMENT REPORT

A part of BMT in Energy and Environment

Infrastructure Data Assessment Report Hays Inlet and Redcliffe Catchments Regional Floodplain Database Stage 2 Package 2

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June 2012

Infrastructure Data Assessment Report Hays Inlet and Redcliffe Catchments Regional Floodplain Database Stage 2 Package 2

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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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	Client : ***Client Contact:*** ***Client Reference***	Moreton Bay Regional Council Steve Roso / Hester van Zijl Regional Floodplain Database Stage 2

Title :	Infrastructure Data Assessment Report for the Hays Inlet and Redcliffe catchments as part of Moreton Bay Regional Council's Regional Floodplain Database Stage 2
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 Hays Inlet and Redcliffe catchments for Moreton Bay Regional Councils RFD Stage 2

REVISION/CHECKING HISTORY

REVISION NUMBER	DATE OF ISSUE	CHECKED BY		ISSUED BY	
0	19/10/2010	R Sharpe		A Kolega	
1	15/06/2012	M Hovey		R Sharpe	

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1 INTRODUCTION

1.1 Background

Moreton Bay Regional Council (MBRC) is currently undertaking Stage 2 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 2 includes the detailed hydrologic and hydraulic modelling of 5 packages, which cover 11 catchments in MBRC LGA. This *Infrastructure Data Assessment report* forms part of the hydrologic and hydraulic modelling report of the Hays Inlet and Redcliffe catchments RFD Stage 2, Package 4.

1.2 Scope

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

- Review available information provided by Council and the Department of Transport and Main Roads (DTMR);
- Undertake a gap analysis based on the broadscale model results and other data provided by Council (i.e. cadastre, local roads, state controlled roads, topographic data);
- 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, more than smaller events.

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 for all 5 packages.

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). The LiDAR data was used to create a 2.5m grid Digital Elevation Model (DEM);
- Hydrography Dataset provided by MBRC in September 2010;
- State controlled roads and minor roads GIS layers provided by MBRC in September 2010;
- As-constructed bridge plans for selected structures along state controlled roads provided by DTMR where available. The categorisation of high, medium and low priority for the DTMR structures was previously undertaken by Aurecon. Based on this desktop assessment, Council requested the as-constructed plans from DTMR to speed up the data consolidation process;
- As-constructed bridge plans for selected minor roads in MBRC LGA were provided by MBRC where available;
- Structure dataset provided by MBRC for the Hays Inlet catchment (derived from the former Pine Rivers Shire Council);
- The flood extents from the Stage 1 broadscale model sub-project were utilised to locate potential structures; and
- A site visit undertaken in the Hays Inlet and Redcliffe catchments on 1 October 2010.

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 state controlled roads layers were overlaid with the broadscale flood extent in the probable maximum flood (PMF) event to locate waterway structures. Each crossing was marked, if none of the available data already existed in these locations (gap analysis).

The DTMR structures that have previously been categorised as *medium* and *low* priority were reviewed and prioritised.

The data prioritisation was undertaken based on the following considerations:

- The location of the structures within the catchment; e.g. structure data were considered lower priority at the upstream end of tributaries;
- The vicinity to denser populated areas; e.g. rural areas in the upper part of the catchment were considered lower priority;
- The height of a bridge structure, i.e. if the road and structure soffit is well above the water level (i.e. Houghton Highway Bridge), it is anticipated that a flow constriction can be applied to the model based on photos and the site visit. Selected photos taken during the site visit are presented in Appendix B (Figures B-1 to B-7); and
- The flood gradient and flood behaviour in the vicinity of the structures based on the broadscale model results; where a structure is located within a wide floodplain and not within the major flowpath, (downstream part of the catchment along Beachmere Road), details were considered of lower priority.

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 Hays Inlet and Redcliffe catchments identified the following summary of available data and potential additional structure locations:

- MBRC bridge plans were provided for 1 structure in the Redcliffe catchment;
- DTMR bridges (high, medium and low category) were provided at approximately 9 locations in the Hays Inlet, and 3 locations in the Redcliffe catchment; and
- Structures with no available information have been located at 31 road and flood extent crossings.

Figure A-1 in the Appendix provides a summary of the available and the additional structures identified from the gap analysis. The data prioritisation undertaken in category A and B for the additional locations and the remaining DTMR structures are illustrated in Figure A-2.

The data prioritisation results in the following summary for bridges and culverts:

- 4 DTMR structures prioritised as category A (that were previously categorised “medium”);
- 4 DTMR structures prioritised as category B (that were previously categorised “low”);
- 19 additional crossings (bridges or culverts) prioritised as category A; and
- 12 additional crossings (bridges or culverts) prioritised as category B.

In consultation with MBRC, it is anticipated that Council will source and provide the DTMR as-constructed bridge plans (at east for priority A).

3.2.2 Channels

From the site visit and aerial photography nine channels have been identified in the Redcliffe catchment. Detailed information for these channels is currently being sourced from Council.

3.2.3 Detention Basins

Two basins were identified in the Hays Inlet catchment in the vicinity of the Black Duck Lakes, to the North and the South of Dohles Rocks Road. Information on the basin embankment height is required for these locations; refer to Figure A-2.

3.2.4 Bathymetry

Based on the current DEM it is anticipated that no additional bathymetry data is required in the Hays Inlet and Redcliffe catchments.

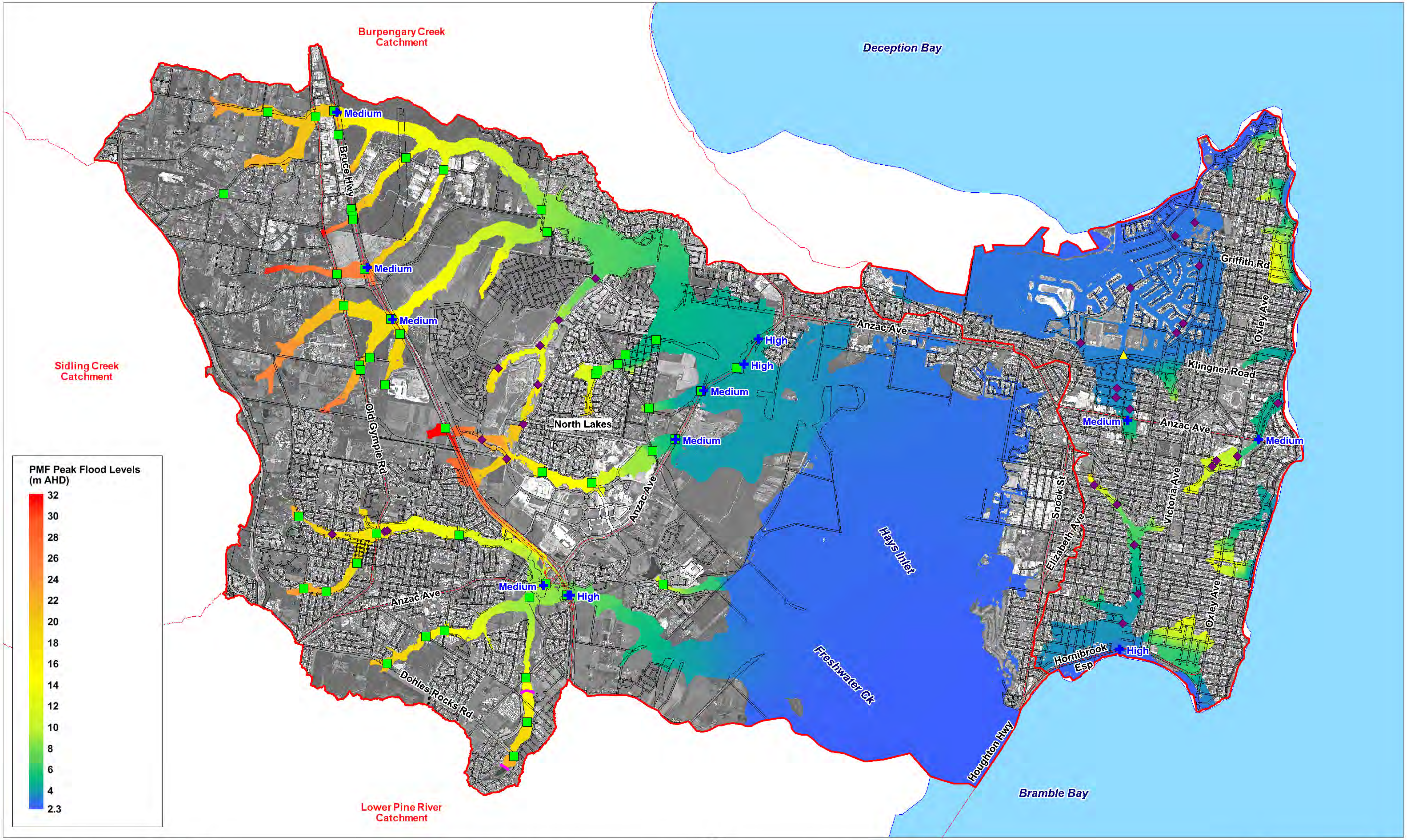
4 CONCLUSION AND RECOMMENDATION

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

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

The development of the Regional Floodplain Database (RFD) will be used not only for the purposes of the RFD, but can also be used for other asset data management purposes by Moreton Bay Regional Council, and therefore this is a good opportunity for Council to collect additional data on waterway structures, especially in the former Caboolture Shire Council and Redcliffe City Council areas.

APPENDIX A: MAPS



LEGEND

- Redcliffe Catchment
- Hays Inlet Catchment
- DMTR Structures (Previous Categories)
- Structure Dataset Provided by MBRC (Former Pine Rivers Shire Council)
- Bridge with As-Construction Plans Provided by MBRC
- Additional Identified Structures
- Basin Embankment
- Road Reserves
- State Controlled Roads
- Minor Roads and Road Reserves

Title:

Infrastructure Data Summary
Hays Inlet and Redcliffe Catchments

Figure: **A-1**

Rev: **A**

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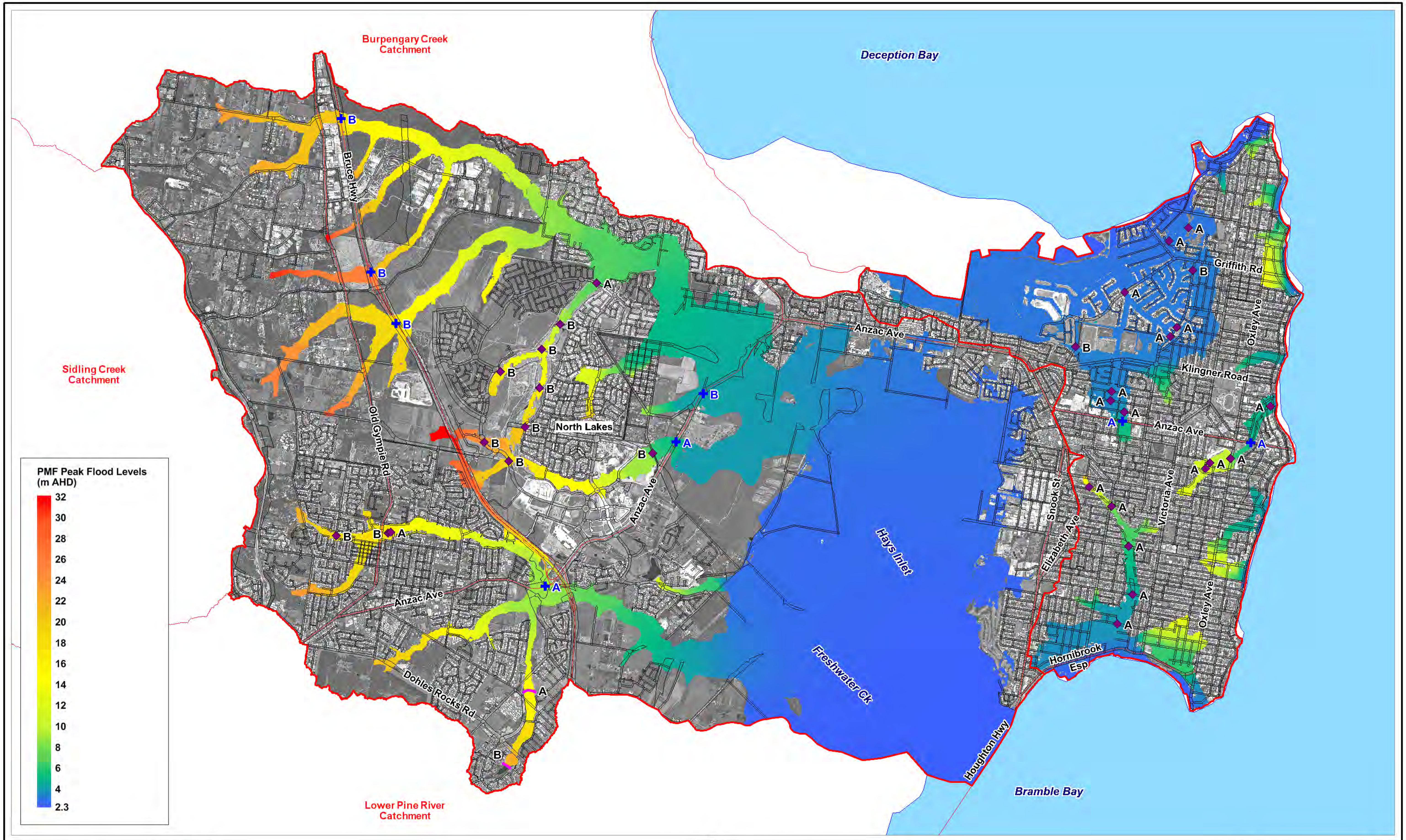

LEGEND

- Redcliffe Catchment
- Hays Inlet Catchment
- DMTR Structures
- Additional Identified Structures
- Basin Embankment
- Road Reserves
- State Controlled Roads
- Minor Roads and Road Reserves

Title:

Data Prioritisation Map
Hays Inlet and Redcliffe Catchments

Figure: A-2

Rev: A

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APPENDIX B: SITE VISIT PHOTOS

Figure B-1 Hays Inlet Catchment Black Duck Lakes, Weir near Dohles Rocks Road

Figure B-2 Hays Inlet catchment Black Duck Lake between Ogg Road and Blackall Road

Figure B-3 Hays Inlet catchment, Dohles Rocks Road

Figure B-4 Hays Inlet Catchment Brays Road

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Figure B-7 Hays Inlet catchment, Bounty Boulevard, North Lakes

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Figure B-9 Redcliffe Catchment, Corner of Walsh and Yates Street, Looking Upstream

Figure B-10 Redcliffe Catchment, Anzac Avenue (near Dorall Street)

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APPENDIX B

APPENDIX B: HYDROGRAPHY REVIEW REPORT

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Our Ref: AK: L.B18104.002.Hydrography Review.doc

10 December 2010

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

Attention: Hester van Zijl

Dear Hester,

RE: Hydrography Review Report for the Hays Inlet, Redcliffe and Caboolture River Catchments Regional Floodplain Database Stage 2, Packages 2 and 4

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 2 of the RFD comprises the detailed modelling of 11 catchments (5 packages) covering the MBRC LGA.

This *Hydrography Review Report* forms part of the modelling of the following two packages, RFD, Stage 2:

- Hays Inlet and Redcliffe catchments (package 2); and
- Caboolture River catchment (package 4).

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);
- Review previous flood studies within the Hays Inlet, Redcliffe and Caboolture River catchments (provided by MBRC);
- Identify areas that are to be refined; 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 Council is heavily involved in the study, which will enhance future usage of the models and data within Council. Council'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 Council'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 catchments, which is consistent with Council'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) provided by MBRC in September 2010;
- Flood extent (100 Year Embedded Design Storm) derived from RFD, Stage 1, broadscale modelling (BMT WBM, 2010);
- Flood extent (100 Year ARI) of the previous flood study for the Caboolture River catchment (Australian Water Engineering, 1994) provided by MBRC in November 2010;
- Flood extent from combined and transition flood study results (100 Year ARI) based on previous flood studies and storm surge studies in the Hays Inlet and Redcliffe catchments (various consultants). The Hays Inlet catchment was previous split into two subcatchments, formerly called Saltwater and Freshwater Creek catchments; and
- Digital Elevation Model for the three catchments provided by MBRC in September 2010 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. It was noted that in some localised areas the resolution of the original subcatchment delineation is too coarse to replicate the flood extent from the previous studies. These areas were identified by comparing the flood extent from the previous studies with the flood extent from the broadscale models, and checking for areas where the flood extent from the previous studies covered additional tributaries or extended further upstream. The difference in the flood extent is due to the subcatchment breakdown, the associated distribution of flow within each subcatchment and/or the location of the inflows to the hydraulic model.

6 Proposed Changes

Subcatchments that were considered too coarse were subdivided, thereby refining the hydrography and the associated future model output and flood information across the catchments. The proposed changes to the subcatchments are illustrated in Figures 1 and 2. Figures 1 and 2 also show the original subcatchment delineation and the flood extent from the broadscale models and the previous studies in the Hays Inlet and Redcliffe catchments and the Caboolture River catchment respectively.

Accompanying this report, two digital datasets have been provided to MBRC on 08 December 2010:

- *DWCP_Hydro_Catchments_Minor_BMTWBMrevised.TAB*, comprising all subcatchments including the proposed subcatchments; and
- *Proposed_catchment_delineation.TAB* including only the catchments that we propose to change within the three catchments of Redcliffe, Hays Inlet and Caboolture.

The following subcatchments are proposed to be subdivided:

Subcatchment Identifier	Catchment	Minor Basin
FWC_01_14222	Freshwater Creek	Hays Inlet
FWC_02_01351	Freshwater Creek	Hays Inlet
FWC_05_00000	Freshwater Creek	Hays Inlet
FWC_05_00808	Freshwater Creek	Hays Inlet
FWC_08_02696	Freshwater Creek	Hays Inlet
SWC_01_18277	Saltwater Creek	Hays Inlet
SWC_01_18995	Saltwater Creek	Hays Inlet
SWC_02_00000	Saltwater Creek	Hays Inlet
SWC_02_00970	Saltwater Creek	Hays Inlet
SWC_04_00264	Saltwater Creek	Hays Inlet
SWC_08_00418	Saltwater Creek	Hays Inlet
SWC_12_03272	Saltwater Creek	Hays Inlet
SWC_14_04906	Saltwater Creek	Hays Inlet
SWC_14_05488	Saltwater Creek	Hays Inlet
SWC_20_00619	Saltwater Creek	Hays Inlet
SWC_22_01072	Saltwater Creek	Hays Inlet
SWC_24_00639	Saltwater Creek	Hays Inlet
SWC_26_01113	Saltwater Creek	Hays Inlet
SWC_28_01496	Saltwater Creek	Hays Inlet
SWC_32_01672	Saltwater Creek	Hays Inlet
SWC_40_00247	Saltwater Creek	Hays Inlet
GYM_01_08692	Gympie Creek	Caboolture River
GYM_04_01218	Gympie Creek	Caboolture River
GYM_06_00322	Gympie Creek	Caboolture River
WAR_01_12320	Wararba Creek	Caboolture River
WAR_01_13474	Wararba Creek	Caboolture River
WAR_44_00000	Wararba Creek	Caboolture River
WAR_50_04019	Wararba Creek	Caboolture River
WAR_50_06071	Wararba Creek	Caboolture River
WAR_52_00000	Wararba Creek	Caboolture River

The subcatchment breakdown for the subcatchment with the ID "WAR_50_06071" is suggested for consistency of subcatchment sizes in this vicinity (not because of previous flood studies).

7 Recommendation

We recommend that Council 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

Australian Water Engineering, 1994, Caboolture Flood Study comprising Caboolture River, King John and Lagoon Creek, prepared for Caboolture Shire Council.

Please contact myself or Richard Sharpe should you wish to discuss the report.

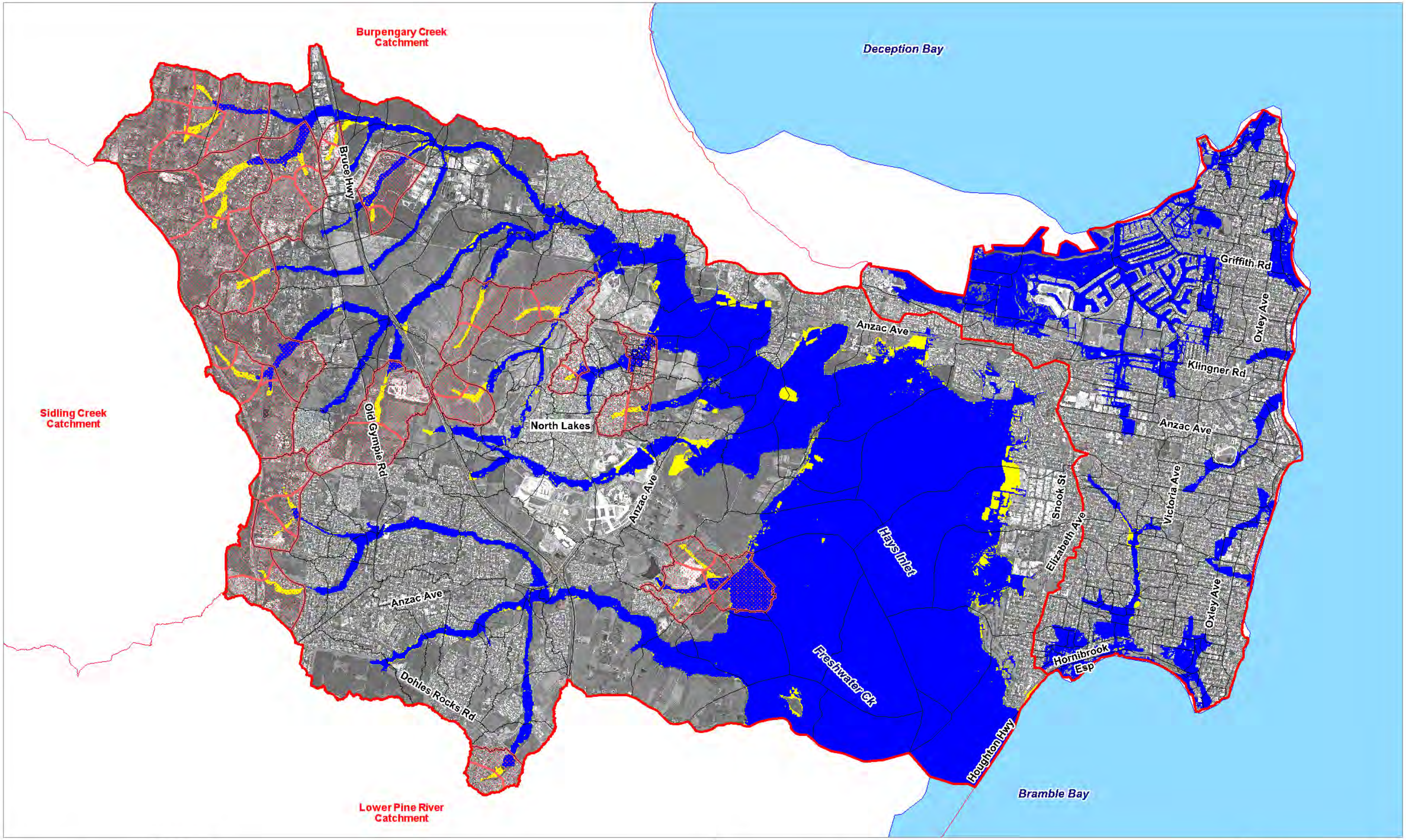
Yours faithfully
BMT WBM Pty Ltd

Anne Kolega

Enclosed:

Figure 1: Hydrography Review and Proposed Changes Hays Inlet and Redcliffe Catchments

Figure 2: Hydrography Review and Proposed Changes Caboolture River Catchment



LEGEND

- Redcliffe Catchment
- Hays Inlet Catchment
- Stage 1 Flood Extent (100 Year EDS)
- Previous Study Flood Extent (100 Year ARI)
- Original Catchment Delineation
- Proposed Catchment Delineation

Title:

Hydrography Review and Proposed Changes
Hays Inlet and Redcliffe Catchments

Figure: 1

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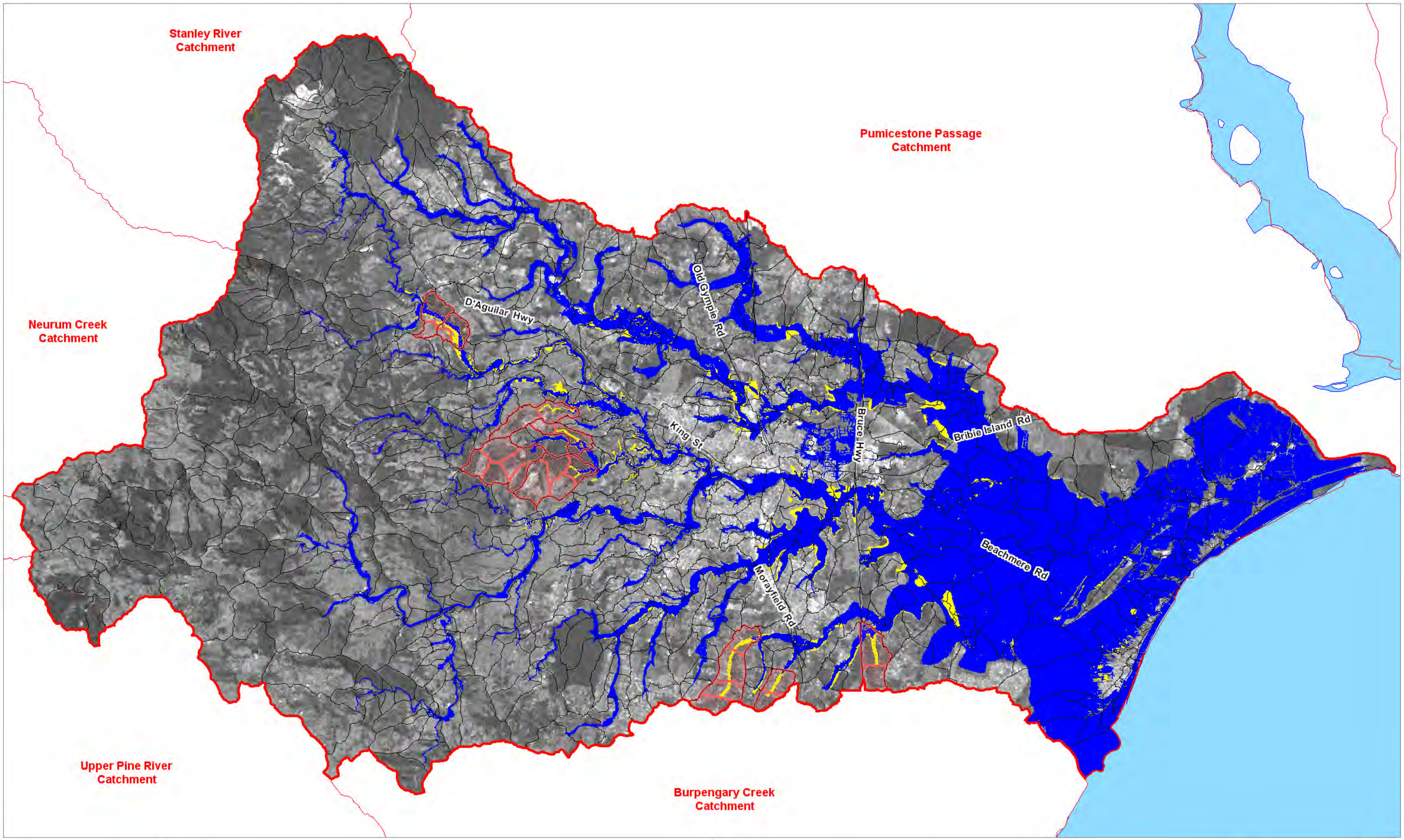

LEGEND

- Caboolture River Catchment
- Stage 1 Flood Extent (100 Year EDS)
- Previous Study Flood Extent (100 Year ARI)
- Original Catchment Delineation
- Proposed Catchment Delineation

Title:

Hydrography Review and Proposed Changes
Caboolture River Catchment

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Figure: 2

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APPENDIX C

APPENDIX C: CALIBRATION AND VALIDATION REPORT

A part of BMT in Energy and Environment

Calibration Feasibility Report Hays Inlet and Redcliffe Catchments Regional Floodplain Database Stage 2

R.B18104.003.01.P2_HAY_RED_Calibration_
Feasibility_Report_doublesided.doc
June 2012

Calibration Feasibility Report Hays Inlet and Redcliffe Catchments Regional Floodplain Database Stage 2

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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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Document :	R.B18104.003.01.P2_HAY_RED_Calibration_Feasibility_Report_doublesided.doc
Project Manager :	Richard Sharpe
Client :	Moreton Bay Regional Council
Client Contact:	Steve Roso
Client Reference	Regional Floodplain Database

Title :	Calibration Feasibility Report Hays Inlet and Redcliffe Catchments Regional Floodplain Database Stage 2
Author :	Richard Sharpe \ Anne Kolega
Synopsis :	Calibration Feasibility Report including the review of available rainfall and river gauge data for the calibration of the combined hydrologic and hydraulic models developed for the Hays Inlet and Redcliffe catchment for Moreton Bay Regional Councils RFD Stage 2.

REVISION/CHECKING HISTORY

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1 INTRODUCTION

1.1 Background

Moreton Bay Regional Council (MBRC) is currently undertaking Stage 2 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 2 includes the detailed hydrologic and hydraulic modelling of 5 packages, which cover 11 catchments in MBRC LGA. This *Calibration Feasibility report* forms part of the hydrologic and hydraulic modelling report of the Hays Inlet and Redcliffe catchments RFD Stage 2, Package 2. Through Stage 2 of the RFD, hydraulic models of the Hays Inlet and Redcliffe catchments will be developed. The aim of this assessment is to investigate the feasibility of calibrating these hydraulic models by considering the quantity and quality of rainfall gauge, river gauge and other information on flooding in the catchments.

1.2 Scope

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

- Review available information on historical flooding provided by MBRC sourced from MBRC and Queensland Department of Environment and Resource Management (DERM);
- Collect river stream gauge data available from the Bureau of Meteorology (BoM);
- Document available data for model calibration, such as rainfall and river levels; and
- Assess the feasibility of using recorded data from historical flood events to calibrate the Hays Inlet and Redcliffe hydraulic models.

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2 HISTORICAL FLOODING

The Redcliffe peninsular has a number of canals and drains that are susceptible to the ingress of sea water or backup of rainfall runoff in the drains during high tides. King tides are known to cause some flooding in the streets of Redcliffe. Rainfall records in the catchment that have been reviewed as part of this assessment (first gauges installed in 1970) suggest that the most significant rainfall events were in 1974, 1980 and 1981.

The Hays Inlet estuary flows into Bramble Bay. As such the lower reaches of the Saltwater and Freshwater Creeks may be susceptible to flooding during high tides and ocean storm surges. The rainfall records reviewed as part of this assessment (first gauges installed in 1970) suggest that the Hays Inlet catchment's most significant rainfall event occurred in 1974. A number of rainfall events have occurred in the catchment, but none in the reviewed records stand out as being especially large and infrequent. This suggests that a large infrequent rainfall event has not occurred in the catchment since the rainfall gauges were installed in 1970.

It is noted that the Pine River and the Caboolture River catchments recorded major rainfall depth in January 2011, resulting in the highest river levels on record for the Caboolture River. However this event did not result in large amounts of rainfall (or flooding issues) in the Hays Inlet and Redcliffe catchments.

3 AVAILABLE DATA

3.1 Stream Gauge Data

Stream data received from MBRC were reviewed and none was identified to be located within the Hays Inlet or Redcliffe catchment areas. BoM's river data stations were also reviewed online (*Source: http://www.bom.gov.au/qld/flood/seast.shtml*) with no gauge stations found within the catchment areas.

3.2 Rainfall Data

Rainfall gauge data was provided by MBRC comprising the three categories:

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

Review was undertaken to identify relevant rainfall data from stations that are located within the Hays Inlet and Redcliffe catchments. Table 3-1 summarises the rainfall data owned by BoM and provided by MBRC for the Hays Inlet and Redcliffe catchments, and Figure 3-1 highlights the gauge locations.

Table 3-1 Rainfall Data Summary

Sensor Name	Sensor Type	BoM Station	Start Date	End Date
Lipscombe Road AL	Rainfall Alert	540445	06/2008	09/2009
Bramble Bay Bowling Club	Rainfall Daily	40807	03/1990	02/1998
Clontarf	Rainfall Daily	40965	01/1987	ongoing
Mango Hill	Rainfall Daily	40986	11/1979	03/2009
Narangba Railway Station	Rainfall Daily	40159	01/1970	10/1986
Margate Collins St	Rainfall Daily	40180	11/1886	ongoing
Redcliffe Council	Rainfall Daily	40697	02/1981	11/2004
Margate Collins St	Pluviometer	40180	03/1963	05/1989
Redcliffe	Pluviometer	40958	11/2004	ongoing
Redcliffe Council	Pluviometer	40697	05/1989	11/2004

3.3 Maximum Height Indicators

Maximum height indicators from MBRC were reviewed. The gauge stations identified within the Hays Inlet catchment are listed in Table 3-2 and shown in Figure 3-1. These height indicators are typically used for road safety purposes and are not appropriate for hydraulic model calibration.

Table 3-2 Maximum Height Indicators Summary

Creek	Location	Level RL
Black duck Creek	Brays Road	9.2
Freshwater Creek	Halpine Dam Spillway	18.5
Freshwater Creek North	Duffield Road	12.1
Freshwater Creek South	Brays Road	7.9
Saltwater creek - Tributary C	North Lakes Golf Course	18.6

3.4 Water Quality Event Monitoring

MBRC has installed a number of Water Quality Event Monitoring data which were also reviewed for utilisation during model calibration. Gauge stations identified within Hays Inlet catchment are listed in Table 3-3.

Table 3-3 Water Quality Event Monitoring Summary

Creek	Location
Saltwater Creek - Tributary C	Kinsellas Road West - Mango Hill
Saltwater Creek - Tributary A	North Ridge Circuit - North Lakes
Freshwater Creek	Bruce Highway - Murrumba Downs
Freshwater Creek - Black Duck 1	Ogg Road - Murrumba Downs
Freshwater Creek - Black Duck 2	McClintock Drive - Murrumba Downs
Freshwater Creek - Halpine Dam	Freshwater Creek Road - Mango Hill
Freshwater Creek - Halpine Dam	Freshwater Creek Road - Mango Hill
Saltwater Creek - Tributary A	Goodwin Road - Narangba
Saltwater Creek - Tributary B	Bounty Boulevard -North Lakes

These gauges record water levels, rainfall and turbidity and were installed in 2007 (except for the Saltwater Creek Tributary C gauge in the North Lakes Development which was installed in 1990). The gauge data may be used as additional information on flood levels for model calibration. The gauge locations are illustrated in Figure 3-1.

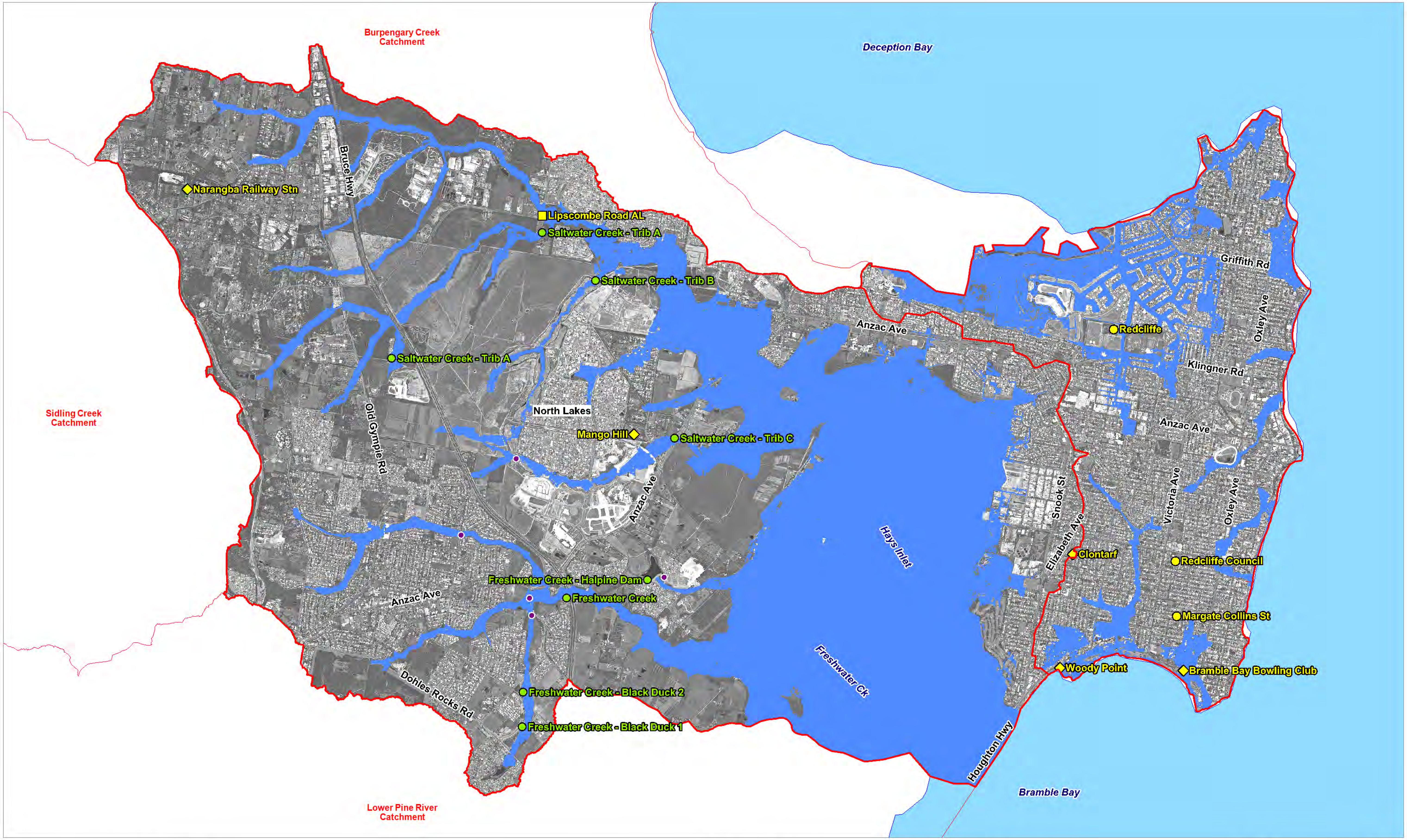
3.5 Historic Flood Levels

It is noted that the former Caboolture Shire Council has a database relating to historical flood events for the Caboolture River catchment. However, a similar database was unavailable from the former Pine Rivers Shire Council or the Redcliffe City Council for the Hays Inlet and Redcliffe catchments.

3.6 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. Due to the flood event in the Pine River and the Caboolture River 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 Council. This data is currently being collated by MBRC through the RFD project website. Information can be 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).

As mentioned in Section 2, the January 2011 event did not record major rainfall (and no major flooding issues) in the Hays Inlet and Redcliffe catchments. Therefore model calibration using data collected from the resident survey for this recent event will not be feasible.



LEGEND

- Redcliffe Catchment
- Hays Inlet Catchment
- 100 Year Embedded Design Storm Flood Extent (Based on Broadscale Model)
- Rainfall Gauges (Alert)
- Rainfall Gauges (Daily)
- Rainfall Gauges (Pluviometer)
- Water Quality Event Monitoring Gauges
- Maximum Height Indicators

Title:
Rainfall and River Stream Gauge Locations
Hays Inlet and Redcliffe Catchments

Figure: 3-1

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4 CONCLUSIONS AND RECOMMENDATIONS

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 also has a great effect on the quality of model calibration; generally the more gauge data available the better, and a good spread of the gauges over various tributaries in the catchment is also advantageous.

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 three pluviometers in the Redcliffe catchment that would enable catchment inflows into the hydraulic models to be determined for various historic events. However there is no river level data in Redcliffe. Therefore it will only be feasible to calibrate the Redcliffe hydraulic model if a reliable dataset of a large number of flood levels from historic flood events would be available. This is not the case and therefore calibration of the combined hydrologic and hydraulic models is not recommended

In the Hays Inlet catchment there are two daily rainfall gauges. The availability of rainfall data is therefore limited, which will inhibit the ability to development representative historical inflows into the hydraulic model. The availability of water level data in the catchment is also limited, but some does exist through water quality event monitoring gauges. There are nine such gauges in the Hays Inlet catchment. Most of these gauges were installed in 2007 with the exception of the Saltwater Creek Tributary C gauge in the North Lakes Development which was installed in 1990. It is acknowledged that for future flood events this data may be used to undertake a calibration (depending on the interval of the data recording). However no significant flood events have occurred since installation of the gauges in 2007. The quality of calibration data available from the water quality monitoring gauges will depend on the record frequency (daily, hourly, etc) and calibration may therefore not be worthwhile.

Based on the conclusions above it is recommended that calibration on the Hays Inlet and Redcliffe catchments is not feasible and should therefore not be carried out.

It is further recommended that:

- As the river height data recorded by these gauges may be used for both water quality and hydraulic model calibration, it is recommended that review of the water quality monitoring gauges is undertaken, in particular the recording frequency of the river levels.. Collection of a detailed time series of river height data is useful for model calibration so that the water volume and timing in the model can be checked as well as the peak flood levels; and
- A number of river height gauges be installed in the Hays Inlet and Redcliffe catchments.

5 REFERENCE

Bureau of Meteorology, 2011, *Water Resources Station Catalogue*, viewed 18 January 2011, <http://www.bom.gov.au/hydro/wrsc>

Moreton Bay Regional Council, 2011, *Share your flood data*, viewed 18 January 2011, <http://www.moretonbay.qld.gov.au/general.aspx?ekfrm=74810&libID=77442>

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APPENDIX D

APPENDIX D: MODELLING QUALITY REPORT

BMT WBM

Technical Note

From:	Richard Sharpe	To:	Moreton Bay Regional Council
Date:	18 May 2012	CC:	
Subject:	Modelling Quality Report; Redcliffe		

1 Background

As part of Moreton Bay Regional Council's (MBRC) Regional Floodplain Database (RFD) project, a detailed TUFLOW model of the Redcliffe catchment has been developed. This technical note has been prepared to demonstrate that the Redcliffe model has been reviewed, that the model performance is suitable for the intended use and that the sensibility of the results has been checked.

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 100 year ARI flood event, and submitted to MBRC for review (on 18th May 2011);

5 MBRC provided feedback from their review of the TUFLOW model on 7th July 2011. 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. Careful attention was provided to ensuring that flow through the 1D structure elements in the model was stable, as well as flow across the floodplain in the 2D domain.

3 Model Amendments – Post Draft Model Review

Various enhancements were recommended by both BMT WBM and MBRC following development of the draft model. The following changes were implemented:

1 MBRC were concerned that the flood behaviour did not match up to expectations in some areas; based on anecdotal evidence and their knowledge of the catchment. The hypothesis for this discrepancy was that in some areas the spread of flood water may be significantly influenced by the storm water drainage network, which was not included in the model. To resolve this issue, MBRC provided storm water network details for

specific portions of the catchment, which were appended to the 1D model network with associated links to the 2D domain at stormwater pits;

2 The edge of the model extent in the south east corner of the catchment intersected the extent of flooding in the model; i.e. the model limit was not extensive enough, and blocked the spread of floodwater. The active area in the 2D domain was therefore extended in the south eastern corner.

3 Additional survey data was used to update the details on some structures, including Humpybong Drain.

Particular consideration was given to the arrangement of the outfall on Humpybong Drain. This structure is important as it controls the flow through Humpybong Creek. MBRC surveyed the structure, which includes a weir at its entrance to develop supercritical flow conditions through the entrance of the outfall culvert. The outfall structure was designed to convey approximately 27m³/s (email communication with Hester van Zijl – 22 December 2011), which is similar to the flow capacity achieved in the TUFLOW model (see Figure 1).

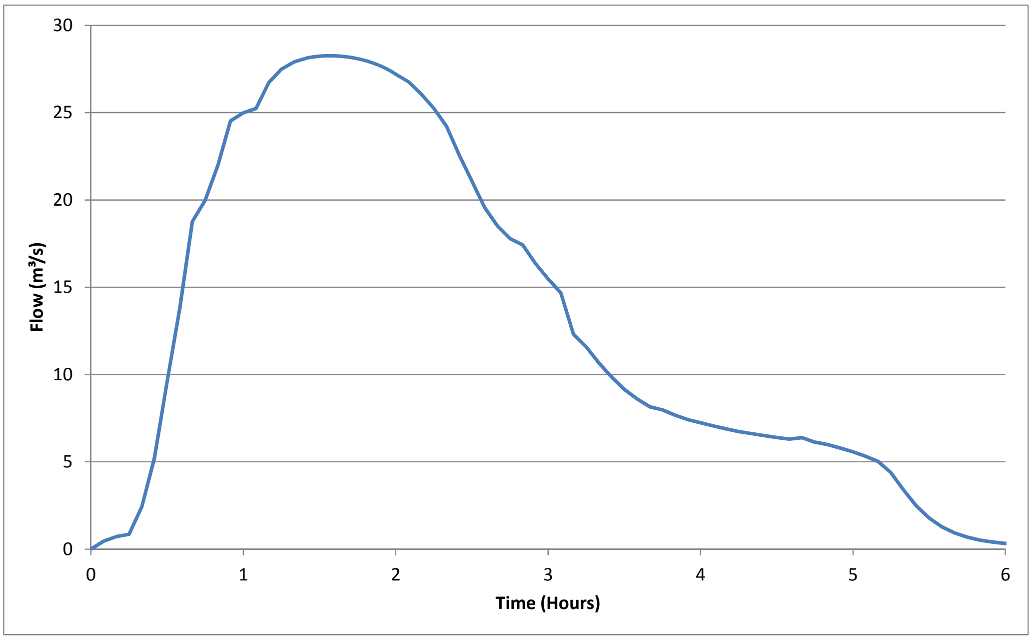


Figure 1: Flow through Humpybong Outfall (100 year ARI; 1 hour storm duration)

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. Sharp 'kinks' in the downstream boundary were smoothened, to eliminate instabilities that occurred during large tidal events (i.e. for sensitivity tests on the downstream boundary).

5 Model Performance

The following model performance checks have been undertaken:

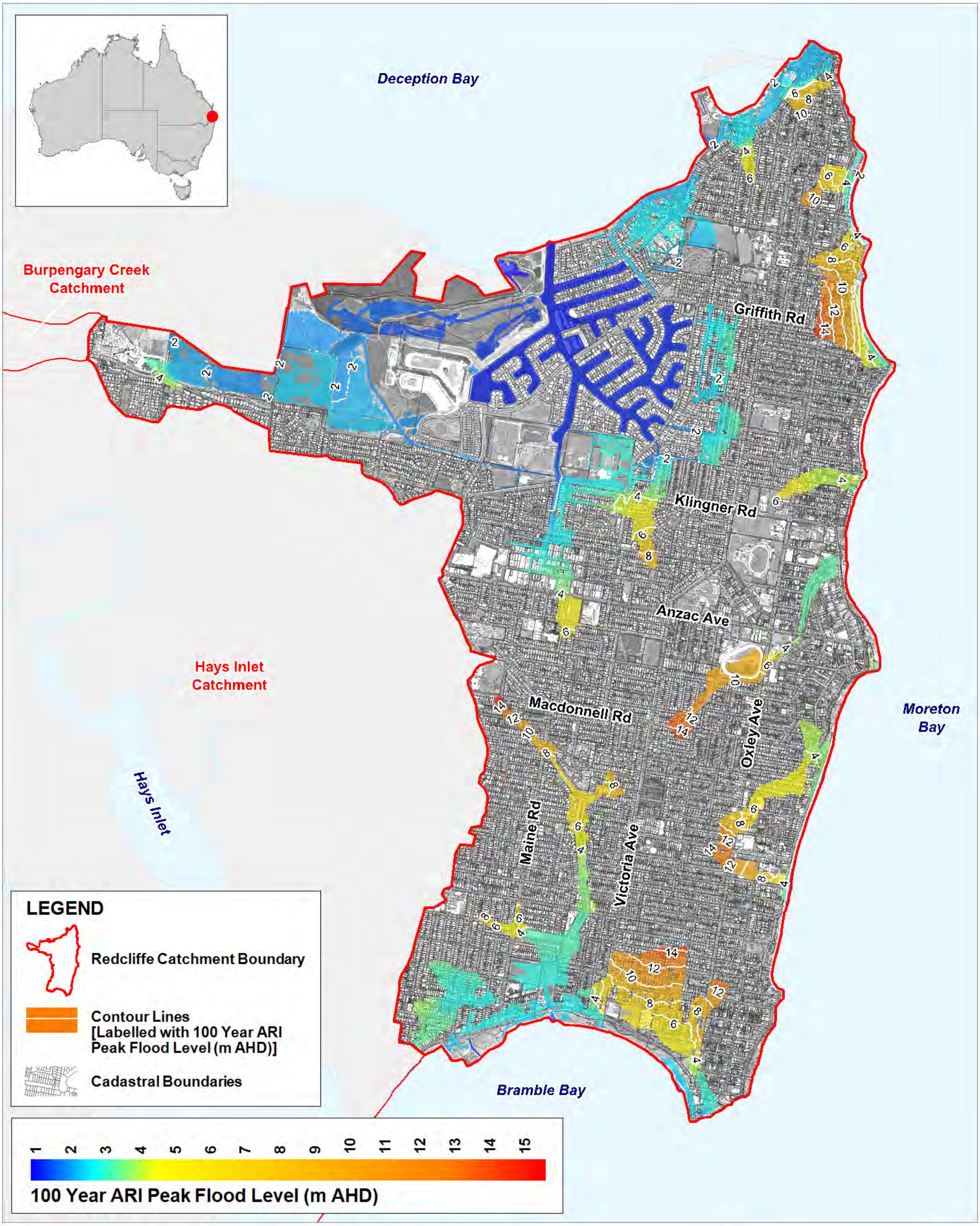
- Stability of flow through key structures (e.g. Figure 1) was checked during model development. The arrangement of SX connections, structures and embankments has been edited to ensure that stable flows have been achieved where necessary;
- TUFLOW warning messages have been minimised. A few negative depth warning messages remain on steep parts of the catchment. But these are localised and limited to short time periods in the overall simulation; and
- Mass balance errors have been minimised. Mass balance errors range from 0.1% for the extreme and large events to 0.7% for the small flood events.

6 Conclusion

The Redcliffe model has been developed with due consideration given to ensuring the quality of the model. The model has been reviewed internally and externally by MBRC. Amendments have been made in light of these reviews, and the overall model performance is suitable for the intended use of the model.

APPENDIX E

APPENDIX E: FLOOD MAPS – 100 YEAR ARI



Title:

Peak Flood Level Map – 100 Year ARI

Figure: **E1**

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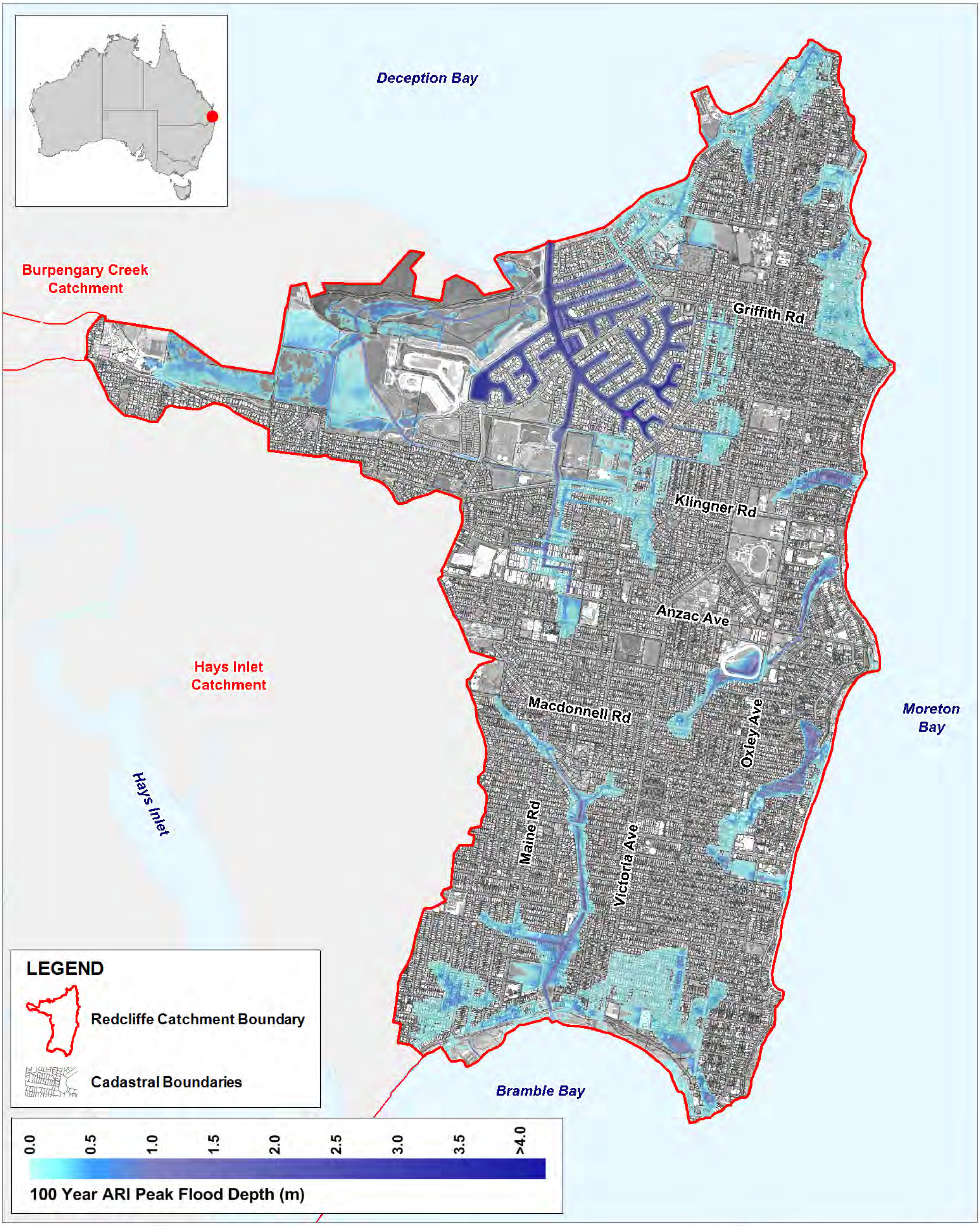

Title:

Peak Flood Depth Map – 100 Year ARI

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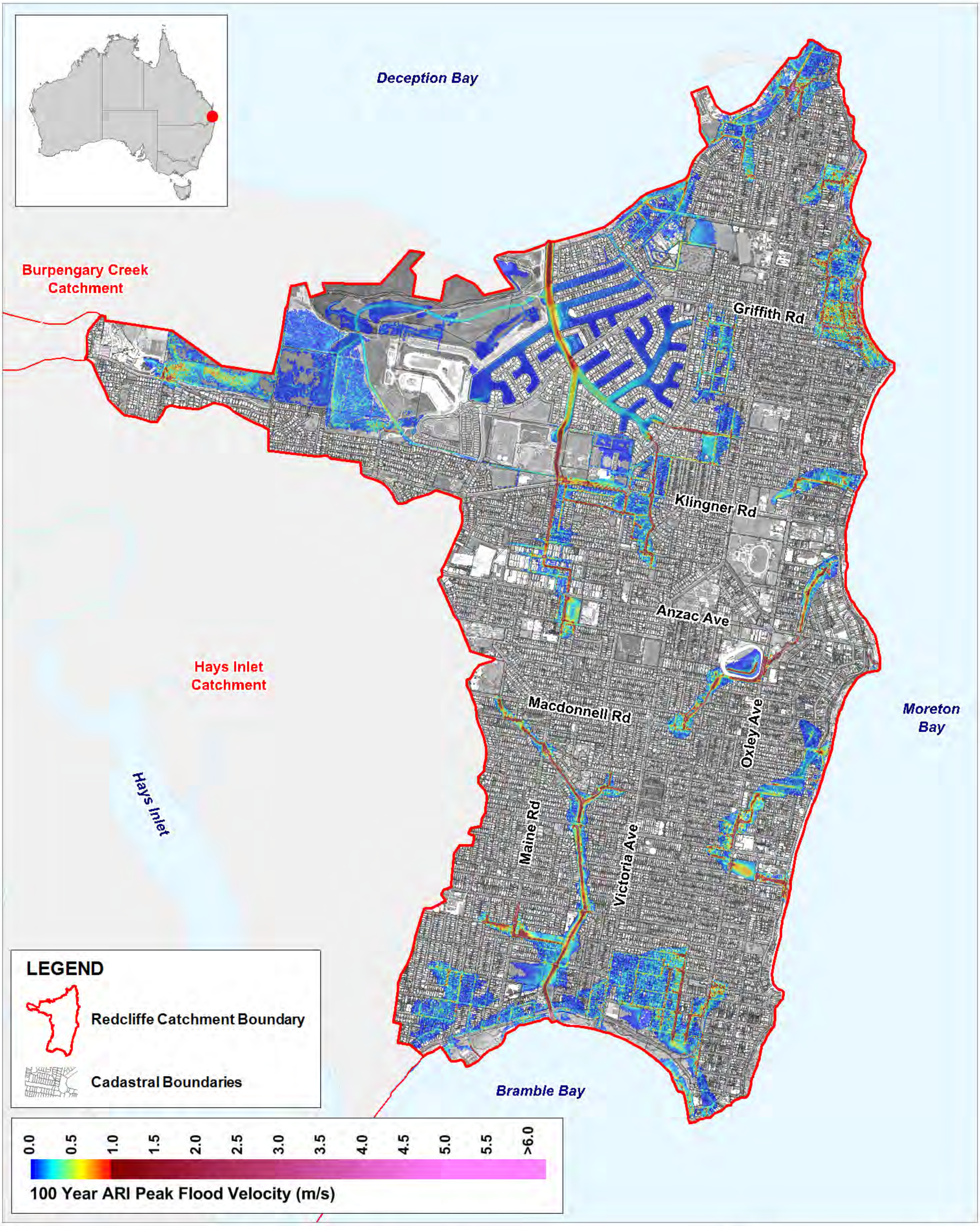

Title:

Peak Flood Velocity Map – 100 Year ARI

Figure: **E3**

Rev: **A**

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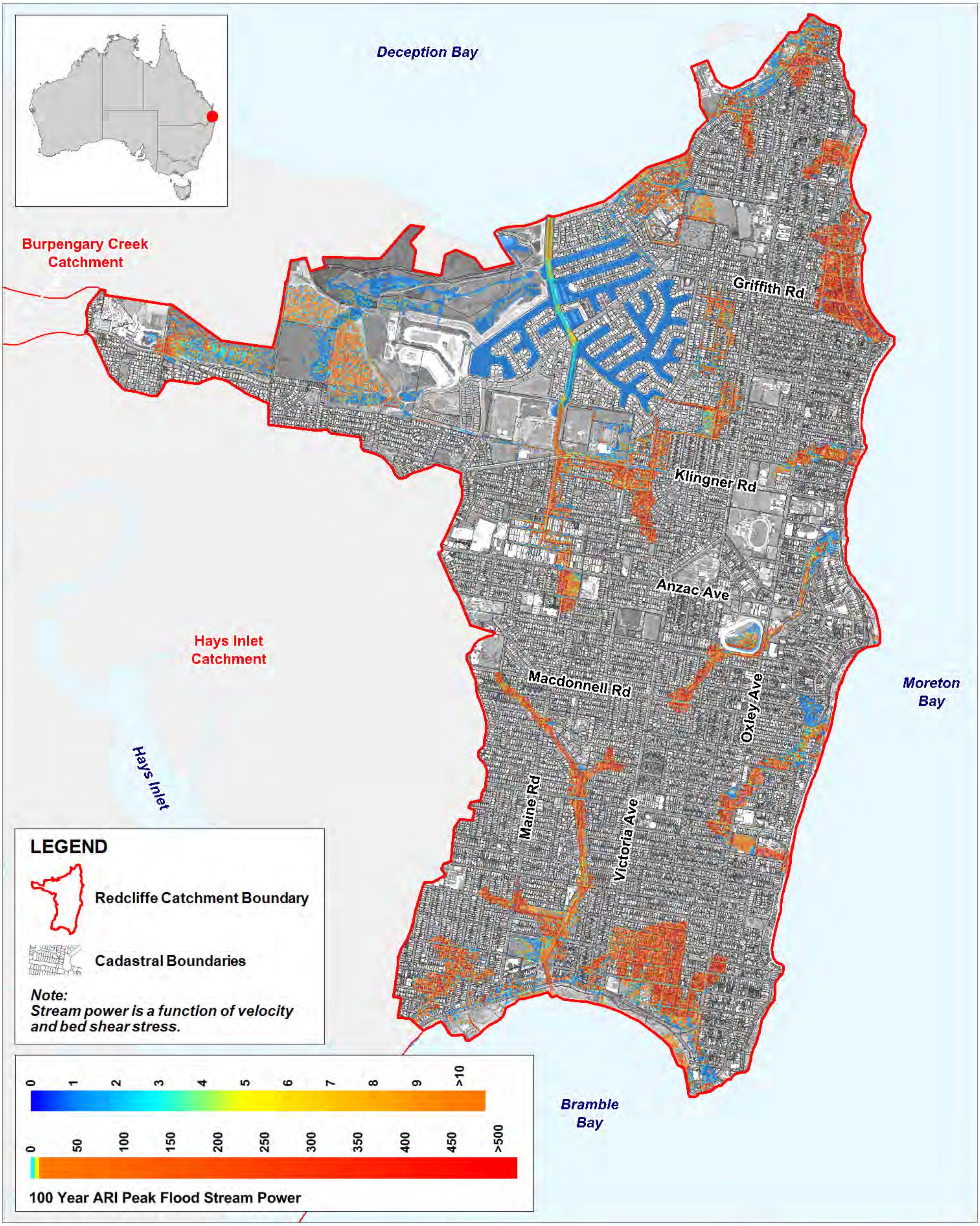

Title:

Peak Flood Stream Power Map – 100 Year ARI

Figure: E4

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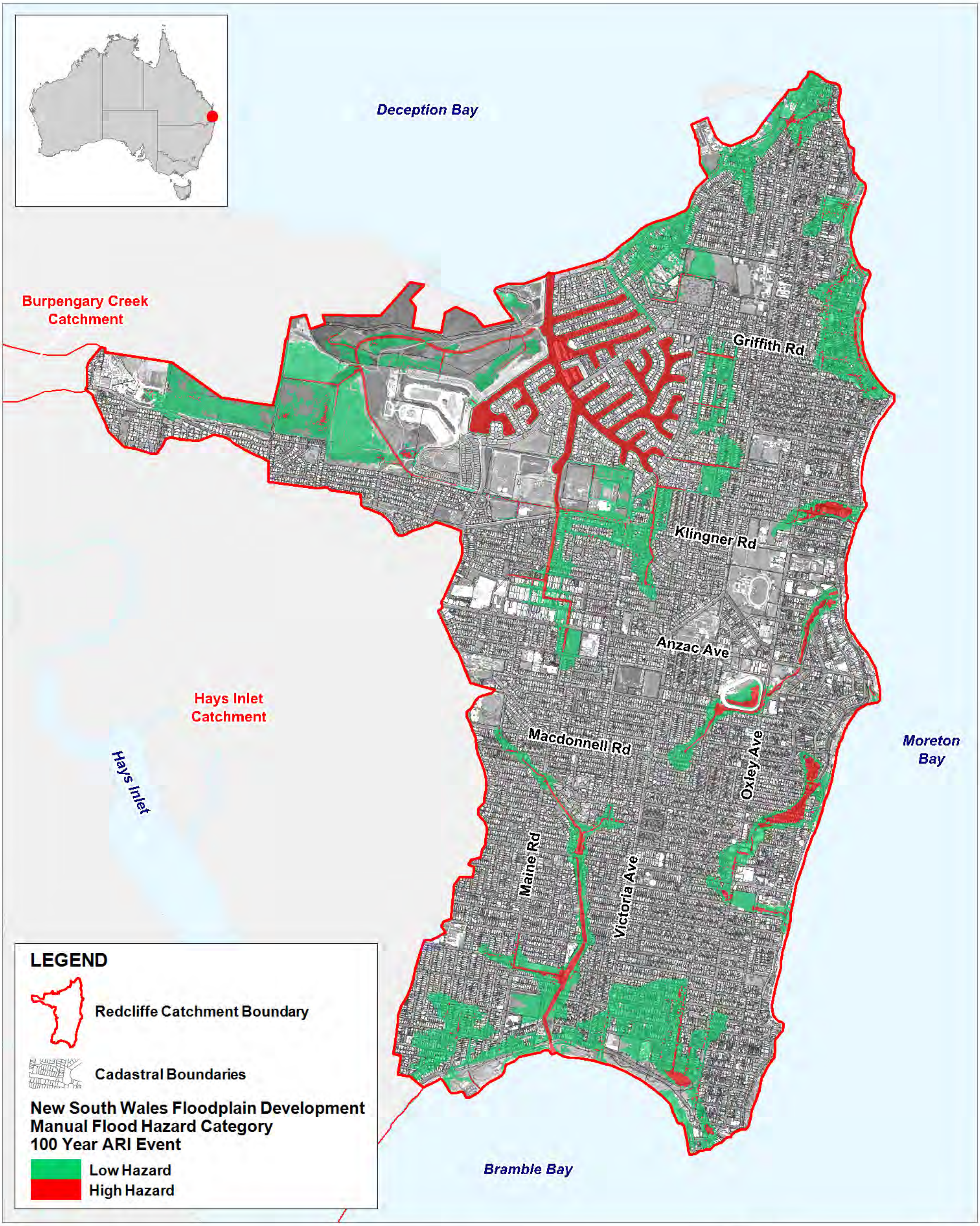

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Peak Flood Hazard Map – 100 Year ARI

Figure: **E5**

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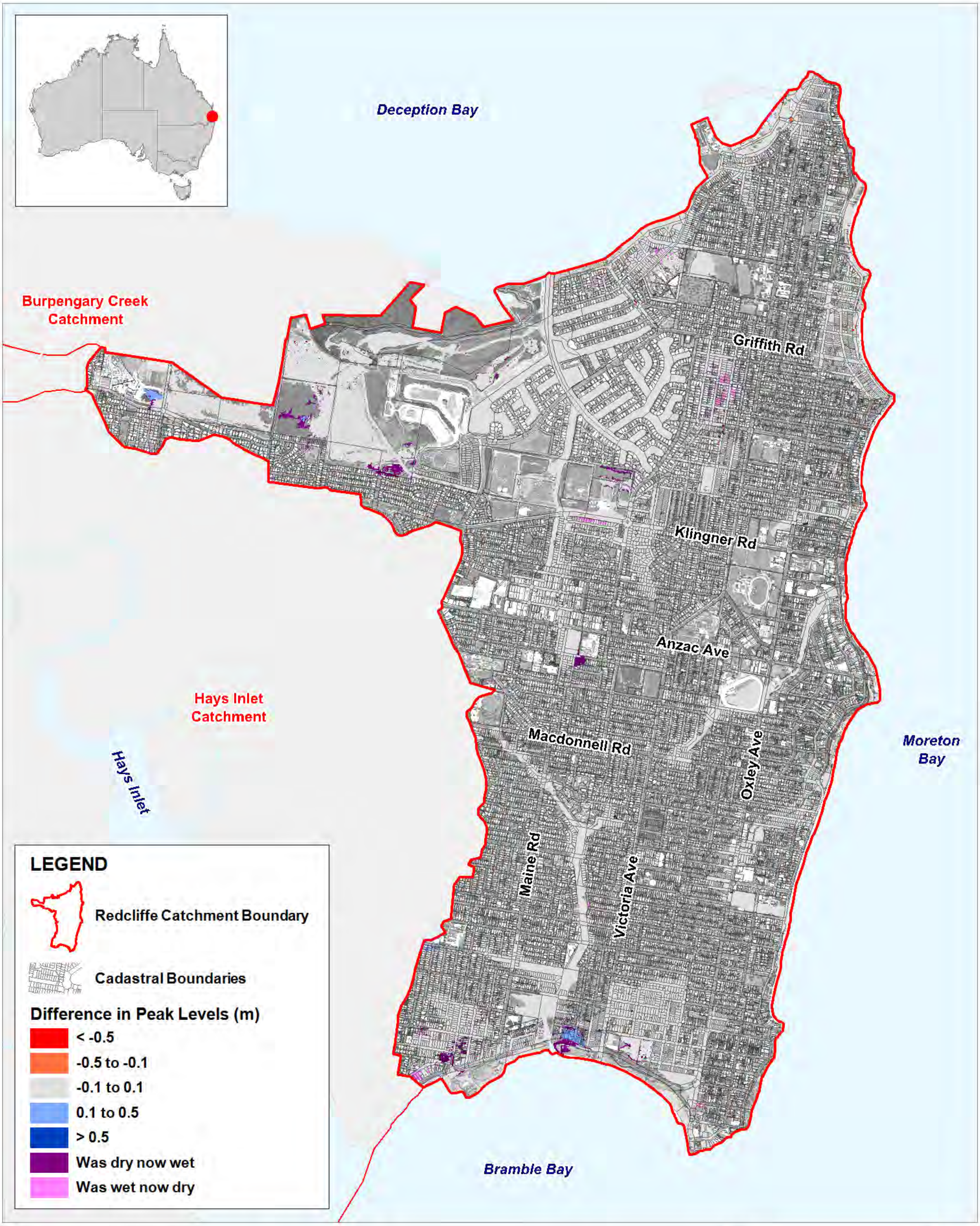
APPENDIX F

APPENDIX F: MODEL SENSITIVITY ANALYSIS MAPS



Title:

100 Year EDS Minus 100 Year 1 Hour and 3 Hour Storm

Figure: **F1**

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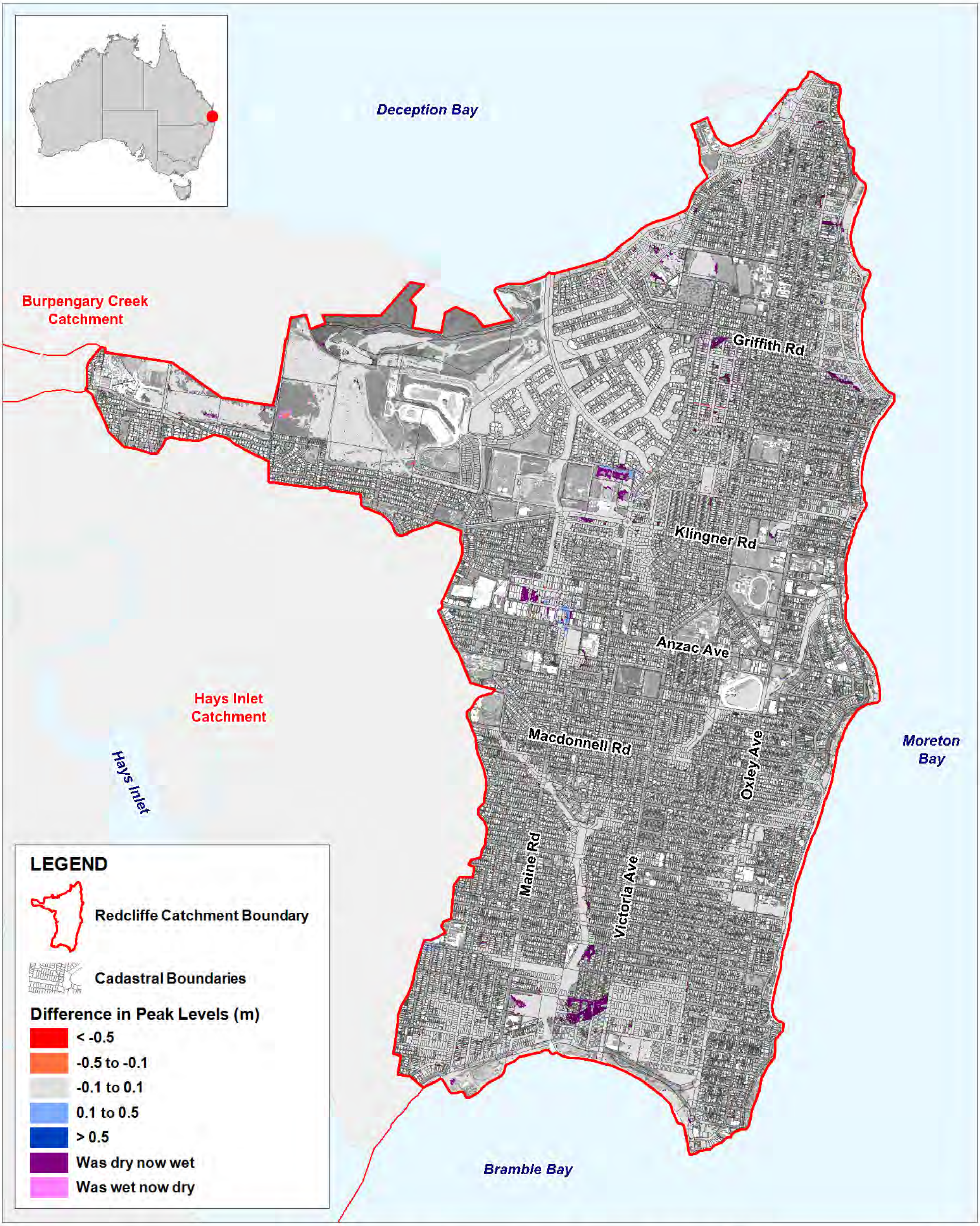

Title:

Increased Roughness Scenario (S2) Minus 100 Year EDS

Figure: F2

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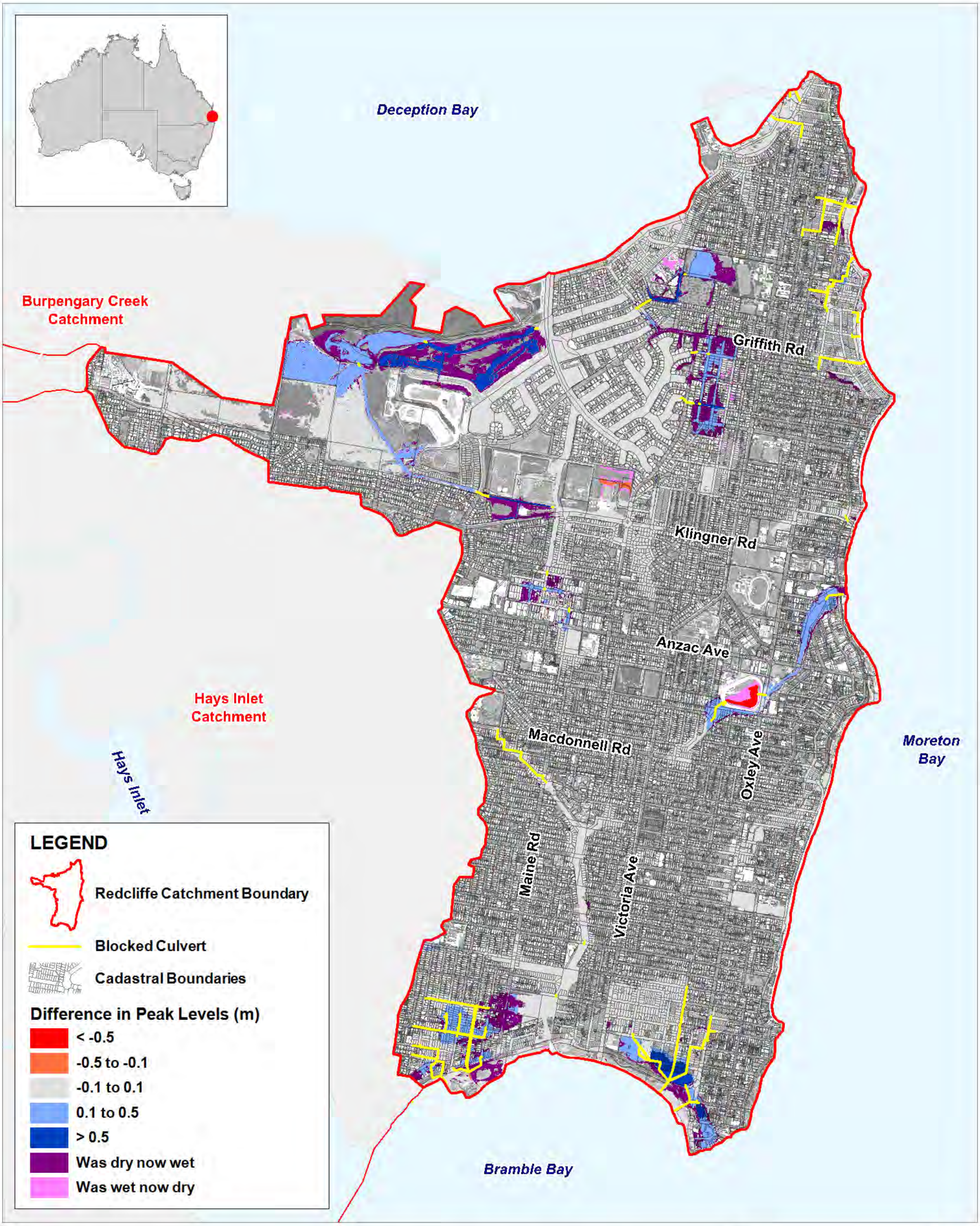

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Culvert Blockage Scenario (S3) Minus 100 Year EDS

Figure: **F3**

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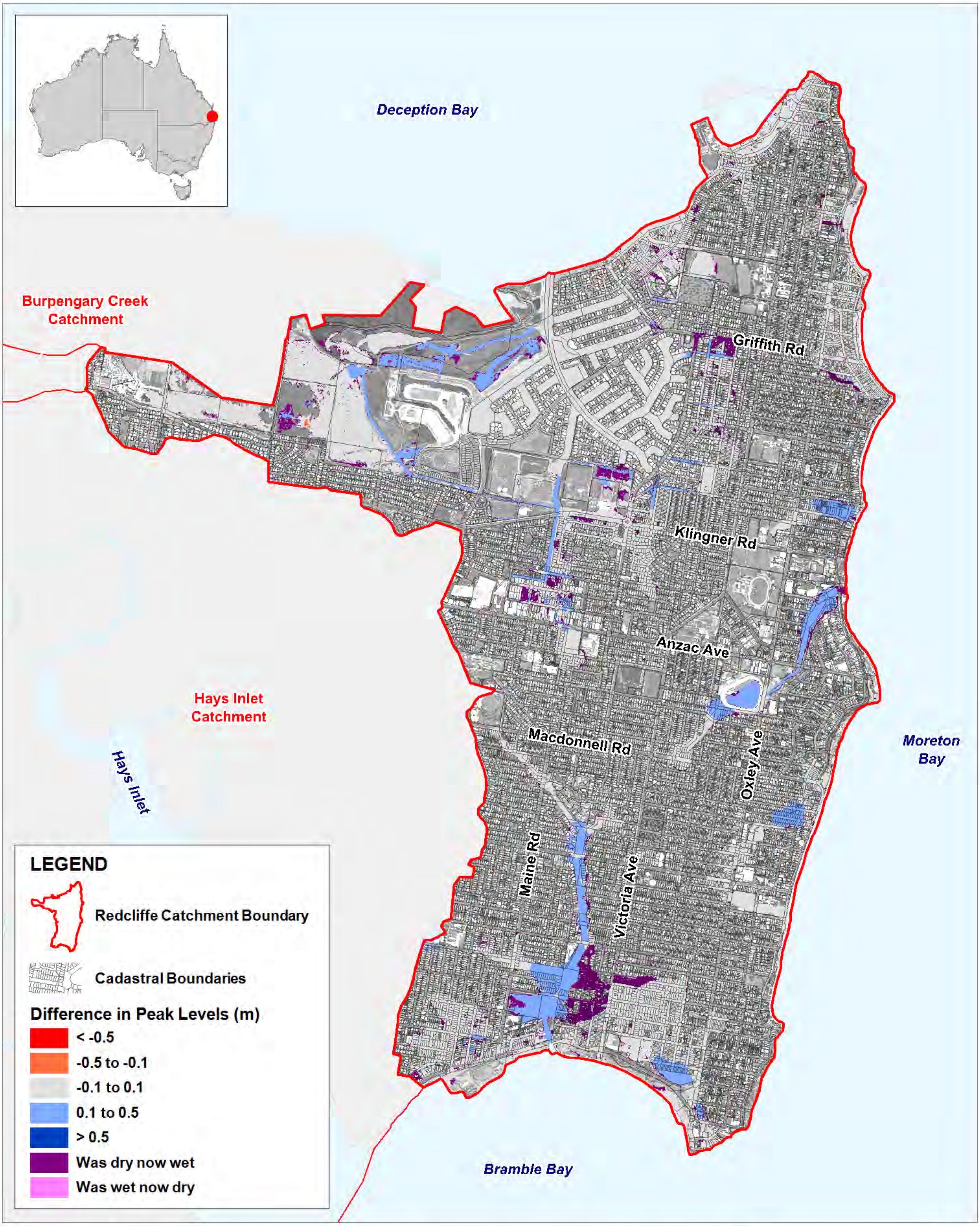

Title:

Increased Rainfall Scenario (S4) Minus 100 Year EDS

Figure: F4

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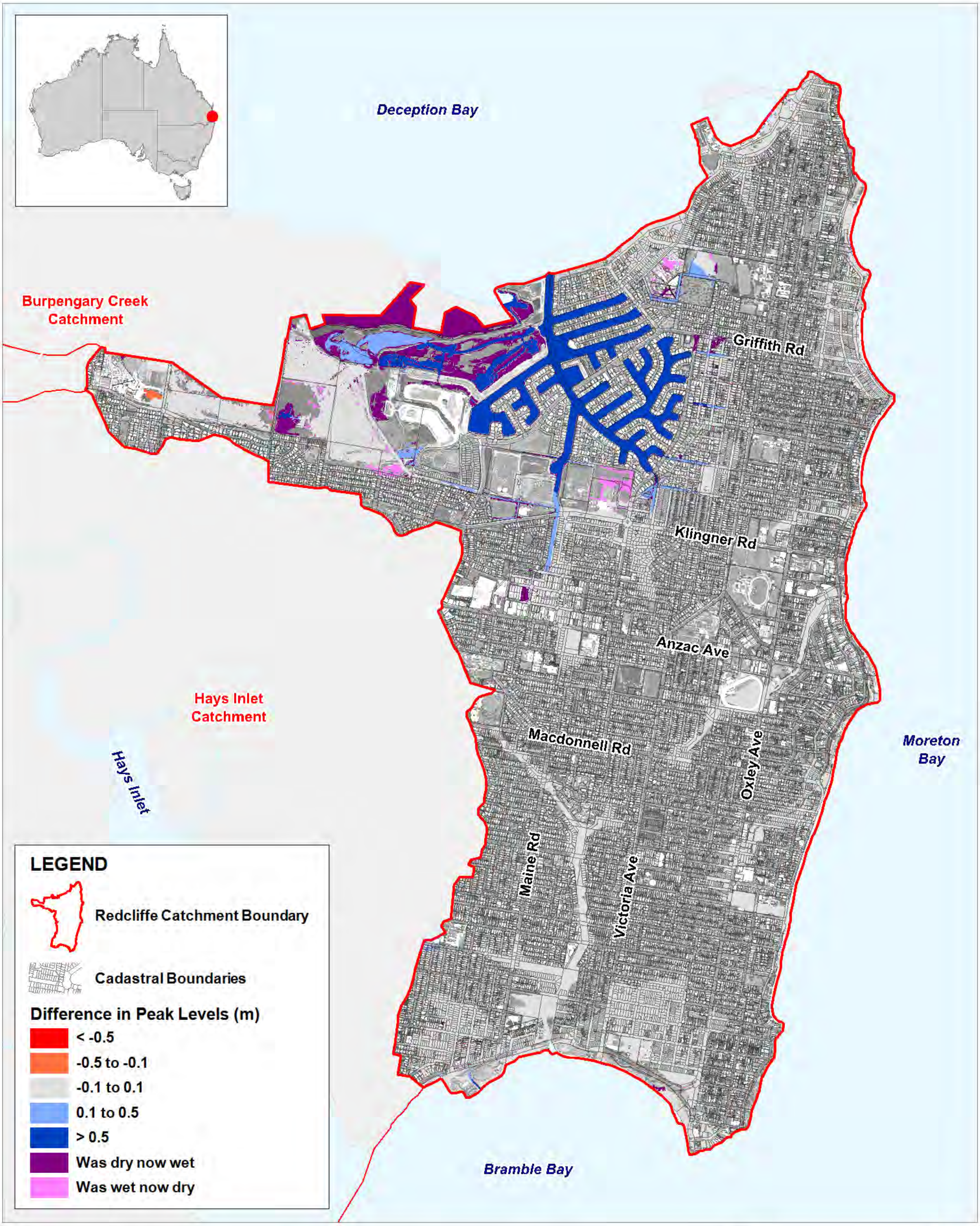

Title:
Increased Downstream Boundary Scenario (S5) Minus 100 Year EDS

Figure: **F5**

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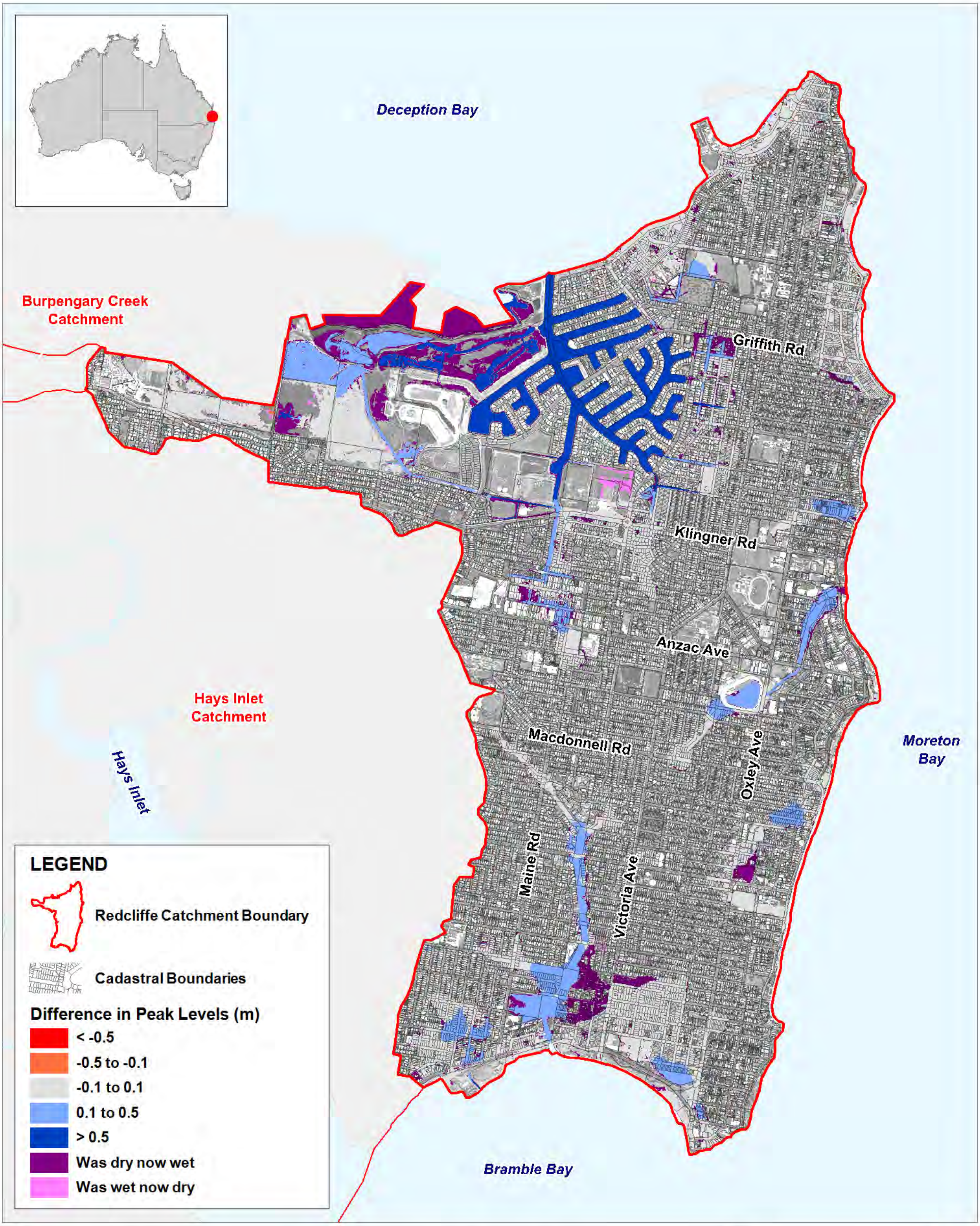

Title:

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

Figure: F6

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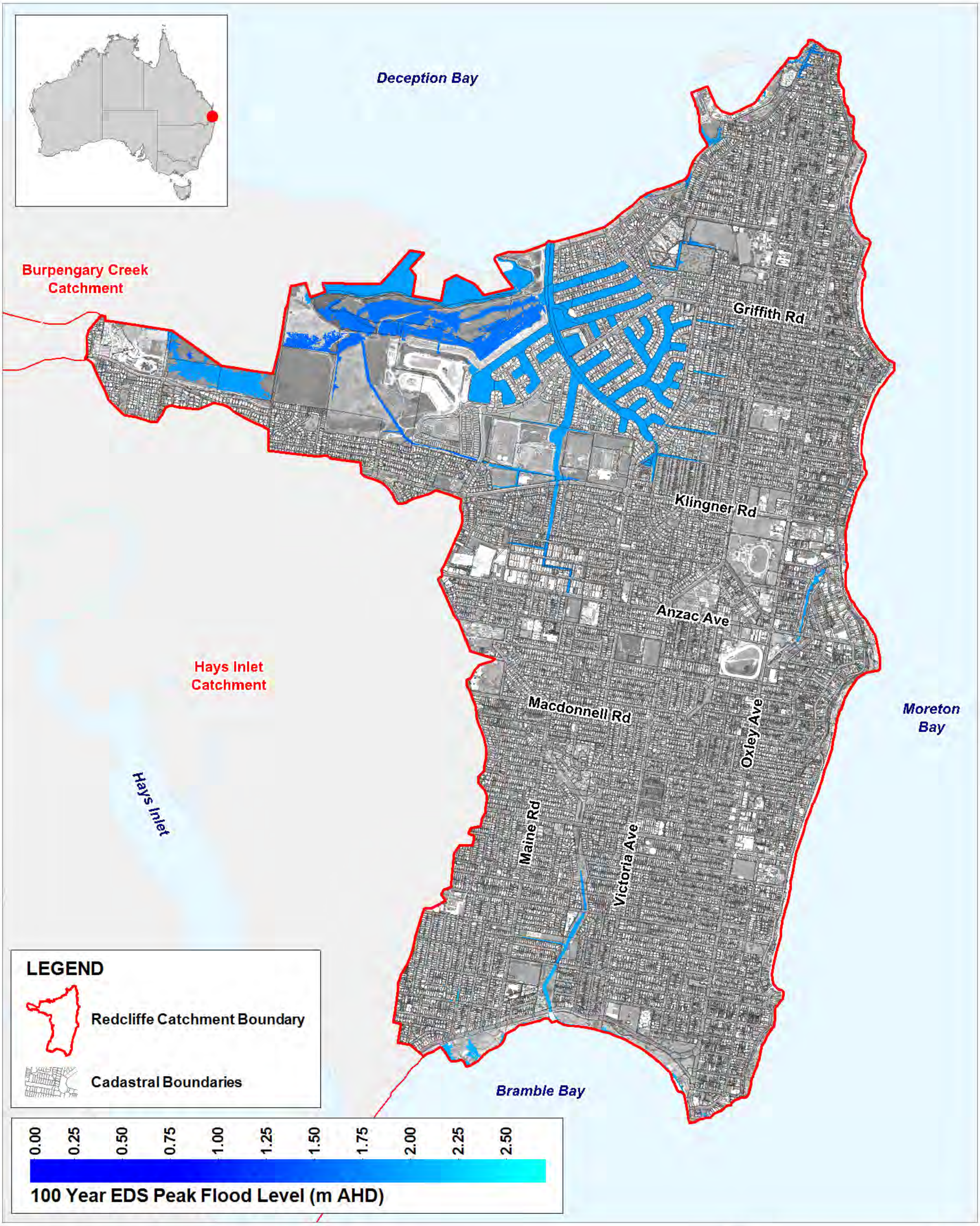

Title:

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

Figure: F7

Rev: A

N

0km 1 2

Approx. Scale

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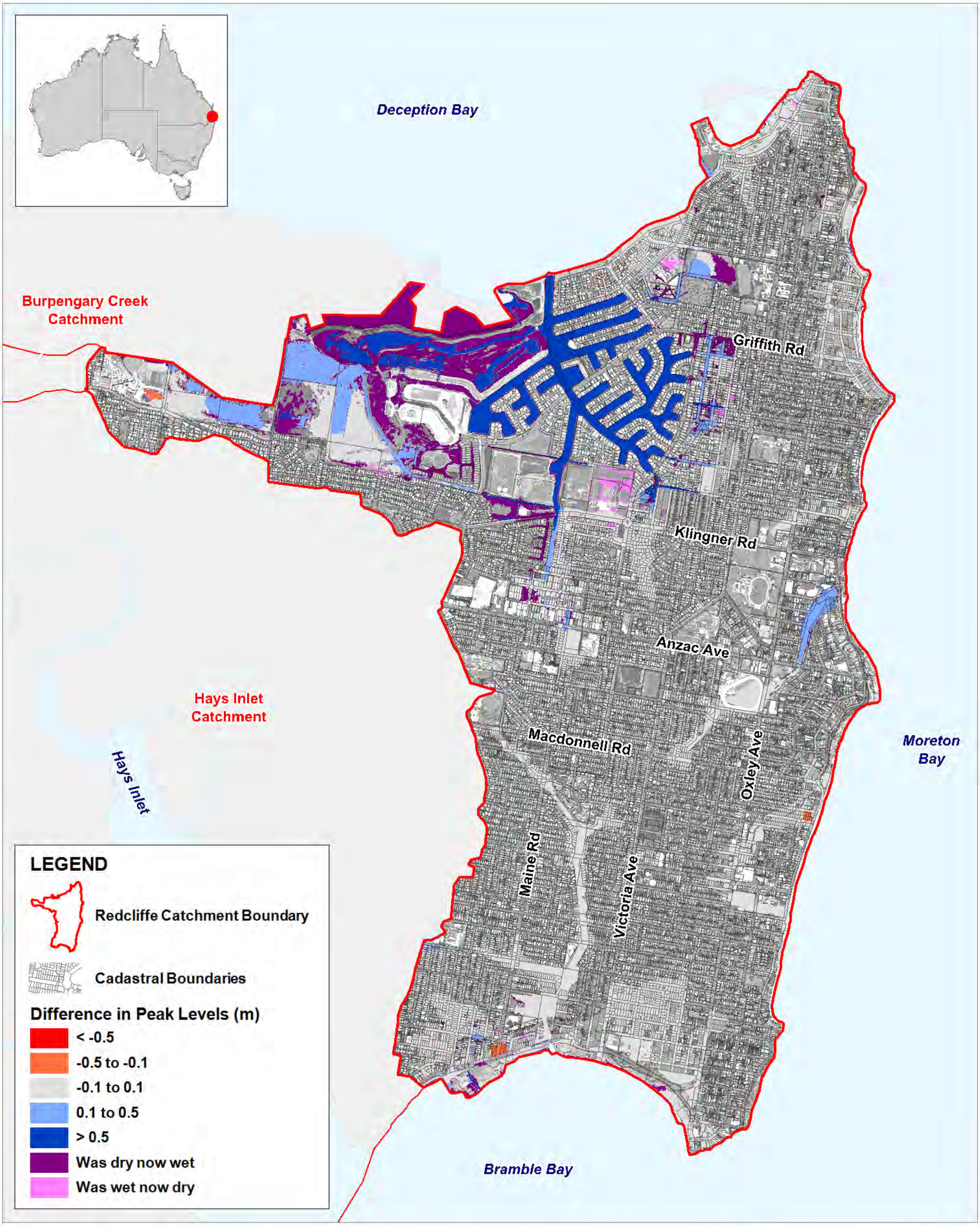
Filepath : I:\B18104_I_BRH Moreton Bay AK\DRG\Redcliffe_Report\FLD_017_120518_Dynamic Storm Tide Peak Flood Level 100Year ARI.WOR



Title:
Static Storm Tide Scenario (S8) Minus 100 Year EDS

Figure: F8

Rev: A

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N

0km 1 2

Approx. Scale

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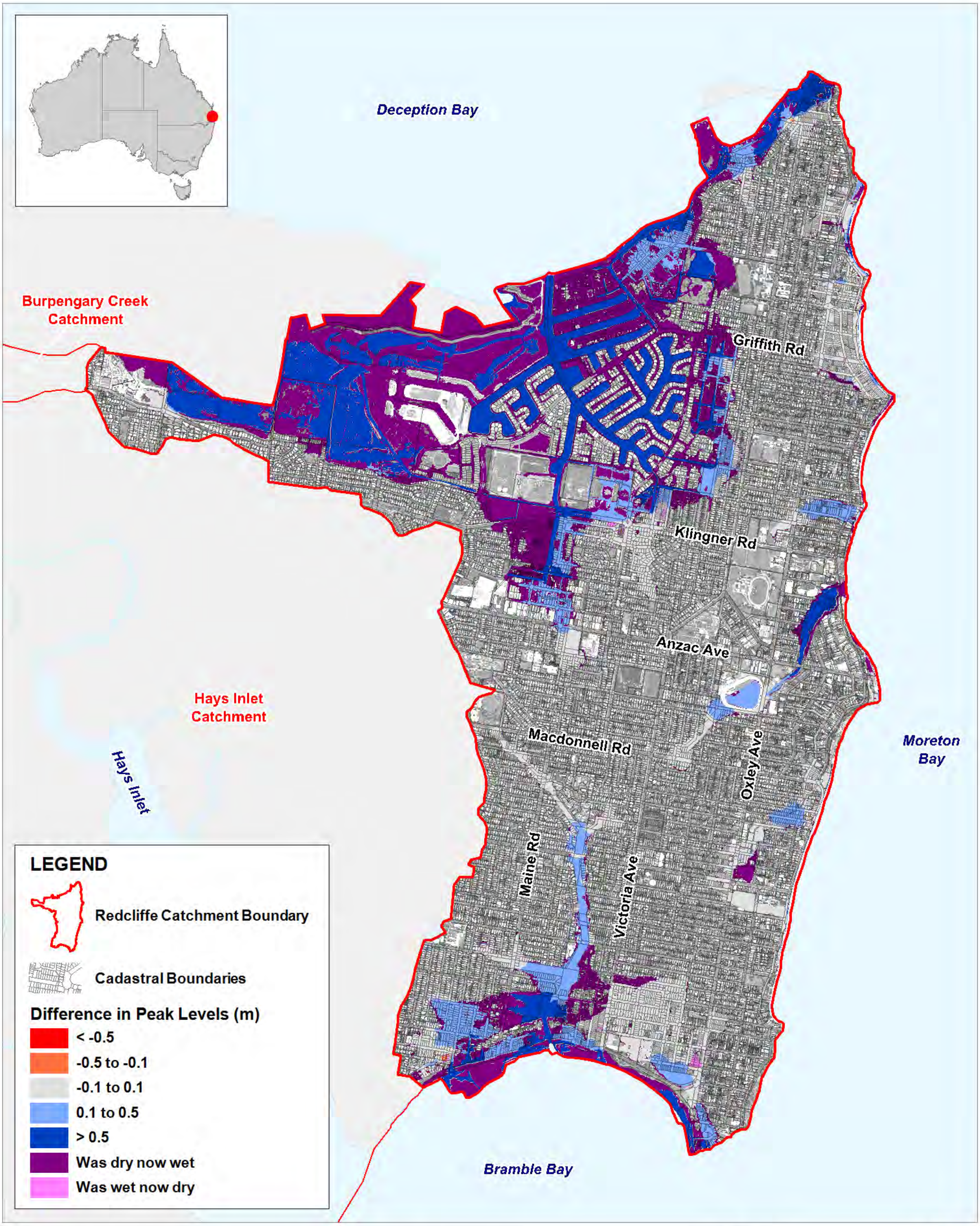
Filepath : I:\B18104_I_BRH Moreton Bay AK\DRG\Redcliffe_Report\FLD_018_120518_Static Storm Tide Flood Level Impact 100Year ARI.WOR



Title:

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

Figure: F9

Rev: A

N

0km 1 2

Approx. Scale

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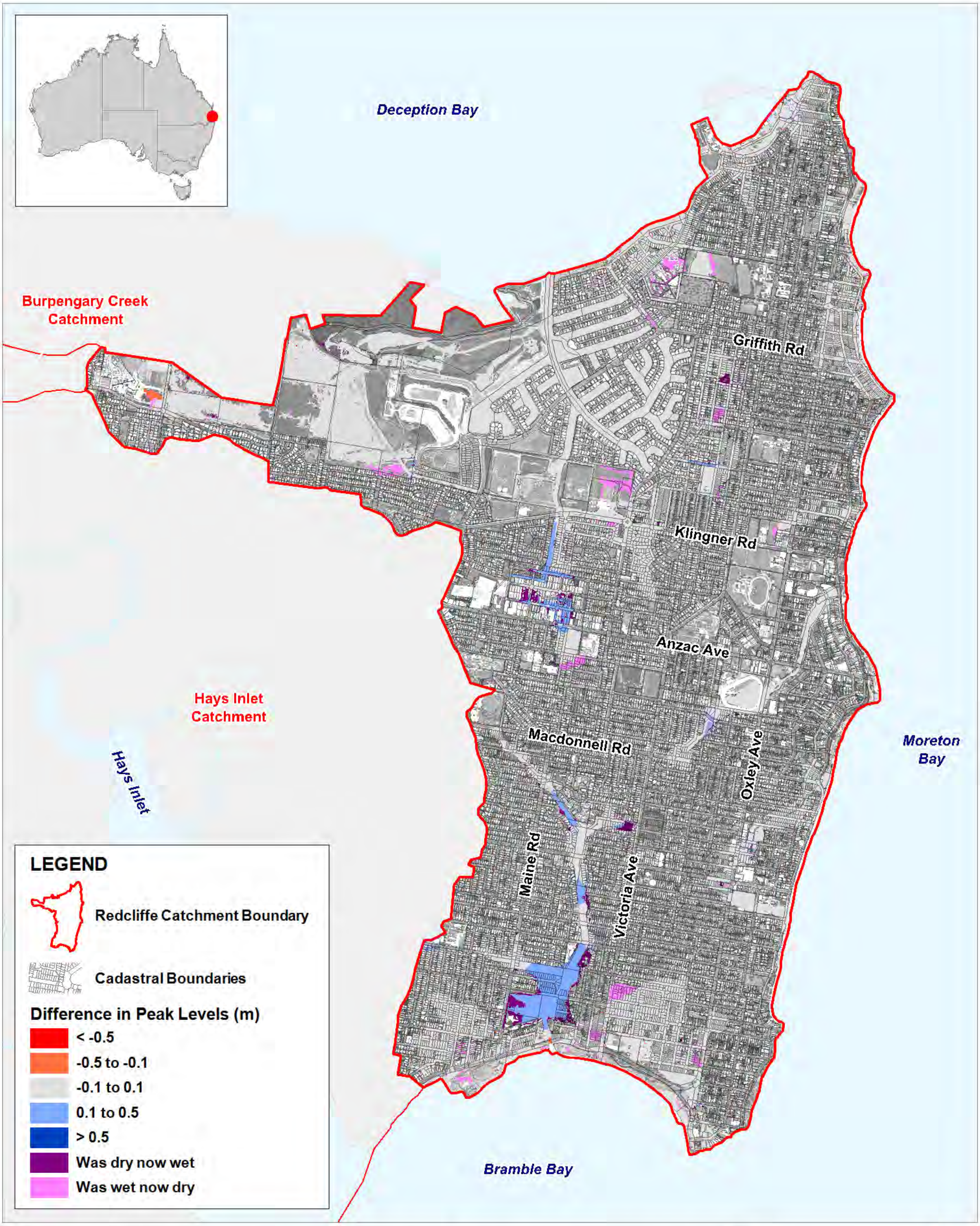
Filepath : I:\B18104_I_BRH Moreton Bay AK\DRG\Redcliffe_Report\FLD_019_120518_Static Storm Tide and Climate Change Flood Level Impact 100Year ARI.WOR



Title:

Increased Vegetation Scenario (S10) Minus 100 Year EDS

Figure: **F10**

Rev: **A**

N

0km 1 2

Approx. Scale

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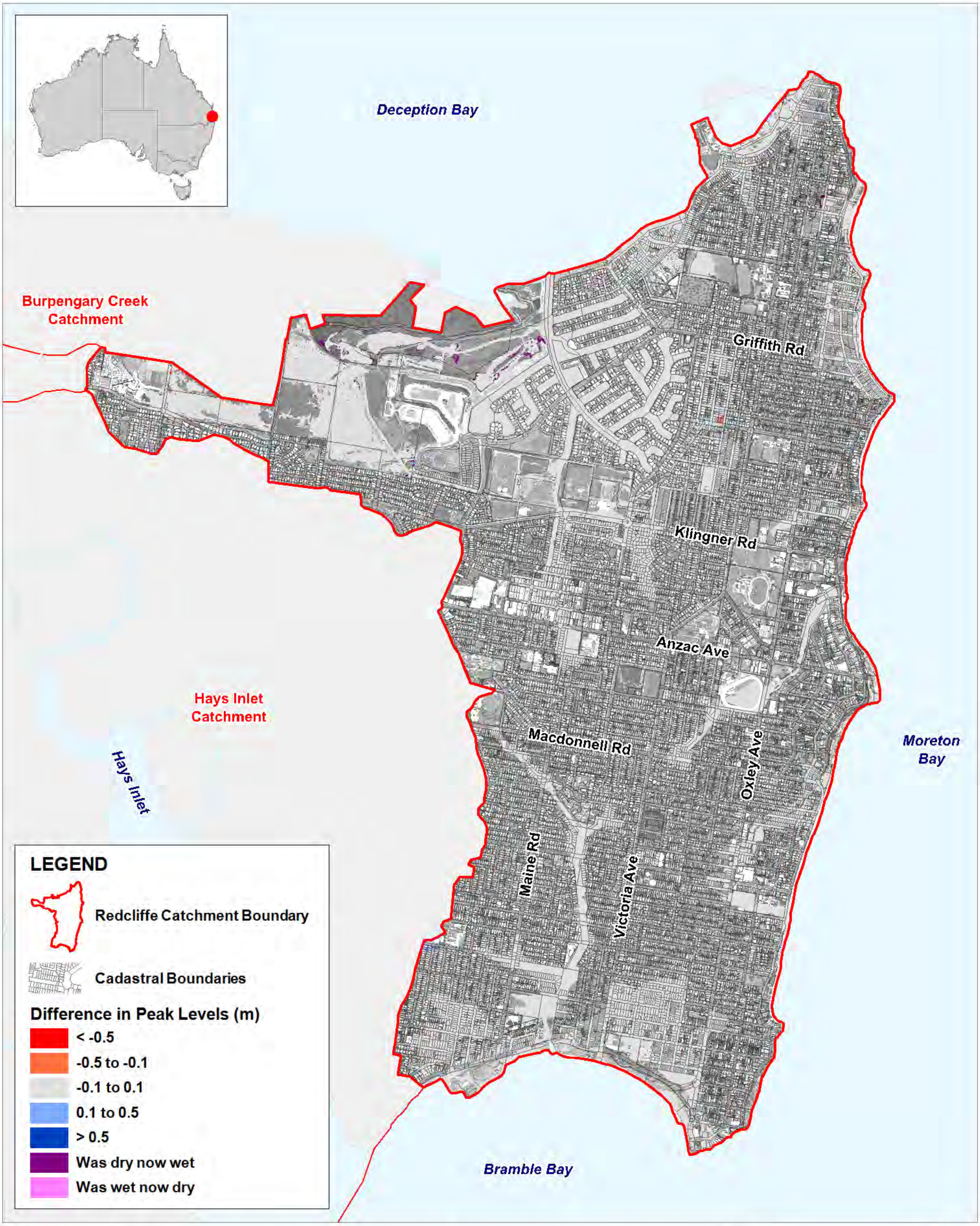
Filepath : I:\B18104_I_BRH Moreton Bay AK\DRG\Redcliffe_Report\FLD_020_120518_Increase in Vegetation Flood Level Impact 100Year ARI.WOR



Title:

Increased Residential Development Scenario (S11) Minus 100 Year EDS

Figure: **F11**

Rev: **A**

N

0km 1 2

Approx. Scale

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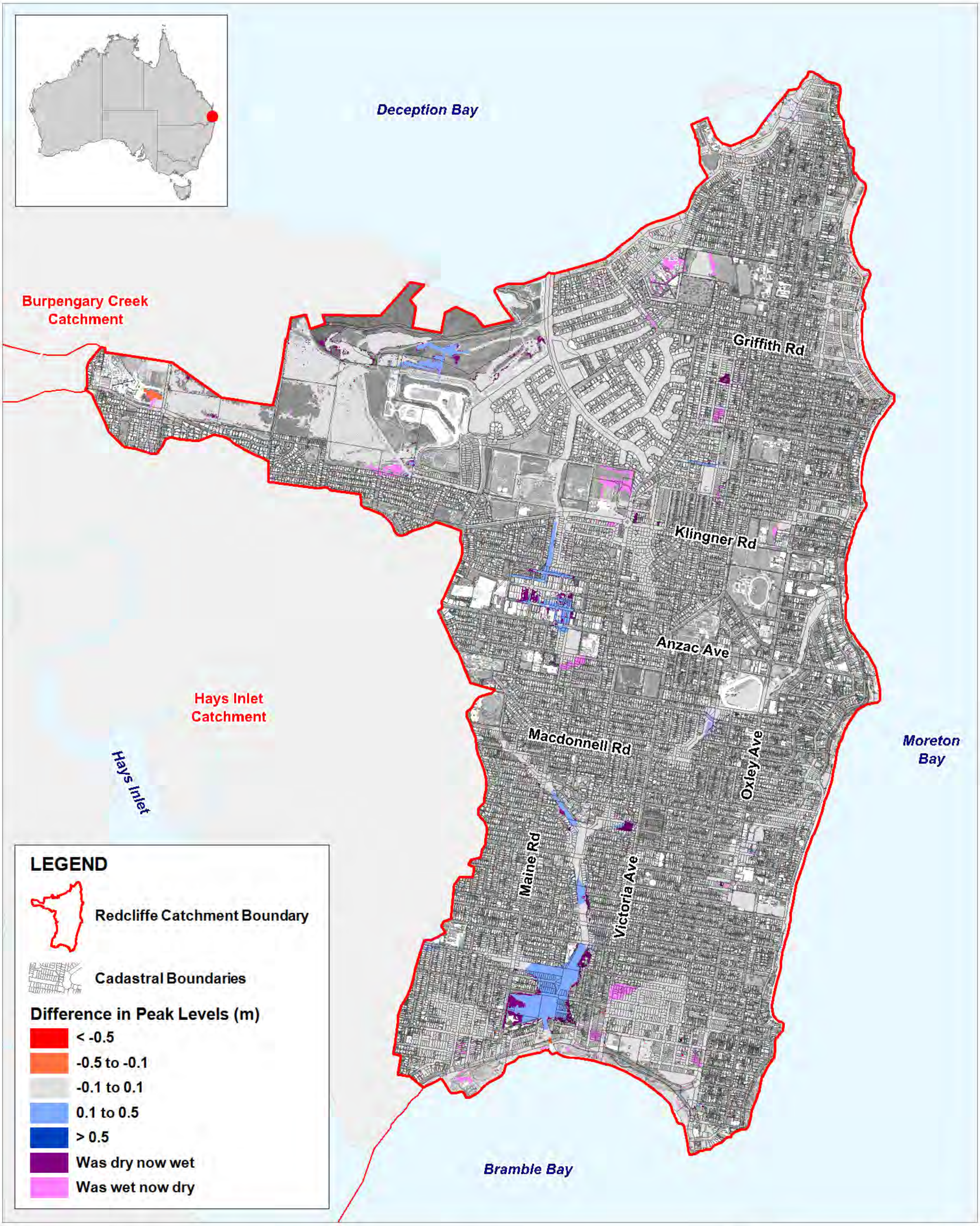
Filepath : I:\B18104_I_BRH Moreton Bay AK\DRG\Redcliffe_Report\FLD_021_120518_Increase in Residential Development Flood Level Impact 100Year ARI.WOR



Title:

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

Figure: **F12**

Rev: **A**

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N

0km 1 2

Approx. Scale

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