Appendix L – Catchment Flooding & Storm Tide Study (BMT)

71-85 Port Douglas Road, Port Douglas, QLD Catchment Flooding & Storm Tide Study

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	Client Reference:	
Synopsis:	This report details the development of hydrologic & two dimensional (2D) hydraulic models of Creek & local catchments, and assessment of storm tide to derive the 1% Annual Exceedance Probability (AEP) Defined Flood Level pertinent specifically for the proposed development site.	

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Executive Summary

BMT Commercial Australia Pty Ltd completed a flood study and site-based assessment of storm tide with respect to the proposed development site located at 71-85 Port Douglas Road, Port Douglas, QLD. The main aim of the study was to derive the 1% Annual Exceedance Probability (AEP) design Defined Flood Level (DFL) pertinent specifically for the proposed development site. The study was conducted in accordance with latest edition of the *Australian Rainfall & Runoff* (ARR2019) design flow estimation guideline.

The DFL estimates were derived based on a combination of regional catchment flow and storm tide tailwater level. Whilst the ARR2019 guideline requires the consideration of the 1% AEP flow with the same AEP (1% AEP in this case) storm tide, the assessment contained herein conservatively adopted the 1% AEP storm tide plus sea level rise for the 2070 and 2100 climate change predictions for consistency with Douglas Shire Council requirements.

A local flood assessment was undertaken to ensure that the level derived from the local flooding event was not higher than the regional flood levels. A sensitivity analysis was also conducted based on a range of Manning's 'n' values for main flow paths. The analysis showed that the DFL estimates were not very sensitive to the adopted roughness values.

Based on the flood model results, the 1% AEP DFL estimates for the proposed development site are:

- 2.70m AHD for the 2100 storm tide combination;
- 2.46m AHD for the 2070 storm tide combination; and
- 2.45m AHD for the local flooding event.

In accordance with the Douglas Shire Planning Scheme, Flood and Storm Tide hazard overlay code, the proposed development floor level must provide flood immunity to the 1% AEP DFL plus a freeboard allowance of 300 mm. The recommended minimum finished floor levels are therefore:

- Development design life of 80-years (i.e. to the year 2100): 3.00 mAHD
- Development deign life of 50-years (i.e. to the year 2070): 2.76 mAHD.

Contents

Executive Summary **i**

1 Introduction **1**

1.1 Background 1

1.2 Objectives of the Study & Report Structure 1

2 Site Description **2**

3 Storm Tide Assessment **3**

3.1 Background 3

3.1.1 Wave Effects 4

3.2 Independent Storm Tide Levels at the Subject Site 4

4 Hydrologic Analysis **6**

4.1 WBNM Model Setup 6

4.1.1 Catchment Delineation and Properties 6

4.1.2 Rainfall Intensity and Temporal Patterns 7

4.1.3 Rainfall Loss Rates 7

4.1.4 Global Lag Parameter 7

4.2 WBNM Output 9

4.3 Model Validation 9

4.3.1 Rational Method 9

4.3.2 RFFE 10

5 Hydraulic Analysis **13**

5.1 Creek Catchment Model 13

5.1.1 2D Model Extent and Grid Size 13

5.1.2 Manning's n 13

5.1.3 Inflow Hydrographs 13

5.1.4 Downstream Boundary Conditions 13

5.1.5 Initial Water Level 14

5.1.6 1D Structure 14

5.2 Local Catchment Model 16

5.2.1 2D Model Extent and Grid Size 16

5.2.2 Inflow Hydrographs 16

5.2.3 Downstream Boundary Conditions 16

5.2.4 Initial Water Level 16

5.3 Model Results 18

5.4 Sensitivity Analysis 18
6 Flood Immunity Requirements 19
6.1 Douglas Shire Planning Scheme 19
7 Conclusions 20
Appendix A Flood Level Mapping A-1

List of Figures

Figure 2-1 Locality Map 2
Figure 3-1 Subset of Storm Tide Study Output Points 5
Figure 4-1 Packers Creek Catchment Layout 8
Figure 4-2 RFFE Layout of Sub-Catchment ‘I’ Outlet 11
Figure 4-3 RFFE Layout of Sub-Catchment ‘S’ Outlet 12
Figure 5-1 Creek Catchment TUFLOW Model Layout 15
Figure 5-2 Local TUFLOW Model Layout 17

List of Tables

Table 3-1 Summary of Outputs from Location 246 (BMT WBM 2013) 3
Table 3-2 Summary of Outputs from Location 254 (BMT WBM 2013) 4
Table 4-1 Sub-Catchment Properties 6
Table 4-2 1% AEP WBNM Peak Flows at Outlets of Sub-Catchments I and S 9
Table 4-3 Rational Method Time of Concentration Calculations 9
Table 4-4 Rational Method 1% AEP Peak Flow Calculations 10
Table 4-5 RFFE 1% AEP Peak Flow Estimates 10
Table 5-1 Joint Probability Model Scenarios 14
Table 5-2 Creek Flood Model 1% AEP Defined Flood Level Estimates 18
Table 5-3 Local Catchment 1% AEP Defined Flood Level Estimate 18
Table 5-4 Sensitivity Case Flood Level Estimates 18

1 Introduction

1.1 Background

Development approval was previously issued by former Douglas Shire Council (DSC) to construct a resort style development on 71-85 Port Douglas Road, Port Douglas, QLD. The approval included conditions in relation to finished floor levels based on the *Cairns Region Storm Tide Inundation Study* (BMT WBM 2013). In the absence of a site-based assessment, a minimum finished floor level of 3.2 mAHD for immunity from storm tide was required.

Recent correspondence from DSC (email on 17 March 2020 to Erin Campbell, GHD) also indicated that there is no available local catchment flood model covering the site and there is some uncertainty in relation to the finished floor levels for immunity from regional and local catchment flooding. In this case, DSC adopts default minimum finished floor level of 3.4 mAHD.

BMT Commercial Australia Pty Ltd has been engaged by Chiodo Corporation Operations Pty Ltd to undertake a flood study and provide site-based storm tide advice to inform the assessment of minimum finished floor levels for the proposed development site.

1.2 Objectives of the Study & Report Structure

General features of the subject site relevant to the flood assessments are described in Section 2. Outputs from the *Cairns Region Storm Tide Inundation Study* (BMT WBM 2013) are included in Section 3 and a site-based interpretation of this previous regional scale assessment is provided.

The study involves the development of a hydrologic model and a 2D hydraulic model in accordance with latest edition of the *Australian Rainfall & Runoff* (ARR2019) design flow estimation guideline, with the aim of deriving the 1% Annual Exceedance Probability (AEP) design Defined Flood Level (DFL) and provided minimum finished floor levels for the proposed development site. Sections 3 and 5 provide the details of the hydrologic and hydraulic modelling, incorporating outcomes of the site-based storm tide assessment presented in Section 3.

DSC flood immunity requirements and recommendations with respect to minimum finished floor levels are provided in Sections 6 and 7. The assessment and recommendations consider two potential planning horizons:

- Development design life of 80-years (i.e. to the year 2100)
- Development deign life of 50-years (i.e. to the year 2070).

Based on current state government recommendations for planning purposes in Queensland, appropriate sea level rise allowances in 2100 and 2070 are 0.8 m and 0.5 m respectively. These assumptions have been incorporated to the assessments described in this report.

2 Site Description

The subject site is located on the western side of Port Douglas Road between the Mirage Country Club and Oaks Resort (Refer to Figure 2-1). The Real description of the property is Lot1SP150468 and the site has an area of approximately 2.1 hectares.

The subject site is perched on high grounds, with most of the site consisting of ground elevations above 3.5m AHD compared to the Creek floodplain level of about 1.0m AHD. The potential exposure to storm tide conditions is either from the open coast approximately 500m east of the site or via Dickson Inlet to north.

Figure 2-1 Locality Map

3 Storm Tide Assessment

3.1 Background

DSC adopts the findings of the *Cairns Regional Storm Tide Inundation Study* (BMT WBM 2013) when providing guidance on minimum requirements for fill and floor levels for areas potentially exposed to coastal processes. Specifically, 1% AEP storm tide level in the year 2100 has been adopted by DSC. This design water level definition includes a 0.8 m allowance for sea level rise.

BMT WBM (2013) report tropical cyclone generated design water levels at 195 unique locations within the DSC local government area. The design water level definitions are as follows:

- The ‘storm tide’ level which includes the influence of the tide plus surge associated with the tropical cyclone climate.
- The ‘storm tide including wave effects’ which includes the additional contribution that wave processes can have on the water level (wave setup and runup).

The ‘storm tide’ level is applicable in areas not directly exposed to waves. This includes tidal extent of rivers and creeks and coastal floodplain more than 200 m inland from the coastline.

The ‘storm tide including wave effects’ level is applicable to areas directly exposed to breaking waves. This is generally limited to open coast beaches where wave setup and wave runup processes occur.

A subset of output points from BMT WBM (2013) is shown in Figure 3-1 indicating that location ‘246’ is the closest representative reporting location to the proposed development site. Table 3-1 provides a summary of outputs from location 246 for the 1% AEP in 2100.

Table 3-1 Summary of Outputs from Location 246 (BMT WBM 2013)

TC Generated Parameters: 1 in 100 (1% AEP) in 2100	Location 246
Significant Wave Height (m)	2.84
Wave Peak Period (s)	7.07
Tide plus Surge (mAHD)	2.73
Tide plus Surge plus Wave Effects (mAHD)	3.90

Storm tide conditions may also reach the development site via Dickson Inlet and Packers Creek. The 1% AEP storm tide conditions at the entrance to Dickson Inlet are used to inform the hydraulic model tailwater condition for the flood assessments described in Section 5. This location corresponds to point ‘254’ in Figure 3-1 where the 1% AEP storm tide (tide plus surge) in 2100 is estimated to be 2.63 mAHD.

As a conservative approach, the slightly higher values at point 246 and referenced in Table 3-1 have been adopted for the independent site-based assessment of storm tide described below. For informing the hydraulic model tailwater condition (refer Section 5), the values at point 254 and referenced in Table 3-2 have been used.

Table 3-2 Summary of Outputs from Location 254 (BMT WBM 2013)

TC Generated Parameters: 1 in 100 (1% AEP) in 2100	Location 246
Significant Wave Height (m)	3.18
Wave Peak Period (s)	7.07
Tide plus Surge (mAHD)	2.63
Tide plus Surge plus Wave Effects (mAHD)	3.97

3.1.1 Wave Effects

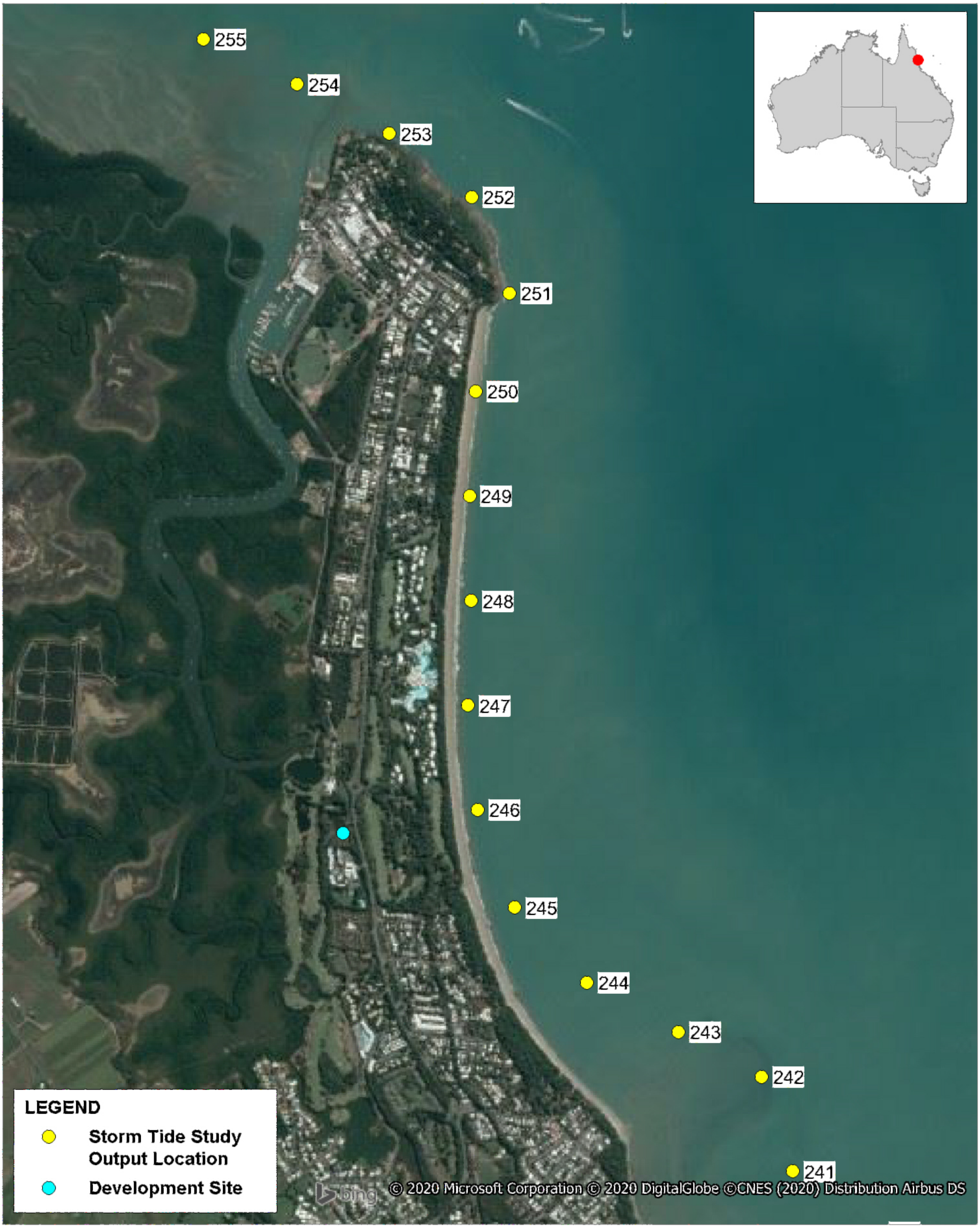
Wave effects diminish with the distance from the coastline due to topography and resistance from vegetation. For the BMT WBM (2013) study, in the absence of site-specific investigations, wave effect penetration was conservatively assumed to reach 200 m from the shoreline, with a linear reduction in wave effects with distance from the shoreline. Beyond 200 m the effects of waves on the extreme water level is assumed negligible. Most of the subject site is greater than 500 m landward of the open coast shoreline and therefore not exposed to the influence of waves. In this scenario, the ‘tide plus surge’ level applies. The influence of waves on the storm tide level is therefore not considered further in this study.

3.2 Independent Storm Tide Levels at the Subject Site

The BMT WBM (2013) study did not assess storm tide in the year 2070. Based on current state government recommendations for planning purposes, an appropriate sea level rise allowance in 2070 is 0.5 m. Design storm tide levels (not including freeboard) for the site and 2100 and 2070 planning horizons are therefore:

- Development design life of 80-years (i.e. to the year 2100): 2.7 mAHD (i.e. the ‘tide plus surge’ level taken from Table 3-1)
- Development deign life of 50-years (i.e. to the year 2070): 2.4 mAHD (i.e. based on the ‘tide plus surge’ level taken from Table 3-1 with a reduced sea level rise allowance).

These levels and the outputs from BMT WBM (2013) are considered further as part of the joint probability assessments of catchment flooding and storm tide presented in Section 5.



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Subset of Storm Tide Study Output Points (BMT WBM 2013)

Figure: 3-1

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Approx. Scale

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4 Hydrologic Analysis

A hydrologic analysis was conducted to derive design inflow hydrographs for use in the hydraulic analysis. The analysis methodology was based on the latest edition of ARR2019 guideline. A hydrologic model of the Packers Creek catchment (adjacent to the subject site) established using the Watershed Bound Network Model (WBNM). The model was validated against the probabilistic Rational Method and the Regional Flood Frequency Estimation (RFFE) method.

The details of the hydrologic analysis are presented in the following sections.

4.1 WBNM Model Setup

The model requires several input parameters to derive design inflow hydrographs. These are detailed in the following sections.

4.1.1 Catchment Delineation and Properties

The delineation of the Packers Creek catchment was carried out based on a 5m grid LiDAR digital terrain model (DTM) sourced from the ELVIS online database. The delineation was completed using a combination of the QGIS Watershed Analysis automated tool and manual adjustment as required.

The overall drainage area was delineated into several sub-catchments to allow for derivation of inflow hydrographs at multiple points of interest. The catchment plan is shown in Figure 4-1. The catchment properties are presented in Table 4-1.

Table 4-1 Sub-Catchment Properties

Sub-Catchment	Area (ha)	Fraction Impervious (%)	Sub-Catchment	Area (ha)	Fraction Impervious (%)
A	408.4	0	K	37.3	0
B	143.5	0	L	7.3	50
C	162.8	0	M	6.2	40
D	85.8	0	N	337.7	0
E	78.4	60	O	117.4	0
F	72.6	50	P	34.6	0
G	21.5	40	Q	27.8	0
H	19.3	35	R	101.3	0
I	32.7	0	S	138.5	25
J	61.2	0	-	-	-

4.1.2 Rainfall Intensity and Temporal Patterns

Site specific intensity frequency duration (IFD) and temporal patterns were derived from the ARR Data Hub based on Latitude of -16.5316 and Longitude of 145.4503.

It is noted that despite the catchment area being greater than 1 km^2 (threshold for application of areal reduction factor), the no areal reduction factor (ARF) was applied to the IFD to provide a more conservative rainfall depth estimate.

4.1.3 Rainfall Loss Rates

The following global rainfall losses were obtained from the ARR Data Hub:

- Storm initial loss (SIL) of 67 mm and continuing loss (CL) of 3.5 mm for pervious surface.
- IL of 0mm and CL of 1 mm for impervious area; and
- Pre-burst rainfall depth varying per storm durations.

Based on the ARR guideline, the design burst initial loss is calculated as the SIL (67 mm) minus the median pre-burst rainfall depth. Based on the supplied SIL and pre-burst rainfall depths, the design IL was calculated to be zero for the durations greater than 60 minutes. For the durations less or equal to 60 minutes, the ARR method calculated an IL of 57 mm. For the local hydrologic analysis however an IL of 0 mm was conservatively adopted for these durations as well.

4.1.4 Global Lag Parameter

The lag parameter is used for the conversion of rainfall to runoff on pervious and impervious surfaces, as well as flood routing in streams. The WBNM user guide recommends a Lag Parameter value between 1.3 and 1.8. For the analysis different values were tested as part of the model validation. For the final analysis, a value of 1.3 was adopted to obtain a close agreement with the validation method.

Legend
- Creek Flow path
- Site Boundary
- Catchment Flow Direction
- Sub-Catchment Boundary

Title:

Catchment Layout

Drawing: 4-1

Rev: A

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4.2 WBNM Output

The 1% AEP peak flows at the outlets of sub-catchments ‘I’ and ‘S’ were derived from the model for the purpose of model validation. The peak flows, critical durations and adopted temporal patterns are summarised in Table 4-2. It is noted that the critical duration and temporal patterns were selected based on the median value.

Table 4-2 1% AEP WBNM Peak Flows at Outlets of Sub-Catchments I and S

Outlet	Area (ha)	Critical Duration (min)	Adopted Temporal Pattern	Peak Flow (m^3/s)
Sub-catchment ‘I’	1,025	180	8781	168.6
Sub-catchment ‘S’	1,894	180	8795	289.8

4.3 Model Validation

The model was validated at the outlet of sub-catchments ‘I’ and ‘S’ by comparing the 1% AEP peak flows derived from the model against the Rational Method and RFFE model. The validation process is detailed in the following sections.

4.3.1 Rational Method

For the Rational Method, the time of concentration (TC) was calculated using the Friend’s Equation (Chart 4.6) and Stream Velocity method in accordance with the Queensland Urban Drainage Manual (QUDM). The calculations of the TC and peak flows are presented in Table 4-3 and Table 4-4. The results show that the Rational Method estimates were found to be generally consistent with those of the WBNM model.

Table 4-3 Rational Method Time of Concentration Calculations

Parameters	Length (m)	Average Slope (%)	Assumed Velocity (m/s)	Travel Time (min)
Sheet Flow	50	10	n/a	15
Reach 1	2,500	13	1.5	27.8
Reach 2	2,300	5	0.9	42.6
Reach 3	2,225	0-1.5	0.7	53.6
Sub-catchment ‘I’ Outlet TC (min)				138.9
Reach 4	3,830	0-1.5	0.7	91.2
Sub-catchment ‘S’ Outlet TC (min)				230.1

Table 4-4 Rational Method 1% AEP Peak Flow Calculations

Outlet	Area (ha)	Fraction Impervious (%)	I_{10y1hr} (mm/hr)	C_{10}	C_{100}	TC (min)	I_{100} (mm/hr)	Peak Flow (m^3/s)
Sub-catchment 'I'	1,025	10	83.7	0.7	0.84	138.9	80.5	193
Sub-catchment 'S'	1,894	10	83.7	0.7	0.84	230.1	64.2	284

4.3.2 RFFE

The RFFE method was used to calculate peak flow estimates at the two validation points using the ARR Data Hub on-line program. Figure 4-2 and Figure 4-3 show the RFFE model layouts for the selected validation points. Table 4-5 presents the 1% AEP peak flow estimates. These estimates were found to be very different from those of both the WBNM and Rational methods.

It is noted that the RFFE method estimates the flow for a given catchment based on statistical correlation of the catchment with the nearest regional catchment flow gauges. Its accuracy is thus dependent on the quantity and distance of the flow gauges used to drive the flow. It is also noted that as the method does not implement non-linear runoff routing techniques like most industry standard hydrologic models, the estimation does not take into consideration distinctive hydrologic/hydraulic characteristics of a given catchment such as the presence of a significant flood storage that can have a significant effect on the flow estimation.

As the study area consists of steep slopes in the upper catchment and very flat slopes in the lower part of the floodplain where there is a significant flood storage, the RFFE method is not considered to provide accurate flow estimation.

Hence, given the consistency between the Rational Method and WBNM estimates, the former was adopted as the preferred validation method.

Table 4-5 RFFE 1% AEP Peak Flow Estimates

Outlet	Area (km^2)	5% Confidence Limit (m^3/s)	95% Confidence Limit (m^3/s)	Expected Quantiles (m^3/s)
Sub-catchment 'I'	10.25	130	1,230	402
Sub-catchment 'S'	18.94	186	1,750	572

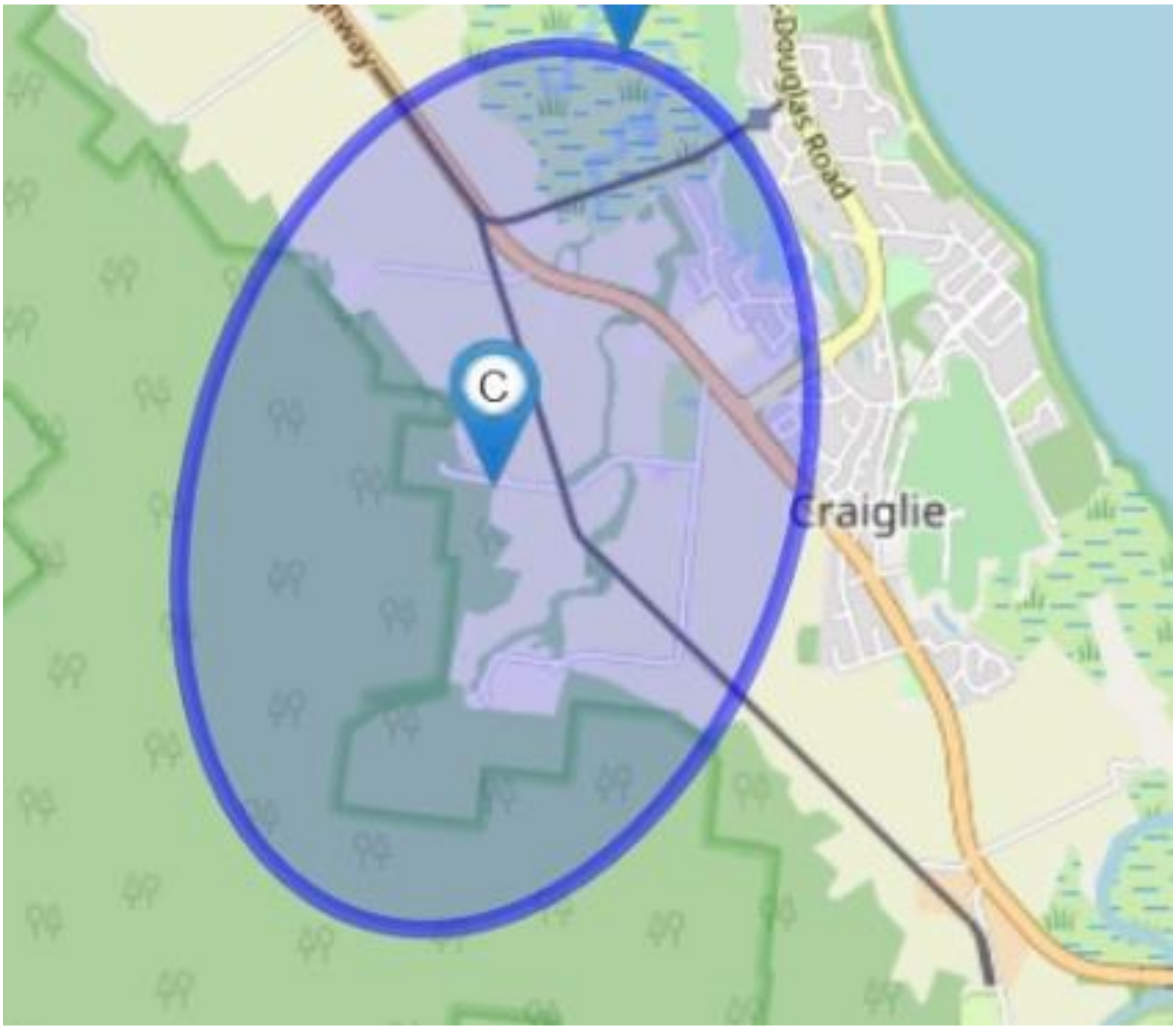


Figure 4-2 RFFE Layout of Sub-Catchment 'I' Outlet

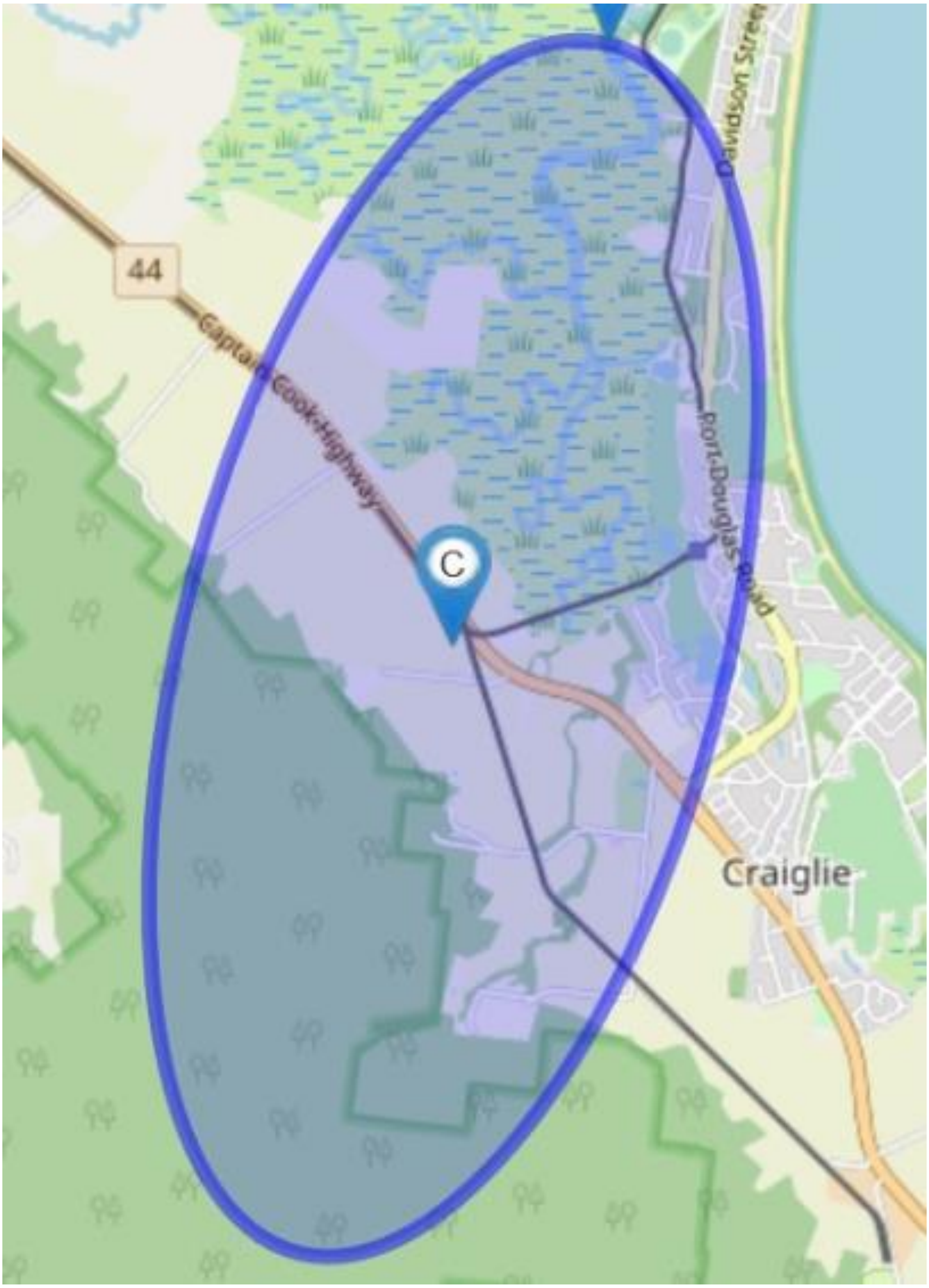


Figure 4-3 RFFE Layout of Sub-Catchment 'S' Outlet

5 Hydraulic Analysis

A combined 1D/2D unsteady flow model of the study area was established using the TUFLOW software package (Version 2018-03-AC-iSP). TUFLOW is a leading industry standard hydraulic modelling package suited for coastal, riverine, and overland flow flood modelling. For the analysis, the latest Highly Parallelised Compute (HPC) TUFLOW engine was utilised to capitalise on the fast runtime. The two models were developed, namely Creek & local catchment flood models, as detailed in the following sections.

5.1 Creek Catchment Model

The Creek catchment model was established to assess a combination of catchment flooding and storm tide across the floodplain. The key components of the model are detailed below.

5.1.1 2D Model Extent and Grid Size

The Creek flood model starts just downstream of Captain Cook-Highway, extending downstream to the Port Douglas Yacht Club near the Port Douglas Crocs AFL ground.

A 10-metre grid size was adopted to achieve a reasonable balance between the requirements of model run time and topographic resolution. The TUFLOW model layout is shown in Figure 5-1.

5.1.2 Manning's n

The Manning's n values adopted within the study area are listed below:

- 0.025 for the water bodies and the mainstream path (Packers Creek);
- 0.1 for densely vegetated areas around the subject site; and
- 0.05 for the remainder of the wider floodplain.

5.1.3 Inflow Hydrographs

The design hydrographs derived from the WBNM model were adopted. For the initial run, several storm durations with full ensemble storms (ten temporal patterns per duration) to identify the final critical durations and temporal patterns based on the hydraulic analysis. The storm durations range from 180min to 1440min.

5.1.4 Downstream Boundary Conditions

The BMT WBM (2013) study includes a reporting point at the entrance of Dickson Inlet that is the most appropriate point for the downstream boundary (also refer Section 3). This study focused on storm tide conditions associated with tropical cyclone activity. As part of a separate study for the Department of Transport and Main Roads (TMR), BMT and Systems Engineering Australia (SEA) has also recently examined the role that 'non-cyclonic' weather systems have on the extreme water level statistic throughout the region. General findings from this recent work have also been considered when establishing a representative downstream boundary condition for the present-day (2020) scenario.

Consideration was given to the ARR2019 Chapter 5 of Book 6 in relation to joint probability of catchment and storm tide flooding. The ARR2019 guideline requires the consideration of a combination of the 1% AEP flow and the 1% AEP storm tide level. The hydraulic analysis detailed herein also incorporates sea level rise allowances for the 2070 and 2100 planning horizons. Table 5-1 presents the 1% AEP storm tide levels at the entrance of Dickson Inlet for the various scenarios.

Table 5-1 Joint Probability Model Scenarios

Scenario	Downstream Tailwater Level (m AHD)	Sea Level Rise allowance (m)	Source
1% AEP Flow with 1% AEP coastal water level (tide plus surge) in 2020	2.08	NA	BMT (2019), unpublished non-cyclonic analysis
1% AEP Flow with 1% AEP coastal water level (tide plus surge) in 2070	2.33	0.5	BMT WBM (2013)*
1% AEP Flow with 1% AEP coastal water level (tide plus surge) in 2100	2.63	0.8	BMT WBM (2013)

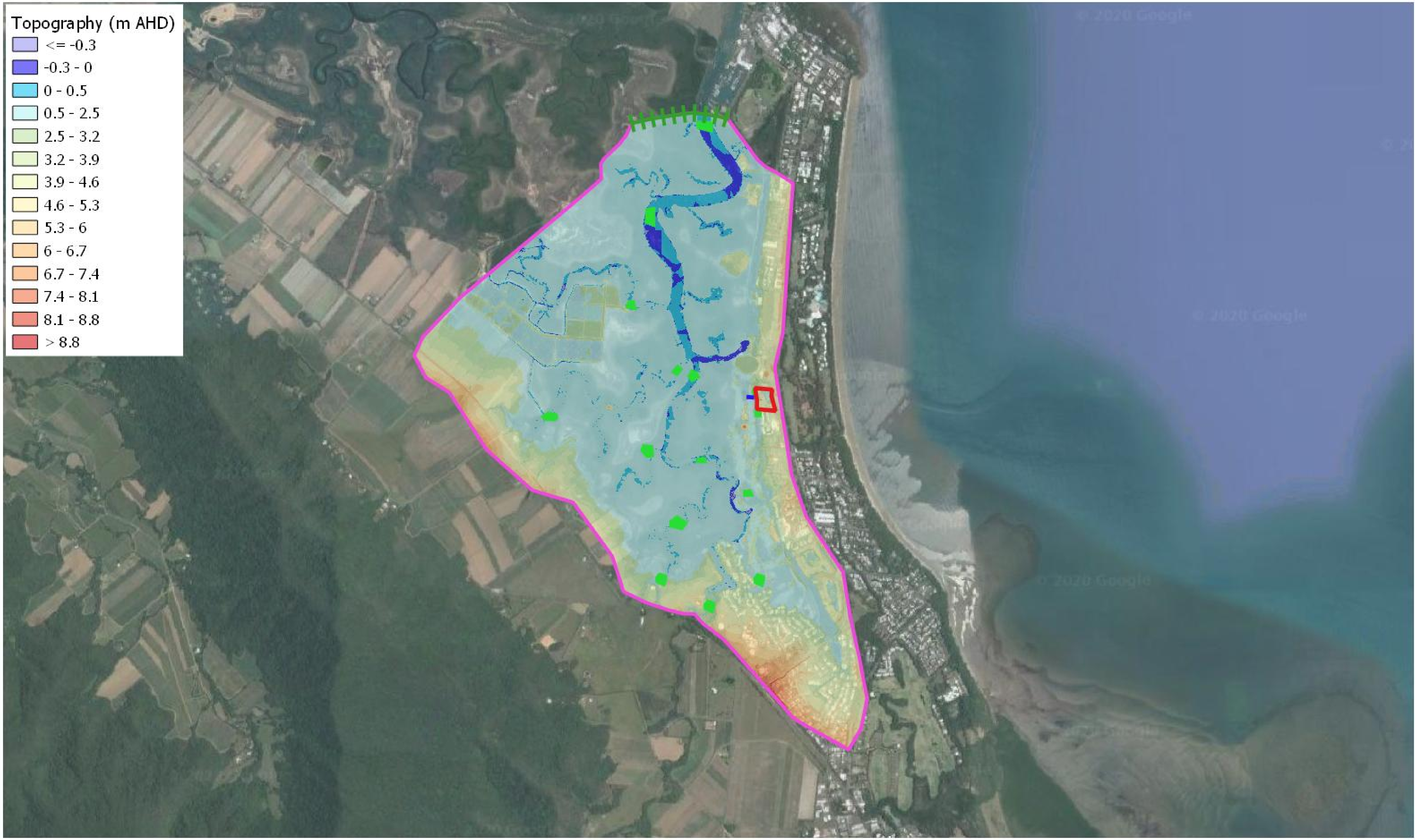
*based on the 1% AEP in 2100 result with a reduced 0.5 m sea level rise allowance

5.1.5 Initial Water Level

An initial water level of 0.91 mAHD was applied in the model at the start of the simulation. This level represents the Mean High-Water Springs (MHWS) level for the current climate scenario published by Maritime Safety Queensland.

5.1.6 1D Structure

There is an existing culvert at the south western corner of the site boundary that conveys the local runoff into the Golf Course Lagoon. The size of this structure was estimated based on measurement of the headwall based on an aerial photo. The modelled structure is 2.4m x 0.6m RCBC.



Legend

- 2d_bc_TWL
- 1d_nwk_EXG_Culvert
- Site Boundary
- 2d_sa_Inflows
- 2d_code_ModelExtent

Title:

Packers Creek TUFLOW Model Layout

Drawing: **5-1**

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5.2 Local Catchment Model

A detailed TUFLOW model was established to assess flooding resulting from short duration intense storms over the local site catchment that is perched on high grounds. The local catchment drains in a westerly direction with the highest section of the catchment defined by Port Douglas Road.

5.2.1 2D Model Extent and Grid Size

The local model covers the subject site and the immediate surroundings that are perched on high grounds. A 2-metre grid size was adopted to provide a more detailed topographic resolution of the terrain. The model extent is shown in Figure 5-2.

5.2.2 Inflow Hydrographs

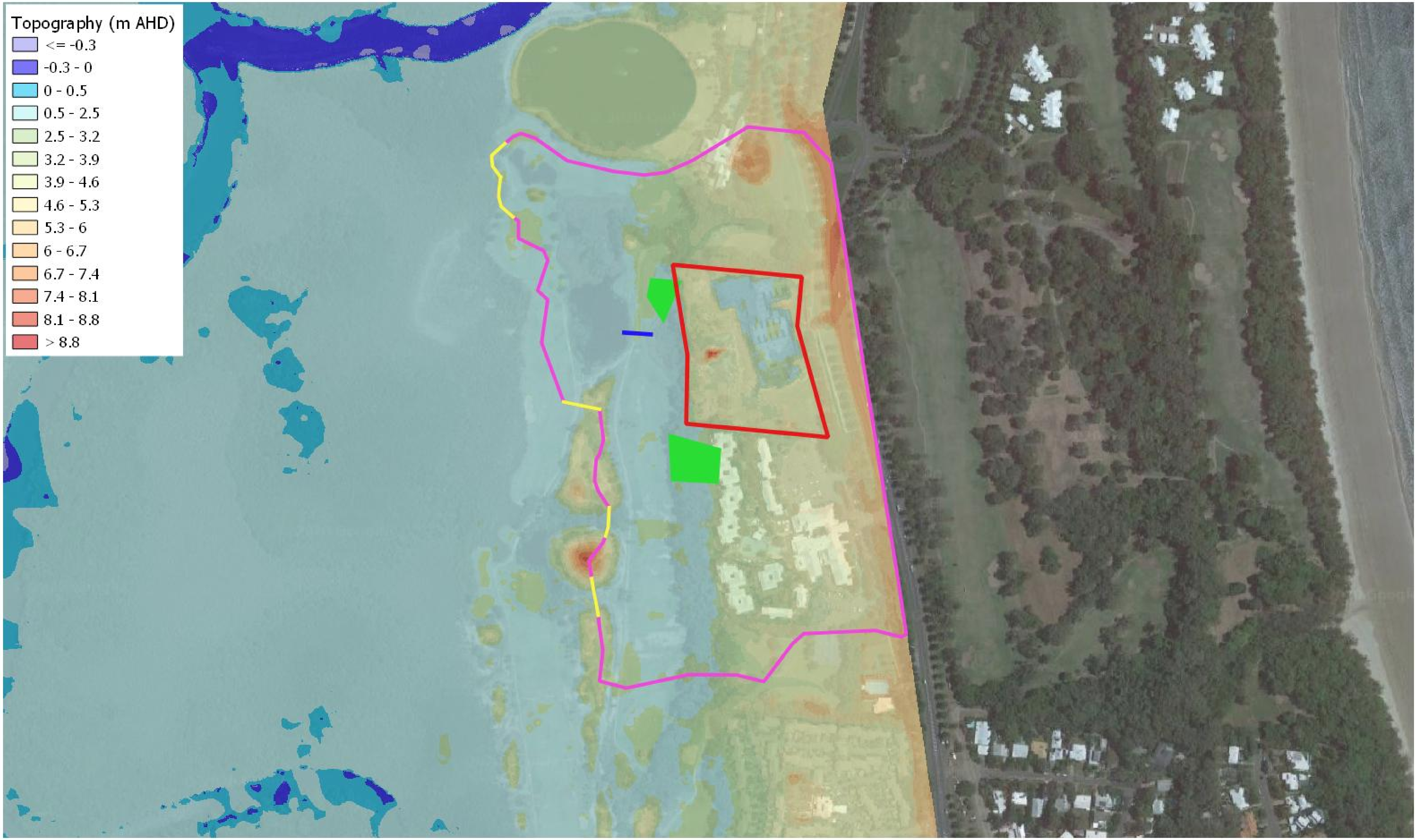
The design hydrographs derived from the WBNM model were adopted. For the initial run, several storm durations with full ensemble storms (ten temporal patterns per duration) to identify the final critical durations and temporal patterns based on the hydraulic analysis. The storm durations range from 25 min to 180 min.

5.2.3 Downstream Boundary Conditions

The downstream boundary conditions were defined based on the Normal Depth slope of 0.01 m/m.

5.2.4 Initial Water Level

An initial water level of 1.88 mAHD was applied in the Lagoon. This level represents the crest level of spillway of the Golf Course Lagoon.



Legend

- 2d_bc_TWL_local
- Site Boundary
- 2d_code_ModelExtent_local
- 1d_nwk_EXG_Culvert
- 2d_sa_Inflows_Local

Title:

Local Catchment TUFLOW Model Layout

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5.3 Model Results

The median flood level was adopted as the DFL in accordance with the ARR2019 guideline. The results are presented in Table 5-2 and Table 5-3. Appendix A contains flood level mapping for both the Creek and Local catchment models.

Table 5-2 Creek Flood Model 1% AEP Defined Flood Level Estimates

Joint Probability	Tailwater Level (m AHD)	DFL (m AHD)	Critical Duration (min)	Median Temporal Pattern
1% AEP Flow with 1% AEP Storm Tide 2070	2.33	2.46	360	8762
1% AEP Flow with 1% AEP Storm Tide 2100	2.63	2.70	180	8781

Table 5-3 Local Catchment 1% AEP Defined Flood Level Estimate

DFL (m AHD)	Critical Duration (min)	Median Temporal Pattern
2.45	90	8630

5.4 Sensitivity Analysis

A sensitivity analysis was undertaken based on a range Manning's n values (lower and higher than the design case of 0.025) for the main flow paths to check the sensitivity of the peak flood level estimation. For the analysis, the 1% AEP flow and the 2100 storm tide combination were adopted, using the critical duration of 180min and median temporal pattern of 8781. The sensitivity case flood level estimates are presented in Table 5-4. It is noted that for the design case, the model predicted a flood level estimate of 2.70m AHD. These indicate that the flood level estimation is not very sensitive to the Manning's n value adopted.

Table 5-4 Sensitivity Case Flood Level Estimates

Scenario	Flood Level (m AHD)
Manning's n 0.020	2.71
Manning's n 0.035	2.69
Manning's n 0.050	2.68

6 Flood Immunity Requirements

6.1 Douglas Shire Planning Scheme

To identify the flood immunity requirements pertinent to the proposed development, a review of the Douglas Shire Planning Scheme, Flood and Storm Tide hazard overlay code was conducted. Table 8.2.4.3.b of the code specifies that a development floor level within the flood and storm tide overlay maps is to be designed to provide immunity to the following defined flood events plus a freeboard of 300 mm:

- 1% AEP for the development; and
- 0.5% AEP for a substation if required.

7 Conclusions

BMT has completed a flood study to derive the 1% AEP DFL and has considered the outcomes of the BMT WBM (2013) storm tide study as they relate to the subject site.

The DFL estimates were derived based on a combination of regional catchment flow and storm tide tailwater level. Whilst the ARR2019 guideline requires the consideration of the 1% AEP flow with the 1% AEP storm tide for the present-climate scenarios, the modelling also conservatively included sea level rise allowances to provide results for the 2070 and 2100 planning horizons.

A local flood modelling assessment was undertaken to ensure that the level derived from this flooding event is not higher than the regional flood levels. A sensitivity analysis was also conducted based on a range of Manning's n values for main flow paths. The analysis showed that the DFL estimates were not overly sensitive to the adopted roughness values.

Based on the flood model results and consideration of storm tide, the DFL estimates for the proposed development site are:

- 2.70 mAHD for the 2100 storm tide combination;
- 2.46 mAHD for the 2070 storm tide combination; and
- 2.45 mAHD for the local flooding event.

In accordance with the Douglas Shire Planning Scheme, Flood and Storm Tide hazard overlay code, the proposed development floor level is to be designed to provide flood immunity to the 1% AEP defined flood and storm tide event plus a freeboard allowance of 300 mm. The recommended minimum finished floor levels are therefore:

- Development design life of 80-years (i.e. to the year 2100): 3.00 mAHD
- Development deign life of 50-years (i.e. to the year 2070): 2.76 mAHD.

Appendix A Flood Level Mapping

Legend

Site Boundary

Title:

1% AEP Flow with 1% Storm Tide 2100 - Creek Flooding

Drawing: **A-1**

Rev: **A**

0 70 140 m

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Legend

Site Boundary

Title:

1% AEP Flow with 1% Storm Tide 2070 - Creek Flooding

Drawing: **A-2**

Rev: **A**

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Legend

Site Boundary

Title:

1% AEP Design Flow - Local Flooding

Drawing: **A-3**

Rev: **A**

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