CIVIL & STRUCTURAL ENGINEERS

FLOOD ASSESSMENT

FLOOD LEVEL ASSESSMENT FOR PROPOSED TELECOMMUNICATIONS TOWER, PRINS ROAD, LOWER DAINTREE

FOR
RPS GROUP / VISIONSTREAM

JOB No: **RPS0010**

ISSUE: **B**

Phone: 07 4725 5550
Fax: 07 4725 5850
Email: mail@nceng.com.au
50 Punari Street Currajong Qld 4812
Milton Messer & Associates Pty Ltd
ACN 100 817 356 ABN 34 100 817 356

NORTHERN CONSULTING engineers

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ISSUE	AUTHOR	APPROVED FOR ISSUE			ISSUED TO:	REASON
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EXECUTIVE SUMMARY

Northern Consulting Engineers (NCE) has been commissioned by RPS Group (on behalf of Visionstream) to undertaken a flood level assessment at a proposed mobile network site (320927) located at Lot 1/RP706308 Prins Road, Lower Daintree. The purpose of this assessment is to provide an understanding as to the 1% Annual Exceedance Probability (AEP) flood level of the site such that an appropriate floor level can be determined for critical infrastructure.

The site is located at Lot 1/RP706308 Prins Road, Lower Daintree which is ~6 km, as the crow files, from the mouth of the Daintree River. The site lies within the floodplain of the Daintree River which includes features such as an anabranch, tributaries, swampland and the low bank of the river, all within a 1 km radius of the site.

The proposed development consists of a Telstra monopole, equipment shelter and associated infrastructure within a 10 m x 11 m fenced compound.

Hydrologic (XPRAFTS) and 2D hydrodynamic (TUFLOW) models have been developed to determine the 1% AEP flood. The final extent of the hydrodynamic model represents ~34 km of the Daintree River, beginning ~1.2 km upstream of Bairds gauging station to the mouth of the river.

Both models were calibrated to the January-February 2019 monsoon event where reasonable agreement between flood levels at BairdTM gauging station and surveyed levels of debris around the site were observed. 1% AEP design event hydrographs were derived in accordance with AR&R with peak flows at BairdsTM checked against the findings of an FFA (undertaken by others) for the BairdTM gauge station to ensure they fell within the confidence limits.

A number of scenarios and sensitivity assessment were analysed with results suggesting the tide level has minimal impact to flood levels at the site. For the baseline scenarios assessed, the 1% AEP flood level ranges from 5.02 m AHD to 5.04 m AHD. Under climate change conditions, the flood level is anticipated to increase to 5.35 m AHD.

A developed scenario was also investigated where the proposed site was filled above the flood level. The predicted 1% AEP flood level for this scenario was 5.04m AHD. The results also demonstrated that filling of the site has negligible impact on flood levels to the road reserve and broader area.

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1.0 INTRODUCTION

1.1 Overview

Northern Consulting Engineers (NCE) has been commissioned by RPS Group (on behalf of Visionstream) to undertaken a flood level assessment at a proposed mobile network site (320927) located at Lot 1/RP706308 Prins Road, Lower Daintree. The purpose of this assessment is to provide an understanding as to the 1% Annual Exceedance Probability (AEP) of the site such that an appropriate floor level can be determined for critical infrastructure.

January-February 2019 saw a monsoon event occur over the site, resulting in flooding depths of ~1.2 m to ~1.8 m. This event was initially considered to be a 1% AEP event, however the findings of a Flood Frequency Analysis (FFA) undertaken by GHD suggested that this event was more likely a 2% AEP based on the flow rates recorded at BairdsTM stream gauge, ~16 km directly upstream of the site. As part of this assessment, NCE undertook a brief review of the rainfall data at BairdsTM and compared it against the Intensity Frequency Duration (IFD) design charts. The results demonstrated reasonable correlation with the findings of the FFA such that the intensity of the monsoon event for durations between 4.5 hrs and 6 hrs aligned with the design predictions of a 2% AEP event.

As the FFA was not able to determine a 1% AEP flood level for the site, NCE have developed hydrologic (XPRAFTS) and hydrodynamic (TUFLOW) models for the site in order to estimate the 1% AEP flood level.

1.2 Study Area

The site is located at Lot 1/RP706308 Prins Road, Lower Daintree which is ~6 km directly from the mouth of the Daintree River. The site lies within the floodplain of the Daintree River which includes features such as an anabranch, tributaries, swampland and the low bank of the river, all within a 1 km radius of the site.

Daintree Village is ~8.5 km directly east-north-east of the site, where the Bureau of Meteorology (BoM) gauging station 531110 is located. This station only records rainfall and water surface level data. A further ~8.6 km directly upstream is the Department of Natural Resources, Mines and Energy (DNRME) BairdsTM gauging station 108002A which records rainfall, flow and water level data. In order to undertake calibration of both the hydrologic and hydrodynamic models, the hydrodynamic model was developed to encompass both of these two (2) gauging stations.

The final extent of the hydrodynamic model represents ~34 km of the Daintree River, beginning ~1.2 km upstream of Bairds gauging station to the mouth of the river. The site and model extent is depicted in **Figure 1-1**.

LOCALITY

NORTHERN CONSULTING engineers

Civil & Structural Engineers
50 Punari Street, Currajong 4812
Phone: [07] 4725 5550 Fax: [07] 4725 5850
Email: mail@nceng.com.au
Milton Messer & Associates Pty. Ltd.
ACN 100 817 356

In Association With:

RPS GROUP & VISIONSTREAM

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Legend

- RP Boundary
- Easements
- Model Extent
- BOM / DNRM Stations
- Site
- Town
- Watercourse

PROPOSED TELECOMMUNICATIONS TOWER, PRINS ROAD, LOWER DAINTREE

SITE LOCALITY & MODEL EXTENTS

Prepared By: JS Reviewed by: AW	Date: **28/05/2019** Revision: **A** NCE Ref: **RPS0010**	Size **A3**	Figure **1-1**

1.3 Scope of Works

The scope of this assessment incorporates;

- development of a hydrologic model;
- development of a 2D hydrodynamic model;
- calibrate the hydrologic and hydrodynamic models to the January-February 2019 monsoon event and validate against and historic flood level information and Flood Frequency Analysis (FFA), where available;
- model the 1% Annual Exceedance Probability (AEP) critical duration design event in order to estimate the 1% AEP flood level;
- undertake sensitivity assessments based on the highest astronomical tide (HAT), the 1996 high tide level and climate change;
- delivery of report and associated flood mapping.

1.4 Limitations

Preparation of the models necessary to undertake this assessment have been conducted in accordance with good engineering practices however, is bound by the practical limitations of the accuracy of information and data used for the modelling, and the software. The information produced in this report is accurate at the time of issue and is based on the information available at the time of the analysis.

NCE otherwise disclaims responsibility to any person other than Visionstream Pty Ltd arising in connection with this report. NCE also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by NCE in connection with preparing this report were limited to those specifically detailed in the scope and limitations of the report.

The opinions, conclusions and any recommendations in this letter are based on assumptions made by NCE described in this letter. NCE disclaims liability arising from any of the assumptions being incorrect.

NCE has prepared this assessment on the basis of information provided by 3rd parties, which NCE has not independently verified or checked beyond the agreed scope of work. NCE does not accept liability in connection with such unverified information, including errors and omissions in the supplied.

It is noted that the available gauge data was incomplete which introduced additional uncertainties with the resulting verification process.

1.5 Proposed Development

In reference to drawing Q115284 Sheet S1-1 and S3, Issue 2, the proposed development consists of a Telstra monopole, equipment shelter and associated infrastructure within a 10 m x 11 m fenced compound, refer **Appendix C**.

2.0 AVAILABLE DATA

2.1 Rainfall & Streamflow Data

Data recorded during a severe weather event associated with the January-February 2019 monsoon was obtained by NCE for use in calibrating the hydrologic and hydrodynamic models developed as part of this flood study.

The datasets used in the calibration included:

- 15-minute rainfall data sourced from the BOM for the “BAIRDS TM” weather station (station number 531029).
- Stream discharge data sourced from DNRME for the gauge station “108002A DAINTREE RIVER AT BAIRDS”, acquired via the DNRME’s “Water Monitoring Portal[1]”. This data was incomplete.

2.2 Topographic Information

A Digital Elevation Model (DEM) based on LiDAR survey data over the entire hydrodynamic model extent was captured as part of the Cairns 2010 Project from August 2010 to August 2011 and sourced online from DNRME’s ELVIS portal. The sourced data has a 1m grid resolution that was converted from .tif to .asc in order to be read into TUFLOW. This conversion had no fundamental change to the data as originally sourced. Metadata of the LiDAR can be sourced online from the DNRME’s ELVIS portal. A brief review of the metadata indicated a vertical accuracy of +/- 0.15 m which aligns with survey information provided for the site, i.e. the approximate level for the site in the TUFLOW DEM is RL2.72 m AHD with the survey noting a level of RL2.66 m AHD. Therefore within the immediate bounds of the site, the LiDAR can be considered to reasonably represent the general terrain.

It is noted that the LiDAR data was incomplete in the downstream portion of the Daintree River, from the mouth to ~3.5 km upstream

2.3 Spatial Data

The following data was acquired to undertake this assessment:

- DNRME sourced 2010 Cairns project LiDAR.
- Cadastral data and other various data sources (i.e. watercourses, broad catchments, etc) of the site and surrounding area, sourced from the Queensland Government’s QSpatial catalogue.
- BOM and DNRME gauging station locations and records.

2.4 Historic Flood Levels

Following the 2019 monsoon event, debris was identified around the site with levels ranging from RL3.64 m AHD to RL4.66 m AHD, refer **Appendix D**. Debris below RL4.18 m AHD was typically found in sugar cane and over binstands which is not considered to be an accurate reflection of the actual flood level as once the flood receded, it is possible that the debris has dropped under its own weight.

Debris lodged in trees range from RL4.18 m AHD to RL4.66 m AHD and is considered less likely to drop significantly, therefore providing a better indication of the actual flood level. Ink markings on a shed post,

[1] https://water-monitoring.information.qld.gov.au/

located ~750m west of the site, suggested the flood reached RL4.64 m AHD. Due to the general consistency in levels recorded in trees and the shed, it is concluded that the flood level at the site during the 2019 monsoon event was in the order of RL4.60 m AHD.

2.5 Aerial Imagery

Aerial imagery has been sourced from Google satellite sources and capture in November 2016. This imagery has been utilised for roughness mapping and flood results mapping.

2.6 Previous Reports

2.6.1 Flood Frequency Analysis

GHD had prepared a letter report titled “Visionstream – Prins Rd Flood Assessment” dated 01/03/2019, which contained a flood frequency analysis (FFA) undertaken for the BairdsTM weather station. This FFA was used to check that the peak flow predicted by the models falls within the 90% confidence limits determined in the FFA.

It should be noted that part-way through development of the NCE flood model, it was found that DNRME had updated the streamflow data for BairdsTM acquired via the “Water Monitoring Portal”, presumably to filter erroneous or poor-quality data. Given that the FFA had been finalised several months prior (March 2019), it is presumed to have been based on the raw, unfiltered results made available by DNRME. As such, the FFA results may be skewed by any erroneous data used for the 2019 monsoon event.

2.6.2 Queensland Flood Mapping Program

In response to the 2010/2011 south Queensland floods, the state commissioned a flood mapping program. As part of this program, AECOM undertook a ‘Level 2’ study on behalf of DNRME with the findings documented in the report ‘Daintree’, Queensland Flood Mapping Program, Revision 1 dated 29 September 2014, document reference 60321740.

3.0 MODELLING METHODOLOGY

A two (2) phase approach has been adopted with the first phase comprising of development and calibration of the hydrologic model extending to the determination of 1% AEP design event hydrographs. The second phase included development and calibration of the hydrodynamic model in order to estimate design 1% AEP flood levels for the site.

The 2019 monsoon event was adopted as the calibration event for both models with the hydrologic and hydrodynamic models being calibrated to the flow hydrograph and water surface recorded at BairdsTM respectively. Validation of the hydrologic models’ design results was undertaken against the FFA, prepared by GHD, and the hydrodynamic model validated against the supplied 2019 monsoon event surveyed flood levels.

Calibration of the hydrodynamic model would not have been possible without the inclusion of the BairdsTM gauging station. Due to the signification catchment size upstream of BairdsTM, it was deemed appropriate that the hydrodynamic model was extended ~1.2 km upstream of BairdsTM to ensure the flows from the upstream catchment were adequately represented in the model.

Further details of each models development, calibration and validation are provided in the succeeding sections of this report.

4.0 HYDROLOGIC ANALYSIS

4.1 Design Rainfall

IFD data for the Study Area was obtained from the ARR Data Hub[2] using coordinates of -16.261 N, 145.351 E for the centroid of the Daintree River catchment. The IFD chart for the Daintree River is plotted in **Figure 4-1**, alongside data acquired from the Bureau of Meteorology (BOM) for the January 2019 monsoon event.

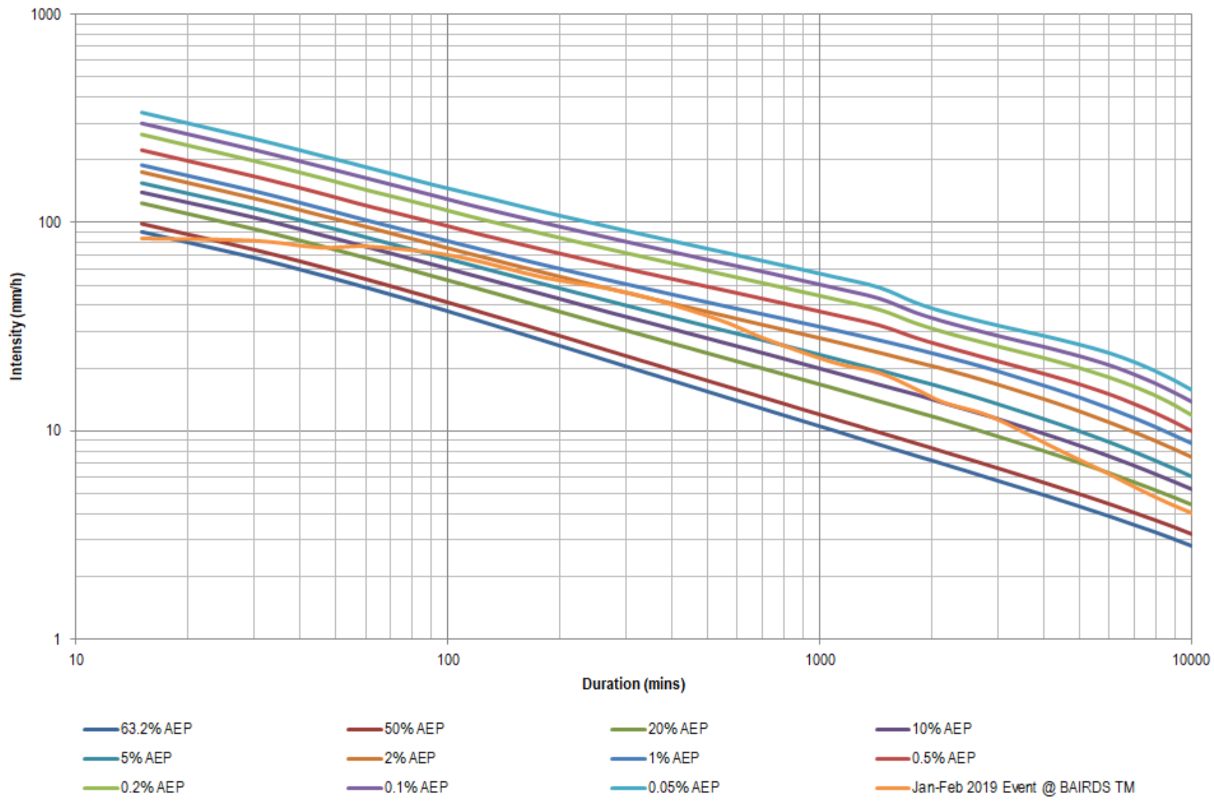


Figure 4-1 IFD chart for Daintree River catchment

4.1.1 January-February 2019 monsoon event

A period of prolonged, heavy rainfall occurred over North Queensland in early 2019, beginning in late January and continuing into February.

As per the "Special Climate Statement 69" report[3] issued by the BOM for the event:

> "On 26 January, a monsoon trough stretched across the northern tropics, from tropical cyclone Riley off the Western Australia coast, across the Northern Territory and further east to a tropical low that was located over Cape York Peninsula. Over the next couple of days, as tropical cyclone Riley moved further away from the continent, the monsoon trough over Western Australia and the Northern Territory broke down. Over Queensland, the monsoon trough and embedded tropical low tracked slowly south over Cape York Peninsula between 26 and 30 January. The highest rainfall totals during this period were generally on the coastal strip between Innisfail and Cooktown, but widespread totals of more than 100 mm were observed as far south as Mackay and over most of

[2] http://data.arr-software.org
[3] http://www.bom.gov.au/climate/current/statements/scs69.pdf

Cape York. Heavy rainfall began on 26 January in areas around Cairns and north to Cooktown, with daily totals of more than 100 mm at many locations in the Herbert and Lower Burdekin District. By 28 January, the focus of the rainfall shifted south to areas centred around Townsville, but still covered a long stretch of coast from Cairns to Mackay."

Figure 4-2 below shows a map of daily rainfall totals for Queensland from 26-30 January 2019, which is the period in which the Daintree River catchment experienced the highest rainfall during the monsoon. This figure was sourced from the above-mentioned BOM report.

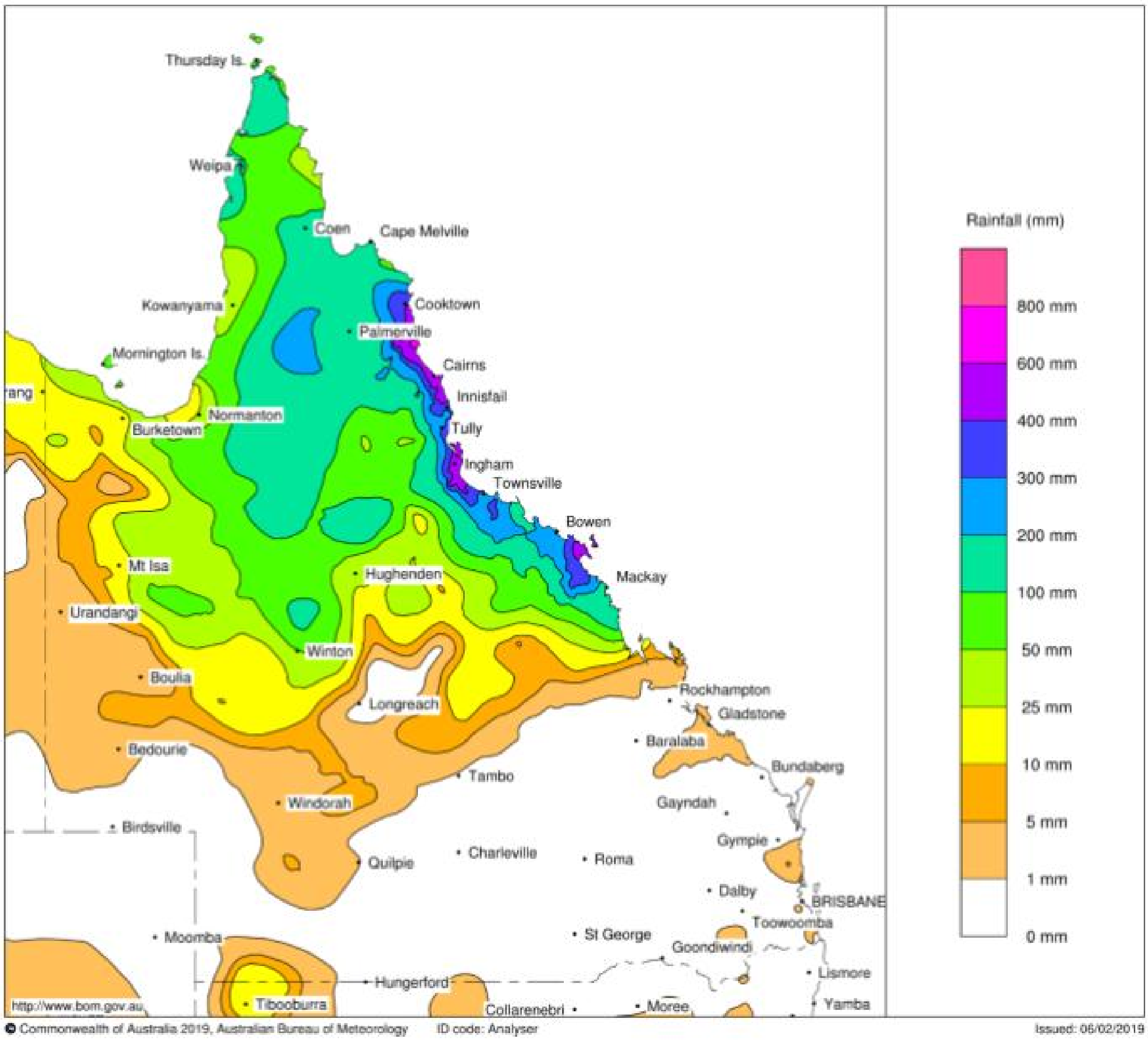


Figure 4-2 Rainfall totals map from 26-30 January 2019 (from the BOM's "Special Climate Statement 69" report)

A breakdown of the daily rainfall from 07/01/2019 to 10/02/2019 is shown in **Figure 4-3**. A clearly-defined burst of rainfall associated with the monsoon can be observed from 25/01/2019 to 27/01/2019, with upwards of 450 mm falling on 26/01/2019.

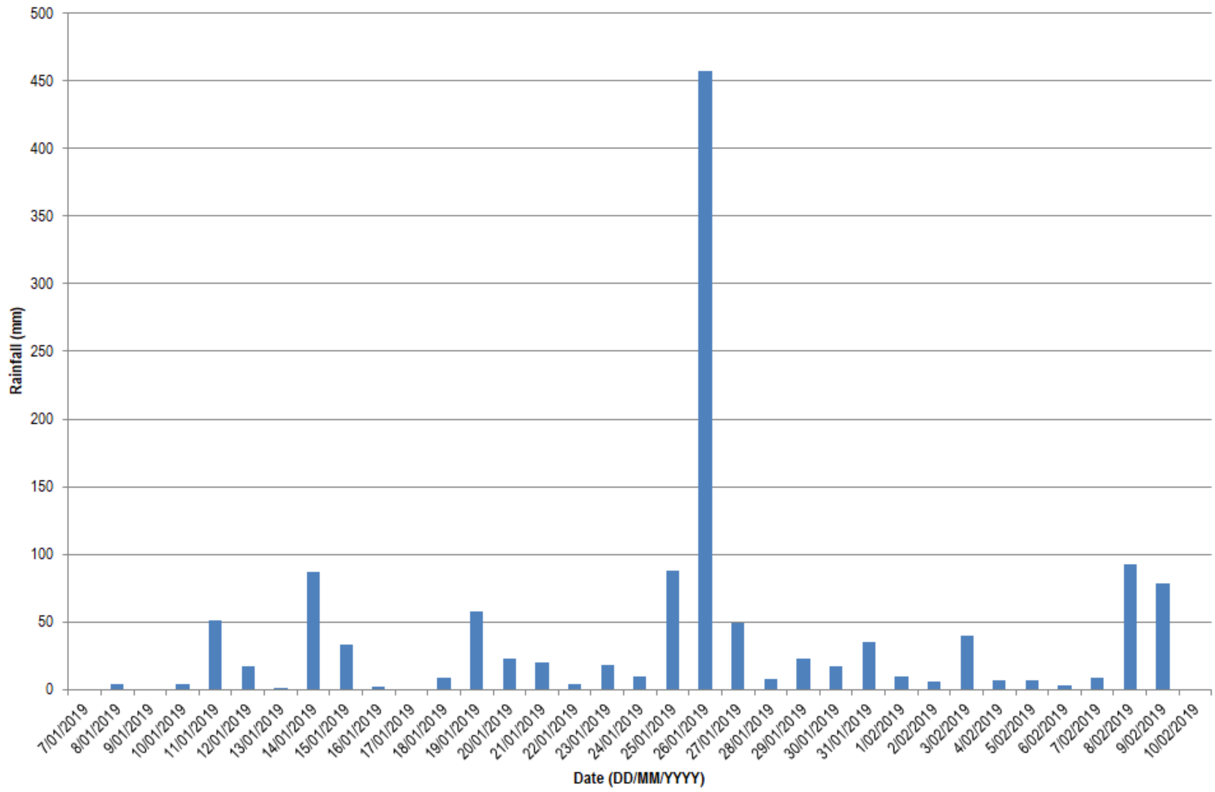


Figure 4-3 Daily rainfall totals at "108002A DAINTREE RIVER AT BAIRDS" for January-February 2019 monsoon

Referring to **Figure 4-1**, which shows IFD data for the Daintree River catchment plotted alongside data acquired from the BOM for the January-February 2019 monsoon event, it can be seen that the peak rainfall intensity of the monsoon correlated with a 2% AEP (50 year ARI) design storm for durations between 4.5 hrs and 6 hrs.

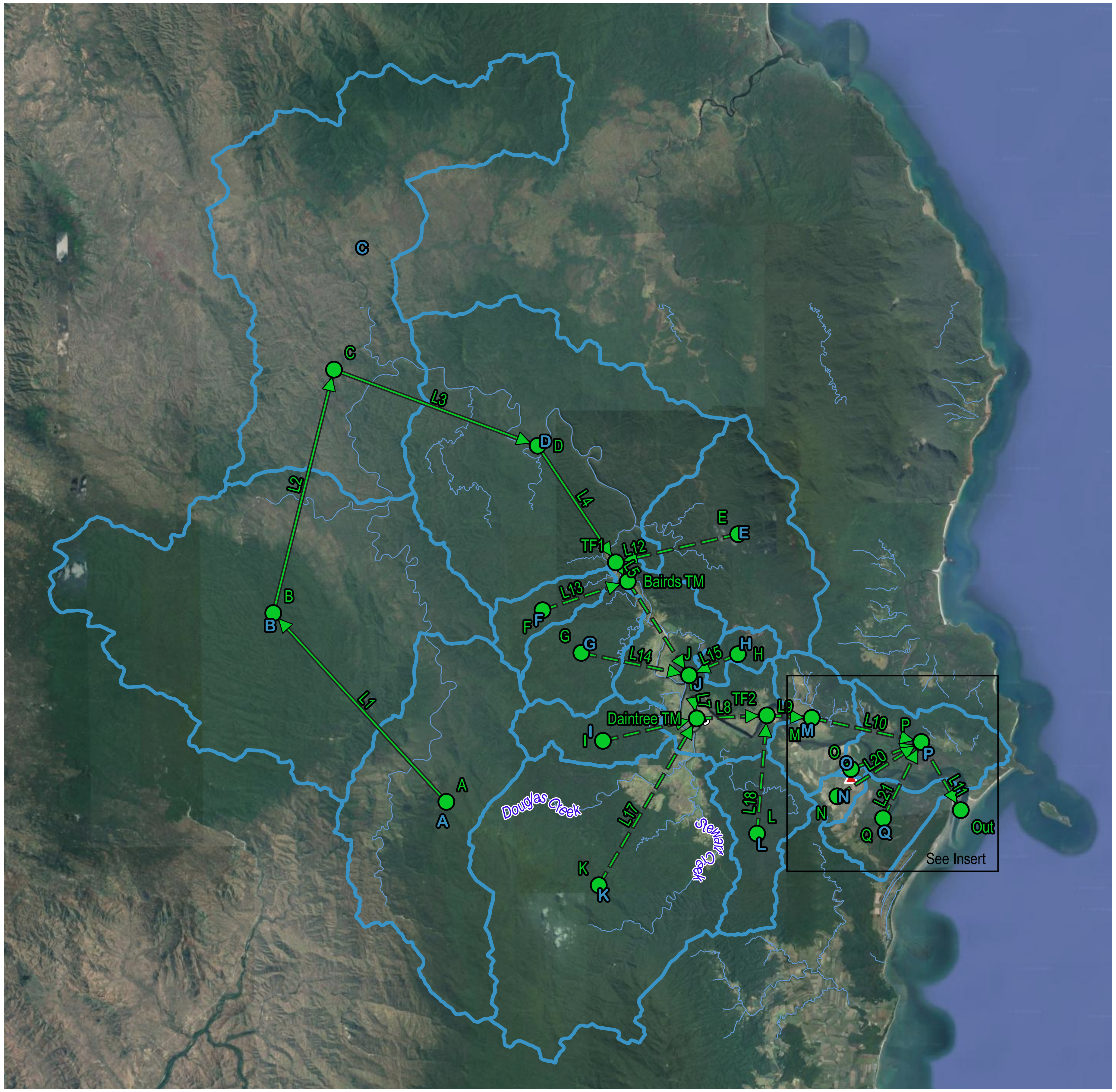
Given the severity of rainfall and flooding that occurred over the site, data collected during this event was used to calibrate the XPRAFTS model.

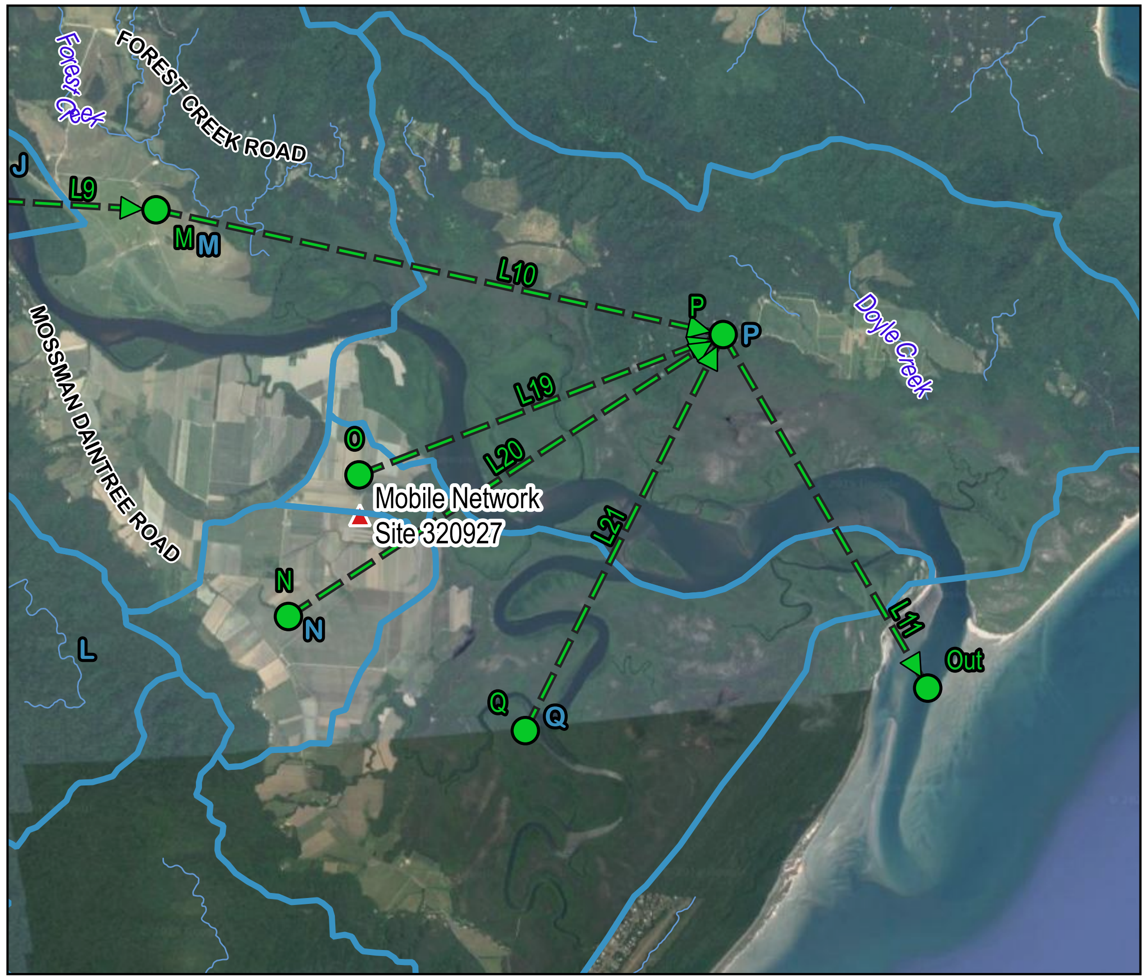
4.2 XPRAFTS

XPRAFTS has been utilised to undertake the hydrologic analyses for the Daintree River catchments. Within XPRAFTS, Laurenson hydrology has been adopted as the runoff routing method. This method utilises the Muskingum procedure to model a catchment's response to rainfall based on its surface characteristics, area and loss inputs. The Muskingum procedure utilises a non-linear storage function to model runoff routing within a catchment.

4.2.1 Catchments

Figure 4-4 shows the Daintree River catchments modelled in XP-RAFTS. Details of the parameters selected for these catchments are contained in **Table 4-1**.





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Name	Area (km2)	Slope (%)	Mannings n
A	129.8	3	0.2
B	252	3	0.2
C	244.8	3	0.2
D	191	3	0.2
E	73.7	3	0.2
F	16.2	3	0.2
G	29.3	3	0.2
H	8.3	3	0.2
I	24	3	0.2
J	55.9	3	0.2
K	178.1	3	0.2
L	32.1	2	0.2
M	26.7	2	0.2
N	5.2	2	0.2
O	1.1	1	0.2
P	32.4	2	0.2
Q	21.1	1	0.2

NORTHERN CONSULTING engineers

Civil & Structural Engineers
50 Punari Street, Currajong 4812
Phone: [07] 4725 5550 Fax: [07] 4725 5850
Email: mail@nceng.com.au
Milton Messer & Associates Pty. Ltd.
ACN 100 817 356

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Legend

- Site
- Town
- Watercourse
- XPRAFTS Channel
- XPRAFTS Lag
- XPRAFTS Node
- Catchments

PROPOSED TELECOMMUNICATIONS TOWER, PRINS ROAD, LOWER DAINTREE

CATCHMENTS & XPRAFTS SETUP

Prepared By: JS Reviewed by: AW	Date: 29/05/2019 Revision: A NCE Ref: RPS0010	Size A3	Figure 4-4

Table 4-1 Daintree River catchment details

Catchment ID	Area (km²)	Fraction impervious (%)	Vectored slope (%)	Manning's n
A	129.8	0	3	0.200
B	252	0	3	0.200
C	244.8	0	3	0.200
D	191	0	3	0.200
E	73.7	0	3	0.200
F	16.2	0	3	0.200
G	29.3	0	3	0.200
H	8.3	0	3	0.200
I	24	0	3	0.200
J	55.9	0	3	0.200
K	178.1	0	3	0.200
L	32.1	0	2	0.200
M	26.7	0	2	0.200
N	5.2	0	2	0.200
O	1.1	0	1	0.200
P	32.4	0	2	0.200
Q	21.1	0	1	0.200

Table 4-2 contains details of the links connecting catchments upstream of BairdsTM which have been modelled as open channels. **Table 4-3** contains details of simplified catchment links that have been modelled using lag times. The lag times have been determined by adopting an average stream velocity of 1.5 m/s over the length of the catchments watercourse.

Table 4-2 Linking channel details – links with cross-sections

Link	Catchments linked	Channel length (km)	Channel slope (%)	Manning's n value	
				Channel	Overbank
1	A to B	14.32	0.70	0.040	0.070
2	B to C	15.40	0.30	0.040	0.070
3	C to D	13.27	0.30	0.040	0.070
4	D to TF1	31.32	0.40	0.040	0.070
5	TF1 to BairdsTM	1.18	1.00	0.040	0.070

Table 4-3 Linking channel details – lagged links

Link	Catchments linked	Lag time (mins)
12	E to TF1	210
13	F to BairdsTM	162

4.2.2 Loss model

The Initial / Continuing loss model was adopted for the hydrologic analyses undertaken as part of this flood study, with the loss values presented in **Table 4-4** being applied. These 1% AEP design storm values were sourced from the ARR Data Hub. For the January-February 2019 monsoon event, a reduced continuing loss value of 3 mm/h was adopted in order to provide a better fit of the XPRAFTS hydrograph to the DNRME data. This reduced value is considered reasonable given the prolonged nature of the monsoon rain event, with rainfall persisting from mid-January to mid-February. Due to this extended period of near-continuous rainfall, the catchment surface would be highly saturated with reduced capacity for soil infiltration to occur.

Table 4-4 Loss values

Event/s	Initial loss (mm)	Continuing loss (mm/h)
1% AEP design storms	53	4.9
2019 monsoon calibration event	53	3

4.2.3 Temporal pattern ensembles & critical duration

An ensemble of ten (10) rainfall patterns is generated using the ARR Data Hub for each design storm event, which represents the variability of observed rainfall events in the region. The computation time necessary to simulate all ensemble members within the two-dimensional TUFLOW model domain would have been prohibitive; therefore as per the methodology recommended in ARR 2016, the XPRAFTS hydrologic model has been used to run all patterns to determine the median storm pattern. It should be noted that the ensemble patterns resulting in the highest runoff were not selected as this would not represent the true target AEP of the storm event (it would be less frequent / more severe).

Using the Ensemble Statistics Utility in XPRAFTS, the upper median temporal patterns were identified for the various 1% AEP storm durations. **Figure 4-5** shows the results of the ensemble assessment. It can be seen that the 24 hour storm represents the critical duration at BAIRDS TM when comparing the upper median results (represented by the lines through the boxes). For the 24 hour storm, the upper median temporal pattern at BAIRDS TM was identified as pattern 9.

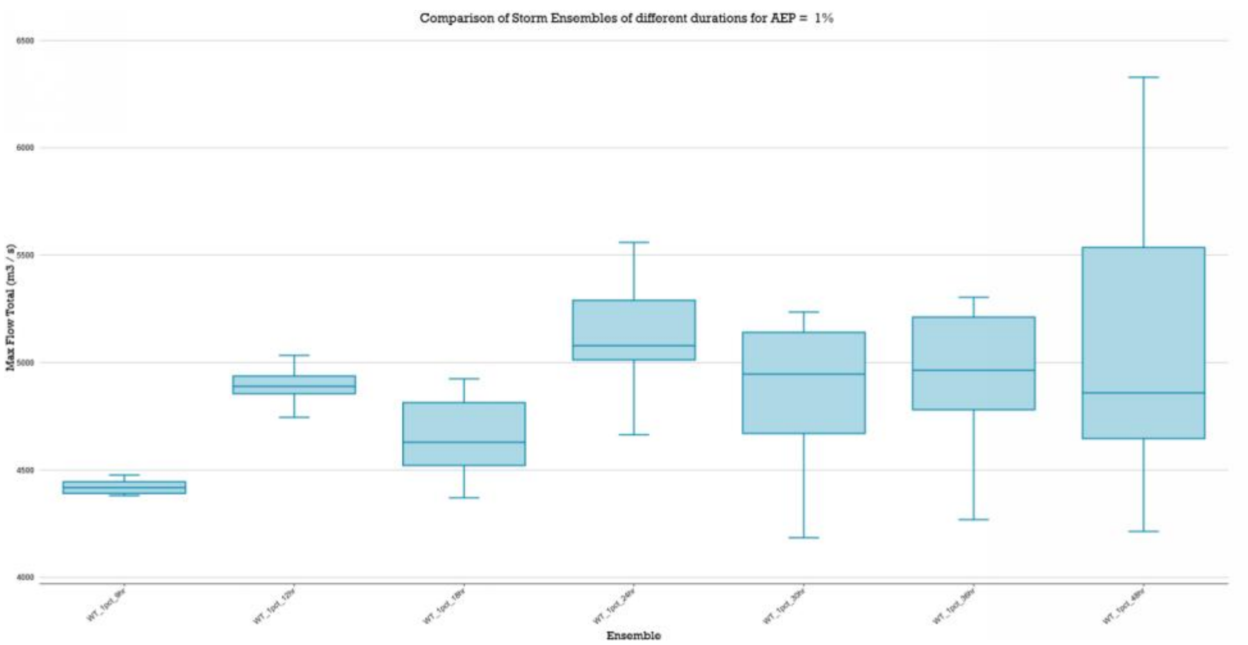


Figure 4-5 Box and whisker plot for 1% AEP storms at “108002A DAINTREE RIVER AT BAIRDS”

4.2.4 Model calibration

The final catchment parameters summarised in **Table 4-1** were determined via an extensive iterative process in which various combinations of catchment parameters for the 2019 monsoon event where trialled in order to identify the set of values that ensures the model outputs fit the recorded data and that the selected parameter values align with modelling guidelines and standards.

Figure 4-6 compares DNRME and XPRAFTS discharge plots for the January-February 2019 monsoon event at the DNRME gauge "108002A DAINTREE RIVER AT BAIRDS". As can be seen, the model results provide a good fit to the DNRME data, with the general shapes of the hydrographs and timing of flows demonstrating adequate correlation. It can be seen that the model overestimates the peak discharge compared with the DNRME data, however modifying model inputs to better align the peaks resulted in an inferior overall hydrograph fit. As such, the model results shown in **Figure 4-6** were deemed acceptable. The DNRME gauge dataset (as updated), notes that the flows in the vicinity of the peak, were listed in the Quality code as "Estimate". Therefore, this introduced uncertainty with the actual peak flows in the dataset. Further discussion is provided in Section 6.1.

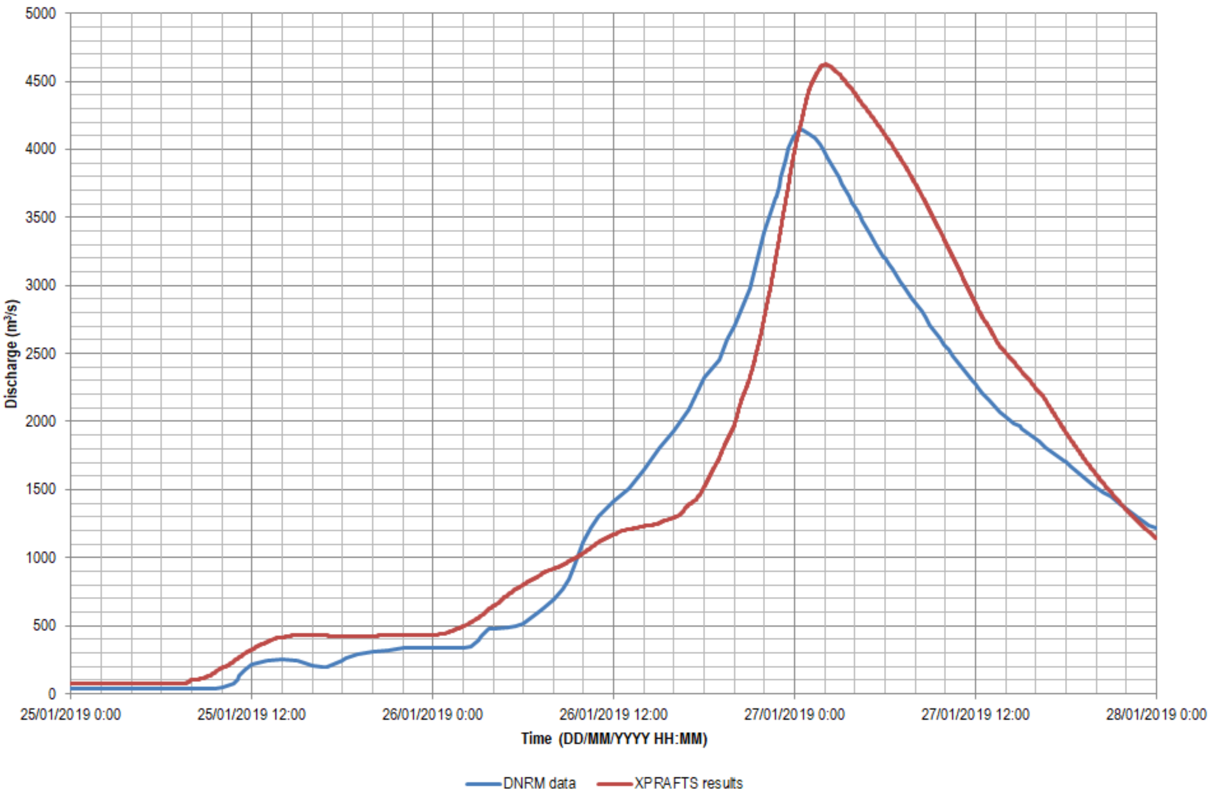


Figure 4-6 Discharge comparison for January-February 2019 monsoon at "108002A DAINTREE RIVER AT BAIRDS"

As an additional check, the peak discharge values predicted by the calibrated model for the 1% AEP design rainfall were compared with the range of values presented by GHD in their flood frequency analysis undertaken at DNRME gauge "108002A DAINTREE RIVER AT BAIRDS".

Table 4-5 Discharge values at "108002A DAINTREE RIVER AT BAIRDS" (GHD FFA)

AEP (%)	Discharge (m^3/s)		
	Expected parameter quantile	Monte Carlo 90% quantile probability limits	
		Lower limit	Upper limit
1	3,932	3,334	5,094

The peak 1% AEP 24 hour discharge calculated by the calibrated XPRAFTS model was 5083 m^3/s, which falls within the 90% confidence limits reported in the GHD FFA report.

Figure 4-7 shows the 1% AEP 24 hour design hydrograph at BaridsTM. Patterns 6 & 9 are shown as a sensitivity assessment (discussed in Section 5.2.8) between predicted levels for the two (2) patterns was undertaken.

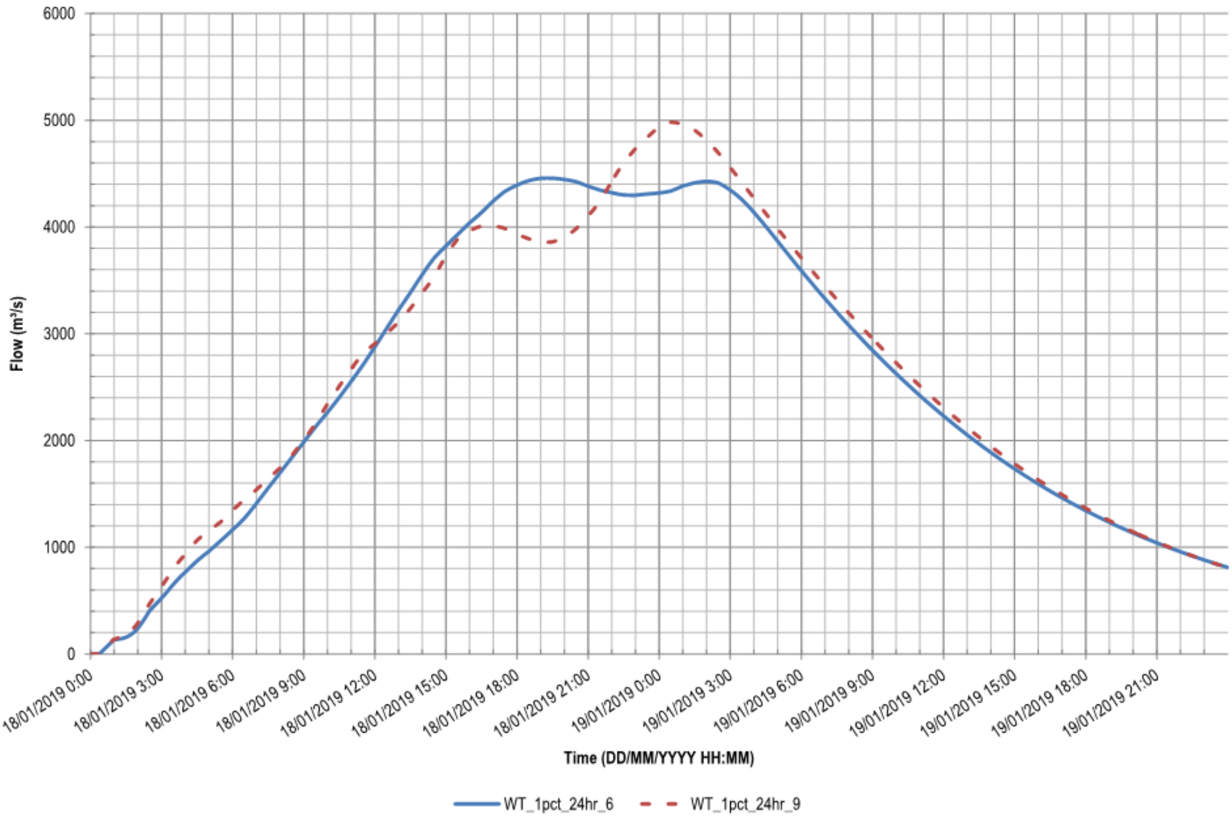


Figure 4-7 Design 1% AEP discharge hydrograph for ensemble patterns 6 and 9

In summary, the model is considered to be suitably calibrated given the agreement of the monsoon results with the DNRME gauge data and fitting the peak 1% AEP design storm flows within the 90% confidence range of the GHD flood frequency analysis.

5.0 HYDRODYNAMIC ANALYSIS

The hydrodynamic analysis has focused on identifying the flood levels and depths, for the baseline scenario at the proposed development site.

5.1 TUFLOW

The TUFLOW (Two-dimensional Unsteady FLOW) modelling software was utilised to undertake the hydrodynamic modelling required for this flood level assessment. TUFLOW is a powerful computational engine that provides one-dimensional (1D) and two-dimensional (2D) solutions of the free-surface flow equations to simulate flood and tidal wave propagation. TUFLOW is specifically oriented towards establishing flow and inundation patterns in floodplains, coastal waters, estuaries, rivers and urban areas where the flow behaviour is essentially 2D in nature and cannot or would be onerous to represent using a 1D model. Subsequently, TUFLOW is ideally suited for this assessment.

TUFLOW currently incorporates two (2) grid based solvers:

- TUFLOW Classic: A second order semi-implicit solution available for computations using CPU hardware on a single core; and
- TUFLOW HPC (Heavily Parallelised Compute): A second order explicit solver. TUFLOW HPC can run a simulation using multiple CPU cores, or alternately GPU hardware for high speed execution (requiring the add-on GPU Hardware module).

Outputs from TUFLOW include GIS compatible maps of flood depths, water surface levels (WSL), velocities and inundation extents.

For this assessment, only the 2D domain was developed, i.e. no 1D components were incorporated into the model. Due to the size of the model and duration of events to be simulated, the HPC solver has been utilised.

5.1.1 Topography

The 1 m DEM resolution LiDAR data sourced from DNRME, refer Section 2.2 for further details, formed the base for the TUFLOW 2D domain. The LiDAR appeared to pick-up the standing water surface level and was also incomplete in the downstream portion of the Daintree River, from the mouth to ~3.5 km upstream. DNRME provides a profile of the approximate cross section of the river at the BairdsTM and this section, as well as consideration for the difference between the actual bed level and the LiDAR level at this location, was utilised to ensure the channel was represented. Civil software package 12D was utilised to construct a channel which was varied from a trapezoidal profile with a 7 m wide base to a 76 m wide channel and a typical depth of 3 m as shown in **Figure 5-1**. The profile was varied based on a visual assessment of the river width along the full river reach and stamped into the base LiDAR. The incomplete section of LiDAR data was infilled via interpolation between the extents of the LIDAR prior to stamping the channel into the combined DEM.

Model elevations were derived from this combined DEM which is illustrated in **Figure 5-2** along with the overall TUFLOW model set-up.

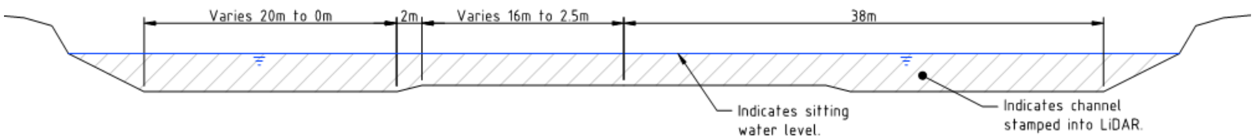
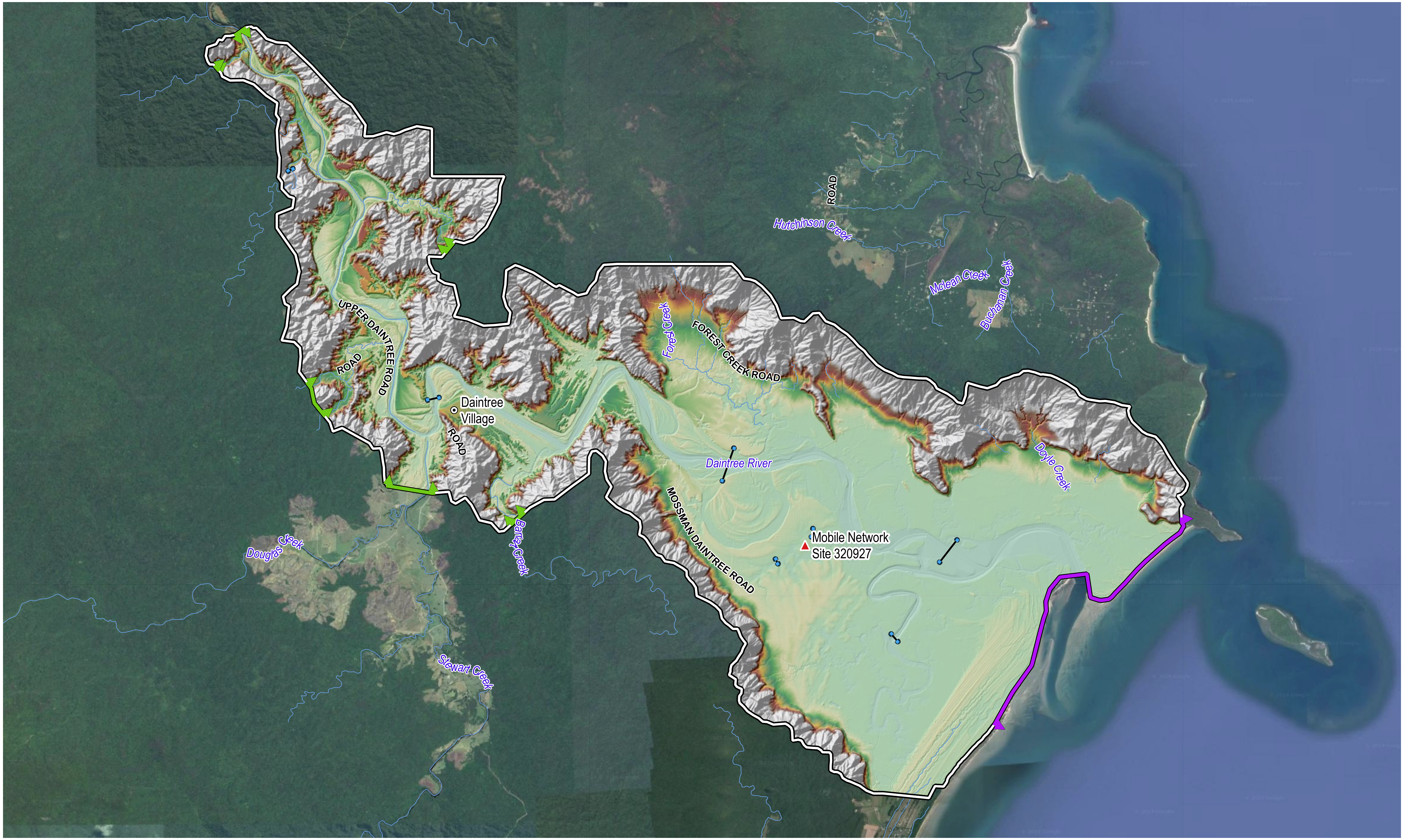


Figure 5-1 Typical Daintree River channel stamped into DEM



NORTHERN CONSULTING engineers
Civil & Structural Engineers
50 Punari Street, Currajong 4812
Phone: [07] 4725 5550 Fax: [07] 4725 5850
Email: mail@nceng.com.au
Milton Messer & Associates Pty. Ltd.
ACN 100 817 356

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0 1000 2000 3000 4000 m

1:80000

N

Legend

- Model Extent
- Site
- Town
- Watercourse
- DS Bounday (HT)
- US Boundary (QT)
- Inflow Source

Surface Elevation (m AHD)

Above 40

Below -0.5

PROPOSED TELECOMMUNICATIONS TOWER, PRINS ROAD, LOWER DAINTREE

TUFLOW MODEL SETUP & BASELINE TOPOGRAPHY

Prepared By: JS Reviewed by: AW	Date: **28/05/2019** Revision: **A** NCE Ref: **RPS0010**	Size **A3**	Figure **5-2**

5.1.2 Domain, Grid Size and Timestep

A single 2D domain was used with a grid size of 10 m, resulting in ~1.44 million cells. Although this created a large model, a 10 m grid was deemed appropriate to ensure minor tributaries and flow paths within the model extent were adequately represented.

The HPC solver implements an adaptive timestep, meaning it changes over time, to meet the conditions of the model. As the adaptive timestep can mask model instabilities, it is recommended that the timestep is graphed to check for noise or extremely low values, i.e. less than 1/10 of a healthy TUFLOW Classic timestep and if there are repeated timesteps. In each simulation, there were no repeated timesteps and **Figure 5-3** plots the timestep against the simulation time for the baseline design event and final calibration simulation. A healthy Classic timestep is considered to be 1/2 to 1/5 of the grid size, therefore an extremely low value for this model would be 0.2 to 0.5 seconds. It is evident from **Figure 5-3** that there is minimal noise in the timestep and the minimum is above 0.5 seconds, therefore the model is considered to be stable.

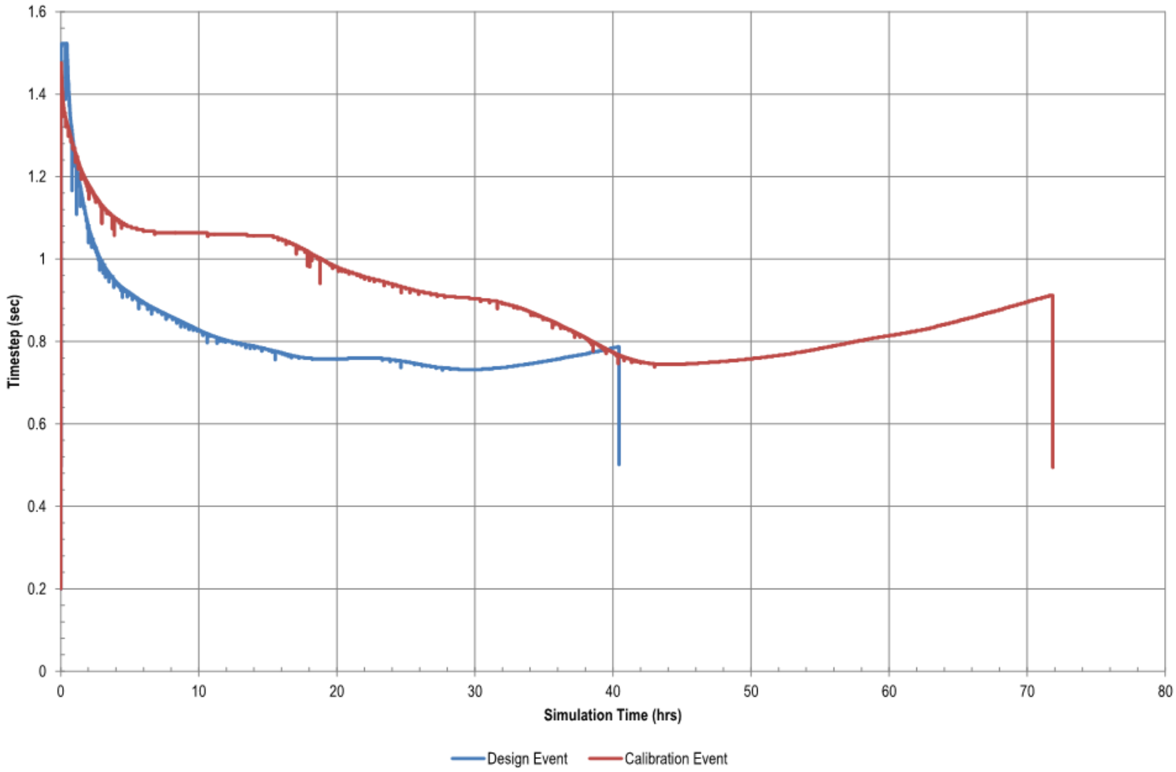


Figure 5-3 HPC adaptive timestep plot

5.1.3 Boundary Conditions and Source Flows

All inflow hydrographs have been derived from the XPRAFTS hydrologic model. In order to reduce simulation times, the calibration event hydrographs were truncated from 25/1/19 at 0800 to 30/1/19 at 1600. This ensured that there was adequate volume in the model prior to the peak (early on 27/1/19) and whilst allowing for the tail of the hydrograph.

5.1.3.1 Upstream Boundaries

Inflow hydrographs have been applied at six (6) upstream boundary locations for all simulations, namely:

- Daintree River upstream of BairdsTM – total flow inclusive of Daintree River upper reaches, i.e catchments A to E.

- Landers Creek – local flow for catchment F.
- Kiely Creek – local flow for catchment H.
- Martins and Intake Creek – local flow for catchment I.
- Stewart Creek – local flow for catchment K.
- Barratt Creek – local flow for catchment L.

5.1.3.2 Downstream Boundaries

One (1) downstream boundary has been placed along the mouth of the Daintree River and extended north and south along the beach front. A fixed tailwater level (TWL) equivalent to the various tide heights has been adopted. The TWL levels adopted for each tide is provided below:

- Mean High Water Springs (MHWS) = 0.91m AHD
- Highest Astronomical Tide (HAT) = 1.73m AHD
- 1996 high tide = 1.32m AHD
- Calibration = 0m AHD

The tide levels have calculated for Low Islets, as per the Queensland Tide Table recommendations, using recorded tide levels at Cairns.

5.1.3.3 Source Flows

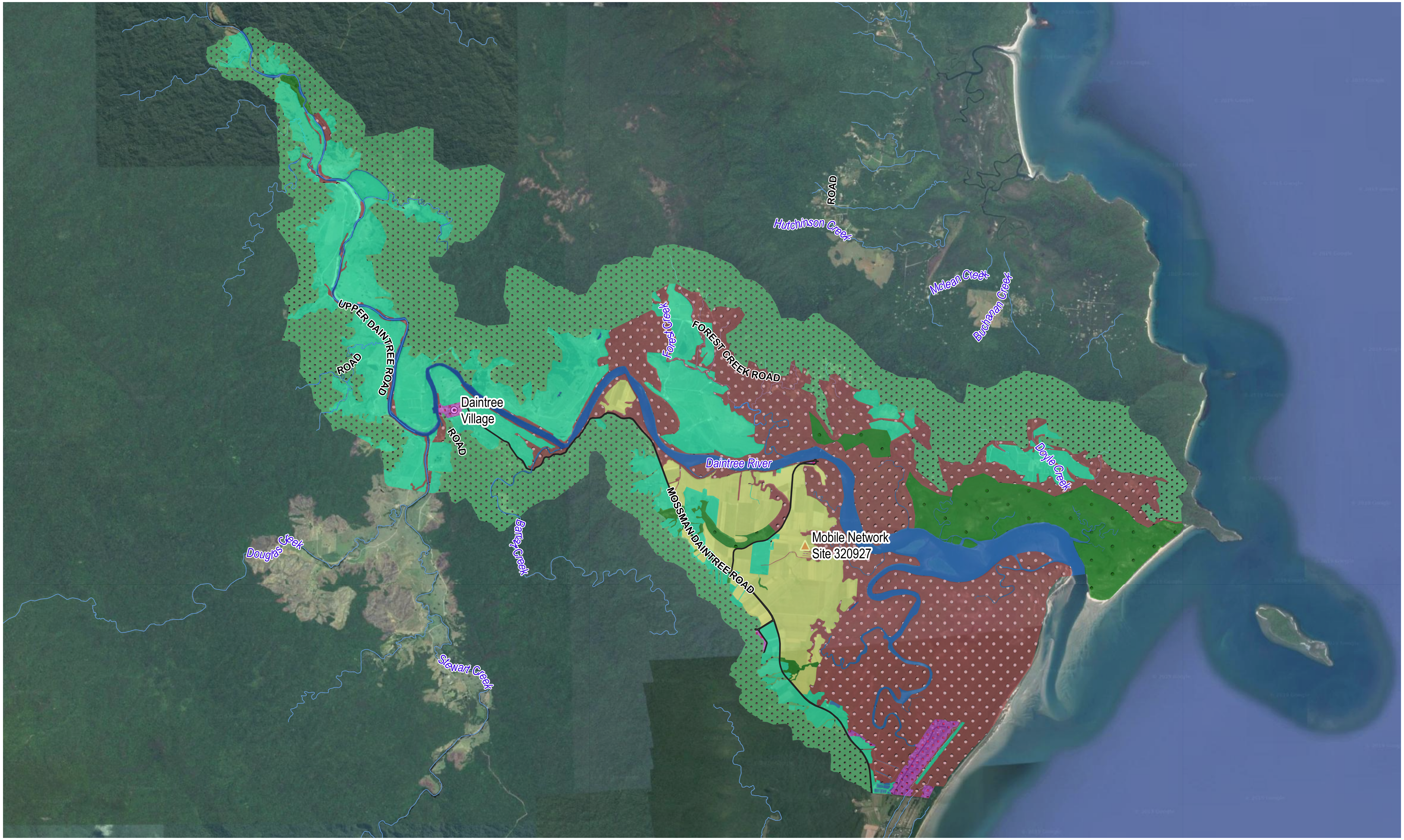
Local flow hydrographs for catchments G, J and M to Q where applied directly to the 2D domain as source points.

5.1.4 Hydraulic Roughness

The hydraulic roughness is a measure of the resistance to flow and is typically defined as the Manning's n value. **Figure 5-4** depicts the Manning's n values applied to the various surface types included in the hydrodynamic model. These roughness values and areas have been defined via aerial imagery and by reference to various guidelines such as Australian Rainfall & Run-off (AR&R) and Townsville City Council's 'Preparation of Flood Studies and Reports – Guidelines' (2010). **Table 5-1** provides a summary of the hydraulic roughness values adopted in the model.

Table 5-1 Roughness values

Material Type	Manning's 'n' value
Floodplain Farming	0.05
Floodplain Vegetated (minor)	0.06
Floodplain Vegetated (medium)	0.08
Floodplain Vegetated (heavy)	0.1
Roads	0.02
Waterways (channel)	0.04
Waterways (riparian)	0.1
Vegetation (dense)	0.15
Urban	0.07



NORTHERN CONSULTING engineers

Civil & Structural Engineers
50 Punari Street, Currajong 4812
Phone: [07] 4725 5550 Fax: [07] 4725 5850
Email: mail@nceng.com.au
Milton Messer & Associates Pty. Ltd.
ACN 100 817 356

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0 1000 2000 3000 4000 m

1:80000

N

Legend

- Floodplain farming (0.05)
- Floodplain Vegetated (minor) (0.06)
- Floodplain Vegetated (medium) (0.08)
- Floodplain Vegetated (heavy) (0.10)
- Roads (0.02)
- Waterways (0.04)
- Riparian (0.10)
- Vegetation (dense) (0.15)
- Urban (0.07)

PROPOSED TELECOMMUNICATIONS TOWER, PRINS ROAD, LOWER DAINTREE

ROUGHNESS MAP MANNING'S 'n'

Prepared By: JS Reviewed by: AW	Date: 28/05/2019 Revision: A NCE Ref: RPS0010	Size A3	Figure 5-4

5.1.5 Drying & Flooding Depths

Drying and flooding depths of 0.002 m were adopted. These values were selected in order to mitigate the risk of mass errors, and are compliant with TUFLOW modelling guidelines.

5.2 Model Simulations

Table 5-2 summarises the final model simulations undertaken as part of the flood assessment with a more detailed description provided in the following sections. Apart from the 'Prelim' scenario, the simulations were undertaken using the HPC grid based solver.

Table 5-2 Mode simulation summary

Simulation	Scenario	AEP % (ARI)	Duration (hr)	Purpose
1	Calibration	Jan-Feb 2019 Event	128	Calibrate the model the to the observations of the Jan-Feb 2019 event
2	Baseline	1 (100yr)	24	Tail water level (TWL) at MHWS
3	HAT	1 (100yr)	24	TWL at HAT
4	High Tide	1 (100yr)	24	TWL at 1996 high tide level
5	Climate	1 (100yr)	24	Advice on potential flood levels associated with climate change.
6	Prelim	1 (100yr)	24	Preliminary uncalibrated results for scenarios 2-4
7	Sensitivity 1	1 (100yr)	24	Comparison of preliminary uncalibrated results against final results
8	Sensitivity 2	1 (100yr)	24	Comparison of ensemble patterns
9	Developed	1 (100yr)	24	Raising of site level to be flood immune

5.2.1 Calibration Scenario

It is noted that the final calibration simulation was a result of an iterative process (upwards of nine (9) different simulations) to arrive at an acceptable solution. Further discussion on calibration and validation is provided in Section 6.1. The TWL adopted for this scenario was equivalent to the coinciding tide on the day, namely 0 m AHD.

5.2.2 Baseline Scenario

Adopted a TWL (0.91 m AHD) equivalent to Mean High Water Springs (MHWS) at the mouth of the Daintree River and simulates the median pattern (pattern 9) for the critical duration (24 hours) 1% AEP hydrographs identified in the hydrologic assessment.

This is typically the design level adopted for majority of works that require flood immunity for a 1% AEP event.

5.2.3 HAT Scenario

Adopted a TWL (1.73 m AHD) equivalent to Highest Astronomical Tide (HAT) at the mouth of the Daintree River and simulates the median pattern (pattern 9) for the critical duration (24 hours) 1% AEP hydrographs identified in the hydrologic assessment.

Provides information on potential 1% AEP flood level should this coincide with the predicted HAT.

5.2.4 High Tide Scenario

Adopted a TWL (1.32 m AHD) equivalent to 1996 high tide level at the mouth of the Daintree River and simulates the median pattern (pattern 9) for the critical duration (24 hours) 1% AEP hydrographs identified in the hydrologic assessment.

Previous assessments have suggested that the 1996 flood was a smaller event than the Jan-Feb 2019, however recorded higher flood levels around Prins Road. It was concluded that this was due to the 1996 flood coinciding with high tide. Therefore an assessment of levels against this tide level was requested by the client in order to gain an appreciation of potential 1% AEP flood levels coinciding with high tide.

5.2.5 Climate Scenario

Adopted a TWL (2.53 m AHD) equivalent to HAT plus 0.8m (to account for potential sea level rise) at the mouth of the Daintree River and simulate a 15% increase in the median pattern (pattern 9) for the critical duration (24 hours) 1% AEP hydrographs identified in the hydrologic assessment.

Provides information on potential 1% AEP flood levels based on current predictions associated with climate change.

5.2.6 Prelim Scenario – Uncalibrated Truncated Model

Due to the overall model size and associated simulation times, a truncated model was developed for this scenario in order to provide the client with preliminary uncalibrated 1% AEP flood levels. The results provided for this scenario were determined via the 'Classic' grid based solver.

5.2.7 Sensitivity 1 Scenario – Calibrated and Solver Comparison

Following completion of calibration works, the revised roughness values were incorporated back into the preliminary truncated model to confirm that any impacts / changes in levels were associated with changes in roughness. The HPC solver was utilised for the assessment in order to understand if there was any significant implications between using the two (2) different solver methods.

5.2.8 Sensitivity 2 Scenario – Ensemble Pattern Comparison

As a result of the ten (10) different temporal patterns applicable for each event and duration and the varying surveyed levels for the 1996 and 2019 flood events, it was considered appropriate to understand the potential impact that these different patterns have on flood levels. Therefore a comparison between the recommended median and the lowest discharge (least conservative) patterns has been undertaken.

5.2.9 Developed Scenario

All the parameters of the baseline scenario were adopted; however the site was raised above the baseline 1% AEP flood level in order to simulate flood immunity. The purpose of this assessment is to understand any potential impacts filling may have on the 1% AEP flood level. It is also noted that filling of the site above the flood level also provides a conservative assessment in relation to the impacts that may occur should blockage (from debris) of the proposed security fence occur.

6.0 FINDINGS, RESULTS AND DISCUSSION

6.1 Calibration & Validation

During the initial calibration runs, flood levels at BairdsTM and Daintree RiverTM were being significantly under-predicted using the initial hydrographs extracted from the XPRAFTS model. It is noted that these original hydrographs were based on calibration to initial data sourced from DNRME at BairdsTM. Following DNRME's release of the updated the streamflow data for BairdsTM (presumably to filter erroneous or poor-quality data) it was observed that the previously calibrated results were under-predicting the peak flow. This led to a review of the loss model in order to re-align the model and BairdsTM recorded hydrographs, see **Figure 4-6** for final results. Due to the nature of the 2019 monsoon event, a continuing loss of 4.9 mm/hr when the peak of the event was occurring was considered to be excessive as in the lead up and during the peak of the event the catchment surface would have been highly saturated, subsequently reducing the capacity for soil infiltration to occur. A value of 3.0 mm/hr was adopted as it was found to improve the correlation between the updated DNRME data and the XPRAFTS model.

This adjustment in the hydrographs and slight increases (+0.02) in the original estimated roughness values for the Floodplain Farming, Floodplain Vegetated (minor), Waterways (channel) and Urban resulting in improved correlation between predicted model levels and BairdsTM recorded levels. The model predicted levels were also validated against the surveyed flood levels provided in the vicinity of the sight. **Table 6-1** provides a summary of the calibration / validation level comparison while **Figure 6-1** provides the point location and WSL results of the final calibration / validation simulation.

Table 6-1 Calibration / Validation level comparison

Point Location	Survey / Gauge Level (m AHD)	Model WSL (m AHD)	Difference (m)
BairdsTM	16.58	16.44	0.14
DaintreeTM	12.6	11.33	1.27
Shed	4.64	4.72	-0.08
Site		4.66	
SL01*	3.69	4.65	-0.96
SL02	4.37	4.63	-0.26
SL03	4.19	4.64	-0.45
SL04	4.28	4.64	-0.36
SL05	4.18	4.61	-0.43
SL06	4.66	4.60	0.06
SL07	4.56	4.60	-0.04
SL08	4.25	4.60	-0.35
SL09	4.29	4.60	-0.31
SL10	4.26	4.65	-0.39
SL11	4.57	4.70	-0.13
SL12	4.55	4.70	-0.15
SL13	4.18	4.61	-0.43
SL14*	3.96	4.65	-0.69
SL15*	3.78	4.65	-0.87

* Levels surveyed from debris found in sugar cane and over bin stands

SL01, SL14 and SL15 are considered to be underestimated as these levels were surveyed from debris found in sugar cane and over bin stands may have dropped under its own weight once the flood receded. The remaining levels prefixed with 'SL' were surveyed from debris found in trees and although debris would be less likely to drop significantly under its own weight when lodged in a tree, some of these levels are considered to be underestimated. For example, SL07 and SL08 are only ~23m apart, yet there is a level change of 0.31 m. The aerial imagery does not suggest that there are any significant hydraulic structure between these two (2) points that would result in such a significant change in level. This suggests there is still some in accuracies with the surveyed levels of debris lodged in the trees. It is evident that the ink markings on a shed post, located ~750m west of the site and levels are SL06, SL07, SL11 and SL12 correlate, suggesting that the flood level for the 2019 monsoon event, from the shed to ~300 m downstream of the site vary from RL4.64 to RL4.56. The modelled levels at these locations are within 0.15 m demonstrating adequate correlation that is reflective of the inaccuracies of surveying flood levels based on debris.

There is a significant difference between the model levels and recordings at DaintreeTM, where the recorded level was RL12.6. It has been reported that this level exceeded any other level within 118 years and is significant higher (1.88 m) than the 1% AEP flood level predicted in the AECOM 'Level 2' flood study for the Daintree. Various characteristics were modified during the calibration phase, such as increasing local flows from catchment K, however modelled levels at this gauge were unable to be matched to the recorded level. There are numerous variables that could be contributing to this, including the spatial variance and direction in which the 2019 monsoon event traversed the catchment. It is considered that these variables may have impacted the timing of the peaks between the upstream and local catchments in a manner that they may have coincided during the event or a larger burst or rainfall may have occurred over the local catchments that coincided with the peak of the upstream flow. To achieve calibration within the vicinity of Daintree Village, these are the types of variables that will need to be reviewed; however as calibration and validation was achieved at BairdsTM and the site, no further assessment around the DaintreeTM was undertaken.

A flow hydrograph at the BairdsTM location was extracted from the model where the same shape and peak timing observed in the XPRAFTS model, see **Figure 4-6**, was presenting in the hydrodynamic model. The only noticeable change was a minor reduction of ~100 cumecs in the peak flow.

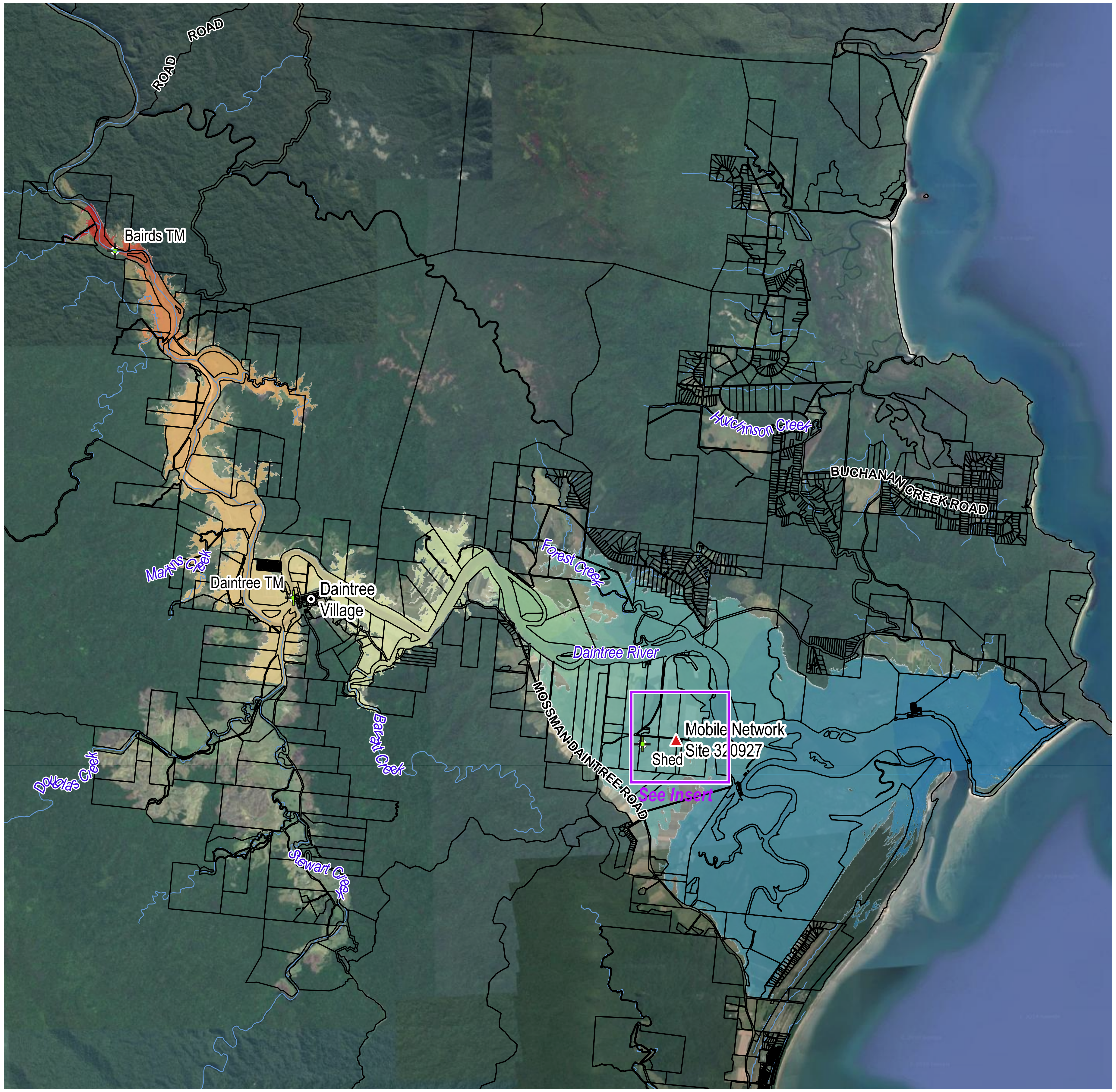
Based on the comparison of the model WSL's at BairdsTM, the shed and points SL06, SL07, SL11 and SL12, the model is believed to be adequately calibrated and validated and represents the flood behaviour at BairdsTM and the site. Levels around Daintree Village should be treated with caution as calibration with the recorded level at DaintreeTM was unable to be achieved. Further modelling input and verification is recommended if flood levels in the vicinity of the Daintree Village are to be used (eg. for a separate purpose to the Prins Road Telecommunications Tower project). However the current model is set up in a method that allows for further model verification.

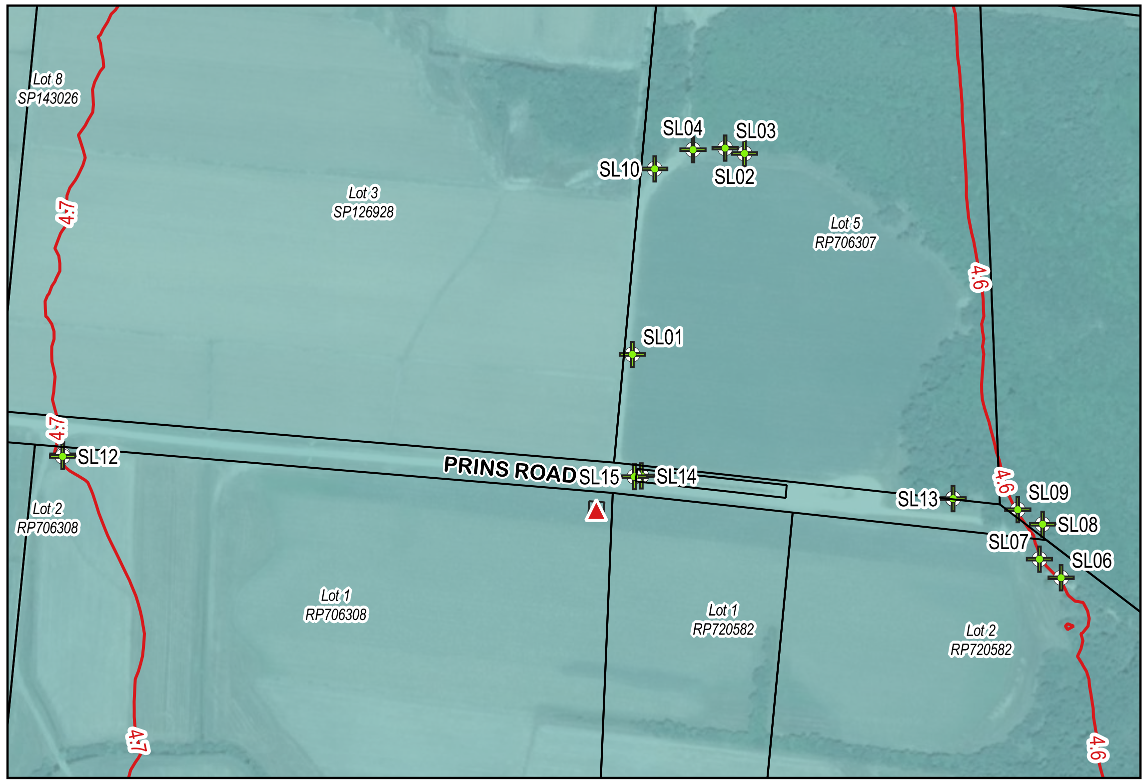
6.2 1% AEP Flood Levels and Depths

Table 6-2 provides a summary of the 1% AEP flood level and depth at the site for each of the baseline scenarios as well as the developed. **Appendix A** contains maps of the results for the predicted 1% AEP WSL and depths for the baseline assessments while **Appendix B** contains the maps for the MHWS developed scenario only.

Table 6-2 Peak flood level and depth summary

Scenario	Baseline Results				Developed
	MHWS	HAT	1996 Tide	Climate	MHWS
1% AEP WSL (m AHD)	5.02	5.04	5.03	5.35	5.04
1% AEP Depth (m)	2.30	2.32	2.31	2.63	2.32





INSERT

0 50 100 150 200 m

1:5000

Label	Survey / Gauge Level (m AHD)	Model WSL (m AHD)	Difference
Bairds TM	16.58	16.44	0.14
Daintree TM	12.6	11.33	1.27
Shed	4.64	4.72	-0.08
Site		4.66	
SL01	3.69	4.65	-0.96
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SL05	4.18	4.61	-0.43
SL06	4.66	4.6	0.06
SL07	4.56	4.6	-0.04
SL08	4.25	4.6	-0.35
SL09	4.29	4.6	-0.31
SL10	4.26	4.65	-0.39
SL11	4.57	4.7	-0.13
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NORTHERN CONSULTING engineers

Civil & Structural Engineers
50 Punari Street, Currajong 4812
Phone: [07] 4725 5550 Fax: [07] 4725 5850
Email: mail@nceng.com.au
Milton Messer & Associates Pty. Ltd.
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0 1000 2000 3000 4000 m

1:100000

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Legend

- RP Boundary
- Easements
- Site
- Town
- Watercourse
- WSL Contour

WSL (m AHD)

Above 17.5

Below 3.0

PROPOSED TELECOMMUNICATIONS TOWER, PRINS ROAD, LOWER DAINTREE

MODEL CALIBRATION & REPORT POINT LOCATIONS JANUARY - FEBRUARY 2019 EVENT

Prepared By: JS Reviewed by: AW	Date: 28/05/2019 Revision: A NCE Ref: RPS0010	Size A3	Figure 6-1

6.3 Tide Level Influence

Contrary to previous reports, i.e. the 1996 flood levels were higher due to the storm coinciding with high tide, the results of this assessment suggest that the tide level has minimal influence on the flood levels at the site. This is evident results as the TWL level for the MHWS and HAT scenarios was 0.91 m AHD and 1.73 m AHD, respectively, and although there is a 0.82 m increase in TWL (tide level), there was only a 0.02 m increase in flood level observed at the site.

In order to confirm there wasn't any impact from the tide at lower levels, an additional simulation of the MHWS scenario was undertaken however the TWL was set to 0 m AHD. The observed 1% AEP flood level at the site was 5.01 m AHD, therefore confirming that a rise in tide level from 0 m AHD to 1.73 m AHD only has an impact of 0.03 m on the flood level at the site.

Beyond the immediate site, the tidal influence may vary and will require confirmation for other sites, particularly closer to the coast.

6.4 Sensitivity Assessments

6.4.1 Sensitivity 1 – Calibrated and Solver Comparison

It was observed that the levels from the overall calibrated model were noticeable higher (~ 0.35 m) than those from the preliminary truncated model. As the calibration process modified the roughness values, the truncated model was re-run using the calibrated roughness. It was also run using the HPC solver. Flood levels of the re-run truncated model, within the vicinity of the site, were observed to be ~0.09 m higher than the calibrated levels of the overall model. This suggests that the roughness values had a significant impact on the flood levels at the site and that there is generally good agreement between the Classic and HPC solvers.

6.4.2 Sensitivity 2 – Ensemble Pattern Comparison

As the 1% AEP design storm ensemble contains ten (10) different temporal patterns, the pattern that produced the lowest peak run-off (pattern 6) was simulated through the model. A decrease in flood level of ~0.1 m was observed within the vicinity of the site. This suggests that even for a 1% AEP design event, flood levels can vary significantly between the lowest, median and highest run-off generating patterns.

6.5 Climate Change Results

In reference to **Table 6-2**, it is estimated that an increase in flood levels of ~0.31 m may be experienced in the future as a direct result of climate change. Therefore if the site is filled to the developed scenario flood level and any critical infrastructure is built 0.31 m above finished surface, then 1% immunity may still be achieved in the future.

6.6 Afflux

Afflux is a result of an increase or decrease in flood levels or flood extents which can impact adjacent or upstream and downstream properties. Afflux is determined by subtracting the baseline peak water level results from the developed peak scenario results. This was undertaken for the developed scenario where an increase in flood level of 0.02 m was observed immediately upstream of the site filling. This increase was back to zero within 25 m upstream of the site. Subsequently, filling of the site has negligible impact on flood levels to the road reserve and broader area.

7.0 SUMMARY AND CONCLUSION

Hydrologic (XPRAFTS) and 2D hydrodynamic (TUFLOW) models have been developed to determine the 1% AEP flood level at new Telstra mobile network site that is located at Lot 1/RP706308 Prins Road, Lower Daintree. The final extent of the hydrodynamic model represents ~34 km of the Daintree River, beginning ~1.2 km upstream of BairdsTM gauging station to the mouth of the river.

Both models were calibrated to the January-February 2019 monsoon event where reasonable agreement between flood levels at BairdTM gauging station and surveyed levels of debris around the site were observed. 1% AEP design event hydrographs were derived in accordance with AR&R with peak flows at BairdsTM checked against the findings of an FFA (undertaken by others) for the BairdTM gauge station to ensure they fell within the confidence limits.

A number of scenarios and sensitivity assessment were analysed with results suggesting the tide level has minimal impact to flood levels at the site. For the baseline scenarios assessed, the 1% AEP flood level ranges from 5.02 m AHD to 5.04 m AHD. Under climate change conditions the flood level is anticipated to increase to 5.35 m AHD. The flood levels and depths for each scenario are noted in **Table 6-2**.

A developed scenario was also investigated where the proposed site was filled above the flood level. The predicted 1% AEP flood level for this scenario was 5.04m AHD. The results also demonstrated that filling of the site has negligible impact on flood levels to the road reserve and broader area.

In reference to the proposed development plan, it is assumed that majority of the key infrastructure (other than poles) is located within the equipment shelter which is current designed to be elevated 1 m above ground level. Subject to a cost benefit analysis and to achieve immunity to a 1% AEP event in the future, it would be recommended that the site is filled to ~4.4 m AHD (1.8 m of fill), which would then place the finished floor level (FFL) of the equipment shelter at ~5.4 m AHD. This results in the FFL of the equipment shelter being above the predicted climate change flood level.