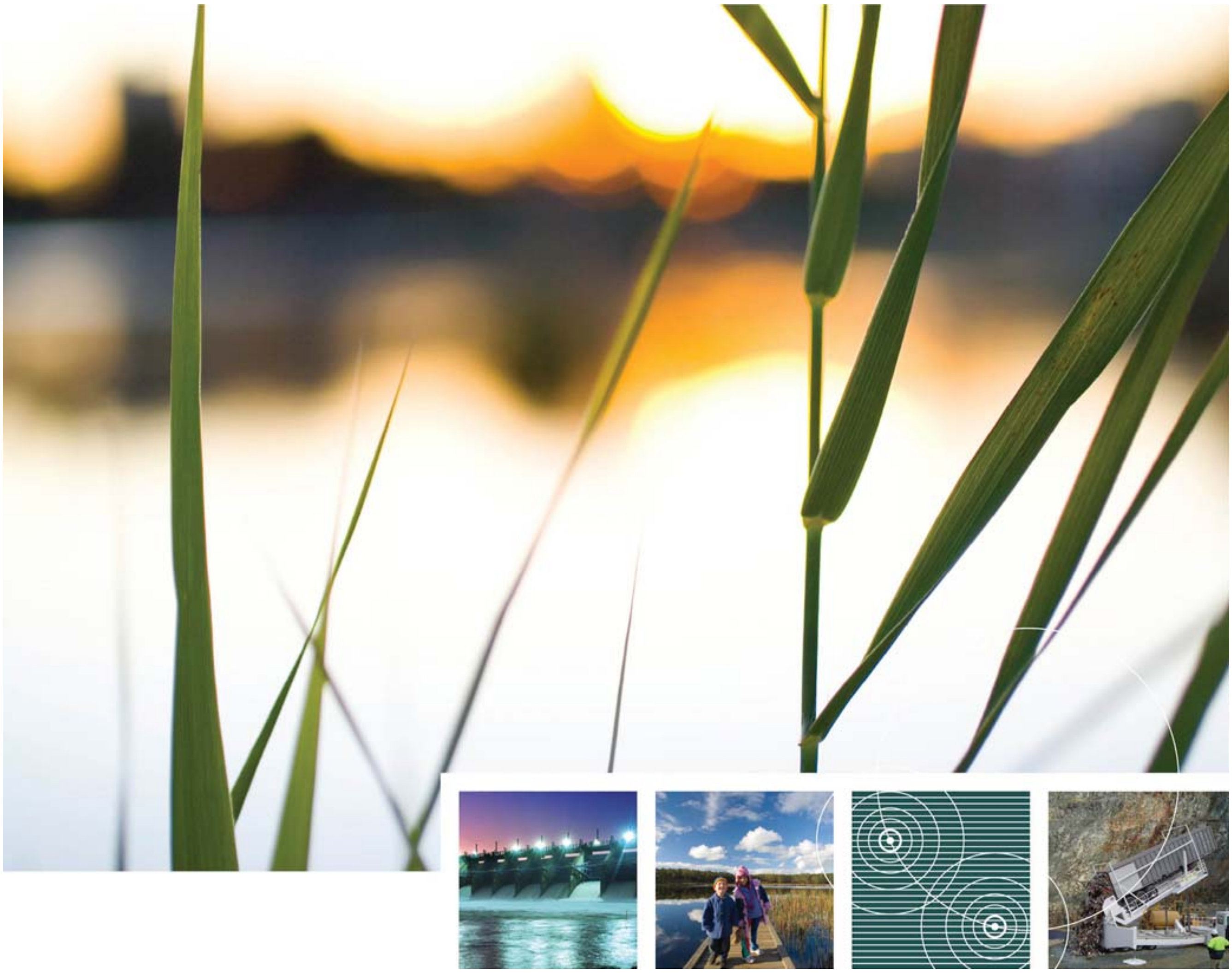

Alligator and Whites Creek Flood Study

Baseline Flood Study

Queensland Department of Main Roads and Townsville City Council

Job No. 80401406
May 2008

Alligator and Whites Creek Flood Study

Prepared for

Queensland Department of Main Roads and Townsville City Council

Prepared by

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Executive Summary

The Southern Access Corridor (SAC) is a proposed major transport route to Townsville from the south. The Queensland Department of Main Roads (DMR) commissioned Maunsell Australia Pty Ltd (Maunsell) to prepare a business case for upgrading existing roads within the corridor. To assess the impacts of the proposed road works baseline flood levels must be established. Townsville City Council (TCC) is also assisting with the baseline flood assessment to establish flood planning levels.

This study quantifies flood levels, flows and velocities for design floods for the 5, 10, 20, 50 and 100 year ARI floods. The 50 year ARI flood is the defined flood event adopted by TCC for landuse planning and assessing the impacts of future works on flood behaviour.

Hydrological models were developed to provide catchment inflows for the flood investigation. Separate models were developed for Alligator and Whites Creek catchments. These were calibrated to rainfall data from the January 2008 rainfall event. The RAFTS-XP model achieved a good calibration to the recorded flows, in terms of peak discharge and flood volume. Flow hydrographs determined from the model were used for input to the hydraulic model, to calculate flood levels and flow velocities.

A detailed hydraulic model was developed for the study area, comprising the area between Whites Creek in the west and Alligator Creek in the east. The model employs a coupled 1-Dimensional / 2-Dimensional approach where a 1-Dimensional component is used for small channels and structures such as bridges and a 2-Dimensional component is used for the broader floodplain.

The hydraulic model was based on the ground topography survey data and also accounted for:

- catchment runoff
- tidal tailwater conditions; and
- roughness due to vegetation.

Recorded flood levels at the Alligator Creek (Allendale) stream gauge and surveyed flood levels were used to calibrate the hydraulic model. A good match was achieved to the flood levels recorded for the January 2008 flood. The calibrated model was used to assess flooding for the range of design floods.

The study showed that the Bruce Highway is inundated:

- west of the Muntalunga Drive turnoff for flood events greater than the 20 year flood;
- adjacent to Country Road in the 50 year flood event;
- adjacent to Olivia Court in the 50 year flood event;
- in the area bordering Willing Drive for the 20 year event;
- adjacent to Alligator Creek Road for the 100 year flood;
- at the Alligator Creek road bridge for the 100 year flood event; and
- east of Williams Road in the 20 year flood.

The 50 year ARI flood which is adopted as the defined flood event by Townsville City Council shows inundation of properties adjacent to Alligator and Whites Creek due to overbank flooding and floodplain formation. Detailed flood maps for the 50 year ARI event are given in **Appendix A**.

1.0 Introduction

1.1 Background

Maunsell was commissioned by DMR and TCC to undertake a flood study of Alligator and Whites Creek to determine baseline flood levels. The flooding assessment has been undertaken to:

- establish existing flood levels for the Southern Access Corridor (SAC) project, to evaluate alignment options and allow future assessment of the flooding impacts of the proposed road; and
- provide TCC with planning flood levels from the 50 year ARI defined flood event.

This report considers only the flood modelling of the base case, i.e. the current state of the Alligator and Whites Creek catchments without the proposed SAC.

1.2 Study Objectives

The objectives of the study were to:

- establish detailed hydrologic and hydraulic models of the Alligator and Whites Creek catchments which are calibrated against recorded rainfall and stream gauging data; and
- determine baseline design flood levels for the Alligator and Whites Creek catchments.

1.3 Scope of Works

The scope of works for the study included:

- review and collation of previous flood studies, survey data, rainfall and stream gauging data, and surveyed flood levels;
- establishment and calibration of a RAFTS-XP hydrologic model for the Alligator and Whites Creek catchments;
- development and calibration of a MIKE FLOOD hydraulic model of the Alligator and Whites Creek floodplains; and
- assessment of existing design flood levels, extents, and velocities using the MIKE FLOOD hydraulic model.

2.0 Available Data

2.1 Previous Investigations

2.1.1 Alligator Creek and Whites Creek Flooding Report (2007)

The Alligator Creek and Whites Creek Flooding Report (2007) was prepared by UDP Consulting Engineers (UDP) in order to determine the 50 Year ARI flood levels for Whites Creek. The Rational Method was used to determine flood flows, which were input into a steady-state 1-D HEC-RAS hydraulic model, encompassing approximately 1 km of Whites Creek downstream of the rail bridge. Surveyed cross sections of Whites Creek at 100m intervals were used to represent the channel and floodplain geometry. No structures (bridges or culverts) were included in the study. This study was used as a comparison for planning flood levels in the Whites Creek areas established with the MIKE FLOOD hydraulic model.

2.1.2 Rocky Springs Integrated Water Cycle Management Study (2007)

The Rocky Springs Integrated Water Cycle Management Study undertaken by Maunsell comprised a flood study and water cycle management study within the proposed Rocky Springs development. This investigation included finding baseline flooding levels within the Rocky Springs site.

An RAFTS-XP hydrological model was developed for the Whites Creek catchment. These flows were input into a MIKE-FLOOD hydraulic model extending from the headwaters of Whites Creek to approximately 250m downstream of the rail bridge at Nome. These models have been adapted and refined for use in the current study.

2.2 Ground Data

2.2.1 Topographic Maps

Topographic maps of the region were obtained from the Department of Natural Resources and Water (NRW) in order to delineate the Alligator Creek and Whites Creek catchment and sub-catchment boundaries. The topographic maps used were:

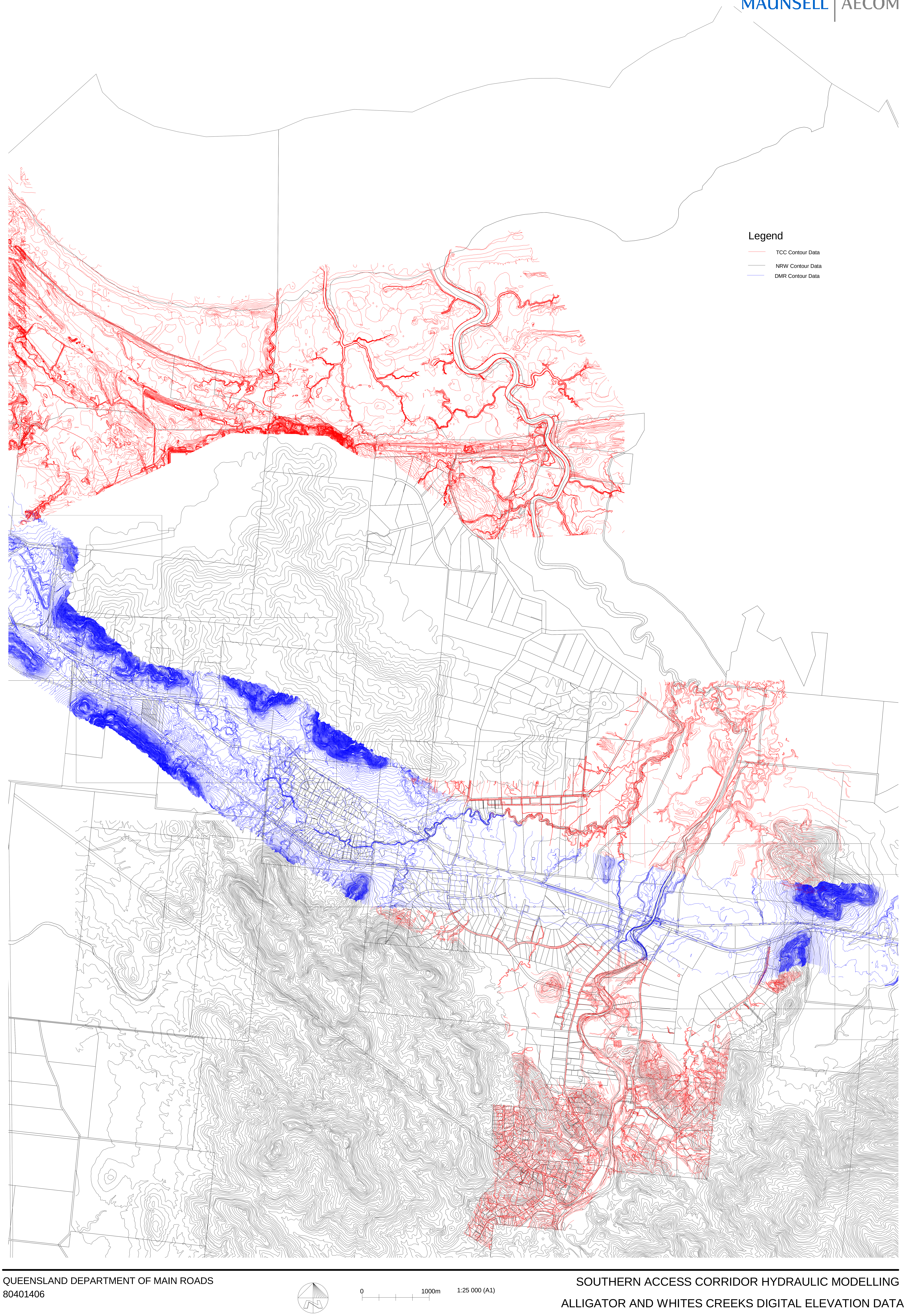
- Alligator Creek (8259-22) – 1:25 000 topographic map;
- Oolbun (8259-21) – 1:25 00 topographic map
- Townsville (8259-2) – 1:50 000 topographic map;
- Bowling Green (8359-3) – 1:50 000 topographic map; and
- Townsville (8259-3AA) – 1:100 000 topographic map;

2.2.2 Digital Elevation Data

Several sources of digital elevation data were used. These were:

- 1:10 000 aerial photogrammetry from existing TCC aerial photography including data supplied by Brazier Motti, with a vertical accuracy of ±0.25 m;
- 1:4000 aerial photogrammetry based on aerial photography flown in 2007 by Schlencker Mapping, with a vertical accuracy of ±0.1 m; and
- 1:25 000 digital contour data for the Alligator Creek topographic map obtained from NRW.

These data sets were combined to produce a DTM of the Alligator and Whites Creek floodplains for a MIKE FLOOD hydraulic model. Approximately a 2 km length of Alligator Creek in the lower mangrove reaches is not included in the aerial photogrammetry. This area is downstream of the study site and is not required to establish baseline levels in the study area. This area was represented using interpolated cross sections extracted from supplied data and is included to assess the impacts of tailwater conditions on flood levels. The approximate extent of the digital elevation data and their source is shown in **Figure 2-1.**



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SOUTHERN ACCESS CORRIDOR HYDRAULIC MODELLING

ALLIGATOR AND WHITES CREEKS DIGITAL ELEVATION DATA

FIGURE 2.1

2.2.3 Bridge and Culvert Data

Details of bridges and culverts within the study area were supplied by DMR and Queensland Rail (QR). This data was used to represent the structure hydraulics in the MIKE FLOOD hydraulic model. Road and Rail culvert information adopted for the study are shown in **Table 2-1** and **Table** 2-2 respectively. Approximate locations of culverts are shown in **Figure 4-2** and **Figure 4-3.**

Table 2-1- Road Culverts

Culvert Name	Upstream Invert	Downstream Invert	Length (m)	Geometry	No. of culverts	Dimensions (m)
Rd 1	48.0	47.6	20	Circular	1	0.9
Rd 2	41.0	40.7	19.5	Circular	1	0.9
Rd 3	41.4	41.0	20	Circular	1	0.75
Rd 4	36.6	36.2	22.5	Circular	2	1.05
Rd 5	33.9	33.6	17	Circular	1	0.6
Rd 6	30.6	30.3	17	Circular	1	1.2
Rd 7	30.6	30.2	20	Circular	1	1.05
Rd 8	32.4	32.1	17.7	Circular	1	0.75
Rd 9	31.1	30.6	17.7	Circular	1	0.6
Rd 10	26.9	26.8	17	Rectangular	3	2.1 x 1.5
Rd 11	27.5	27.1	21	Circular	2	1.05
Rd 12	27.7	27.3	21	Rectangular	2	2.13 x 2.1
Rd 13	26.3	26.1	22.5	Circular	1	1.2
Rd 14	24.7	24.4	18	Circular	3	0.9
Rd 15	26.1	25.8	18	Circular	1	0.525
Rd 16	26.9	26.6	18.3	Circular	1	1.2
Rd 17	23.6	23.1	16	Rectangular	2	1.2 x 0.6
Rd 18	25.3	25.1	12	Circular	2	0.525
Rd 19	24.8	24.5	15.9	Circular	1	0.525
Rd 20	25.0	24.7	16	Rectangular	1	2.13 x 1.22
Rd 21	24.5	24.3	12	Circular	3	1.05
Rd 22	24.0	23.7	16.5	Circular	1	0.6
Rd 23	22.8	22.6	7	Rectangular	2	0.9 x 0.6
Rd 24	23.4	23.1	16.5	Circular	1	0.75
Rd 25	22.8	22.5	15.6	Rectangular	2	2.13 x 1.23
Rd 26	23.1	22.9	14	Circular	6	1.05
Rd 27	22.2	22.0	17	Circular	1	0.525
Rd 28	21.8	21.6	14	Circular	2	0.675
Rd 29	22.3	22.0	18.3	Circular	1	0.75
Rd 30	20.2	20.1	16	Rectangular	2	2.13 x 1.4
Rd 31	21.7	21.5	20	Circular	1	0.525
Rd 32	18.6	18.4	9	Circular	1	0.525
Rd 33	17.1	17.1	9	Rectangular	4	2.1 x 2.1
Rd 34	17.2	17.0	9.6	Rectangular	1	0.45 x 0.3
Rd 35	12.6	12.5	9.6	Rectangular	1	0.6 x 0.3
Rd 36	9.8	9.6	9.6	Rectangular	2	0.6 x 0.45
Rd 37	8.4	8.4	8	Rectangular	8	2.1 x 1.2
Rd 38	8.9	8.8	12	Rectangular	3	2.1 x 1.2
Rd 39	0.15	0.13	6.5	Bridge		
Rd 40	10.2	9.9	15	Circular	1	1.2
Rd 41	10.5	10.2	14	Circular	4	0.525
Rd 42	10.1	9.8	13	Rectangular	2	2.1 x 0.6

Culvert Name	Upstream Invert	Downstream Invert	Length (m)	Geometry	No. of culverts	Dimensions (m)
Rd 43	9.8	9.7	15	Circular	10	0.525
Rd 44	10.0	9.8	15	Circular	12	0.525
Rd 45	9.7	9.5	15	Circular	14	0.525
Rd 46	9.8	9.8	7.2	Circular	1	1.2
Rd 47	11.2	11.0	14.4	Circular	1	0.9
Rd 48	18.0	17.8	14	Circular	1	0.9

Table 2-2- Rail Culverts

Culvert Name	Upstream Invert	Downstream Invert	Length	Geometry	No. of culverts	Dimensions (m)
RL1	39.3	39.1	10	Circular	2	0.6
RL2	36.7	36.6	10	Circular	1	1.65
RL3	37.7	37.6	10	Circular	1	0.6
RL4	35.4	35.3	10	Circular	3	1.35
RL5	34.2	34.0	10	Circular	4	0.6
RL6	32.9	32.8	10	Circular	2	0.6
RL7	30.1	29.9	10	Circular	2	1.5
RL8	29.1	29.0	10	Circular	2	1.5
RL9	29.1	29.0	10	Circular	4	0.5
RL10	30.6	30.5	10	Circular	1	0.6
RL11	28.2	28.1	10	Circular	2	0.6
RL12	26.9	26.7	10	Circular	2	0.6
RL13	22.6	22.5	10	Circular	4	1.05
RL14	21.8	21.5	10	Circular	1	0.6
RL15	19.9	19.8	10	Circular	2	1.35
RL16	19.7	19.6	10	Circular	2	0.6
RL17	12.2	12.1	4	Bridge		
RL18	13.6	13.6	10	Circular	1	0.45
RL19	12.7	12.7	10	Rectangular	2	1.2 x 0.9
RL20	7.5	7.4	10	Rectangular	8	1.2 x 1.2
RL21	8.9	8.9	10	Circular	1	0.6
RL22	9.1	9.0	10	Rectangular	1	1.2 x 0.6
RL23	8.8	8.7	10	Rectangular	2	2.1 x 2.1
RL24	0.13	0.12	4	Bridge		
RL25	9.9	9.8	10	Rectangular	1	0.6 x 0.45
RL26	9.7	9.7	10	Rectangular	1	0.6 x 0.45
RL27	9.5	9.4	10	Rectangular	1	1.2 x 0.6
RL28	9.0	8.9	10	Rectangular	1	0.6 x 0.6
RL29	8.1	8.0	10	Rectangular	1	0.6 x 0.6
RL30	8.7	8.6	10	Rectangular	1	1.2 x 0.6
RL31	39.3	39.1	10	Rectangular	1	1.2 x 0.6

2.3 Climate Data

2.3.1 Historical Rainfall Data

Historical rainfall was acquired from the Bureau of Meteorology (BOM) for input to the hydrological modelling. Daily rainfall data was obtained for the entire period of record at relevant gauges. Pluviograph data was obtained for the Alligator Creek alert gauge for the entire period of record. A summary of the rainfall stations used in the study is shown in **Table 2-3**. Historical rainfall data was used to calibrate the RAFTS-XP model parameters.

Table 2-3 - Summary of Historical Rainfall Data Obtained

Number	Site Name	Source	Latitude (°S)	Longitude (°E)	Period of Record	Data Interval
032040	Townsville Aero	BOM	19.248	146.766	30/01/1953-Present	Continuous
032057	Oonoonba	BOM	19.290	146.811	29/09/1959-Present	Daily
032157	Yabulu	BOM	19.288	146.607	30/03/1988-Present	Daily
033001	Burdekin Shire Council	BOM	19.578	147.408	29/11/1986-Present	Daily
033028	Giru Post Office	BOM	19.511	147.106	30/08/1932-Present	Daily
033151	Majors Ck	BOM	19.595	146.934	1934-Present	Daily
532034	Alligator Ck Alert	BOM	19.386	146.956	01/05/2000-Present	Continuous

2.3.2 Design Rainfall Data

Site specific design rainfall intensities, or Intensity Frequency Duration (IFD) data, were determined using the design intensity isopleths from Volume 2 of *Australian Rainfall and Runoff* (AR&R, 1987). The adopted IFD input parameters for the Alligator and Whites Creek catchments are shown in **Table 2-4** and **Table 2-5** respectively. Design rainfalls were used to generate flow hydrographs for each design storm.

Table 2-4 - Adopted IFD Input Parameters for Alligator Creek Catchment

Parameter	Value
Longitude (° E)	146.85
Latitude (° S)	19.27
1 hour, 2 year Intensity (mm/h)	57
12 hour, 2 year Intensity (mm/h)	14.2
72 hour, 2 year Intensity (mm/h)	5.95
1 hour, 50 year Intensity (mm/h)	111.5
12 hour, 50 year Intensity (mm/h)	30
72 hour, 50 year Intensity (mm/h)	10.5
Average Regional Skewness	0.06
Geographic Factor F_2	3.92
Geographic Factor F_{50}	17.1

Table 2-5 - Adopted IFD Input Parameters for Whites Creek Catchment

Parameter	Value
Longitude (° E)	146.88
Latitude (° S)	19.38
1 hour, 2 year Intensity (mm/h)	55
12 hour, 2 year Intensity (mm/h)	13
72 hour, 2 year Intensity (mm/h)	4.6
1 hour, 50 year Intensity (mm/h)	110.5
12 hour, 50 year Intensity (mm/h)	27
72 hour, 50 year Intensity (mm/h)	10
Average Regional Skewness	0.06
Geographic Factor F_2	3.94
Geographic Factor F_{50}	17.15

Standard techniques from AR&R were used to determine rainfall intensities for durations up to 72 h and ARIs up to a 100 year ARI event. The calculated intensities are shown in **Table 2-6** and **Table 2-7.**

Table 2-6 - IFD Data for Alligator Creek Catchment

Duration	5 Year ARI (mm/h)	10 Year ARI (mm/h)	20 Year ARI (mm/h)	50 Year ARI (mm/h)	100 Year ARI (mm/h)
15 min	137	156	180	211	236
30 min	102	116	133	157	175
45 min	84	95	110	130	145
1 h	73	83	96	113	126
1.5 h	59	67	78	92	102
2 h	50	57	67	79	88
3 h	40.4	46.1	54	64	71
4.5 h	32.3	36.9	43	51	58
6 h	27.5	31.6	36.9	43.9	49.4
9 h	22	25.3	29.6	35.4	39.9
12 h	18.8	21.7	25.4	30.4	34.3
18 h	15.4	17.6	20.5	24.3	27.3
24 h	13.3	15.1	17.5	20.7	23.1
30 h	11.9	13.4	15.5	18.2	20.3
36 h	10.8	12.2	14	16.4	18.2
48 h	9.26	10.4	11.8	13.8	15.3
72 h	7.33	8.12	9.2	10.6	11.7

Table 2-7 - IFD Data for Whites Creek Catchment

Duration	5 Year ARI (mm/h)	10 Year ARI (mm/h)	20 Year ARI (mm/h)	50 Year ARI (mm/h)	100 Year ARI (mm/h)
15 min	135	153	178	210	235
30 min	100	114	132	156	175
45 min	82	94	109	129	144
1 h	71	81	94	112	125
1.5 h	57	65	75	89	100
2 h	48.3	55	64	76	85
3 h	38.2	43.7	51	60	68
4.5 h	30.2	34.5	40.3	47.9	54
6 h	25.5	29.3	34.1	40.6	45.6
9 h	20.2	23.2	27	32.2	36.3
12 h	17.1	19.6	22.9	27.4	30.8
18 h	13.8	15.8	18.5	22.2	25
24 h	11.8	13.6	15.9	19	21.5
30 h	10.4	12	14.1	16.9	19.1
36 h	9.4	10.9	12.7	15.3	17.3
48 h	7.95	9.19	10.8	13	14.7
72 h	6.17	7.15	8.42	10.1	11.5

2.3.3 Stream Flows

Stream gauging data obtained from NRW is for the Allendale gauge at Alligator Creek (gauge number 118106A). Stream heights and discharges were obtained for the entire period of record (from September 1974 to present). Stream flows from this gauge were used to calibrate the RAFTS-XP model to the flows in the 13-14 January 2008 flood.

2.4 Surveyed Flood Levels

Flood levels for the January 2008 rainfall event were obtained at five separate locations in the Alligator and Whites Creek study area through survey by DMR. Surveyed flood levels were used to calibrate the MIKE FLOOD model to the 2008 flood.

3.0 Hydrological Modelling

3.1 Overview

RAFTS-XP was used to model flood hydrology of the Alligator and Whites Creek catchments. The catchments were modelled separately, with each catchment divided into sub-catchments based on the natural topography and required flow locations. The RAFTS-XP model was calibrated to recorded stream gauge data to confirm catchment parameters. The calibrated model was then used to generate design flow hydrographs to apply as boundary conditions in the hydraulic model.

3.2 Catchment Description

3.2.1 Alligator Creek

The Alligator Creek catchment rises to approximately 1200 m above sea level in Mount Elliot to the south of the Bruce Highway and has a total area of approximately 80 km². Alligator Creek flows north through Bowling Green National Park, the Bruce Highway and the North Coast Railway before discharging into Cleveland Bay, approximately 15 km downstream of the highway. The creek has relatively steep, well vegetated banks and an alluvial bed in the downstream sections. Riparian corridors are dense in the upper reaches, but reduce in the lower reaches. The upper reaches include areas of dense rocky outcrops. The Alligator Creek floodplain includes areas of rural residential development and marine swamp with mangrove forests and inter-tidal plains in the lower flood-plain. The Alligator Creek catchment is shown in **Figure 3-1**.

3.2.2 Whites Creek

The Whites Creek catchment rises approximately 300 m in the Muntalunga Range to the north of the highway and has a total area of approximately 35 km². Whites Creek flows east through Nome with three road and one rail crossing before discharging into Alligator Creek approximately 5 km north of the highway. The creek has relatively steep, well vegetated banks, with some evidence of existing bank erosion. The creek has an alluvial bed with some gravel in the upper reaches. There is a narrow riparian corridor, with wide grassed overbank areas. The majority of the riparian zone and understorey of the banks is comprised of exotic vegetation. Land uses within the catchment are primarily rural residential with some pastoral properties in the lower reaches. The Whites Creek catchment is shown in **Figure 3-1**.

3.2.3 Sub-Catchment Delineation

The Alligator and Whites Creek catchments were divided into sub-catchments based on the natural topography and the need to obtain hydrographs at key locations for input into the hydraulic model. The sub-catchment boundaries are shown in **Figure 3-1.**

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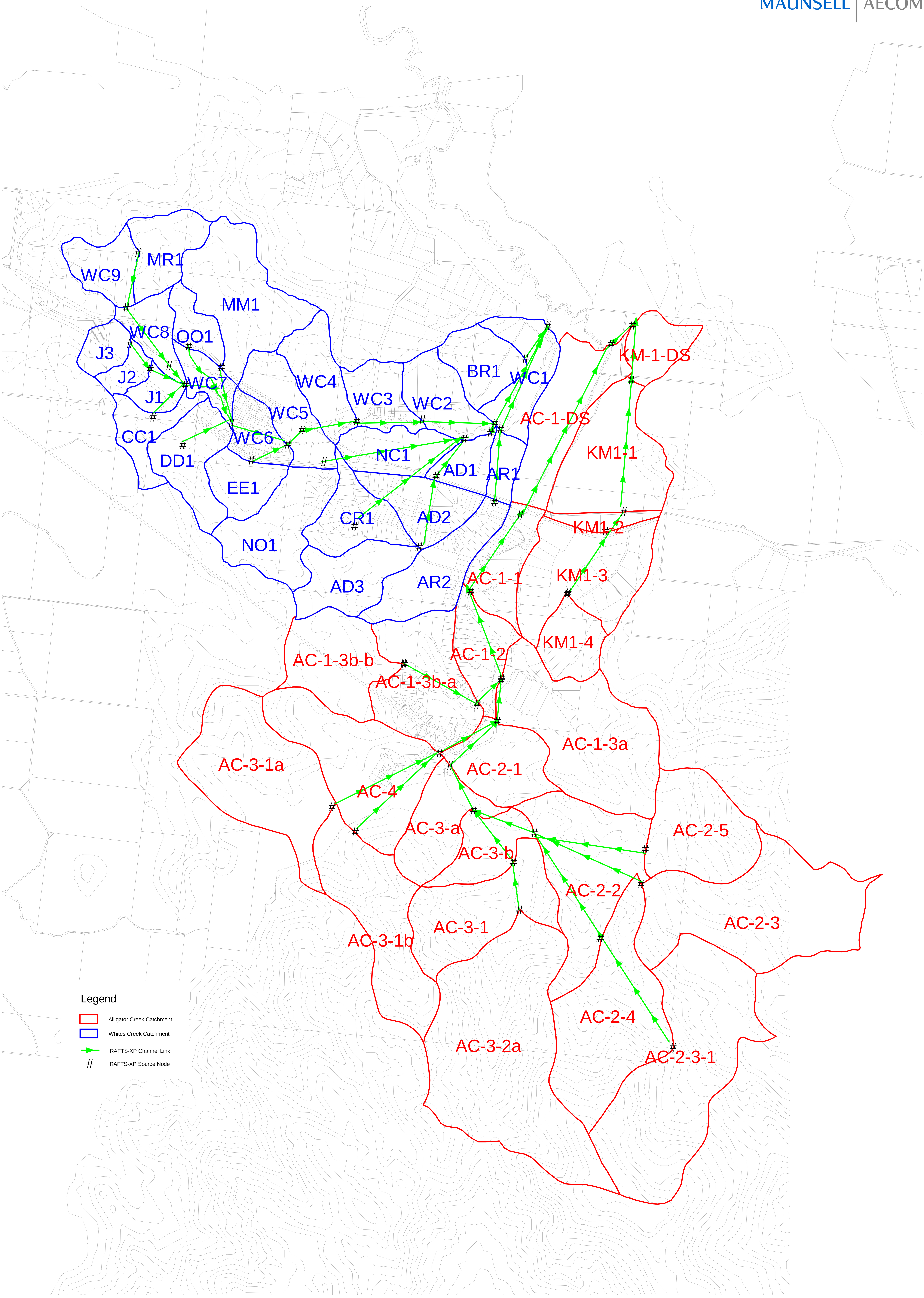

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SOUTHERN ACCESS CORRIDOR HYDRAULIC MODELLING

ALLIGATOR AND WHITES CREEKS SUB-CATCHMENTS

FIGURE 3.1

3.3 RAFTS-XP

The hydrologic modelling software RAFTS-XP calculates catchment flows from rainfall based on Laurenson's non-linear routing method. The model is able to predict flows for both urban and rural catchments and is widely used in Queensland. The model allows for surface roughness, soil infiltration and depression storage losses. It is well suited to the study area due to the need for detailed sub-catchment definition. RAFTS-XP has been successfully used in similar applications in North Queensland.

3.4 Model Parameters

3.4.1 Sub-Catchment Parameters

For each sub-catchment in RAFTS-XP, the area, slope, roughness and impervious fraction were defined based on topographic maps and aerial photography. The Pervious Initial Losses were higher in upstream catchments due to the heavily forested nature of these areas. Catchments in the upper reaches of Alligator Creek were given higher roughness values due to the dense vegetation and concentrated areas of rocky terrain within the flow path and surrounding area. Catchments in the upper reaches of Whites Creek were assigned a roughness value of 0.06 due to the dense vegetation and undefined flow paths. Catchments with concentrated residential areas within the Alligator Creek area were assigned higher Fraction Impervious due to the large volume of development. RAFTS-XP inputs for the Alligator and Whites Creek catchments are shown in **Table 3-1** and **Table 3-2** respectively.

Table 3-1 - Alligator Creek Existing Case RAFTS-XP Inputs

Sub-catchment	Area [ha]	Roughness (Pern n*)	Fraction Impervious [%]	Slope [%]	Pervious Initial Loss (mm/h)	Pervious Continuing Loss (mm/h)
AC-1-DS	262.1	0.05	0	0.3	25	2.5
KM-1-DS	104.7	0.05	0	1	25	2.5
KM1-1	324.6	0.05	0	1	25	2.5
AC-1-1	154.4	0.05	25	2	25	2.5
KM1-2	45.5	0.05	0	1	25	2.5
AC-1-2	142.7	0.05	20	3	25	2.5
AC-1-3b-a	323.6	0.06	10	3.3	25	2.5
AC-4	422	0.05	5	8	25	2.5
AC-2-3	590.4	0.05	0	15	45	2.5
AC-1-3a	502.8	0.05	5	10	25	2.5
AC-3-1a	457.6	0.05	0	7.5	25	2.5
AC-2-2	411.6	0.05	0	10	25	2.5
AC-2-1	196.5	0.05	5	5	25	2.5
AC-3-2a	853.1	0.05	0	9.4	45	2.5
AC-3-1	316.5	0.05	0	12	45	2.5
AC-3-1b	370.7	0.05	0	9.5	25	2.5
AC-3-a	188	0.07	5	8.5	25	2.5
KM1-3	342.4	0.05	10	0.5	25	2.5
AC-2-3-1	702.1	0.05	0	10.2	45	2.5
AC-2-4	484.1	0.05	0	12	45	2.5
AC-2-5	296.8	0.1	0	13.8	45	2.5
AC-1-3b-b	252.7	0.07	0	9.5	25	2.5
AC-3-b	135.8	0.08	5	11.9	25	2.5
KM-1-4	122.9	0.05	10	3.8	25	2.5

Table 3-2 - Whites Creek Existing Case-RAFTS-XP Inputs

Sub-catchment	Area [ha]	Roughness (Pern n*)	Fraction Impervious [%]	Slope [%]	Pervious Initial Loss (mm/h)	Pervious Continuing Loss (mm/h)
WC9	113.5	0.06	0	6.5	45	2.5
WC8	96.6	0.05	0	2.6	25	2.5
WC7	70.9	0.05	1	0.5	25	2.5
WC6	92.6	0.05	1	0.2	25	2.5
WC5	162.9	0.05	1	2.6	25	2.5
WC4	151.3	0.06	0	3.7	25	2.5
WC3	117	0.05	1	0.9	25	2.5
WC2	145.5	0.05	1	0.8	25	2.5
WC1	154.7	0.05	0	0.15	25	2.5
AR2	210.9	0.05	1	1.9	25	2.5
AR1	57.9	0.05	0	0.15	25	2.5
BR1	133.7	0.05	0	3.8	25	2.5
AD3	182.3	0.06	0	5.9	25	2.5
AD2	155.8	0.05	1	0.4	25	2.5
AD1	76.4	0.05	0	0.2	25	2.5
CR1	154.4	0.05	1	5.1	25	2.5
NO1	238.9	0.06	0.1	5.3	25	2.5
EE1	109.8	0.05	0	7.4	25	2.5
DD1	162.4	0.06	0.1	5	45	2.5
CC1	102.8	0.06	0	2.6	45	2.5
J1	51.1	0.06	0	4.5	45	2.5
MR1	140.7	0.06	0	5.9	45	2.5
OO1	75.3	0.05	0	7.4	45	2.5
MM1	323.5	0.06	0	7.1	45	2.5
NC1	136.5	0.05	0.1	0.4	25	2.5
J2	45.8	0.06	0	6.7	45	2.5
J3	62.9	0.06	0.1	7.6	45	2.5

3.4.2 Rainfall Losses

An initial and continuing loss model was used to represent infiltration and storage of runoff in surface depressions. The values for initial and continuing loss were determined from calibration to stream gauge data for the 2008 flood event. The values determined are within that range of values typical for the area as specified in AR&R, Book 2. (1987). AR&R recommends initial losses of 2.5 mm/hr and continuing losses of 15-35 mm/hr. The continuing loss value of 45 mm/hr applied to the upper reaches of each catchment are within the threshold of 140 mm/hr designated as heavily forested areas by AR&R.

3.4.3 Channel Routing

The Muskingum-Cunge routing method was used to route hydrographs between sub-catchments. This method requires a defined channel geometry and roughness to determine the appropriate hydrograph routing. The general channel geometry was defined from topographic maps and field observations.

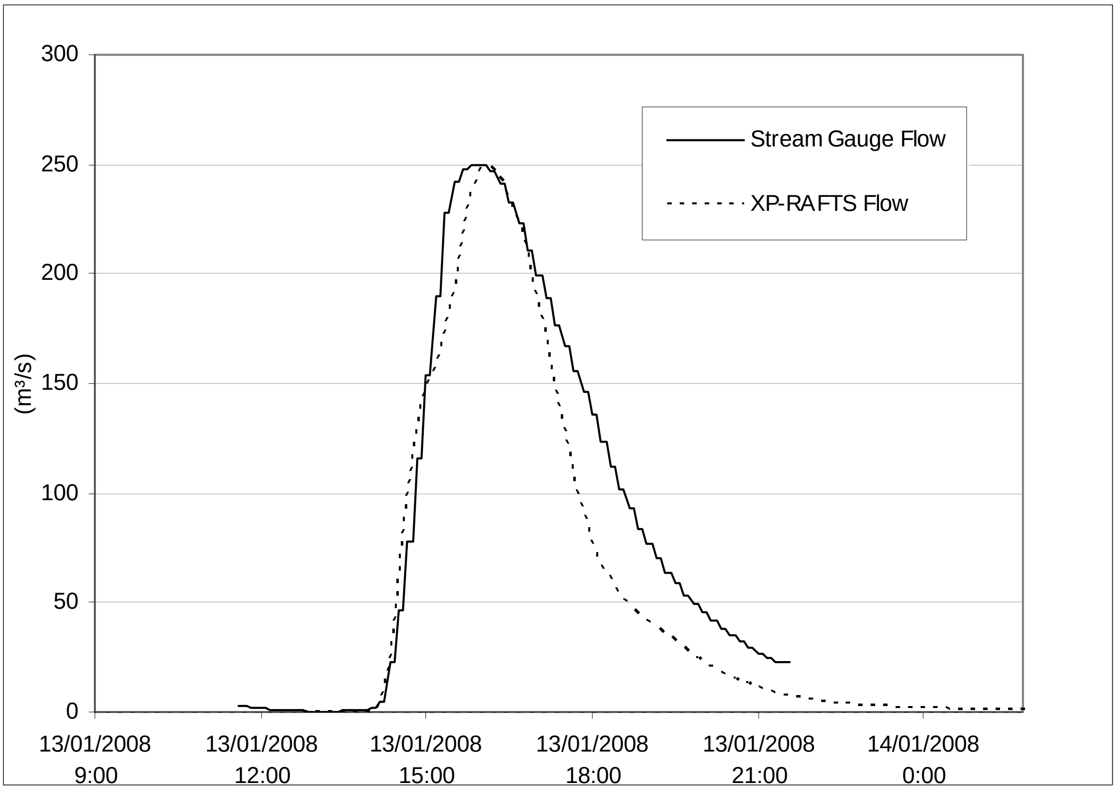
3.5 Calibration

The RAFTS-XP hydrological model was calibrated to the rainfall event of the 13-14 January 2008 using recorded stream flows from the Alligator Creek gauge at Allendale. This event was estimated to correspond to approximately a 4-5 year ARI. Base flows below a threshold of 20 m³/s were removed from the hydrograph to ensure runoff from the event was not over-estimated.

Pluviograph data from the Alligator Creek Alert gauge were used to construct a temporal pattern for the event. Daily totals from nearby gauges were used to determine varying rainfall intensities for each sub-catchment using an inverse distance squared weighting method.

The RAFTS-XP model was calibrated by adjusting design loss values and channel routing parameters to achieve a similar discharge to the gauge data. The modelled RAFTS-XP discharge plot and the gauge data are shown in **Figure 3-2.**

Figure 3-2 - RAFTS-XP Hydrologic Verification



The comparison between gauge discharge data modelled discharge shows good agreement between the recorded levels and those predicted by RAFTS-XP. The RAFTS-XP model was jointly calibrated with the MIKE FLOOD model. The calibration of the model confirms its suitability for determining flood discharges for Alligator and Whites Creek.

The 2008 rainfall event is the only flood event for which pluviograph data is available at the Alligator Creek Alert station. Attempts to correlate the Allendale gauge data to Townsville Aero pluviograph data showed no relationship between data for any significant rainfall events. Accordingly the RAFTS-XP model was only calibrated to one storm event.

3.6 Design Events

The Alligator Creek and Whites Creek catchments RAFTS-XP models were run for the 50 year ARI events for a range of durations to determine the critical duration storm. The 24 hour design storm was adopted as the critical duration storm for both catchments. Hydrographs from the RAFTS-XP models were exported and applied as source points in the MIKE FLOOD hydraulic model.