5 MODEL VERIFICATION

5.1 Event Selection

Verification of the flood model performance was carried out by modelling the heavy rainfall event of 20 and 21 May 2009. The May 2009 event was caused by an East Coast Low moving down the coast from South East Queensland. Analysis of recorded rainfall at Myocum indicates that during the 36 hour period from 10:45 on Wednesday 20 May to 22:45 on Thursday 21 May, the rainfall had an average rainfall intensity between a 10 and 20 year ARI event.

Although the rainfall did not lead to substantial flooding within the Brunswick River catchment, the timing of the event enabled field survey to be undertaken for this assessment. Flood debris marks supplemented by verbal reports from local residents were recorded on 4 June 2009, and subsequently surveyed on 24 June 2009.

A good coverage of pluviographic rainfall records and tidal levels are available for this event. Therefore, due to the lack of alternative flood records, verification to this event is considered appropriate for use with this study.

5.2 Rainfall Analysis

Rainfall time series graphs, recorded between 19 and 25 May 2009, at eight rainfall stations surrounding the study catchment are shown on Figure 5-5. Cumulative rainfall for each of the stations is shown on Figure 5-1. As can be seen from Figure 5-5 and Figure 5-1, the temporal pattern of the storm is similar across each of the eight stations.

Cumulative rainfall, as a percentage of the total for each station, is shown on Figure 5-2 for the first rainfall burst. Again, Figure 5-2 highlights the similarity in rainfall pattern across the different stations.

A Theissen distribution was used to assign recorded temporal patterns to each of the sub-catchments of Simpsons Creek as shown on Figure 5-5. Using this distribution, all sub-catchments are assigned temporal patterns from either Myocum or Belongil Creek. Cumulative rainfall and cumulative rainfall as a percentage of the total rainfall are shown on Figure 5-3 and Figure 5-4 respectively. All of the cumulative rainfall plots have shown the similarity in temporal patterns between the different stations, thus, indicating that the method used for rainfall distribution, will not significantly influence flow rates.

Using the rainfall totals from the first burst (19 to 22 May 2009), rainfall isohyets were derived as shown on Figure 5-6. Each sub-catchment was assigned a weighting based on the rainfall totals to factor the total of each rainfall station according to the total rainfall assumed at the centroid of each sub-catchment.

The resultant temporal patterns and spatial distribution were input into the hydrological model to derive hydrographs for input into the hydraulic model.

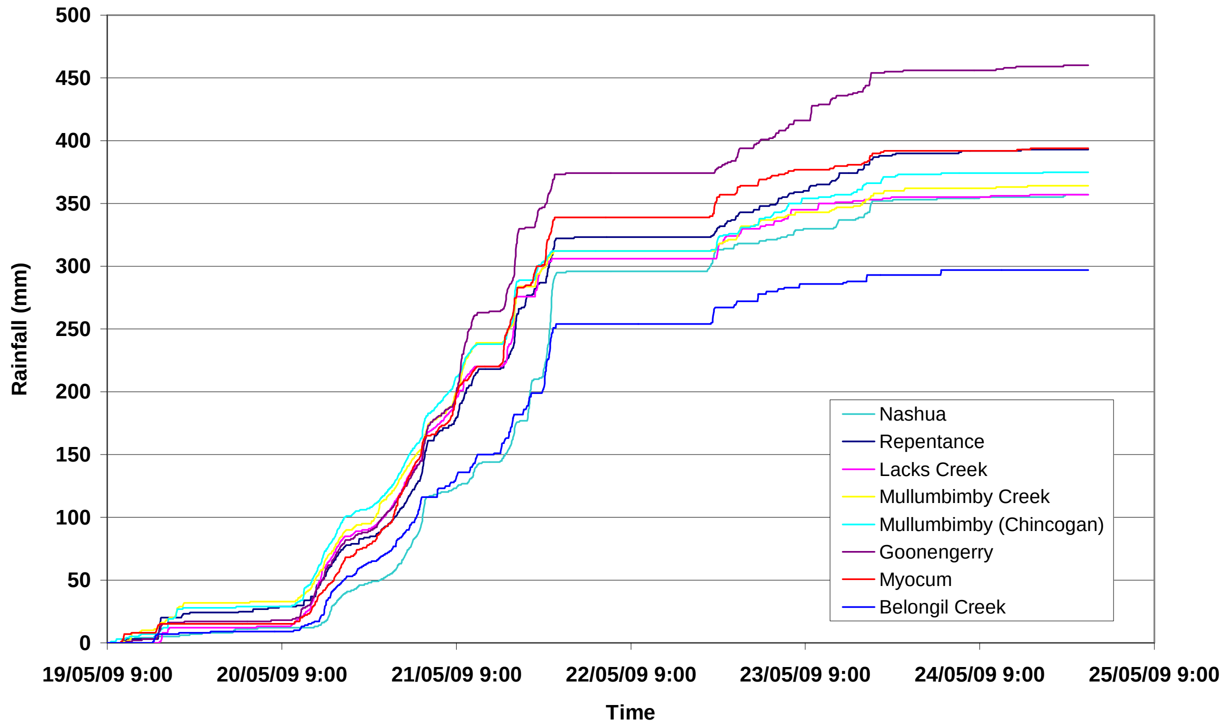


Figure 5-1 May 2009 Event Cumulative Rainfall (mm) – Brunswick River

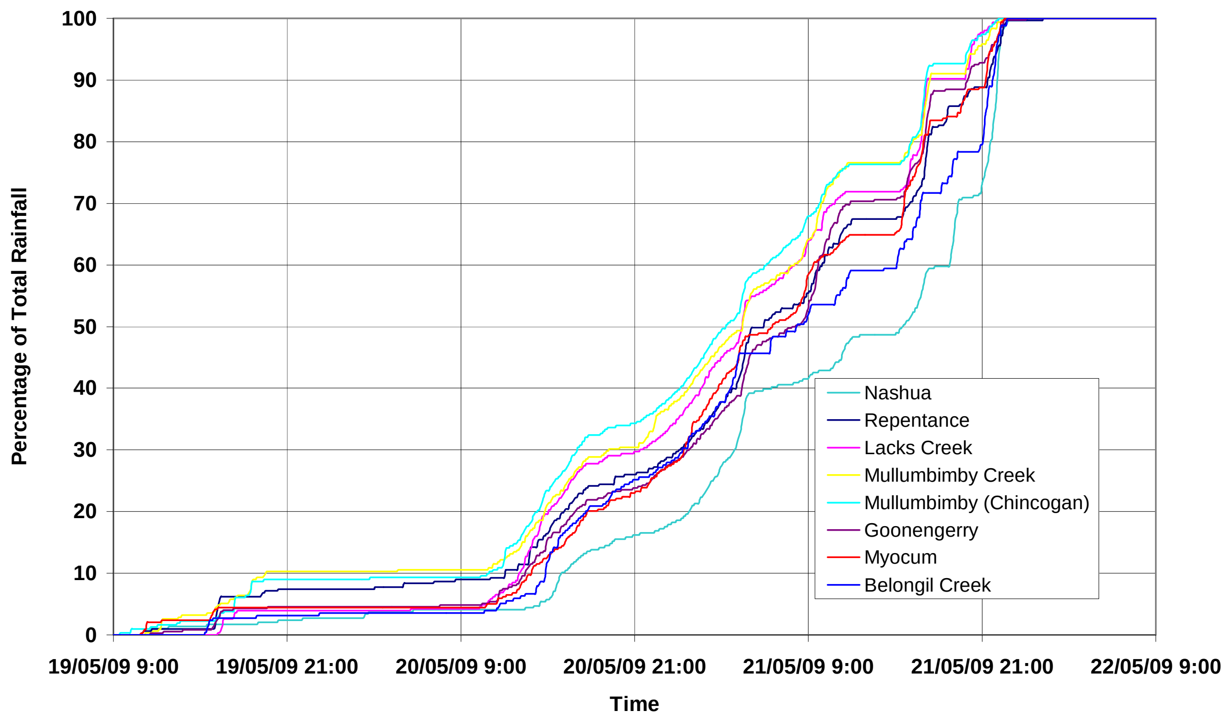


Figure 5-2 May 2009 Event Relative Cumulative Rainfall (%) – Brunswick River

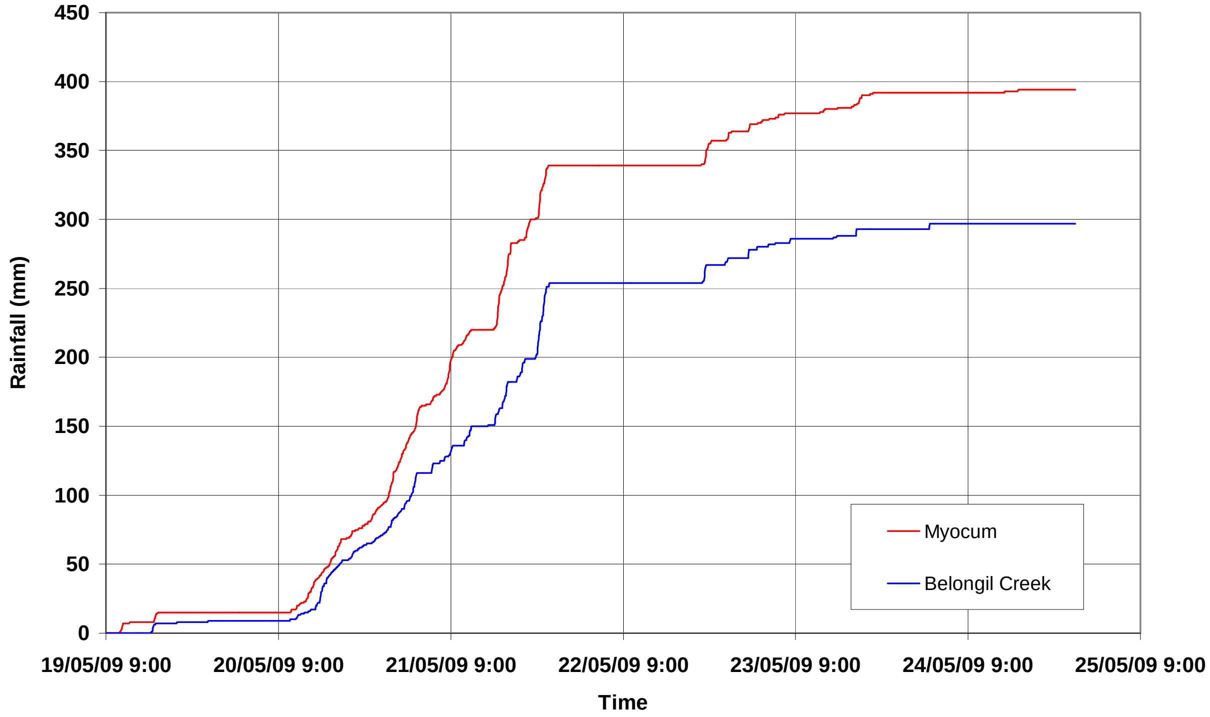


Figure 5-3 May 2009 Event Cumulative Rainfall (mm) – Simpsons Creek

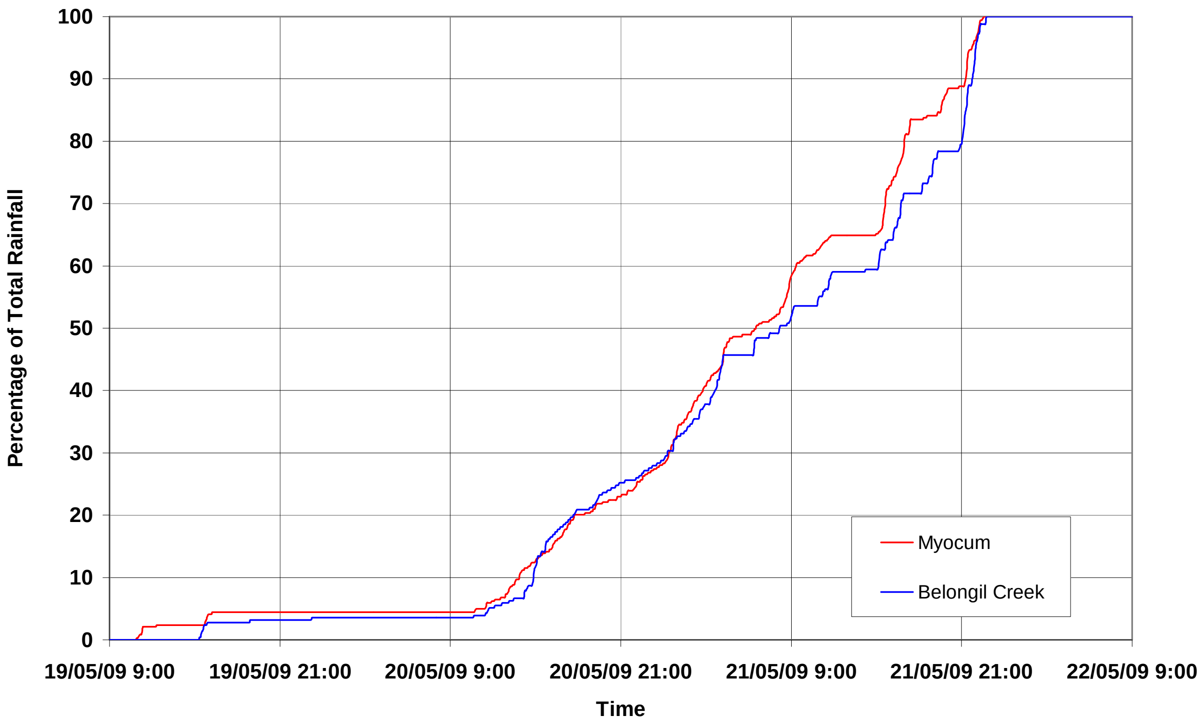


Figure 5-4 May 2009 Event Cumulative Relative Rainfall (%) – Simpsons Creek

5.3 Model Verification Process

Based on recorded rainfall and inflow hydrographs derived from the WBNM model, and recorded tide levels, the hydraulic model was used to simulate the May 2009 event. Surface roughness, losses and runoff routing lag parameters were adjusted to achieve a best fit with surveyed flood marks. In addition, the percentage of flow from sub-catchment S_11.01 entering the Simpsons Creek catchment was adjusted during the model verification process.

It should be noted that the flood marks recorded for this study consist mostly of flood debris marks collected after the flood event, although flood debris marks provide some indication of the maximum flood level that was reached during a flood event, they do not necessarily indicate peak flood levels during that event. Furthermore, debris marks do not provide information on the timing of the flood wave. Therefore, it is important that the modelled flood level is at least as high as the debris marks.

5.4 Model Verification Summary

5.4.1 Peak Flood Levels and Extents

A comparison between recorded and modelled peak flood levels is presented in Table 5-1. Modelled peak flood levels are presented on Figure 5-7. Only the flood marks with a high reliability are presented.

Table 5-1 Verification Results Summary

Flood Mark ID	*Recorded Level (m AHD)*	*Modelled Level (m AHD)*	*Difference (m)*
FLD_02	1.40	1.60	0.20
FLD_05	1.73	1.82	0.09
FLD_12	1.90	2.32	0.42
FLD_14	2.74	2.86	0.12
FLD_15	2.91	3.28	0.37

The levels and extents of flooding are consistent with the following verbal reports:

- No visible flooding from Ocean Place, Bayside in floodplain to the west;
- Ponding around the Tyagarah Airstrip, although the main runway was flood free; and
- No flooding across Gulgan Road as reported by the State Emergency Service.

5.4.2 Inter-catchment Flow

The optimum model performance was achieved when allowing 20 percent of the flow from sub-catchment S_11.01 to flow into sub-catchment S_11.02. This assumption is considered reasonable based on the following:

- The peak flow rate from sub-catchment S_11.01 during a 100 year ARI event is approximately $50m^3/s$;

- The Casino-Murwillumbah bridge appears unlikely to convey more than $10m^3/s$ prior to the embankment being overtopped, hence, 20 percent of the total flow;
- To the north of Brunswick Heads, the June 2005 flood event was considered to be marginally larger than a 100 year ARI event; and
- There was no evidence to suggest that the railway embankment had been overtopped since decommissioning, prior to June 2005.

The remaining 80 percent of flow from that sub-catchment, including all flow from sub-catchment S_14.01 has been assumed to flow along Pipeclay Creek into Kings Creek.

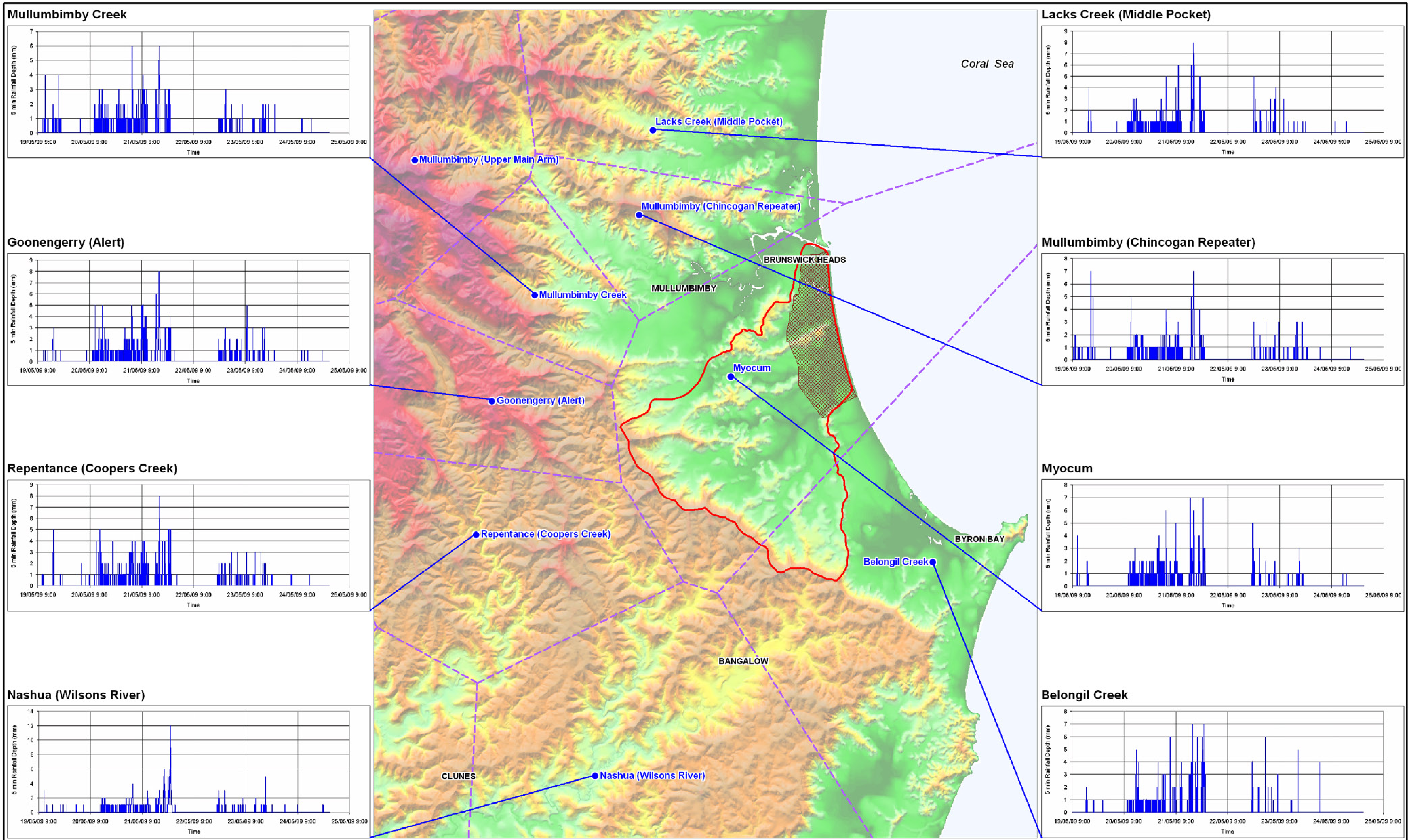
5.4.3 Surface Roughness

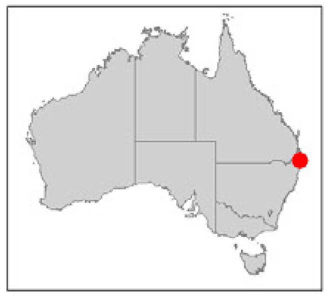
Manning's 'n' values for surface roughness are presented in Table 5-2.

Table 5-2 Mannings 'n' Roughness Coefficients

Land Use Type	*Manning's 'n' Value*
Sandy River Bed	0.02
Lightly Vegetated Creek Bed	0.04
Pasture	0.04
Scattered Trees / Vegetation	0.05
Medium Density Trees / Vegetation	0.07
Forest / Dense Trees / Vegetation	0.09
Urban Block	1.00

Although the aerial photography shows dense vegetation, actual conditions on the ground show a dense canopy layer, with a relatively open understorey. Therefore, the relatively low Manning's 'n' values are considered appropriate for the forested parts of the floodplain.





LEGEND

Simpsons Creek Catchment Boundary

Hydraulic Model Extents

Rainfall Station

Theissen Rainfall Distribution

Title:

May 2009 Event
Pluviograph Distribution

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N

0 3 6km

Approx. Scale

Figure:

5-5

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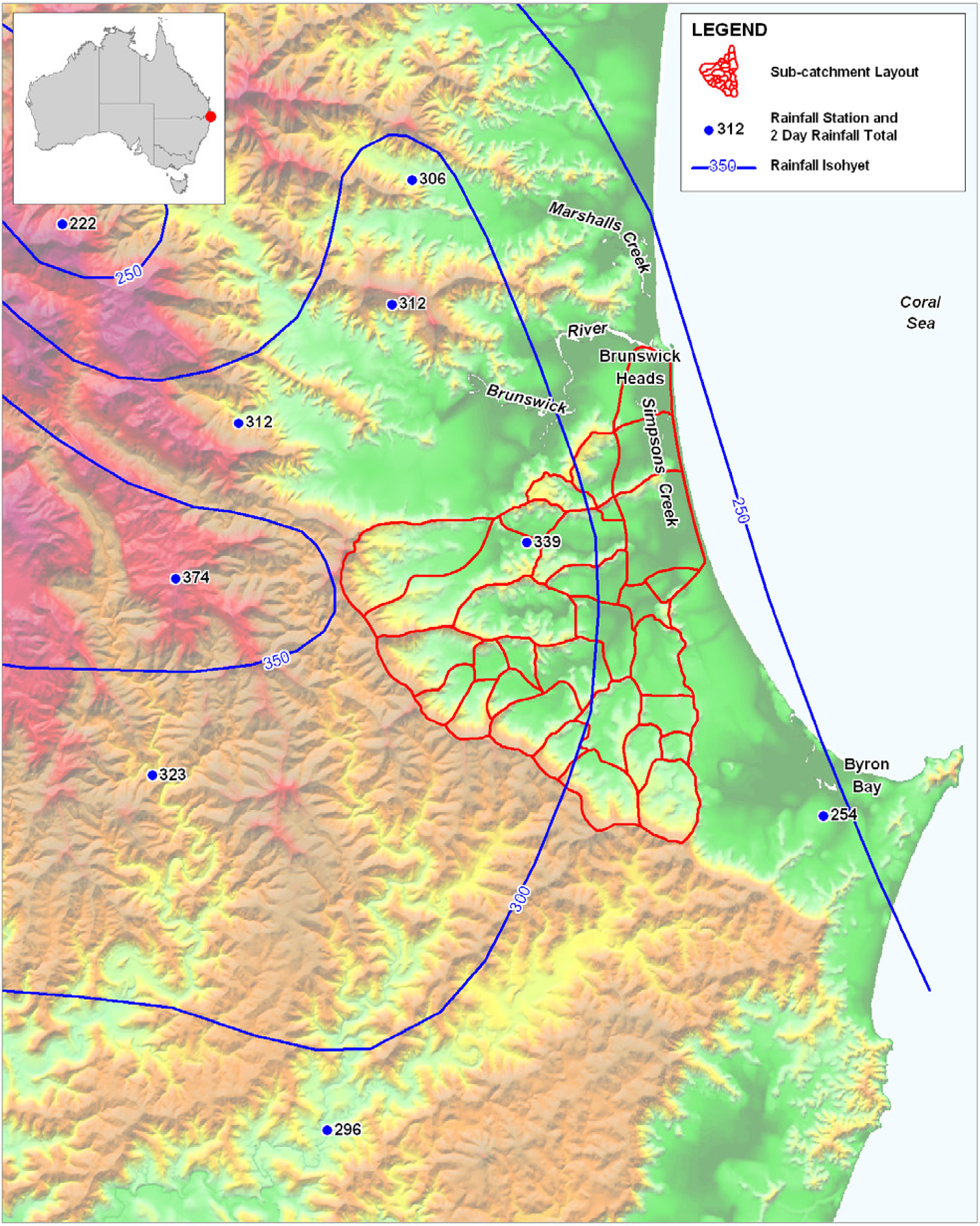

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May 2009 Event Rainfall Distribution

Figure: 5-6

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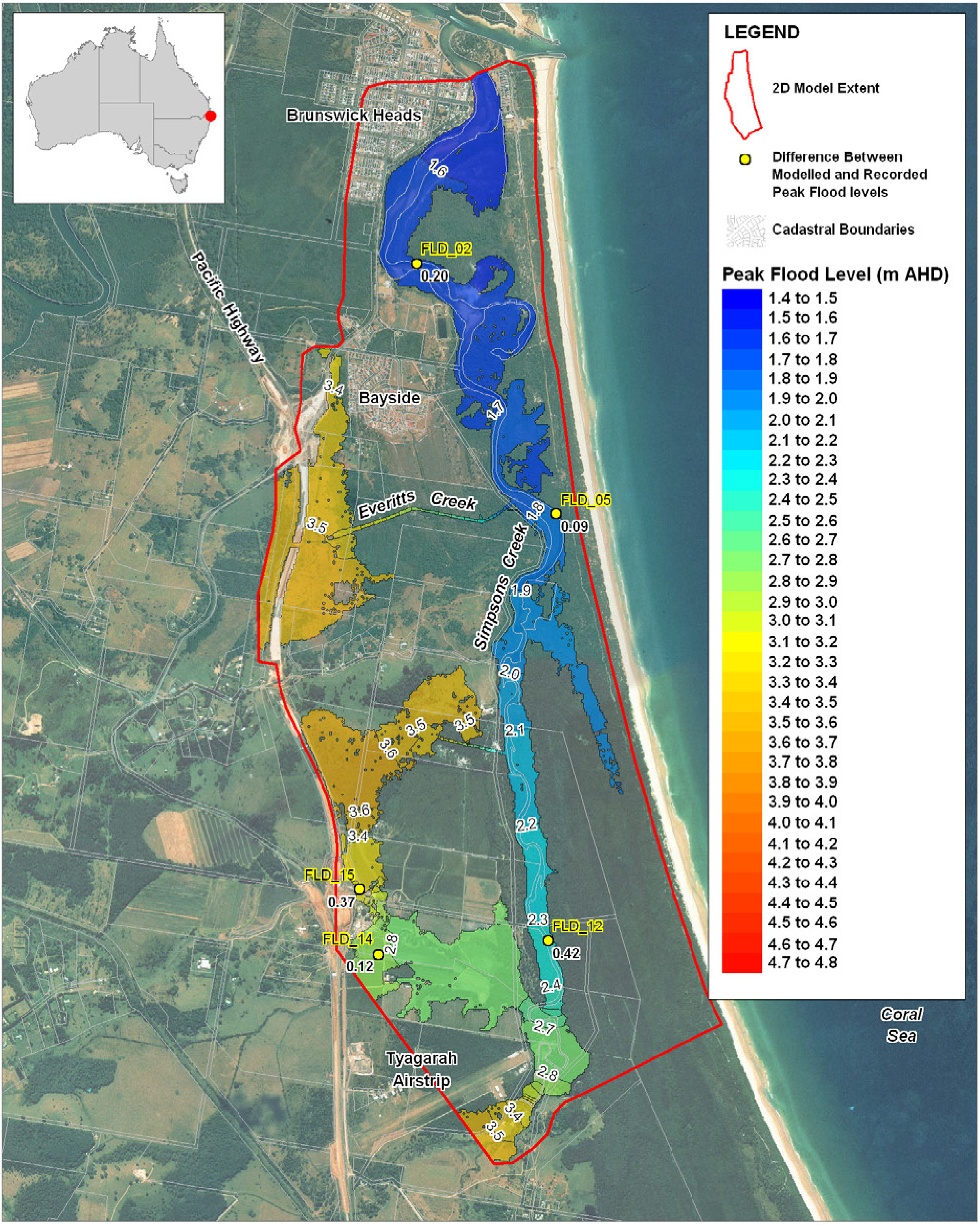

Title:

May 2009 Event Model Verification Results

Figure: 5-7

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Approx. Scale

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6 DESIGN FLOOD EVENT MODELLING

6.1 Introduction

In order to define the flood conditions of the subject site and assess possible flood impacts caused by the proposed development, design flood events were simulated using the flood model. Design flood events are hypothetical floods used for planning purposes and are based on a probability of occurrence. For this current study, the 20, 100 year ARI and the Probable Maximum Flood (PMF) storm events were assessed.

6.2 Design Rainfall Parameters

Intensity-Frequency-Duration (IFD) parameters have been extracted from Volume 2 of Australian Rainfall and Runoff (IEAust., 1987). The parameters were used to derive an IFD table for the catchment, which was compared against tables listed in Part N5 of Byron Shire Council's Development Control Plan (2002). The resulting rainfall intensities were comparable, with minimal differences across the range of storm durations and average recurrence intervals.

The design rainfall inputs for the PMF event were based the Revised Generalised Tropical Storm Method (GTSMR) (BoM, 2004).

6.3 Tidal Boundary Conditions

Downstream tidal boundary conditions applied for the 20, 100 year ARI and PMF events are based on the Draft Tweed Byron Coastal Creeks Flood Study (BMT WBM, 2009). The boundary conditions have been derived during earlier studies, and include storm surge effects from wind, barometric setup and an allowance for wave setup. The boundary conditions used are presented in Figure 6-1.

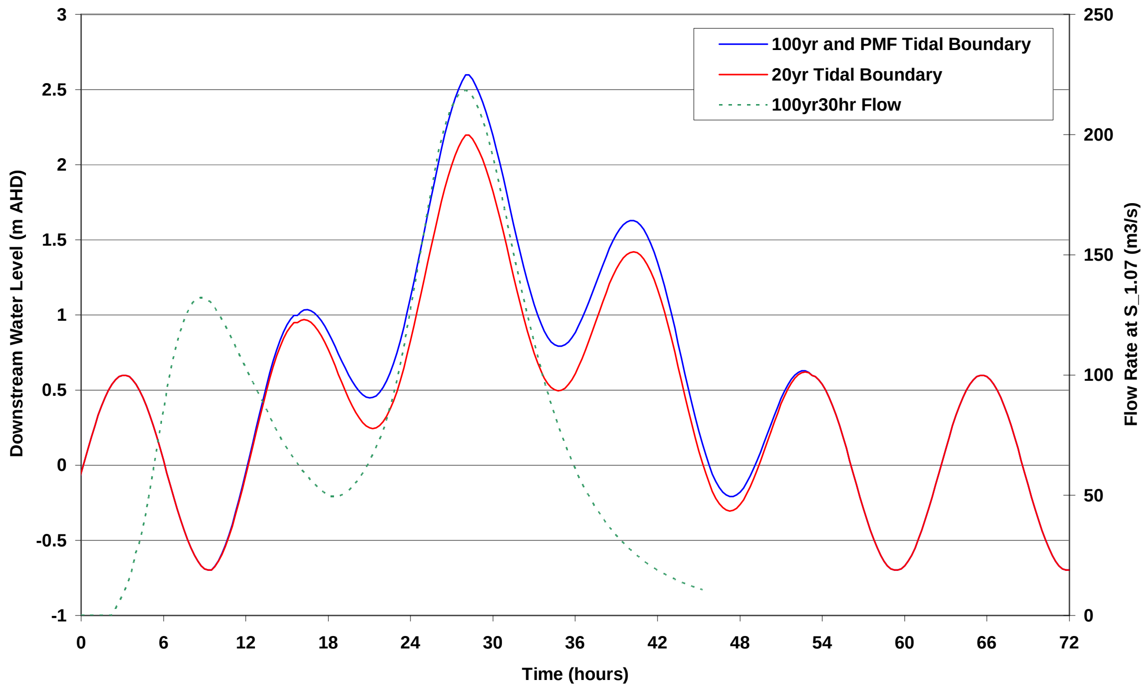


Figure 6-1 Design Event Downstream Boundary Conditions

The timing of the model simulation has been adjusted so that the peak storm tide coincides with the peak flow rate at the upstream end of the hydraulic model, i.e. sub-catchment S_1.07. The subject site is between these two boundaries, hence, this approach will represent a 'worst case' scenario for flooding on the subject site.

6.4 Critical Duration Analysis

The existing case hydraulic model was used to simulate nine separate 100 year ARI storm durations ranging from 4.5 hours to 48 hours. Results of the simulations indicated that across the majority of the study area, the 30 hour storm produced the highest flood levels, with the exception of isolated areas where the 9 hour storm produced marginally higher peak flood levels.

The 30 hour critical storm duration is consistent with the results of modelling presented by WBM (1992) and Kinhill Cameron McNamara (1997). Therefore, this duration event has been adopted for all subsequent design event modelling.

7 EXISTING CASE ASSESSMENT

7.1 Flood Behaviour

Existing case peak flood levels for the 20, 100 year ARI and PMF 30 hour events are presented on Figure 7-2, Figure 7-7 and Figure 7-12 respectively, for the entire hydraulic model area.

Peak flood level, depth, velocity and hazard results for the 20, 100 year ARI and PMF 30 hour event at Bayside are presented on Figure 7-3 to Figure 7-16. Within this results set, the criteria used to define the flood hazard categories is shown in Figure 7-1, based on the Australian NSW Floodplain Development Manual (DIPNR, 2005).

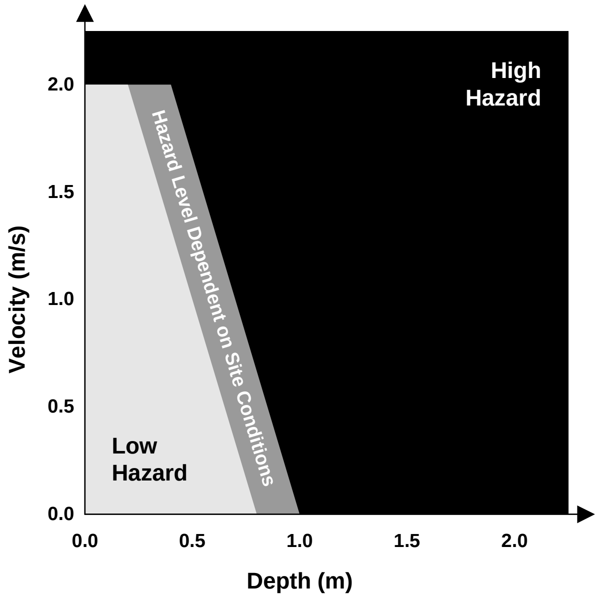


Figure 7-1 Flood Hazard Definition

From the model results, the following observations have been made:

- The flood gradient along Simpsons Creek is relatively constant from the Tyagarah Airstrip to upstream of Brunswick Heads;
- There is little discernable difference in flood gradient adjacent to Andersons Ridge, to the rest of Simpsons Creek. This is inconsistent with results of the 1D modelling undertaken by Kinhill Cameron McNamara (1992) and WBM (1997). Due to the improved data and techniques used for this study, the results are considered appropriate;
- Flooding within the floodplain areas to the west of the western bank ridge are characteristic of storage basins. The flood gradient is flat, and velocities are generally low;
- There is significant head drop between these floodplain areas and Simpsons Creek. This shows that the geometry of the connecting drainage channels are heavily influencing the peak flood levels in the floodplain; and
- There is minimal flooding within the subject site.

At the subject site, the following peak flood levels apply:

- 3.60m and 2.45m AHD at the western and eastern boundaries for the 20 year ARI event;
- 3.75m and 2.85m AHD at the western and eastern boundaries for the 100 year ARI event; and
- 4.40m and 3.40m AHD at the western and eastern boundaries for the PMF event.

7.1.1 Model Sensitivity Assessment

Throughout the model verification process, various values for surface roughness were trialled. During this process, a good understanding of the sensitivity of the surface roughness was gained.

Further sensitivity testing has been undertaken to determine the impact on flood behaviour in Simpsons Creek, should more flow from the Pipeclay Creek catchment and sub-catchment S_11.01 be routed into Simpsons Creek. Two scenarios have been investigated:

1 100% of sub-catchment S_11.01 runoff flows into Simpsons Creek; and

2 As per scenario 1, plus 100% of Pipeclay Creek flow.

Peak flood levels for the 100 year ARI 30 hour event are presented on Figure 7-17 and Figure 7-18 for scenarios 1 and 2 respectively. Included on these figures are points indicating the increase at specific locations due to the additional flow.

The results show a zero increase in peak flood level to the west of the development site, and a maximum 100mm increase within Simpsons Creek to the east of the subject site. These results indicate that the flood levels within the study area site are relatively insensitive to the additional inflows originating from sub-catchment S_11.01 and Pipeclay Creek.

7.1.2 Climate Change Assessment

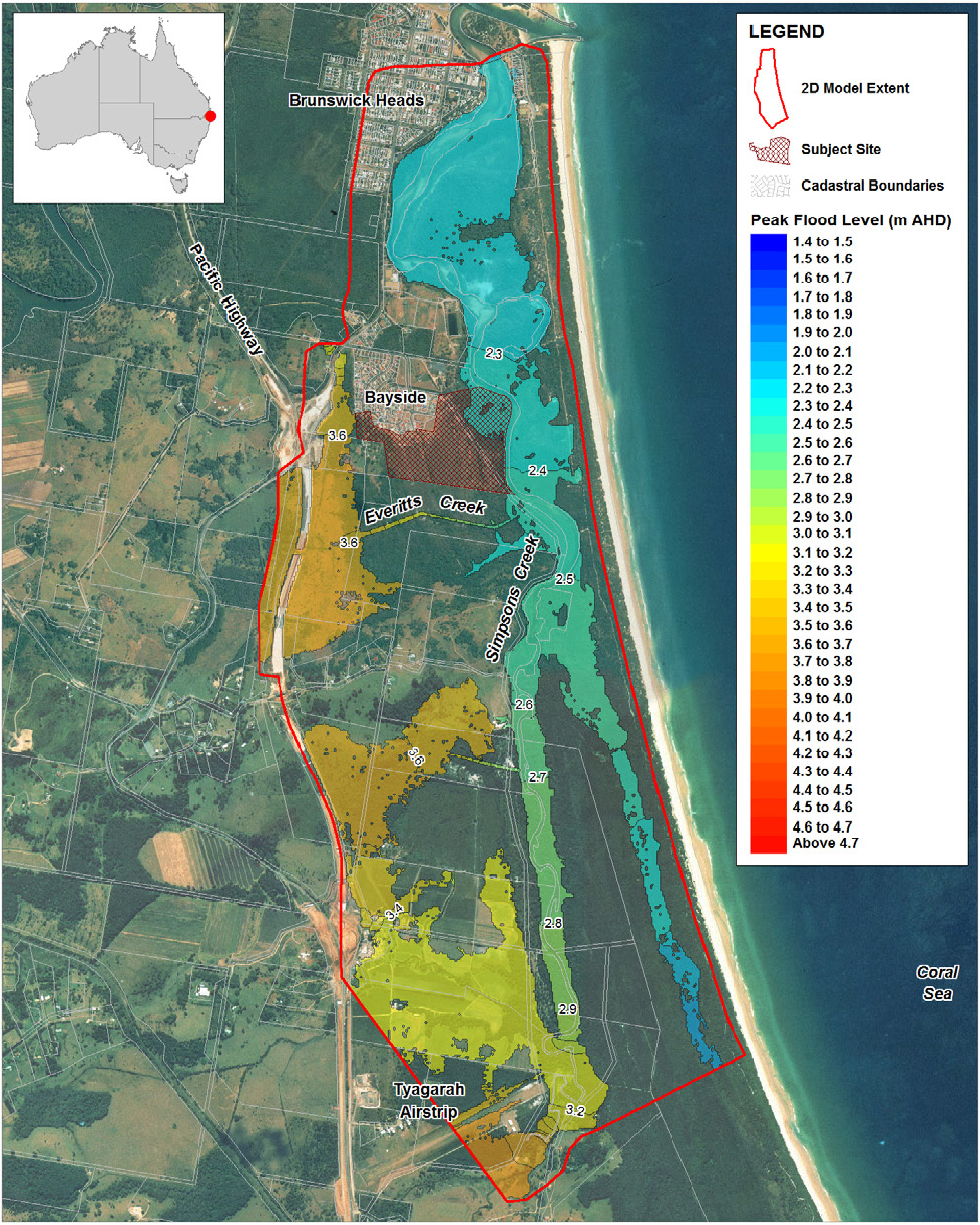
To address item 5.6 of the Director General's Requirements, two climate change scenarios have been investigated as listed in Table 7-1 and in accordance with the following documents:

- Practical Consideration of Climate Change – Floodplain Risk Management Guideline (DECC, 2007);
- Sea Level Rise Policy Statement (DECCW, 2009); and
- Byron Shire Council's Draft 100 year Climate Change Flood Planning Scenarios (BSC, 2009).

Table 7-1 Climate Change Scenarios

Scenario	*Ocean Boundary Contributions (m)*				*Upstream Model Inflows*
	Coincident Tide Level	*Storm Tide*	*Wave Setup*	*Sea Level Rise*	*Rainfall Intensity Increase*
1. Department of Environment, Climate Change and Water	0.94	0.9	0.45	**0.9**	**30%**
2. Byron Shire Council	0.94	**1.2**	0.45	**0.9**	**30%**

Peak flood levels for scenarios 1 and 2 are presented on Figure 7-19 and Figure 7-20 respectively.



Title:

20 Year ARI Peak Flood Levels - Existing Case Simpsons Creek

Figure: 7-2

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Approx. Scale

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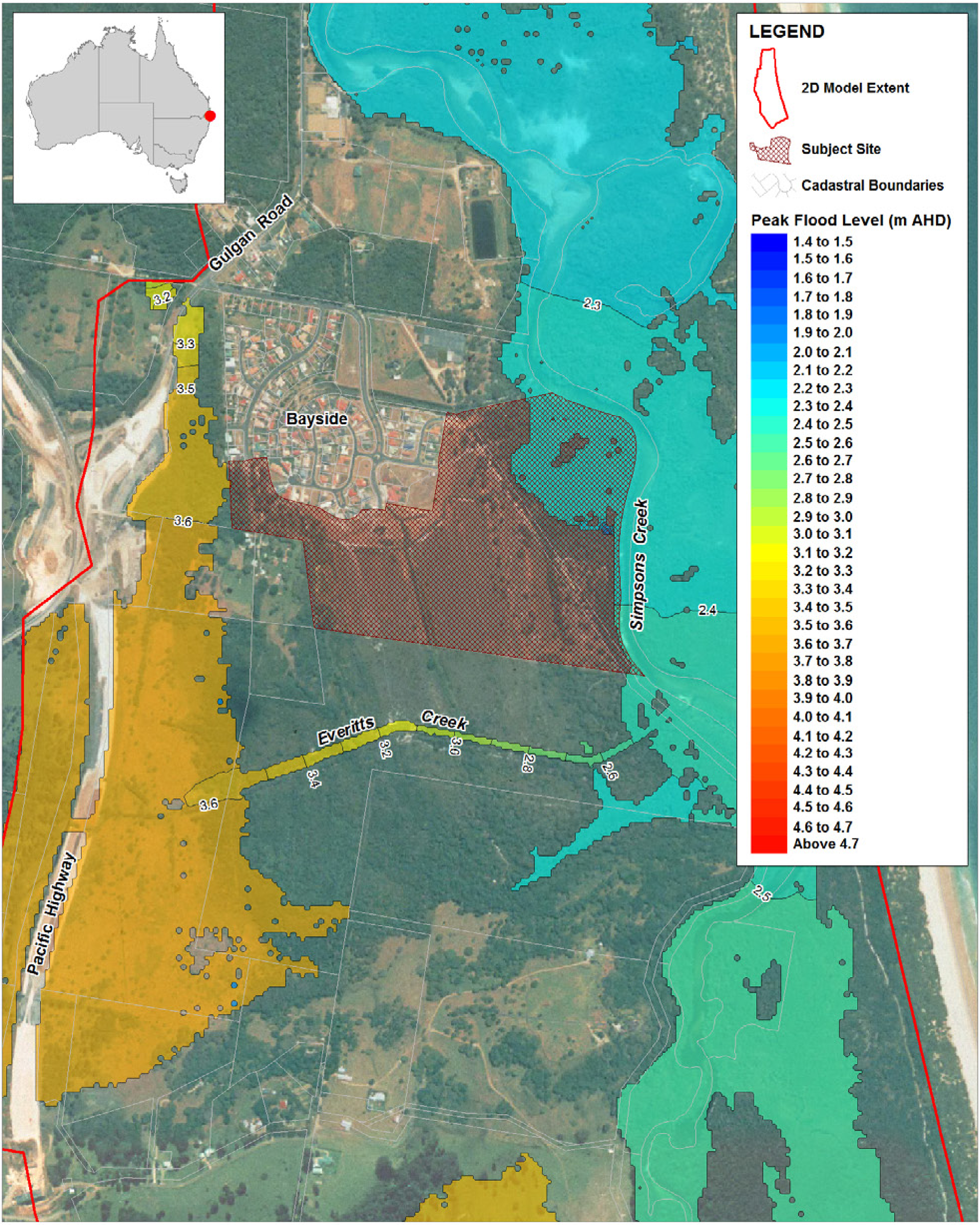

Title:

20 Year ARI Peak Flood Levels - Existing Case Bayside

Figure: 7-3

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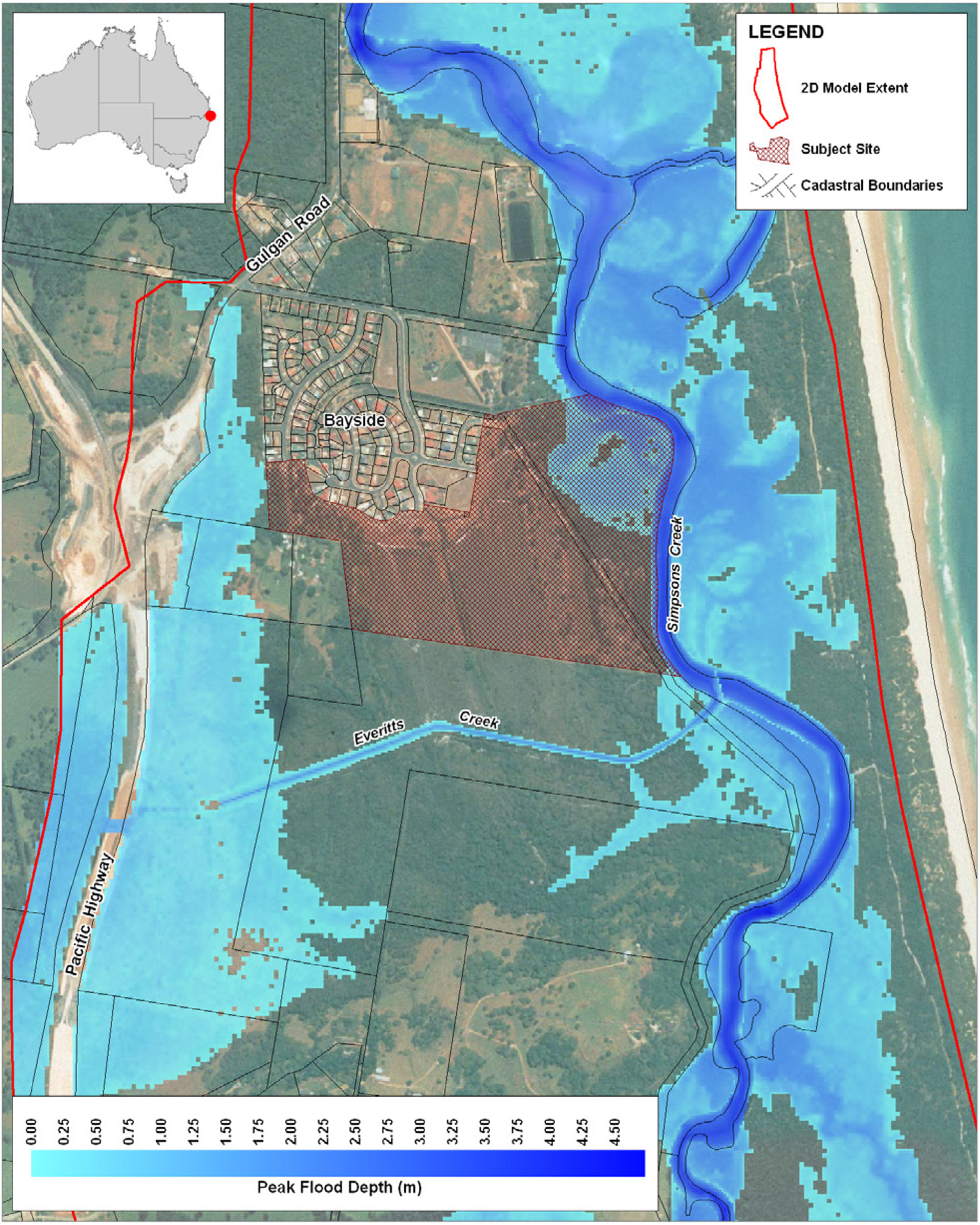

Title:

20 Year ARI Peak Flood Depths - Existing Case Bayside

Figure: 7-4

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Approx. Scale

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