Wolston Creek Flood Study
Volume 1 of 2

Flood Study Report

Prepared by Brisbane City Council's, City Projects Office

June 2018

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Note: *The Wolston Creek Flood Study is a joint initiative of Brisbane City Council and the Queensland Government.*

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Executive Summary

Introduction

Brisbane City Council is in the process of updating all of its creek flood studies to reflect the current conditions of the catchment and best practice flood modelling techniques. The most recent studies undertaken of Wolston Creek were the Wolston Creek Water Quantity Assessment (2000) and Wolston Creek Flood Study (1996).

Wolston Creek Catchment has a total area of 44 km^2 and the catchment centroid is located approximately 19 km south-west of the Brisbane CBD. The major creeks / tributaries within the catchment are: Wolston Creek; Sandy Creek; Bullockhead Creek and Ric Nattrass Creek. The catchment area covers three local governments, namely Brisbane City Council; Ipswich City Council and Logan City Council. Suburbs within the catchment include Springfield, Greenbank, Camira, Carole Park, Gailes, Ellen Grove, Richlands, Wacol and Sumner. The lower section of the catchment is dominated by flooding originating from the Brisbane River.

Project Objectives

The primary objectives of the project were as follows:

- Update the Wolston Creek flood models (hydrologic and hydraulic) to represent the current catchment conditions and best practice flood modelling techniques.
- Adequately calibrate and verify the flood models to historical storm events to confirm that the models are suitable for the purpose of simulating design flood events.
- Estimate design and rare / extreme flood magnitudes.
- Determine flood levels for the design and rare / extreme events.
- Quantify the impacts of Minimum Riparian Corridor (MRC) and filling / development outside the "Modelled Flood Corridor."
- Produce flood extent mapping for the selected range of design, rare and extreme events.
- Quantify the sensitivity of catchment flooding to climate variability.

Project Elements

The flood study consists of two main components, as follows:

Model Set-up and Calibration

Hydrologic and hydraulic models of the Wolston Creek Catchment have been developed using the URBS and TUFLOW modelling software, respectively.

The hydrologic model simulates the catchment rainfall-runoff and runoff-routing processes. The hydrologic model also utilises high-level reach routing to simulate the flow of floodwater in the major waterways within the catchment. The URBS model incorporated 82 sub-catchments and the sub-catchment delineation was based upon the 2014 ALS contours. The sub-catchment delineation considered the location of major tributaries, hydrometric gauges, stormwater drainage as well as man-made boundaries such as the Ipswich and Centenary Motorways.

The hydraulic model uses more sophisticated reach routing to simulate the movement of this floodwater through these waterways in order to predict flood levels, flood discharges and velocities. The hydraulic model takes into account the effects of the channel / floodplain topography, downstream tailwater conditions and hydraulic structures. The hydraulic model consists largely of a 1d / 2d linked schematisation, with the 1d domain modelled in ESTRY and the 2d domain in TUFLOW. The model incorporated Wolston Creek; Sandy Creek; Bullockhead Creek; Ric Nattrass Creek; Spinks Creek; Scott Creek and Tributaries 1, 2 and 3.

Calibration is the process of refining the model parameters to achieve a good agreement between the modelled results and the historical / observed data. Model calibration is achieved when the model simulates the historical event to within specified tolerances. Verification is then undertaken on additional flooding event(s) to confirm the calibrated model is suitable for use in simulating synthetic design storm events.

Calibration of the URBS and TUFLOW models was undertaken utilising three historical storms; namely, May 2015, January 2013 and May 2009. Verification of the URBS and TUFLOW models utilised the March 2017 historical storm event.

An acceptable correlation was achieved between the simulated and historical records for all three calibration events. At the Maximum Height Gauges (MHGs), the simulated peak levels were generally within the specified tolerance of ± 0.3 m.

The verification was undertaken utilising the adopted parameters from the calibration process. Similar to the calibration, the verification achieved an acceptable correlation between the simulated and historical records.

Given the results of the calibration and verification process were quite reasonable, the URBS and TUFLOW models were considered acceptable for use in the second part of the flood study, in which design flood levels were estimated.

Design and Extreme Event Modelling

The calibrated hydrologic and hydraulic models were used to simulate a range of synthetic design flood events. Design and extreme flood magnitudes were estimated for the full range of events from 2-yr ARI (50 % AEP) to PMF. These analyses assumed ultimate catchment hydrological conditions in accordance with BCC City Plan 2014. A fixed tidal boundary was used at the downstream model extent to represent the Brisbane River.

Three waterway scenarios were considered, as follows:

- Scenario 1 – Existing Waterway Conditions: Based on the current waterway conditions. Some minor modifications were made to the TUFLOW model developed as part of the calibration / verification phase to update the hydraulic roughness (as required) based on City Plan 2014.
- Scenario 2 – Minimum Riparian Corridor (MRC): Includes an allowance for a riparian corridor along the edge of the channel.
- Scenario 3 – Ultimate Conditions: Includes an allowance for the minimum riparian corridor (as per Scenario 2) and also assumes development infill to the boundary of the “Modelled Flood Corridor” in order to simulate potential development.

The “Modelled Flood Corridor” is the greater extent of Flood Planning Areas (FPAs) 1, 2 and 3 and the Waterway Corridor.

The results from the TUFLOW modelling were used to determine / produce the following:

- Design flood discharges (Section 6.4.1)
- Design flood levels at 100 m intervals along the AMTD line (Appendices F, G, I and J)
- Scenario 1 design flood extent mapping (Volume 2 of 2)

The lower section of the catchment is dominated by flooding originating from the Brisbane River, as such, the reported design flood levels in this area will be lower than the Brisbane River design flood levels for each respective ARI (AEP).

As part of the required sensitivity analysis, a climate variability analysis was undertaken to determine the impacts for four climate futures; namely Year 2050 RCP4.5; Year 2050 RCP8.5; Year 2100 RCP4.5 and Year 2100 RCP8.5. This included making allowances for increased rainfall intensity and increased mean sea level. This analysis was undertaken for the 100-yr ARI (1% AEP), 200-yr ARI (0.5% AEP) and 500-yr ARI (0.2% AEP) events.

The results indicated that the effects of climate variability impacts within the catchment will increase the magnitude of flooding. The following observations were made from the results:

- Flood level increases are greater under RCP8.5 climate projections when compared with RCP4.5 climate projections.
- 2050 RCP8.5 and 2100 RCP4.5 flood levels are almost identical for those areas not affected by projected sea level increases.
- Based on RCP8.5 climatic projections, by the year 2100, the 100-yr ARI (1 % AEP) flood levels are likely to be of similar magnitude to the present day 200-yr ARI (0.5 % AEP) flood levels for those areas not affected by projected sea level increases.
- Based on RCP8.5 climatic projections, by the year 2100, the 200-yr ARI (0.5 % AEP) flood levels are likely to be of similar magnitude to the present day 500-yr ARI (0.2 % AEP) flood levels for those areas not affected by projected sea level increases.

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Glossary of Terms

Term	Definition
2014 ALS Data	This dataset is part of the SEQ 2014 LiDAR capture project and covers an area of approximately 1392 km^2 over Brisbane City. This project was undertaken by Fugro Spatial Solutions Pty Ltd on behalf of the Queensland Government.
AHD	Australian Height Datum (AHD) is the reference level for defining reduced levels adopted by the National Mapping Council of Australia. The level of 0.0 mAHD is approximately mean sea level.
Annual Exceedance Probability(AEP)	The probability that a given rainfall total or flood flow will be exceeded in any one year.
AR&R 2016 Data Hub (Beta)	The Australian Rainfall and Runoff Data Hub is a tool that allows for easy access to the design inputs required to undertake flood estimation in Australia. Background on the development and use of this data can be found in Australian Rainfall and Runoff (2016).
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrence of a flood as big as (or larger than) the selected event. For example, floods with a discharge as great as (or greater than) the 20 year ARI design flood will occur on average once every 20 years.
Brisbane Bar	Location at the mouth of the Brisbane River
Catchment	The area of land draining through the main stream (as well as tributary streams) to a particular site. It always relates to an area above a specific location.
Digital Elevation Model (DEM)	A three-dimensional model of the ground surface elevation.
Design Event, Design Storm	A hypothetical flood/storm representing a specific likelihood of occurrence (for example the 100 year ARI).
ESTRY	ESTRY is the 1d hydrodynamic engine used by TUFLOW.
Floodplain	Area of land subject to inundation by floods up to and including the Probable Maximum Flood (PMF) event.
Flood Frequency Analysis (FFA)	Method of predicting flood flows at a particular location by fitting observed values at the location to a standard statistical distribution.
Flood Planning Area (FPA)	Flood Planning Areas (FPAs) were introduced in BCC City Plan 2014 to better advise on the susceptibility of flooding.
HEC-RAS	Hydraulic modelling software package.
Hydrograph	A graph showing how the discharge or stage/flood level at any particular location varies with time during a flood.
Manning's 'n'	The Gauckler–Manning coefficient, used to represent hydraulic roughness in 1d / 2d flow equations.
MIKE11	Hydraulic modelling software package.

Glossary of Terms (cont)

Term	Definition
Minimum Riparian Corridor (MRC)	An area where future revegetation of the creek riparian zone has been assumed for modelling purposes. Modelled as dense vegetation (nominal Manning's n=0.15) and typically extending for a maximum of 15 m on either side of the low-flow channel.
Modelled Flood Corridor	The "Modelled Flood Corridor" is the greater extent of the Waterway Corridor (WC) and Flood Planning Areas (FPAs) 1, 2, 3 and represents a zone of assumed no filling.
Probable Maximum Flood (PMF)	An extreme flood deemed to be the largest flood that could conceivably occur at a specific location.
Probable Maximum Precipitation (PMP)	The theoretical greatest depth of precipitation that is physically possible over a particular catchment
RUBICON	Hydraulic modelling software package
URBS	Hydrologic modelling software package developed by Don Carroll
WBNM	Hydrologic modelling software package developed by the University of Wollongong

Adopted ARI to AEP Conversion

The use of the terms "*recurrence interval*" and "*return period*" has been criticised as leading to confusion in the minds of some decision-makers and members of the public. The recently updated AR&R 2016 utilises different terminology whereby for the larger flood magnitudes the term AEP (%) is now preferred to ARI.

The relationship between ARI and AEP can be expressed by the following equation:

$AEP = 1 – exp (-1 / ARI)$

Substituting the "Actual ARI" into this equation results in the "Actual AEP" as indicated in the table below. However, it is quite common within the industry to see *AEP = 1 / ARI (nominal)* used for simplicity.

Actual ARI (years)	Nominal ARI (years)	Actual AEP (%)
1.44	2	50
4.48	5	20
10	10	10
20	20	5
50	50	2
100	100	1
200	200	0.5
500	500	0.2
2000	2000	0.05

For the purpose of this study, the "Actual AEP" has been used in conjunction with the "Nominal ARI." The flood probability will be firstly expressed by the "Nominal ARI" and then secondly in brackets by the equivalent "Actual AEP."

List of Abbreviations

Abbreviation	Definition
1d	One dimensional, in the context of hydraulic modelling
2d	Two dimensional, in the context of hydraulic modelling
AMTD	Adopted Middle Thread Distance
ALS	Airborne Laser Scanning
AR&R 1987	Australian Rainfall and Runoff (1987)
AR&R 2016	Australian Rainfall and Runoff (2016)
BCC	Brisbane City Council
CBD	Central Business District
CL	Continuing rainfall loss (mm/hr)
DEA AR&R 1987	Design Event Approach Australian Rainfall and Runoff (1987)
DEA AR&R 2016	Design Event Approach Australian Rainfall and Runoff (2016)
DTMR	Department of Transport and Main Roads (Queensland)
FPA	Flood Planning Area
ICC	Ipswich City Council
IFD	Intensity Frequency Duration
IL	Initial rainfall loss (mm)
IL_s	Initial loss for the rainfall event (mm)
IL_b	Initial loss for the rainfall burst (mm)
IWL	Initial Water Level (mAHD)
LCC	Logan City Council
mAHD	metres above AHD
MHG	Maximum Height Gauge
MRC	Minimum Riparian Corridor
MSQ	Maritime Safety Queensland
POT	Peak Over Threshold
RCBC	Reinforced Concrete Box Culvert
RCP	Reinforced Concrete Pipe
RCP4.5	Representative Concentration Pathway 4.5
RCP8.5	Representative Concentration Pathway 8.5
QUDM	Queensland Urban Drainage Manual (Draft 2013)

Abbreviation	Definition
WC	Waterway Corridor
WQA	Water Quantity Assessment

1.0 Introduction

1.1 Catchment Location

Wolston Creek Catchment is located approximately 19 km south-west of the Brisbane CBD and includes the suburbs of Springfield, Greenbank, Camira, Carole Park, Gailes, Ellen Grove, Richlands, Wacol and Sumner. The catchment has a total area of 44 km^2 and features three major creeks; namely Sandy Creek, Bullockhead Creek and Wolston Creek. The upper section of the catchment is located within both Ipswich City Council (ICC) and Logan City Council (LCC) areas. The middle and lower sections of the catchment are located within the Brisbane City Council (BCC) area. Figure 1.1 indicates the locality of the catchment as well as the local government boundaries.

1.2 Study Background

BCC is in the process of updating all of its flood studies to reflect the current catchment conditions and best practice flood modelling techniques. This flood study has been undertaken in accordance with the current BCC Flood Study Procedure document.[1]

The most recent flood studies undertaken by BCC are:

- Wolston Creek Water Quantity Assessment in 2000 [2]
- Wolston Creek Flood Study in 1996. [3]

For the purposes of this report these previous reports are termed the (i) 2000 WQA and (ii) 1996 Flood Study.

1.3 Study Objectives

The primary objectives of the project are as follows:

- Update the Wolston Creek flood models (hydrologic and hydraulic) to represent the current catchment conditions and best practice flood modelling techniques.
- Adequately calibrate and verify the flood models to historical storm events to confirm that the models are suitable for the purposes of simulating design flood events.
- Estimate design and rare / extreme flood magnitudes.
- Determine flood levels for the design and rare / extreme events, accounting for the effects of Minimum Riparian Corridor (MRC) and floodplain development / filling in accordance with current planning policy.
- Produce flood extent mapping for the selected range of design and rare / extreme events.
- Quantify the sensitivity of catchment flooding to climate variability.

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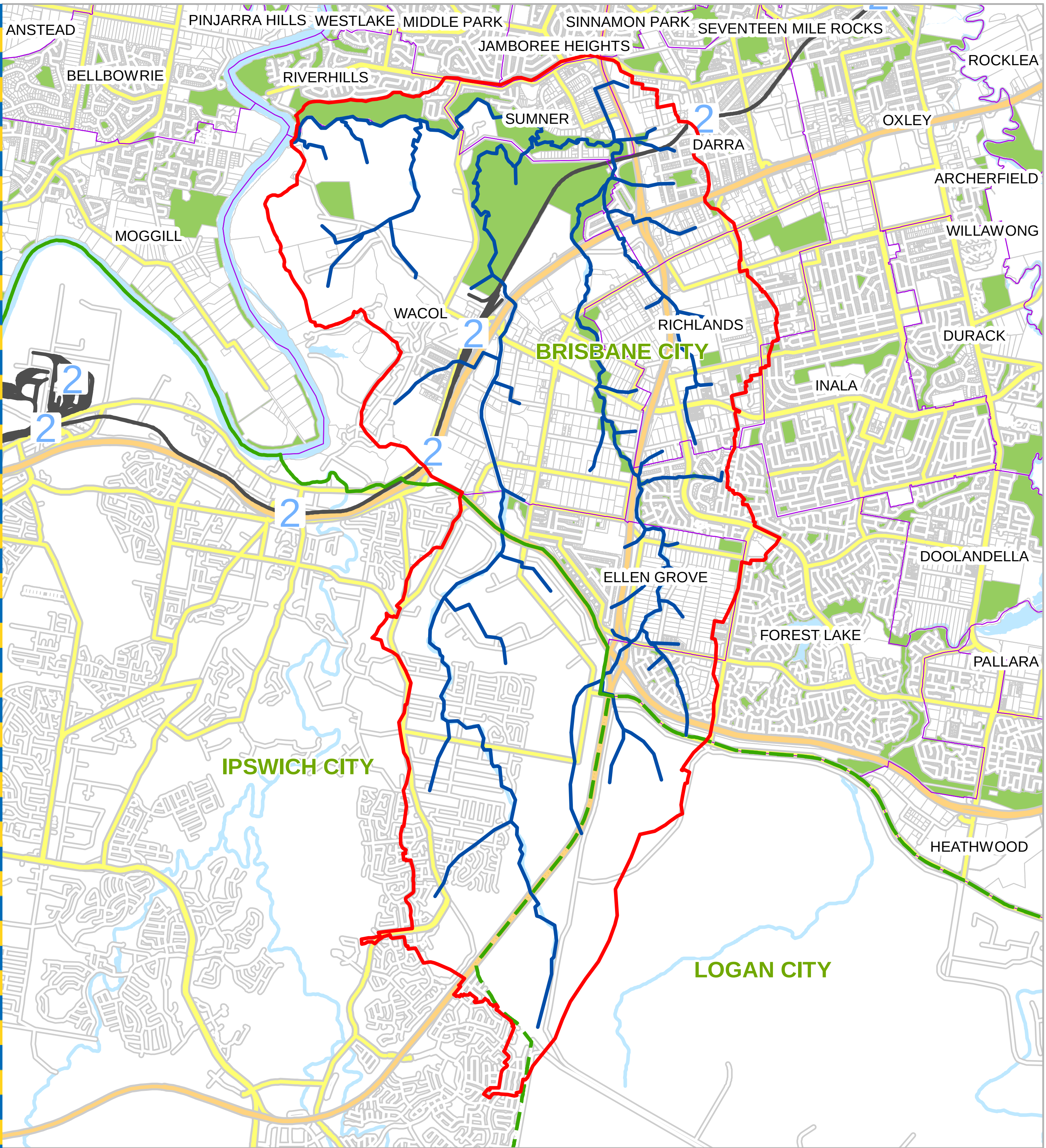
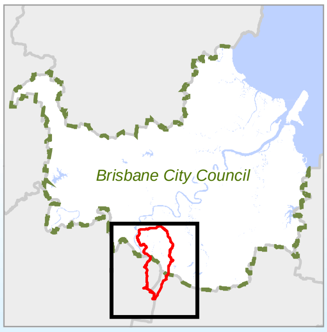
[1] Brisbane City Council 2017, *Creek Flood Study Procedure Document Version 8.0*

[2] Brisbane City Council Water and Environment September 2000, *Wolston Creek Water Quantity Assessment (Final Report)*

[3] Brisbane City Council Department of Works 1996, *Wolston Creek Flood Study*





Legend

2	Railway Station
	Railway Line
	Freeways/Highways
	Major Roads
	Streets
	Creek Centreline
	LGA Boundaries
	Park Boundaries
	Suburb Boundaries
	Property Holdings
	Waterways/ Waterbodies
	Catchment Area

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Wolston Creek Flood Study

Figure 1.1: Locality Plan

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1.4 Scope of the Study

The following tasks were undertaken to achieve the project objectives as outlined in Section 1.3:

- Develop an URBS hydrologic model of the catchment, superseding the previous URBS model.
- Develop a 1-dimensional (1d) / 2-dimensional (2d) TUFLOW hydraulic model of the creek system to replace the existing 1d RUBICON model.
- Calibrate the hydrologic and hydraulic models to the May 2015, January 2013 and May 2009 historical flood events.
- Verify the hydrologic and hydraulic models against the March 2017 historical flood event.
- Estimate the design, rare and extreme flood magnitudes for the full range of events from 2-yr ARI (50% AEP) to PMF.
- Simulate synthetic Australian Rainfall and Runoff (AR&R 2016) design storms for multiple ensembles and durations to determine the representative design flow at numerous locations within the catchment.
- Utilise the calibrated flood models to determine design flood levels for the design, rare and extreme events.
- Adjust the "Existing Condition" hydraulic model to simulate the impacts of MRC and filling outside the "Modelled Flood Corridor."
- Produce flood extent mapping for the selected range of design, rare and extreme events.
- Undertake climate variability modelling for the 100-yr ARI (1% AEP), 200-yr ARI (0.5% AEP) and 500-yr ARI (0.2% AEP) events to determine the potential changes to the flood behaviour within the catchment.

1.5 Study Limitations

In utilising the flood models it is important to be aware of their limitations which can be summarised as follows:

- The models have only been calibrated / verified at locations where Stream Gauge / MHG records exist. This should be taken into account when considering the accuracy of results outside the influence of the gauge locations. Refer to Figure 3.1 for the hydrometric gauge locations.
- These models are catchment scale and have been developed to simulate the flooding characteristics at a broad scale. As a result, smaller more localised flooding characteristics may not be apparent in the results.
- 2014 ALS data has been used to represent the hydraulic model floodplain topography. Detailed checks have not been undertaken on the accuracy of the ALS data, it is assumed that the data is representative of the topography and "fit for purpose."
- The accuracy of the model results is directly linked to the following:
  - The accuracy limits of the data used to develop the model (e.g. ALS, survey information, bridge data, etc).
  - The accuracy and quality of the hydrometric data used to calibrate / verify the models.
  - The number of observed records, including MHG locations throughout the catchment.

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2.0 Catchment Description

2.1 Catchment and Waterway Characteristics

2.1.1 General

Wolston Creek Catchment has an area of approximately 44 km^2 and comprises the following three major creeks:

- Sandy Creek: 19.6 km^2
- Bullockhead Creek: 18.5 km^2, and
- Wolston Creek: 5.9 km^2

The catchment drains into the Brisbane River, approximately 3.4 km upstream of the Centenary Motorway Bridge at Jindalee. Figure 2.1 indicates the major creeks and tributaries within the catchment.

2.1.2 Wolston Creek

Wolston Creek is located in the lower section of the catchment and commences at the confluence of Sandy Creek and Bullockhead Creek. The catchment area is only sparsely developed and the primary development is a number of correctional centres. The catchment is bounded by Mt. Ommaney Creek / Brisbane River (north); Brisbane River (west); Woogaroo Creek (south) and Sandy Creek (east). The catchment headwaters are along the southern boundary, where the highest ground elevation is approximately 75 mAHD. The catchment and main waterway are constrained by high ground to the north with elevations up to 50 mAHD.

Wolston Creek flows in a westerly direction over a length of approximately 4.3 km and discharges into the Brisbane River at a location where the creek channel is quite incised. The creek is in a relatively natural condition over its entire length with only one major waterway crossing at Wacol Station Road. The average bed slope of the creek over its entire 4.3 km length is approximately 0.14 %.

There are three main tributaries, which all drain in a northerly direction and join the main creek at separate locations along the length of the creek. The creek is subject to downstream hydraulic interaction from a number of sources including the Brisbane River and the ocean tidal cycle.

2.1.3 Sandy Creek

Sandy Creek is the largest waterway within the catchment with a length of approximately 14 km from the upstream extent to the confluence with Bullockhead Creek at Sumner. The catchment drains in a northerly direction and is very elongated with an average length to width ratio of approximately 10 to 1. The catchment is bounded by Bullockhead Creek / Oxley Creek (east) and Wolston Creek / Woogaroo Creek (west). The catchment headwaters are at Springfield Lakes where the highest ground elevation is approximately 95 mAHD.

Sandy Creek is an open waterway over its entire length and has been heavily modified by development for the majority of this length. Within the BCC area, the floodplain of the creek is considerably wider than the adjacent Bullockhead Creek. For the reach downstream of the

Logan Motorway (6.6 km length), the total floodplain is up to 1 km wide and for half of this length is occupied by industrial development which tightly bounds the main creek.

Within the BCC area are two major motorway crossings of Sandy Creek, namely the Logan Motorway and the Ipswich Motorway. The Logan Motorway crossing occurs at the boundary between Brisbane City Council and Ipswich City Council. The Ipswich Motorway crossing occurs approximately 290 m upstream of the Ipswich Railway crossing.

The average bed slope of the creek over its entire 14 km length is approximately 0.44 %, with the most upstream 1 km of creek having an average bed slope of approximately 1 %. Within the BCC area, the average bed slope is 0.29 %. The invert of the creek at the upstream extent within the BCC area is approximately 21.6 mAHD.

Within the BCC area, there is one tributary (Tributary 3) which drains land to the west of the Ipswich Motorway and joins Sandy Creek approximately 280 m upstream of Progress Road.

The lower section of the creek is subject to downstream hydraulic interaction from a number of sources including the Brisbane River and the ocean tidal cycle.

2.1.4 Bullockhead Creek

Bullockhead Creek is the second largest waterway within the catchment with a length of approximately 12 km from the upstream extent to the confluence with Sandy Creek at Sumner. The catchment drains in a northerly direction and is bounded by Oxley Creek (east) and Sandy Creek (west). The catchment headwaters are within Logan City Council upstream of the Centenary Motorway, where the highest ground elevation is approximately 92 mAHD.

Bullockhead Creek is an open waterway over its entire length and has been modified by development for the majority of this length. The creek is considerably more constrained with regard to the floodplain width when compared with Sandy Creek.

The creek flows through the Logan Motorway – Centenary Motorway Interchange and also crosses the Centenary Motorway (AMTD 5950 m); Ipswich Motorway (AMTD 2860 m) and both the Springfield and Ipswich Railways.

The average bed slope of the creek over its entire 12 km length is approximately 0.52 %, with the most upstream 1 km of creek having an average bed slope of approximately 1 %. Within the BCC area, the average bed slope is 0.38 %, which is slightly steeper than Sandy Creek. The invert of the creek at the upstream extent within the BCC area is approximately 37.1 mAHD.

Bullockhead Creek features a number of tributaries of which the largest is Ric Nattrass Creek; the smaller tributaries include Scott Creek and Spinks Creek. The catchment areas of these tributaries are as follows:

- Ric Nattrass Creek: 4.3 km^2
- Spinks Creek: 1.0 km^2
- Scott Creek: 0.4 km^2

2.1.5 Ric Nattrass Creek

Ric Nattrass Creek is the largest tributary of Bullockhead Creek with a length of approximately 3.8 km. The creek joins Bullockhead Creek approximately 320 m upstream of the Ipswich Railway at AMTD 1900 m. The catchment drains in a north-westerly direction and is bounded by Oxley Creek (east) and Bullockhead Creek (west). The catchment headwaters are located at Richlands, where the highest ground elevation is approximately 83 mAHD.

The creek is an open waterway for its entire length and is heavily modified with 17 hydraulic structures located along the creek. The creek crosses the Centenary Motorway (AMTD 1650 m); Ipswich Motorway (AMTD 600 m) and the Springfield Railway. Within the Coca Cola Amatil precinct (AMTD 1870 to 2490 m) the channel is concrete-lined and comprises a number of drop structures and pedestrian bridges.

The invert of the creek at the upstream extent of the open waterway is approximately 45.1 mAHD and the average slope of the creek is 1.1 %.

2.1.6 Scott Creek

Scott Creek is a small steep tributary of Bullockhead Creek with a length of approximately 0.9 km. The creek flows in a westerly direction and joins Bullockhead Creek just upstream of the Centenary Motorway. The catchment headwaters are located in Forest Lake, where the highest ground elevation is approximately 82 mAHD.

The creek is an open waterway for the majority of its length, apart from approximately 90 m of piped drainage that conveys flow underneath Forest Lake Boulevard. The average bed slope of the creek over its entire length is approximately 3.3 % and the upstream invert level is approximately 55.2 mAHD.

2.1.7 Spinks Creek

Spinks Creek is a small tributary of Bullockhead Creek that flows in a north-westerly direction largely between the Logan Motorway and Roxwell Street. The catchment headwaters are within the Logan City Council area (upstream of the Logan Motorway), where the highest ground elevation is approximately 73 mAHD.

The creek is approximately 1.5 km long and joins Bullockhead Creek approximately 300 m downstream of Roxwell Street at AMTD 8260 m. The creek is culverted underneath the Logan Motorway and flows through an online detention basin upstream of Woodvale Crescent. Downstream of the detention basin, the creek is an open waterway for its entire length. The average bed slope of the creek over its entire length is approximately 1.7 % and the upstream invert level is approximately 62 mAHD.

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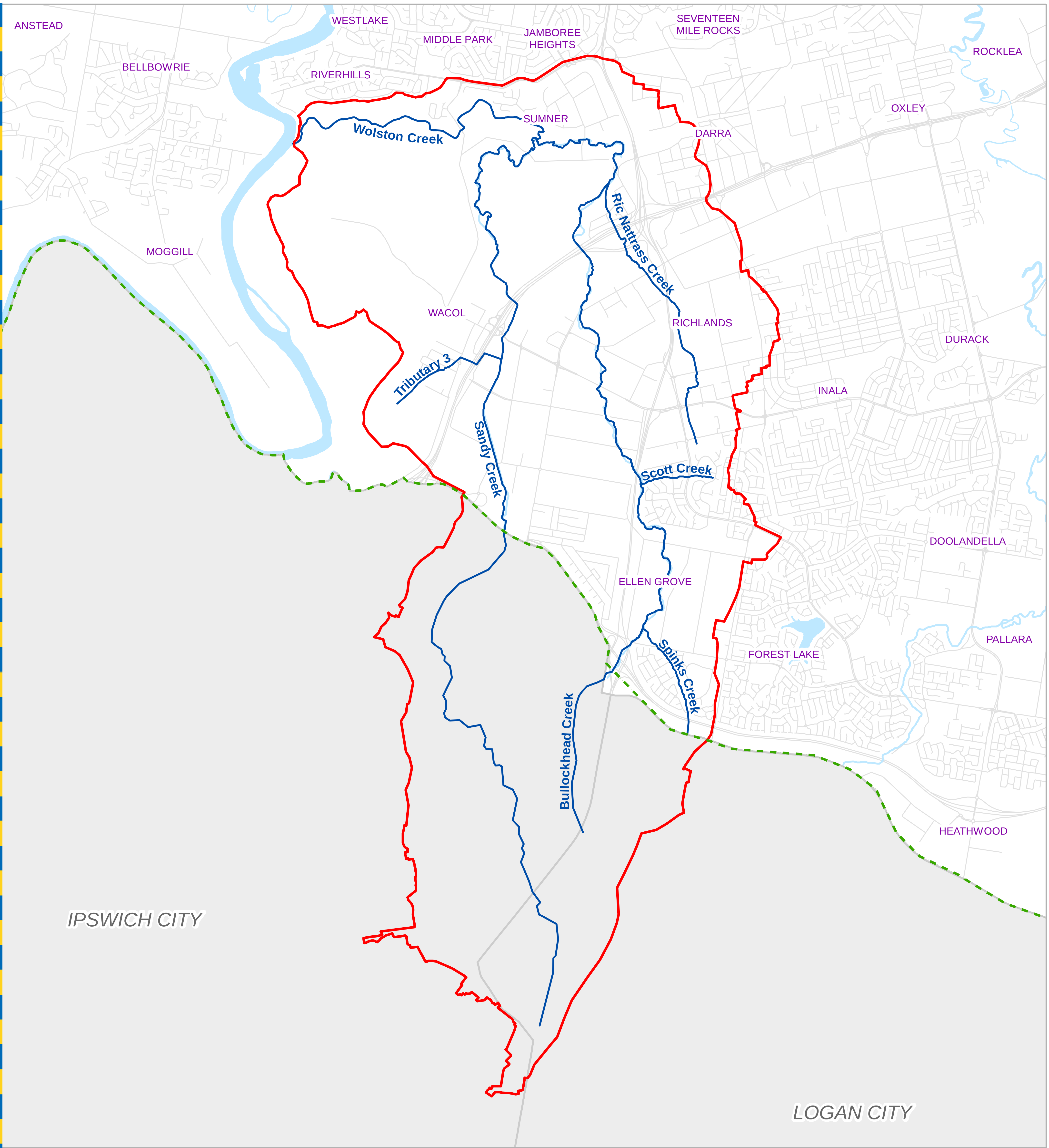

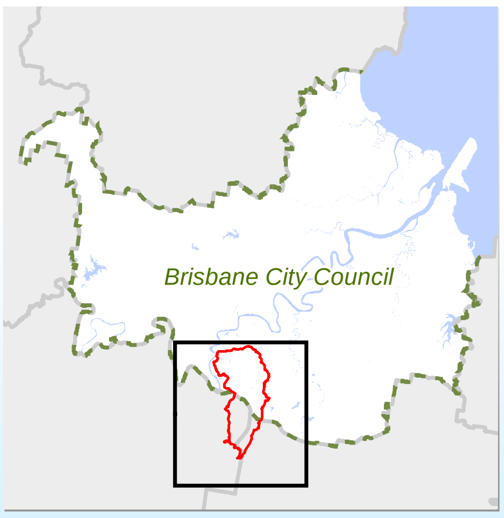

Legend

- Brisbane Boundary
- Waterway Centreline
- Streets
- Other LGA
- Catchment Boundary

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0 0.5 1 1.5 2
Kilometers

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Wolston Creek Flood Study

Figure 2.1: Major Creeks and Tributaries

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2.2 Land Use

Significant development exists throughout the catchment with the predominant land-use zoning being "Industry" / "Mixed Industry and Business", which occupies over 25 % of the catchment area. The next largest is "Environmental Management and Conservation" (14.5 %) and then "Low Density Residential" (12.3 %). Figure 2.2 provides a breakdown of the catchment land-use by percentage and Appendix C provides a map indicating the distribution of the land-use throughout the catchment. Both figures are based upon BCC City Plan 2014. [4]

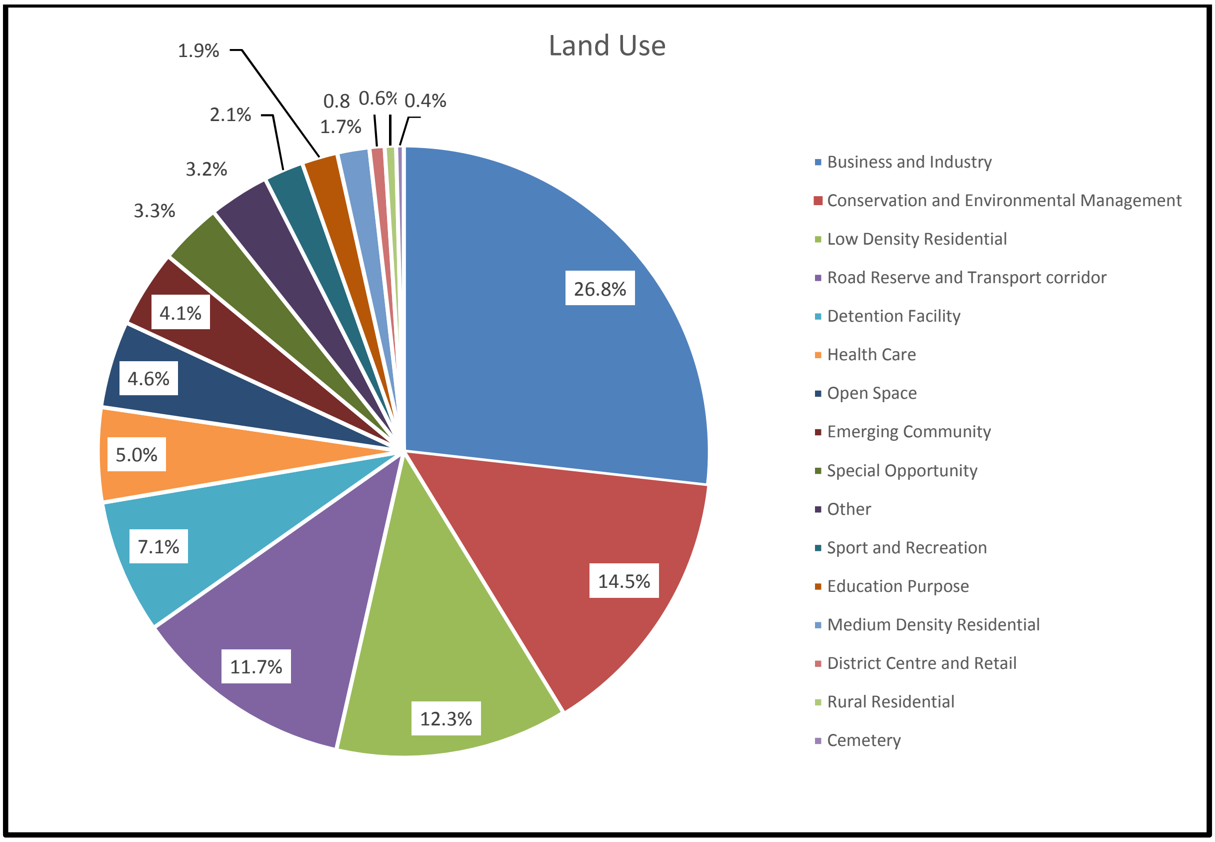


Figure 2.2: Wolston Creek Catchment Land-use

The "Environmental Management and Conservation" areas are primarily within the catchment headwaters upstream of Logan Motorway within the Logan City Council area. The majority of areas surrounded by the Ipswich Motorway, Wolston Road and Wacol Station Road are also zoned as "Environmental Management and Conservation".

The majority of the area downstream of Ipswich Motorway has been allocated to "Detention Facility", "Cemetery", "Major Health Care" and "Education and Research Facility".

[4] *Brisbane City Plan 2014*, Brisbane City Council

The "Emerging Community" zone is typically for land that would become urban development in the future. There are two significant areas zoned as "Emerging Community" within the catchment. One area is located in the upstream part of the catchment within the Ipswich City Council area and the other area is bounded by Centenary Highway, Roxwell Street and Woogaroo Street. The value of 4.1 % indicates that there is just over 1.8 km^2 of land remaining only in the catchment for the purpose of urban development.

3.0 Hydrometric Data and Storm Selection

3.1 Selection of Historical Storm Events

Table 3.1 indicates the more significant flooding events that have occurred within the catchment over the previous 39 years. This table includes the peak flood level in Bullockhead Creek at MHG BH150 (U/S Bukulla Street), the availability of MHG information, as well as the approximate size of the event at this location.

Table 3.1 – Historical Peak Levels on Bullockhead Creek

Event	Peak Flood Level (mAHD) MHG BH150	Number of MHGs and/or recorded levels	Approximate Size of Event
April 1978	19.15	4	< 2-yr ARI (50 % AEP)
May 1980	19.34	12	2-yr ARI (50 % AEP)
November 1981	18.48	5	< 2-yr ARI (50 % AEP)
June 1983	19.23	12	< 2-yr ARI (50 % AEP)
April 1988	19.04	8	< 2-yr ARI (50 % AEP)
July 1988	18.85	9	< 2-yr ARI (50 % AEP)
March 1992	19.58	7	2-yr ARI (50 % AEP) to 5-yr ARI (20 % AEP)
January 1996	18.84	6	< 2-yr ARI (50 % AEP)
May 1996	19.55	11	2-yr ARI (50 % AEP) to 5-yr ARI (20 % AEP)
February 1999	18.35	4	< 2-yr ARI (50 % AEP)
May 2009	19.56	12	2-yr ARI (50 % AEP) to 5-yr ARI (20 % AEP)
January 2013	-	7	Approx. 5-yr ARI (20 % AEP)
May 2015	19.69	12	5-yr ARI (20 % AEP)
March 2017	19.67	8	5-yr ARI (20 % AEP)

The table indicates that there has not been any substantial events within the catchment over the period of record. The most recent events appear to be the more significant and generally have the greatest number of recorded levels.

The selection of specific historical events for calibration and verification was based upon the criteria as listed below.

- Higher priority for those events with consistent rainfall throughout the catchment.
- Higher priority for events where the catchment / creek conditions are similar to the present.
- Higher priority for larger events.
- Higher priority for events that had the greatest number of MHGs in operation.

As well as these criteria, it was considered important to cover a wide range of flood magnitudes, if possible. On the basis of these selection criteria, the following events were selected for calibration and verification:

- Calibration
  - May 2015
  - January 2013
  - May 2009

- Verification
  - March 2017

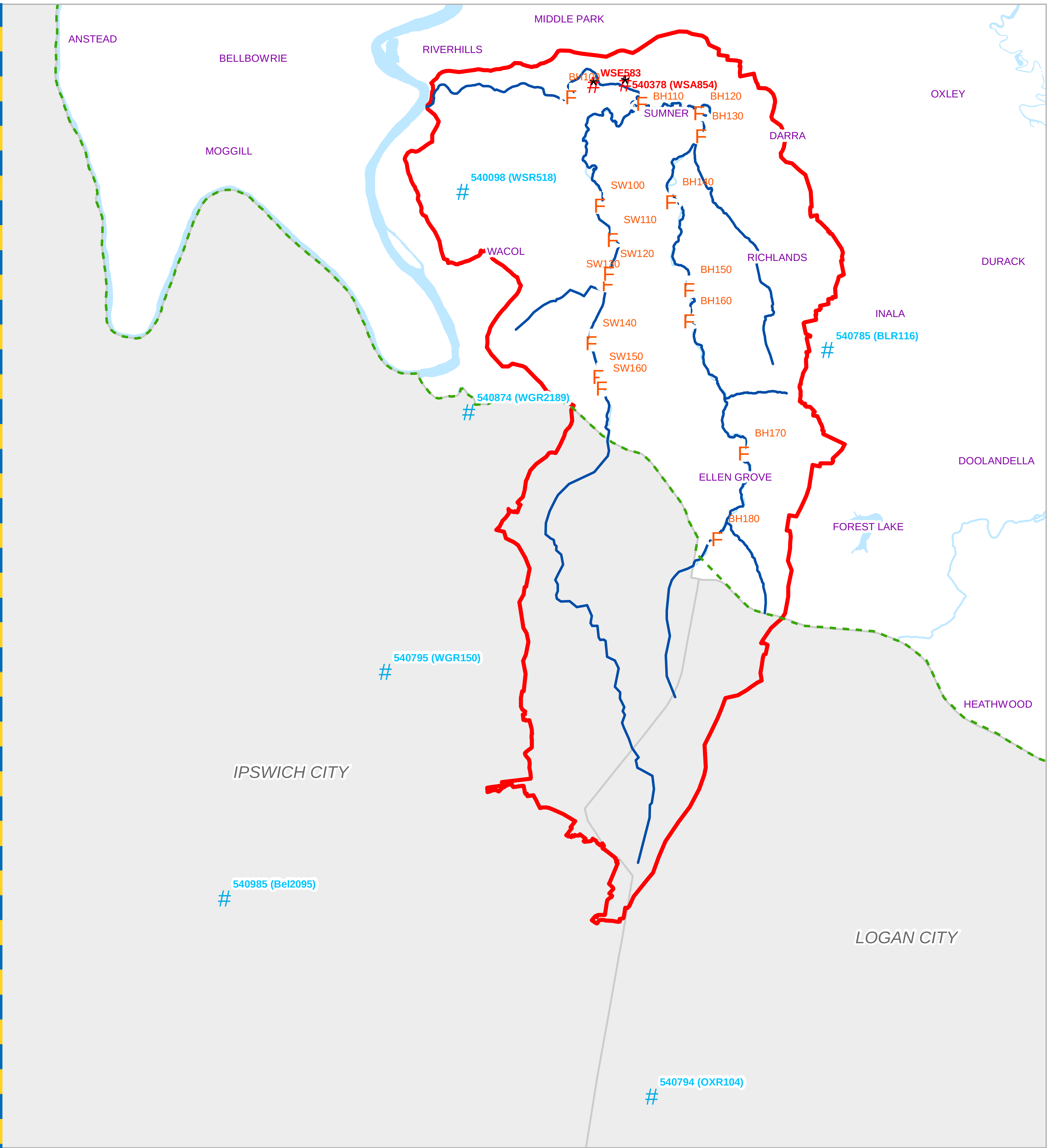
3.2 Availability of Historical Data for Selected Storms

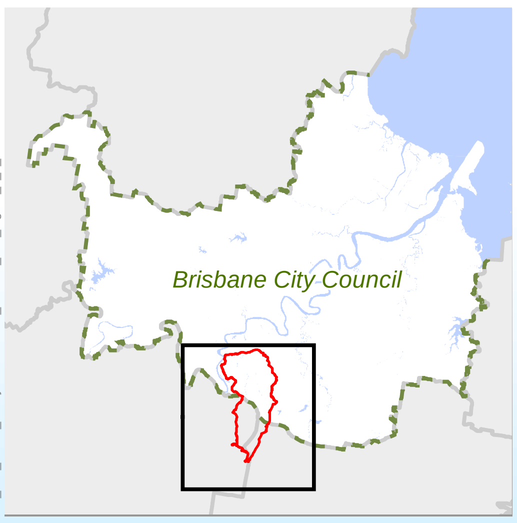
3.2.1 Continuous Recording Rainfall Stations

Six rainfall stations were utilised for the calibration and verification events. Figure 3.1 and Table 3.2 indicate the location and current status of each rainfall station.

Table 3.2 – Rainfall Station details

Gauge ID	Old BCC ID	Catchment	Location	Current Status
540098	WSR518	Wolston Creek	Wacol Sewerage Treatment Plant, Wacol	Open
540785	BLR116	Blunder Creek	Blunder Creek at Richlands	Open
540874	WGR2189	Woogaroo Creek	Brisbane Road Alert, Gailes	Open
540795	WGR150	Woogaroo Creek	Opossum Creek at Woogaroo Creek, Camira	Open
540985	Bel2095	Woogaroo Creek	Bellbird Park Alert, Augustine Heights	Open
540794	OXR104	Oxley Creek	Greenbank (Thompson Road) Alert	Open





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Kilometers

Legend

- F Maximum Height Gauges
- # Pluviograph Stations
- Continuous Recording Stream Gauges
- Creek Centreline
- Brisbane Boundary
- Catchment Boundary
- Other LGA

Brisbane City Council
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DATA INFORMATION

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Wolston Creek Flood Study

Figure 3.1: Catchment Map and Gauge Location

GIM - 180355 - 003

Table 3.3 indicates the availability of the rainfall station data for each of the selected storm events.

Table 3.3 – Rainfall Station data availability

Gauge ID	Old BCC ID	Location	Data Availability			
			March 2017	May 2015	January 2013	May 2009
540098	WSR518	Wacol Sewerage Treatment Plant, Wacol	✓	✓	✓	✓
540785	BLR116	Blunder Creek at Richlands	✓	✓	✓	✓
540874	WGR2189	Brisbane Road Alert, Gailes	✓	✓	✗	✗
540795	WGR150	Opossum Creek at Woogaroo Creek, Camira	✓	✗	✗	✓
540985	Bel2095	Bellbird Park Alert, Augustine Heights	✓	✓	✓	✓
540794	OXR104	Greenbank (Thompson Road) Alert	✓	✓	✓	✓

3.2.2 Continuous Recording Stream Gauges

Continuous recording stream height gauges collect instantaneous water level information over time. They are important for calibration purposes as they provide important information on the timing of the flood as well as the total shape and volume of the flood hydrograph.

For the Wolston Creek Catchment, there is one operational continuous recording stream gauge (540378 / WSA854), which commenced operation in May 2010. This gauge is located in Wolston Creek, approximately 500 m downstream of the Sandy Creek – Bullockhead Creek confluence.

Prior to May 2010, there was a stream gauge (WSE583) located approximately 400 m further downstream, which was in operation from 1978 to 2010. The 1996 Flood Study noted that this stream gauge was installed by the Queensland Water Resources Commission in 1978 and was taken over by BCC in October 1981. Approximately 87 % of the catchment area drains to the location of these stream gauges.

3.2.3 Maximum Height Gauges (MHGs)

Maximum Height Gauges (MHGs) record the maximum water level experienced in a flooding event at the gauge location. MHG data is manually read by BCC staff following the flooding event. However, if the gauge has malfunctioned during the event and there is a nearby debris mark, then the recorded water level is typically based on this debris level.

There are 14 currently operating MHGs within the total catchment area, of which two are located on Wolston Creek and six located on each of Sandy and Bullockhead Creeks. There are currently no MHGs located on Ric Nattrass Creek or the other minor tributaries.

Table 3.4 indicates the period of operation for the MHGs on Wolston, Sandy and Bullockhead Creeks.

Table 3.4 – Maximum Height Gauge period of record

Creek	Gauge ID	Location	Records From	Records To
Wolston	BH100	U/S Wacol Station Rd	1976	Present
	BH110	D/S of Sandy Creek / Bullockhead Creek Confluence	1978	Present
Bullockhead	BH120	Between Ipswich Railway and Spine Street	1976	Present
	BH130	U/S Sananandа Street	1977	Present
	BH140	Ipswich Motorway	1976	1992
	BH150	80 m U/S of Bukulla Street	1979	Present
	BH160	40 m U/S Progress Road	1977	Present
	BH170	U/S Waterford Road	1976	Present
	BH180	U/S of Roxwell Street	1976	Present
Sandy	SW100	Between Ipswich Railway and Wacol Station Road	1979	1999
	SW110	D/S Ipswich Motorway	1976	Present
	SW120	D/S Progress Road	1976	Present
	SW130	130 m U/S Progress Road	1976	Present
	SW140	300 m U/S Campbell Avenue	1976	Present
	SW150	100 m D/S Formation Street	1976	Present
	SW160	50 m U/S Formation Street	1976	Present

Table 3.5 indicates the availability of MHG data for each of the selected flooding events. The total number of MHGs available for each event is indicated below:

- March 2017 – 8 x MHGs
- May 2015 – 12 x MHGs
- January 2013 – 7 x MHGs
- May 2009 – 12 x MHGs

For the May 2015 event, three of the 12 records were from debris marks and for the May 2009 event, one record was from a debris mark.

Table 3.5 – Maximum Height Gauge data availability

Creek	Gauge ID	Data Availability			
		March 2017	May 2015	January 2013	May 2009
Wolston	BH100	✓	× (O/T)	✓	✓
	BH110	✓	✓	✓	✓
Bullockhead	BH120	✓	✓	✓	✓
	BH130	✓	×	✓	✓
	BH140	×	×	×	×
	BH150	✓	✓	×	✓
	BH160	×	✓ (d)	×	✓ (d)
	BH170	✓	✓	✓	✓
	BH180	×	✓ (d)	×	×
Sandy	SW100	×	×	×	×
	SW110	×	✓	✓	×
	SW120	×	✓	×	✓
	SW130	✓	✓	✓	✓
	SW140	×	✓ (d)	×	✓
	SW150	×	✓	×	✓
	SW160	✓	✓	×	✓

(O/T) MHG Overtopped

(d) Reading from debris mark

3.2.4 Brisbane River Stream Gauges

Brisbane River stream gauges are used to generate downstream boundary conditions for the hydraulic model in the calibration and verification events.

Table 3.6 indicates the details of the nearest upstream and downstream gauges to the mouth of Wolston Creek; Brisbane River AMTD 59.35 km. There are two stream gauges located at Jindalee upstream of the mouth of Moggill Creek on opposing banks of the Brisbane River. The Seqwater owned gauge (540192) has recorded data from November 1994, whereas the BCC gauge (540682) was installed more recently in May 2014 for redundancy purposes. The Seqwater stream gauge was used in preference to the BCC gauge due to its longer period of operation.

Table 3.6 – Nearest Brisbane River Stream Gauges

Gauge ID	Old BCC ID	Owner	BNE AMTD (km)	Location	Current Status
540274	OXA588	BCC	38.7	Mouth of Oxley Creek	Open
540192	BNA731	Seqwater	52.1	Jindalee	Open
540682	BNA765	BCC	52.2	Mount Ommaney Drive, Jindalee	Open
540201	BNA764	BCC	69.2	Aitcheson Street (East), Moggill	Open
540200	BNA755	BOM / Seqwater	72.2	Moggill	Open
540812	BNE009	BOM / Seqwater	72.2	Moggill	Open

Table 3.7 indicates the availability of stream gauge data for the four calibration / verification events. For three out of four events there was both upstream and downstream stream gauge data; however for the May 2009 event there was only downstream stream gauge information available; refer to Section 5.3.7 for further details on the adoption of downstream boundary conditions.

Table 3.7 – Brisbane River Stream Gauge data availability

Gauge ID	Old BCC ID	Data Availability			
		March 2017	May 2015	January 2013	May 2009
540274	OXA588	✓	✓	✓	✓
540192	BNA731	✓	✓	✓	×
540682	BNA765	✓	✓	✓	×
540201	BNA764	✓	✓	×	×
540200	BNA755	✓	✓	✓	×
540812	BNE009	✓	✓	✓	×

3.3 Characteristics of Historical Events

3.3.1 March 2017 event

This event was a relatively small flooding event which produced a flood level of 6.42 mAHD at the stream gauge on Wolston Creek, approximately 500 m downstream of the confluence of Sandy Creek and Bullockhead Creek. Minor flooding occurred in the middle and lower reaches of the creek.

Rainfall fell for approximately 22 hours from around midnight on the 29th March till 10 pm on the 30th March. The total event rainfall varied quite considerably across the region, with approximately 200 mm at Wacol Sewerage Treat Plant (540098 – WSR518) to 300 mm at Richlands (540785 – BLR116).

The most prolonged burst occurred over six hours between 5 am and 11 am, where up to 165 mm of rainfall was recorded. A second shorter more intense burst occurred between 6pm and 8pm, which resulted in a double peaked hydrograph being recorded at the stream gauge in Wolston Creek. The cumulative rainfall for each rainfall station is presented in Appendix A.

Table 3.8 indicates the 4-day and 14-day antecedent rainfall as well as statistics on the event rainfall at the five rainfall stations. The catchment experienced from 1 to 20 mm of rainfall in the 4-day lead up to the event and from 90 to 136 mm in the preceding 14 days, meaning that the soil is likely to have been wet, but not saturated when the event occurred.

Table 3.8 - Rainfall characteristics (March 2017 event)

Gauge ID	Old BCC ID	Location	Antecedent Rainfall (mm)		Event Rainfall (mm)	
			14-day	4-day	Peak 1hr burst	Peak 6hr burst
540098	WSR518	Wacol Sewerage Treatment Plant, Wacol	136	3	38	69
540785	BLR116	Blunder Creek at Richlands	126	7	65	165
540874	WGR2189	Brisbane Road Alert, Gailes	106	1	38	90
540795	WGR150	Opossum Creek at Woogaroo Creek, Camira	116	2	42	105
540794	OXR104	Greenbank (Thompson Road) Alert	90	20	40	108

Figure 3.2 provides a comparison of the IFD curve for the five rainfall stations against the AR&R 2016 IFD curve generated at the catchment centroid. The equivalent design rainfall ARI at Rainfall Station 540098 (WSR518) at the Wacol Sewerage Treatment Plant would have been as follows:

- 1-hour rainfall: 2-yr ARI (50 % AEP)
- 2-hour rainfall: 2-yr ARI (50 % AEP)
- 3-hour rainfall: 2-yr ARI (50 % AEP)
- 6-hour rainfall: 2-yr ARI (50 % AEP) to 5-yr ARI (20 % AEP)

It should be noted however that 540098 (WSR518) at the Wacol Sewerage Treatment Plant recorded the lowest rainfall of the five rainfall gauges; meaning that the average rainfall ARI (AEP) across the catchment is likely to be higher than the values presented above.

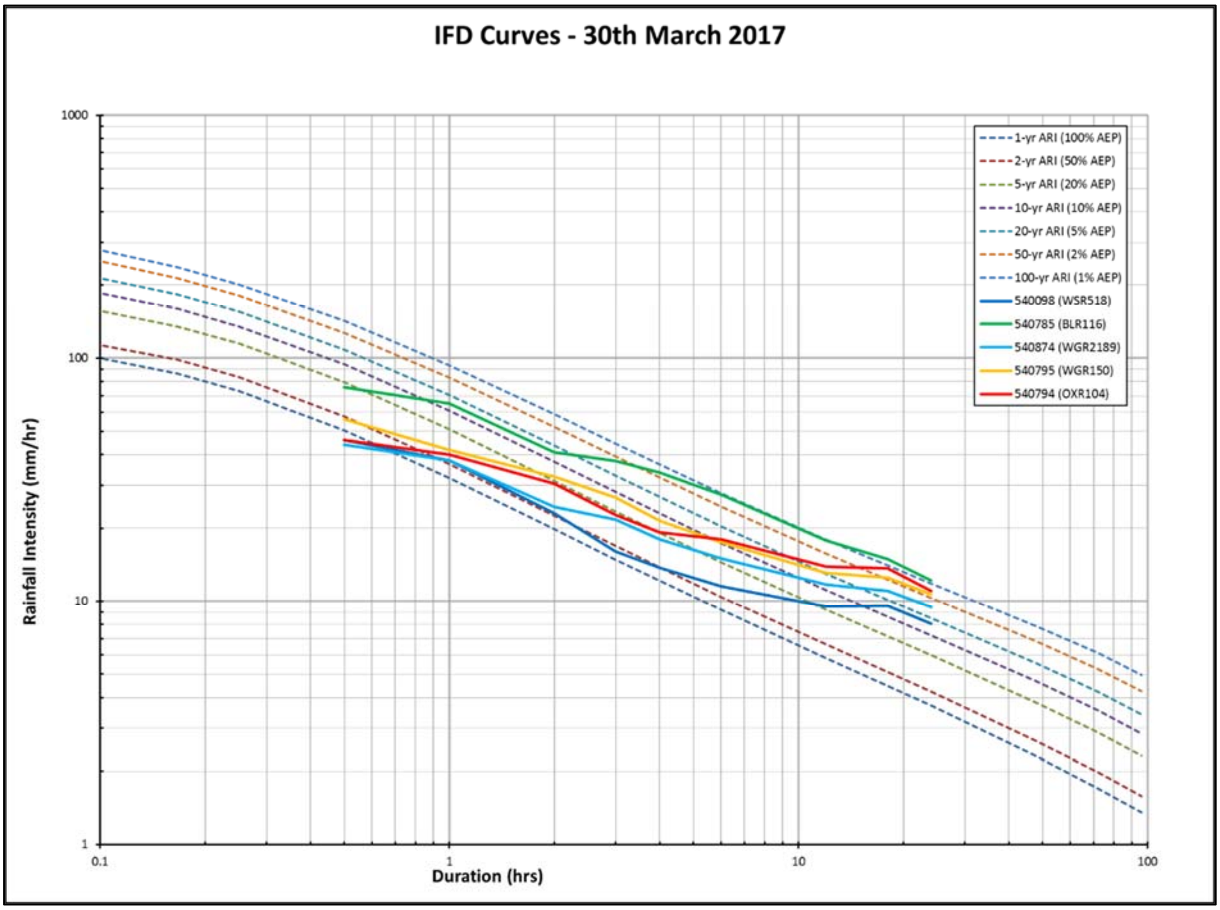

Figure 3.2: IFD Curve for March 2017 event.

3.3.2 May 2015 event

This event was a relatively small flooding event which produced a flood level of 7.04 mAHD at the stream gauge on Wolston Creek, approximately 500 m downstream of the confluence of Sandy Creek and Bullockhead Creek. Minor flooding occurred in the middle and lower reaches of the creek.

The total event rainfall was relatively consistent over the entire catchment with between 160 and 180 mm being recorded in 24 hours on the 1st May. The most intense burst occurred over six hours between 1:30 pm and 7:30 pm on the 1st May, where up to 138 mm of rainfall was recorded. The cumulative rainfall for each rainfall station is presented in Appendix A.

Table 3.9 indicates the 4-day and 14-day antecedent rainfall as well as statistics on the event rainfall at the five rainfall stations. The catchment experienced up to 24 mm of rainfall in the 4-day lead up to the event and from 24 to 44 mm in the preceding 14 days, meaning that the soil is unlikely to have been saturated when the event occurred.

Table 3.9 - Rainfall characteristics (May 2015 event)

Gauge ID	Old BCC ID	Location	Antecedent Rainfall (mm)		Event Rainfall (mm)	
			14-day	4-day	Peak 1hr burst	Peak 6hr burst
540098	WSR518	Wacol Sewerage Treatment Plant, Wacol	35	21	35	119
540785	BLR116	Blunder Creek at Richlands	37	24	38	138
540874	WGR2189	Brisbane Road Alert, Gailes	44	20	36	117
540985	Bel2095	Bellbird Park Alert, Augustine Heights	24	0	33	85
540794	OXR104	Greenbank (Thompson Road) Alert	41	18	38	131

Figure 3.3 provides a comparison of the IFD curve for the five rainfall stations against the AR&R 2016 IFD curve generated at the catchment centroid.

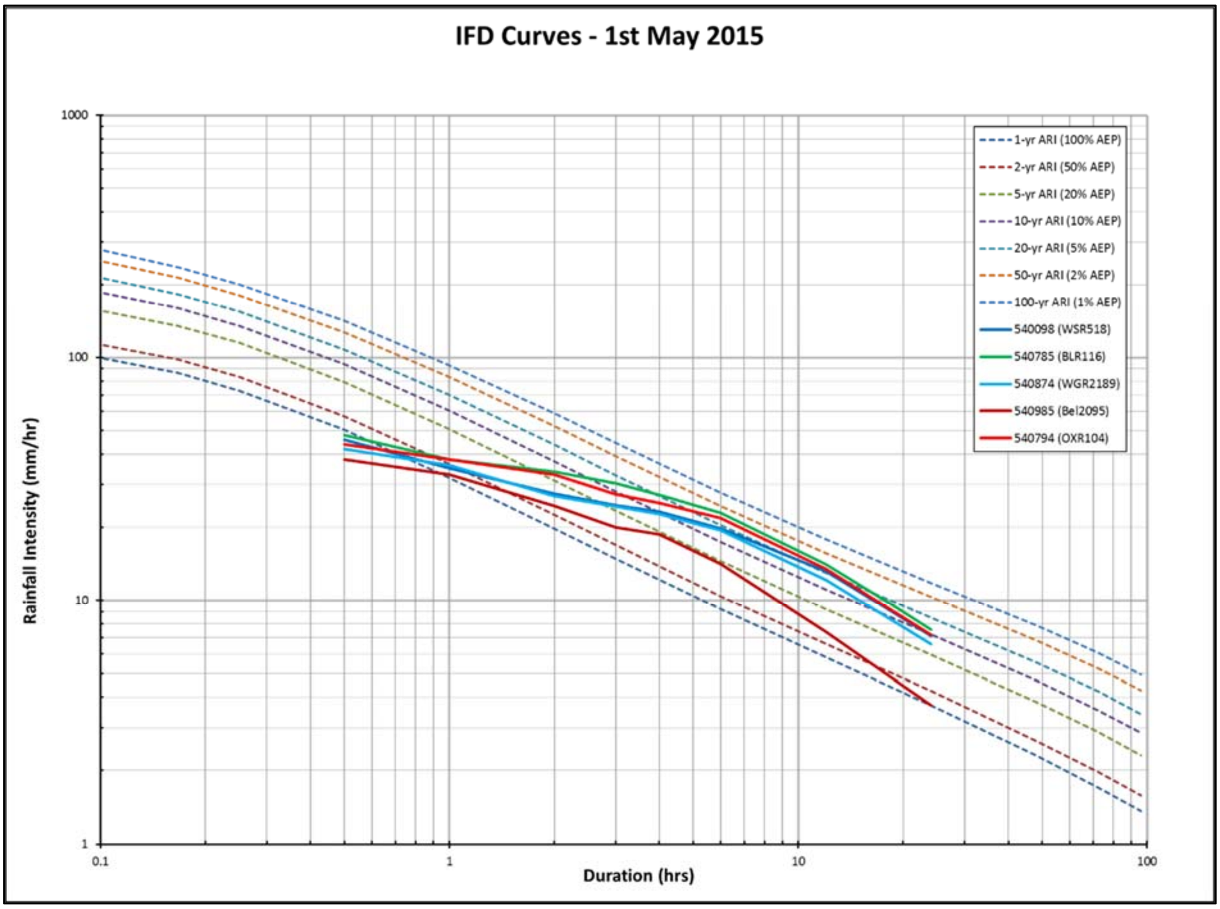

Figure 3.3: IFD Curve for May 2015 event.

The equivalent design rainfall ARI at Rainfall Station 540098 (WSR518) at the Wacol Sewerage Treatment Plant would have been as follows:

- 1-hour rainfall: 2-yr ARI (50 % AEP)
- 2-hour rainfall: 2-yr ARI (50 % AEP) to 5-yr ARI (20 % AEP)
- 3-hour rainfall: 5-yr ARI (20 % AEP)
- 6-hour rainfall: 10-yr ARI (10 % AEP)

3.3.3 January 2013 event

This event was a relatively small flooding event which produced a flood level of 6.54 mAHD at the stream gauge on Wolston Creek, approximately 500 m downstream of the confluence of Sandy Creek and Bullockhead Creek. Minor flooding occurred in the middle and lower reaches of the creek.

The predominant rainfall fell from around 6 pm on the 26th January to 8 am on the 28th January. The most intense burst occurred on the 27th January over a 10 hour period between 10 am and 8 pm, where from 170 mm to 220 mm of rainfall fell across the catchment. The event was slightly more intense in the upper sections of the catchment with Rain Gauge 540794 (OXR104) at Greenbank recording the most intense bursts. The cumulative rainfall for each rainfall station is presented in Appendix A.

Table 3.10 indicates the 4-day and 14-day antecedent rainfall as well as statistics on the event rainfall at the four rainfall stations. The catchment experienced between 72 and 99 mm of rainfall in the 4-day lead up to the event and between 84 and 110 mm in the preceding 14 days, meaning that the soil would have been quite saturated due to the rainfall in the days prior to the main storm event.

Table 3.10 - Rainfall characteristics (January 2013 event)

Gauge ID	Old BCC ID	Location	Antecedent Rainfall (mm)		Event Rainfall (mm)	
			14-day	4-day	Peak 1hr burst	Peak 6hr burst
540098	WSR518	Wacol Sewerage Treatment Plant, Wacol	96	93	28	96
540785	BLR116	Blunder Creek at Richlands	84	72	37	114
540985	Bel2095	Bellbird Park Alert, Augustine Heights	96	78	41	111
540794	OXR104	Greenbank (Thompson Road) Alert	110	99	31	116

Figure 3.4 provides a comparison of the IFD curve for the four rainfall stations against the AR&R 2016 IFD curve generated at the catchment centroid. The equivalent design rainfall ARI at Rainfall Station 540098 (WSR518) at the Wacol Sewerage Treatment Plant would have been as follows:

- 1-hour rainfall: Less than 2-yr ARI (50 % AEP)
- 2-hour rainfall: 2-yr ARI (50 % AEP)
- 3-hour rainfall: 2-yr ARI (50 % AEP) to 5-yr ARI (20 % AEP)
- 6-hour rainfall: 5-yr ARI (20 % AEP) to 10-yr ARI (10 % AEP)

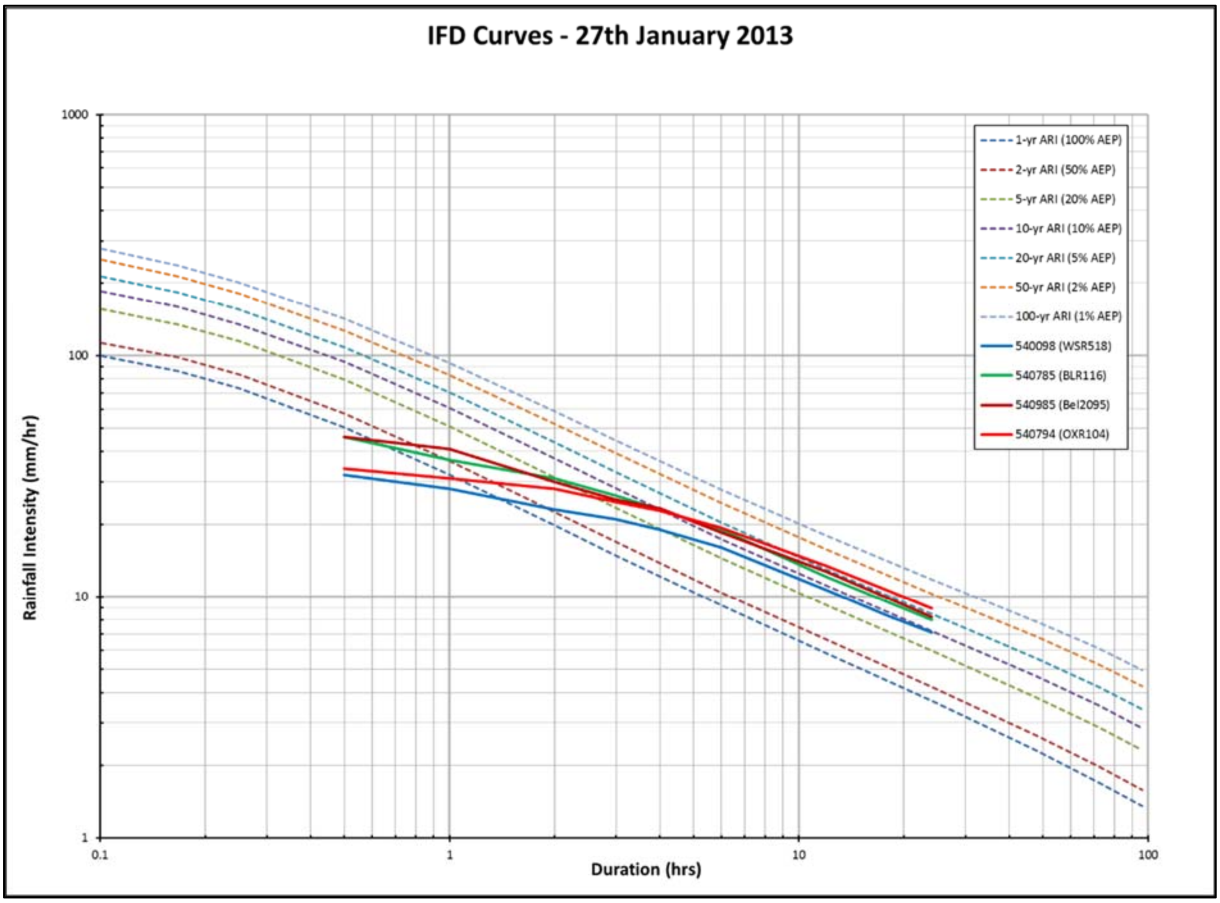

Figure 3.4: IFD Curve for January 2013 event.

3.3.4 May 2009 Event

This event was a minor flooding event and of similar magnitude to the other selected historical events. This event produced a flood level of 6.31 mAHD at the stream gauge (since closed) on Wolston Creek, approximately 900 m downstream of the confluence of Sandy Creek and Bullockhead Creek. Minor flooding occurred in the middle and lower reaches of the creek.

Rainfall fell over a 24 hour period from late on the night of the 19th May till late on the night of the 20th May. There was considerable variation in the depth of rainfall across the catchment with between 190 mm and 305 mm falling within this 24 hour period. The predominant rainfall fell over a 14 hour period starting at approximately 7 am on the 20th May and was characterised by two intense bursts of rainfall. The first burst occurred between approximately 1 pm and 3 pm, where up to 66 mm of rainfall fell across the catchment. The second burst occurred between approximately 7 pm and 9 pm, with up to 70 mm of rainfall falling across the catchment. These two distinct bursts were responsible for the double peaked hydrograph, which is apparent from the stream gauge records on Wolston Creek.

Table 3.11 indicates the 4-day and 14-day antecedent rainfall as well as statistics on the event rainfall at the five rainfall stations. The catchment experienced between 3 and 11 mm of rainfall in the 14-day lead up to the event with practically all occurring within the 4 days prior. Therefore, it is likely that the soil would not have been saturated prior to the main storm event.

Table 3.11 - Rainfall characteristics (May 2009 event)

Gauge ID	Old BCC ID	Location	Antecedent Rainfall (mm)		Event Rainfall (mm)	
			14-day	4-day	Peak 1hr burst	Peak 6hr burst
540098	WSR518	Wacol Sewerage Treatment Plant, Wacol	8	7	59	124
540785	BLR116	Blunder Creek at Richlands	3	3	29	71
540795	WGR150	Opossum Creek at Woogaroo Creek, Camira	8	3	40	91
540985	Bel2095	Bellbird Park Alert, Augustine Heights	11	6	50	112
540794	OXR104	Greenbank (Thompson Road) Alert	11	8	28	75

Figure 3.5 provides a comparison of the IFD curve for the five rainfall stations against the AR&R 2016 IFD curve generated at the catchment centroid. The equivalent design rainfall ARI at Rainfall Station 540098 (WSR518) at the Wacol Sewerage Treatment Plant would have been as follows:

- 1-hour rainfall: 10-yr ARI (10 % AEP)
- 2-hour rainfall: 10-yr ARI (10 % AEP)
- 3-hour rainfall: 20-yr ARI (5 % AEP)
- 6-hour rainfall: 20-yr ARI (5 % AEP)

It should be noted however that 540098 (WSR518) at the Wacol Sewerage Treatment Plant recorded the highest rainfall of the five rainfall gauges; meaning that the average rainfall ARI (AEP) across the catchment is likely to be lower than the values presented above.

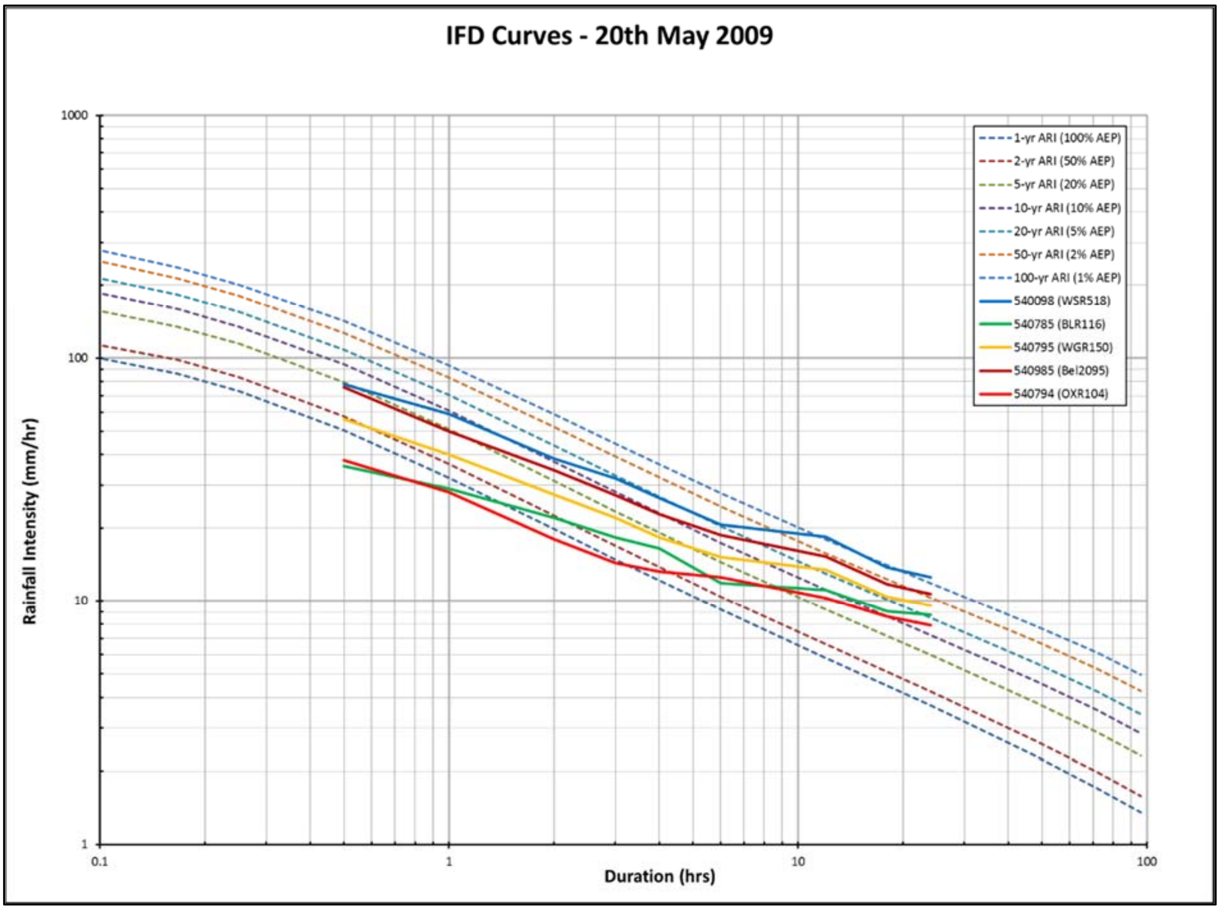

Figure 3.5: IFD Curve for May 2009 event.

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4.0 Hydrologic Model Development and Calibration

4.1 Overview

The hydrologic model simulates the rainfall-runoff-routing process within the catchment. Hydrologic modelling for this study was performed using the URBS (version 6.34) software. URBS allows the effects of development / urbanisation to be assessed, which makes it suitable for largely urbanised catchments such as Wolston Creek. URBS also provides the option of modelling the sub-catchment and channel routing separately by selecting the “Split” modelling approach. This approach allows better compatibility with the hydraulic model, as the channel routing component can be matched to the hydraulic model, while varying the sub-catchment routing parameters to achieve calibration to recorded events.

An URBS model was previously developed for the Wolston Creek Catchment as part of the 1996 Flood Study. This model was developed to be used in conjunction with the previous RUBICON hydraulic model; which only modelled the main creeks and not the tributaries. As this current study involves the hydraulic modelling of considerably more tributaries, the previous URBS model was considered unsuitable, which necessitated the development of a new URBS model.

Sub-catchment routing using the “Split” modelling approach is undertaken by routing through a non-linear reservoir, of which the storage-discharge relationship is based upon the following equation:

$$S_{catch} = \{\beta \sqrt{A}(1 + F)^2 / (1 + U)^2\}Q^m$$

where:

S_{catch} = catchment storage
β = catchment lag parameter
A = area of sub-catchment
U = fraction urbanisation of sub-catchment
F = fraction of sub-catchment forested
m = catchment non-linearity parameter
Q = outflow

Routing of all major open waterways and tributaries utilised the Muskingum methodology, which is based on the following equation:

$$S_{chnl} = \alpha f(\mathrm{n}L / \sqrt{S_c})(xQ_u + (1 - x)Q_d)^n$$

where:

S_{chnl} = channel storage
α = channel lag parameter
f = reach length factor
L = length of reach
S_c = slope of reach
Q_u = inflow at upstream end of the reach
Q_d = inflow at downstream end of the reach
x = Muskingum translation parameter
n = Muskingum non-linearity parameter
n = Manning’s ‘n’ or channel roughness

For further details on this modelling approach refer to the URBS User Manual.[5]

4.2 URBS Sub-catchment Data

4.2.1 General

This section describes the sub-catchment information used in the URBS model. URBS allows the user to define the sub-catchment with differing levels of detail depending on the type of catchment and requirements for the study.

For this study the following parameters were utilised:

Area:	Sub-catchment area (mandatory)
UL:	Urban Low Density Index
UM:	Urban Medium Density Index
UH:	Urban High Density Index
UR:	Urban Rural Index
I:	Impervious Fraction

The adopted sub-catchment parameters for the calibration and verification events are presented in Appendix B. The same sub-catchment parameters have been used for all events due to the relatively recent age of the calibration and verification events and the minimal changes in catchment / channel topography and development during this period.

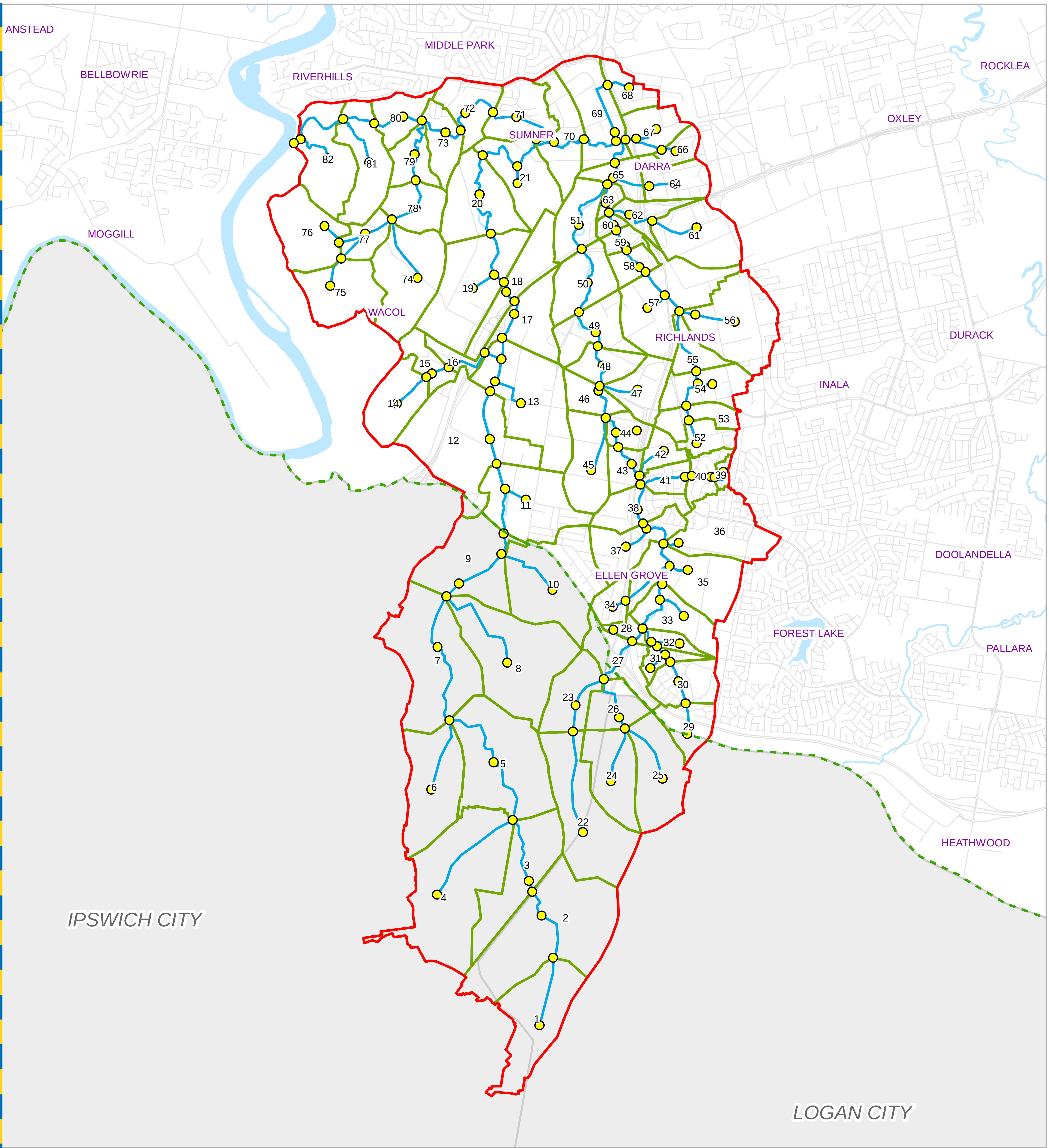
4.2.2 Sub-catchment Delineation

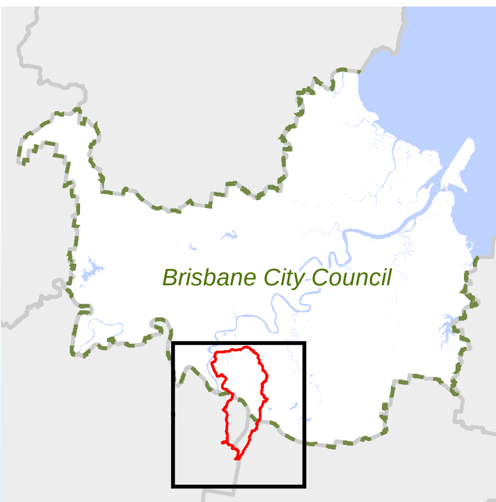
The URBS model was divided into 82 sub-catchments as indicated in Figure 4.1. Based on a total catchment area of 44 km^2, the average sub-catchment size was 0.54 km^2. The sub-catchment delineation was based upon the 2014 ALS contours and considered the location of major tributaries, hydrometric gauges, stormwater drainage as well as man-made boundaries such as motorways and railways.

4.2.3 Land-use and Impervious Area

The effect of development / urbanisation is modelled in URBS using an Urbanisation Index (U) and Impervious Fraction (I). The Urbanisation Index (U) is used to determine the decrease in catchment lag and the Impervious Fraction (I) is used to determine the increase in runoff volume as a result of development. The Urbanisation Index (U) for each sub-catchment is determined with respect to the urbanisation indices; namely UL, UM, UH and UR for this study. These represent the fraction of the sub-catchment area occupied by that specific URBS urbanisation category. For example, a value of UL = 0.1 equates to 10 % of the sub-catchment area being occupied by the Urban Low Density (UL) urbanisation category.

[5] *URBS A Rainfall Runoff Routing Model for Flood Forecasting and Design Version 6.00*, DG Carroll 2016





Legend

- URBS Nodes
- URBS Links/Routes
- Streets
- Brisbane Boundary
- Catchment Area
- URBS Subcatchments (1 - 82)
- Other LGA

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0 0.5 1 1.5 2
Kilometers

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DATA INFORMATION

Prepared :	104515
Checked :	JS
Revision :	1
Publication Date :	07 Jun 2018
Project Number :	180355

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Wolston Creek Flood Study

Figure 4.1: URBS Model Schematisation

GIM - 180355 - 004

To determine the value of UL, UM, UH and UR for each sub-catchment it was firstly required to adopt impervious fractions for each and secondly determine the total impervious area.

Impervious Fractions
The urbanisation indices were assigned the following impervious fractions: UL (0.15), UM (0.5), UH (0.9) and UR (0.0 - default). The threshold Urban Impervious Fraction (UI) was assigned the default value of 0.5.

Total Impervious Area
Using the catchment land-use maps from BCC City Plan 2014 and the adopted land-use percentage impervious (refer Appendix C); the total impervious area for the sub-catchment was able to be determined. The impervious fraction for the road reserve was assigned on a sub-catchment to sub-catchment basis to reflect the actual conditions. From this, the Impervious Fraction (I) for each sub-catchment was able to be determined.

Once the Impervious Fractions were assigned and the Total Impervious Area determined the following process was used to assign values to the urbanisation indices (UL, UM, UH and UR):

(i) Each BCC City Plan 2014 land-use category within the catchment was assigned to the most appropriate urbanisation index (UL, UM, UH or UR) and the respective area of each determined.
(ii) The impervious area for each sub-catchment was calculated using the adopted fraction impervious for each urbanisation index.
(iii) This calculated impervious area was compared to the total impervious area for each sub-catchment.
(iv) The values of the urbanisation indices were adjusted (as required) so that this calculated impervious area matched the total impervious area for each sub-catchment.

4.3 URBS Channel Data

URBS allows the user to define the channel with differing levels of detail depending on the type of catchment and requirements for the study. For this study the following parameters were utilised:

L: Channel length (mandatory)
Sc: Channel slope

The channel length was determined using GIS software and the channel slope from channel survey or 2014 ALS (at locations where channel survey was not available).

4.4 Event Rainfall

4.4.1 Observed Rainfall

Recorded rainfall data from each calibration and verification event was incorporated into the URBS model at five minute intervals, noting that the rainfall gauge only records information when 1 mm or more of rain has fallen.

Thiessen Polygons were utilised for each event to enable the gauged rainfall to be apportioned to each of the sub-catchments in the URBS model. Those sub-catchments which fell totally within a polygon were fully assigned to the respective rainfall station. Those sub-catchments which bridged across two or more polygons were generally apportioned a weighted average of the total rainfall depth based on the respective rainfall gauges. The Thiessen Polygon distributions for the four events are presented in Appendix A for reference.

4.4.2 Rainfall Losses

The Initial Loss (IL) and Continuing Loss (CL) methodology was used to simulate the rainfall losses. For impervious areas, the URBS model assumes by default that there is no initial loss and 100 % runoff. Therefore, rainfall losses are only subtracted from the pervious portion of the sub-catchment.

The IL (mm) is known to be the amount of rainfall that occurs before the start of surface runoff. The initial loss comprises factors such as interception storage (e.g. tree leaves); depression storage (e.g. ditches, surface puddles, etc.) and the initial infiltration capacity of the soil, whereby a dry soil has a larger capacity than a saturated soil.

The CL (mm/hr) is assumed to be the average loss rate throughout the remainder of the rainfall event and is predominantly dependant on the underlying soil type and porosity.

4.5 Stream Gauge Rating Curve

In order to undertake the hydrological calibration, the following stream gauges were utilised:

- 540378 (WSA854) - Wolston Creek at AMTD 3750 m
- WSE583 - Wolston Creek at AMTD 3375 m

As noted previously, Stream Gauge WSE583 was only in place for the May 2009 event. Stream Gauge 540378 (WSA584) subsequently replaced this gauge and was in place for the remainder of the calibration / verification events.

To convert gauged water levels into discharge, it was necessary to utilise a rating curve at the two stream gauge locations. BCC Hydrometrics does not keep records of rating curves for stream gauges, therefore, it was required to generate a rating curve at each location using the TUFLOW hydraulic model. For further discussions on the TUFLOW model refer to Section 5.

The location of both stream gauges is subject to backwater effects from the Brisbane River in minor river flooding events. These backwater effects have the potential to impact the rating curves, depending on the flood level in the Brisbane River and flow in Wolston Creek. In order to understand whether the peak flood level for the selected historical events was backwater affected by the

Brisbane River flood level, some testing with the TUFLOW hydraulic model was undertaken. Simulations with the TUFLOW model were undertaken using Brisbane River flood levels ranging from 1.0 mAHD to 3.0 mAHD with Wolston Creek flows ranging from 200 m^3/s to 400 m^3/s. This range of flows and tailwater conditions captured those present when the peak flood level occurred at the stream gauge(s) for the four selected historical events. The modelling results indicated that this range of tailwater levels in the Brisbane River did not influence the peak flood level at the stream gauge for this range of flows.

Figure 4.2 and Figure 4.3 indicate the rating curve used at 540378 (WSA584) and WSE583 respectively. At both locations there is considerable hysteresis (looping of the rating curve), which can result in quite different rated flows depending on whether the rising limb, falling limb or average of both is used. For both locations, the rating curve derivation was undertaken by applying a gradually increasing flow to the TUFLOW hydraulic model. As the TUFLOW model was updated / changed (resulting from the calibration process), the rating curves were also updated. The resultant rating curve for each gauge lies between the rising limb and falling limb rating curve. These rating curves were used for all hydrologic calibration and verification events.

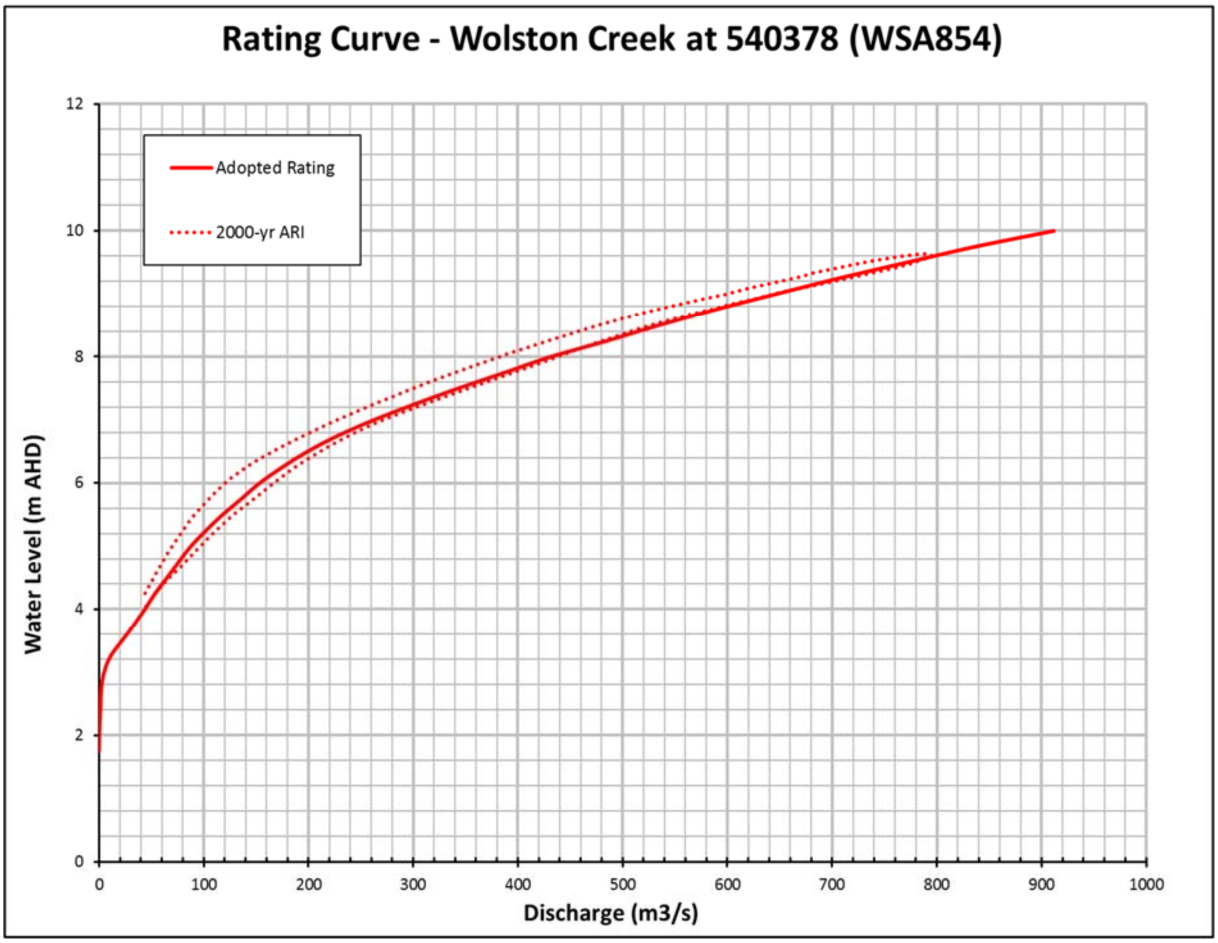


Figure 4.2: Rating Curve – Wolston Creek at AMTD 3750 m (540378)

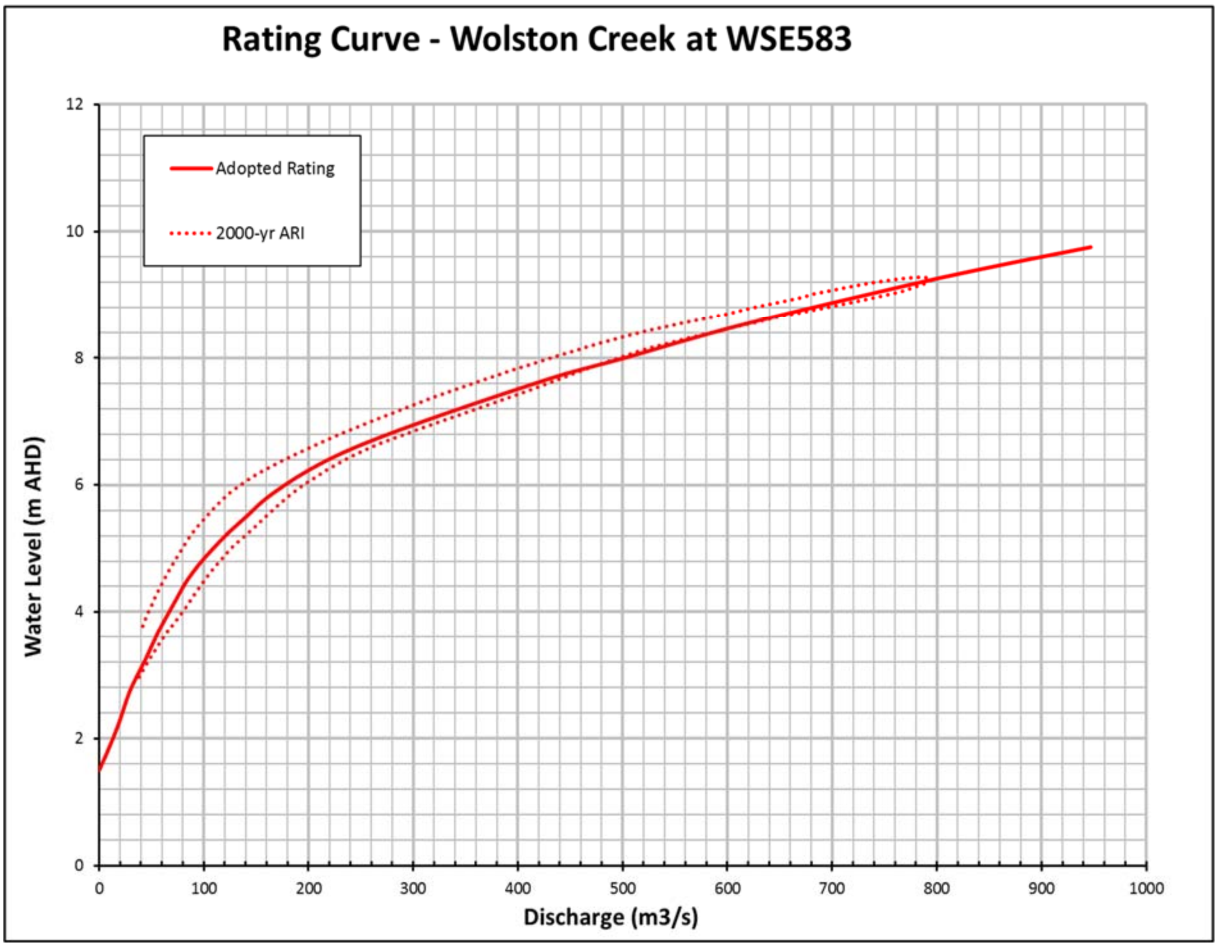


Figure 4.3: Rating Curve – Wolston Creek at AMTD 3375 m (WSE583)

4.6 Calibration and Verification Procedure

4.6.1 General

The calibration and verification process was adopted to suit the study objectives and requirements. The general requirements were to produce a hydrologic model sufficiently robust to accurately predict design discharges without the need to run the hydraulic model. This requirement meant that the approach adopted was to undertake a separate hydrologic calibration to ensure the URBS model was suitable to be used as a "standalone" model. The general approach adopted for the calibration and verification is indicated in Section 4.6.3.

4.6.2 Tolerances

The current BCC Flood Study Procedure document is not prescriptive in relation to the ideal hydrologic calibration and verification tolerances. For the purposes of this study, the calibration and verification process has aimed to achieve the following tolerances:

- Volume - within +20 % to -10 %
- Peak Flow - within +25 % to -15 %
- Good replication of the hydrograph shape (especially the rising limb)
- Good replication of the timing of peaks and troughs.

4.6.3 Methodology

The methodology applied to the calibration and verification of the URBS model was as follows:

1) Input the observed rainfall data and apportion the rainfall to each sub-catchment. This was undertaken using the Thiessen Polygon methodology as described in Section 4.4.
2) Using the TUFLOW model, establish an appropriate rating curve at the stream gauge and convert the stage recordings to flow. This was detailed in Section 4.5.
3) Run the calibration events (i.e. May 2015, January 2013 and May 2009) through the URBS model and compare the simulated results against the observed (rated) flow records.
4) Iteratively adjust the model parameters and re-run the model to achieve the best possible fit with the observed data. The predominant model parameters adjusted included the IL (mm); CL (mm/hr); channel lag parameter (α); catchment lag parameter (β) and catchment non-linearity parameter (m).
5) Adopt a single set of model parameters (typically CL, α, β and n) based on the calibration results.
6) Run the verification event (i.e. March 2017) through the calibrated URBS model and compare the simulated results against the observed (rated) flow records.
7) Adjust the initial loss (as required) to represent the event specific rainfall lost at the start of the verification event.
8) Repeat steps 2 to 7 (as necessary) following the results of the hydraulic model simulations. If required, adjust the reach length factor (f) to better replicate the results of the hydraulic model. Refer to Section 5 for more detail on the hydraulic modelling.

4.7 Simulation Parameters

Table 4.1 indicates the start and finish times of the hydrologic simulations as well as the time step used in the URBS model.

Table 4.1 – Hydrologic Simulation Parameters

Event	Start Time	Finish Time	Duration (hours)	Time Step (min)
March 2017	30/03/17 00:00	31/03/17 12:00	36	0.5
May 2015	01/05/15 06:00	02/05/15 06:00	24	0.5
January 2013	27/01/13 00:00	28/01/13 10:00	34	0.5
May 2009	19/05/09 18:00	21/05/09 12:00	42	0.5

4.8 Hydrologic Model Calibration Results

4.8.1 May 2015

Figure 4.4 provides a comparison of the URBS results and the rated flow (established using the adopted rating curve) at the stream gauge (540378). The results indicate a good fit to the peak flow and flood volume, however, the URBS model peaks approximately 1.5 hours before the observed flood peak.

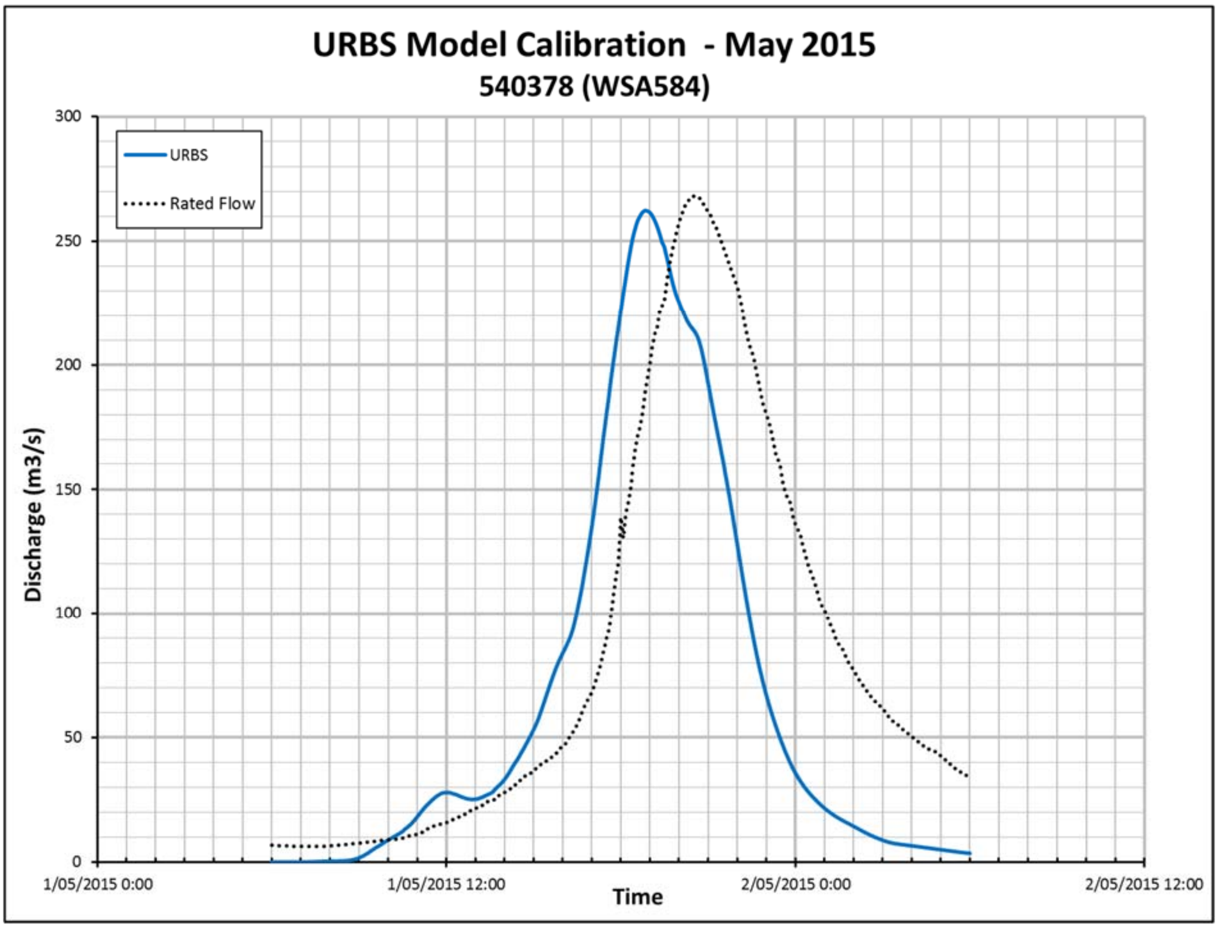


Figure 4.4: May 2015 URBS Model Calibration at 540378 (WSA584)

The adopted URBS parameters as part of the calibration were as follows:

- Impervious Area: IL = 0 mm, CL = 0 mm/hr (URBS default)
- Pervious Area: IL = 20 mm, CL = 1.5 mm/hr
- Catchment lag parameter (β) = 4
- Channel lag parameter (α) = 0.008
- Catchment non-linearity parameter (m) = 0.65

Further results from the calibration are provided in Section 5.5 and a discussion on the overall calibration / verification results is provided in Section 5.9.

4.8.2 January 2013

Figure 4.5 provides a comparison of the URBS results and the rated flow (established using the adopted rating curve) at the stream gauge (540378). The results indicate a reasonable replication of the hydrograph shape, although the URBS model peaks approximately 1 hour before the observed flood peak. The simulated peak flow is approximately 23 % higher than the rated peak flow and there is an acceptable match between the simulated and rated flood volumes.

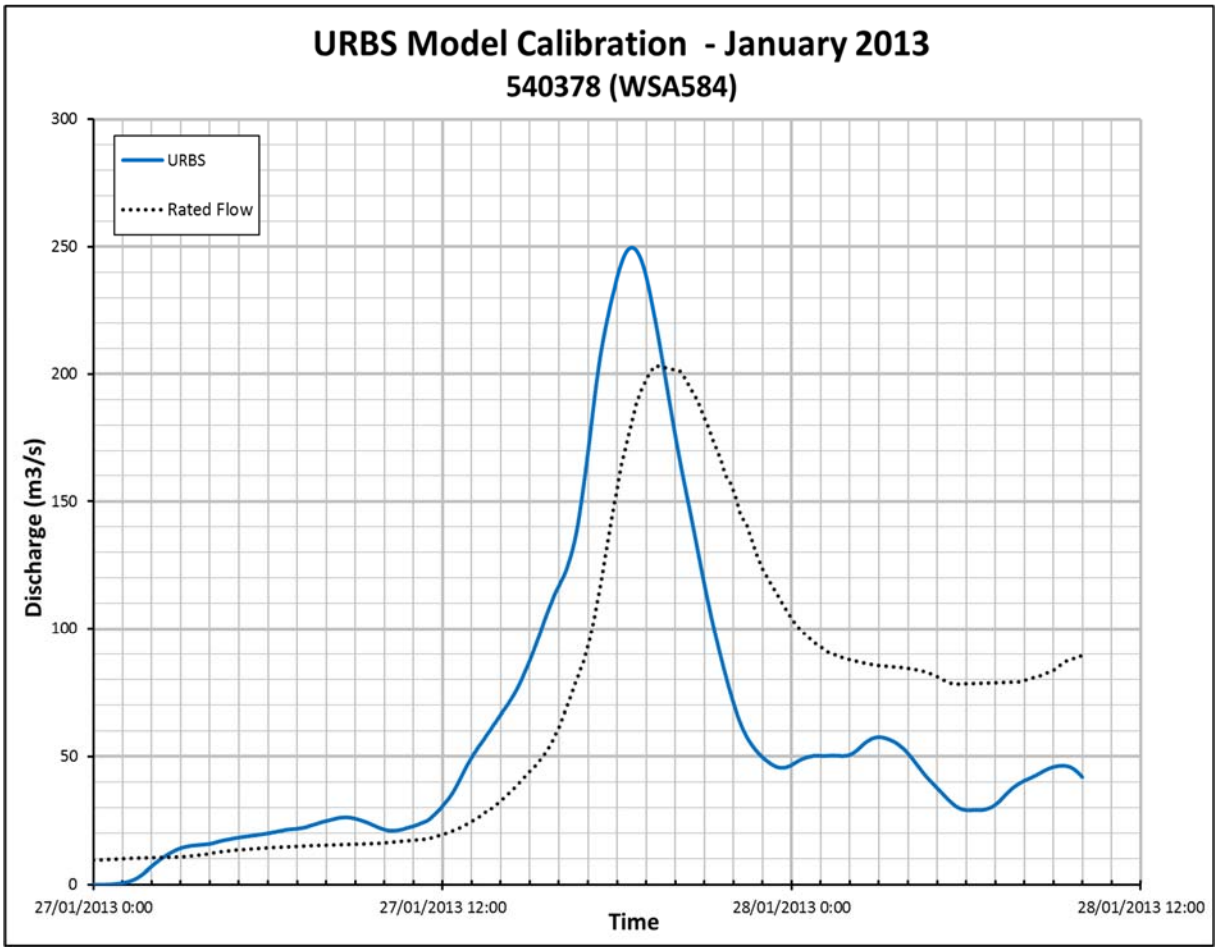


Figure 4.5: January 2013 URBS Model Calibration at 540378 (WSA584)

The adopted URBS parameters as part of the calibration were as follows:

- Impervious Area: IL = 0 mm, CL = 0 mm/hr (URBS default)
- Pervious Area: IL = 0 mm, CL = 1.5 mm/hr
- Catchment lag parameter (β) = 4
- Channel lag parameter (α) = 0.008
- Catchment non-linearity parameter (m) = 0.65

Further results from the calibration / verification are provided in Section 5.5 and a discussion on the overall calibration / verification results is provided in Section 5.9.

4.8.3 May 2009

Figure 4.6 provide a comparison of the URBS results and the rated flows (established using the adopted rating curves) at the stream gauge WSE583. It should be noted that the historical gauged flood level records were reduced by 200 mm after discussions with the BCC Hydrometrics Officer, who advised that the gauged records were known to be too high. The results indicate a reasonable replication of the double peaked hydrograph shape, although the URBS model peaks approximately 1 hour before each of the two observed flood peaks. The simulated peak flow correlates well with the second and larger flood peak and is approximately 11 % higher than the rated peak flow for the first flood peak. The simulated flood volume is outside the 10 % lower bound.

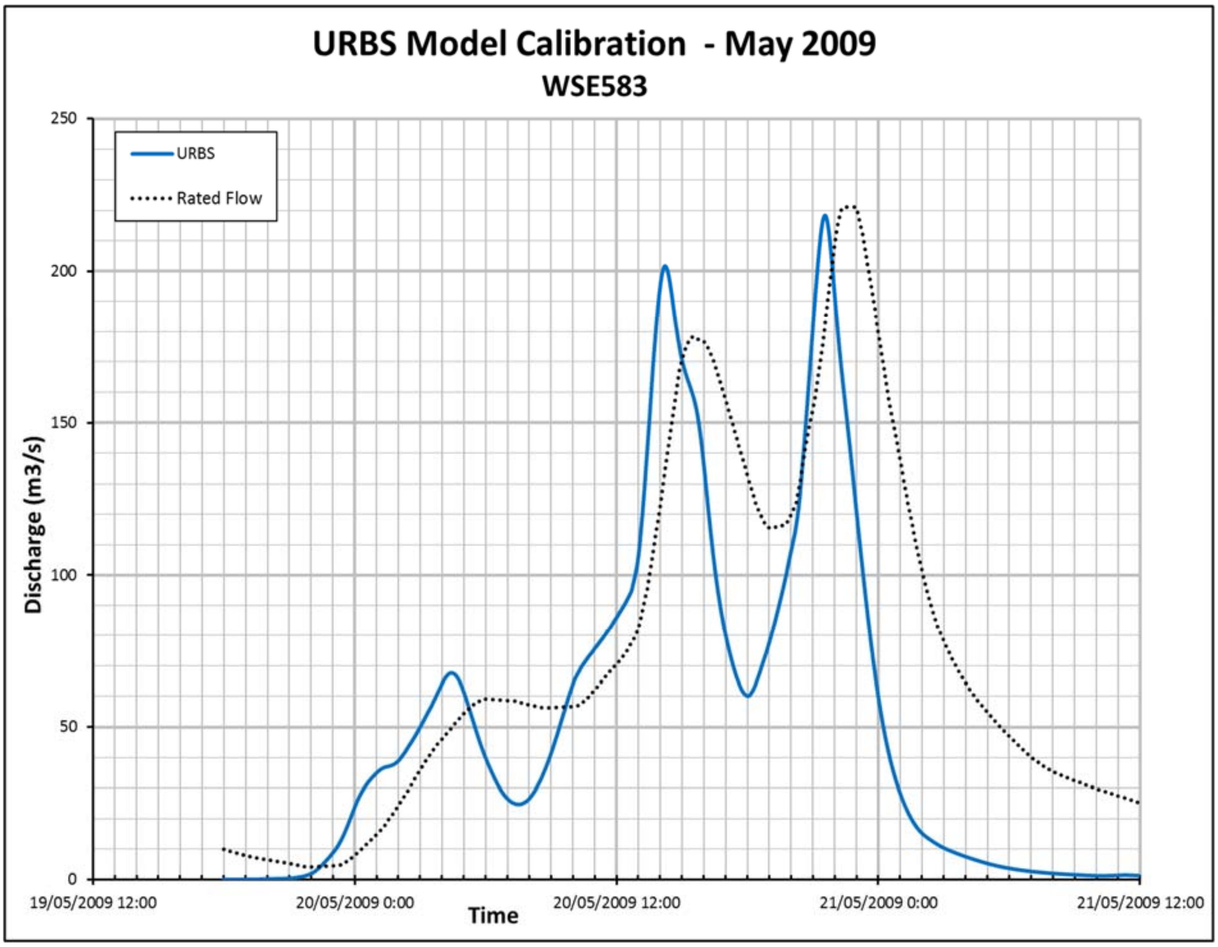


Figure 4.6: May 2009 URBS Model Calibration at WSE583

The adopted URBS parameters as part of the calibration were as follows:

- Impervious Area: IL = 0 mm, CL = 0 mm/hr (URBS default)
- Pervious Area: IL = 40 mm, CL = 1.5 mm/hr
- Catchment lag parameter (β) = 4
- Channel lag parameter (α) = 0.008
- Catchment non-linearity parameter (m) = 0.65

Further results from the calibration / verification are provided in Section 5.5 and a discussion on the overall calibration / verification results is provided in Section 5.9.

4.9 Hydrologic Model Verification Results

Table 4.2 indicates the parameters adopted from the hydrologic calibration of the three historical events. These parameters were used to verify the URBS model to the one verification event (i.e. March 2017).

Table 4.2 – Adopted URBS parameters

Parameter	Description	Adopted Value
Imp CL	Impervious Area Continuing Loss (mm/hr)	0
Perv CL	Pervious Area Continuing Loss (mm/hr)	1.5
α	Channel lag parameter	0.008
β	Catchment lag parameter	4
m	Catchment non-linearity parameter	0.65

Using the adopted model parameters, the March 2017 event was simulated in URBS. Figure 4.7 provides a comparison of the URBS results and the rated flows (established using the adopted rating curves) at the stream gauge (540378).

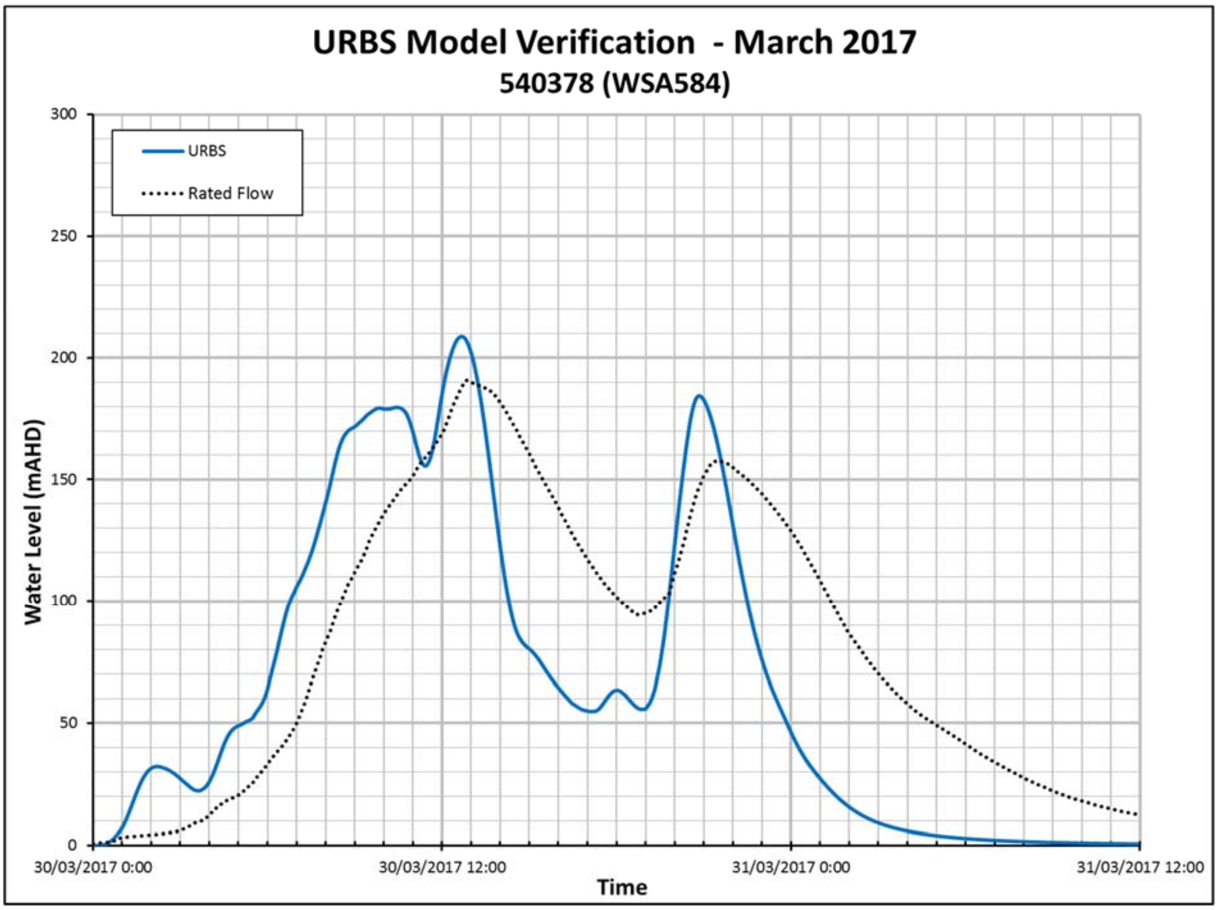


Figure 4.7: March 2017 URBS Model Verification at 540378 (WSA584)

The adopted URBS rainfall loss parameters adopted for this simulation were as follows:

- Impervious Area: IL = 0 mm, CL = 0 mm/hr (URBS default)
- Pervious Area: IL = 35 mm, CL = 1.5 mm/hr

The results indicate a fair replication of the double peaked hydrograph shape, with good timing of both peaks. The simulated peak flow is approximately 10 % higher than the rated peak flow for the first peak and approximately 15 % higher than the rated peak flow for the second peak. The simulated flood volume correlates well with the rated flood volume.

Further results from the calibration / verification are provided in Section 5.5 and a discussion on the overall calibration / verification results is provided in Section 5.9.

4.10 URBS Model Consistency Checks (Historical Events)

As noted previously, the results of the hydrologic – hydraulic model consistency checks are presented in Section 5.8. As part of these consistency checks, the URBS model channel routing was adjusted in order to better replicate the shape and timing of the TUFLOW model hydrograph. This was typically undertaken by increasing the Reach Length Factor (*f*), for which the range of values adopted is indicated in Table 4.3.

Table 4.3 – Adopted Reach Length Factor (*f*)

Creek	Adopted Value
Sandy	1.0 to 2.0
Bullockhead	1.0 to 1.5
Ric Nattrass	1.5
Wolston	1.0

5.0 Hydraulic Model Development and Calibration

5.1 Overview

The previous hydraulic model of Wolston Creek was a 1d RUBICON model, developed for the 1996 Flood Study. To achieve best practice, it was considered appropriate to upgrade this 1d model into a 1d / 2d model. This would provide a better representation of the floodplain flooding characteristics in the middle to lower sections of the catchment as well as a more efficient tool to produce flood mapping products.

The TUFLOW hydrodynamic model (version 2017-09-AC) was selected for the hydraulic analysis of the Wolston Creek Catchment.

5.2 Available Data

The following data was utilised in the development of the TUFLOW model:

- RUBICON model – 1996 Flood Study
- HEC2 bridge models – 1996 Flood Study
- 1992 and 1996 cross-section survey – 1996 Flood Study
- 2017 cross-section survey (90 x cross-sections)
- Aerial photography – 1995 to 2017
- 2014 Airborne Laser Scanning (ALS) data (refer Section 5.3.2 for further details)
- BCC City Plan 2014
- ICC and LCC land-use planning information
- Hydraulic structure drawings / reference sheets. Refer to Appendix M for further details.
- QLD Digital Cadastre Database (DCDB)
- BCC GIS databases

5.3 Model Development

5.3.1 Model Schematisation

Figure 5.1 indicates the extent of the TUFLOW model, as well as the inflow locations and the hydraulic structures included in the model. The model consists largely of a 1d / 2d linked schematisation, with the 1d domain modelled in ESTRY and the 2d domain in TUFLOW. The hydraulic model can be broken up into nine major sections on the basis of the creek / drainage type and the modelling methodology as follows:

- Sandy Creek (Logan Motorway to Ipswich Motorway) – the modelled reach extends from downstream of the Logan Motorway to upstream of the Ipswich Motorway; a length of approximately 2.9 km. The creek is open waterway for the entire length and has been modelled as 1d / 2d. The creek has been straightened / heavily modified and flows through a dedicated waterway reserve / corridor which is approximately 80 m wide. The floodplain on both sides of the creek typically contains dense industrial development. There are three main road crossings within the reach, namely Formation Street; Campbell Avenue and Progress Road. There are two inline weir structures - one is located approximately 210 m upstream of Campbell Avenue and the other 280 m upstream of Progress Road.

- Tributary 3 – the modelled reach extends from approximately 240 m upstream of Wilga Street on the western side of the Ipswich Motorway to the confluence with Sandy Creek; 280 m upstream of Progress Road. This waterway commences as an open channel and transitions into piped drainage for the majority of its 1.1 km length. The open section of the waterway has been modelled as 1d / 2d and there is one culvert crossing at Wilga Street. The piped section of the waterway conveys flow underneath the Ipswich Railway and the Ipswich Motorway, before discharging into Sandy Creek on the eastern side of the motorway.

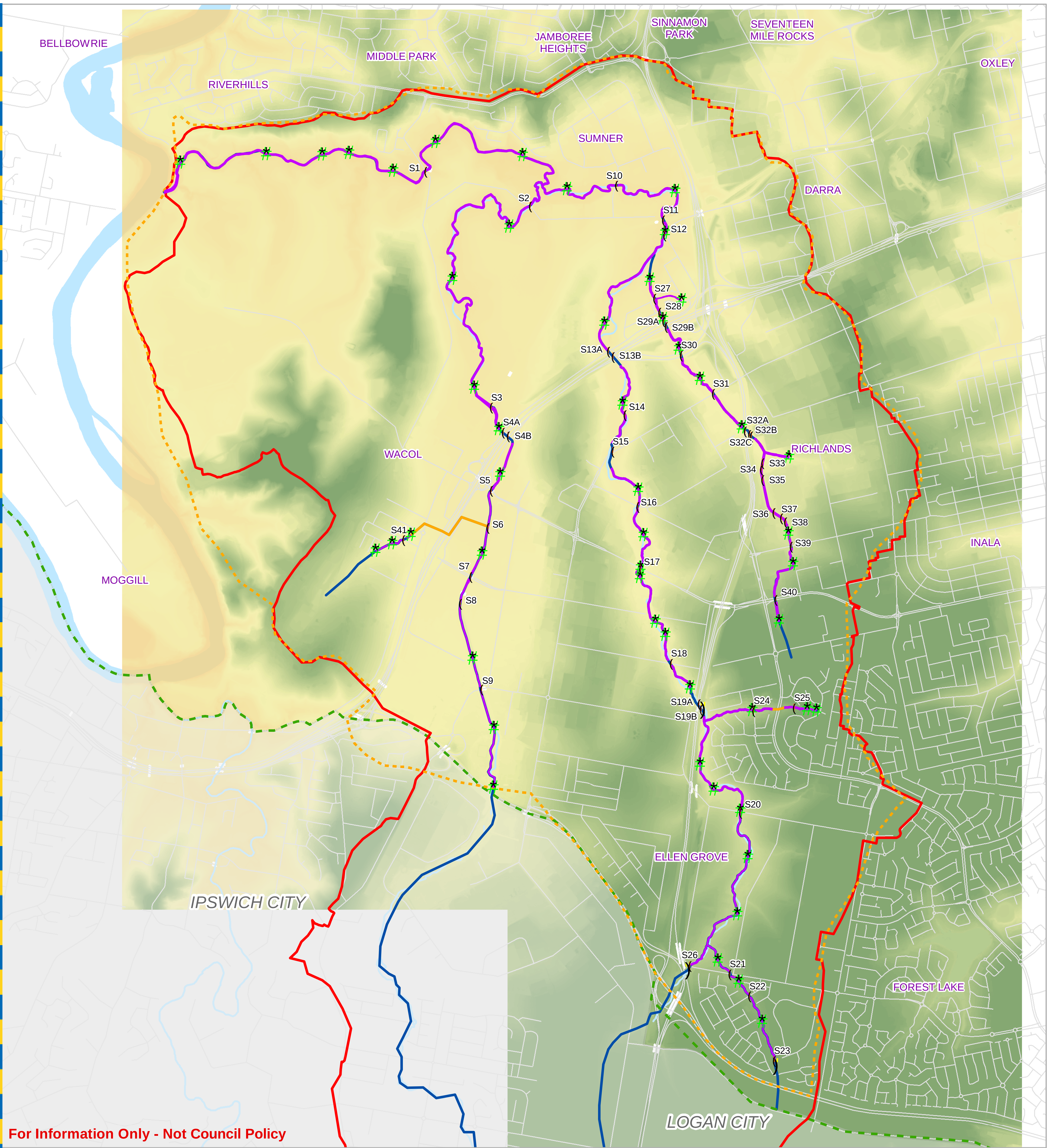
- Sandy Creek (Ipswich Motorway to Wolston Creek) – the modelled reach extends from the Ipswich Motorway to Wolston Creek at the confluence with Bullockhead Creek; a length of approximately 3.5 km. The creek is open waterway for the entire length and has been modelled as 1d / 2d. There are two main waterway crossings, namely the Ipswich Railway and Wolston Road. The creek flows through an area of medium density vegetation that is classified by City Plan 2014 as Environmental Management and Conservation.

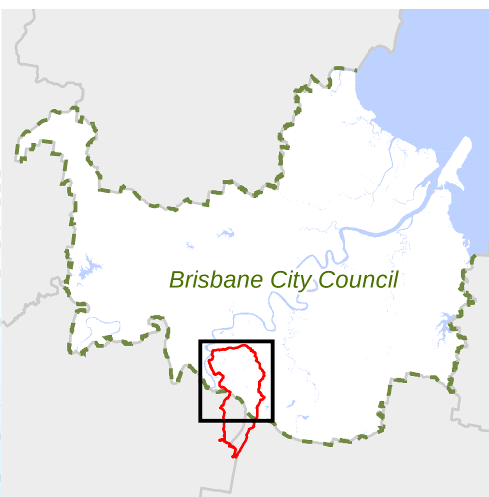
- Bullockhead Creek (Roxwell Street to Centenary Motorway) – the modelled reach extends from downstream of the Logan Motorway – Centenary Motorway Interchange to the Centenary Motorway; a length of approximately 2.7 km. The creek is open waterway for its entire length and typically flows through rural residential private properties, which are classified by City Plan 2014 as emerging community. The creek has been modelled as 1d / 2d and there are two main road crossings, namely Roxwell Street and Waterford Road.

- Spinks Creek – the modelled reach extends from the small detention basin at Woodvale Crescent to the confluence with Bullockhead Creek; a length of approximately 1.1 km. The creek is open waterway for its entire length and flows through a mix of rural residential, open space and emerging community. The creek has been modelled as 1d / 2d and there are two main road crossings, namely Jubilee Avenue and Roxwell Street. The culvert at Roxwell Street has flow control structures incorporated into it, which limit discharges downstream of Roxwell Street.

- Scott Creek – the modelled reach extends from downstream of Renoir Crescent to the confluence with Bullockhead Creek; a length of approximately 0.9 km. The creek has been modelled as 1d / 2d for its entire length and joins Bullockhead Creek approximately 100 m upstream of the Centenary Motorway. The creek is open waterway for its entire length and flows through dedicated open space with low-density residential development on the overbank areas. There are two main road crossings, namely Forest Lake Boulevard and Cardwell Street, as well as the minor timber pedestrian bridge crossing adjacent to Signac Close.

- Bullockhead Creek (Centenary Motorway to Ipswich Motorway) – the modelled reach extends from the Centenary Motorway to the Ipswich Motorway; a length of approximately 3.2 km. The creek is open waterway for its entire length and flows primarily through dedicated open space with industrial development on the overbank areas. The creek has been modelled as 1d / 2d and there are four main road crossings, namely Coulson Street; Progress Road; Bukulla Street and Boundary Road.





Legend

- (Structures
- 1d Inflow Locations
-) 2d Inflow Locations
- 1d Channel Boundary
- Pipes
- Model Boundary
- Catchment Area
- Brisbane Boundary
- Creek Centreline
- Other LGAs
- Streets
- Other LGA

0 0.5 1 1.5 2
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Wolston Creek Flood Study

Figure 5.1: TUFLOW Model Schematisation

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- Bullockhead Creek (Ipswich Motorway to Wolston Creek) – the modelled reach extends from the Ipswich Motorway to Wolston Creek at the confluence with Sandy Creek; a length of approximately 3 km. The creek is open waterway for its entire length and flows primarily through dedicated open space with some low-density residential and industrial development on the overbank areas. The creek has been modelled as 1d / 2d and there are two main waterway crossings, namely the Ipswich Railway and Spine Street.
- Ric Nattrass Creek – the modelled reach extends from approximately 160 m upstream of Progress Road to the confluence with Bullockhead Creek; a length of approximately 3.5 km. The creek is open waterway for its entire length and flows through a mix of development categories, which are primarily of an industrial and commercial nature. The creek has been modelled as 1d / 2d and there are eight main waterway crossings, of which the two major crossings are the Centenary Motorway and the Ipswich Motorway. The channel is concrete-lined within the Coca Cola Amatil precinct and comprises a number of drop structures; energy dissipators and pedestrian bridges.
- Wolston Creek – the modelled reach includes the entire length of Wolston Creek to the confluence with the Brisbane River; a length of approximately 4.3 km. The creek is open waterway for its entire length and flows primarily through dedicated open space and sparsely developed areas. The creek has been modelled as 1d / 2d and there is one main road crossing at Wacol Station Road.

5.3.2 Topography

1d Domain

The 1d open channel bathymetry was obtained from a number of sources, which included:

- 1996 cross-section survey of Sandy Creek, Bullockhead Creek and Wolston Creek
- 2017 cross-section survey
- As-built / design drawings

The 1d channel bathymetry for Sandy Creek, Bullockhead Creek and Wolston Creek was primarily from the 1996 cross-section survey and supplemented with 2017 cross-section survey and ALS 2014.

The 1d channel bathymetry for Ric Nattrass Creek was almost entirely from the 2017 cross-section survey. The concrete channel within the Coca Cola Amatil precinct utilised a combination of 2017 cross-section survey, design drawings and ALS 2014.

Spinks Creek, Scott Creek and Tributaries 1, 2 and 3 were comprised of 2017 cross-section survey.

2d Domain

The 2d bathymetry consisted of a 5 m grid which was created from a 1 m ASCII grid file (MGA Zone 56) of the 2014 ALS data.

The 2014 ALS data was captured as part of the SEQ 2014 LiDAR Capture Project, undertaken by Fugro Spatial Solutions Pty Ltd on behalf of the Queensland Government. The ALS data was acquired from a fixed wing aircraft flying over Brisbane City on the 28th October 2014.

The SEQ 2014 LiDAR Capture Project's technical processes and specifications were designed to achieve the following data accuracies:

- Vertical data: 0.3 m @ 95 % threshold accuracy
- Horizontal data: 0.8 m @ 95 % threshold accuracy

Detailed validation checks have not been undertaken on the accuracy of the 2014 ALS data as part of this flood study. It is assumed that the data is representative of the topography and "fit for purpose."

5.3.3 Land Use

The Manning's 'n' values shown in Table 5.1 were adopted within the 2d section of the TUFLOW model. The assignment of the appropriate roughness values to the land-use / topographical feature was based upon experience with similar studies and relevant hydraulic literature.

The discretisation of the land-use and topographical areas was undertaken utilising a combination of aerial photography, BCC City Plan 2014 and a number of site visits.

In the 1d ESTRY section, the Manning's 'n' values ranged from 0.015 to 0.15, depending on the type of channel material and degree of vegetation.

5.3.4 Hydraulic Structures – Culverts and Bridges

The major bridge and culvert structures within the model extents were represented in the TUFLOW model. These structures generally consisted of the waterway crossing from motorways, railways, local roads and footbridges.

The most significant structures are the five major motorway crossings. The Ipswich Motorway crosses Sandy, Bullockhead and Ric Nattrass Creeks and the Centenary Motorway crosses both Bullockhead and Ric Nattrass Creeks. Typically, these motorway crossings comprise multiple inline bridges for the motorway carriageways; on / off ramps and service roads. The Centenary Motorway crossings also incorporate the Springfield Railway, which was built as part of the motorway upgrade (circa 2009 and 2010).

Table 5.2 indicates the location and details of the structures as well as the modelling approach used. The structures at Wacol Station Road (S1) and Progress Road (S17) are in the process of being upgraded, however for the purpose of this study the new designs have not been included in the hydraulic model. The modelled head-loss across selected structures was checked utilising the HEC-RAS modelling software, as recommended in the TUFLOW manual. Refer to Section 5.7 for further details.

The TUFLOW "z-shape" function was utilised to more accurately model the bridge deck and handrail levels for structures which incorporated a 2d representation of the weir flow across the bridge / road embankment.

Table 5.1 – Adopted TUFLOW roughness parameters

Topographical feature / Land-use	Adopted Manning's 'n'
Land-use BCC City Plan 2014	
Low Density Residential	0.12
Low – Medium Density Residential	0.15
Medium Density Residential	0.15
Neighbourhood Centre	0.15
District Centre	0.15
Low Impact Industry	0.12
Industry (General Industry A,B and C)	0.15
Industry Investigation	0.12
Sport And Recreation	0.04
Open Space	0.04
Environmental Management and Conservation	0.08
Emerging Communities	0.06
Extractive Industry	0.10
Rural Residential	0.06
Community Facilities (Major Health Care)	0.06
Community Facilities (Cemetery)	0.04
Community Facilities (Community Purposes)	0.10
Community Facilities (Education Purposes)	0.10
Community Facilities (Emergency Services)	0.15
Specialised Centre (Major Education and Research)	0.12
Specialised Centre (Large Format Retail)	0.12
Specialised Centre (Mixed Industry and Business)	0.12
Special Purpose (Detention Facility)	0.08
Special Purpose (Transport Infrastructure)	0.04
Special Purpose (Utility Services)	0.04
Additional Roughness	
Road pavement	0.02
Road verge	0.03
Channel – concrete lined	0.015
Vegetation – light to high density	0.035 to 0.15
Minimum Riparian Corridor (MRC)	0.15

Table 5.2 – Hydraulic Structures represented in the TUFLOW model

Creek	Structure ID	AMTD	Structure location	Structure details	Modelled structure representation	Origin of data used for coding the structure
Wolston	S1	2560	Wacol Station Road	Two span road bridge	1d bridge / 2d weir	1996 HSRS + creek survey (2017)
Sandy	S2	260	Wolston Road	Single span road bridge	1d bridge / 2d weir	Detailed survey (2017)
Sandy	S3	2980	Ipswich Railway	8 / 3 x 3 m RCBC	1d culvert / 2d weir	1996 HSRS + 2014 ALS
Sandy	S4a	3200	Ipswich Road	Single span road bridge + footbridge	2d bridge / 2d weir (ped) 2d bridge / 2d weir (road)	DTMR design drawings + creek survey (2017)
Sandy	S4b	3250	Ipswich Motorway	Multiple single span road bridges	2d bridge / 2d weir	DTMR design drawings + creek survey (2017)
Sandy	S5	3725	Progress Road	Single span road bridge	1d bridge / 2d weir	DTMR design drawings + creek survey (2017)
Sandy	S6	4130	Adjacent 7 Industrial Avenue, Wacol	Inline weir	1d weir	Detailed survey (2017)
Sandy	S7	4450	Campbell Avenue	6 / 3 x 2.7 m RCBC	1d culvert / 2d weir	1996 HSRS + 2014 ALS
Sandy	S8	4670	Adjacent 59 Industrial Avenue, Wacol	Inline weir	1d weir	Detailed survey (2017)
Sandy	S9	5350	Formation Street	6 / 3 x 2.7 m RCBC	1d culvert / 2d weir	1996 HSRS + 2014 ALS
Bullockhead	S10	670	Spine Street	Three span road bridge	2d bridge / 2d weir	Detailed survey (2017)
Bullockhead	S11	1560	Ipswich Railway	6 / 1.8 m dia RCPs + Single span bridge	1d culvert / 2d weir 2d bridge / 2d weir	1996 HSRS + 2014 ALS
Bullockhead	S12	1690	Sananānda Street	2 / 1.5 m dia RCPs	1d culvert / 2d weir	1996 HSRS + 2014 ALS
Bullockhead	S13a	2810	Ipswich Road	Single span road bridge	2d bridge / 2d weir	DTMR design drawings + creek survey (2017)
Bullockhead	S13b	2860	Ipswich Motorway	Multiple twin span road bridges	2d bridge / 2d weir	DTMR design drawings + creek survey (2017)

Creek	Structure ID	AMTD	Structure location	Structure details	Modelled structure representation	Origin of data used for coding the structure
Bullockhead	S14	3370	Private bridge	Three span road bridge	1d culvert / 2d weir	DTMR Safelink model + creek survey (2017) + 1996 HSRS
Bullockhead	S15	3700	Boundary Road	Five span road bridge	2d bridge / 2d weir	Design Drawings
Bullockhead	S16	4260	Bukulla Street	Causeway	2d weir	2014 ALS
Bullockhead	S17	4770	Progress Road	5 / 2.7 x 2.4 m RCBCs	1d culvert / 2d weir	Progress Road Upgrade HEC-RAS model + 1996 HSRS
Bullockhead	S18	5590	Coulson Street	5 / 2.1 x 1.35 m RCBCs	1d culvert / 2d weir	1996 HSRS + 2014 ALS
Bullockhead	S19a	5950	Centenary Motorway	Three span road bridge	2d bridge / 2d weir	DTMR drawings + creek survey (2017)
Bullockhead	S19b	6020	Springfield Railway	Three span rail bridge	2d bridge / 2d weir	QLD Rail design drawings + creek survey (2017)
Bullockhead	S20	7040	Waterford Road	4 / 3.0 x 2.4 m RCBCs	1d culvert / 2d weir	1996 HSRS + 2014 ALS
Spinks	S21	280	Roxwell Street	2 / 2.4 x 1.8 m RCBCs + 1 / 2.4 x 2.4 m RCBC	1d culvert / 2d weir	2017 Site measurements + 2014 ALS
Spinks	S22	510	Jubilee Avenue	Single Arch Bridge	1d bridge / 2d weir	Detailed survey (2017)
Spinks	S23	1060	Woodvale Crescent	2 / 2.7 x 1.2 m RCBCs	1d culvert / 2d weir	Design drawings + 2014 ALS
Scott	S24	420	Cardwell Street	1 / 3.6 x 2.4 RCBC m with low flow channel	1d culvert / 2d weir	Design drawings + 2014 ALS
Scott	S25	750	Signac Close	Wooden three span footbridge	1d bridge / 1d weir	2017 Site measurements + 2014 ALS
Bullockhead	S26	8475	Roxwell Street	3 / 2.4 x 1.8 m RCBCs + 2 / 2.4 x 2 m SLBCs	1d culverts / 2d weir	Detailed survey (2017)
Ric Nattrass	S27	350	Wau Road	7 / 2.1 x 0.9 m RCBCs	1d culvert / 2d weir	DTMR drawings + 2014 ALS
Ric Nattrass	S28	470	Kokoda Street	7 / 2.1 x 0.9 m RCBCs	1d culvert / 2d weir	DTMR drawings + 2014 ALS

Creek	Structure ID	AMTD	Structure location	Structure details	Modelled structure representation	Origin of data used for coding the structure
Ric Nattrass	S29a	550	Ipswich Road + motorway off ramp	Multiple single span road bridges	2d bridge / 2d weir	DTMR drawings + 2014 ALS
Ric Nattrass	S29b	600	Ipswich Motorway	Multiple single span road bridges	2d bridge / 2d weir	DTMR drawings + 2014 ALS
Ric Nattrass	S30	850	Bakery Road + motorway on ramp	3 / 1.5 x 1.5 m RCBCs inside 15 x 5 m Classic Arch Culvert	1d culverts / 2d weir	DTMR drawings + 2014 ALS
Ric Nattrass	S31	1265	Boundary Road	4 / 1.95 m dia RCPs	1d culvert / 2d weir	Design drawings + 2014 ALS
Ric Nattrass	S32a	1650	Centenary Motorway	9 / 1.95 m dia RCPs	1d culvert / 2d weir	DTMR drawings + 2014 ALS
Ric Nattrass	S32b	1690	Springfield Railway	Three span rail bridge	2d bridge / 2d weir	QLD Rail design drawings + 2014 ALS
Ric Nattrass	S32c	1710	Centenary Motorway Footbridge	Two span footbridge	2d bridge / 2d weir	DTMR drawings + 2014 ALS
Ric Nattrass	S33	1965	Coca Cola Footbridge #2	Single span footbridge	1d bridge / 1d weir	Design drawings + 2014 ALS
Ric Nattrass	S34	2010	Coca Cola Drop Structure #3	Steepened channel with downstream energy dissipator	1d concrete channels	Design drawings + 2014 ALS
Ric Nattrass	S35	2100	Coca Cola Drop Structure #2	Steepened channel with downstream energy dissipator	1d concrete channels	Design drawings + 2014 ALS
Ric Nattrass	S36	2385	Coca Cola Footbridge #1	Single span footbridge	1d bridge / 1d weir	Design drawings + 2014 ALS
Ric Nattrass	S37	2475	Coca Cola Drop Structure #1	Steepened channel with downstream energy dissipator	1d concrete channels	Design drawings + 2014 ALS
Ric Nattrass	S38	2490	Coca Cola Spillway / Weir	Rectangular spillway with debris screen	1d weir	Design drawings + 2014 ALS
Ric Nattrass	S39	2695	Pine Road	2 / 3 x 1.5 m RCBCs	1d culvert / 2d weir	Design drawings + 2014 ALS
Ric Nattrass	S40	3130	Progress Road	3 / 1.8 x 1.2 m RCBCs	1d culvert / 2d weir	Design drawings + 2014 ALS
Tributary 3	S41	N/A	Wilga Street	4 / 0.75 m dia RCPs	1d culvert / 2d weir	Design drawings + 2014 ALS

Six of the more complex hydraulic structures are discussed as follows:

Ipswich Motorway (S4a and S4b) - Sandy Creek

This crossing comprises five separate inline bridge structures, including from upstream to downstream:

- Southern Service Road Bridge
- Out-bound Motorway Bridge
- In-bound Motorway Bridge
- Ipswich Road Bridge
- Cycleway Bridge

This crossing was modelled as five separate 2d bridges using the 2d layered flow constriction methodology in TUFLOW.

Ipswich Motorway (S13a and S13b) - Bullockhead Creek

This crossing comprises three separate inline bridge structures, including from upstream to downstream:

- On-ramp / Out-bound Motorway Bridge
- In-bound Motorway Bridge
- Ipswich Road Bridge

This crossing was modelled as three separate 2d bridges using the 2d layered flow constriction methodology in TUFLOW.

Centenary Motorway (S19 and S20) - Bullockhead Creek

This crossing comprises two inline bridge structures, including from upstream to downstream:

- Springfield Railway Bridge
- In-bound / Out-bound Motorway Bridge

This crossing was modelled as two separate 2d bridges using the 2d layered flow constriction methodology in TUFLOW. The piers of the railway bridge are not aligned parallel to the direction of flow so higher form losses were used to represent the effective pier width.

Roxwell Street (S21) – Spinks Creek

This crossing comprises a three cell RCBC with hydraulic controls at the inlet of all three cells. The central 2.4 x 2.4 m RCBC contains a v-shaped weir with a 0.9 m high rectangular opening above. The outer two 2.4 x 1.8 m RCBCs contain a horizontal weir at approximately 0.9 m above the culvert base. The modelling of this culvert arrangement proved quite unstable and as a result a simplified approach was adopted. The hydraulic controls were modelled as zero length culverts, with the central cell hydraulic control being represented by an irregular culvert and the outer cell hydraulic controls as rectangular culverts. Head-losses across the culvert were checked using an EPA-SWMM model and found to be of similar magnitude to the TUFLOW model.

Ipswich Motorway (S29a and S29b) - Ric Nattrass Creek

This crossing comprises four separate inline bridge structures, including from upstream to downstream:

- Out-bound Motorway Bridge
- In-bound Motorway Bridge
- Off-ramp Bridge
- Ipswich Road Bridge

This crossing was modelled as two separate 2d bridges using the 2d layered flow constriction methodology in TUFLOW. The motorway bridges were modelled as one bridge and the Ipswich Road / Off-ramp bridges as a second bridge.

Bakery Road + Ipswich Motorway On-ramp (S30) – Ric Nattrass Creek

This crossing of Ric Nattrass Creek includes both a low-flow culvert and a high-flow culvert. The low-flow culvert is within the larger high-flow culvert and comprises 3 / 1.5 x 1.5 m RCBCs. The high-flow culvert is a 15 m wide x 5 m high classic arch culvert and incorporates a cycleway. The low-flow culvert has been modelled in 1d using a standard culvert modelling approach. The high-flow culvert has been modelled as an irregular culvert using a height - width table to define the effective culvert area.

Centenary Motorway (S32a, 32b and S32c) - Ric Nattrass Creek

This crossing comprises two inline bridge structures and a piped culvert crossing, including from upstream to downstream:

- Cycleway Bridge
- Springfield Railway Bridge
- In-bound / Out-bound Motorway Culvert

This crossing was modelled as two separate 2d bridges and a 1d culvert / 2d weir. The bridges were modelled using the 2d layered flow constriction methodology in TUFLOW. The piers of both the railway bridge and cycleway bridge are not aligned parallel to the direction of flow so higher form losses were used to represent the effective pier width.

5.3.5 Piped Drainage

Although this flood study essentially analyses open channel / creek systems, it was considered necessary to include piped drainage in two areas to more accurately determine flood levels. In both areas, the flow interchange between the 2d channel and the 1d pipe network was assumed to occur "freely" at the inlet pits. This assumes that the hydraulic control will be the limiting size of the pipe and not the size of the pit inlet.

The two areas where piped drainage has been included in the study are discussed as follows:

Tributary 3 of Sandy Creek - Downstream of Wilga Street

From approximately 290 m upstream of Ipswich Motorway to 385 m downstream, the reach consists of a low-flow pipe in conjunction with a high-flow open channel. The low-flow pipe size ranges between 0.9 m and 1.65 m in diameter. The low-flow pipe was modelled as a 1d element and the high-flow channel in 2d. The pipe network schematisation in this area has been simplified which means that not all of the pits and manholes were included in the model. The pipe network runs through the low-density residential and industrial areas for the majority of its length. The piped section conveys the flow underneath the Ipswich Railway and the Ipswich Motorway, before discharging into Sandy Creek on the eastern side of the motorway.

Scott Creek - Forest Lake Boulevard

From approximately 35 m upstream of Forest Lake Boulevard to 35 m downstream, the reach consists of a low-flow pipe in conjunction with a high-flow open channel. The low-flow pipe sizes are 1.65 m diameter upstream of Forest Lake Boulevard and 1.8 m diameter downstream of Forest Lake Boulevard. The pipes have been represented in the model as 1d elements with the high-flow channel in 2d.

5.3.6 Concrete Lined Channel - Coca Cola Amatil

This heavily modified concrete-lined section of Ric Nattrass Creek commences approximately 180 m downstream of Pine Street and extends for 620 m through the Coca Cola Amatil Precinct. Within this reach there are numerous hydraulic structures, including from upstream to downstream:

- Spillway / Weir (S38)
- Drop Structure #1 including energy dissipator (S37)
- Footbridge #1 (S36)
- Drop Structure #2 including energy dissipator (S35)
- Drop Structure #3 including energy dissipator (S34)
- Footbridge #2 (S33)

These in-channel structures have all been modelled as fully 1d using the ESTRY structure routines. The drop structures are typically around 24 m in length with longitudinal grades of between 6.5 % and 10 %. These drop structures have been modelled as steep concrete channels, with 1d cross-sections used to represent the change in cross-section over the 24 m length. Both footbridges have been represented as a 1d BB type bridge with a 1d weir.

5.3.7 Boundary Conditions

Inflow Boundaries

Inflows to the TUFLOW hydraulic model were taken from the URBS hydrologic model. All inflows were represented as a discharge versus time (Q-T) relationship, with the inflow locations as indicated in Figure 5.1. The inflow locations were generally adopted to match the URBS model sub-catchment schematisation.

Downstream Boundary

A varying water level versus time (H-T) boundary was used to represent the downstream boundary conditions at the mouth of Wolston Creek. As there is no stream gauge at the mouth of Wolston Creek, the H-T boundary was derived based on interpolation between the closest upstream and downstream river gauges. The mouth of Wolston Creek is located along the Brisbane River at AMTD 59.35 km, resulting in the closest upstream stream gauge being 540201 (BNA764) at Moggill AMTD 69.2 km and downstream 540192 (BNA731) at Jindalee AMTD 52.1 km. As not all the same stream gauges had data for the historical events, the H-T was derived from the best available gauge information, as follows:

For the March 2017 and May 2015 events, the H-T boundary was interpolated based on upstream 540201 (BNA764) at Moggill and the downstream 540192 (BNA731) at Jindalee.

For the January 2013 event, the H-T boundary was interpolated based on upstream 540812 (BNE009) at Moggill and the downstream 540192 (BNA731) at Jindalee.

For the May 2009 event, nearby upstream stream gauge data was not available, which resulted in a constant H-T boundary of MHWS being adopted. As discussed previously in Section 4.5, due to the minor nature of Brisbane River flows during the historical events, the adoption of a H-T boundary of MHWS would be appropriate as the recorded flood levels at the stream gauge and MHGs are not backwater affected from the Brisbane River.

5.3.8 Run Parameters

Time Step

The 1d ESTRY component was run using a 1 second time step and 2d TUFLOW component using a 1 second time step.

Eddy Viscosity

The Smagorinsky method was used for specifying the eddy viscosity in the 2d domain. This method is recommended in the TUFLOW manual and the default approach, in lieu of the Constant method. The method uses the Smagorinsky formula with a "Constant Coefficient" of 0.1 and "Smagorinsky Coefficient" of 0.2. This method has been successfully used on other similar BCC flood studies.

5.4 Calibration Procedure

5.4.1 Tolerances

BCC flood studies aim to achieve the following tolerances with regard to the hydraulic model calibration / verification:

- Continuous recording stream gauges - within ± 0.15 m of the peak flood level
- MHGs - within ± 0.30 m of the peak flood level
- Debris marks - within ± 0.40 m of the peak flood level
- Good replication of the timing of peaks and troughs.

5.4.2 Methodology

The methodology applied to the calibration and verification of the TUFLOW model was as follows:

1) Run a large slowing increasing flow through the TUFLOW model to enable hydraulic structure head-loss checks to be undertaken against the HEC-RAS model(s).
2) Iteratively adjust the bridge loss parameters (as required) and re-run the model to establish a reasonable correlation with the HEC-RAS model(s).

3) Using the flow inputs from the URBS model, run the calibration events through the TUFLOW model and compare the simulated results against the observed flood levels at both the stream gauge and the MHGs.
4) Iteratively adjust the TUFLOW model parameters and re-run the model with the aim of achieving a good fit with the observed data. The predominant model parameters adjusted included Manning's 'n' and the hydraulic structure losses.
5) Adopt model parameters based on the calibration results.
6) Using the flow inputs from the URBS model, run the single verification event through the calibrated TUFLOW model and compare the simulated results against the observed flood levels at the stream gauge and the MHGs.

The exact same TUFLOW model set-up has been used for all four historical events. Although the Ipswich and Centenary Motorway upgrade construction works were in progress when the May 2009 event occurred, it is likely that due to the location of the MHGs, the construction works would not have influenced the recorded levels. Therefore, the only difference between the hydraulic modelling of the historical events is with the hydrologic flow inputs and the downstream boundary conditions at Brisbane River. This methodology ensures that the TUFLOW model is sufficiently robust to be utilised for the design and extreme event modelling.

5.5 Hydraulic Model Calibration Results

5.5.1 May 2015

The May 2015 flood was simulated in TUFLOW for 24 hours from 6 am on the 1st May 2015 to 6 am on the 2nd May 2015. Figure 5.2 provides a comparison between the TUFLOW (and URBS) results and the gauged flood level on Wolston Creek at 540378 (WSA584). Table 5.3 provides a comparison between the TUFLOW results and the recorded peak flood levels at the MHGs.

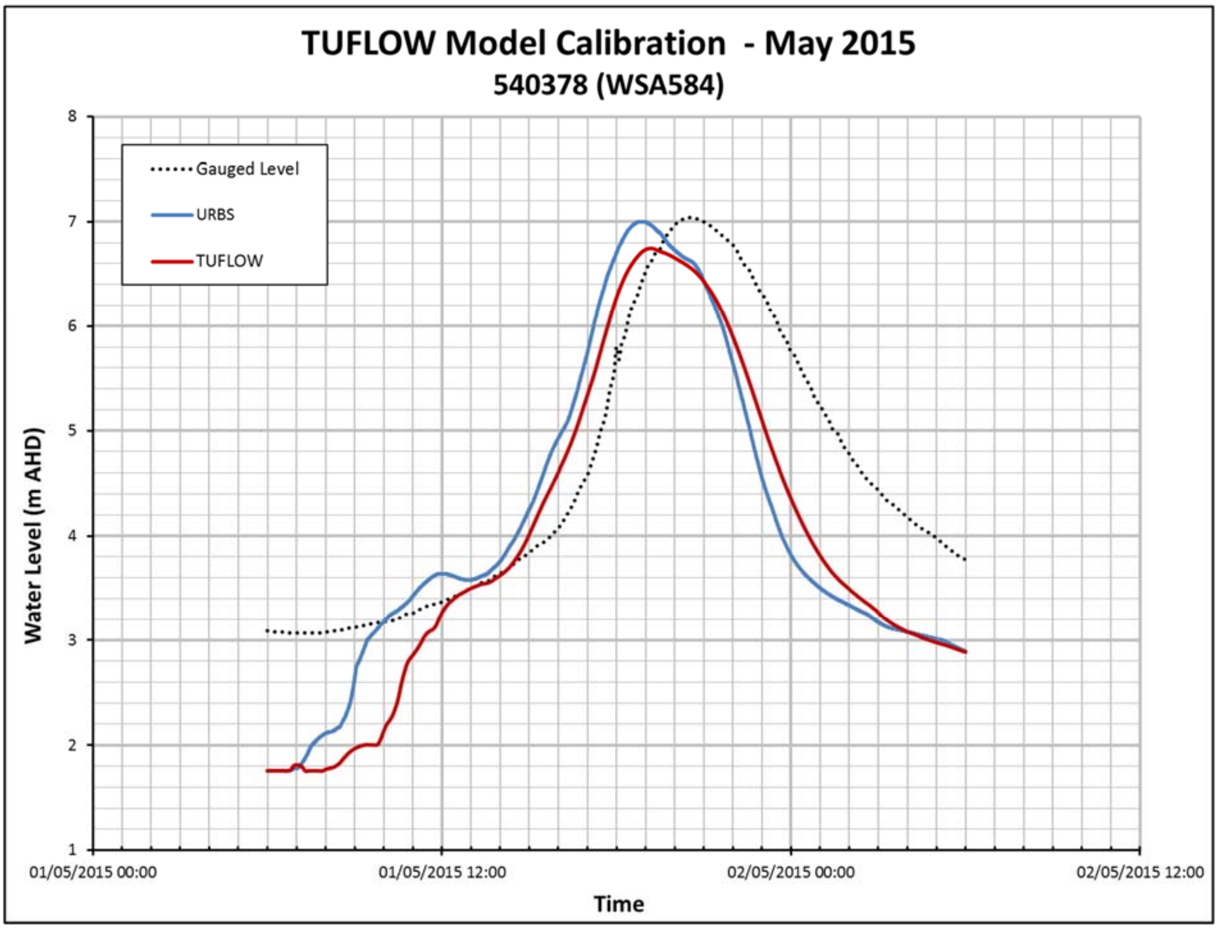

Figure 5.2: May 2015 TUFLOW Model Calibration - Wolston Creek at 540378 (WSA584)

From review of the peak level / MHG results, it was apparent that at 9 out of 10 locations the desired peak flood level tolerance was able to be achieved. Two MHG records from debris marks (BH160 and SW140) were disregarded, as there were considerable discrepancies and inconsistencies when compared with the upstream and downstream MHG records and with the other historical event MHG records in the vicinity.

At the stream gauge, the TUFLOW simulated peak flood level was slightly outside the ± 0.15 m tolerance. The overall shape of the hydrograph was good, however the TUFLOW flood peak occurred approximately 1.5 hours before the observed flood peak.

Table 5.3 – Calibration to Peak Flood Level Data (May 2015)

Gauge ID	Location	Recorded Peak WL (mAHD)	Simulated Peak WL (mAHD)	Difference (m)
Wolston Creek				
BH100	U/S Wacol Station Road	-	6.03	-
540378	Stream Gauge	7.04	6.75	-0.29
BH110	D/S of Sandy Creek / Bullockhead Creek Confluence	7.05	6.81	-0.24
Bullockhead Creek				
BH120	400 m U/S of Spine Street	9.82	9.56	-0.26
BH130	U/S Sananda Street	-	11.40	
BH140	Closed	-	-	-
BH150	80 m U/S of Bukulla Street	19.69	19.72	0.03
BH160	40 m U/S Progress Road	~~20.48 (d)~~	~~21.08~~	~~0.60~~
BH170	U/S Waterford Road	31.41	31.25	-0.16
BH180	U/S of Roxwell Street	39.17 (d)	39.16	-0.01
Sandy Creek				
SW100	Closed	-	-	-
SW110	D/S Ipswich Motorway	13.06	12.99	-0.07
SW120	D/S Progress Road	14.46	14.21	-0.25
SW130	130 m U/S Progress Road	15.47	15.06	-0.41
SW140	300 m U/S Campbell Avenue	~~17.55 (d)~~	~~18.29~~	~~0.74~~
SW150	100 m D/S Formation Street	19.13	19.12	-0.01
SW160	50 m U/S Formation Street	21.24	21.54	0.30

(d) Reading from debris mark

5.5.2 January 2013

The January 2013 flood was simulated in TUFLOW for 34 hours from 12 am on the 27th January 2013 to 10 am on the 28th January 2013. Figure 5.3 provides a comparison between the TUFLOW (and URBS) results and the gauged flood level on Wolston Creek at 540378 (WSA584). Table 5.4 provides a comparison between the TUFLOW results and the recorded peak flood levels at the MHGs for which records were available.

From review of the peak level / MHG results, it was apparent that at 7 out of 7 locations the desired peak flood level tolerance was able to be achieved.

At the stream gauge, the TUFLOW simulated peak flood level was within the ± 0.15 m tolerance. The overall shape of the hydrograph was reasonable, however the TUFLOW flood peak occurred approximately 1 hour before the observed flood peak.

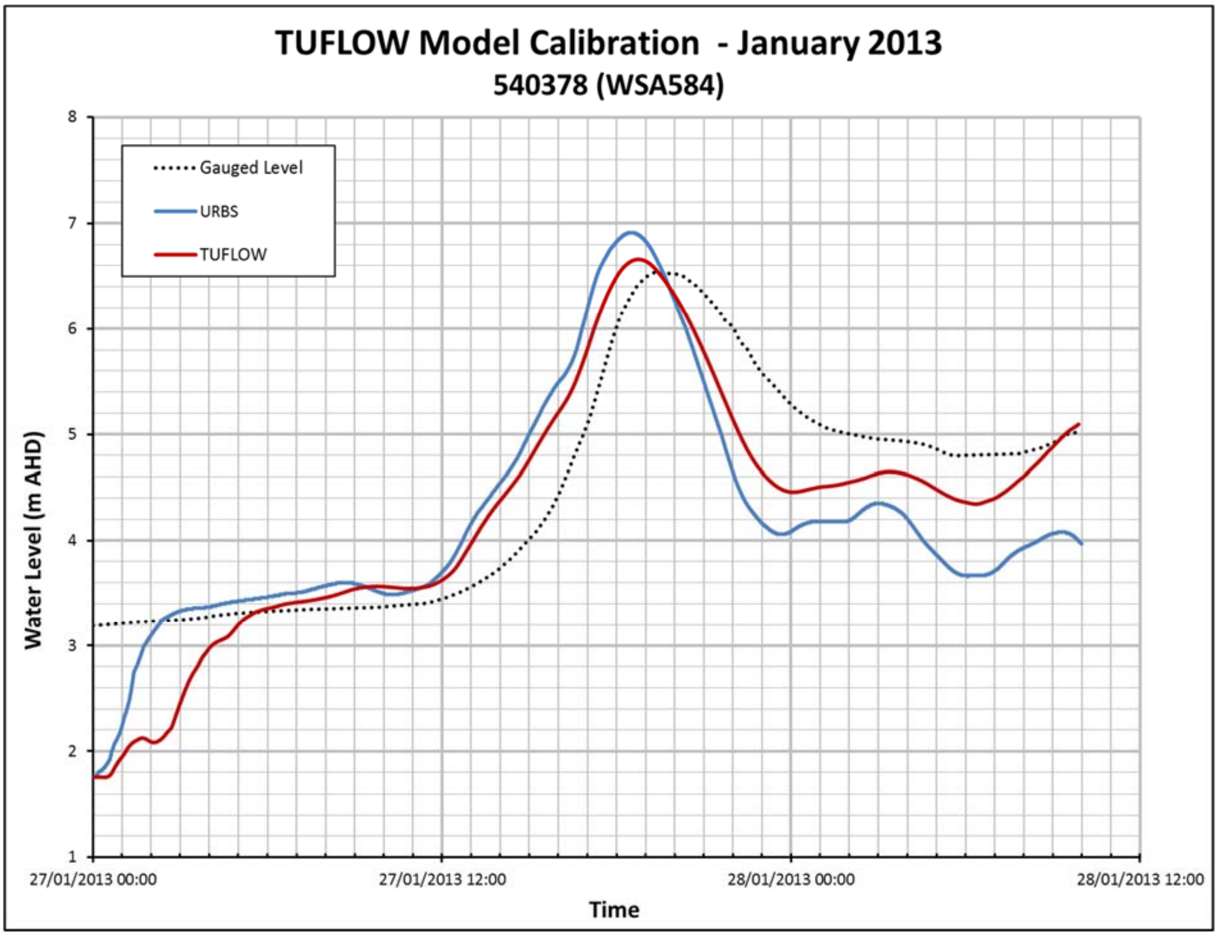

Figure 5.3: January 2013 TUFLOW Model Calibration - Wolston Creek at 540378 (WSA584)

Table 5.4 – Calibration to Peak Flood Level Data (January 2013)

Gauge ID	Location	Recorded Peak WL (mAHD)	Simulated Peak WL (mAHD)	Difference (m)
Wolston Creek				
BH100	U/S Wacol Station Road	5.95	5.97	0.02
540378	Stream Gauge	6.54	6.67	0.13
BH110	D/S of Sandy Creek / Bullockhead Creek Confluence	6.64	6.72	0.08
Bullockhead Creek				
BH120	400 m U/S of Spine Street	9.47	9.47	0.00
BH130	U/S Sananda Street	10.91	11.19	0.28
BH140	Closed	-	-	-
BH150	80 m U/S of Bukulla Street	-	19.64	-
BH160	40 m U/S Progress Road	-	20.99	-
BH170	U/S Waterford Road	31.03	31.15	0.12
BH180	U/S of Roxwell Street	-	39.13	-

Gauge ID	Location	Recorded Peak WL (mAHD)	Simulated Peak WL (mAHD)	Difference (m)
Sandy Creek				
SW100	Closed	-	-	-
SW110	D/S Ipswich Motorway	12.81	12.95	0.14
SW120	D/S Progress Road	-	14.14	-
SW130	130 m U/S Progress Road	15.06	14.99	-0.07
SW140	300 m U/S Campbell Avenue	-	18.26	-
SW150	100 m D/S Formation Street	-	19.06	-
SW160	50 m U/S Formation Street	-	21.49	-

5.5.3 May 2009

The May 2009 flood was simulated in TUFLOW for 42 hours from 6 pm on the 19th May 2009 to 12 noon on the 21st May 2009. Figure 5.4 provides a comparison between the TUFLOW (and URBS) results and the gauged flood level on Wolston Creek at WSE583. Table 5.5 provides a comparison between the TUFLOW results and the recorded peak flood levels at the MHGs for which records were available

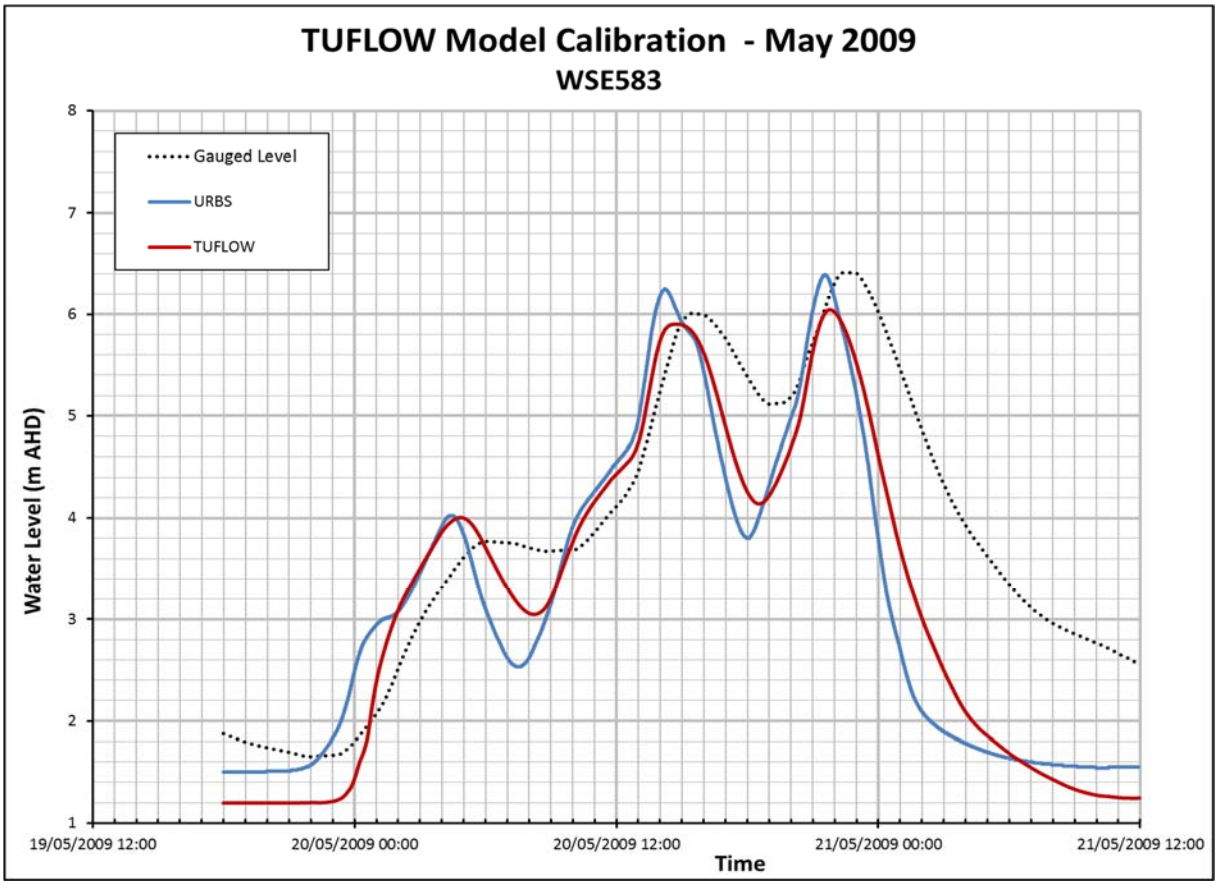

Figure 5.4: May 2009 TUFLOW Model Calibration - Wolston Creek at WSE583

Table 5.5 – Calibration to Peak Flood Level Data (May 2009)

Gauge ID	Location	Recorded Peak WL (mAHD)	Simulated Peak WL (mAHD)	Difference (m)
Wolston Creek				
BH100	U/S Wacol Station Road	~~4.11~~	~~5.62~~	~~1.51~~
WSE583	Stream Gauge	6.41	6.04	-0.37
BH110	D/S of Sandy Creek / Bullockhead Creek Confluence	6.43	6.38	-0.05
Bullockhead Creek				
BH120	400 m U/S of Spine Street	9.67	9.14	-0.53
BH130	U/S Sanananda Street	11.07	10.58	-0.49
BH140	Closed	-	-	-
BH150	80 m U/S of Bukulla Street	19.56	19.38	-0.18
BH160	40 m U/S Progress Road	21.01 (d)	20.76	-0.25
BH170	U/S Waterford Road	31.05	30.90	-0.15
BH180	U/S of Roxwell Street	-	39.07	-
Sandy Creek				
SW100	Closed	-	-	-
SW110	D/S Ipswich Motorway	-	12.91	-
SW120	D/S Progress Road	14.35	14.03	-0.32
SW130	130 m U/S Progress Road	15.18	14.84	-0.34
SW140	300 m U/S Campbell Avenue	18.01	18.10	0.09
SW150	100 m D/S Formation Street	19.08	18.83	-0.25
SW160	50 m U/S Formation Street	20.9	21.20	0.30

(d) Reading from debris mark

From review of the peak level / MHG results, it was apparent that at 7 out of 11 locations the desired peak flood level tolerance was able to be achieved. The recorded flood level at BH100 was disregarded, as there were considerable discrepancies and inconsistencies when compared with the upstream MHG records and with the other historical event MHG records in the vicinity.

At the stream gauge, the TUFLOW simulated peak flood level was outside the ± 0.15 m tolerance. The overall shape of the double peaked hydrograph was reasonable, however for both peaks, the TUFLOW flood peak occurred approximately 1 hour before the observed flood peak.

At most locations, the simulated flood level was less than the observed flood level and at two locations (BH110 and BH120) approximately 0.5 m lower. From review of the simulated flood hydrograph against the observed flood hydrograph at the stream gauge, it is apparent that there is considerably less flood volume for the simulated flood hydrograph. This is conceivable due to the highly variable rainfall experienced in the event (refer to Section 3.3.4) and the likelihood that the

Thiessen Polygon representation did not fully represent the actual rainfall distribution. This is the most likely explanation for the simulated flood levels being typically lower than the observed.

5.6 Hydraulic Model Verification Results

5.6.1 March 2017

The March 2017 flood was simulated in TUFLOW for 36 hours from 12 am on the 30th March 2017 to 12 noon on the 31st March 2017. Figure 5.5 provides a comparison between the TUFLOW (and URBS) results and the gauged flood level on Wolston Creek at 540378 (WSA584). Table 5.6 provides a comparison of the TUFLOW results and the recorded peak flood levels at the MHGs for which records were available

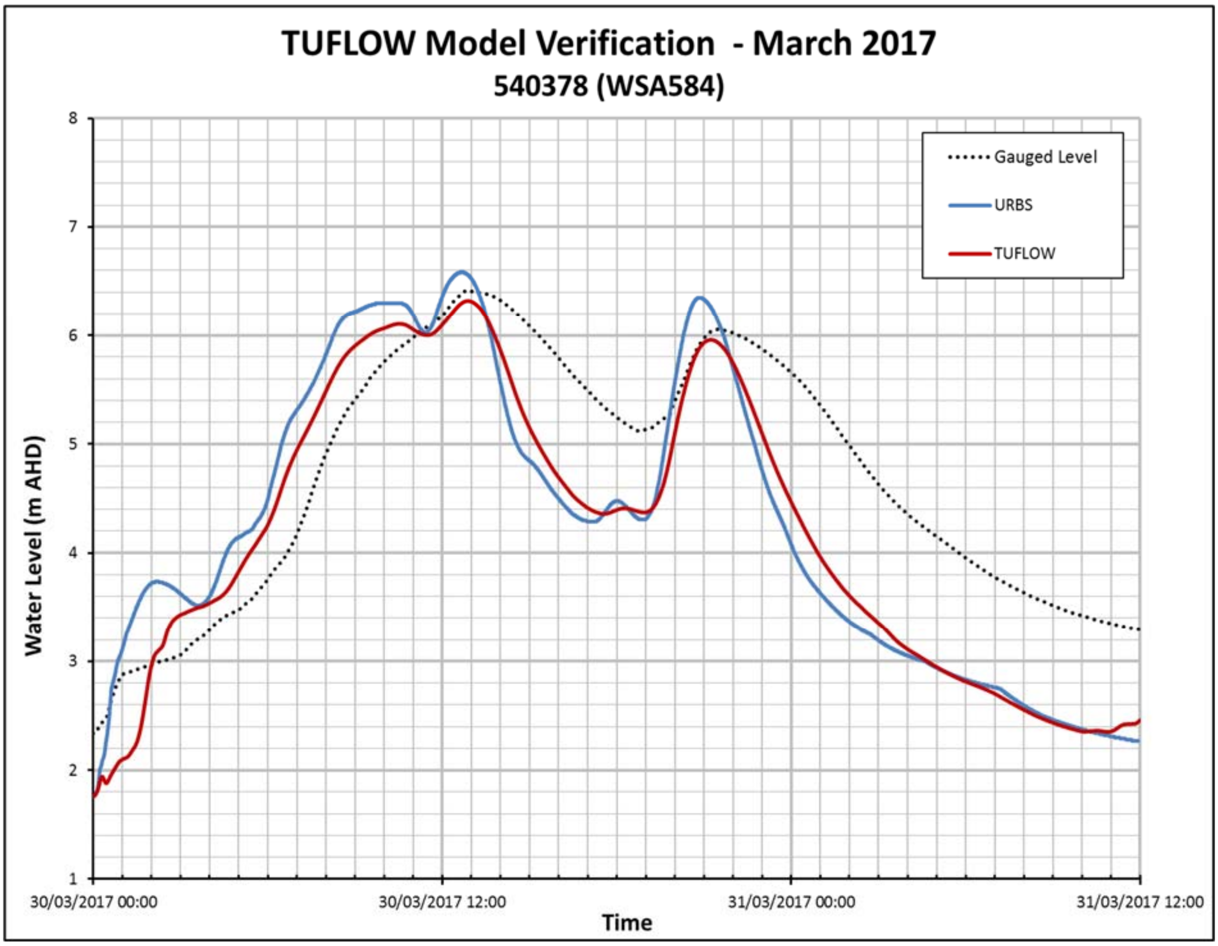

Figure 5.5: March 2017 TUFLOW Model Verification - Wolston Creek at 540378 (WSA584)

From review of the peak level / MHG results, it was apparent that at 6 out of 8 locations the desired peak flood level tolerance was able to be achieved.

At the stream gauge, the TUFLOW simulated peak flood level was within the ± 0.15 m tolerance. The overall shape of the TUFLOW hydrograph was fair and the timing of the TUFLOW flood peak was within 30 minutes for both peaks.

Table 5.6 – Calibration to Peak Flood Level Data (March 2017)

Gauge ID	Location	Recorded Peak WL (mAHD)	Simulated Peak WL (mAHD)	Difference (m)
Wolston Creek				
BH100	U/S Wacol Station Road	5.49	5.62	0.13
540378	Stream Gauge	6.42	6.32	-0.10
BH110	D/S of Sandy Creek / Bullockhead Creek Confluence	6.49	6.41	-0.08
Bullockhead Creek				
BH120	400 m U/S of Spine Street	9.77	9.73	-0.04
BH130	U/S Sanananda Street	11.30	11.89	0.59
BH140	Closed	-	-	-
BH150	80 m U/S of Bukulla Street	19.67	19.96	0.29
BH160	40 m U/S Progress Road	-	21.41	-
BH170	U/S Waterford Road	31.27	31.42	0.15
BH180	U/S of Roxwell Street	-	39.12	-
Sandy Creek				
SW100	Closed	-	-	-
SW110	D/S Ipswich Motorway	-	12.83	-
SW120	D/S Progress Road	-	14.01	-
SW130	130 m U/S Progress Road	15.00	14.85	-0.15
SW140	300 m U/S Campbell Avenue	-	18.19	-
SW150	100 m D/S Formation Street	-	18.98	-
SW160	50 m U/S Formation Street	21.00	21.41	0.41

5.7 Hydraulic Structure Verification

5.7.1 General

The TUFLOW manual recommends confirming the head-loss across hydraulic structures as follows:

It is strongly recommended that the losses through a structure be validated through:

- *Calibration to recorded information (if available).*
- *Cross-checked using desktop calculations based on theory and/or standard publications (e.g. Hydraulics of Bridge Waterways, US FHA 1973).*
- *Cross-checked with results using other hydraulic software.*

5.7.2 HEC-RAS Checks

It is common practice in BCC flood studies to cross-check structure head-losses against results from the HEC-RAS hydraulic modelling software. Generally, HEC-RAS is regarded as one of the better hydraulic modelling packages when it comes to more accurately representing hydraulic structures such as bridges. Many of the hydraulic structures within the catchment(s) are culverts, for which the TUFLOW and HEC-RAS algorithms would be reasonably similar. Therefore, it was considered more important to check the head-loss at a number of the bridge structures.

The bridge structures where HEC-RAS checks were undertaken included:

- Wacol Station Road (S1)
- Wolston Road (S2)
- Ipswich Motorway (S4a and S4b) – Sandy Creek
- Progress Road (S5)
- Spine Street (S10)
- Ipswich Motorway (S13a and S13b) – Bullockhead Creek
- Boundary Road (S15)
- Centenary Motorway (S19 and S20) – Bullockhead Creek
- Ipswich Motorway (S29a and S29b) – Ric Nattrass Creek
- Centenary Motorway (S32a,S32b and S32c) – Ric Nattrass Creek

Table 5.7 provides a comparison of the head-loss across the structure between TUFLOW and the HEC-RAS model. Generally, the TUFLOW head-losses for those bridge structures checked were within ± 0.3 m of the HEC-RAS values for the full range of flows considered. This is considered a good result and gives credence to the TUFLOW results.

Table 5.7 – HEC-RAS Bridge Head-loss Checks

Flow (m^3/s)	HEC-RAS Head-loss (m)	TUFLOW Head-loss (m)	Difference (m)
Structure S1 – Wacol Station Road			
103.8	0.18	0.37	-0.19
205.2	0.66	0.78	-0.12
298.8	0.48	0.54	-0.06
400.0	0.25	0.27	-0.02
500.1	0.14	0.11	0.03
607.6	0.09	0.09	0.00
705.2	0.07	0.08	-0.01
793.6	0.05	0.07	-0.02
Structures S2 – Wolston Road			
51.0	0.01	0.01	0.00
100.5	0.02	0.05	0.03
152.9	0.05	0.11	0.06
199.3	0.09	0.15	0.06
253.5	0.12	0.21	0.09
299.4	0.26	0.24	-0.02
365.8	0.64	0.73	0.09

Flow (m^3/s)	HEC-RAS Head-loss (m)	TUFLOW Head-loss (m)	Difference (m)
Structures S4a and S4b – Ipswich Motorway (Sandy Creek)			
49.9	0.34	0.33	-0.01
99.9	0.53	0.41	-0.12
150.7	0.74	0.81	0.07
199.8	0.92	1.20	0.28
248.3	2.05	1.46	-0.59 *
Structure S5 – Progress Road			
49.0	0.25	0.14	-0.11
98.6	0.27	0.19	-0.08
149.8	0.89	0.83	-0.06
199.1	0.77	0.83	0.06
236.9	0.53	0.62	0.09
Structure S10 – Spine Street			
54.1	0.06	0.07	0.01
104.6	0.09	0.09	0.00
201.5	0.12	0.11	-0.01
300.0	0.15	0.13	-0.02
400.1	0.17	0.16	-0.01
500.6	0.20	0.16	-0.04
Structures S13a and S13b – Ipswich Motorway (Bullockhead Creek)			
50.8	0.24	0.31	0.07
102.0	0.32	0.35	0.03
150.9	0.41	0.50	0.09
201.1	0.50	0.65	0.15
248.0	0.52	0.62	0.10
302.8	1.07	0.84	-0.23
350.9	1.43	1.13	-0.30
Structure S15 – Boundary Street			
52.8	0.38	0.44	0.06
99.7	0.43	0.39	-0.04
152.7	0.35	0.41	0.06
202.0	0.36	0.42	0.06
252.4	0.42	0.50	0.08
301.6	0.43	0.54	0.11
350.4	0.41	0.53	0.12
Structures S19 and S20 – Centenary Motorway (Bullockhead Creek)			
50.0	0.89	1.01	0.12
99.9	1.17	1.13	-0.04
149.5	1.26	1.26	0.00
203.6	1.42	1.20	-0.22
250.1	1.48	1.18	-0.30
301.3	1.54	1.23	-0.31
352.0	1.68	1.35	-0.33

Flow (m^3/s)	HEC-RAS Head-loss (m)	TUFLOW Head-loss (m)	Difference (m)
Structures S29a and S29b – Ipswich Motorway (Ric Nattrass Creek)			
26.3	0.70	0.77	0.07
51.6	0.25	0.35	0.10
77.0	0.38	0.45	0.07
99.2	0.54	0.51	-0.03
125.7	0.74	0.68	-0.06
181.4	1.22	0.38	-0.84 *
221.5	1.34	0.82	-0.52 *
285.0	1.39	1.41	0.02
Structures S32a, S32c and S32c – Centenary Motorway (Ric Nattrass Creek)			
24.6	0.65	0.40	-0.25
49.9	0.61	0.49	-0.12
74.6	0.77	0.59	-0.18
99.4	1.15	0.92	-0.23
124.5	1.31	1.38	0.07
149.1	1.64	1.80	0.16
174.3	1.87	2.03	0.16

* Considerable differences between TUFLOW and HEC-RAS values

The asterisked values indicate flow magnitudes where there was considerable difference between the TUFLOW and HEC-RAS head-loss values. These differences are discussed below:

Ipswich Motorway – Sandy Creek (S4a and S4b)

At flows of approximately 250 m^3/s, there are head-loss differences greater than 0.3 m between the TUFLOW and HEC-RAS results. On closer inspection of the results of both models, it is apparent that this is because the downstream flood level is around the soffit level of the downstream Ipswich Road Bridge. Sharp increases in head-loss typically occur once the water surface comes into contact (or approaches) the bridge soffit and the hydraulic model simulates fully pressurised flow through the bridge opening. Differences in head-loss when the water surface is around the bridge soffit level are common between models, as each uses different criteria for changing to and representing pressurised flow. At this flow value, the HEC-RAS model is using fully pressurised flow equations to represent the Ipswich Road Bridge whereas the TUFLOW model is only representing partially pressurised flow due to the 3d representation of the sloping soffit of the bridge(s) not being in full contact with the water surface level. HEC-RAS changes to pressurised flow when the upstream total energy line (or optionally the upstream water surface) comes into contact with the bridge soffit and in the case of a sloping soffit; this is the lowest soffit level.

Ipswich Motorway – Ric Nattrass Creek (S29a and S29b)

At flows of approximately 180 m^3/s and 220 m^3/s, there are head-loss differences greater than 0.3 m between the TUFLOW and HEC-RAS results. The reason for these differences is similar to discussed above, where one model (HEC-RAS) is representing pressurised flow and the other model (TUFLOW) is not. Results better align when the flows are higher (i.e. 285 m^3/s) and both models are simulating pressurised flow conditions through the bridge opening.

5.7.3 EPA-SWMM Check

The EPA-SWMM drainage model was used to check the head-loss across the Roxwell Street Culvert on Spinks Creek. The structure is described in Section 5.3.4 and incorporates hydraulic controls at the inlets of the three culvert cells. It was considered that a drainage type model would be more suitable then HEC-RAS to check the head-losses for this structure. The EPA-SWMM model checks considered flows up to the overtopping of the road embankment.

Table 5.8 provides a comparison of the head-loss across the structure between TUFLOW and the EPA-SWMM model. The head-loss differences between the two models is within the specified tolerance of ± 0.3 m for the range of flows considered.

Table 5.8 – EPA-SWMM Roxwell Street Culvert Head-loss Check

Flow (m^3/s)	EPA-SWMM Head-loss (m)	TUFLOW Head-loss (m)	Difference (m)
5.1	1.48	1.60	0.12
10.3	1.87	1.94	0.07
15.2	2.03	2.00	-0.03
20.1	2.36	2.21	-0.15

5.8 Hydrologic-Hydraulic Model Consistency Checks (Historical Events)

5.8.1 General

Comparison checks were undertaken between the URBS and TUFLOW models to understand how closely the hydrologic and hydraulic models were matching and as a means of confirming whether the URBS model was adequately calibrated. The locations where comparative plots were undertaken are as follows:

(i) Sandy Creek – Formation Street
(ii) Sandy Creek – Ipswich Motorway
(iii) Sandy Creek – Wolston Road
(iv) Bullockhead Creek – Centenary Motorway
(v) Bullockhead Creek – Ipswich Motorway
(vi) Bullockhead Creek – Ipswich Railway
(vii) Ric Nattrass Creek – Centenary Motorway
(viii) Wolston Creek – Wacol Station Road
(ix) Wolston Creek – Catchment Outlet

Figure 5.6 to Figure 5.13 provide comparative plots for the Ipswich Motorway crossings of Sandy Creek and Bullockhead Creek. The remainder of the comparative plots are provided in Appendix D.

Table 5.9 provides a comparison of the peak flows at these nine locations plus one additional location.

Table 5.9 – Peak Flow Comparison, URBS and TUFLOW

Location	Model	Peak Flow (m^3/s)			
		March 2017	May 2015	Jan 2013	May 2009
Sandy Creek at Formation Street	URBS	77.8	86.2	83.0	65.2
	TUFLOW	76.9	84.8	82.3	64.6
Sandy Creek at Ipswich Motorway	URBS	93.3	110.0	105.7	102.9
	TUFLOW	89.8	106.4	101.4	88.7
Sandy Creek at Wolston Road	URBS	99.0	121.8	118.6	122.1
	TUFLOW	94.9	116.2	113.7	113.7
Bullockhead Creek at Centenary Motorway	URBS	96.0	73.5	66.6	51.4
	TUFLOW	94.0	72.5	65.6	50.3
Bullockhead Creek at Ipswich Motorway	URBS	120.2	93.1	86.4	60.8
	TUFLOW	118.2	93.2	84.8	60.0
Bullockhead Creek at Ipswich Railway	URBS	160.4	136.1	122.0	88.3
	TUFLOW	155.8	129.1	116.6	82.7
Ric Nattrass Creek at Centenary Motorway	URBS	33.3	23.4	22.0	18.4
	TUFLOW	32.7	23.2	20.9	17.8
Ric Nattrass Creek at Ipswich Motorway	URBS	52.3	36.6	33.7	27.9
	TUFLOW	51.5	36.5	32.6	26.2
Wolston Creek – Wacol Station Road	URBS	208.8	263.7	250.8	218.6
	TUFLOW	195.3	246.7	233.9	191.2
Wolston Creek – Catchment Outlet	URBS	214.9	286.9	269.0	235.9
	TUFLOW	200.3	267.6	247.6	210.4

The results of the comparison indicate that the URBS and TUFLOW models show a good correlation with peak flow and hydrograph timing / shape throughout the model. Based on the good correlation between URBS and TUFLOW, it is considered that the URBS model would be suitable for use as a ‘standalone’ model on the basis that there are not considerable backwater effects from the Brisbane River. If there are backwater effects, then the hydraulic model would be more suitable for generating accurate flows / flood levels.

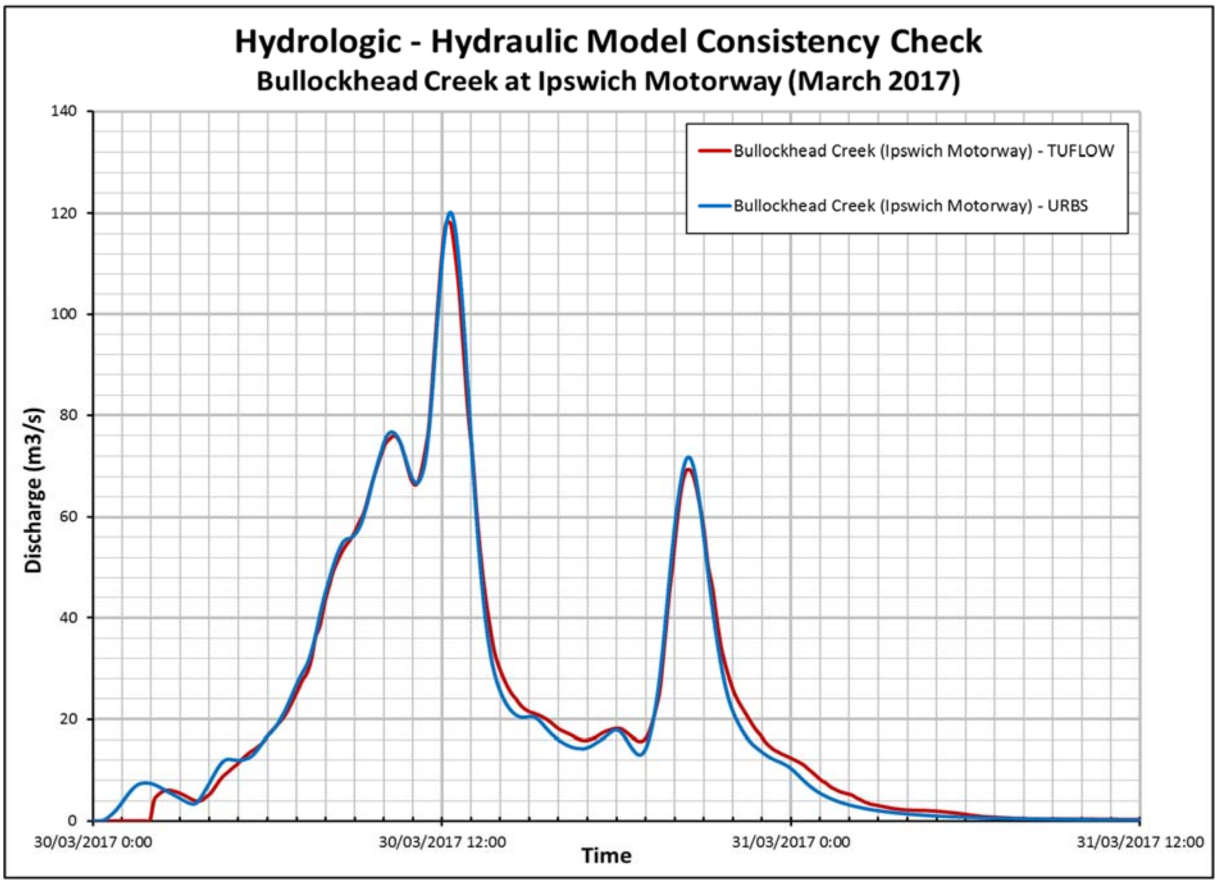

Figure 5.6: Bullockhead Creek at Ipswich Motorway (March 2017)

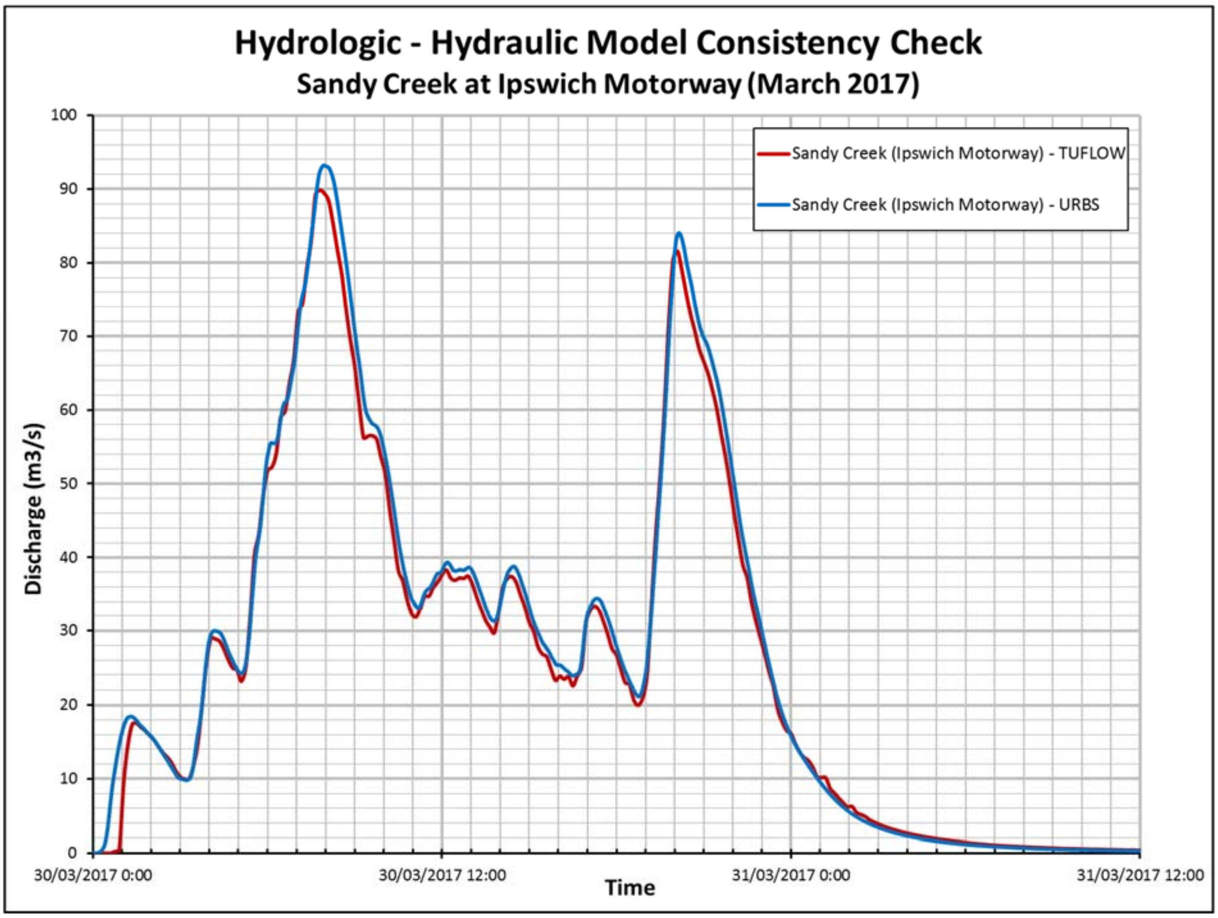

Figure 5.7: Sandy Creek at Ipswich Motorway (March 2017)

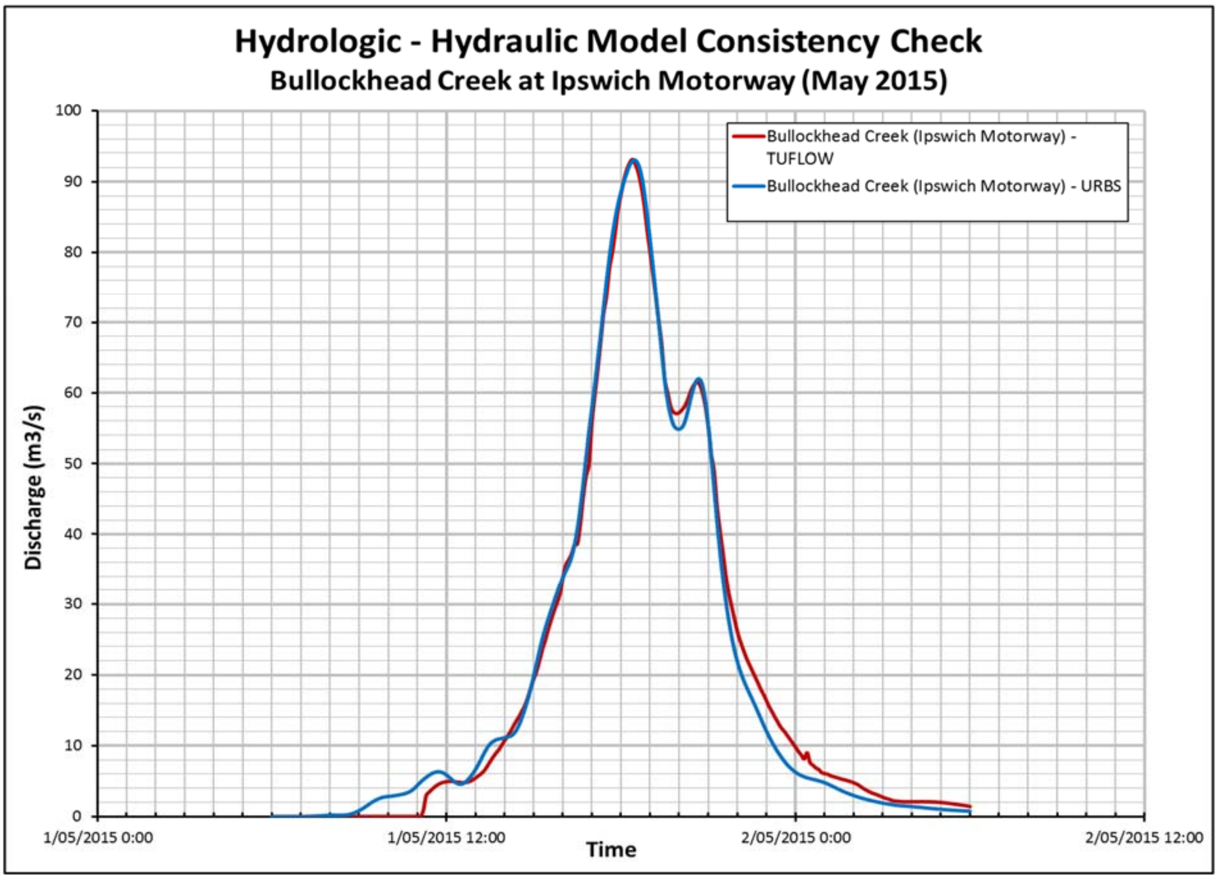

Figure 5.8: Bullockhead Creek at Ipswich Motorway (May 2015)

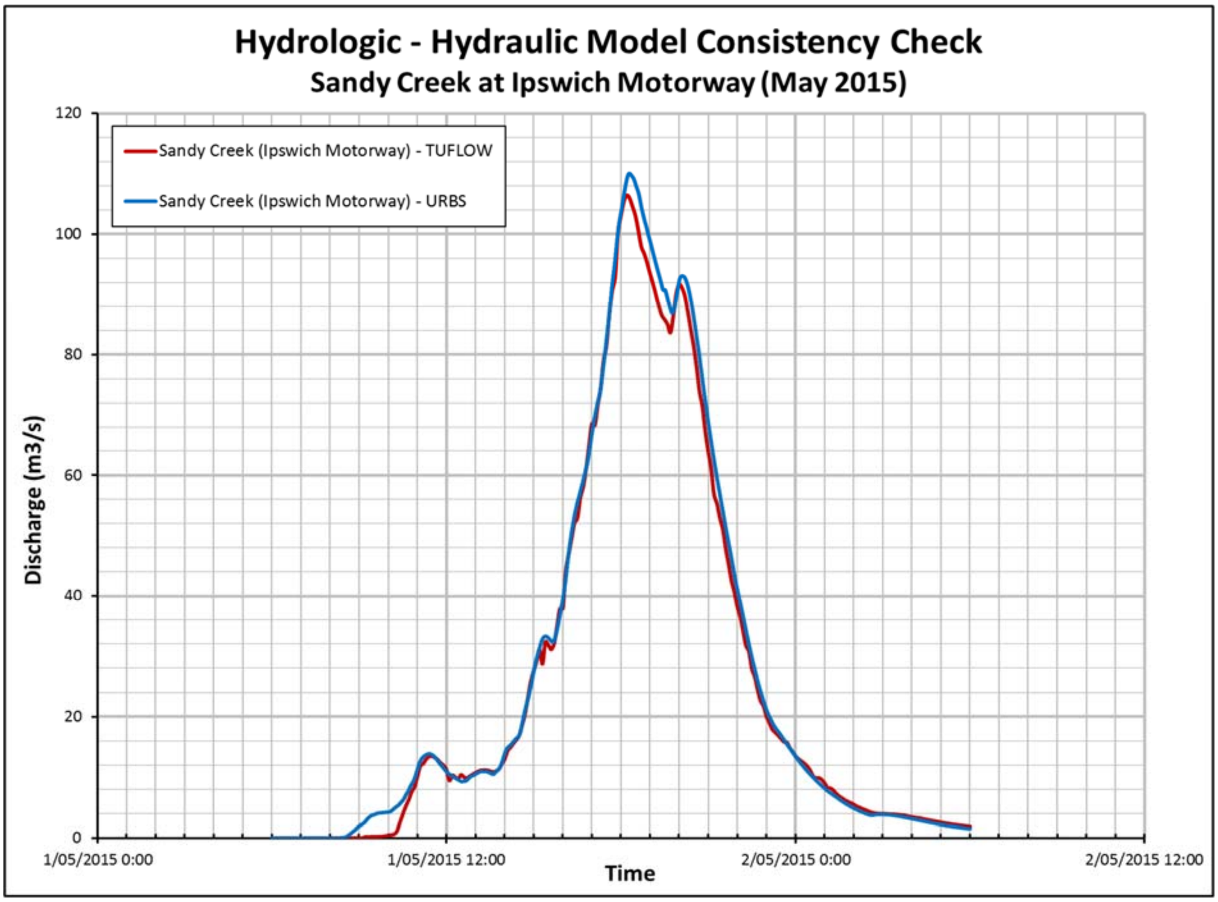

Figure 5.9: Sandy Creek at Ipswich Motorway (May 2015)

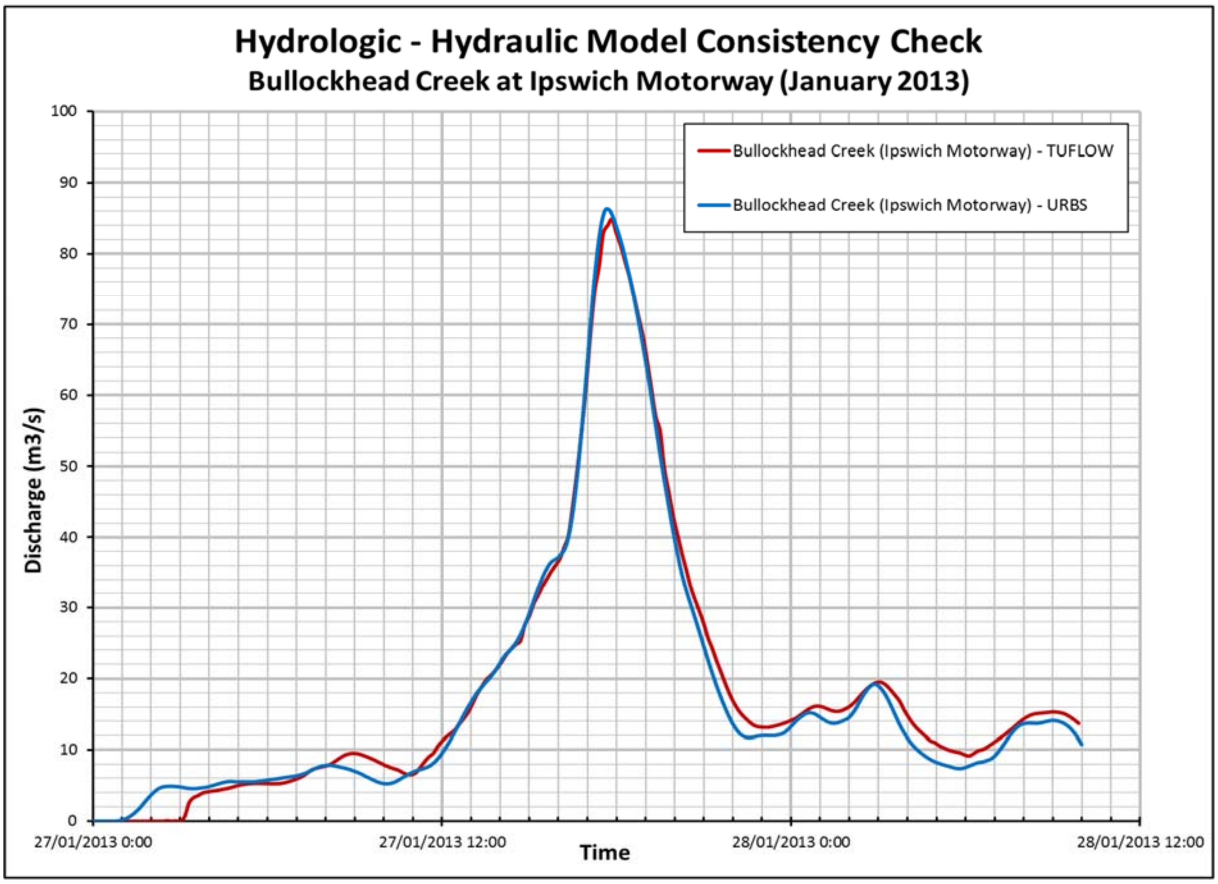

Figure 5.10: Bullockhead Creek at Ipswich Motorway (January 2013)

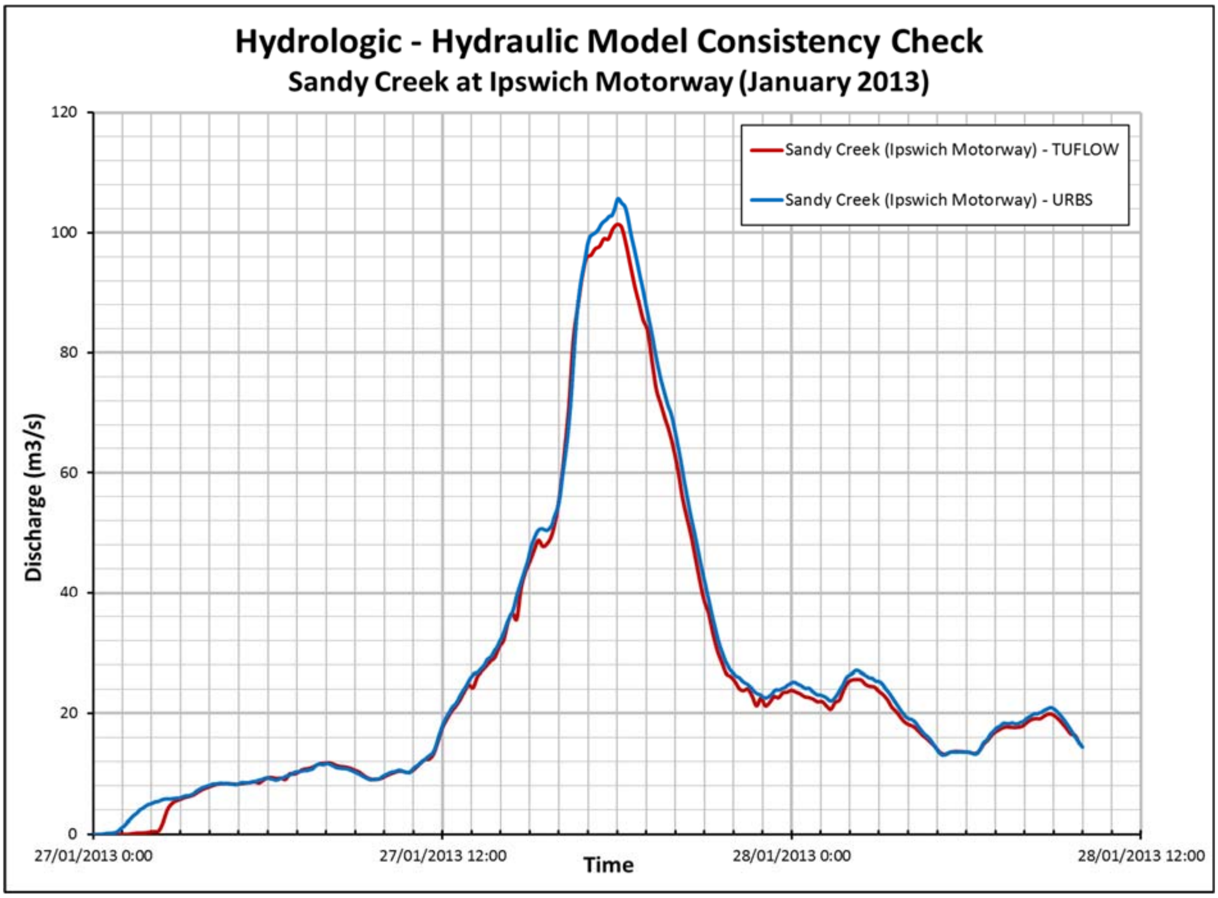

Figure 5.11: Sandy Creek at Ipswich Motorway (January 2013)

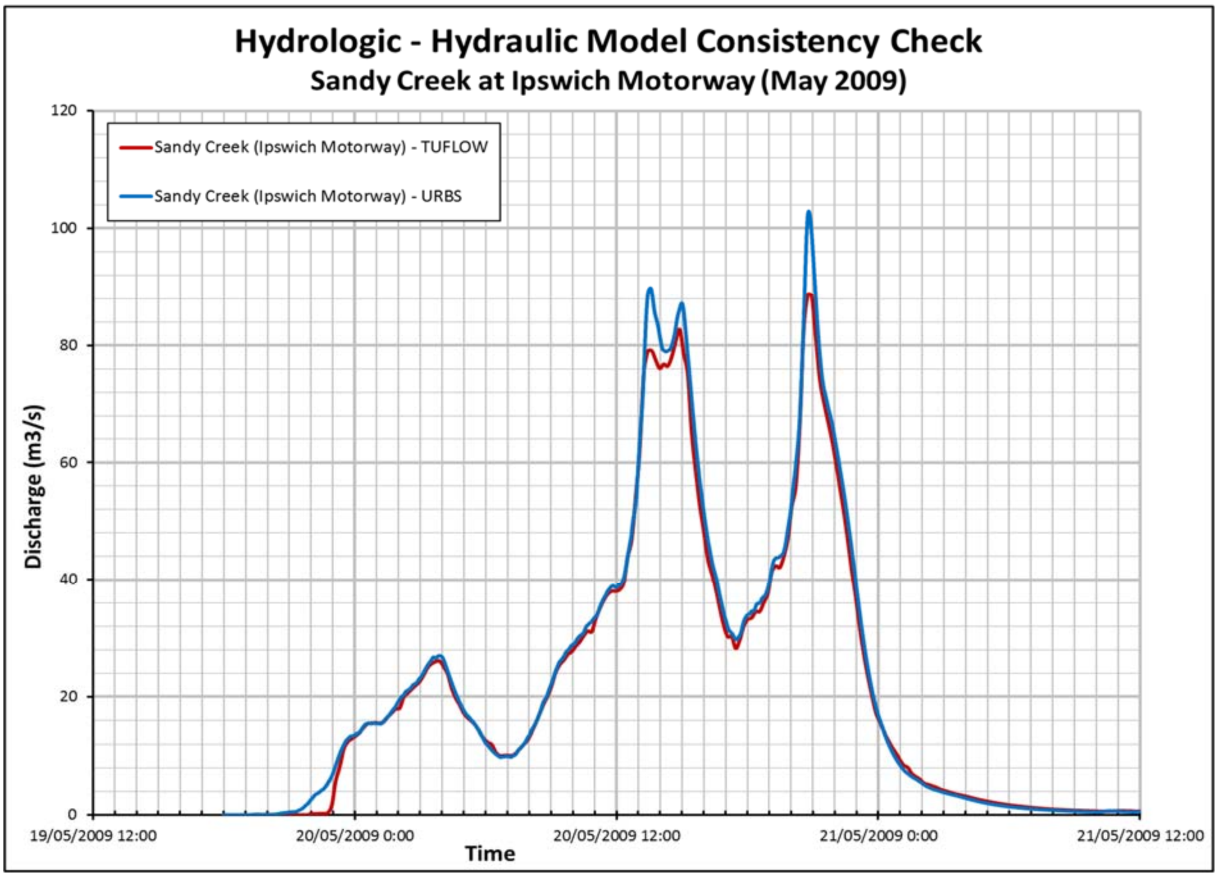

Figure 5.12: Bullockhead Creek at Ipswich Motorway (May 2009)

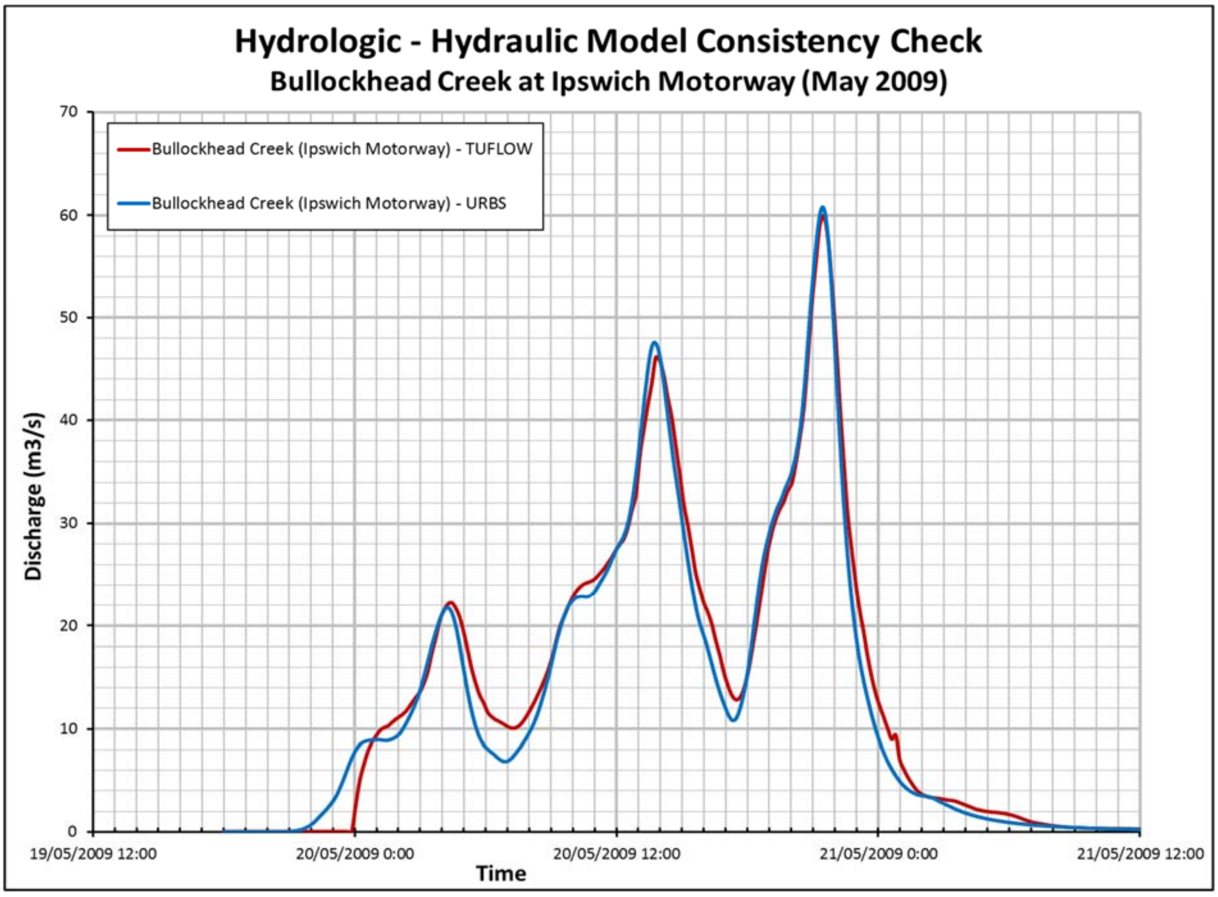

Figure 5.13: Sandy Creek at Ipswich Motorway (May 2009)

5.9 Discussion on Calibration and Verification

The results of the calibration and verification are considered acceptable and there is confidence that the hydrologic and hydraulic models would be suitable for producing accurate flood levels for the full range of design floods.

Generally, the calibration / verification results were better for the historical flooding events that had consistent rainfall depths throughout the catchment. Those events that had the most consistent rainfall depths were the May 2015 and January 2013 events.

The replication of peak flood levels to within the desired tolerance at the MHGs was very good with the following being achieved:

- May 2015 – successful replication at 9 out of 10 MHGs
- January 2013 – successful replication at 7 out of 7 MHGs
- May 2009 – successful replication at 7 out of 11 MHGs
- March 2017 – successful replication at 6 out of 8 MHGs

The shape and timing of the simulated flood hydrograph at the stream gauge(s) was acceptable with the better results occurring for the May 2015 and January 2013 events. For all four historical events, the timing of the peak was of the order of 1 hour to 1.5 hours before the actual peak.

The flood volumes were within an acceptable range for all of the historical events apart from the May 2009 event for which the simulated flood volume was too low. The peak flood level results for this event were typically lower than the recorded values, which appears to suggest that there was insufficient rainfall and hence flow in the URBS model. From review of the rainfall records, this event had a significant variation of rainfall depth across the catchment and it is likely that the adopted Thiessen polygon distribution of rainfall across the URBS sub-catchments was not realistic, resulting in the simulation of less intense rainfall and lower flows than actually occurred.

The March 2017 and November 2009 events had double peaked hydrographs and the simulated results were able to replicate these occurrences; noting the timing of the peak as discussed above.

As part of the calibration, investigations were undertaken to determine whether it was possible to improve the shape and timing of the hydrographs, whilst maintaining the good replication of the MHG records. These focussed on significant testing of the URBS Catchment Lag Parameter (β) and the URBS Catchment Non-linearity Parameter (m) to increase the storage and slow down the flow.

The URBS Manual advises that the standard range for β is 1 to 9; the adopted value of 4 is within this range. Increasing the catchment storage by increasing the value of β from 4 to 9 improves the timing of the peaks, however for the May 2015 and May 2009 events, results in significantly less flow throughout the model, such that it would be difficult to match any of the MHG records. It's worthwhile considering that the May 2015 event has the most consistent rainfall depths across the catchment, so the inability to match the MHG records is unlikely to be able to be attributed to rainfall distribution issues, like can possibly be attributed to the May 2009 event.

The standard range for m is 0.6 to 1.0; the adopted value of 0.65 is within this range. Increasing the catchment storage by increasing the value of m from 0.65 to 1 slightly improves the timing of the peaks, however similar to increasing the β value; it would be more difficult to match the MHG records for the May 2015 and May 2009 events, which already have flood levels that are typically on the low side. The recently completed flood studies of Moggill Creek and Cubberla Creek adopted a calibrated m value of 0.65.

The 1996 Flood Study adopted a calibrated β = 7 and m = 0.6, however, when the flood model(s) were subsequently tested against the May 1996 flooding (as part of the 2000 WQA) the simulated peak flood levels were consistently too low throughout the catchment and unable to replicate the MHG records. This is possibly suggesting that the calibrated value of β = 7 was too high.

The adopted URBS parameters of β = 4 and m = 0.65 give the best average results across the catchment when considering both the stream gauge results and the MHG results for the four historical events.

To assist the improvement of the hydrograph shape / timing, it is recommended that a separate stream gauge be installed in both Sandy Creek and Bullockhead Creek. These gauges would help identify where the timing issue(s) originates and would be beneficial in improving the overall hydrograph shape / timing.

In addition, given that the historical events were all of a minor nature, it would be prudent to further verify the hydrologic and hydraulic models, when a large flooding event occurs.

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6.0 Design Event Analysis

6.1 Design Event Scenarios

Table 6.1 indicates the three scenarios utilised in the modelling of the design events, noting that all design event scenarios were modelled using ultimate hydrological conditions.

For the purpose of this report, the term "design events" refers to those events from 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP).

Table 6.1 – Design Event Scenarios

ARI (year)	AEP (%)	Scenario 1	Scenario 2	Scenario 3
2	50	✓	✗	✓
5	20	✓	✗	✓
10	10	✓	✗	✓
20	5	✓	✗	✓
50	2	✓	✗	✓
100	1	✓	✓	✓

The following describes the design event scenarios:

Scenario 1: Existing Waterway Conditions
Scenario 1 is based on the current waterway conditions. Some minor modifications were made to the TUFLOW model developed as part of the calibration / verification; refer to Section 6.3 for further details.

Scenario 2: Minimum Riparian Corridor (MRC)
Scenario 2 includes an allowance for a riparian corridor along the edge of the channel. This involved firstly reviewing the existing vegetation and land-use adjacent to the channel to determine an appropriate Manning's 'n' roughness value for the riparian corridor. In most locations the default value of n = 0.15 was used, however where the existing Manning's 'n' is higher than n = 0.15, the Manning's 'n' was left unchanged.

A 30 m wide corridor (15m wide each side from the low flow channel) was defined by changing the Manning's 'n' roughness of the 1d cross sections (as applicable) and a new 2d materials layer within the TUFLOW model. In areas where the 15 m width was not available, the MRC was set to the maximum possible width (i.e. up to 15 m) up to the boundary of the "Modelled Flood Corridor."

Scenario 3: Filling to the Modelled Flood Corridor + Minimum Riparian Corridor (MRC)
The "Modelled Flood Corridor" is the greater extent of the Waterway Corridor (WC) and Flood Planning Areas (FPAs) 1, 2 and 3. Figure 6.1 indicates the "Modelled Flood Corridor" for all creeks.

Scenario 3 assumes filling to the "Modelled Flood Corridor" boundary to represent potential development. In the design events, 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP), the filling acts as a barrier and the "Modelled Flood Corridor" can be modelled simplistically as a glass-wall of infinite height. This is a simple and conservative assumption used to develop design planning levels. It does not necessarily reflect allowable development assumptions under BCC City Plan.

6.2 Design Event Hydrology

6.2.1 Background

The recent update of Australian Rainfall and Runoff (AR&R 2016) [6] has resulted in significant changes with respect to the hydrological methods when compared to the previous version (AR&R 1987) [7]. This study utilises the AR&R 2016 approach to design flood estimation, which is detailed in the following sections.

6.2.2 Suitability of Flood Frequency Analysis

Design flood estimation is generally best determined by undertaking some form of flood frequency analysis (FFA) of annual maximum and / or peak over threshold (POT) series from observed long-term stream flow records. If FFA is not suitable, then the other established method used to estimate the design flood is the rainfall (event) based design storm concept, common to both AR&R 1987 and AR&R 2016.

Since 1978, there has been a stream gauge in the lower section of the catchment in Wolston Creek, resulting in approximately 39 years of records. A requirement of FFA is that the catchment is homogeneous and has not undergone change, for example development / urbanisation. From review of the historical aerial photography, it is apparent that the catchment urbanisation has been steadily increasing since 1978. Whilst there is likely to have been some statutory development controls applied to the catchment development to reduce the urbanised runoff (e.g. detention basins), it is considered that if the same storm occurred in 1978 and 2017 that the resultant flooding would not be the same due to the degree of urbanisation which has taken place within this period.

For this reason, it was not considered suitable to undertake FFA based on recorded floods within the catchment. The MHG records are not suitable for statistical analysis due to the random nature of the sampling interval, which could range from numerous times a year during a wet year to many years apart during times of drought. Manual reading at each MHG is also discretionary and not dependent on, for example, exceeding a nominated flood level.

Regional Flood Frequency Estimation was not considered, as the catchment is deemed unsuitable because of the high degree of urbanisation.

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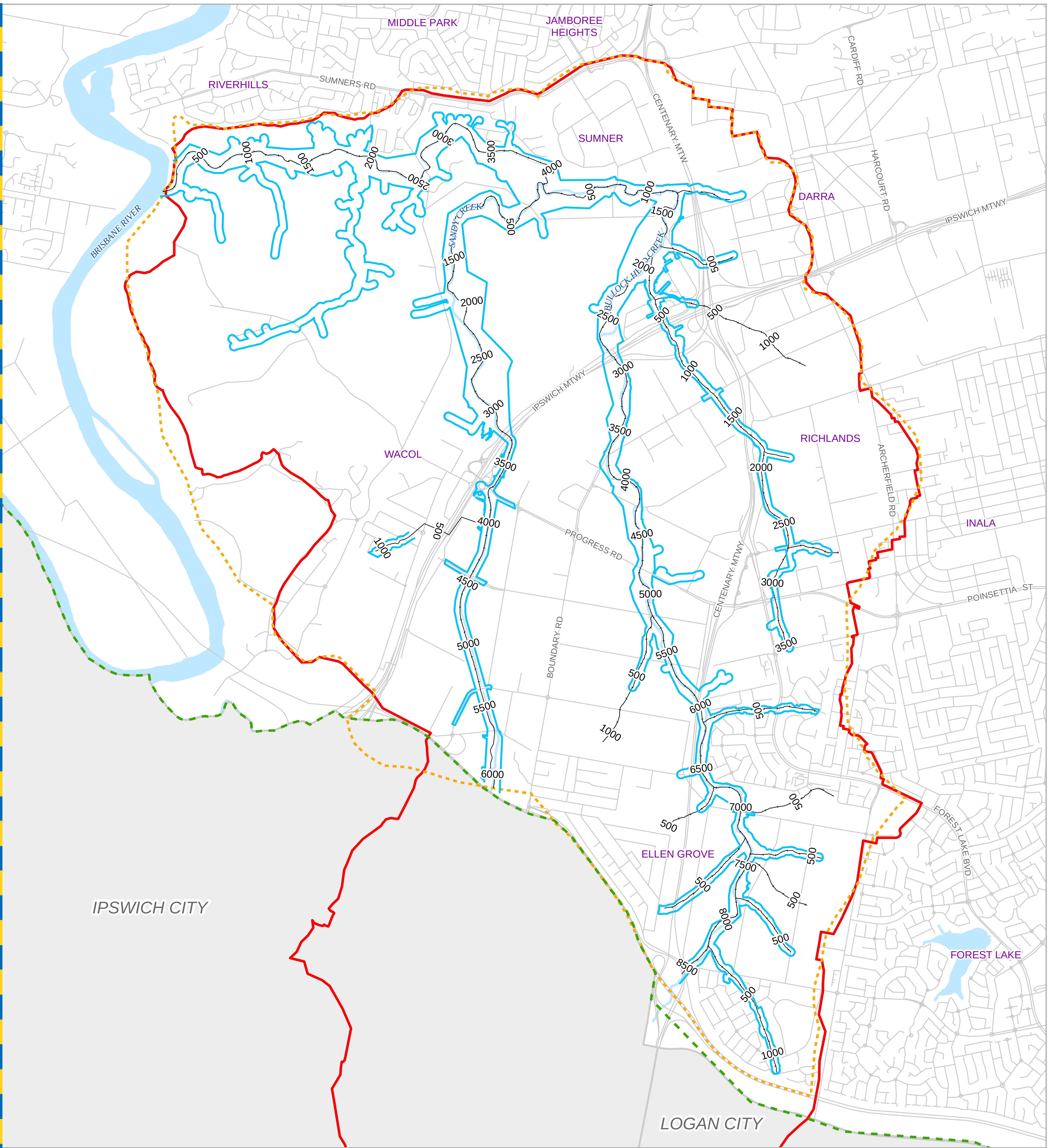
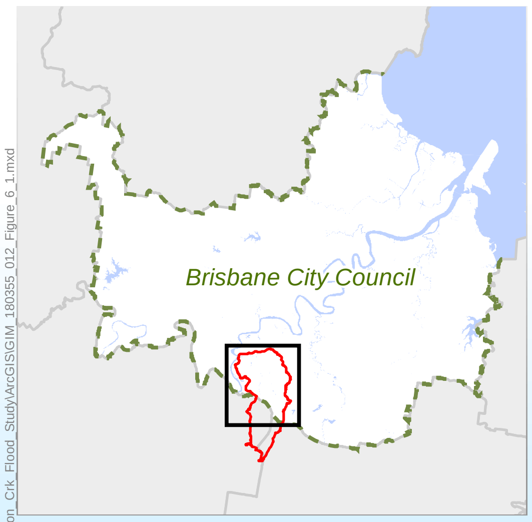
[6] Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) - Australian Rainfall and Runoff: A Guide to Flood Estimation, © Commonwealth of Australia (Geoscience Australia), 2016.
[7] Institution of Engineers, Australia – Australian Rainfall and Runoff: A Guide to Flood Estimation (Volume 1), 1987.





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Meters

Legend

- AMTD
- Flood Corridor
- Road
- Brisbane Boundary
- Model Boundary
- Catchment Area
- Other LGA

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DATA INFORMATION

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Prepared :	104515
Checked :	JS
Revision :	0
Publication Date :	08 Jun 2018
Project Number :	180355

Wolston Creek Flood Study

Figure 6.1: Modelled Flood Corridor

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6.2.3 Rainfall (Event) Based Flood Estimation

The use of event-based approaches to derive design floods is common to both AR&R 1987 and AR&R 2016 and most overseas countries. A major difference between AR&R 1987 and AR&R 2016 is the move away from a 'simple' event based approach to the more complex 'ensemble' and 'monte-carlo' methods. Figure 6.2 (from AR&R 2016) illustrates the major differences between these approaches.

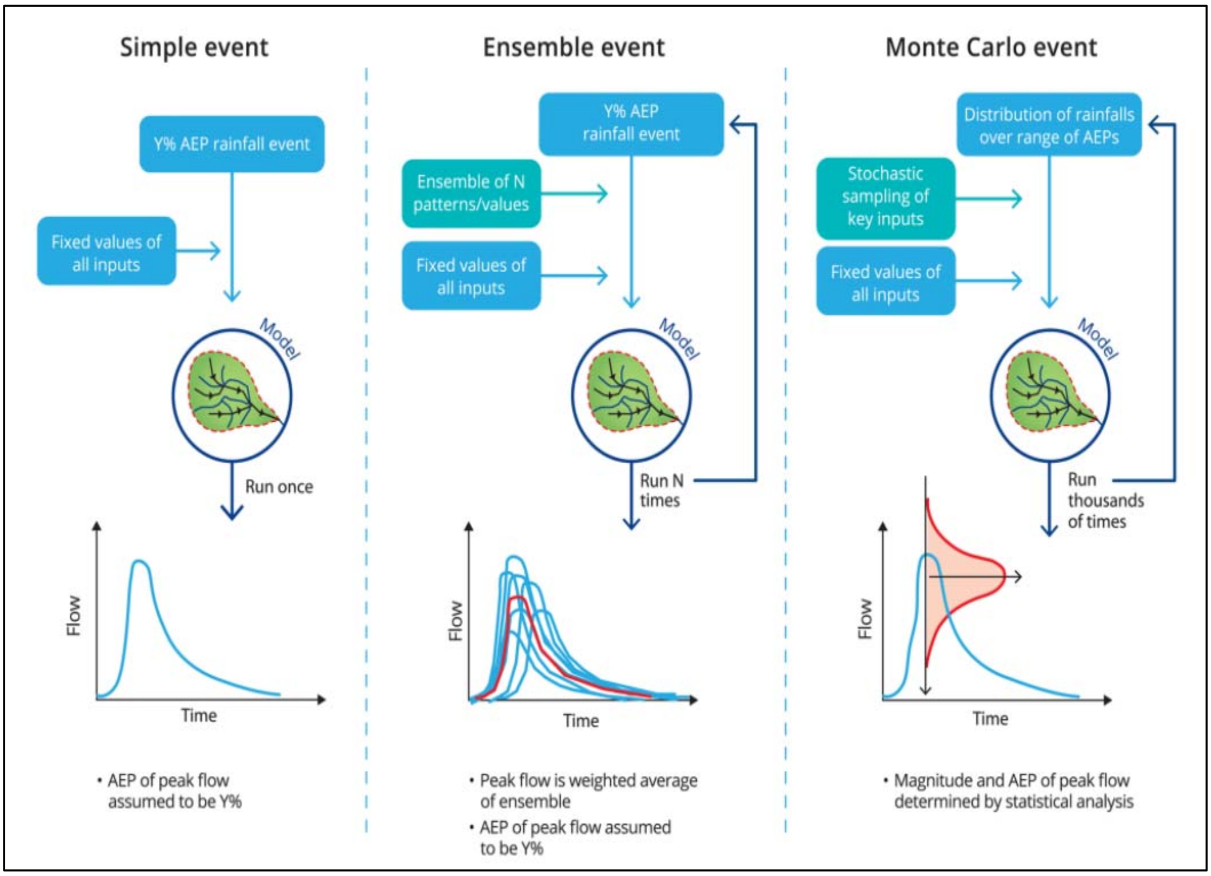

Figure 6.2: Differing Hydrological Methods

For the purpose of this flood study, the AR&R 2016 Ensemble Design Event Approach (DEA AR&R 2016) was adopted for use. This is consistent with the current BCC Flood Study Procedure document.

6.2.4 Major Differences between DEA AR&R 2016 and AR&R 1987

The DEA AR&R 2016 represents a significant change from the DEA AR&R 1987 with the move from a single event to an ensemble event approach. The major changes are listed below:

- Pre-burst Rainfall – new as part of AR&R 2016 and used to reduce the Storm Burst Initial Loss (IL_b) to account for pre-burst rainfall occurring prior to the main storm burst.
- Temporal Patterns – updated as part of AR&R 2016 with the most significant change being that there are now 10 patterns (ensembles) per duration for each of the four temporal pattern ranges; namely frequent, intermediate, rare and very rare. AR&R 1987 used one temporal

pattern per duration for ARI ≤ 30 years and one temporal pattern per duration for ARI > 30 years.

- Areal Reduction Factor (ARF) – updated as part of AR&R 2016 with the recommendation to apply to catchments greater than 1 km^2. AR&R 1987 advocated the use of ARFs, however there was little supporting practitioner guidance.
- Rainfall Losses – updated as part of AR&R 2016 with distinction now provided between the Storm Event Initial Loss (IL_s) and the Burst Initial Loss (IL_b). Generic values for the IL_s and the Continuing Loss (CL) are now provided for most geographic regions in Australia (refer to AR&R 2016 Data Hub: http://data.arr-software.org/). However, the AR&R 2016 Data Hub states that these loss values are only for rural use and not for use in urban areas.
- Baseflow – updated as part of AR&R 2016 with the recommendation to consider the inclusion of baseflow for rural catchments. AR&R 1987 guidance was non-prescriptive with regard to the inclusion of baseflow.
- IFD Data – new IFD data was released as part of AR&R 2016. This data supersedes both the 2013 Interim and AR&R 1987 IFD data.

6.2.5 Adopted Methodology for the DEA AR&R 2016

AR&R 2016 (Book 1, Table 1.3.2) recommends the use of a simple average (or median value) to represent the flood magnitude at a location within the catchment. AR&R 2016 (Book 2 Section 5.9.2) also advises that "*it is not recommended that the temporal pattern that represents the worst (or best) case be used itself for design*." The methodology used for undertaking the design hydrology is as follows:

- Obtain the relevant URBS input data from the AR&R 2016 Data Hub, using the catchment centroid coordinates
- Populate the URBS model from the Data Hub information. This is an automated process undertaken within URBS. Refer to Section 6.2.6 for further details on the URBS parameters used.
- Run the ten ensembles in URBS for durations 30 minute to 4.5 hours and ARIs (AEPs) 2-yr (50 %) to 100-yr (1 %).
- Select the representative design flow at the location of interest. For this analysis, the representative design flow was adopted as the median flow from the ten ensembles for the critical duration at the location of interest.

6.2.6 URBS Model Set-up

The calibrated URBS model was used to simulate the design storm rainfall-runoff and sub-catchment routing process. The following describes the parameters used and the adjustments made to the calibration model in order to simulate the design events.

Catchment Development

The design events were modelled using ultimate catchment hydrological conditions. These conditions assume that the state of development within the catchment is at its ultimate condition, with reference to the current adopted planning scheme. Depending on the developed state of the catchment, an increase in development will typically increase the impervious land-use factors.

Appendix B presents the URBS catchment parameters that were adopted for the design event modelling scenarios. The current adopted version of BCC City Plan (2014) was used to establish the ultimate catchment hydrological conditions. The adopted land-use for the ultimate catchment development is shown on a catchment map in Appendix C.

Design IFD Data

Design rainfall depth / intensity data was obtained from the Bureau of Meteorology (BOM) website, based on AR&R 2016. Table 6.2 indicates the adopted design IFD data, which was extracted at the centroid of the catchment.

Checks were undertaken at some selected locations around the catchment, from which it was ascertained that there was only a small variation in design rainfall depth throughout the catchment. On this basis, it was deemed appropriate to adopt a consistent design rainfall depth throughout the catchment.

Table 6.2 – Adopted Design Event IFD Data

Duration (hrs)	Rainfall Intensity (mm/hr)					
	2-yr ARI (50 % AEP)	5-yr ARI (20 % AEP)	10-yr ARI (10 % AEP)	20-yr ARI (5 % AEP)	50-yr ARI (2 % AEP)	100-yr ARI (1 % AEP)
0.5	57.4	79.4	94.1	108	127	142
1	36.6	50.8	60.6	70.3	83.2	93.2
1.5	27.6	38.3	45.8	53.4	63.5	71.4
2	22.5	31.2	37.4	43.7	52.1	58.8
3	16.9	23.4	28.1	32.8	39.3	44.5
4.5	12.7	17.6	21.2	24.8	29.8	33.8
6	10.4	14.5	17.4	20.4	24.5	27.8

Burst Initial Loss (IL_b)

The Burst Initial Loss (IL_b) = Storm Initial Loss (IL_s) – pre-burst rainfall.

- IL_b (impervious area) – a value of 0 mm was adopted for the impervious areas within the catchment, which is the URBS default value.
- IL_b (pervious areas) – AR&R 2016 Data Hub provides a Storm Event Initial Loss (IL_s) value of 25 mm as being representative for the geographical region in which this catchment is located. However, the AR&R 2016 Data Hub advises that this loss value is only for rural use and not for use in urban areas. AR&R 2016 (Section 3.5.3.3) recommends to adopt the losses for urban pervious areas from the loss values for rural catchments, taken from the AR&R 2016 Data Hub in the absence of better information. As there is some uncertainty regarding the appropriate IL_b (pervious) value to use, a comparative analysis was undertaken to understand the sensitivity of this selection on the results; which is presented in Section 6.2.7.

Continuing Loss (CL)

The following values were adopted for the Continuing Loss:

- CL (impervious area) – a value of 0 mm/hr was adopted for the impervious areas within the catchment, which is the URBS default value.
- CL (pervious area) – AR&R 2016 Data Hub provides a CL (pervious) value of 1.1 mm/hr as being representative for the geographical region in which this catchment is located. However, this was replaced by a value of 1.5 mm/hr from the results of the calibration and verification process.

Areal Reduction Factor

The advice from AR&R 2016 is that Areal Reduction Factors (ARFs) should be considered for catchments with an area of at least 1 km^2. The formula below is appropriate for catchments between 10 km^2 and 1000 km^2.

$$ARF = Min\left[1, 1 - 0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right) . Duration^{-0.36} + 2.26 \text{ x } 10^{-3} \text{ x } Area^{0.226} . Duration^{0.125}\,(0.3 + \log_{10}(AEP)) + 0.0141 \text{ x } Area^{0.213} \text{ x } 10^{-0.021\frac{(Duration-180)^2}{1440}}\,(0.3 + \log_{10}(AEP))\right]$$

The determination of ARFs is primarily a function of catchment area, storm event duration and to a lesser extent, ARI (AEP). The issue with ARFs for catchments such as Wolston Creek (where a significant proportion of the catchment is the study area and there are numerous tributaries of various sizes) is that there is not a single catchment area that can be applied for calculating an ARF that is representative over the entire study area. For this reason and for simplicity, BCC has chosen to adopt an ARF of 1, as documented in the current version of the BCC Flood Study Procedure document.

Baseflow

AR&R 2016 (Book 5, Section 4.2) advises the following with regard to the suitability of the AR&R 2016 baseflow methodology to urban catchments "*the approach and catchments considered in development of the method were selected to represent rural conditions, therefore the approach is not applicable to urban catchments (flood estimation for urban catchments is covered in Book 9). Baseflow is typically a small contribution to the flows.*" Given that this catchment is highly urbanised, baseflow has not been included. This is consistent with the current version of the BCC Flood Study Procedure document.

6.2.7 Sensitivity of IL_b (Pervious) Value

Historically, many BCC flood studies have typically adopted an IL_b of 0 mm for both the impervious and pervious areas of the catchment, with the understanding that the IL_b (pervious) value is conservative, especially for the smaller design events. The AR&R 2016 Data Hub provides a Storm Event Initial Loss (IL_s) value of 25 mm, with the caveat that it is only applicable for rural use and not for urban areas. The AR&R 2016 Data Hub also provides pre-burst rainfall loss values to account for the rainfall lost before the main storm burst.

To understand how sensitive the URBS peak flow values are to the selection of the IL_b (pervious) value, a comparative analysis was undertaken considering two IL options:

- Option 1 – IL_b (pervious) = 0 mm
- Option 2 – IL_b (pervious) = IL_s (pervious) minus the AR&R 2016 pre-burst rainfall losses, where IL_s (pervious) = 25 mm.

The IL_s (pervious) value of 25 mm was considered representative for this analysis as (i) when considering the historical calibration and verification events, the average of the IL_s (pervious) values determined through the modelling process is 23.75 mm, and (ii) this is the value given from the AR&R 2016 Data Hub, noting the caveat as mentioned previously.

Table 6.3 indicates the differences in design flow when using the two initial loss options. The results indicate the largest differences are for the 2-yr ARI (50 % AEP) and 5-yr ARI (20% AEP) events, particularly at locations where the upstream catchment is small (e.g. Scott Creek at Forest Lake Boulevard). For the larger events, the differences become significantly smaller, with there being very little difference in the 100-yr ARI (1 % AEP) event.

Table 6.3 – Sensitivity of Initial Loss Selection

Location	Initial Loss Option	URBS Design Flow (m^3/s)					
		ARI (AEP)					
		2-yr (50 %)	5-yr (20 %)	10-yr (10 %)	20-yr (5 %)	50-yr (2 %)	100-yr (1 %)
Sandy Creek at Campbell Avenue	1	61.0	87.9	106.9	126.9	151.6	172.9
	2	50.8	79.2	101.0	122.0	147.3	169.5
Spinks Creek at Jubilee Avenue	1	6.4	9.8	12.5	14.9	17.9	20.5
	2	4.4	7.8	9.6	12.2	15.7	18.7
Scott Creek at Forest Lake Boulevard	1	3.5	5.3	6.1	7.2	8.7	9.9
	2	2.3	4.1	5.4	6.6	8.3	9.6
Bullockhead Creek at Centenary Motorway	1	54.8	80.4	96.8	114.6	137.4	156.1
	2	39.7	65.7	83.5	100.8	125.8	145.9
Bullockhead Creek at Ipswich Motorway	1	60.8	87.9	107.7	127.4	151.9	172.5
	2	47.6	78.7	95.8	116.3	143.3	165.3
Ric Nattrass Creek at Centenary Motorway	1	22.1	33.2	39.8	47.0	57.3	65.4
	2	17.9	28.9	36.8	44.3	55.0	63.5
Wolston Creek at Catchment Outlet	1	167.2	238.1	288.1	339.3	402.5	457.1
	2	139.6	216.3	276.0	331.0	393.2	450.1

From the results of this analysis, it was decided to adopt the Option 1 approach (i.e. IL_b (pervious) = 0 mm). The primary reasons are as follows:

- This approach is slightly conservative, meaning that there is some inherent allowance for uncertainty (e.g. structure blockage, climate change, etc.) in the design flood level.
- This approach ensures some consistency with the historical BCC flood studies.
- The AR&R 2016 guidance with respect to the selection of an appropriate IL_s (pervious) value appears contradictory. Using an IL_b (pervious) value of 0 mm is a somewhat standardised approach that can be adopted for future flood studies.
- The BCC Planning Scheme places greater emphasis on the larger design floods (e.g. 50-yr ARI (2 % AEP) and 100-yr ARI (1 % AEP)). There is very little difference in results of both options for these larger design events.

6.3 Design Event Hydraulic Modelling

6.3.1 Overview

The TUFLOW model was used to determine design flows and flood levels for those scenarios as detailed in Table 6.1 for the 2-yr ARI (50 % AEP) to the 100-yr ARI (1 % AEP) events. These events were simulated for durations from 30 minute to 4.5 hours using the DEA AR&R 2016 as discussed in the previous section.

6.3.2 Methodology

The number of hydraulic model simulations required to run all ensembles would be 60 runs / ARI (AEP), which equates to a total number of 360 runs. In order to reduce this significant number of simulations, the following approach was undertaken:

- Identify a number of important locations within the hydraulic model extents from which to establish the critical duration and the representative design flow.
- At each location, extract the URBS peak flow for each ensemble and rank from Rank 10 (highest) to Rank 1 (lowest), for each duration. Identify the critical duration and adopt the Rank 6 ensemble (median) as being the representative design flow for each ARI (AEP).
- Identify the ensemble (E1 to E10) which corresponds to Rank 6 and Rank 5 flow at each of the chosen locations. Select up to two ensembles (per duration) which correspond to those which occur the most frequently as Rank 6 and Rank 5 flow.
- Check the URBS results to ensure that the chosen ensembles for other locations do not produce a higher flow than the adopted ensemble at that specific location.
- Run the chosen ensemble(s) through the URBS model for each of the 30-minute to 180-minute storm events for the 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP) events to create inflow hydrographs for the TUFLOW model.
- Run the TUFLOW model with the URBS inflow hydrographs, extract the results and undertake a peak flood level analysis for each ARI (AEP). Adopt the peak flood level as the design flood level.

6.3.3 Locations for Selecting Design Ensembles

Table 6.4 indicates the seven locations chosen from which to select the ensembles for use in the hydraulic modelling. The locations chosen are considered sufficient to represent the entire catchment and are typically situated near the more flood sensitive areas.

Table 6.4 – Locations for Selecting Design Ensembles

Creek	Location	Contributing Catchment Area (km^2)
Sandy Creek	Campbell Avenue	14.2
Bullockhead Creek	Centenary Motorway	8.4
	Ipswich Motorway	11.3
Ric Nattrass Creek	Centenary Motorway	2.0
Spinks Creek	Jubilee Avenue	0.7
Scott Creek	Forest Lake Boulevard	0.3
Wolston Creek	Catchment Outlet	44.0

6.3.4 Selected Ensembles for Hydraulic Modelling

Table 6.5 indicates the median ranking(s) as well as the critical duration for the full range of ARIs (AEPs) at each of the seven locations. These results are from the URBS hydrologic analysis. Based on the methodology presented in the previous sections, the ensembles selected for the hydraulic analysis using the TUFLOW model are as follows:

- 30-minute storm duration – Ensemble 8 (of 10)
- 1-hour storm duration – Ensemble 5 (of 10)
- 1.5-hour storm duration – Ensemble 5 (of 10)
- 2-hour storm duration – Ensemble 8 (of 10)
- 3-hour storm duration – Ensemble 8 (of 10)

The tabulated results in Appendix E (highlighted in yellow) indicate where the selected ensemble is ranked (as well as the discharge) for all durations and ARIs (AEPs) at the seven selected locations. Also shown either side of the critical duration (highlighted in light pink) is the ranking (and discharge) as a result of the ensemble(s) chosen for other locations.

Table 6.5 – Critical Duration and Ensemble Ranking (Design Events)

Location	Statistics	Ensemble #					
		ARI (AEP)					
		2-yr (50 %)	5-yr (20 %)	10-yr (10 %)	20-yr (5 %)	50-yr (2 %)	100-yr (1 %)
Sandy Creek at Campbell Avenue	Critical Duration	2-hr	2-hr	2-hr	2-hr	2-hr	2-hr
	Rank 6	8	8	7	7	2	2
	Rank 5	4	4	9	9	8	8
Spinks Creek at Jubilee Avenue	Critical Duration	30-min	30-min	30-min	30-min	30-min	30-min
	Rank 6	5	8	8	8	2	2
	Rank 5	8	5	4	4	4	4
Scott Creek at Forest Lake Boulevard	Critical Duration	30-min	30-min	30-min	30-min	30-min	30-min
	Rank 6	9	9	8	2	2	2
	Rank 5	5	5	4	8	1	1
Bullockhead Creek at Centenary Motorway	Critical Duration	1-hr	1-hr	1-hr	1-hr	1-hr	1-hr
	Rank 6	4	4	9	9	5	5
	Rank 5	7	7	5	5	1	1
Bullockhead Creek at Ipswich Motorway	Critical Duration	1-hr	1-hr	1.5-hr	1.5-hr	1.5-hr	1.5-hr
	Rank 6	4	4	9	9	5	5
	Rank 5	8	8	5	5	9	9
Ric Nattrass Creek at Centenary Motorway	Critical Duration	30-min	30-min	30-min	30-min	30-min	30-min
	Rank 6	8	8	3	3	7	7
	Rank 5	5	5	4	6	10	10
Wolston Creek at Catchment Outlet	Critical Duration	2-hr	2-hr	3-hr	3-hr	2-hr	2-hr
	Rank 6	7	7	8	8	9	9
	Rank 5	8	8	4	4	8	8

Table 6.6 indicates a summary of the locations where the adopted ensemble did not produce the Rank 5 / 6 (median) flow and the respective differences. At locations where the adopted ensemble(s) did not produce the Rank 5 / 6 (median) flow, there is typically not a large difference (%) in flow. Considering the 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP) events, the adopted ensemble(s) produced the Rank 5 / 6 (median) flow 26 out of 42 times. The adopted ensemble(s) produced the Rank 7 flow 9 out of 42 times and the Rank 8 flow 7 out of 42 times. For those 16 times when the Rank 5 / 6 (median) flow was not produced, the flow differences when compared to the Rank 6 (median) flow are quite small as indicated in Table 6.6.

Table 6.6 – Differences from Median Flow

Location	Rank 5 / 6 flow not produced	Difference (%) from Rank 6 Flow		
		Average	Maximum	Minimum
Sandy Creek at Campbell Avenue	2 out of 6 times	1.49	1.51	1.47
Spinks Creek at Jubilee Avenue	2 out of 6 times	1.47	1.66	1.29
Scott Creek at Forest Lake Boulevard	4 out of 6 times	4.13	5.63	1.70
Bullockhead Creek at Centenary Motorway	2 out of 6 times	1.84	1.90	1.78
Bullockhead Creek at Ipswich Motorway	2 out of 6 times	0.63	0.64	0.61
Ric Nattrass Creek at Centenary Motorway	4 out of 6 times	2.19	2.68	1.71
Wolston Creek at Catchment Outlet	0 out of 6 times	N/A	N/A	N/A

6.3.5 TUFLOW Model Set-up

TUFLOW model extents

The Scenario 1, 2 and 3 TUFLOW model extents were the same as the TUFLOW model developed for the calibration and verification events.

TUFLOW model roughness

The hydraulic roughness in the calibrated TUFLOW model was updated (as required) to represent the ultimate catchment conditions; which included MRC for Scenarios 2 and 3.

TUFLOW model boundaries

Design Inflows

The design inflow (Q-T) boundaries to the TUFLOW model were taken from the URBS model for each ARI (AEP) and duration. The inflow locations were the same as for the TUFLOW model developed for the calibration and verification events.

Design Tailwater Boundary

The design event TUFLOW model utilised a fixed Mean High Water Springs (MHWS) water level (H-T) boundary at the downstream boundary with the Brisbane River. At this location the value of MHWS is 1.18 mAHD.

6.4 Results and Mapping

6.4.1 Design Discharge Results

A full range of durations (30 minute to 4.5 hour) were simulated for the 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP) events. Table 6.7 provides design flow results at selected major roads for the Scenario 1 conditions. This information is from the TUFLOW hydraulic model.

Table 6.7 – Design Discharge at Selected Major Roads (Scenario 1)

Location	Design Discharge (m^3/s)					
	2-yr ARI (50 % AEP)	5-yr ARI (20 % AEP)	10-yr ARI (10 % AEP)	20-yr ARI (5 % AEP)	50-yr ARI (2 % AEP)	100-yr ARI (1 % AEP)
Sandy Creek						
Formation Street (S9)	54.8	80.3	97.3	115.5	137.1	155.6
Campbell Avenue (S7)	60.2	86.3	107.0	126.4	148.7	168.9
Ipswich Motorway (S4b)	70.2	100.7	122.4	140.8	156.5	179.4
Wolston Road (S2)	76.2	108.1	132.2	155.2	172.6	196.8
Bullockhead Creek						
Roxwell Street (S26)	21.5	32.9	40.9	48.7	59.6	68.6
Centenary Motorway (S19a)	54.5	78.8	93.3	112.3	133.7	151.1
Progress Road (S17)	55.2	82.3	100.3	120.6	142.5	162.3
Ipswich Motorway (S13b)	57.3	83.2	100.7	121.4	150.8	171.7
Ipswich Railway (S3)	72.9	104.4	127.1	149.5	180.5	197.3
Ric Nattrass Creek						
Centenary Motorway (S32a)	20.4	30.5	37.2	44.3	54.2	59.8
Ipswich Motorway (S29b)	30.3	43.5	48.0	54.4	70.1	80.9
Wolston Creek						
Wacol Station Road (S1)	133.6	190.8	246.7	293.6	336.6	380.1

6.4.2 Design Flood Levels

Tabulated design flood level results for the 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP) events are provided at the following locations for all creeks:

- Scenario 1: 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP) events – Appendix F
- Scenario 3: 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP) events – Appendix G

The design flood levels are the maximum flood level when considering the selected ensembles used for the hydraulic modelling as previously indicated in Section 6.3.4. The design flood levels are extracted along the current AMTD line for all creeks. Where there was no AMTD line, an assumed line was drawn to enable flood levels to be extracted. At some locations, the current AMTD line did not intersect the flood surface, which resulted in a null value (indicated by N/R). The lower section of the catchment is dominated by flooding originating from the Brisbane River; as such the reported peak flood levels in this area will be lower than the Brisbane River design flood levels for each respective ARI (AEP).

6.4.3 Return Periods of Historic Events

In order to estimate the return period of the historical events modelled, a flood frequency curve was developed at a number of locations within the catchment. These flood frequency curves were based on the Scenario 1 modelling and are indicated in Figure 6.3 and Figure 6.4. Table 6.8 indicates the estimated return period of the historical events at the selected locations; based on the flood frequency curves.

Table 6.8 – Estimated Magnitude of Historical Events

Location	Event Magnitude			
	March 2017	May 2015	Jan 2013	May 2009
Sandy Creek				
MHG SW160	2-yr ARI (50 % AEP)	2-yr to 5-yr ARI (50 % to 20 % AEP)	No data	< 2-yr ARI (50 % AEP)
MHG SW130	5-yr ARI (20 % AEP)	10-yr ARI (10 % AEP)	5-yr ARI (20 % AEP)	5-yr to 10-yr ARI (20 % to 10 % AEP)
Bullockhead Creek				
MHG BH170	5-yr ARI (20 % AEP)	5-yr to 10-yr ARI (20 % to 10 % AEP)	2-yr to 5-yr ARI (50 % to 20 % AEP)	2-yr to 5-yr ARI (50 % to 20 % AEP)
MHG BH150	5-yr ARI (20 % AEP)	5-yr ARI (20 % AEP)	No data	2-yr to 5-yr ARI (50 % to 20 % AEP)
MHG BH110	5-yr to 10-yr ARI (20 % to 10 % AEP)	10-yr to 20-yr ARI (10 % to 5 % AEP)	5-yr to 10-yr ARI (20 % to 10 % AEP)	5-yr ARI (20 % AEP)
Wolston Creek				
Stream Gauge 540378 (WSA584)	5-yr to 10-yr ARI (20 % to 10 % AEP)	20-yr ARI (5 % AEP)	5-yr to 10-yr ARI (20 % to 10 % AEP)	No data
Stream Gauge WSE583	No data	No data	No data	5-yr to 10-yr ARI (20 % to 10 % AEP)
MHG BH100	5-yr ARI (20 % AEP)	No data	5-yr to 10-yr ARI (20 % to 10 % AEP)	No data

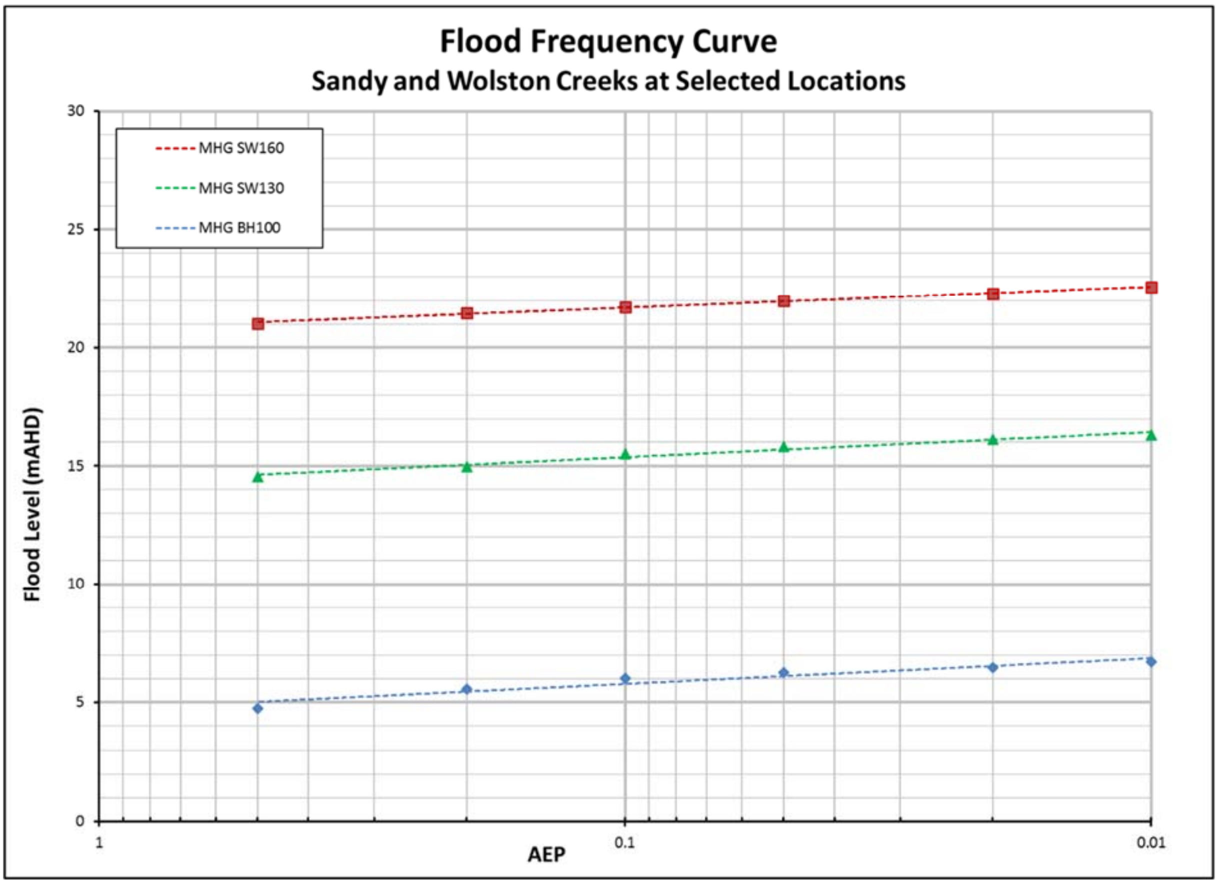

Figure 6.3: Flood Frequency Curve – Sandy and Wolston Creeks at Selected Locations

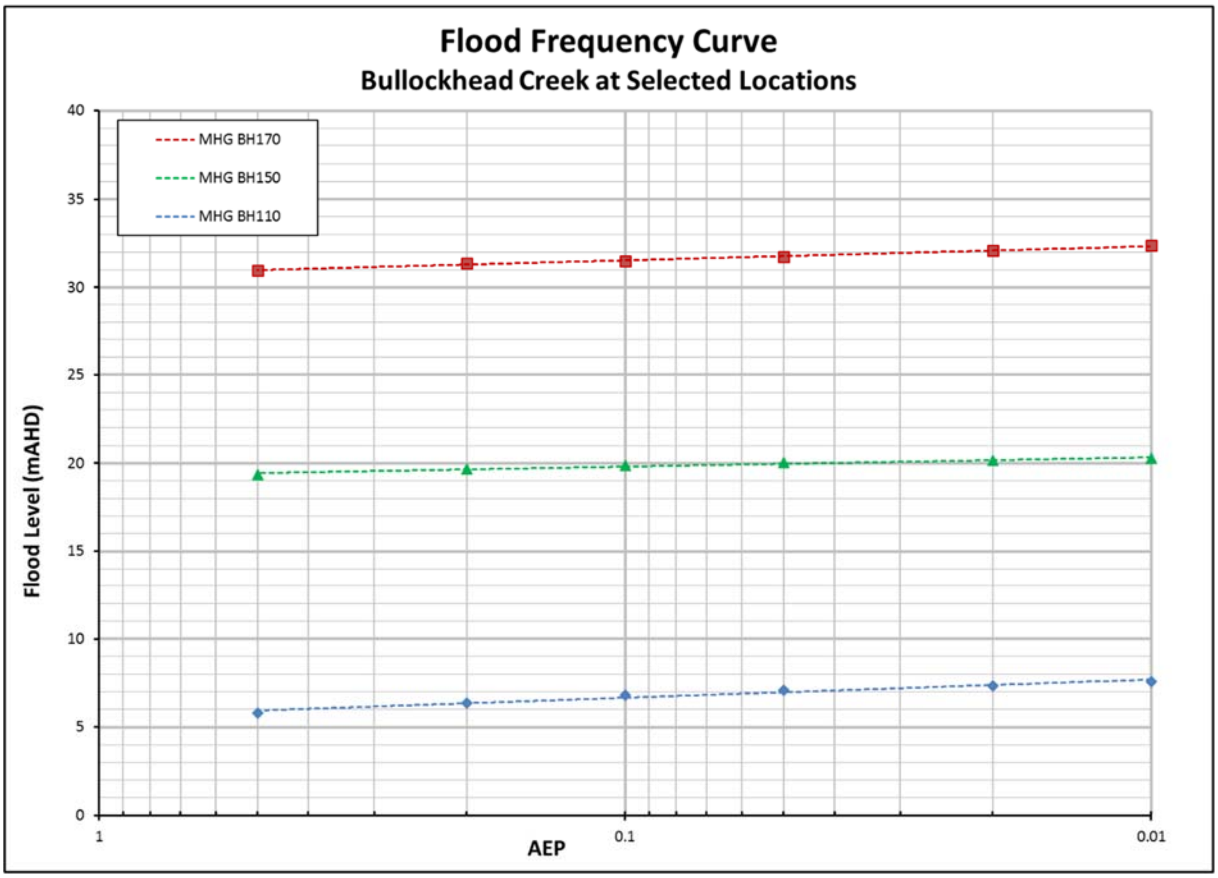

Figure 6.4: Flood Frequency Curve – Bullockhead Creek at Selected Locations

6.4.4 Rating Curves

Rating curves (H-Q) have been derived at a number of locations within the catchment and are provided in Appendix L. These locations are generally in the vicinity of hydraulic structures and include:

- Formation Street (S9) – Sandy Creek
- Ipswich Motorway (S4b) – Sandy Creek
- Wolston Road (S2) – Sandy Creek
- Centenary Motorway (S19a) – Bullockhead Creek
- Ipswich Motorway (S13b) – Bullockhead Creek
- Ipswich Railway (S11) – Bullockhead Creek
- Progress Road (S40) – Ric Nattrass Creek
- Centenary Motorway (S32a) – Ric Nattrass Creek
- Wacol Station Road (S1) – Wolston Creek

The rating curves were developed using the 2000-yr ARI (0.05 % AEP), with a constant tailwater level in the Brisbane River of HAT (1.69 mAHD). Typically, the adopted rating curve lies between the rising limb rating curve and the falling limb rating curve of the hydrograph. In the lower reaches of the catchment, care should be taken if utilising the rating curves, as they have the potential to change depending on the flow conditions in the Brisbane River. Also, some of the ratings are close to the confluence of the major creeks, which also has the potential to backwater the rating depending on the flow in each creek.

6.4.5 Comparison with AR&R 1987 for the 100-yr ARI (1 % AEP)

In order to understand the differences between the AR&R 2016 and AR&R 1987 methodologies, a comparison was undertaken of the Scenario 1 100-yr ARI (1 % AEP) design flows. This comparison was undertaken using similar URBS hydrological parameters and the respective 2016 IFD or 1987 IFD data.

Table 6.9 indicates the 100-yr ARI (1 % AEP) design flows at selected locations from the TUFLOW results for both methods. The results indicate that the AR&R 1987 methodology produces considerably higher design flows at all locations across the catchment. A review of the 2016 IFD and 1987 IFD storm intensities for the 100-yr ARI (1 % AEP) indicates that the 1987 IFD values are between 10 % and 14 % higher than the 2016 IFD values at the catchment centroid. These IFD differences would contribute to the higher flow for the AR&R 1987 methodology, however even if the 2016 IFD and 1987 IFD values were the same, it is considered that at the majority of locations across the catchment the AR&R 1987 methodology would still produce higher flows.

Table 6.9 – Comparison of 100-yr ARI (1 % AEP) Design Flow

Location	100-yr ARI (1 % AEP)		
	AR&R 1987	AR&R 2016	Difference (%)
Sandy Creek			
Formation Street (S9)	174.1	155.6	11.9
Campbell Avenue (S7)	185.9	168.9	10.0
Ipswich Motorway (S4b)	201.4	179.4	12.3
Wolston Road (S2)	225.1	196.8	14.4
Bullockhead Creek			
Roxwell Street (S26)	86.9	68.6	26.7
Centenary Motorway (S19a)	187.7	151.1	24.2
Progress Road (S17)	199.5	162.3	22.9
Ipswich Motorway (S13b)	210.8	171.7	22.8
Ipswich Railway (S3)	228.4	197.3	15.8
Ric Nattrass Creek			
Centenary Motorway (S32a)	75.2	59.8	25.8
Ipswich Motorway (S29b)	110.6	80.9	36.7
Wolston Creek			
Wacol Station Road (S1)	435.5	380.1	14.6

6.4.6 Comparison of Design Flood Levels with the Full Ensemble Method

As a means of verifying the simplified ensemble methodology used in this flood study, checking of flood level results was undertaken against the full ensemble method for both the 10-yr ARI (10 % AEP) and the 100-yr ARI (1 % AEP) events.

The full ensemble method consisted of running 10 ensembles for each of five durations (0.5, 1, 1.5, 2 and 3 hours) for each design ARI event; which totalled 50 hydraulic model runs per design ARI event. The median flood level for each duration was determined (five in total) and the design flood level was adopted as the maximum of these five median flood levels.

The flood level results / differences from this comparison are presented in Appendix H and a summary of the results in Table 6.10. The results indicate that the simplified ensemble approach compares very well with the full ensemble method. The average water level difference across the catchment is only 0.01 m for both the 10-yr ARI (10 % AEP) and 100-yr ARI (1 % AEP) events. Those few locations where the larger differences occur are upstream of hydraulic structures where it would appear that the water level is sensitive to small changes in flow.

Table 6.10 – Summary of Flood Level Compaison Results

Creek	ARI (AEP)	Average Difference (m)	Maximum Negative Difference (m)	Maximum Positive Difference (m)
Wolston	10-yr (10 %)	0.00	0.00	0.00
	100-yr (1 %)	-0.01	0.02	0.00
Sandy	10-yr (10 %)	0.02	0.00	0.09
	100-yr (1 %)	0.00	0.00	0.02
Bullockhead	10-yr (10 %)	0.00	0.03	0.02
	100-yr (1 %)	0.00	0.01	0.02
Ric Nattrass	10-yr (10 %)	0.01	0.01	0.05
	100-yr (1 %)	0.03	0.00	0.29
Full Model	10-yr (10 %)	0.01	0.03	0.09
	100-yr (1 %)	0.01	0.02	0.29

6.4.7 Hydrologic-Hydraulic Model Consistency Check (Design Events)

Comparison checks on flow were undertaken between the URBS and TUFLOW models for the 5-yr ARI (20 % AEP), 20-yr ARI (5 % AEP) and 100-yr ARI (1 % AEP) events at selected locations to understand how closely the hydrologic and hydraulic models were matching. Comparisons were undertaken utilising Ensemble 5 and the 60-minute duration storm event.

The locations where comparative plots were undertaken are as follows:

(i) Sandy Creek – Formation Street
(ii) Sandy Creek – Ipswich Railway
(iii) Sandy Creek – Wolston Road
(iv) Bullockhead Creek – Centenary Motorway
(v) Bullockhead Creek – Ipswich Motorway
(vi) Bullockhead Creek – Ipswich Railway
(vii) Ric Nattrass Creek – Centenary Motorway
(viii) Wolston Creek – Wacol Station Road
(ix) Wolston Creek – Catchment Outlet

Figure 6.5 to Figure 6.10 provide comparative plots at six of the nine locations. The remainder of the comparative plots are provided in Appendix D. Table 6.11 provides a comparison of the peak flows at these nine locations.

Table 6.11 – Peak Flow Comparison (Ensemble 5 - 60-minute duration), URBS and TUFLOW

Location	Model	60-minute Duration Peak Flow (m^3/s)		
		5-yr ARI (20 % AEP)	20-yr ARI (5 % AEP)	100-yr ARI (1 % AEP)
Sandy Creek at Formation Street	URBS	72.7	103.5	141.9
	TUFLOW	72.5	102.1	140.5
Sandy Creek at Ipswich Railway	URBS	100.9	143.7	195.5
	TUFLOW	96.6	138.0	168.7
Sandy Creek at Wolston Road	URBS	103.1	146.5	199.2
	TUFLOW	100.1	142.9	178.8
Bullockhead Creek at Centenary Motorway	URBS	81.9	114.5	156.1
	TUFLOW	78.8	112.3	151.1
Bullockhead Creek at Ipswich Motorway	URBS	88.5	125.1	169.0
	TUFLOW	81.2	121.4	165.9
Bullockhead Creek at Ipswich Railway	URBS	100.5	137.3	178.3
	TUFLOW	91.0	135.2	180.5
Ric Nattrass Creek at Centenary Motorway	URBS	28.7	36.8	51.3
	TUFLOW	27.9	35.9	50.7
Wolston Creek at Wacol Station Road	URBS	203.3	282.2	372.2
	TUFLOW	164.7	242.1	332.0
Wolston Creek at Catchment Outlet	URBS	206.4	285.6	375.7
	TUFLOW	163.5	238.5	326.1

The results indicate an acceptable comparison between the URBS and TUFLOW models. The peak flow is generally within ±10 % and the shape and timing of the hydrographs are consistent at the majority of locations. In the upper and middle sections of the catchment, there is a very good comparison between the URBS and TUFLOW hydrographs for all three events. However, towards the bottom of the catchment, the differences between URBS and TUFLOW tend to increase, with the URBS model typically over predicting the TUFLOW flow values.

On closer inspection of the TUFLOW results, it was apparent that the Ipswich Railway crossing of Bullockhead Creek was providing flow attenuation in the larger events. As a result, the URBS routing for this area was changed from Muskingum to Reservoir routing by the inclusion of a detention basin upstream of the railway. This improved the comparison for the selected locations downstream, however there still remains some reasonable peak flow differences. These differences are likely to be a result of the superior modelling of the floodplain storage by the hydraulic model in the lower sections of the catchment.

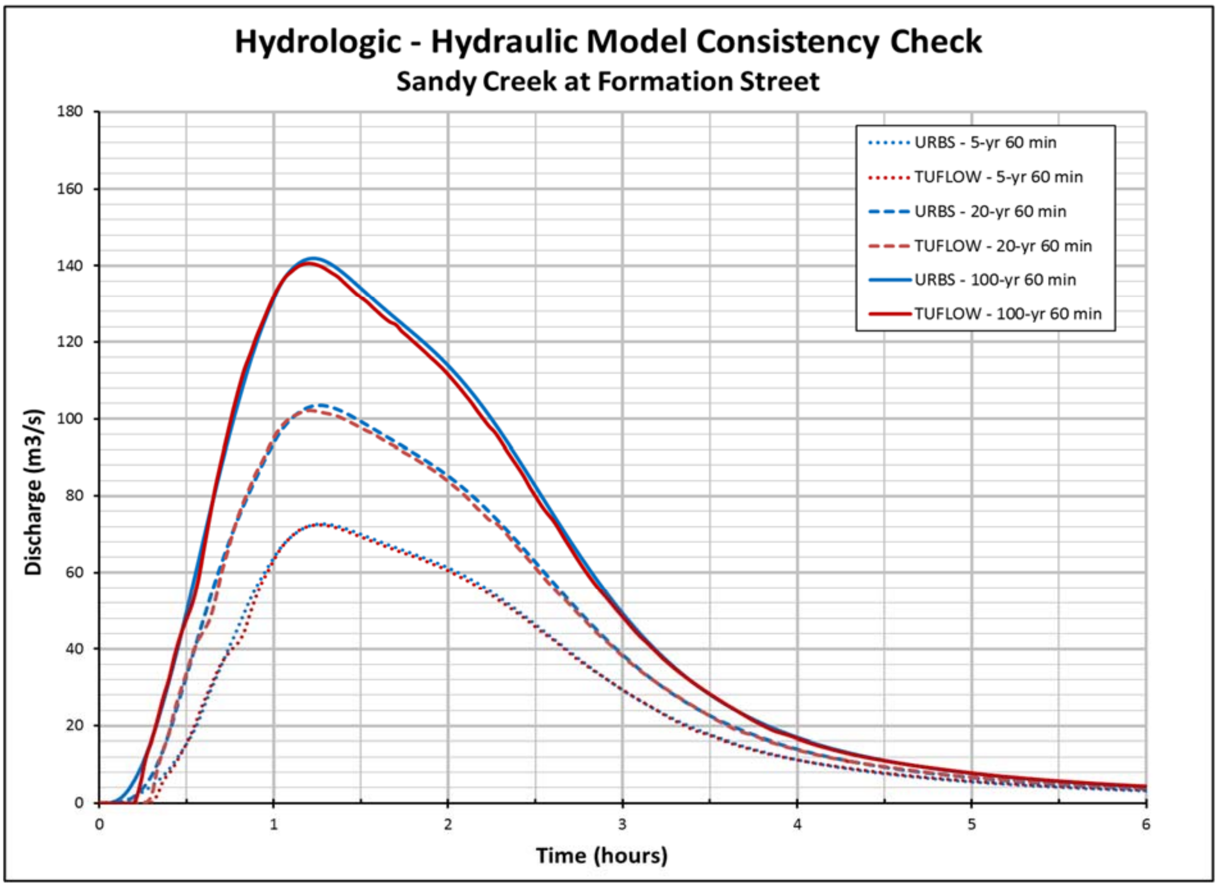

Figure 6.5: Sandy Creek at Formation Street

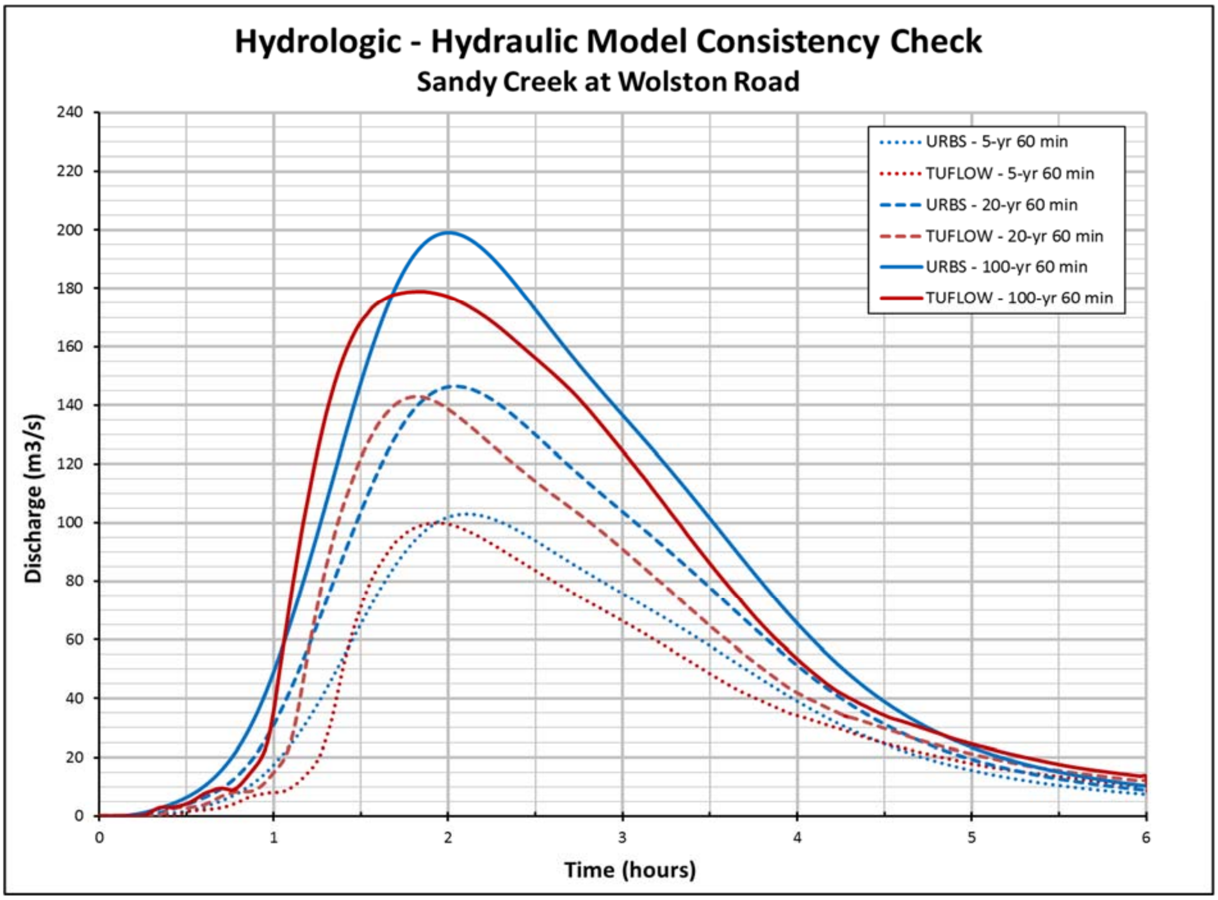

Figure 6.6: Sandy Creek at Wolston Road

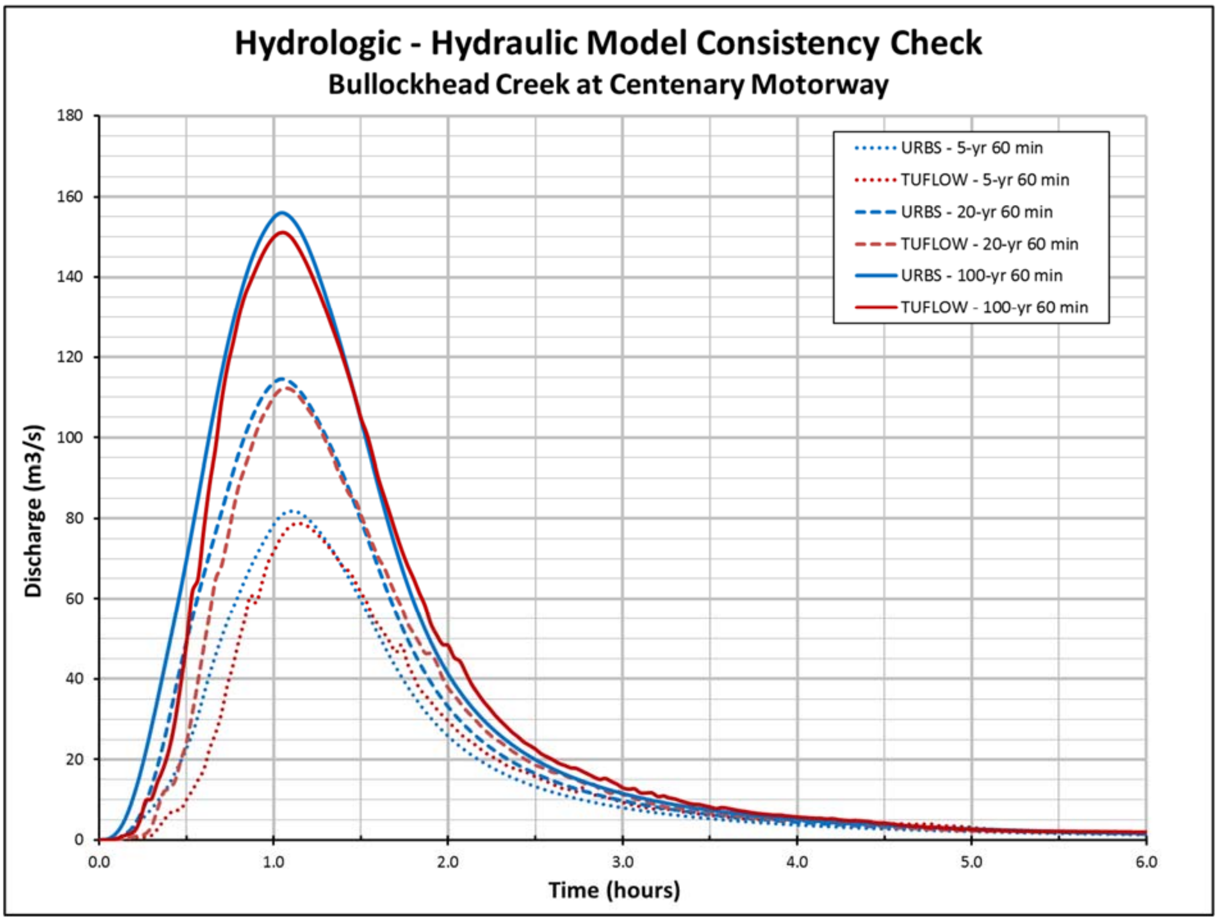

Figure 6.7: Bullockhead Creek at Centenary Motorway

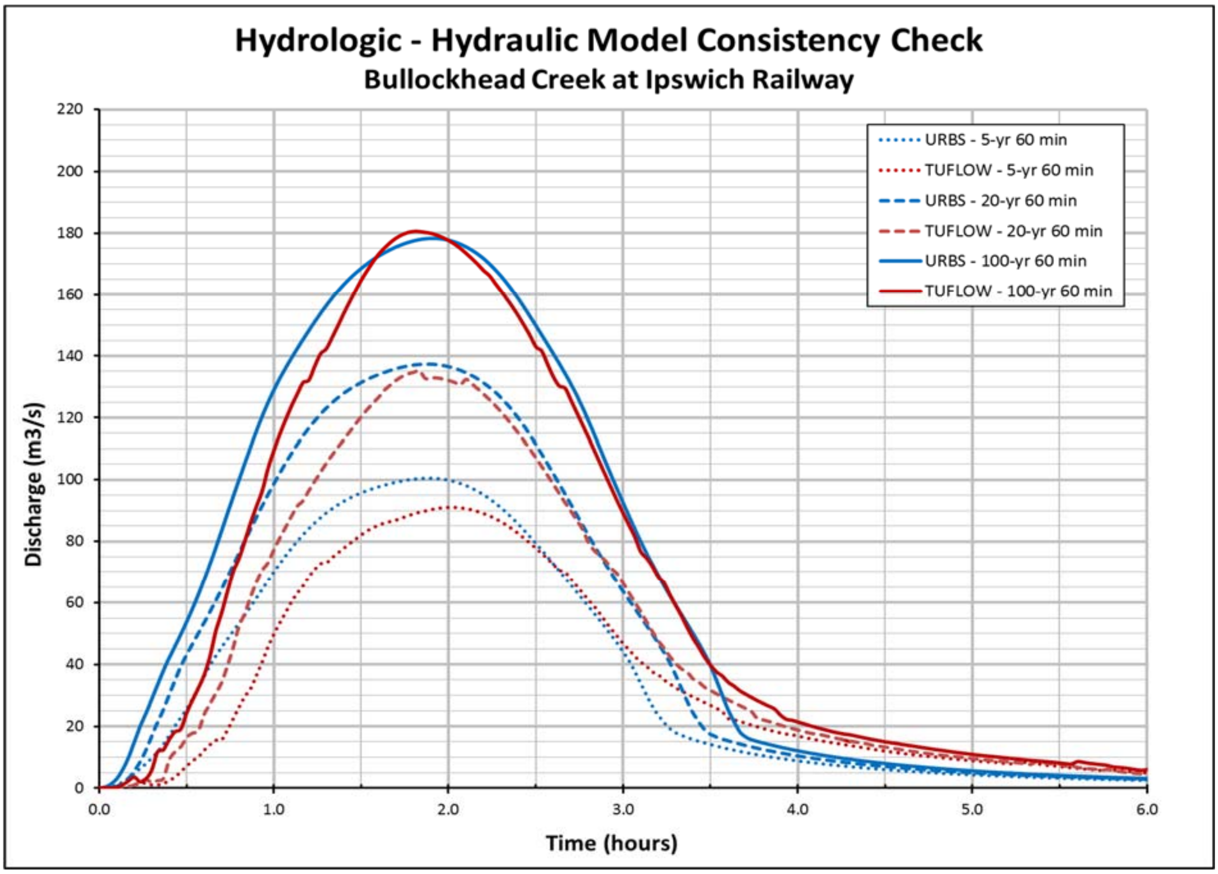

Figure 6.8: Bullockhead Creek at Ipswich Railway

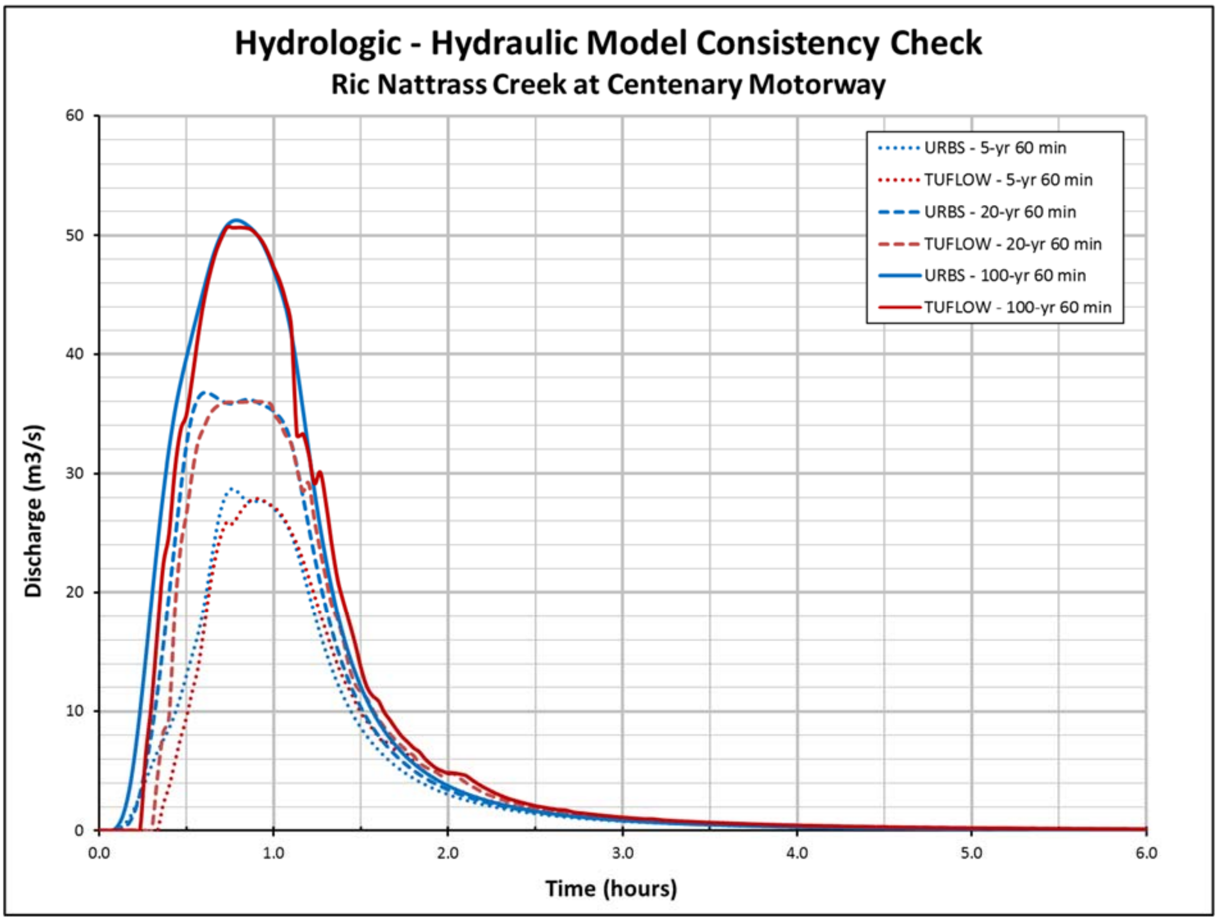

Figure 6.9: Ric Nattrass Creek at Centenary Motorway

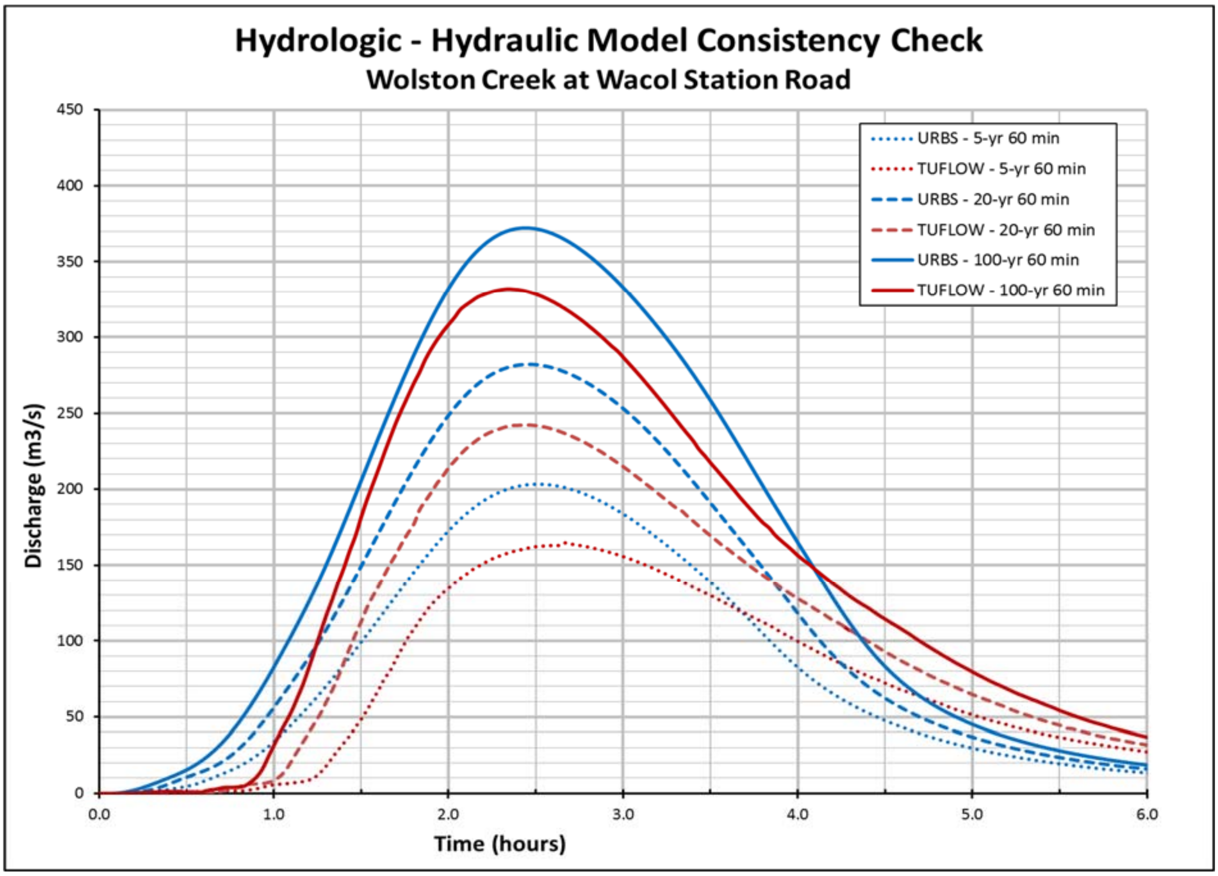

Figure 6.10: Wolston Creek at Wacol Station Road

6.4.8 Hydraulic Structure Reference Sheets

Details of flood level and flow data derived for the hydraulic structure crossings modelled are summarised in the Hydraulic Structure Reference Sheets and included in Appendix M.

6.4.9 Flood Mapping

The flood mapping products are provided in Volume 2 and include the following:

- Scenario 1
    - Flood Extent Mapping: 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP)

7.0 Rare and Extreme Event Analysis

7.1 Rare and Extreme Event Scenarios

Table 7.1 indicates the events and scenarios modelled as part of the rare and extreme event analysis. These scenarios have been previously described in Section 6.1. All rare and extreme event modelling was undertaken using ultimate hydrological conditions.

Table 7.1 – Rare and Extreme Event Scenarios

ARI (year)	AEP (%)	Scenario 1	Scenario 2	Scenario 3
200	0.5	✓	✗	✓
500	0.2	✓	✗	✓
2000	0.05	✓	✗	✗
PMF		✓	✗	✗

For the modelling of the Scenario 3 events, the fill height outside of the "Modelled Flood Corridor" is set to the Scenario 3 100-yr ARI (1 % AEP) flood level plus an additional height allowance of 0.3 m. The "100-yr ARI (1 % AEP) plus 0.3 m flood surface" is then required to be stretched, for which the methodology is detailed below.

7.2 Flood Extent Stretching Process

With the move to two-dimensional flood models, the production of flood levels, extents and depth-velocity products is inherent in simulating a model, i.e. a flood map is a direct output from a model simulation removing the requirement to apply a separate process. For the Scenario 1 "existing" simulations, the model is run and the direct output is able to be mapped or referenced in a GIS environment. In order to simulate the "ultimate" scenario, the model topography must be modified to represent filling associated with development. This in turn affects the resulting flood mapping with the flood extent limited to the edge of the filled floodplain. Post processing of the model output is required to represent the modelled flood levels against the current floodplain conditions.

In order to create the "stretched" flood surface(s), the Scenario 3 "ultimate" flood level surfaces were firstly required to be generated. As previously discussed in Section 6.1, the ultimate scenario involves modifying the flood model topography to represent a fully developed (filled) floodplain in accordance with BCC City Plan 2014 and in most instances making further allowances for a riparian corridor.

The WaterRIDE™ Flood Manager software was utilised for the purpose of stretching the Scenario 3 "ultimate" case results and producing the "stretched" flood surface(s). The WaterRIDE™ 'buffer width' tool was used, whereby the surface is extended by an equal number of grid cells (or TIN triangles) as a buffer around the current wet cells. A minimum depth threshold is used to determine what surrounding cells (within the buffer width) are considered 'available' for stretching. For this purpose, a value of 200 was used for the buffer width and -5 for the minimum depth threshold. Using these high values / tolerances ensured the flood surface was initially stretched far beyond the realistic limit of stretching. The stretched flood surface was then mapped onto the ground surface terrain grid to produce the mapped flood extents of the stretched flood surface.

From experience to date, it is known that there are inherent anomalies with the automated stretching process and some degree of manual intervention is typically required by an experienced / skilled practitioner to produce a more realistic stretched flood surface. To facilitate this process, a comparison of the mapped extent against the "existing" flooding extents (including larger events) was undertaken. In areas where there were obvious anomalies, some minor adjustments were made to the mapped extents of the stretched flood surface.

7.3 Rare and Extreme Event Hydrology

7.3.1 Overview

Rare and extreme event flood hydrology was determined for the following events, as detailed further in Sections 7.3.2 to 7.3.3.

(i) 200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP) events,

(ii) Probable Maximum Precipitation (PMP)

7.3.2 200-yr ARI (0.5 % AEP) to 2000-yr ARI (0.05 % AEP) Events

The DEA AR&R 2016 was used for the 200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP) events, similar to previously detailed in Section 6.2.

The design IFD rainfall data from the Bureau of Meteorology (BOM) website is yet to be finalised for storm durations less than 12 hours for events of this magnitude, which required all IFD values to be determined. The process undertaken to determine the IFD values involved logarithmic extrapolation of the available IFD rainfall data to determine the missing IFD values. Table 7.2 indicates the adopted design rainfall intensities with comparison to the adopted 100-yr ARI (1 % AEP).

Table 7.2 – Adopted Rare Event IFD Data

Duration (hrs)	Rainfall Intensity (mm/hr)			
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
0.5	142.0	156.0	175.2	204.9
1	93.2	103.5	117.4	139.5
1.5	71.4	79.8	91.1	109.5
2	58.8	66.0	75.9	92.1
3	44.5	50.2	57.9	70.8
4.5	33.8	38.2	44.2	54.3

7.3.3 Probable Maximum Precipitation (PMP)

In order to create a simplified PMP hyetograph that could be utilised across all BCC catchments, a simplified super-storm method was used. A 6-hr super-storm was developed to represent all storm durations up to 6 hours. The super-storm was developed in 30-minute blocks and incorporates the 0.5-hr, 1-hr, 1.5-hr, 2-hr and 3-hr storm bursts. Durations less than 30-minutes were not considered.

This methodology was documented in the memorandum "Technical Memorandum for Adopted Methodology – Extreme Events Modelling" from BCC Flood Management to BCC Natural Environment Water and Sustainability Branch (NEWS) on the 15th March 2013. This same methodology has also been used on other BCC flood studies recently undertaken. Table 7.3 indicates the adopted super-storm temporal pattern and hyetograph for the PMP.

Table 7.3 – Adopted Super-storm Hyetograph

Time (hr)	Cumulative Rainfall (%)	Rainfall (mm)	Time (hr)	Cumulative Rainfall (%)	Rainfall (mm)
0.00	0	0.00	3.17	58	75.08
0.17	1	9.92	3.33	70	75.08
0.33	3	9.92	3.50	75	38.25
0.50	4	9.92	3.67	77	27.63
0.67	5	9.92	3.83	80	27.63
0.83	6	9.92	4.00	82	27.63
1.00	8	9.92	4.17	84	18.42
1.17	9	13.46	4.33	86	18.42
1.33	10	13.46	4.50	89	18.42
1.50	11	13.46	4.67	90	13.46
1.67	14	18.42	4.83	91	13.46
1.83	16	18.42	5.00	92	13.46
2.00	18	18.42	5.17	94	9.92
2.17	20	27.63	5.33	95	9.92
2.33	23	27.63	5.50	96	9.92
2.50	25	27.63	5.67	97	9.92
2.67	30	38.25	5.83	99	9.92
2.83	34	38.25	6.00	100	9.92
3.00	46	75.08	**TOTAL**		**816**

The total PMP rainfall depth was derived from the 6-hr storm duration using the Generalised Short Duration Method (GSDM). For the tropical and sub-tropical coastal areas it is recommended that this method is to be used to estimate the PMP over areas up to 520 km2 and for durations up to 6 hours. To apply a consistent methodology across the majority of BCC an average catchment size of 60 km2 and moisture adjustment factor of 0.85 were adopted. The total rainfall depth of the super-storm was set equal to the 6-hr GSDM PMP rainfall depth, which was determined as 816 mm.

7.4 Rare and Extreme Event Hydraulic Modelling

7.4.1 General

The TUFLOW model was used to simulate the scenarios as detailed in Section 7.1 to enable design flood levels and flood mapping products to be determined / produced.

7.4.2 Methodology

The methodology used is similar to that discussed previously in Sections 6.3.2 and 6.3.3.

7.4.3 Selected Ensembles for Hydraulic Modelling

Table 7.4 indicates the median ranking(s) as well as the critical duration for the full range of ARIs (AEPs) at each of the seven locations. These results are from the URBS hydrologic analysis and based on the methodology presented in the previous sections, the ensembles selected for the hydraulic analysis using the TUFLOW model are as follows:

- 30-minute storm duration – Ensemble 2 (of 10)
- 1-hour storm duration – Ensemble 5 (of 10)
- 1.5-hour storm duration – Ensemble 5 (of 10)
- 2-hour storm duration – Ensemble 8 (of 10)
- 3-hour storm duration – Ensemble 9 (of 10)

The tabulated results in Appendix I (highlighted in yellow) indicate where the selected ensemble is ranked (as well as the discharge) for all durations and ARIs (AEPs) at the seven selected locations. Also shown (highlighted in light pink) either side of the critical duration is the ranking (and discharge) resulting from the ensemble(s) chosen for other locations.

Table 7.4 – Critical Duration and Ensemble Ranking (Rare Events)

Location	Statistics	Ensemble #		
		200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
Sandy Creek at Campbell Avenue	Critical Duration	2-hour	2-hour	2-hour
	Rank 6	2	2	2
	Rank 5	8	8	8
Spinks Creek at Jubilee Avenue	Critical Duration	30-min	30-min	30-min
	Rank 6	2	2	2
	Rank 5	4	4	4
Scott Creek at Forest Lake Boulevard	Critical Duration	30-min	30-min	30-min
	Rank 6	2	2	6
	Rank 5	1	1	2
Bullockhead Creek at Centenary Motorway	Critical Duration	1-hour	1-hour	1.5-hour
	Rank 6	5	1	3
	Rank 5	1	5	5
Bullockhead Creek at Ipswich Motorway	Critical Duration	1.5-hour	1.5-hour	1.5-hour
	Rank 6	5	5	5
	Rank 5	9	9	9
Ric Nattrass Creek at Centenary Motorway	Critical Duration	30-min	30-min	30-min
	Rank 6	7	7	7
	Rank 5	10	10	10
Wolston Creek at Catchment Outlet	Critical Duration	2-hour	2-hour	3-hour
	Rank 6	9	9	1
	Rank 5	8	8	9

7.4.4 TUFLOW Model Set-up

TUFLOW model extents

No changes were made from the design event TUFLOW model(s).

TUFLOW model roughness

No changes were made from the design event TUFLOW model(s).

TUFLOW model boundaries

Design Inflows

The rare and extreme event inflow (Q-T) boundaries to the TUFLOW model were taken from the results of the URBS model for each ARI and duration. The inflow locations did not change from the design event TUFLOW model(s).

Design Tailwater Boundary

The rare and extreme event TUFLOW model utilised a fixed Highest Astronomical Tide (HAT) water level (H-T) boundary at the downstream boundary with the Brisbane River. At this location the value of HAT is 1.69 mAHD.

7.4.5 Hydraulic Structures

The TUFLOW model(s) for the 200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP) events incorporated the same hydraulic structures as the design event TUFLOW model(s).

To limit issues with model instabilities generated by extreme flows, all structures within the Coca Cola Amatil reach of Ric Nattrass Creek were removed and the 1d channel representation was changed to 2d for the PMF event.

7.5 Results and Mapping

7.5.1 Peak Flood Levels

Tabulated peak flood level results for the rare and extreme events are provided at the following locations for all creeks:

- Scenario 1: 200-yr ARI (0.5 % AEP) to 2000-yr ARI (0.05 % AEP) events – Appendix J
- Scenario 3: 200-yr ARI (0.5 % AEP) and 500-yr ARI (0.2 % AEP) events – Appendix K

The lower section of the catchment is dominated by flooding originating from the Brisbane River. As such the reported peak flood levels in this area will be lower than the Brisbane River peak flood levels for each respective ARI (AEP).

7.5.2 Flood Mapping

The flood mapping products are provided in Volume 2 and include the following:

- Scenario 1
    - Flood Extent Mapping: 200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP)

7.5.3 Discussion of Results

A longitudinal plot of the Scenario 1 100-yr ARI (1 % AEP) to PMF flood profiles for the major creeks is provided in Figure 7.1 to Figure 7.4.

The flood profiles for the 200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP) events are observed to follow a very similar trend when compared to the 100-yr ARI (1 % AEP) flood profile along all of the creeks.

Generally, as the bed slope (gradient) of the creek increases towards the head of the catchment, the relative differences in flood level between events decreases. This is also because the relative differences between the design flows are typically less towards the head of the catchment. The largest differences in relative flood level typically occur towards the lower section of the creeks, where the relative differences in design flow are greatest.

At the five major motorway crossings, the largest head-losses typically occur in the PMF when the road is overtopped and the concrete safety barriers impede the flow of water across the road. The average increase in flood level along the length of each major creek, when compared to the 100-yr ARI (1 % AEP) flood profile, is indicated in Table 7.5. The results indicate the largest average differences are in Wolston Creek and the smallest in Ric Nattrass Creek.

Table 7.5 – Average Increase in Flood Level

Event	Average Increase in Flood Level (m) with reference to the 100-yr ARI (1 % AEP) flood level			
	Sandy Creek	Bullockhead Creek	Wolston Creek	Ric Nattrass Creek
200-yr ARI (0.5 % AEP)	0.16	0.16	0.30	0.15
500-yr ARI (0.2 % AEP)	0.37	0.36	0.61	0.30
2000-yr ARI (0.05 % AEP)	0.64	0.66	1.06	0.54
PMF	2.93	3.26	5.25	2.35

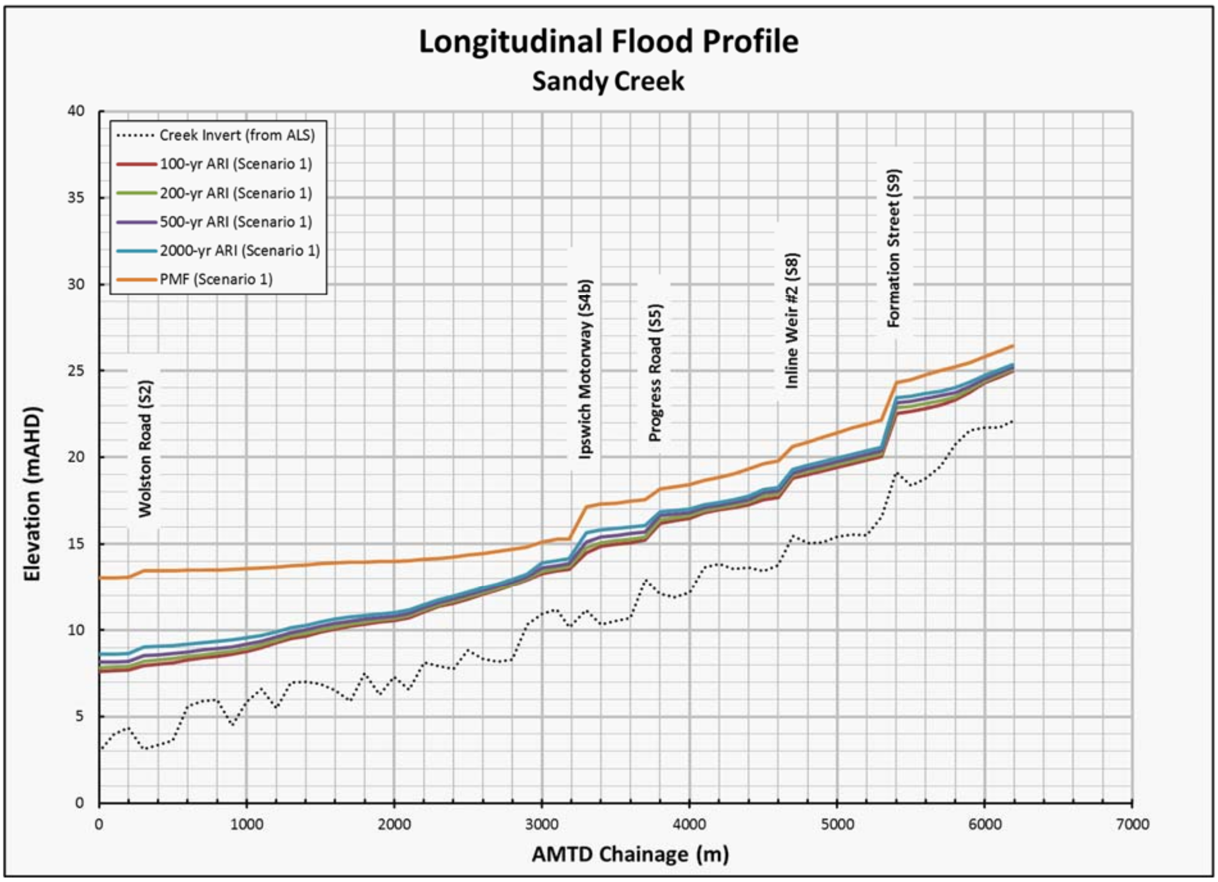

Figure 7.1: Longitudinal Flood Profile – Sandy Creek

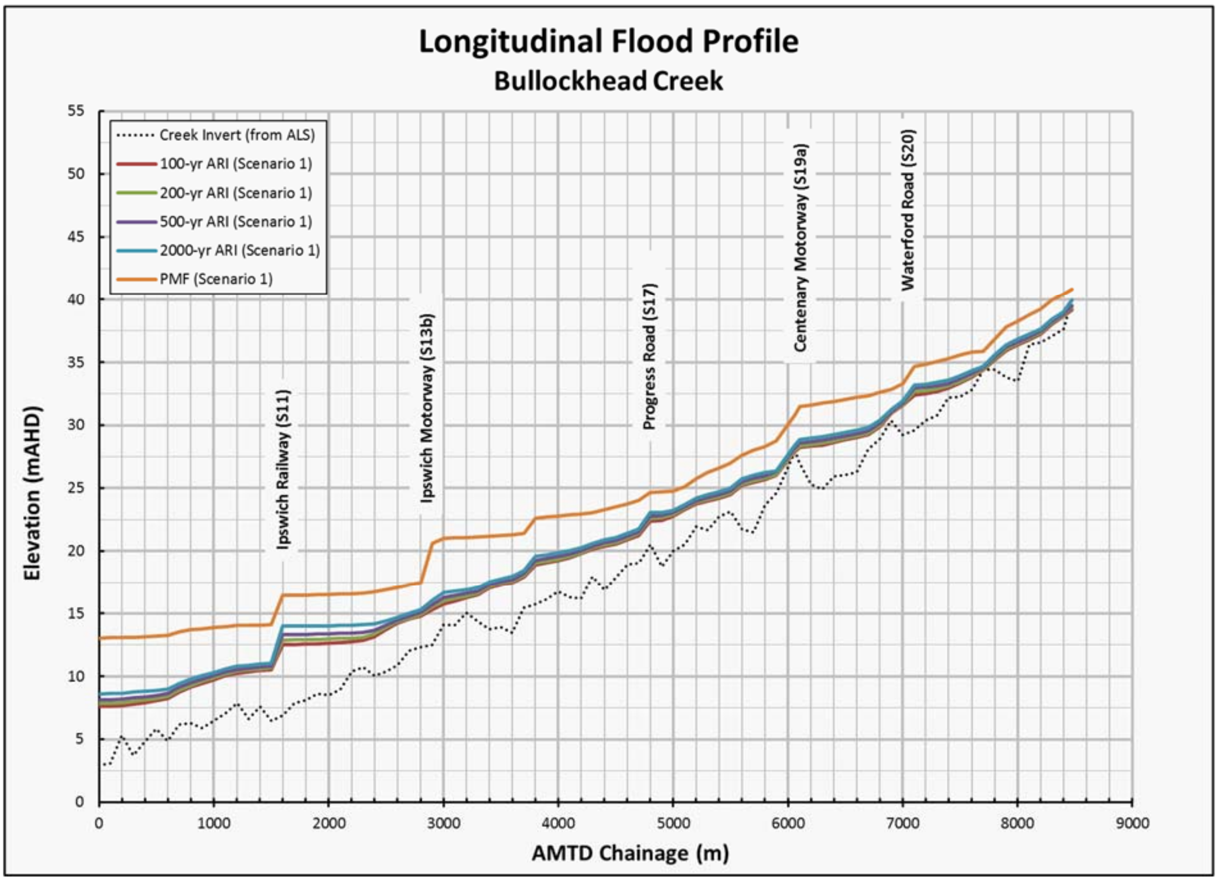

Figure 7.2: Longitudinal Flood Profile – Bullockhead Creek

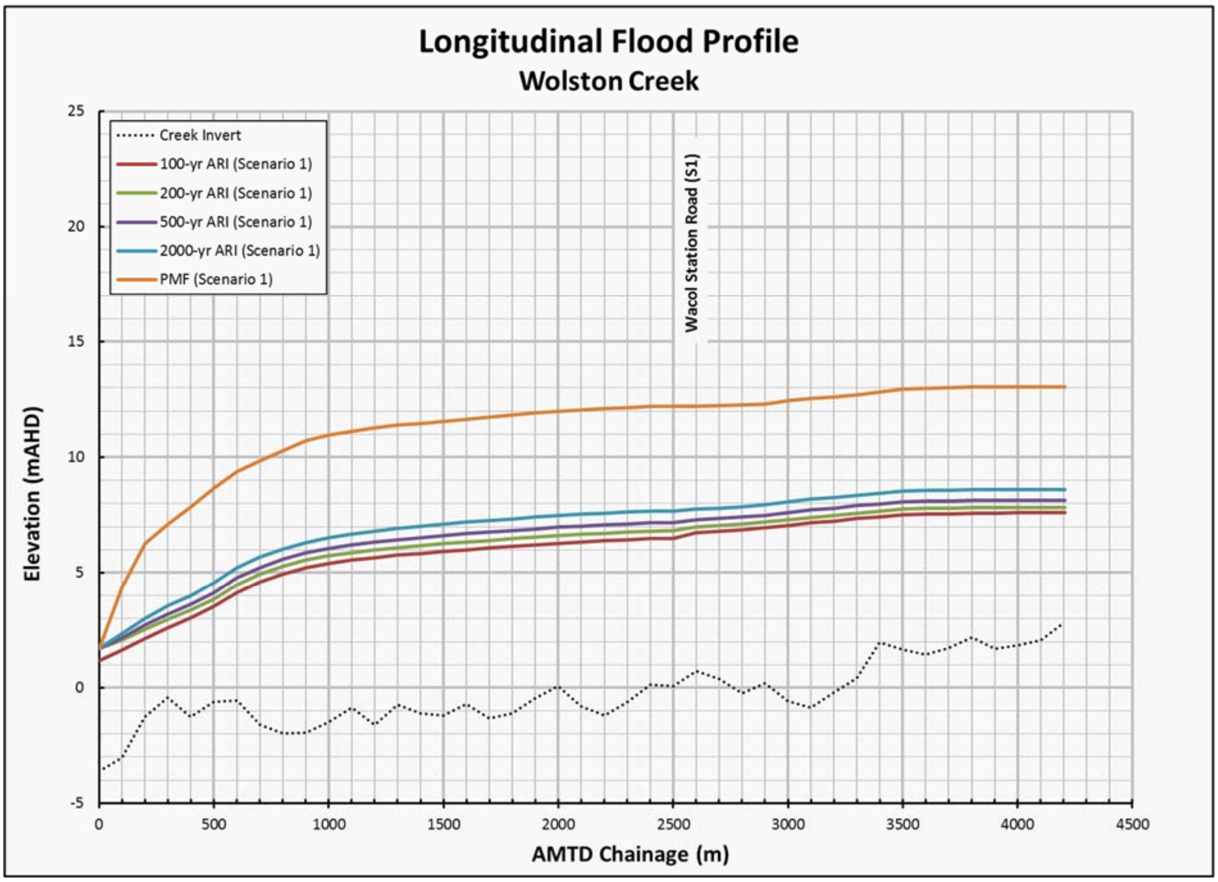

Figure 7.3: Longitudinal Flood Profile – Wolston Creek

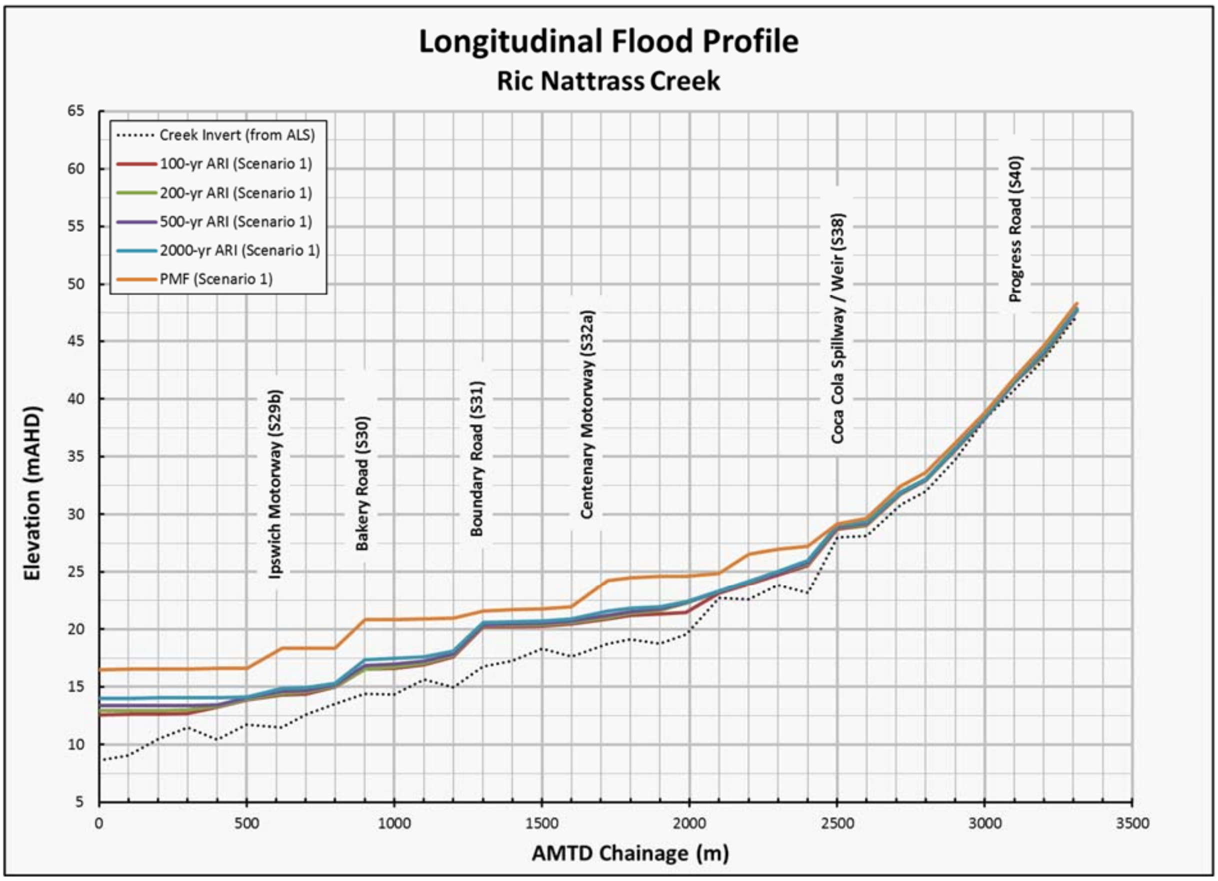

Figure 7.4: Longitudinal Flood Profile – Ric Nattrass Creek

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8.0 Climate Variability

8.1 Overview

There is general consensus that human activities are contributing to observed changes in climate. Human induced climate change has the potential to alter the prevalence and severity of rainfall extremes, storm surge and floods. [8]

BCC flood studies are required to undertake a sensitivity analysis to assess climate variability. The following sections provide the details of these analyses.

8.2 Climate Variability

8.2.1 Overview

In order for BCC to undertake informed future land-use planning and climate change adaption, there is a requirement to understand the impacts of climate variability on flooding. As part of this climate variability assessment, two future planning horizons were considered, namely 2050 and 2100.

The latest practitioner guidance on the climate change impacts of rainfall intensity is from AR&R 2016. AR&R 2016 recommends the consideration of two representative concentration pathways; namely RCP4.5 and RCP8.5. RCP8.5 assumes greater greenhouse gas emissions than RCP4.5, resulting in increased rainfall intensity.

The four climate futures included in the modelling are as follows:

- Year 2050 (RCP4.5)
  - 6.7 % increase in rainfall intensity
  - 0.3 m increase in mean sea level
- Year 2050 (RCP8.5)
  - 8.8 % increase in rainfall intensity
  - 0.3 m increase in mean sea level
- Year 2100 (RCP4.5)
  - 9.3 % increase in rainfall intensity
  - 0.8 m increase in mean sea level
- Year 2100 (RCP8.5)
  - 21 % increase in rainfall intensity
  - 0.8 m increase in mean sea level

[8] Bates B, McLuckie D, Westra S, Johnson F, Green J, Mummery J, Abbs D, 2016, Climate Change Considerations, Chapter 6 Book 1 in Australian Rainfall and Runoff – A Guide to Flood Estimation, Commonwealth of Australia

Currently the guidance on rainfall intensity increases due to climate change only extend as far as 2090. The AR&R 2016 Data Hub (Beta) only provides values from 2030 to 2090. In order to obtain a value for 2100 a linear extrapolation was undertaken based on the values of 2080 and 2090.

8.2.2 Modelled Scenarios

Modelling was undertaken to determine the climate variability impacts for the 100-yr ARI (1 % AEP), 200-yr ARI (0.5 % AEP) and 500-yr ARI (0.2 % AEP) events. Table 8.1 indicates the events modelled and the respective climate variability modifications undertaken.

Table 8.1 – Climate Modelling Scenarios

ARI (year)	AEP (%)	Planning horizon	RCP	Rainfall Intensity	Tailwater Condition	Scenario 1	Scenario 3
100	1	2050	4.5	+ 6.7 %	MHWS + 0.3 m = 1.48mAHD	✓	✓
			8.5	+ 8.8 %		✓	✓
		2100	4.5	+ 9.3 %	MHWS + 0.8 m = 1.98mAHD	✓	✓
			8.5	+ 21 %		✓	✓
200	0.5	2050	4.5	+ 6.7 %	HAT + 0.3 m = 1.99mAHD	✓	×
			8.5	+ 8.8 %		✓	×
		2100	4.5	+ 9.3 %	HAT + 0.8 m = 2.49mAHD	✓	×
			8.5	+ 21 %		✓	×
500	0.2	2100	4.5	+ 9.3 %	HAT + 0.8 m = 2.49mAHD	✓	×
			8.5	+ 21 %		✓	×

8.2.3 Selected Ensembles for Hydraulic Modelling

The same ensembles which were previous adopted in Section 6.3.4 (100-yr ARI (1 % AEP)) and Section 7.4.3 (200-yr ARI (0.5 % AEP) and 500-yr ARI (0.2 % AEP)) were used for the hydraulic modelling of the climate variability events. Checks were undertaken using the URBS hydrologic model and these ensembles produced a similar ranking as documented previously.

8.2.4 Hydraulic Modelling

The TUFLOW model(s) used for the climate variability modelling incorporated the same model set-up as the design event TUFLOW model(s), apart from the boundary conditions.

The URBS model was utilised to derive the inflow boundary conditions for the 2050 (RCP4.5); 2050 (RCP8.5); 2100 (RCP4.5) and 2100 (RCP8.5) rainfall intensity scenarios. The inflow boundary locations did not change from the design event modelling.

8.2.5 Impacts of Climate Variability

Table 8.2 to Table 8.4 indicate a comparison of the peak flood levels for the Scenario 1 climate conditions. The flood level results are provided at selected locations along the major creeks for the 100-yr ARI (1 % AEP), 200-yr ARI (0.5 % AEP) and 500-yr ARI (0.2 % AEP) events. Figure 8.1 to Figure 8.4 indicate the differences in the 100-yr ARI (1 % AEP) event at four locations within the major creeks.

The results indicate the greatest change in flood level is generally in the lower reaches where the projected sea level rise has the greatest impact.

The results indicate that climate variability impacts within the catchment will increase the magnitude of flooding. The following observations were made from the results:

- Flood level increases are greater under RCP8.5 climate projections when compared with RCP4.5 climate projections.
- 2050 RCP8.5 and 2100 RCP4.5 flood levels are almost identical for those areas not affected by projected sea level increases.
- Based on RCP8.5 climatic projections, by the year 2100, the 100-yr ARI (1 % AEP) flood levels are likely to be of similar magnitude to the present day 200-yr ARI (0.5 % AEP) flood levels for those areas not affected by projected sea level increases.
- Based on RCP8.5 climatic projections, by the year 2100, the 200-yr ARI (0.5 % AEP) flood levels are likely to be of similar magnitude to the present day 500-yr ARI (0.2 % AEP) flood levels for those areas not affected by projected sea level increases.

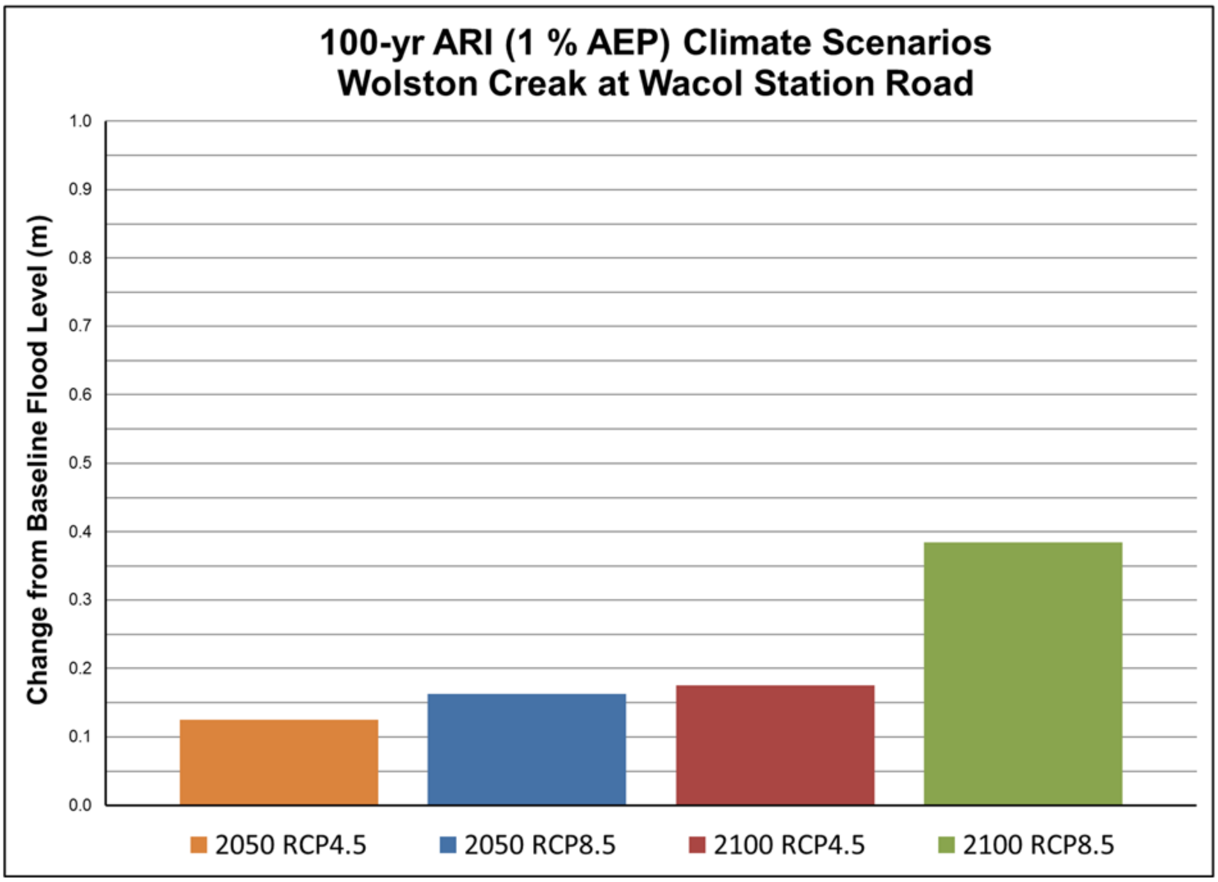

Figure 8.1: 100-yr ARI (1% AEP) Climate Differences – Wolston Creek at Wacol Station Road

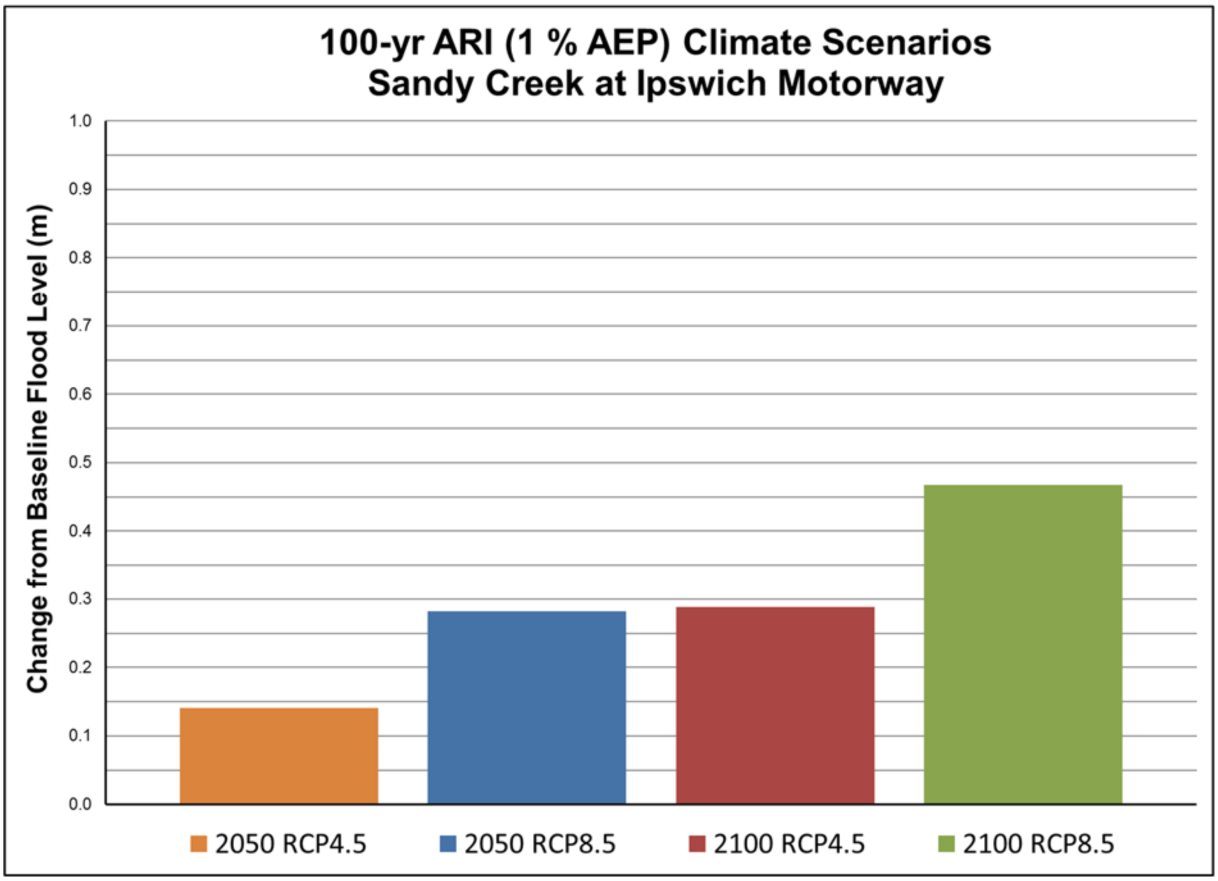

Figure 8.2: 100-yr ARI (1% AEP) Climate Differences – Sandy Creek at Ipswich Motorway

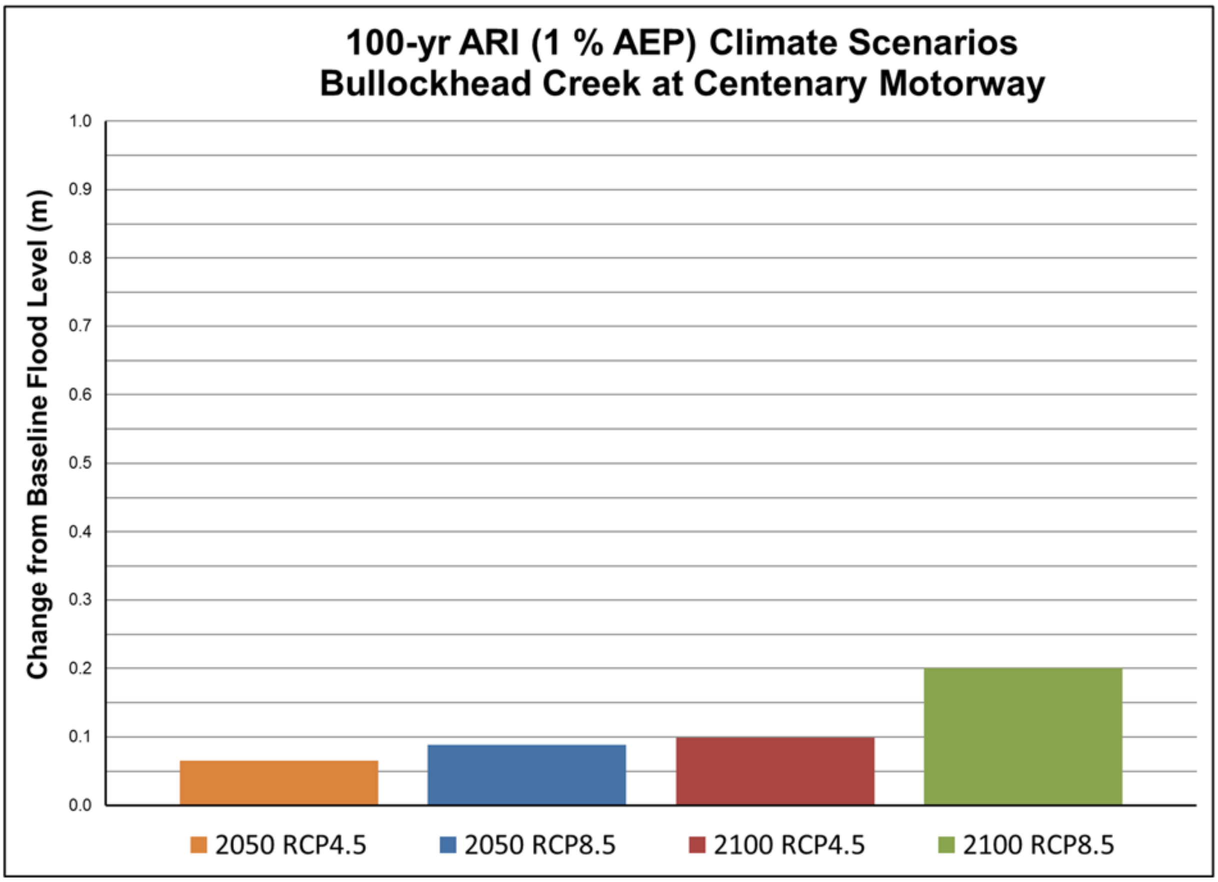

Figure 8.3: 100-yr ARI (1% AEP) Climate Differences – Bullockhead Creek at Centenary Motorway

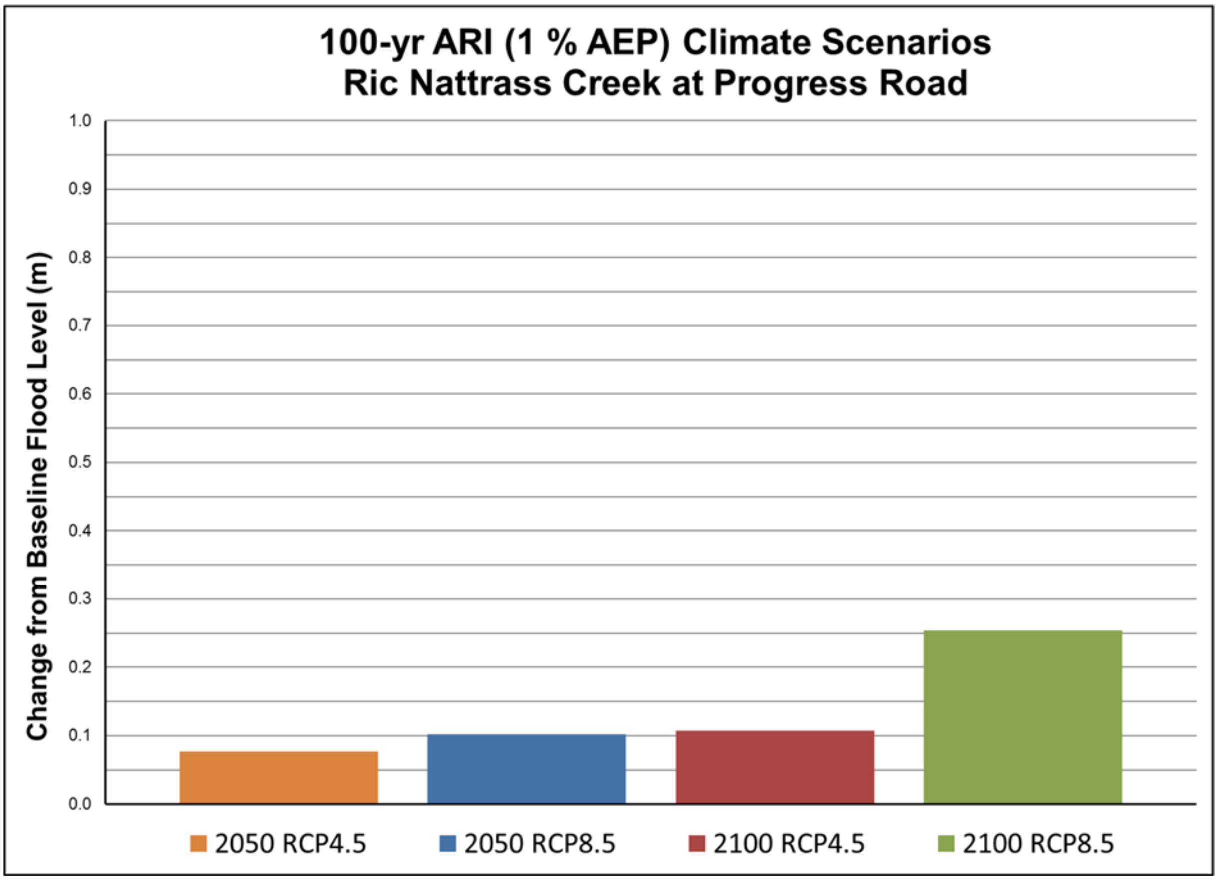

Figure 8.4: 100-yr ARI (1% AEP) Climate Differences – Ric Nattrass Creek at Progress Road

Table 8.2 – 100-yr ARI (1 % AEP) Climate Impacts at Selected Locations (Scenario 1)

Structure Location	100-yr ARI (1 % AEP)								
	Existing WL (mAHD)	2050 RCP4.5		2050 RCP8.5		2100 RCP4.5		2100 RCP8.5	
		WL (mAHD)	Afflux (m)	WL (mAHD)	Afflux (m)	WL (mAHD)	Afflux (m)	WL (mAHD)	Afflux (m)
Sandy Creek									
Formation Street (S9)	22.49	22.62	0.14	22.67	0.18	22.67	0.19	22.94	0.46
Campbell Avenue (S7)	17.55	17.66	0.11	17.69	0.14	17.70	0.15	17.85	0.30
Ipswich Motorway (S4b)	14.67	14.79	0.12	14.89	0.22	14.89	0.22	15.09	0.42
Wolston Road (S2)	7.89	8.03	0.14	8.06	0.17	8.07	0.18	8.31	0.42
Bullockhead Creek									
Waterford Road (S20)	32.36	32.53	0.17	32.58	0.22	32.59	0.23	32.81	0.45
Centenary Motorway (S19a)	28.00	28.08	0.08	28.11	0.11	28.12	0.12	28.24	0.24
Progress Road (S17)	22.37	22.49	0.13	22.53	0.16	22.54	0.17	22.73	0.37
Ipswich Motorway (S13b)	15.44	15.60	0.16	15.63	0.19	15.64	0.20	15.83	0.39
Ipswich Railway (S11)	12.53	12.73	0.20	12.79	0.26	12.80	0.27	13.11	0.57
Spine Street (S10)	8.69	8.79	0.10	8.82	0.13	8.83	0.14	8.97	0.28
Ric Nattrass Creek									
Progress Road (S40)	42.58	42.76	0.18	42.81	0.24	42.82	0.25	43.13	0.55
Centenary Motorway (S32a)	20.95	21.08	0.13	21.09	0.14	21.09	0.15	21.23	0.29
Ipswich Motorway (S29b)	14.31	14.42	0.12	14.43	0.12	14.44	0.13	14.56	0.25
Wolston Creek									
Wacol Station Road (S1)	6.71	6.84	0.13	6.87	0.17	6.89	0.18	7.10	0.39

Table 8.3 – 200-yr ARI (0.5 % AEP) Climate Impacts at Selected Locations (Scenario 1)

Structure Location	200-yr ARI (1 % AEP)								
	Existing WL (mAHD)	2050 RCP4.5		2050 RCP8.5		2100 RCP4.5		2100 RCP8.5	
		WL (mAHD)	Afflux (m)	WL (mAHD)	Afflux (m)	WL (mAHD)	Afflux (m)	WL (mAHD)	Afflux (m)
Sandy Creek									
Formation Street (S9)	22.81	22.93	0.11	23.02	0.21	23.03	0.22	23.20	0.39
Campbell Avenue (S7)	17.74	17.83	0.10	17.87	0.13	17.87	0.13	17.99	0.25
Ipswich Motorway (S4b)	14.92	15.07	0.15	15.09	0.18	15.10	0.18	15.41	0.49
Wolston Road (S2)	8.13	8.28	0.15	8.33	0.19	8.34	0.21	8.58	0.45
Bullockhead Creek									
Waterford Road (S20)	32.63	32.77	0.14	32.81	0.18	32.82	0.18	32.99	0.36
Centenary Motorway (S19a)	28.13	28.21	0.08	28.23	0.11	28.26	0.13	28.39	0.26
Progress Road (S17)	22.57	22.69	0.12	22.73	0.16	22.73	0.16	22.89	0.32
Ipswich Motorway (S13b)	15.68	15.81	0.13	15.84	0.16	15.84	0.16	16.03	0.35
Ipswich Railway (S11)	12.88	13.08	0.19	13.14	0.26	13.15	0.27	13.48	0.60
Spine Street (S10)	8.85	8.95	0.10	8.98	0.13	8.99	0.13	9.15	0.29
Ric Nattrass Creek									
Progress Road (S40)	42.75	42.97	0.21	43.03	0.27	43.04	0.29	43.36	0.61
Centenary Motorway (S32a)	21.11	21.19	0.08	21.23	0.12	21.23	0.12	21.43	0.32
Ipswich Motorway (S29b)	14.45	14.53	0.08	14.56	0.11	14.57	0.12	14.68	0.23
Wolston Creek									
Wacol Station Road (S1)	6.96	7.11	0.14	7.15	0.19	7.17	0.21	7.40	0.44

Table 8.4 – 500-yr ARI (0.2 % AEP) Climate Impacts at Selected Locations (Scenario 1)

Structure Location	500-yr ARI (0.2 % AEP)				
	Existing WL (mAHD)	2100 RCP4.5		2100 RCP8.5	
		WL (mAHD)	Afflux (m)	WL (mAHD)	Afflux (m)
Sandy Creek					
Formation Street (S9)	23.12	23.26	0.14	23.40	0.27
Campbell Avenue (S7)	17.93	18.02	0.10	18.11	0.18
Ipswich Motorway (S4b)	15.27	15.47	0.20	15.60	0.33
Wolston Road (S2)	8.45	8.68	0.23	8.94	0.49
Bullockhead Creek					
Waterford Road (S20)	32.88	33.03	0.14	33.17	0.29
Centenary Motorway (S19a)	28.31	28.42	0.11	28.57	0.27
Progress Road (S17)	22.78	22.93	0.14	23.06	0.28
Ipswich Motorway (S13b)	15.95	16.07	0.13	16.33	0.39
Ipswich Railway (S11)	13.32	13.61	0.30	13.98	0.66
Spine Street (S10)	9.05	9.21	0.16	9.38	0.33
Ric Nattrass Creek					
Progress Road (S40)	43.11	43.38	0.27	43.52	0.42
Centenary Motorway (S32a)	21.29	21.46	0.17	21.70	0.41
Ipswich Motorway (S29b)	14.60	14.79	0.19	14.97	0.36
Wolston Creek					
Wacol Station Road (S1)	7.28	7.50	0.22	7.74	0.46

9.0 Summary of Study Findings

This flood study report details the calibration and verification, design event, rare / extreme event and sensitivity modelling for the Wolston Creek Catchment. This includes the major tributaries of Wolston Creek; Sandy Creek; Bullockhead Creek and Ric Nattrass Creek as well as a number of minor tributaries. New hydrologic and hydraulic models have been developed for the study using the URBS and TUFLOW modelling software, respectively.

Hydrometric information was sourced from the available rainfall, stream and maximum height gauge records. Calibration of the URBS and TUFLOW models was undertaken for the May 2015, January 2013 and May 2009 events. Verification of the URBS and TUFLOW models was undertaken for the March 2017 event.

The results of the hydraulic calibration and verification indicated that the URBS and TUFLOW models were able to adequately replicate the historical flooding events to within the specified tolerances for the majority of areas. On this basis, it was concluded that the URBS and TUFLOW models were sufficiently robust to be used to accurately simulate the synthetic design flood events.

Cross-checks of the TUFLOW hydraulic structure head-losses were undertaken at selected structures using the HEC-RAS software, from which it was confirmed that the model was representing the structures adequately.

Design, rare and extreme flood magnitudes were estimated for the full range of events from 2-yr ARI (50% AEP) to PMF. These analyses assumed hydrologic ultimate catchment development conditions in accordance with BCC City Plan 2014 and utilised the recently released AR&R 2016 methodology. A fixed tidal boundary was used at the downstream model extent to represent the Brisbane River.

Three waterway scenarios were considered as follows:

- Scenario 1 is based on the current waterway conditions. No further modifications were made to the TUFLOW model developed as part of the calibration / verification phase.
- Scenario 2 includes an allowance for a riparian corridor along the edge of the channel.
- Scenario 3 includes an allowance for the riparian corridor (as per Scenario 2) and also assumes filling to the “Modelled Flood Corridor” boundary to simulate potential development.

The results from the TUFLOW modelling were used to produce the following:

- Peak flood discharges at selected locations
- Peak flood levels at 100 m intervals along the AMTD line
- Peak flood extent mapping (Scenario 1 only)
- Hydraulic structure flood immunity data

The lower section of the catchment is dominated by flooding originating from the Brisbane River. As such, the reported peak flood levels in this area will be lower than the Brisbane River peak flood levels for each respective ARI (AEP).

As part of the required sensitivity analysis, a climate variability analysis was then undertaken to determine the impacts for four climate futures; namely:

- Year 2050 RCP4.5
- Year 2050 RCP8.5
- Year 2100 RCP4.5
- Year 2100 RCP8.5.

This included making allowances for increased rainfall intensity and increased mean sea level. This analysis was undertaken for the 100-yr ARI (1% AEP), 200-yr ARI (0.5% AEP) and 500-yr ARI (0.2% AEP) events.

The results indicated that climate variability impacts within the catchment will increase the magnitude of flooding. The following observations were made from the results:

- Flood level increases are greater under RCP8.5 climate projections when compared with RCP4.5 climate projections.
- 2050 RCP8.5 and 2100 RCP4.5 flood levels are almost identical for those areas not affected by projected sea level increases.
- Based on RCP8.5 climatic projections, by the year 2100, the 100-yr ARI (1 % AEP) flood levels are likely to lie between the present day 200-yr ARI (0.5 % AEP) and 500-yr ARI (0.2 % AEP) flood levels for those areas not affected by projected sea level increases.
- Based on RCP8.5 climatic projections, by the year 2100, the 200-yr ARI (0.5 % AEP) flood levels are likely to be greater than the present day 500-yr ARI (0.2 % AEP) flood levels for those areas not affected by projected sea level increases.

Hydraulic Structure Reference Sheets (HSRS) for all major crossings within the TUFLOW model area were also prepared. The HSRS provide data for each hydraulic structure and include data relating to the structure description, location, hydraulic performance and history.

APPENDICES

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Appendix A: Rainfall Distribution

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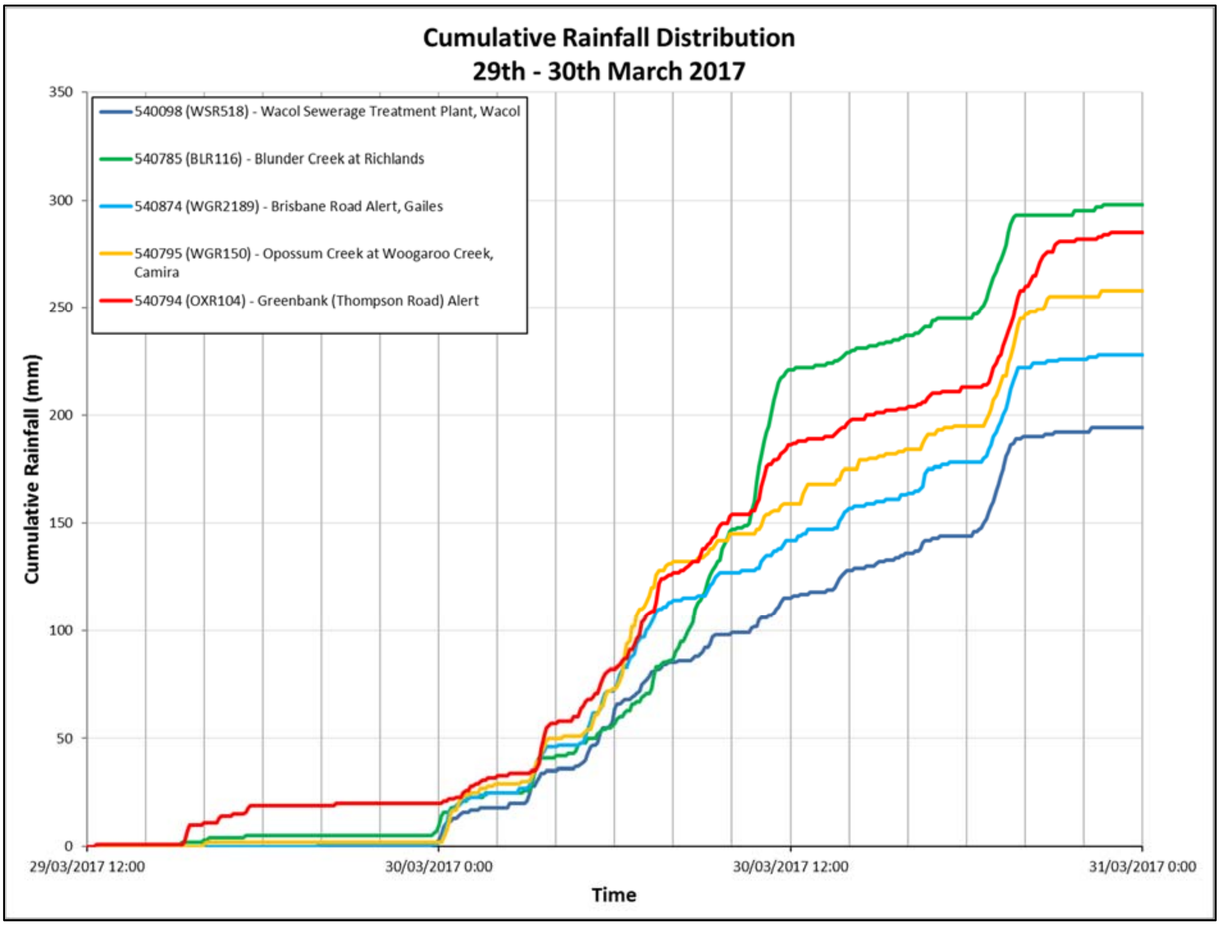
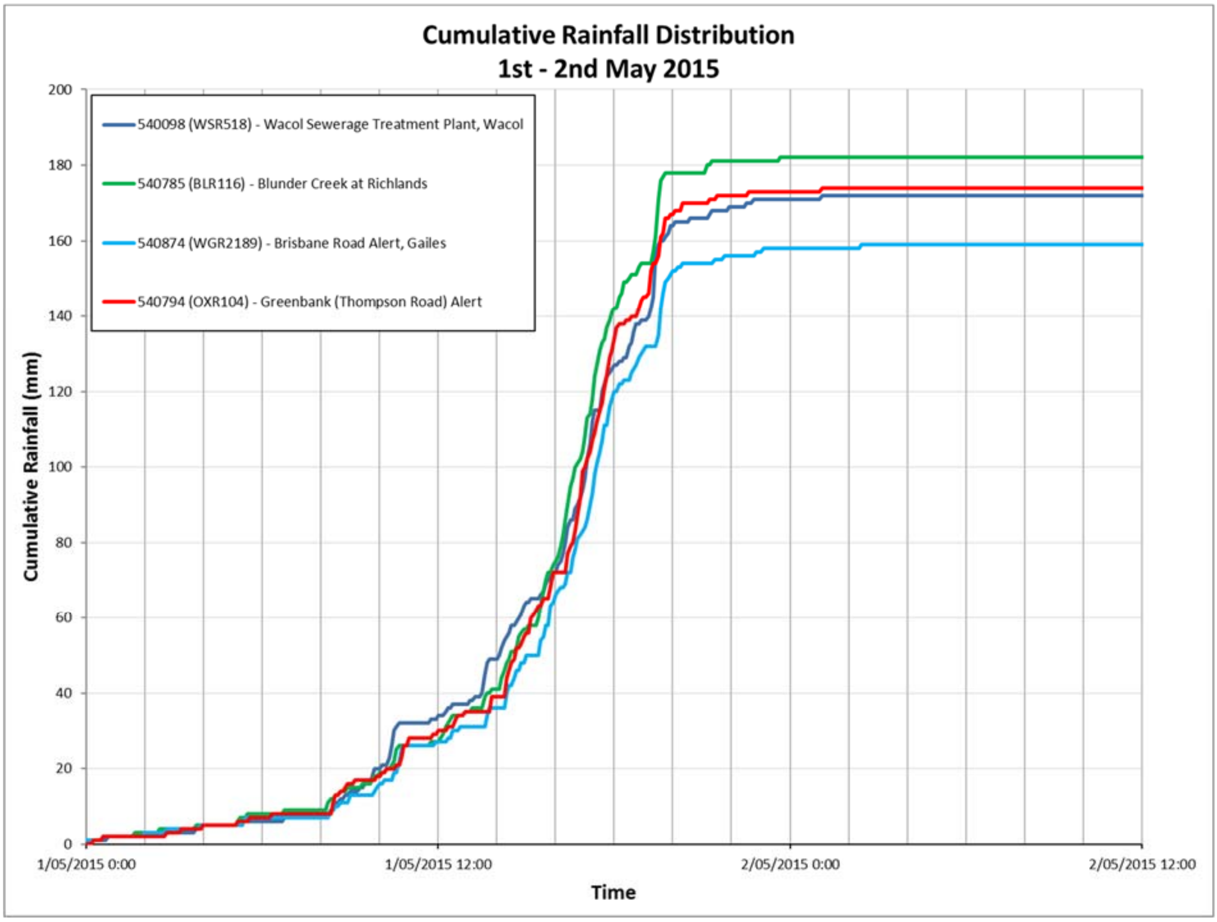
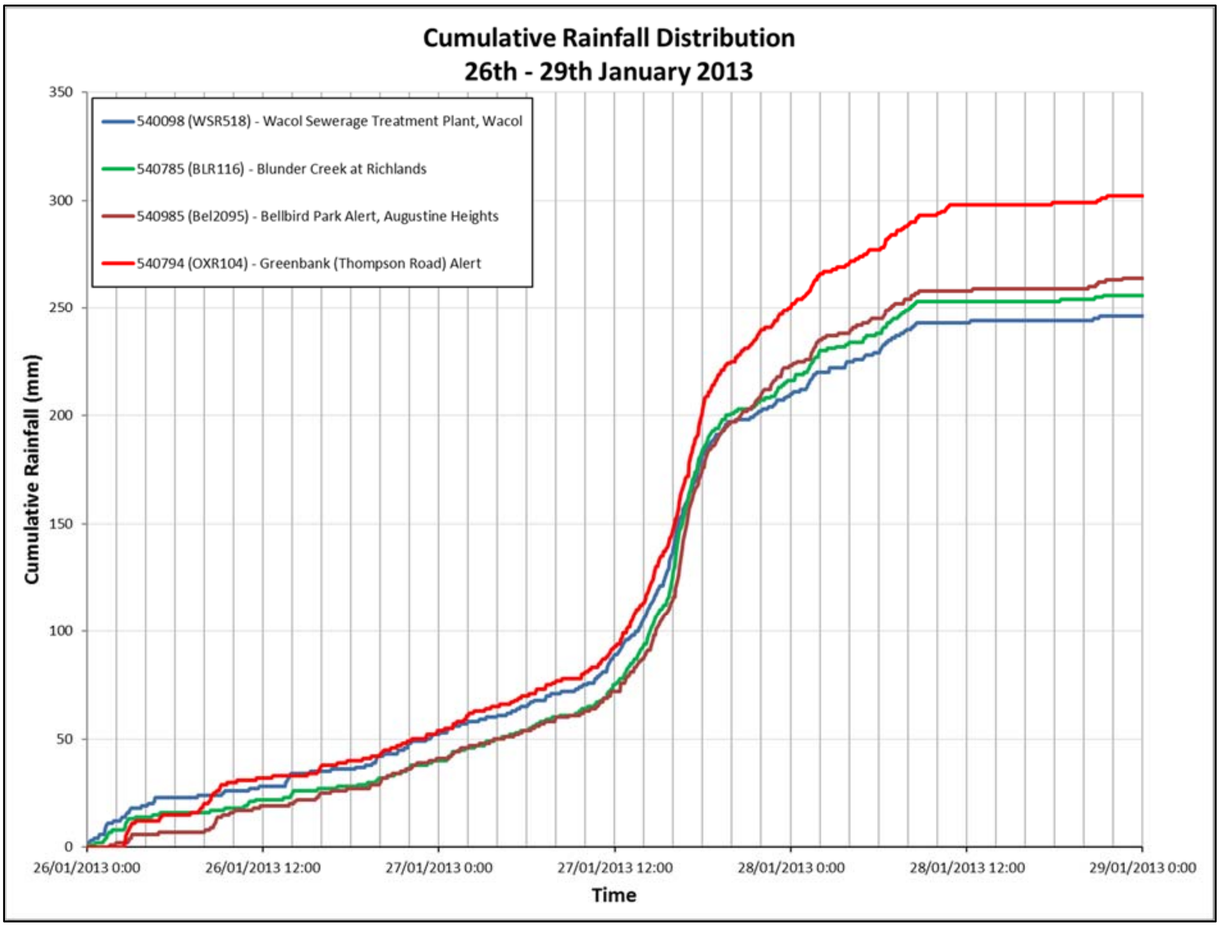

Cumulative Rainfall Distribution
29th - 30th March 2017
540098 (WSR518) - Wacol Sewerage Treatment Plant, Wacol
540785 (BLR116) - Blunder Creek at Richlands
540874 (WGR2189) - Brisbane Road Alert, Gailes
540795 (WGR150) - Opossum Creek at Woogaroo Creek, Camira
540794 (OXR104) - Greenbank (Thompson Road) Alert
Cumulative Rainfall (mm)
0
50
100
150
200
250
300
350
29/03/2017 12:00
30/03/2017 0:00
30/03/2017 12:00
31/03/2017 0:00
Time


Cumulative Rainfall Distribution
1st - 2nd May 2015
540098 (WSR518) - Wacol Sewerage Treatment Plant, Wacol
540785 (BLR116) - Blunder Creek at Richlands
540874 (WGR2189) - Brisbane Road Alert, Gailes
540794 (OXR104) - Greenbank (Thompson Road) Alert
Cumulative Rainfall (mm)
0
20
40
60
80
100
120
140
160
180
200
1/05/2015 0:00
1/05/2015 12:00
2/05/2015 0:00
2/05/2015 12:00
Time


Cumulative Rainfall Distribution
26th - 29th January 2013
540098 (WSR518) - Wacol Sewerage Treatment Plant, Wacol
540785 (BLR116) - Blunder Creek at Richlands
540985 (Bel2095) - Bellbird Park Alert, Augustine Heights
540794 (OXR104) - Greenbank (Thompson Road) Alert
Cumulative Rainfall (mm)
350
300
250
200
150
100
50
0
26/01/2013 0:00
26/01/2013 12:00
27/01/2013 0:00
27/01/2013 12:00
28/01/2013 0:00
28/01/2013 12:00
29/01/2013 0:00
Time

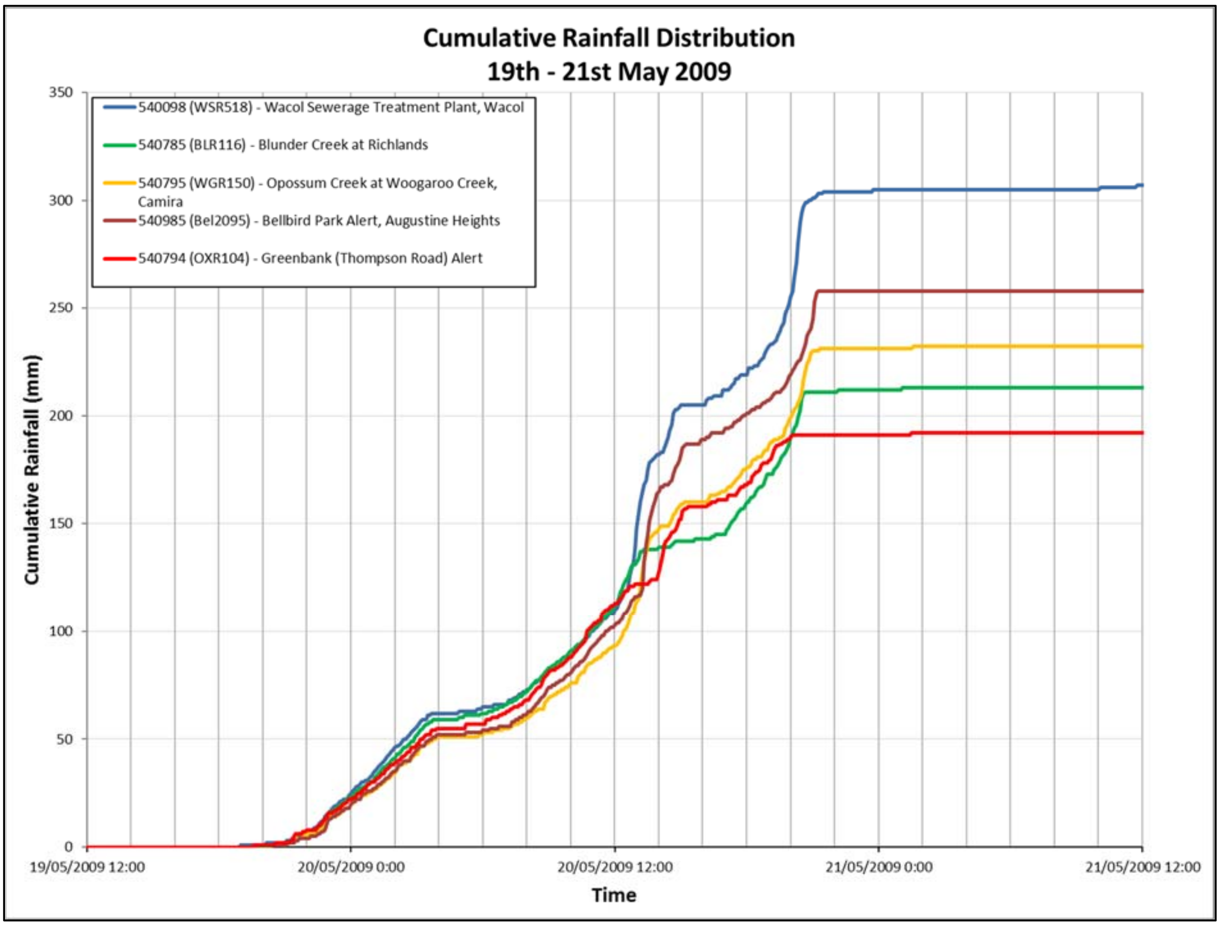

Cumulative Rainfall Distribution
19th - 21st May 2009
540098 (WSR518) - Wacol Sewerage Treatment Plant, Wacol
540785 (BLR116) - Blunder Creek at Richlands
540795 (WGR150) - Opossum Creek at Woogaroo Creek, Camira
540985 (Bel2095) - Bellbird Park Alert, Augustine Heights
540794 (OXR104) - Greenbank (Thompson Road) Alert
Cumulative Rainfall (mm)
350
300
250
200
150
100
50
0
19/05/2009 12:00
20/05/2009 0:00
20/05/2009 12:00
21/05/2009 0:00
21/05/2009 12:00
Time

Figure A-1: Thiessen Polygons for March 2017

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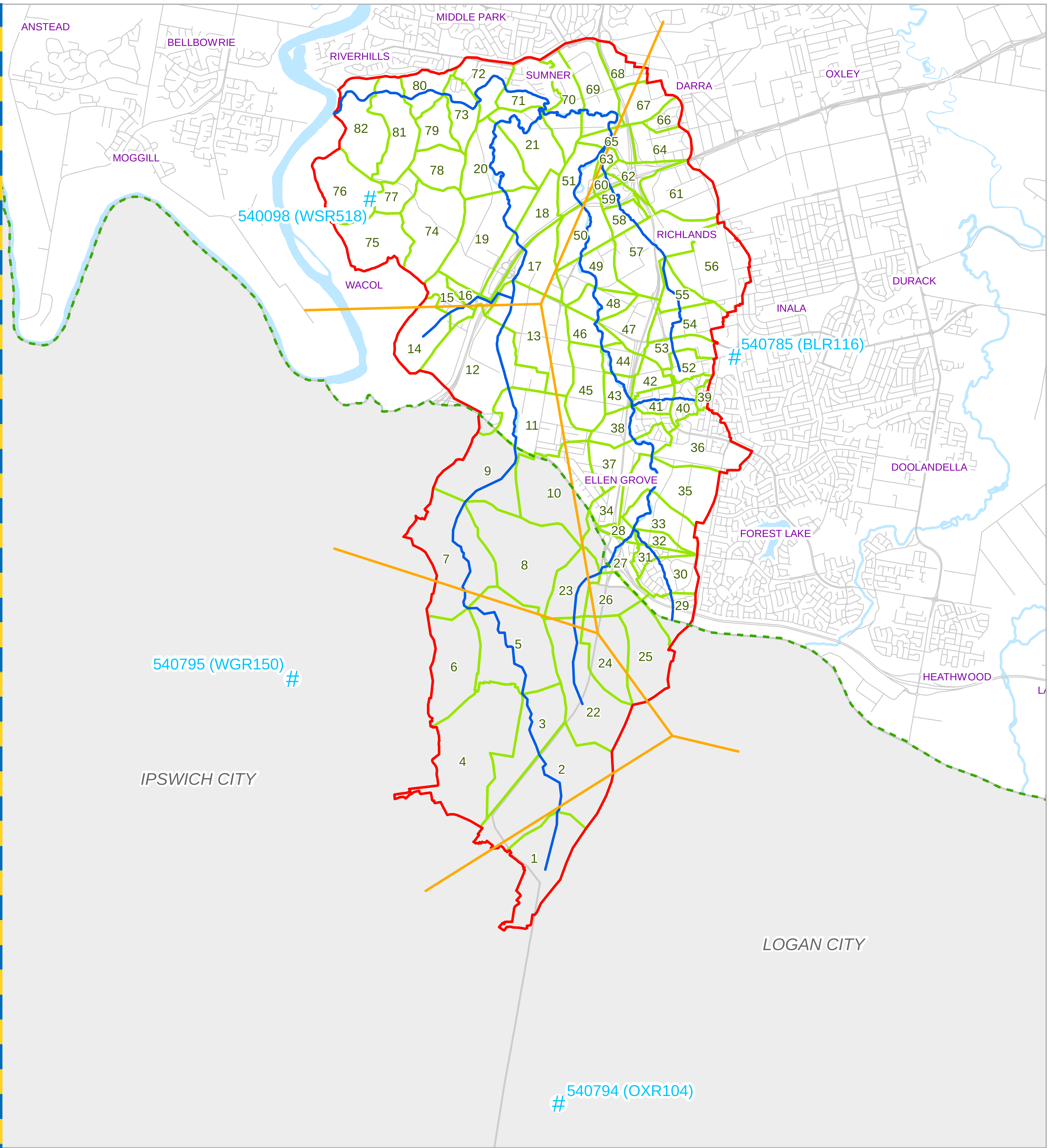

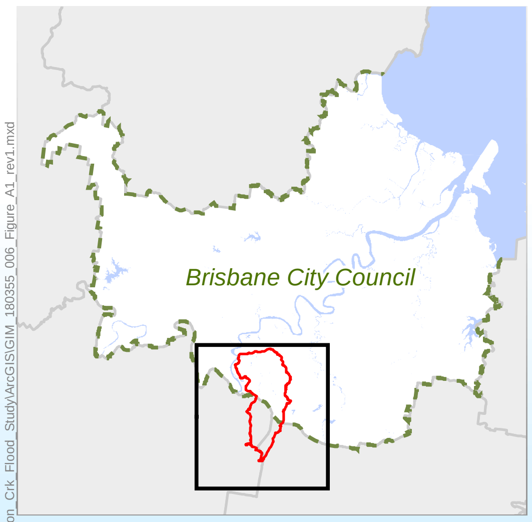

Legend

- Brisbane Boundary
- # Pluviograph Stations
- Rainfall Distribution
- Creek Centreline
- Catchment Area
- URBS Substations (1 - 82)
- Other LGA
- Road

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0 0.5 1 1.5 2
Kilometers

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DATA INFORMATION

Prepared : 104515
Checked : JS
Revision : 1
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Figure A1: Thiessen Polygons for March 2017

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Figure A-2: Thiessen Polygons for May 2015

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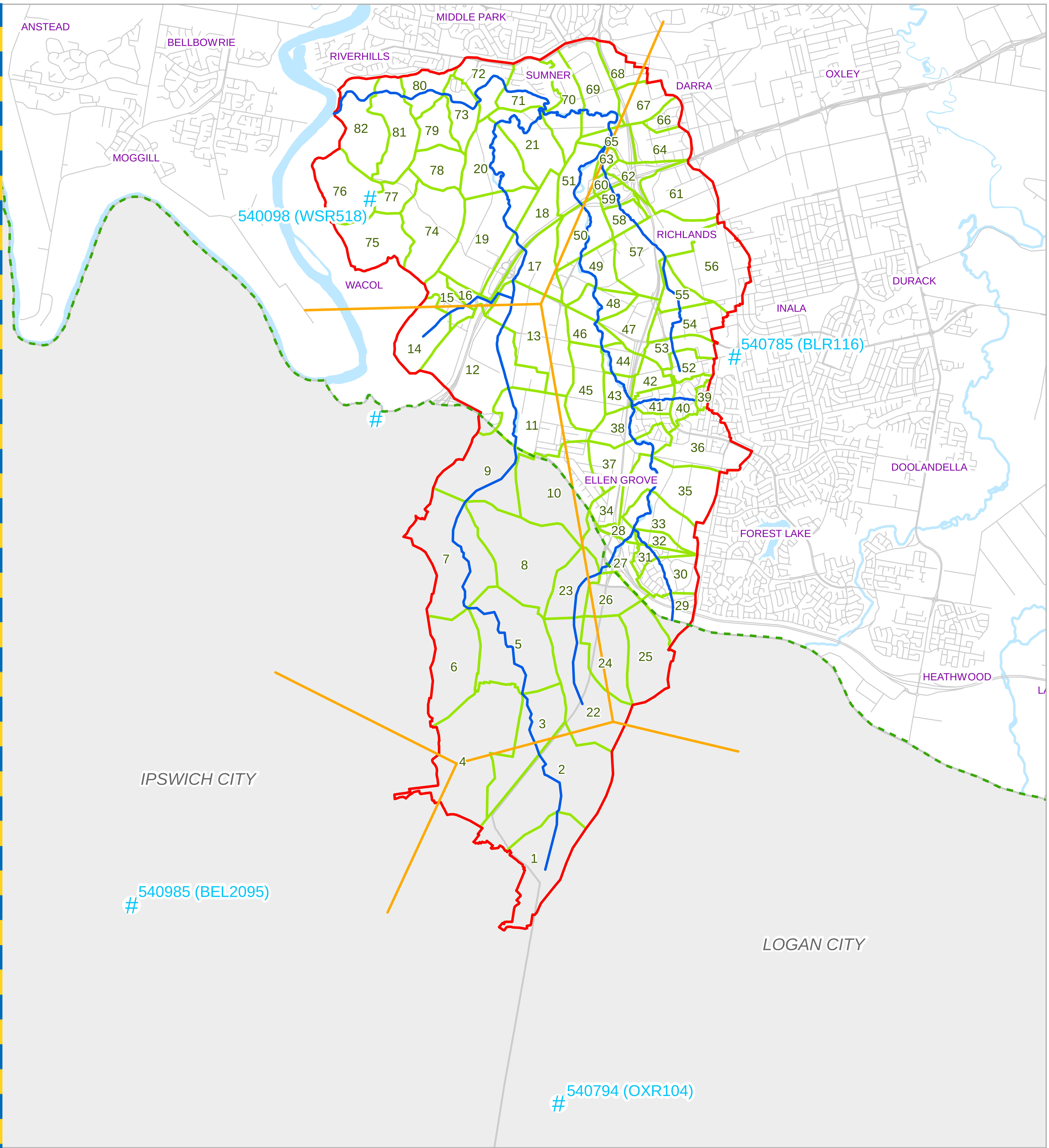

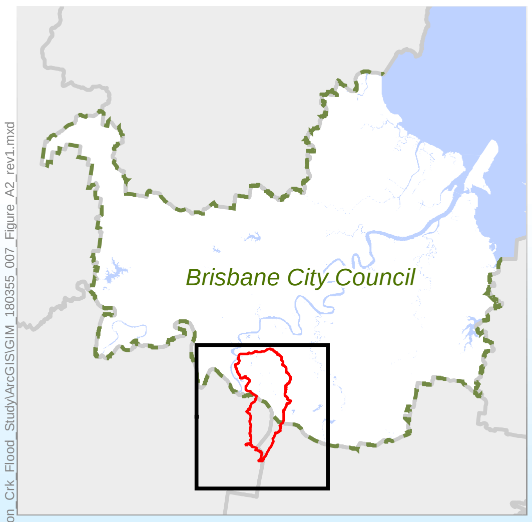

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Legend

- Brisbane Boundary
- Pluviograph Stations
- Rainfall Distribution
- Creek Centreline
- Catchment Area
- URBS Substations (1 - 82)
- Other LGA
- Road

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Figure A2: Thiessen Polygons for May 2015

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Figure A-2: Thiessen Polygons for January 2013

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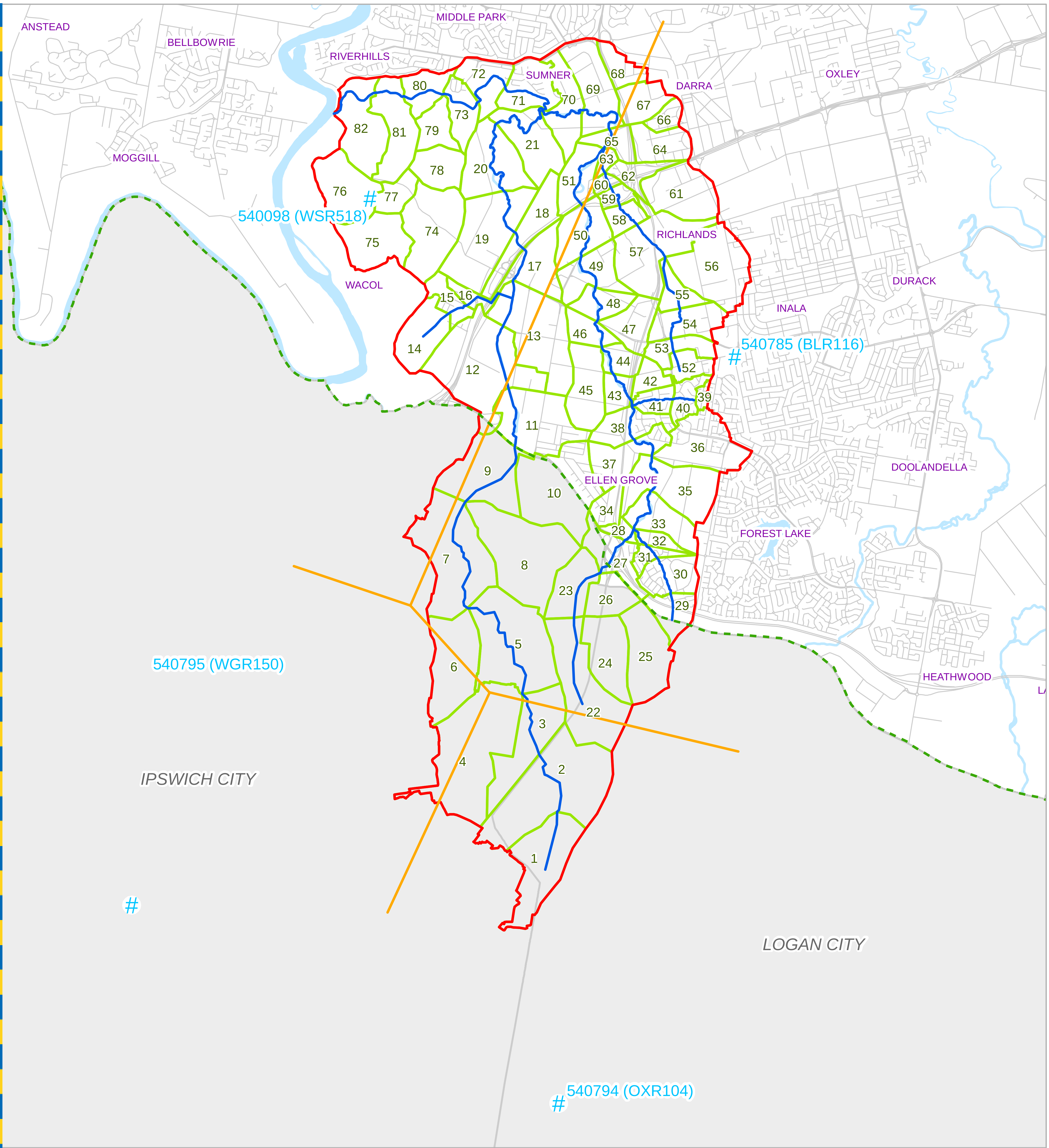

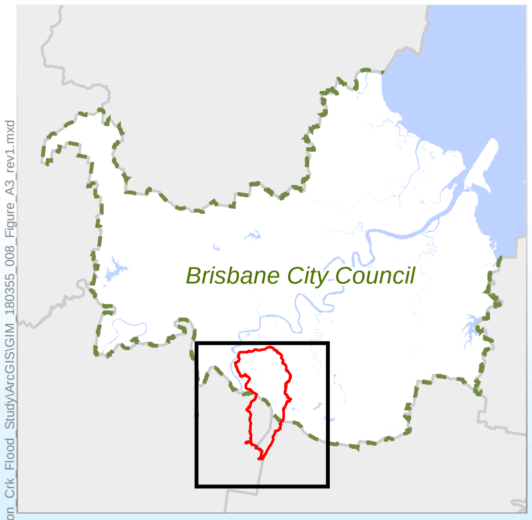

Legend

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- Brisbane Boundary
- Pluviograph Stations
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- Creek Centreline
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- URBS Substations (1 - 82)
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- Road

0 0.5 1 1.5 2
Kilometers

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Figure A3: Thiessen Polygons for January 2013

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Project Number : 180355

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Figure A-2: Thiessen Polygons for May 2009

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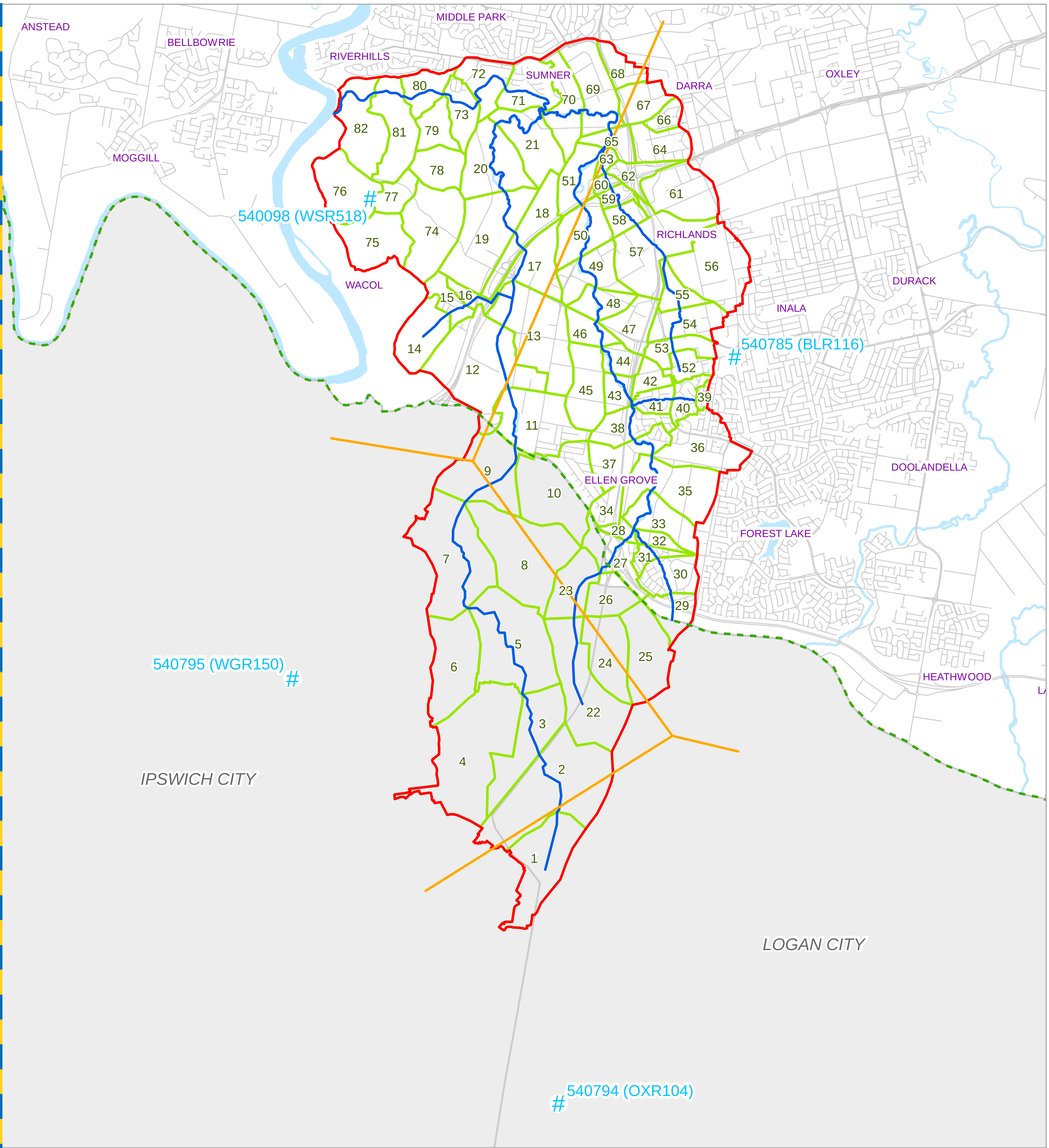

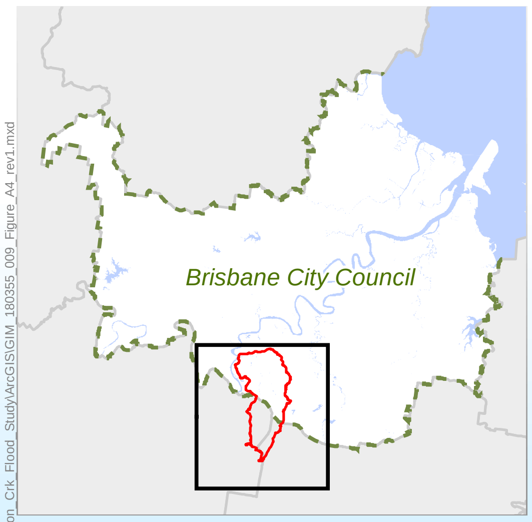

Legend

- Brisbane Boundary
- Pluviograph Stations
- Rainfall Distribution
- Creek Centreline
- Catchment Area
- URBS Substations (1 - 82)
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Wolston Creek Flood Study

Figure A4: Thiessen Polygons for May 2009

GIM - 180355 - 009

Appendix B: URBS Model Parameters

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URBS Calibration / Verification Event Sub-catchment Parameters

Sub-catchment	Area (km^2)	UL	UM	UH	UR	I
1	0.888	0.000	0.204	0.026	0.771	0.125
2	1.660	0.000	0.054	0.022	0.924	0.047
3	0.807	0.001	0.005	0.151	0.843	0.138
4	1.652	0.050	0.302	0.339	0.308	0.464
5	1.305	0.121	0.000	0.453	0.426	0.426
6	0.875	0.042	0.162	0.541	0.255	0.574
7	1.326	0.090	0.000	0.479	0.431	0.444
8	1.313	0.000	0.000	0.703	0.297	0.633
9	0.897	0.000	0.000	0.709	0.290	0.639
10	1.158	0.000	0.173	0.789	0.038	0.797
11	0.859	0.054	0.451	0.461	0.035	0.648
12	1.444	0.164	0.025	0.711	0.099	0.677
13	1.106	0.000	0.000	0.936	0.064	0.843
14	0.515	0.893	0.013	0.094	0.000	0.225
15	0.232	0.418	0.341	0.241	0.001	0.450
16	0.132	0.038	0.392	0.507	0.062	0.659
17	0.499	0.000	0.000	0.587	0.413	0.528
18	0.513	0.000	0.021	0.667	0.312	0.611
19	1.043	0.238	0.150	0.276	0.336	0.359
20	0.740	0.339	0.000	0.093	0.568	0.134
21	0.625	0.000	0.000	0.096	0.904	0.086
22	1.112	0.090	0.000	0.083	0.827	0.088
23	0.475	0.000	0.000	0.396	0.604	0.356
24	0.603	0.004	0.000	0.135	0.861	0.122
25	0.719	0.000	0.000	0.000	1.000	0.000
26	0.337	0.000	0.000	0.279	0.721	0.251
27	0.430	0.000	0.099	0.784	0.117	0.756
28	0.091	0.493	0.038	0.469	0.000	0.515
29	0.317	0.021	0.154	0.452	0.373	0.487
30	0.395	0.524	0.185	0.290	0.000	0.432
31	0.135	0.121	0.465	0.291	0.123	0.512
32	0.125	0.474	0.064	0.460	0.002	0.517
33	0.446	0.772	0.000	0.227	0.001	0.320

Sub-catchment	Area (km^2)	UL	UM	UH	UR	I
34	0.200	0.000	0.607	0.393	0.001	0.657
35	0.804	0.737	0.039	0.224	0.000	0.332
36	0.727	0.285	0.372	0.343	0.000	0.537
37	0.491	0.170	0.490	0.199	0.140	0.450
38	0.390	0.017	0.319	0.354	0.310	0.481
39	0.054	0.000	0.646	0.354	0.000	0.641
40	0.213	0.000	0.585	0.284	0.131	0.548
41	0.180	0.000	0.608	0.263	0.129	0.541
42	0.182	0.239	0.193	0.514	0.054	0.595
43	0.198	0.000	0.000	0.453	0.547	0.408
44	0.207	0.314	0.000	0.444	0.243	0.446
45	0.556	0.000	0.000	0.711	0.289	0.640
46	0.241	0.000	0.000	0.439	0.561	0.395
47	0.378	0.000	0.000	0.786	0.214	0.707
48	0.284	0.000	0.000	0.713	0.287	0.641
49	0.473	0.000	0.000	0.460	0.540	0.414
50	0.505	0.000	0.000	0.145	0.855	0.130
51	0.419	0.000	0.054	0.255	0.692	0.256
52	0.216	0.329	0.106	0.485	0.081	0.538
53	0.262	0.479	0.000	0.371	0.150	0.406
54	0.423	0.135	0.038	0.624	0.202	0.601
55	0.234	0.191	0.082	0.563	0.164	0.576
56	0.896	0.065	0.010	0.841	0.084	0.771
57	0.956	0.000	0.000	0.806	0.194	0.726
58	0.189	0.000	0.000	0.346	0.654	0.312
59	0.123	0.000	0.000	0.827	0.173	0.745
60	0.072	0.000	0.288	0.540	0.172	0.630
61	0.654	0.015	0.000	0.955	0.030	0.862
62	0.224	0.000	0.157	0.681	0.162	0.691
63	0.078	0.000	0.272	0.150	0.578	0.271
64	0.379	0.000	0.325	0.473	0.202	0.589
65	0.224	0.000	0.047	0.368	0.585	0.355
66	0.150	0.000	0.013	0.833	0.154	0.756
67	0.341	0.000	0.000	0.861	0.139	0.775

Sub-catchment	Area (km^2)	UL	UM	UH	UR	I
68	0.242	0.000	0.000	0.952	0.048	0.856
69	0.669	0.000	0.004	0.823	0.173	0.742
70	0.507	0.000	0.008	0.606	0.386	0.549
71	0.472	0.086	0.233	0.348	0.333	0.442
72	0.405	0.409	0.232	0.256	0.103	0.408
73	0.332	0.607	0.097	0.162	0.135	0.285
74	0.866	0.887	0.000	0.113	0.000	0.235
75	0.613	0.933	0.000	0.067	0.000	0.200
76	0.645	0.336	0.000	0.061	0.604	0.105
77	0.240	0.906	0.000	0.090	0.004	0.217
78	0.374	0.932	0.000	0.067	0.001	0.200
79	0.291	0.932	0.000	0.067	0.001	0.200
80	0.307	0.353	0.038	0.099	0.510	0.161
81	0.639	0.854	0.001	0.073	0.072	0.194
82	0.707	0.697	0.002	0.085	0.216	0.182

URBS Design Event Sub-catchment Parameters

Sub-catchment	Area (km^2)	UL	UM	UH	UR	I
1	0.888	0.000	0.204	0.026	0.771	0.125
2	1.660	0.000	0.054	0.022	0.924	0.047
3	0.807	0.001	0.005	0.877	0.117	0.792
4	1.652	0.050	0.304	0.412	0.233	0.531
5	1.305	0.121	0.000	0.649	0.230	0.602
6	0.875	0.042	0.162	0.541	0.255	0.574
7	1.326	0.090	0.000	0.738	0.171	0.678
8	1.313	0.000	0.000	0.919	0.081	0.827
9	0.897	0.000	0.000	0.985	0.015	0.886
10	1.158	0.000	0.173	0.789	0.038	0.797
11	0.859	0.054	0.490	0.456	0.000	0.663
12	1.444	0.000	0.025	0.818	0.156	0.749
13	1.106	0.000	0.000	0.937	0.063	0.843
14	0.515	0.000	0.013	0.560	0.427	0.510
15	0.232	0.000	0.409	0.411	0.179	0.575
16	0.132	0.000	0.392	0.526	0.081	0.670
17	0.499	0.000	0.000	0.926	0.074	0.833
18	0.513	0.000	0.021	0.667	0.312	0.611
19	1.043	0.000	0.150	0.395	0.455	0.430
20	0.740	0.000	0.000	0.262	0.738	0.236
21	0.625	0.000	0.000	0.096	0.904	0.086
22	1.112	0.090	0.000	0.372	0.538	0.348
23	0.475	0.000	0.000	1.000	0.000	0.900
24	0.603	0.004	0.000	0.165	0.831	0.149
25	0.719	0.000	0.000	0.000	1.000	0.000
26	0.337	0.000	0.000	0.349	0.651	0.314
27	0.430	0.000	0.099	0.796	0.105	0.766
28	0.091	0.000	0.465	0.532	0.002	0.712
29	0.317	0.021	0.154	0.452	0.373	0.487
30	0.395	0.524	0.185	0.290	0.000	0.432
31	0.135	0.121	0.465	0.291	0.123	0.512
32	0.125	0.000	0.481	0.518	0.001	0.707

Sub-catchment	Area (km^2)	UL	UM	UH	UR	I
33	0.446	0.000	0.493	0.506	0.001	0.702
34	0.200	0.000	0.607	0.393	0.001	0.657
35	0.804	0.000	0.536	0.464	0.000	0.686
36	0.727	0.076	0.555	0.369	0.000	0.621
37	0.491	0.000	0.660	0.209	0.131	0.518
38	0.390	0.000	0.336	0.526	0.138	0.641
39	0.054	0.000	0.646	0.354	0.000	0.641
40	0.213	0.000	0.585	0.284	0.131	0.548
41	0.180	0.000	0.608	0.263	0.129	0.541
42	0.182	0.000	0.193	0.713	0.094	0.738
43	0.198	0.000	0.000	0.821	0.179	0.739
44	0.207	0.000	0.000	0.754	0.246	0.678
45	0.556	0.000	0.000	0.985	0.015	0.886
46	0.241	0.000	0.000	0.794	0.206	0.714
47	0.378	0.000	0.000	0.924	0.075	0.832
48	0.284	0.000	0.000	0.766	0.234	0.689
49	0.473	0.000	0.000	0.775	0.225	0.698
50	0.505	0.000	0.000	0.778	0.222	0.700
51	0.419	0.000	0.054	0.255	0.692	0.256
52	0.216	0.000	0.106	0.749	0.146	0.727
53	0.262	0.000	0.000	0.846	0.154	0.761
54	0.423	0.020	0.038	0.863	0.079	0.799
55	0.234	0.337	0.082	0.581	0.000	0.615
56	0.896	0.031	0.010	0.910	0.049	0.829
57	0.956	0.000	0.000	0.960	0.040	0.864
58	0.189	0.000	0.000	0.825	0.175	0.743
59	0.123	0.000	0.000	0.835	0.165	0.751
60	0.072	0.000	0.288	0.540	0.172	0.630
61	0.654	0.015	0.000	0.955	0.030	0.862
62	0.224	0.000	0.157	0.681	0.162	0.691
63	0.078	0.000	0.272	0.150	0.578	0.271
64	0.379	0.000	0.325	0.473	0.202	0.589
65	0.224	0.000	0.047	0.368	0.585	0.355
66	0.150	0.000	0.013	0.833	0.154	0.756

Sub-catchment	Area (km^2)	UL	UM	UH	UR	I
67	0.341	0.000	0.000	0.861	0.139	0.775
68	0.242	0.000	0.000	0.952	0.048	0.856
69	0.669	0.000	0.004	0.823	0.173	0.742
70	0.507	0.000	0.008	0.606	0.386	0.549
71	0.472	0.086	0.233	0.348	0.333	0.442
72	0.405	0.409	0.232	0.256	0.103	0.408
73	0.332	0.000	0.097	0.465	0.438	0.467
74	0.866	0.000	0.000	0.576	0.424	0.518
75	0.613	0.000	0.000	0.556	0.444	0.500
76	0.645	0.000	0.221	0.435	0.344	0.502
77	0.240	0.000	0.001	0.568	0.432	0.511
78	0.374	0.000	0.000	0.556	0.444	0.500
79	0.291	0.000	0.000	0.556	0.444	0.500
80	0.307	0.000	0.038	0.275	0.687	0.267
81	0.639	0.067	0.001	0.470	0.461	0.434
82	0.707	0.187	0.002	0.395	0.415	0.385

Appendix C: Adopted Land-use

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Figure C-1: BCC City Plan 2014 Zones

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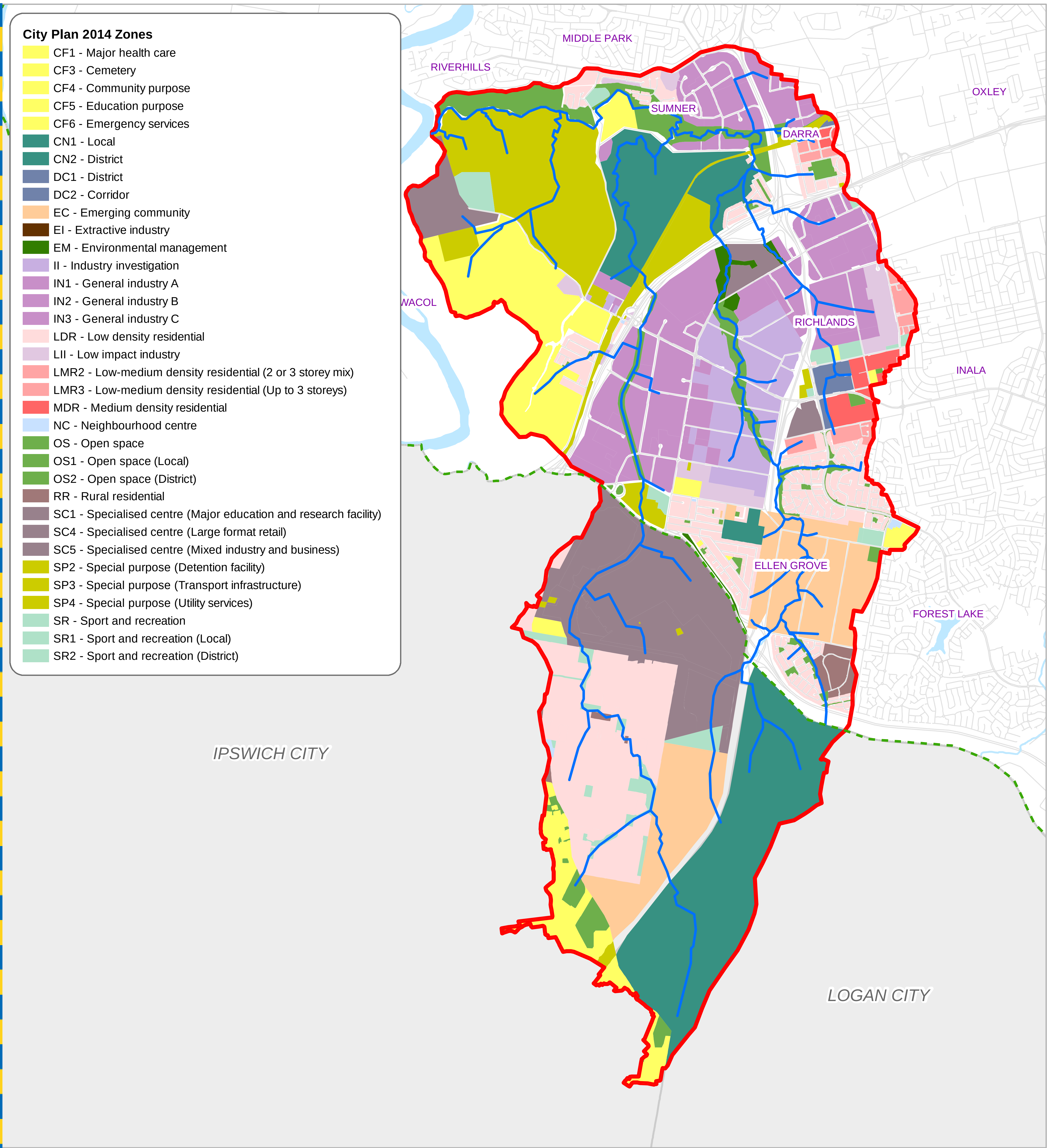

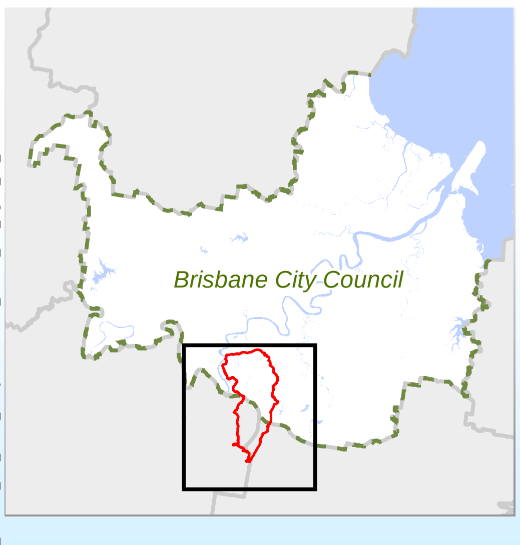

For Information Only - Not Council Policy

0 0.5 1 1.5 2
Kilometers

Legend

- Brisbane Boundary
- Creek Centreline
- Streets
- Other LGAs
- Catchment Area

Brisbane City Council
City Projects Office
GPO Box 1434
Brisbane Qld 4001
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DATA INFORMATION

Prepared : 104515
Checked : JS
Revision : 1
Publication Date : 07 Jun 2018
Project Number : 180355

Wolston Creek Flood Study

Figure C1: 2014 City Plan Zones

GIM - 180355 - 010

Figure C-2: 2015 Aerial Photo

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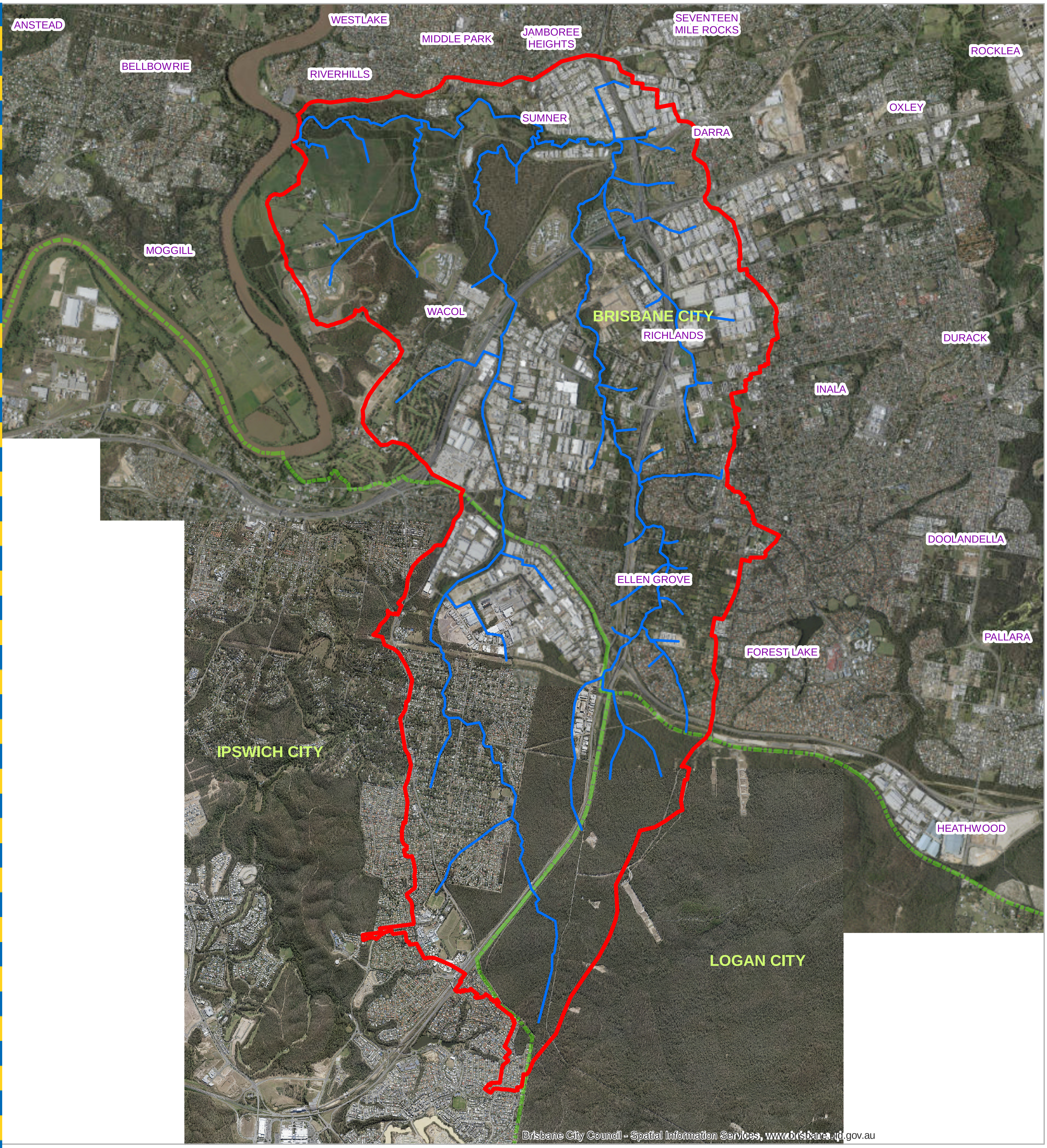

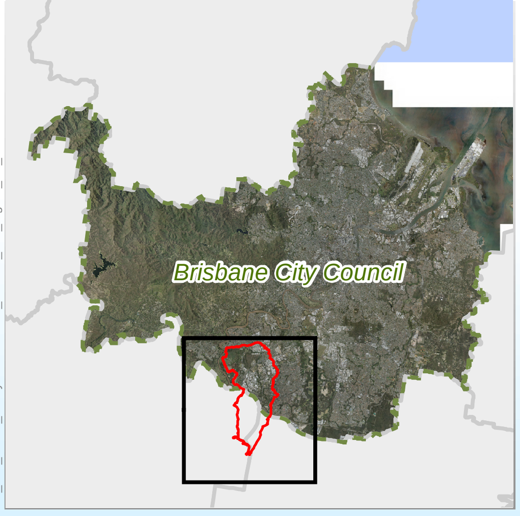

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0 0.5 1 1.5 2
Kilometers

Legend

- Creek Centreline
- Catchment Area
- LGA Boundaries

Brisbane City Council
City Projects Office
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Brisbane Qld 4001

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DATA INFORMATION

The flood maps must be read in conjunction with the flood study report and interpreted by a qualified professional engineer. The flood maps are based on the best data available to Brisbane City Council ("Council") at the time the maps were developed. Council, and the copyright owners listed below, give no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) presented in these maps and the user uses and relies upon the data in the maps at their own sole risk and liability. Council is not liable for errors or omissions in the flood maps. To the full extent that it is able to do so in law, the Council disclaims all liability (including without limitation, liability in negligence) for any loss, damage or costs (including indirect and consequential loss and damage), caused by or arising from anyone using or relying on the data contained in the flood maps for any purpose whatsoever.

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Prepared : 104515
Checked : JS
Revision : 1
Publication Date : 07 Jun 2018
Project Number : 180355

Wolston Creek Flood Study

Figure C2: 2017 Aerial Photo

GIM - 180355 - 011

Land-use Type	% Impervious
Low density residential	60
Character residential (Character)	70
Character residential (Infill housing)	70
Low-medium density residential (2 storey mix)	70
Low-medium density residential (2 or 3 storey mix)	70
Low-medium density residential (Up to 3 storeys)	70
Medium density residential	80
High density residential (Up to 8 storeys)	90
High density residential (Up to 15 storeys)	90
Tourist accommodation	80
Neighbourhood centre	90
District centre (District)	90
District centre (Corridor)	90
Major centre	90
Principal centre (City centre)	90
Principal centre (Regional centre)	90
Low impact industry	90
Industry (General industry A)	90
Industry (General industry B)	90
Industry (General industry C)	90
Special industry	90
Industry investigation	90
Sport and recreation	20
Sport and recreation (Local)	20
Sport and recreation (District)	20
Sport and recreation (Metropolitan)	20
Open space	5
Open space (Local)	5
Open space (District)	5
Open space (Metropolitan)	5
Environmental management	5
Conservation	0
Conservation (Local)	0
Conservation (District)	0
Conservation (Metropolitan)	0

Land-use Type	% Impervious
Emerging community	70
Extractive industry	5
Mixed use (Inner city)	90
Mixed use (Centre frame)	90
Mixed use (Corridor)	90
Rural	5
Rural residential	30
Township	80
Community facilities (Major health care)	50
Community facilities (Major sports venue)	60
Community facilities (Cemetery)	20
Community facilities (Community purposes)	70
Community facilities (Education purposes)	70
Community facilities (Emergency services)	70
Community facilities (Health care purposes)	50
Specialised centre (Major education and research facility)	50
Specialised centre (Entertainment and conference centre)	90
Specialised centre (Brisbane Markets)	90
Specialised centre (Large format retail)	90
Specialised centre (Mixed industry and business)	90
Specialised centre (Marina)	80
Special purpose (Defence)	80
Special purpose (Detention facility)	50
Special purpose (Transport infrastructure)	75
Special purpose (Utility services)	50
Special purpose (Airport)	60
Special purpose (Port)	60

Appendix D: URBS – TUFLOW Comparative Plots

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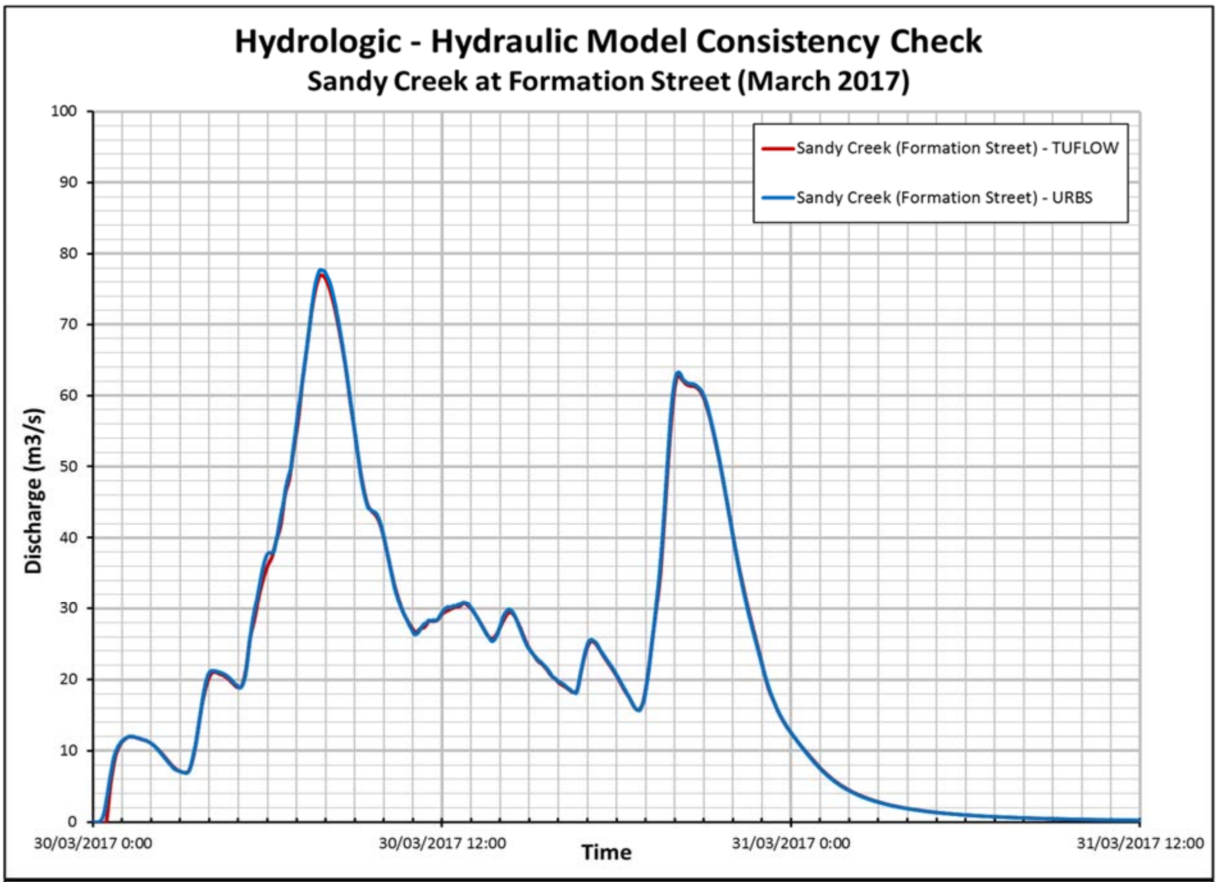
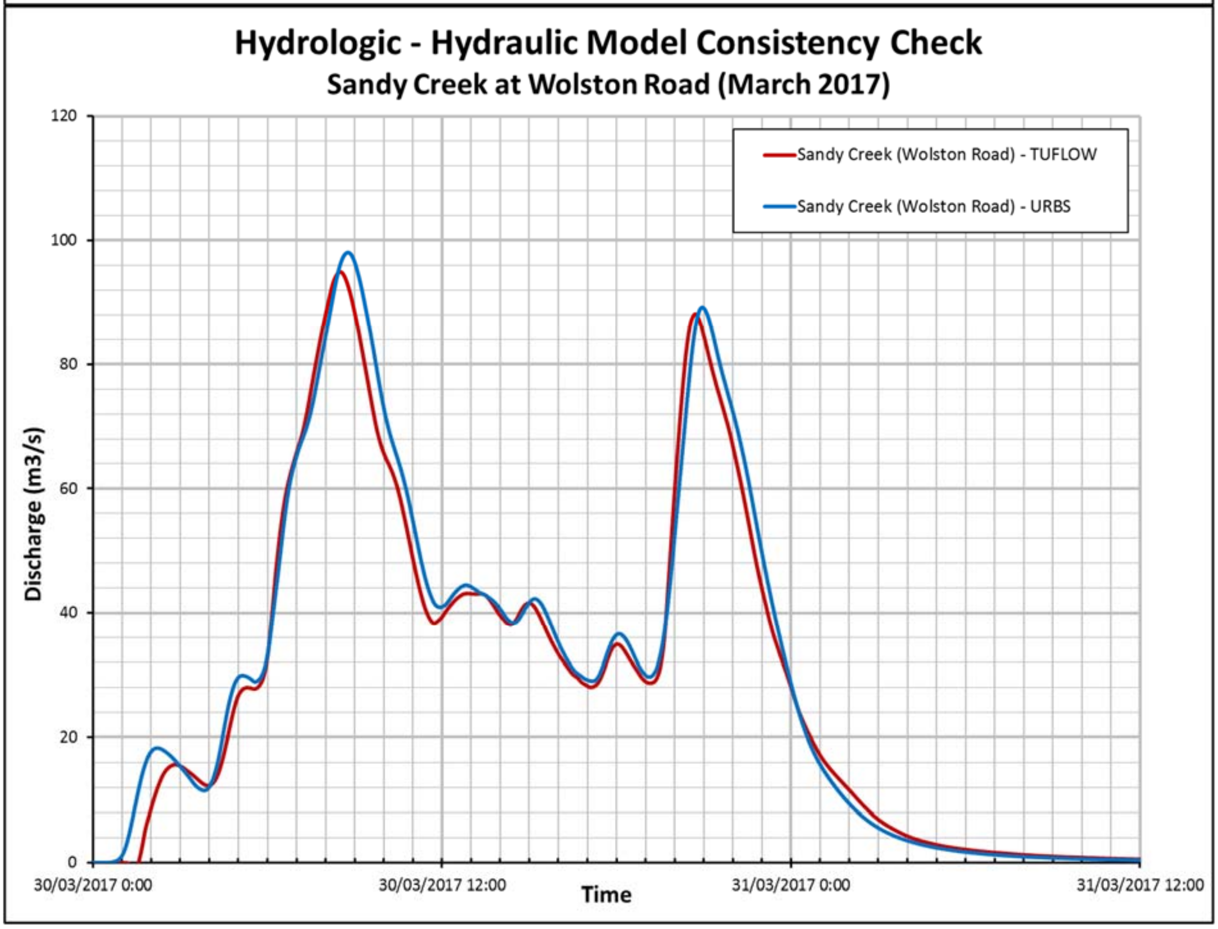
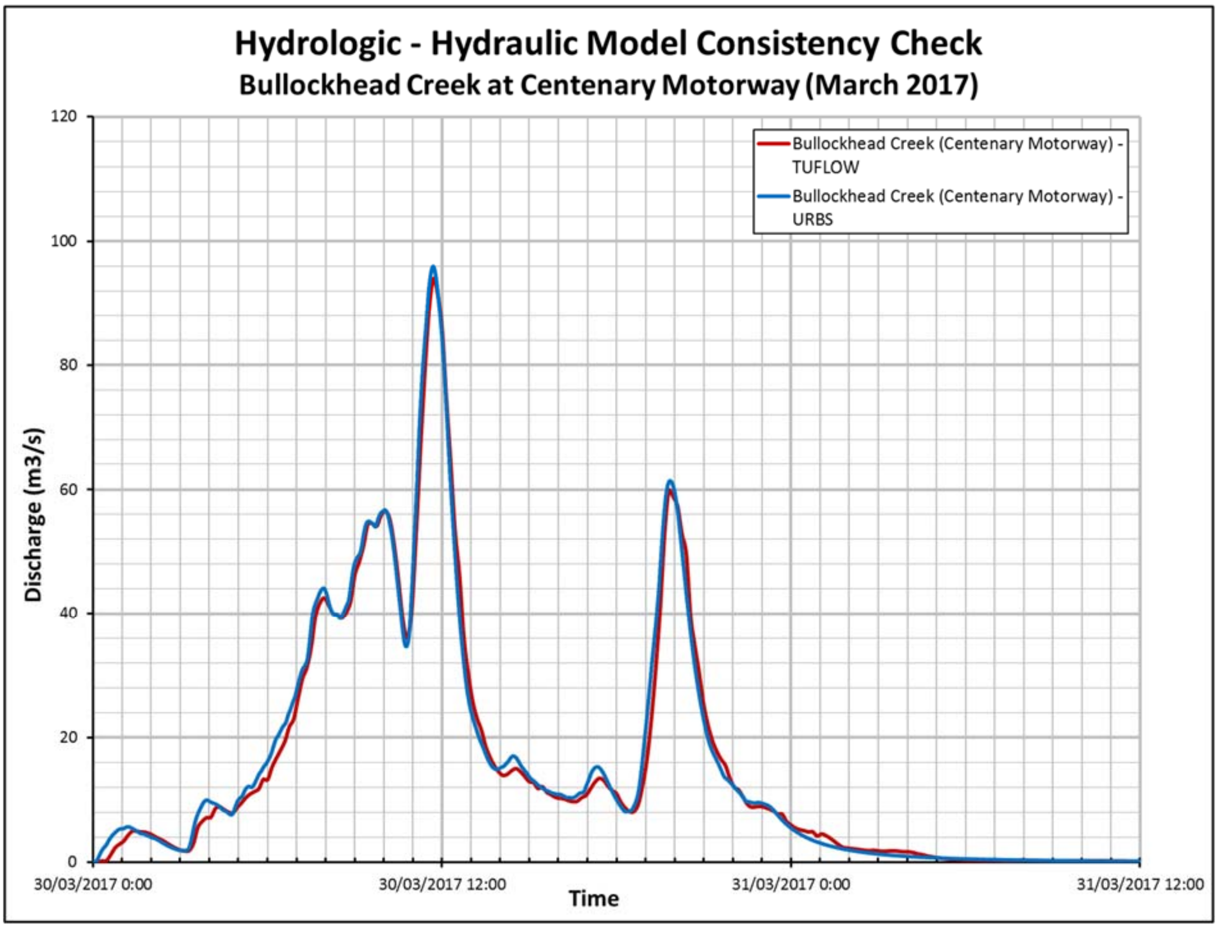
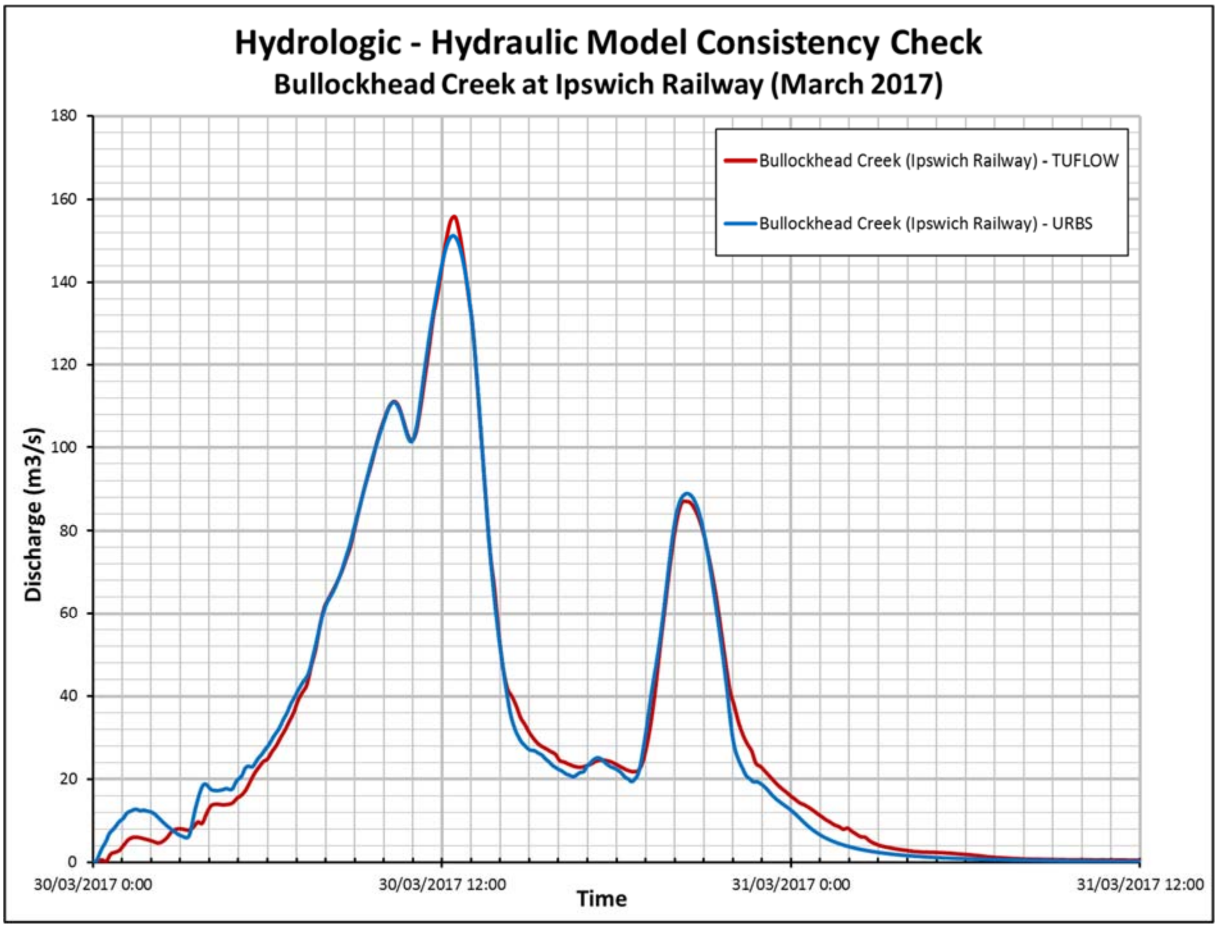
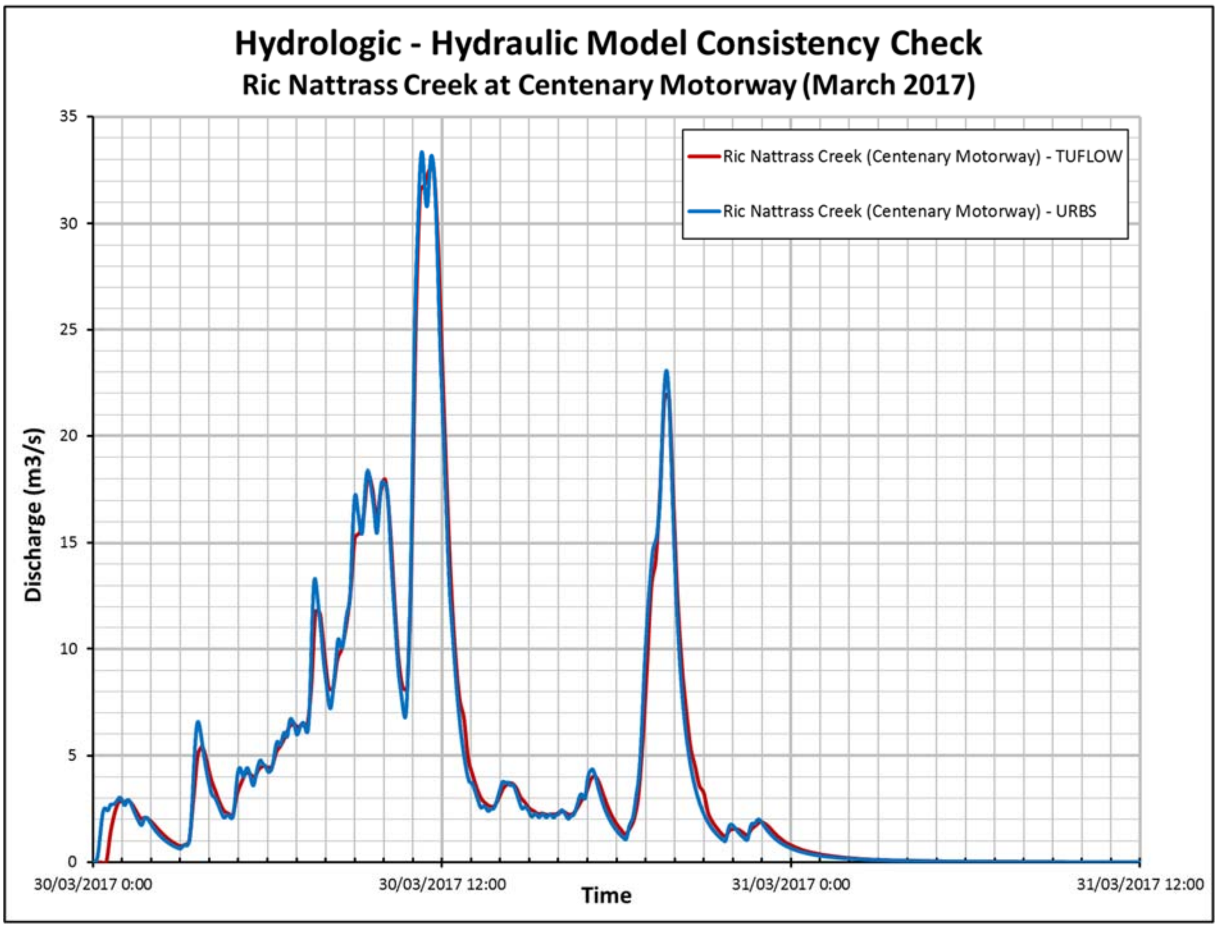
Historical Events



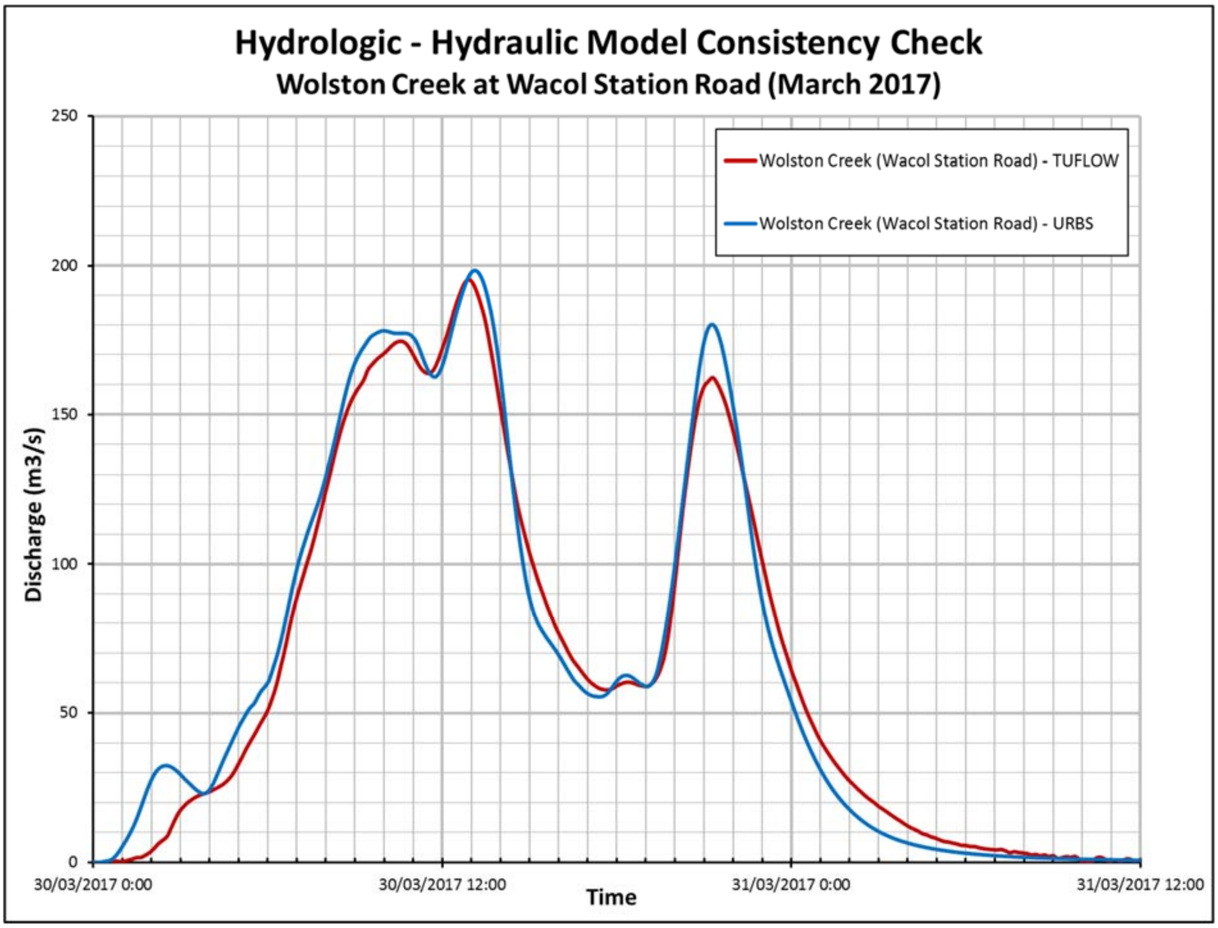



Hydrologic - Hydraulic Model Consistency Check
Bullockhead Creek at Centenary Motorway (March 2017)
Bullockhead Creek (Centenary Motorway) - TUFLOW
Bullockhead Creek (Centenary Motorway) - URBS
Discharge (m3/s)
Time
0
20
40
60
80
100
120
30/03/2017 0:00
30/03/2017 12:00
31/03/2017 0:00
31/03/2017 12:00

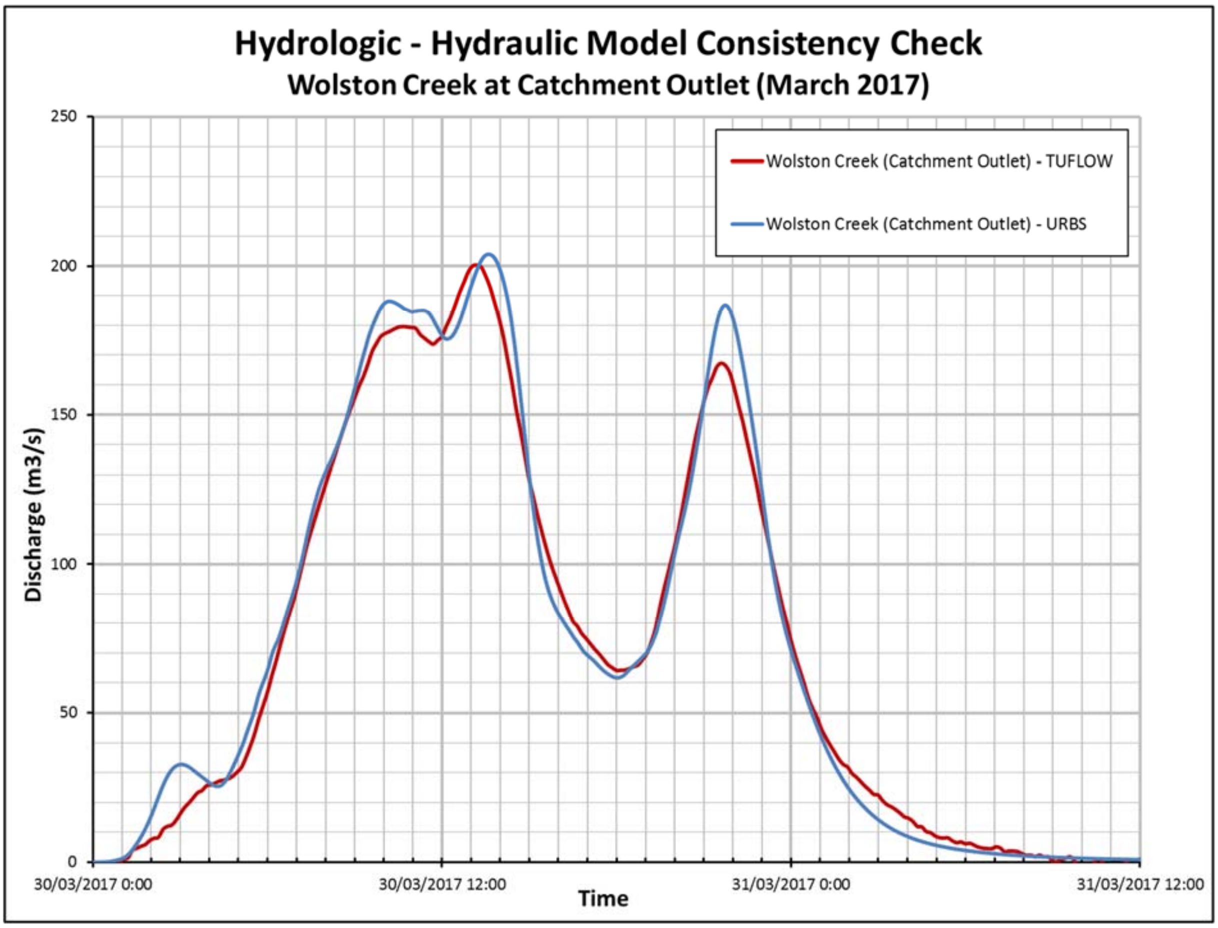

Hydrologic - Hydraulic Model Consistency Check
Bullockhead Creek at Ipswich Railway (March 2017)
Bullockhead Creek (Ipswich Railway) - TUFLOW
Bullockhead Creek (Ipswich Railway) - URBS
Discharge (m3/s)
Time
0
20
40
60
80
100
120
140
160
180
30/03/2017 0:00
30/03/2017 12:00
31/03/2017 0:00
31/03/2017 12:00



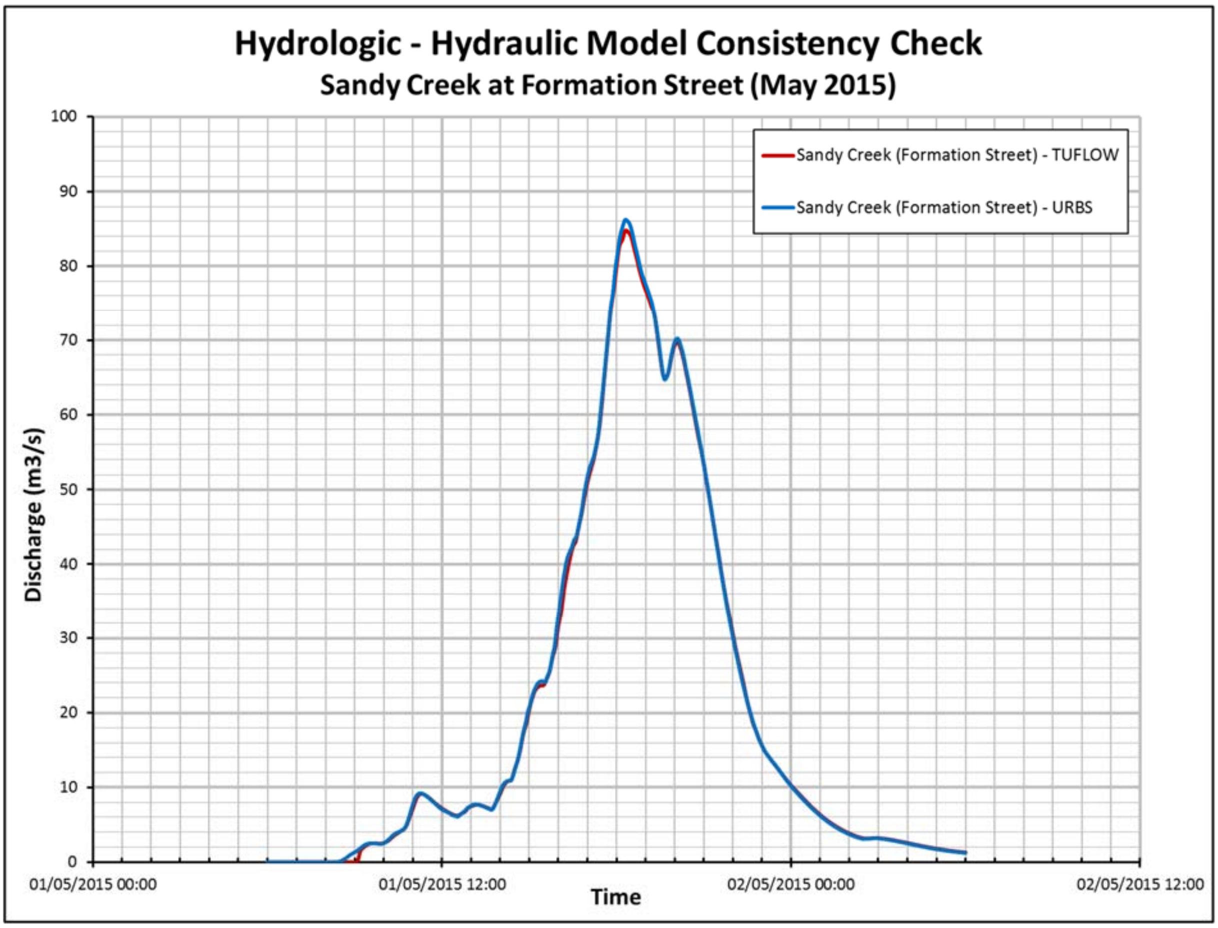
Hydrologic - Hydraulic Model Consistency Check
Ric Nattrass Creek at Centenary Motorway (March 2017)
Ric Nattrass Creek (Centenary Motorway) - TUFLOW
Ric Nattrass Creek (Centenary Motorway) - URBS
Discharge (m3/s)
Time
0
5
10
15
20
25
30
35
30/03/2017 0:00
30/03/2017 12:00
31/03/2017 0:00
31/03/2017 12:00

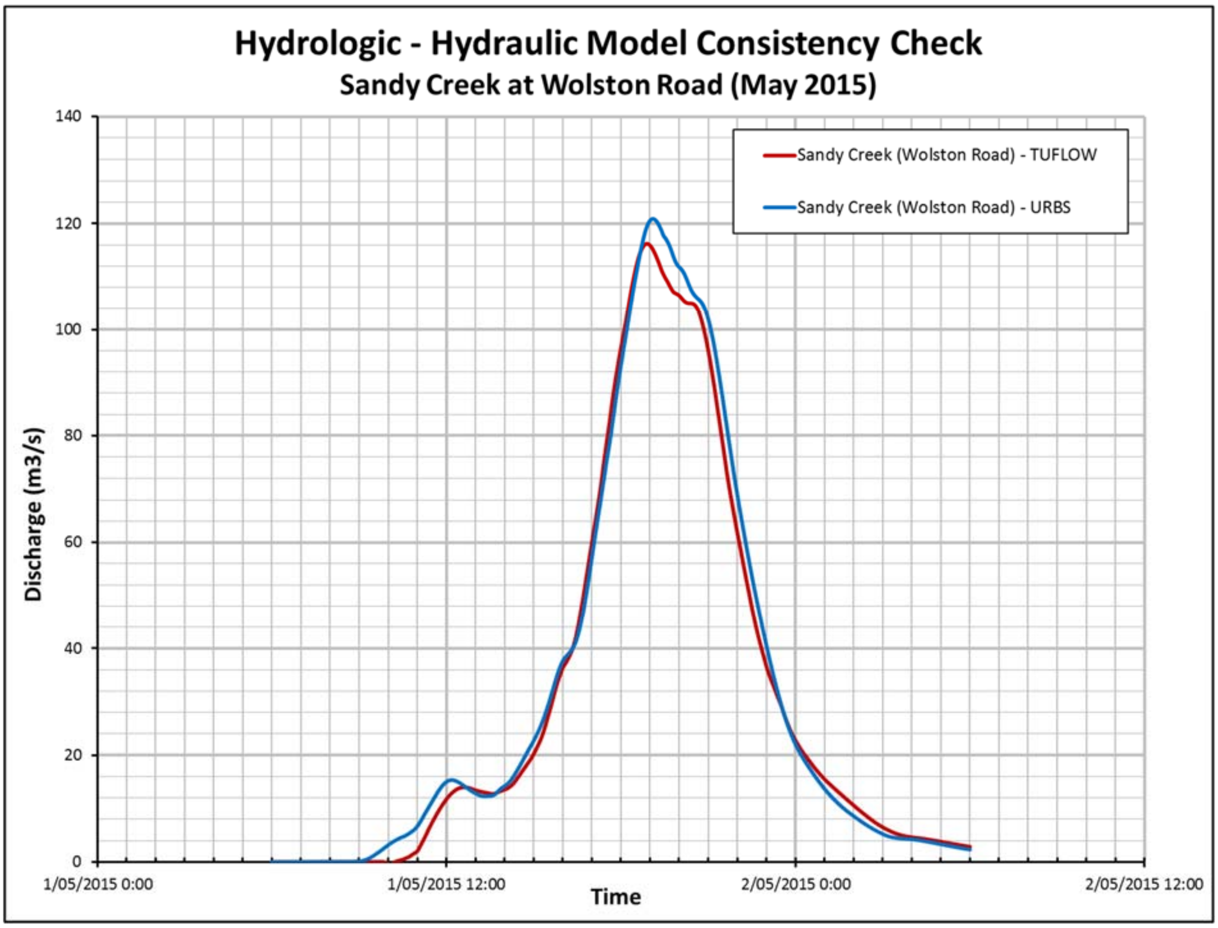


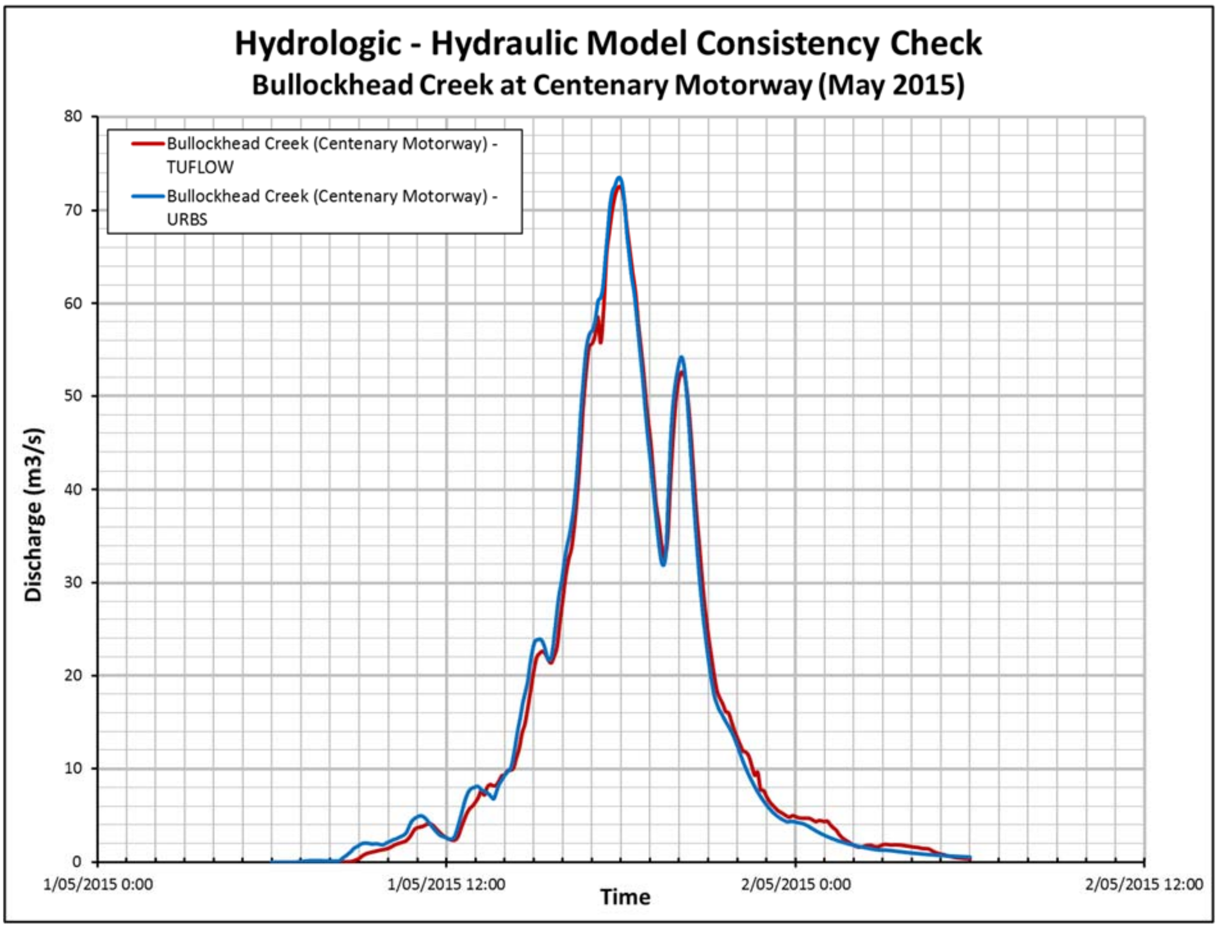
Hydrologic - Hydraulic Model Consistency Check
Wolston Creek at Wacol Station Road (March 2017)
Wolston Creek (Wacol Station Road) - TUFLOW
Wolston Creek (Wacol Station Road) - URBS
Discharge (m3/s)
Time
0
50
100
150
200
250
30/03/2017 0:00
30/03/2017 12:00
31/03/2017 0:00
31/03/2017 12:00



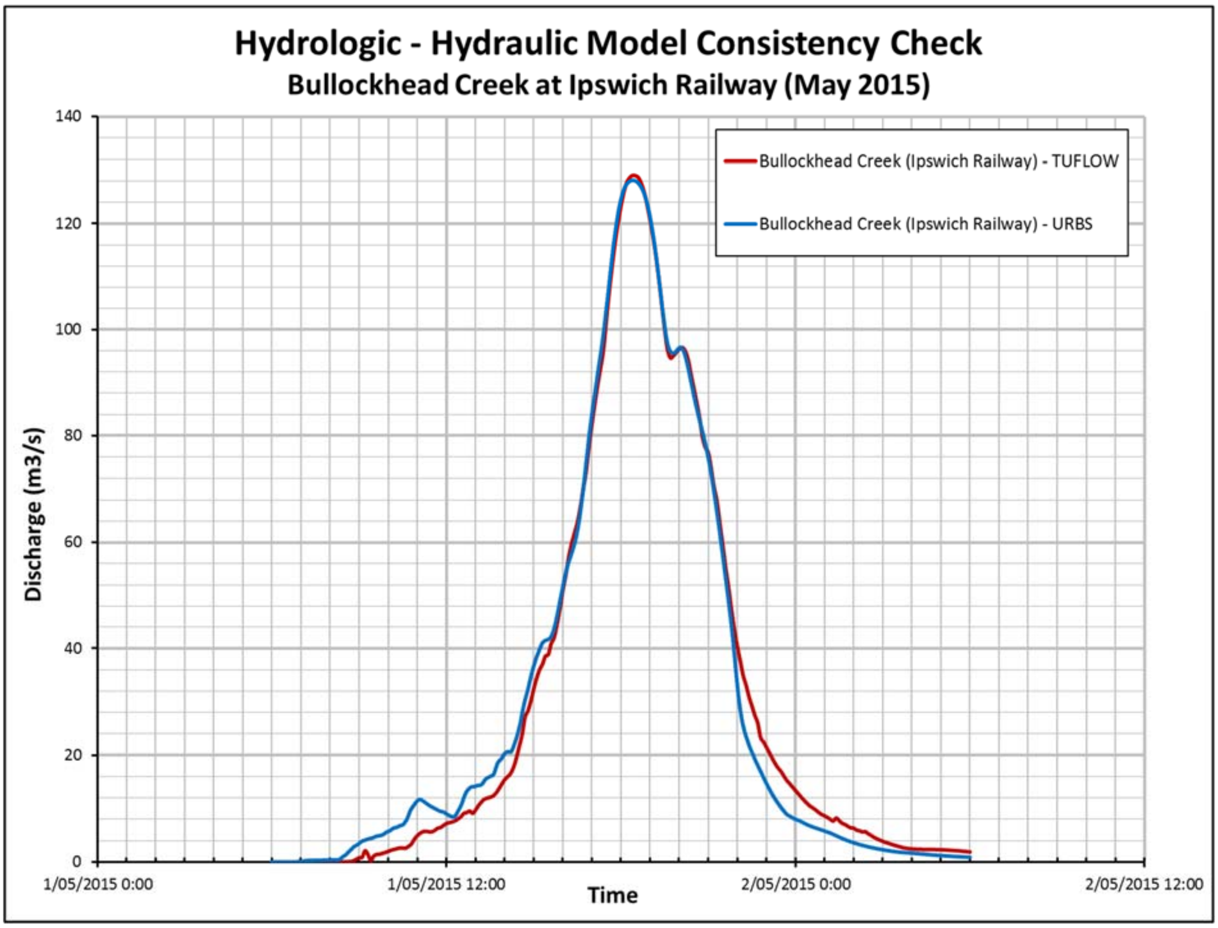
Hydrologic - Hydraulic Model Consistency Check
Wolston Creek at Catchment Outlet (March 2017)
Wolston Creek (Catchment Outlet) - TUFLOW
Wolston Creek (Catchment Outlet) - URBS
Discharge (m3/s)
250
200
150
100
50
0
30/03/2017 0:00
30/03/2017 12:00
31/03/2017 0:00
31/03/2017 12:00
Time


Hydrologic - Hydraulic Model Consistency Check
Sandy Creek at Formation Street (May 2015)
Sandy Creek (Formation Street) - TUFLOW
Sandy Creek (Formation Street) - URBS
Discharge (m3/s)
Time
0
10
20
30
40
50
60
70
80
90
100
01/05/2015 00:00
01/05/2015 12:00
02/05/2015 00:00
02/05/2015 12:00

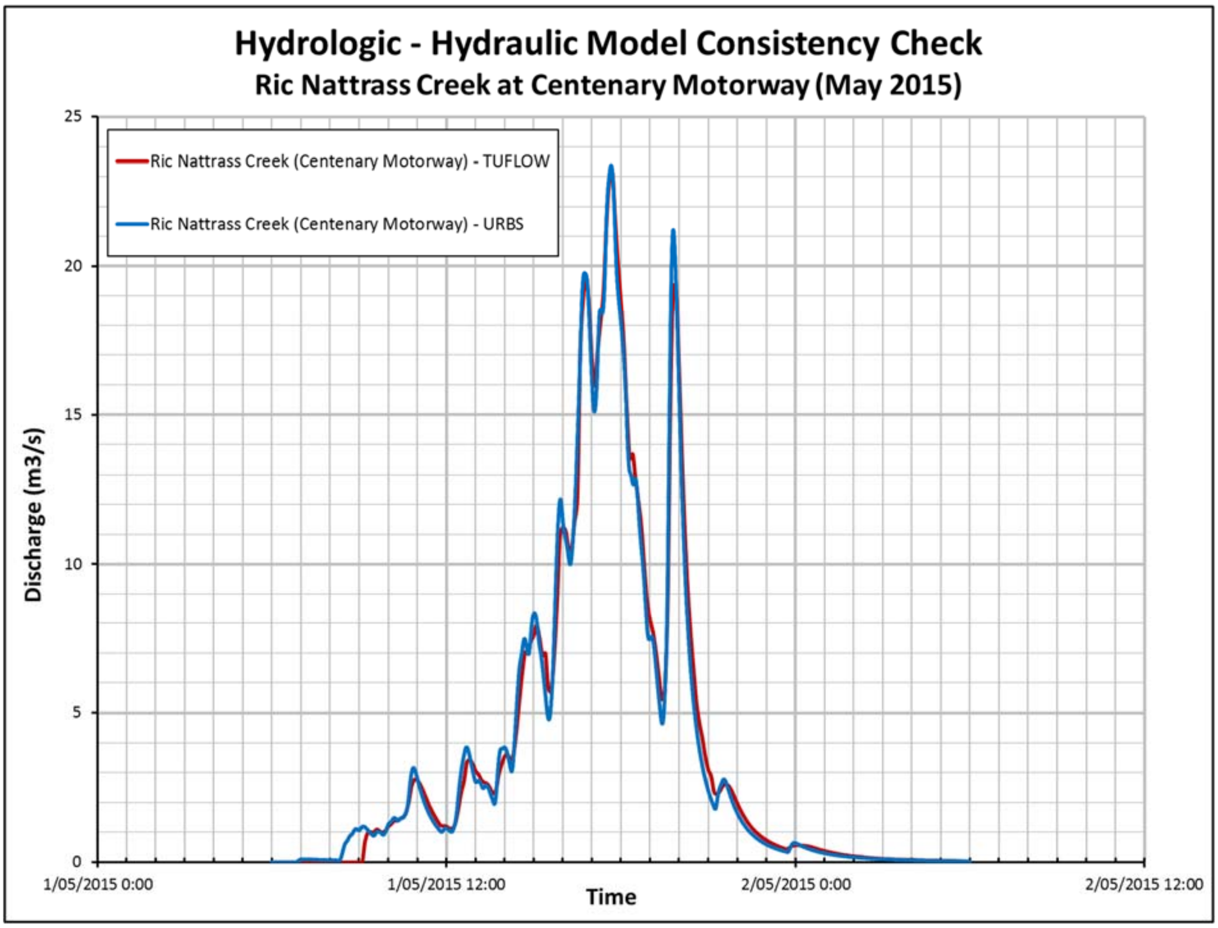

Hydrologic - Hydraulic Model Consistency Check
Sandy Creek at Wolston Road (May 2015)
Sandy Creek (Wolston Road) - TUFLOW
Sandy Creek (Wolston Road) - URBS
Discharge (m3/s)
Time
0
20
40
60
80
100
120
140
1/05/2015 0:00
1/05/2015 12:00
2/05/2015 0:00
2/05/2015 12:00

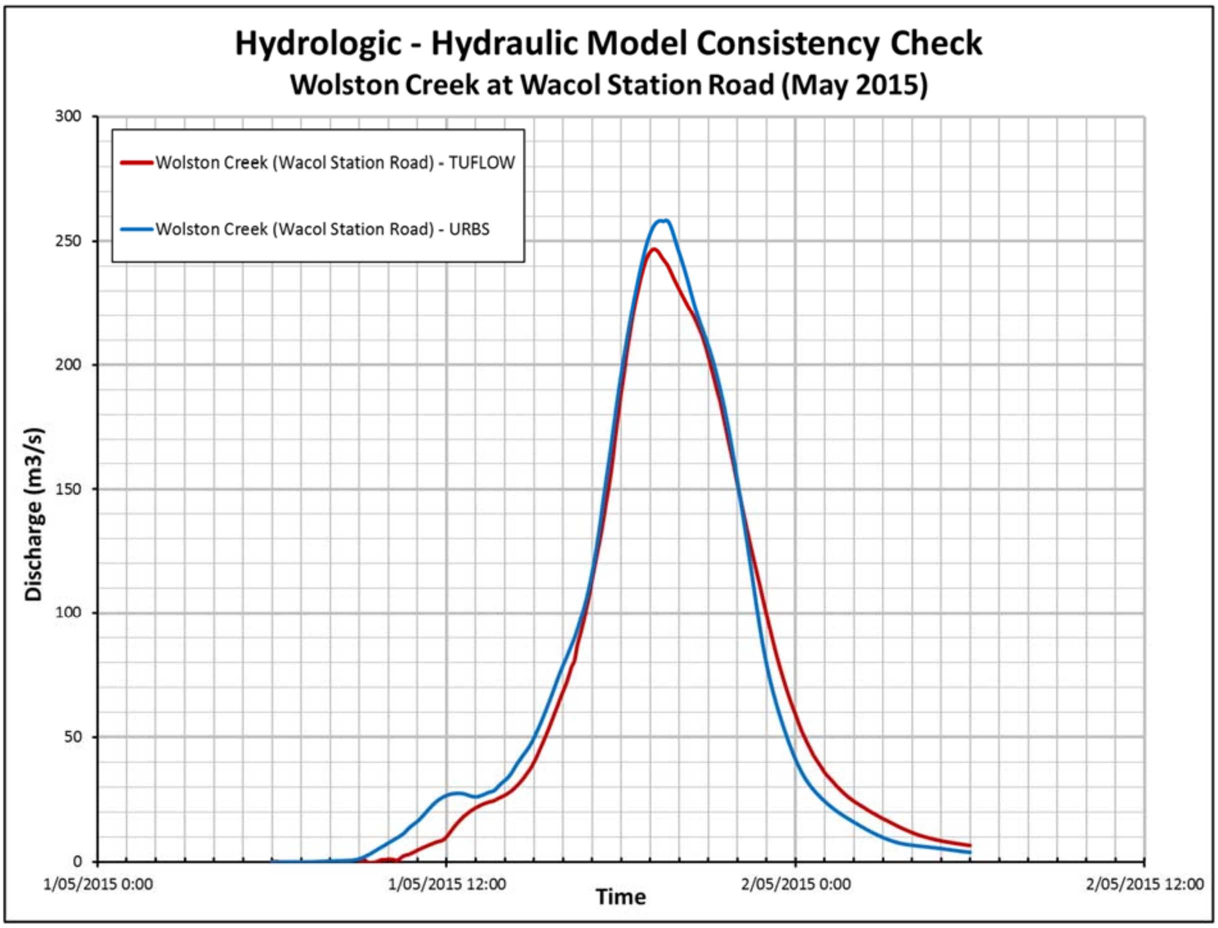


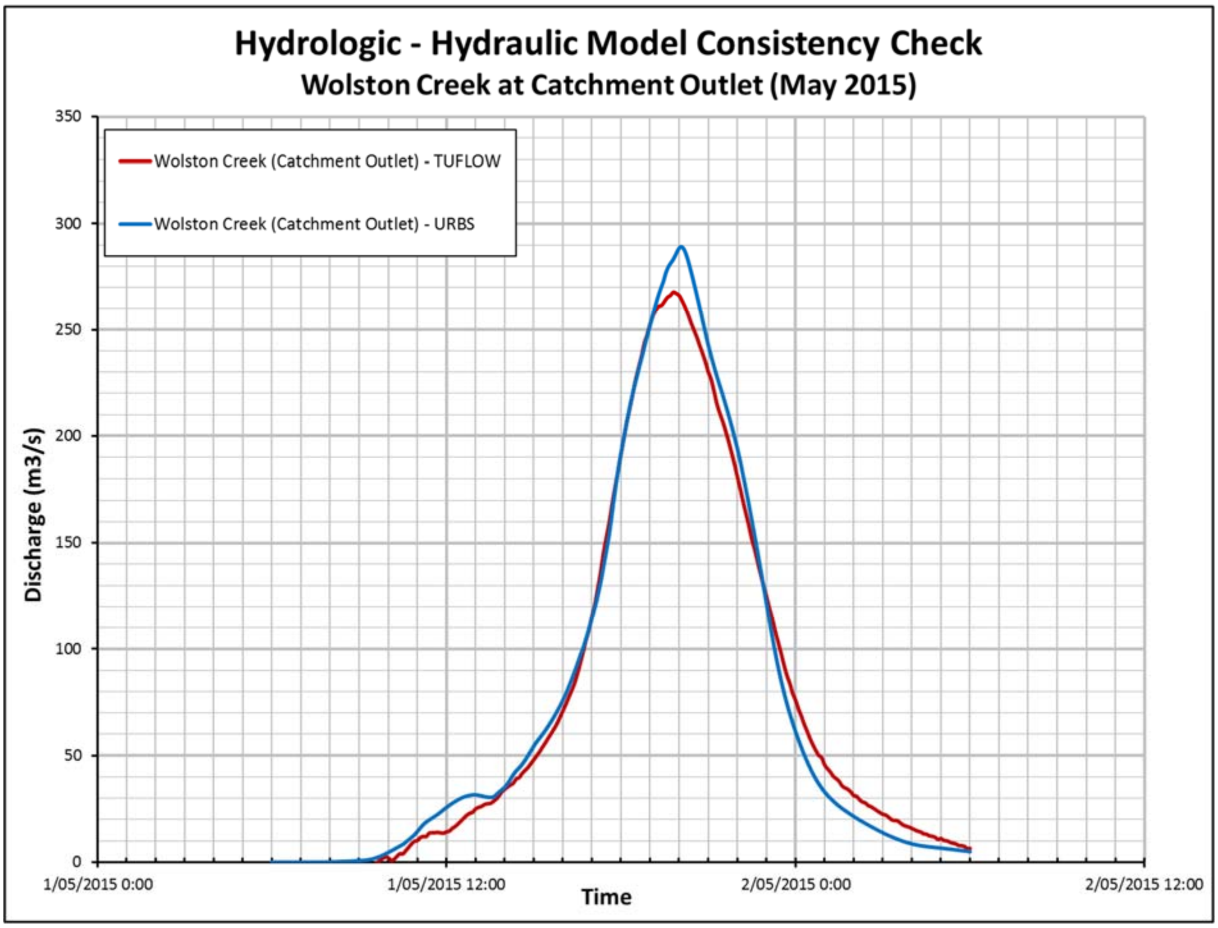
Hydrologic - Hydraulic Model Consistency Check
Bullockhead Creek at Centenary Motorway (May 2015)
Bullockhead Creek (Centenary Motorway) - TUFLOW
Bullockhead Creek (Centenary Motorway) - URBS
Discharge (m3/s)
0
10
20
30
40
50
60
70
80
1/05/2015 0:00
1/05/2015 12:00
2/05/2015 0:00
2/05/2015 12:00
Time



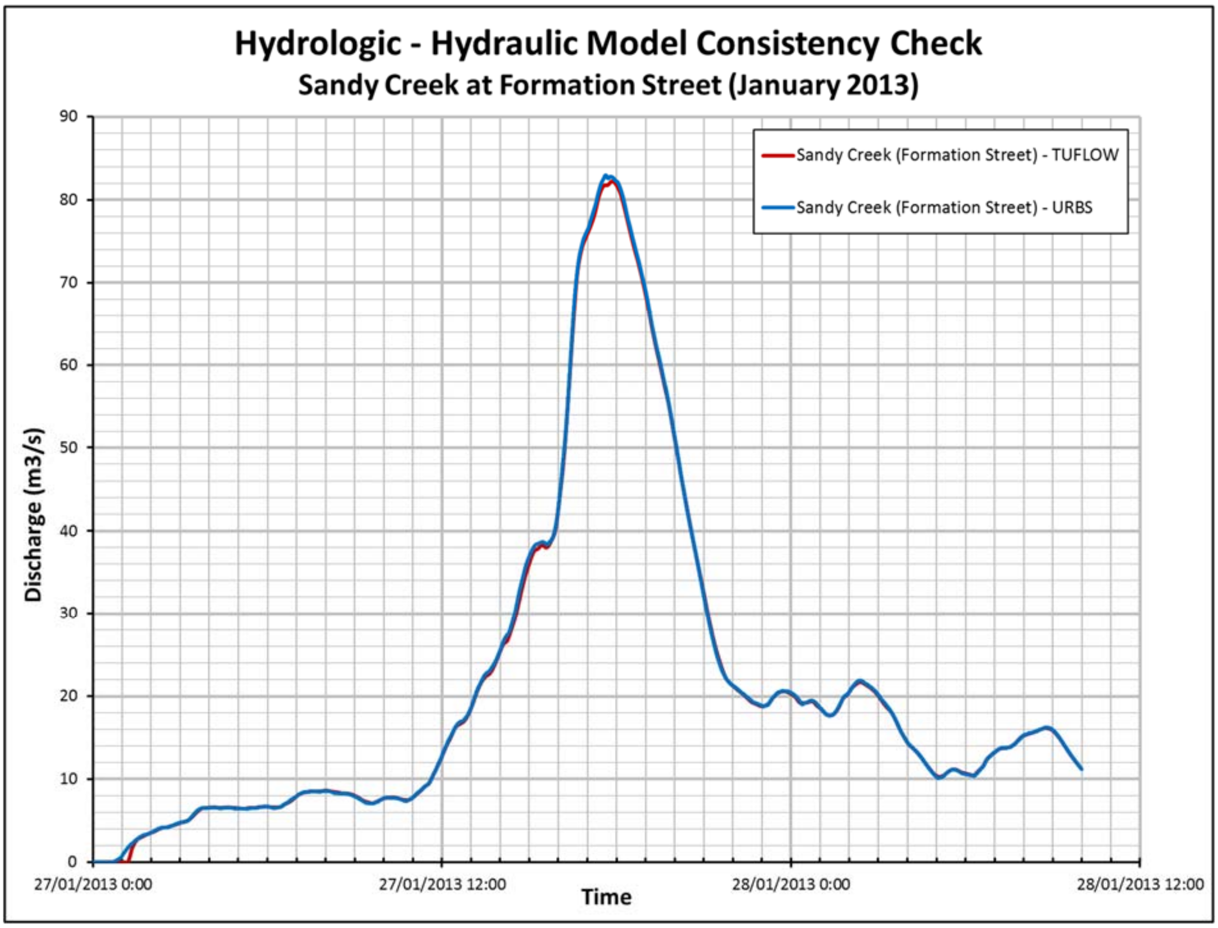
Hydrologic - Hydraulic Model Consistency Check
Bullockhead Creek at Ipswich Railway (May 2015)
Bullockhead Creek (Ipswich Railway) - TUFLOW
Bullockhead Creek (Ipswich Railway) - URBS
Discharge (m3/s)
0
20
40
60
80
100
120
140
1/05/2015 0:00
1/05/2015 12:00
2/05/2015 0:00
2/05/2015 12:00
Time

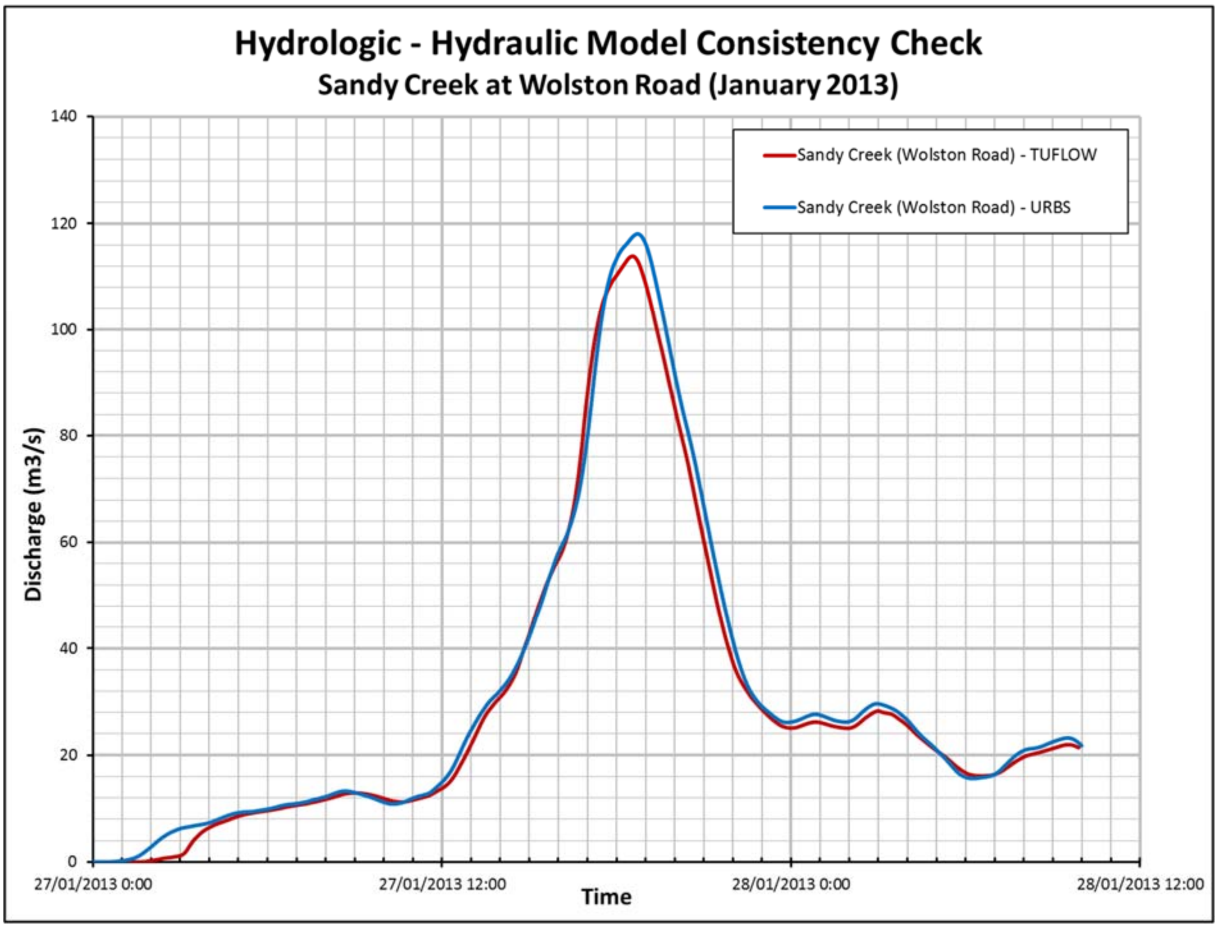

Hydrologic - Hydraulic Model Consistency Check
Ric Nattrass Creek at Centenary Motorway (May 2015)
Ric Nattrass Creek (Centenary Motorway) - TUFLOW
Ric Nattrass Creek (Centenary Motorway) - URBS
Discharge (m3/s)
0
5
10
15
20
25
1/05/2015 0:00
1/05/2015 12:00
2/05/2015 0:00
2/05/2015 12:00
Time

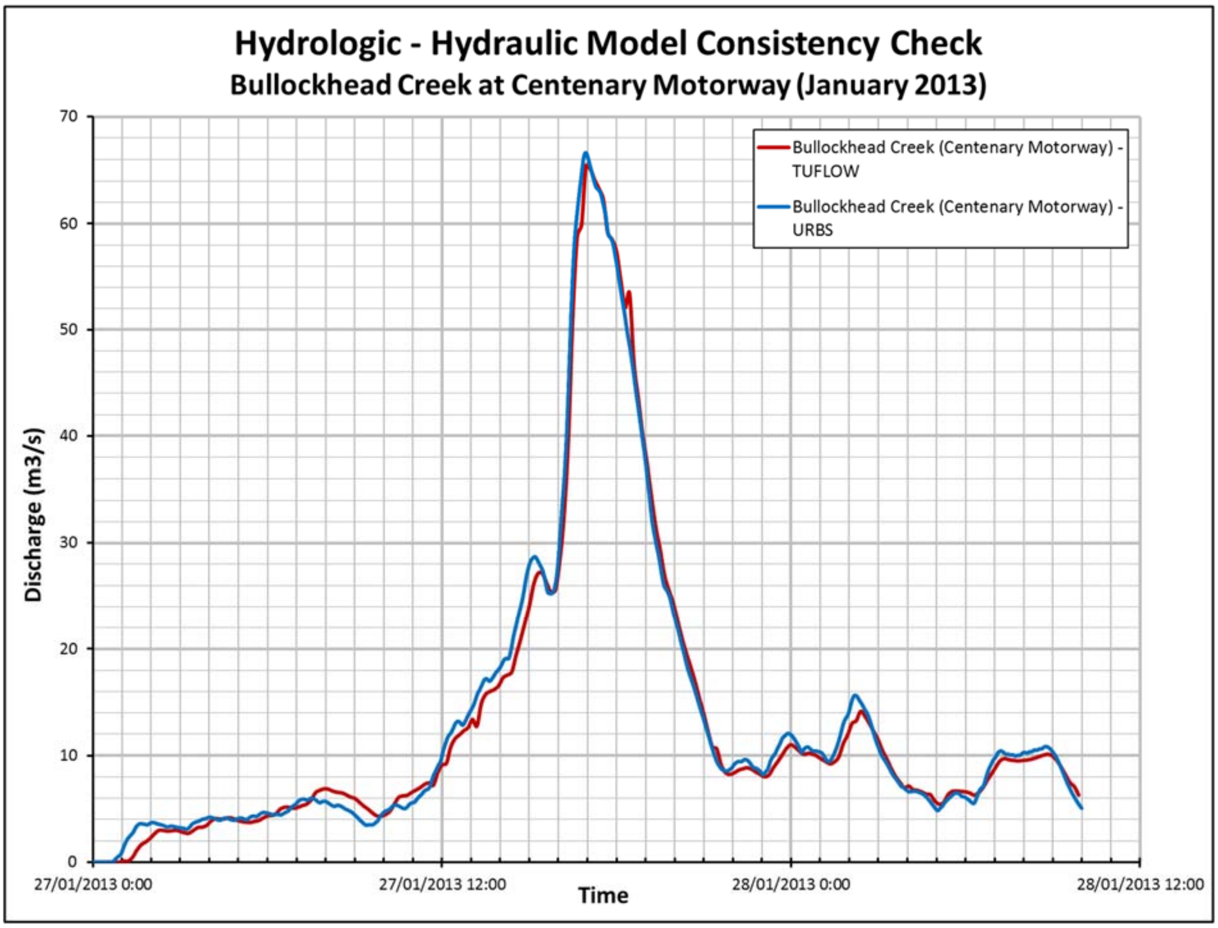

Hydrologic - Hydraulic Model Consistency Check
Wolston Creek at Wacol Station Road (May 2015)
Wolston Creek (Wacol Station Road) - TUFLOW
Wolston Creek (Wacol Station Road) - URBS
Discharge (m3/s)
0
50
100
150
200
250
300
1/05/2015 0:00
1/05/2015 12:00
2/05/2015 0:00
2/05/2015 12:00
Time

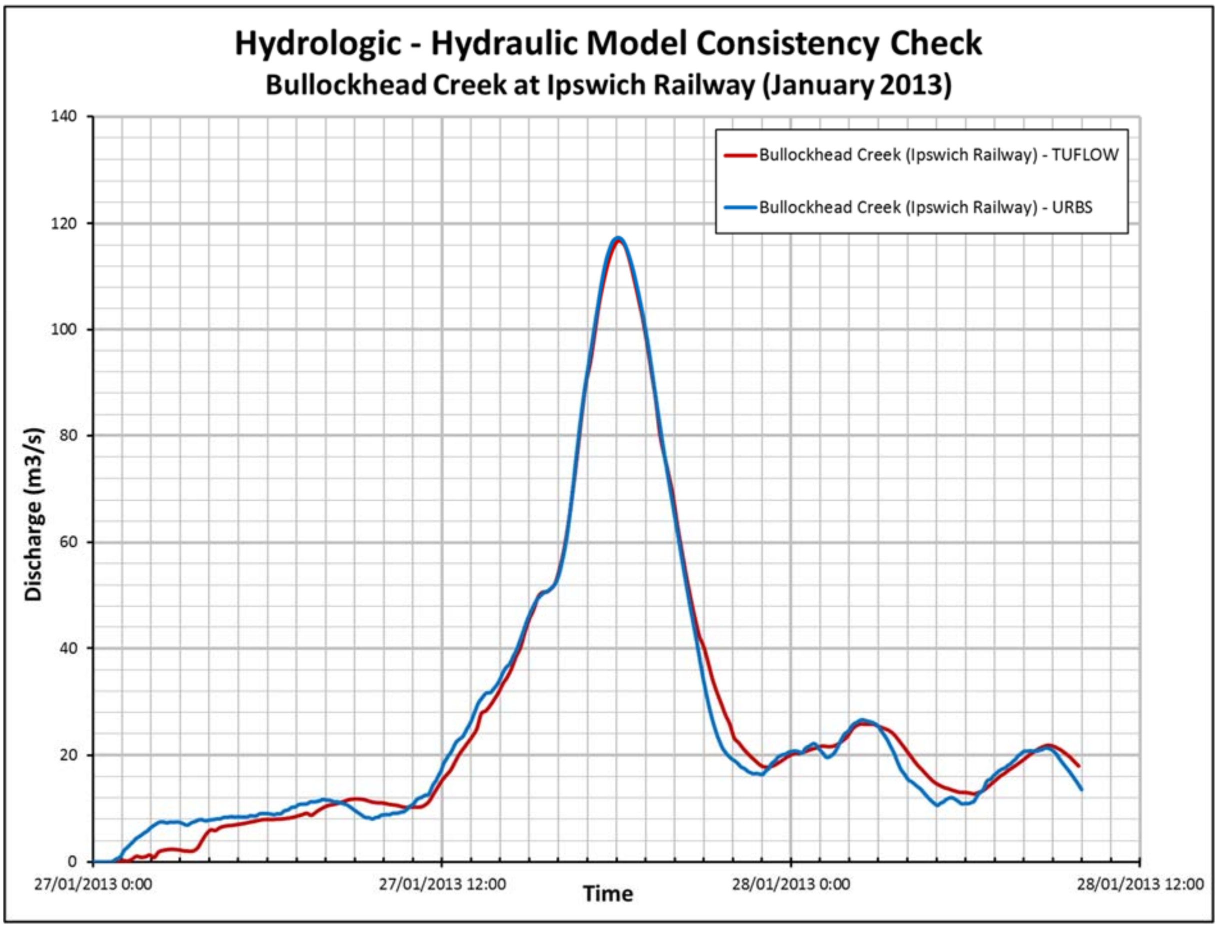


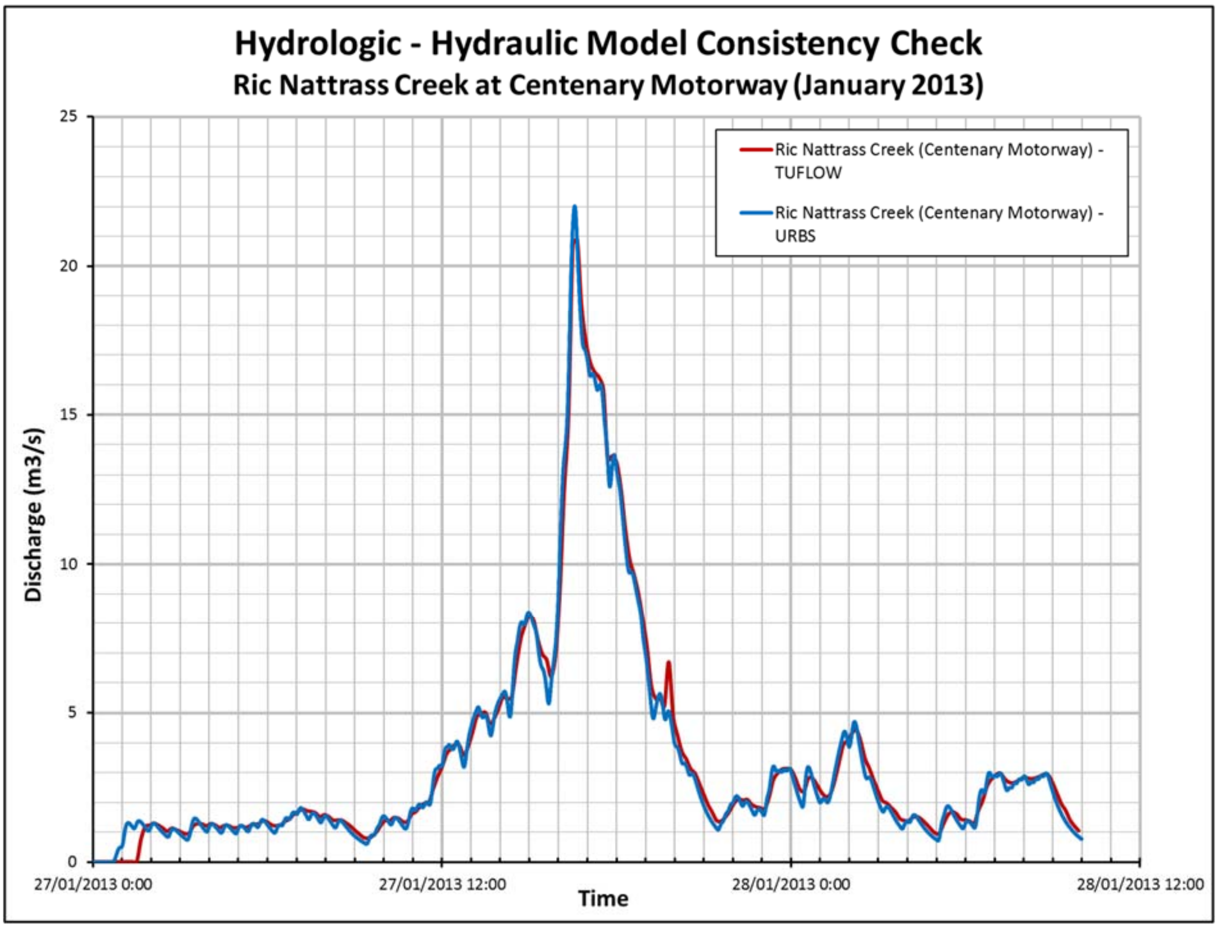
Hydrologic - Hydraulic Model Consistency Check
Wolston Creek at Catchment Outlet (May 2015)
Wolston Creek (Catchment Outlet) - TUFLOW
Wolston Creek (Catchment Outlet) - URBS
Discharge (m3/s)
350
300
250
200
150
100
50
0
1/05/2015 0:00
1/05/2015 12:00
2/05/2015 0:00
2/05/2015 12:00
Time

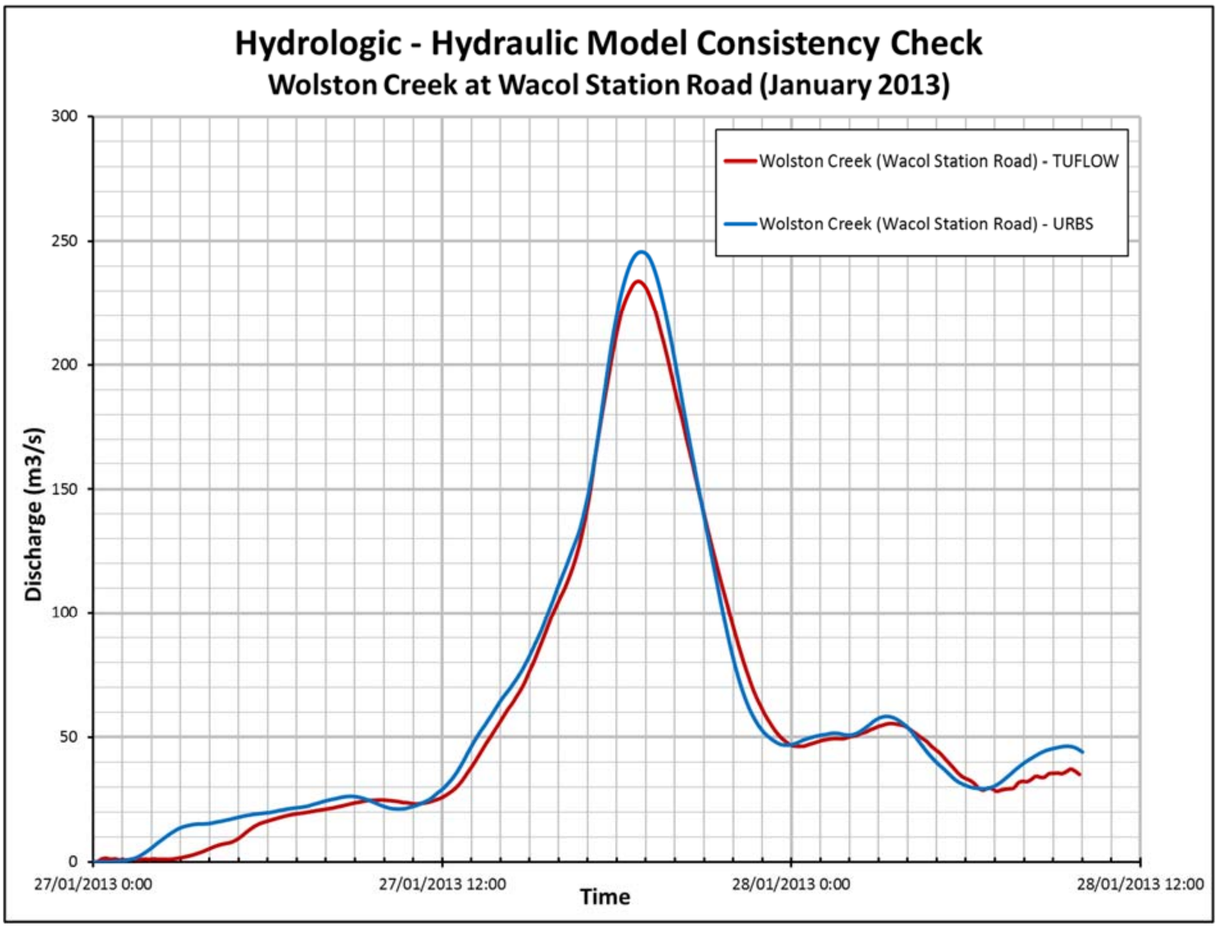

Hydrologic - Hydraulic Model Consistency Check
Sandy Creek at Formation Street (January 2013)
Sandy Creek (Formation Street) - TUFLOW
Sandy Creek (Formation Street) - URBS
Discharge (m3/s)
0
10
20
30
40
50
60
70
80
90
27/01/2013 0:00
27/01/2013 12:00
28/01/2013 0:00
28/01/2013 12:00
Time

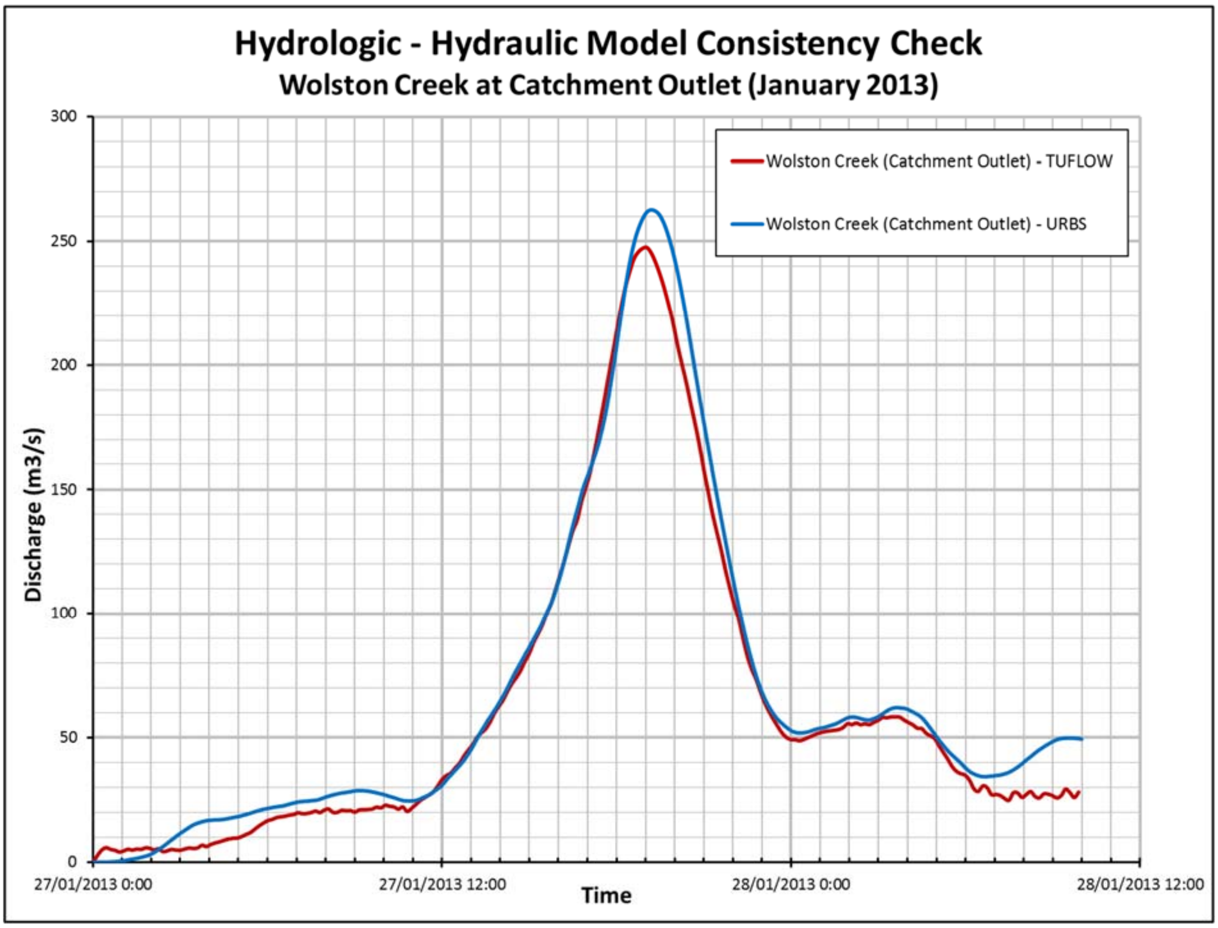

Hydrologic - Hydraulic Model Consistency Check
Sandy Creek at Wolston Road (January 2013)
Sandy Creek (Wolston Road) - TUFLOW
Sandy Creek (Wolston Road) - URBS
Discharge (m3/s)
0
20
40
60
80
100
120
140
27/01/2013 0:00
27/01/2013 12:00
28/01/2013 0:00
28/01/2013 12:00
Time


Hydrologic - Hydraulic Model Consistency Check
Bullockhead Creek at Centenary Motorway (January 2013)
Bullockhead Creek (Centenary Motorway) - TUFLOW
Bullockhead Creek (Centenary Motorway) - URBS
Discharge (m3/s)
Time
0
10
20
30
40
50
60
70
27/01/2013 0:00
27/01/2013 12:00
28/01/2013 0:00
28/01/2013 12:00

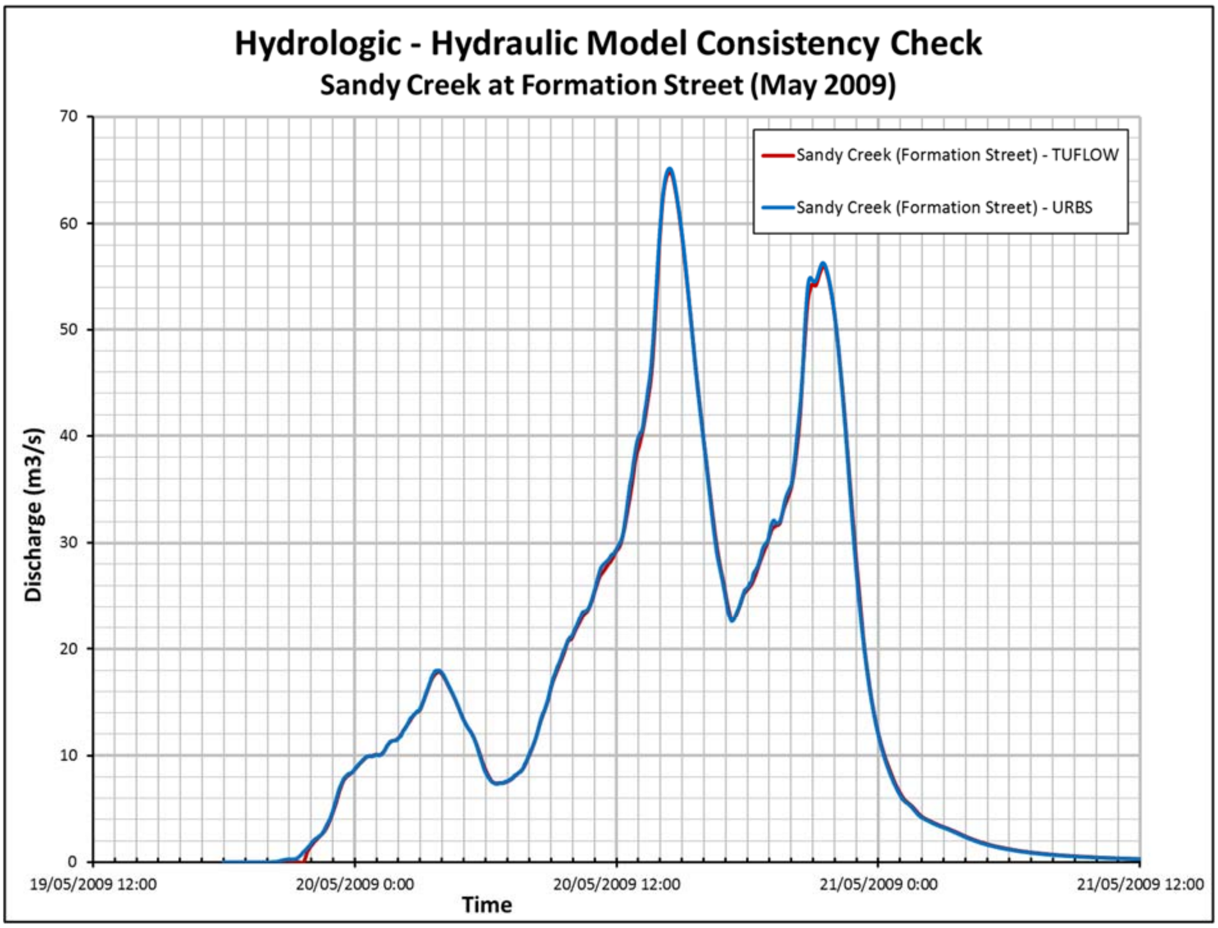

Hydrologic - Hydraulic Model Consistency Check
Bullockhead Creek at Ipswich Railway (January 2013)
Bullockhead Creek (Ipswich Railway) - TUFLOW
Bullockhead Creek (Ipswich Railway) - URBS
Discharge (m3/s)
Time
0
20
40
60
80
100
120
140
27/01/2013 0:00
27/01/2013 12:00
28/01/2013 0:00
28/01/2013 12:00

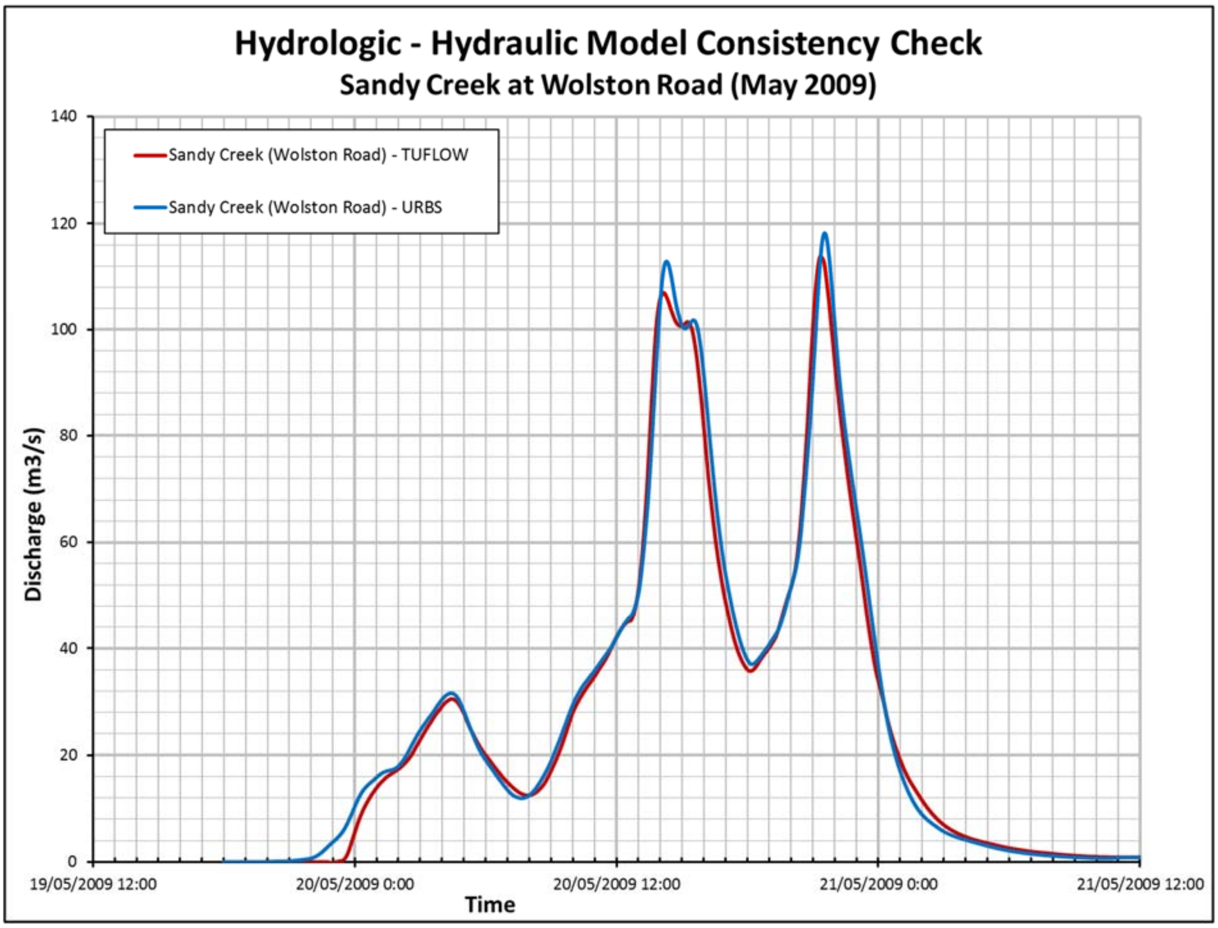

Hydrologic - Hydraulic Model Consistency Check
Ric Nattrass Creek at Centenary Motorway (January 2013)
Ric Nattrass Creek (Centenary Motorway) - TUFLOW
Ric Nattrass Creek (Centenary Motorway) - URBS
Discharge (m3/s)
25
20
15
10
5
0
27/01/2013 0:00
27/01/2013 12:00
28/01/2013 0:00
28/01/2013 12:00
Time

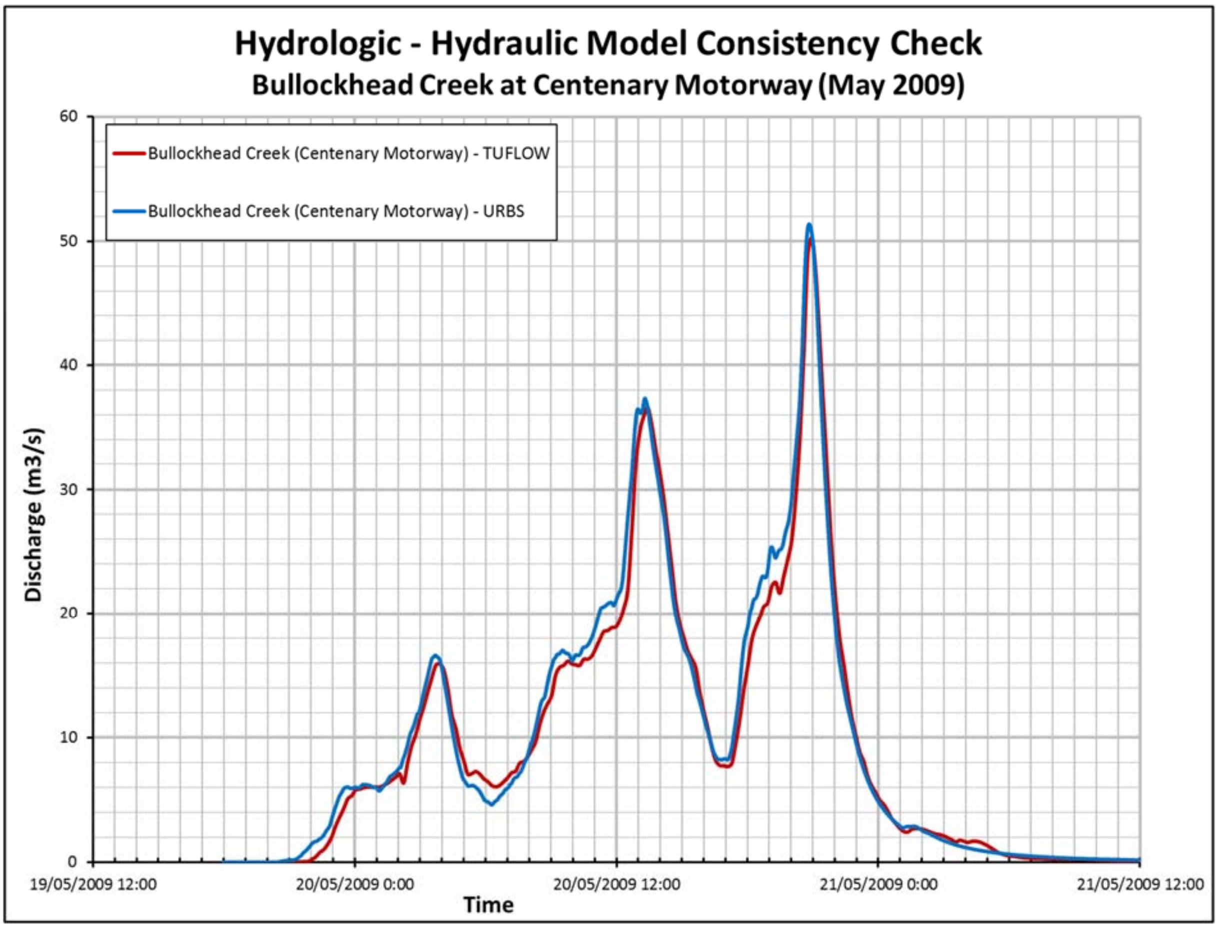

Hydrologic - Hydraulic Model Consistency Check
Wolston Creek at Wacol Station Road (January 2013)
Wolston Creek (Wacol Station Road) - TUFLOW
Wolston Creek (Wacol Station Road) - URBS
Discharge (m3/s)
300
250
200
150
100
50
0
27/01/2013 0:00
27/01/2013 12:00
28/01/2013 0:00
28/01/2013 12:00
Time



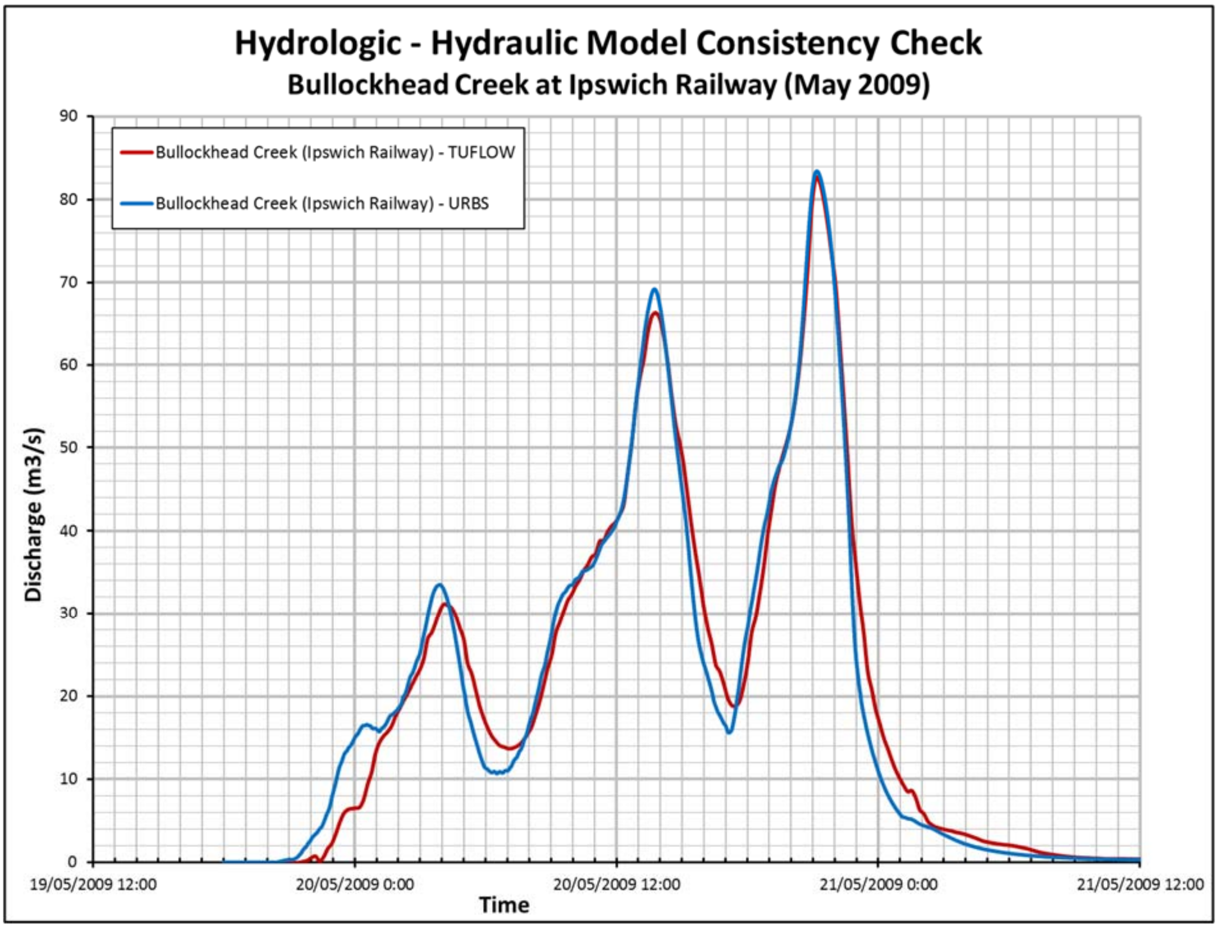
Hydrologic - Hydraulic Model Consistency Check
Wolston Creek at Catchment Outlet (January 2013)
Wolston Creek (Catchment Outlet) - TUFLOW
Wolston Creek (Catchment Outlet) - URBS
Discharge (m3/s)
300
250
200
150
100
50
0
27/01/2013 0:00
27/01/2013 12:00
28/01/2013 0:00
28/01/2013 12:00
Time


Hydrologic - Hydraulic Model Consistency Check
Sandy Creek at Formation Street (May 2009)
Sandy Creek (Formation Street) - TUFLOW
Sandy Creek (Formation Street) - URBS
Discharge (m3/s)
70
60
50
40
30
20
10
0
19/05/2009 12:00
20/05/2009 0:00
20/05/2009 12:00
21/05/2009 0:00
21/05/2009 12:00
Time

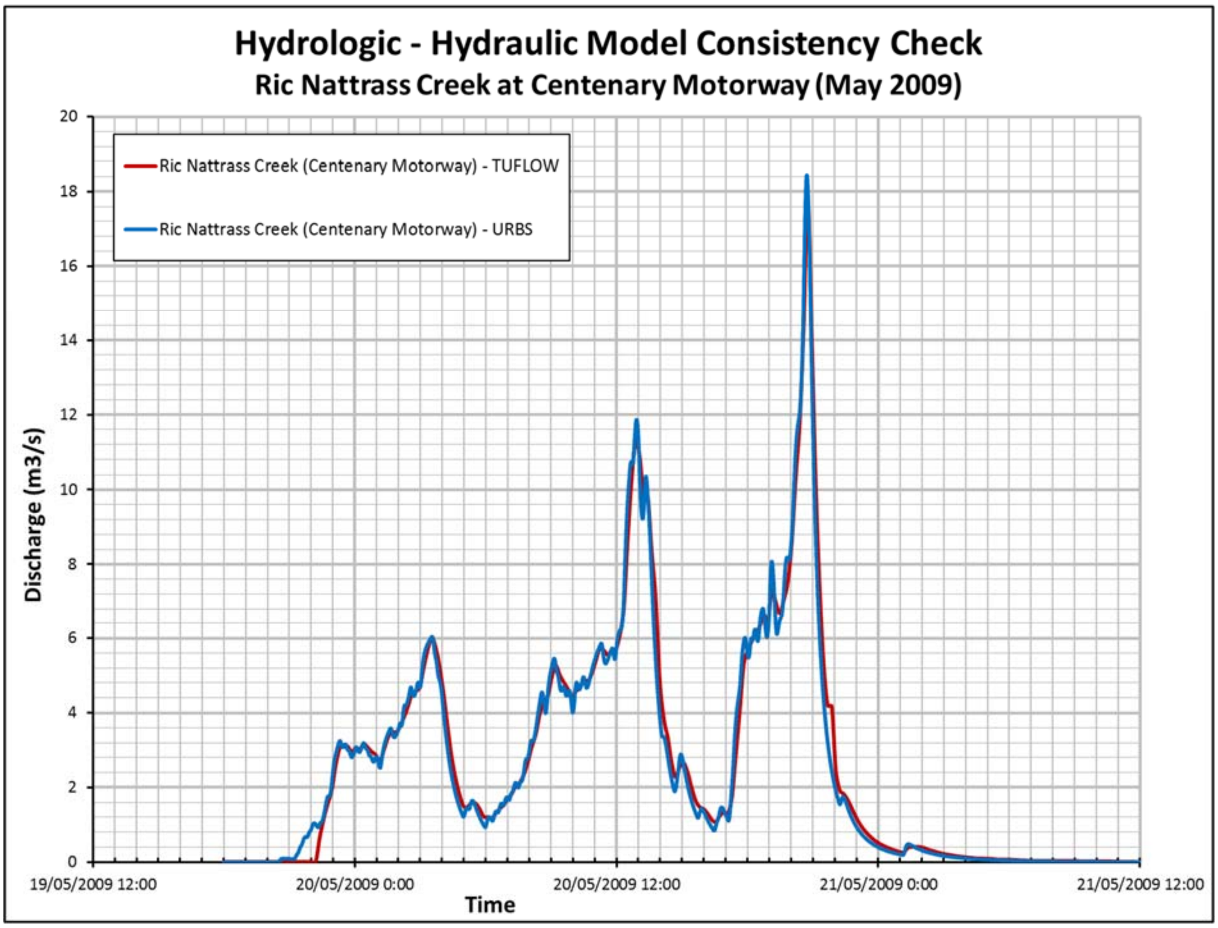

Hydrologic - Hydraulic Model Consistency Check
Sandy Creek at Wolston Road (May 2009)
Sandy Creek (Wolston Road) - TUFLOW
Sandy Creek (Wolston Road) - URBS
Discharge (m3/s)
140
120
100
80
60
40
20
0
19/05/2009 12:00
20/05/2009 0:00
20/05/2009 12:00
21/05/2009 0:00
21/05/2009 12:00
Time



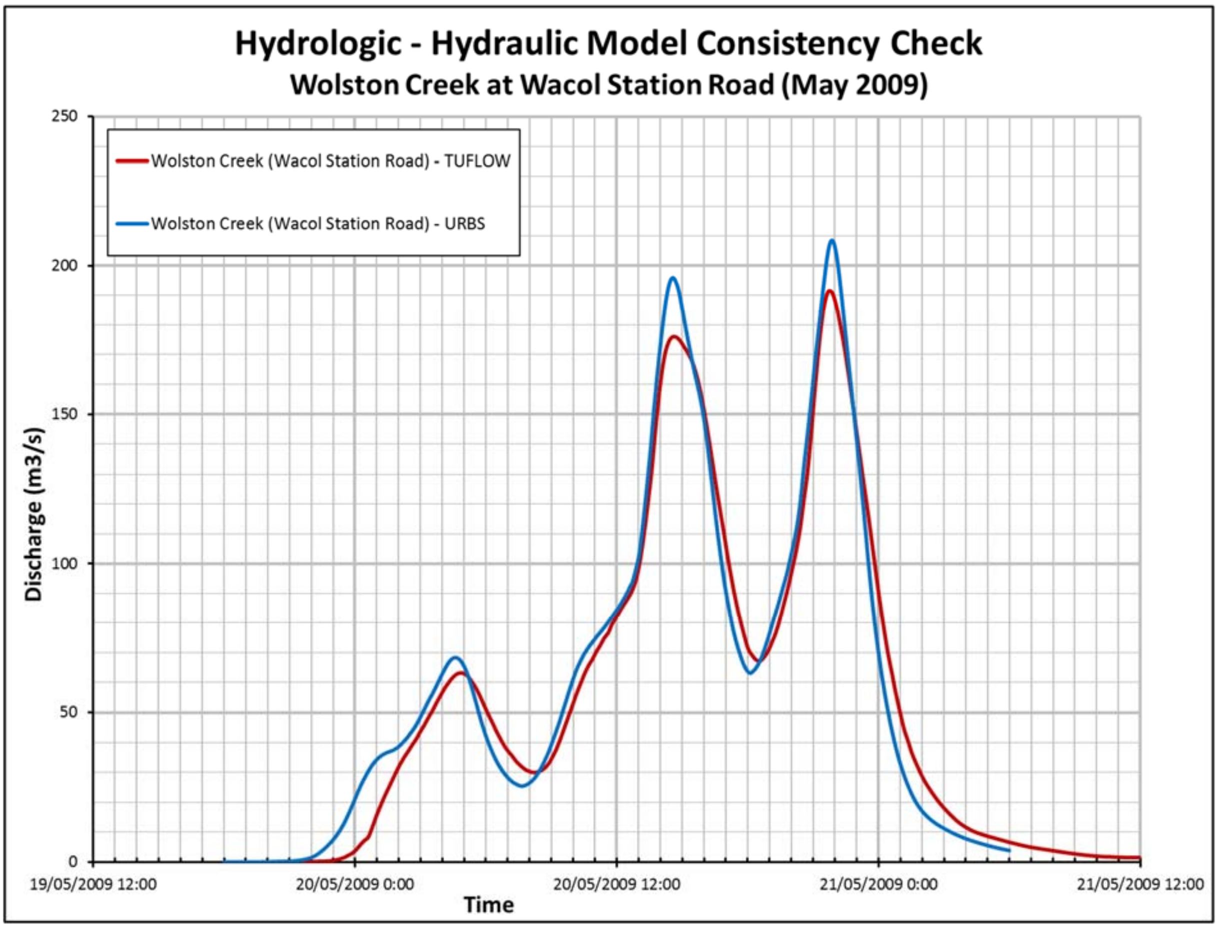
Hydrologic - Hydraulic Model Consistency Check
Bullockhead Creek at Centenary Motorway (May 2009)
Bullockhead Creek (Centenary Motorway) - TUFLOW
Bullockhead Creek (Centenary Motorway) - URBS
Discharge (m3/s)
0
10
20
30
40
50
60
19/05/2009 12:00
20/05/2009 0:00
20/05/2009 12:00
21/05/2009 0:00
21/05/2009 12:00
Time



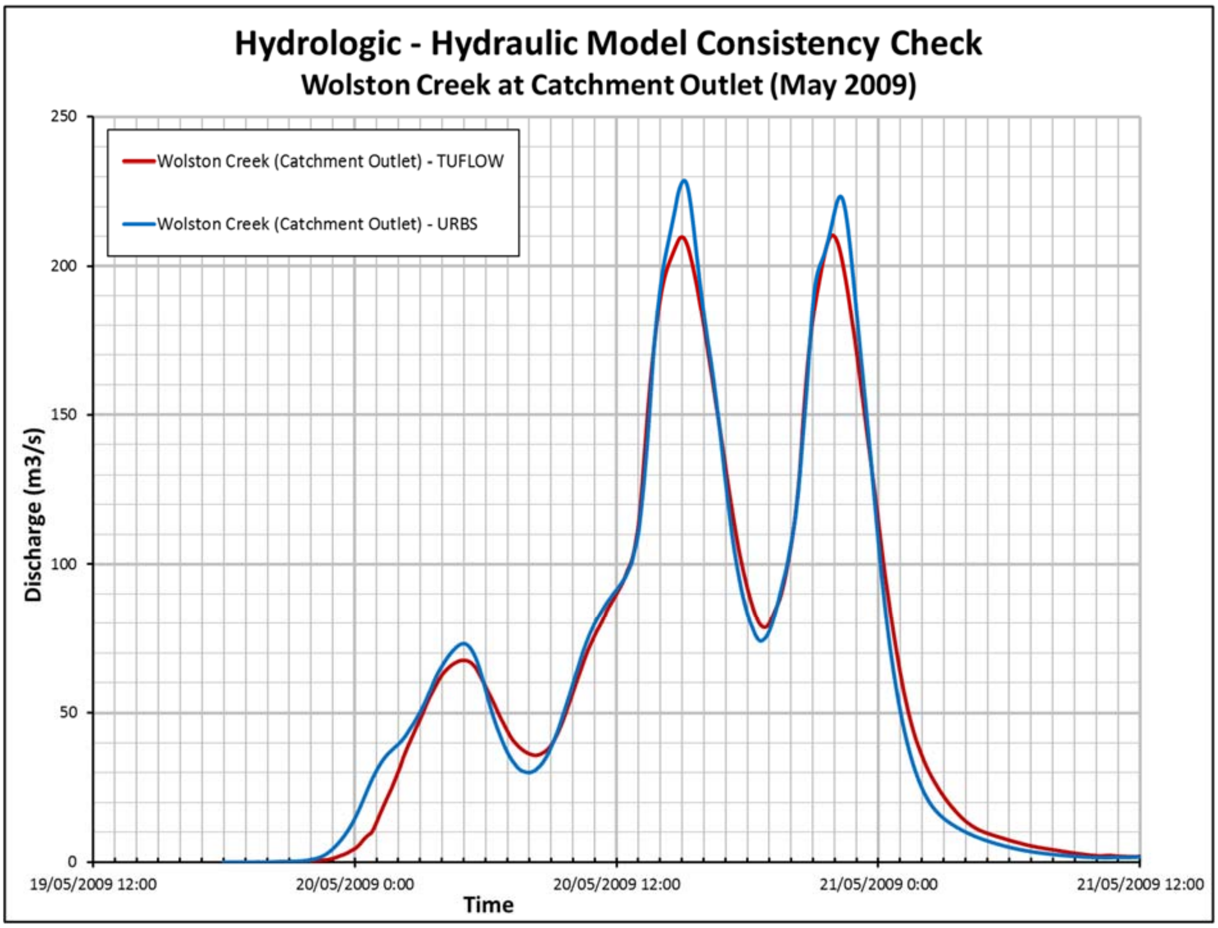
Hydrologic - Hydraulic Model Consistency Check
Bullockhead Creek at Ipswich Railway (May 2009)
Bullockhead Creek (Ipswich Railway) - TUFLOW
Bullockhead Creek (Ipswich Railway) - URBS
Discharge (m3/s)
0
10
20
30
40
50
60
70
80
90
19/05/2009 12:00
20/05/2009 0:00
20/05/2009 12:00
21/05/2009 0:00
21/05/2009 12:00
Time



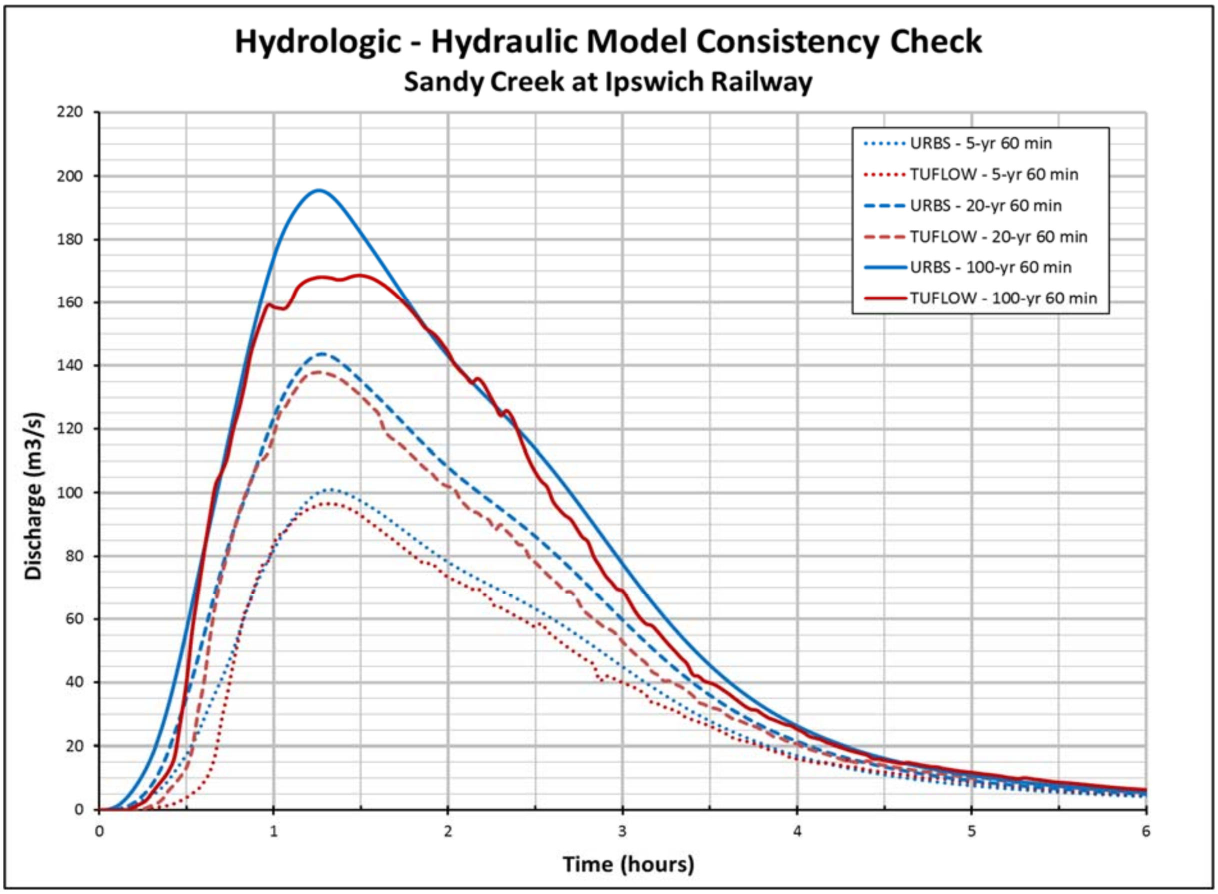
Hydrologic - Hydraulic Model Consistency Check
Ric Nattrass Creek at Centenary Motorway (May 2009)
Ric Nattrass Creek (Centenary Motorway) - TUFLOW
Ric Nattrass Creek (Centenary Motorway) - URBS
Discharge (m3/s)
0
2
4
6
8
10
12
14
16
18
20
19/05/2009 12:00
20/05/2009 0:00
20/05/2009 12:00
21/05/2009 0:00
21/05/2009 12:00
Time

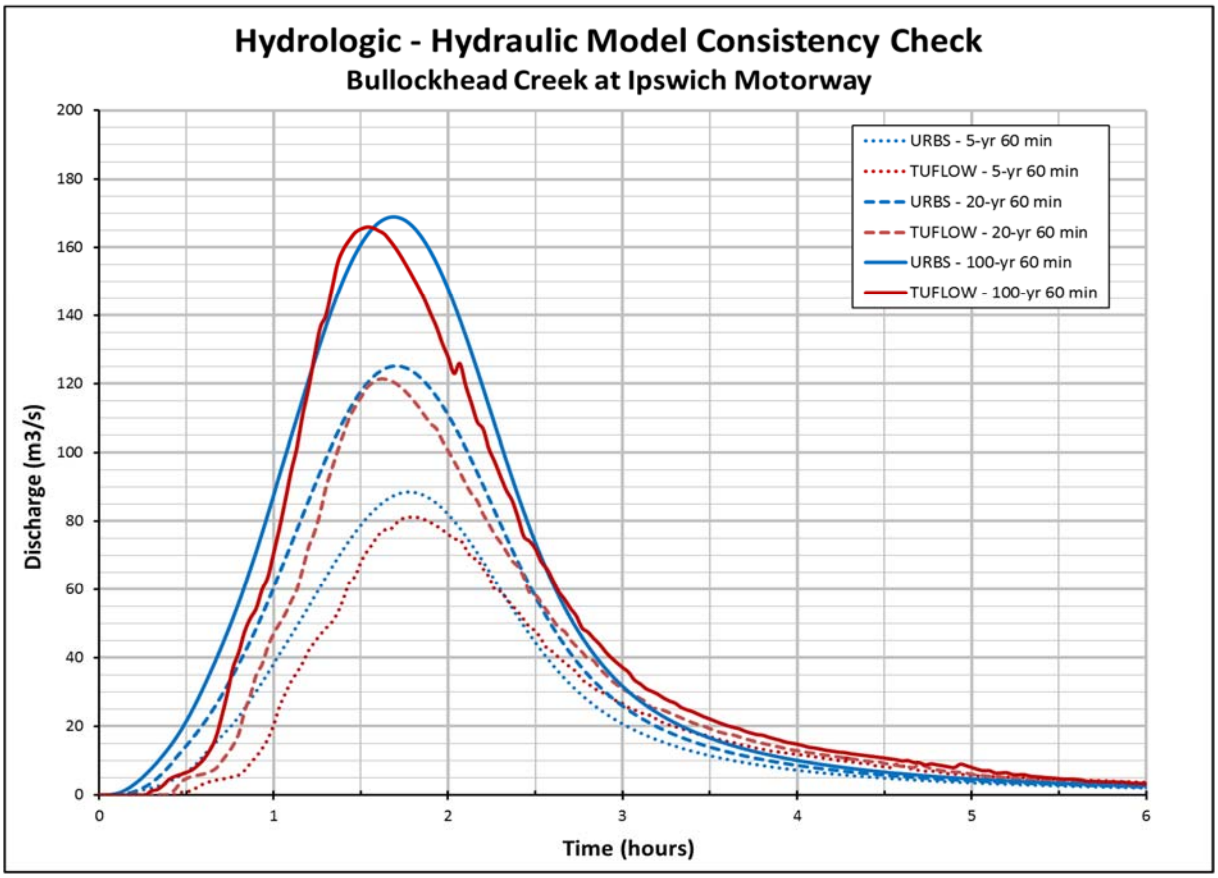


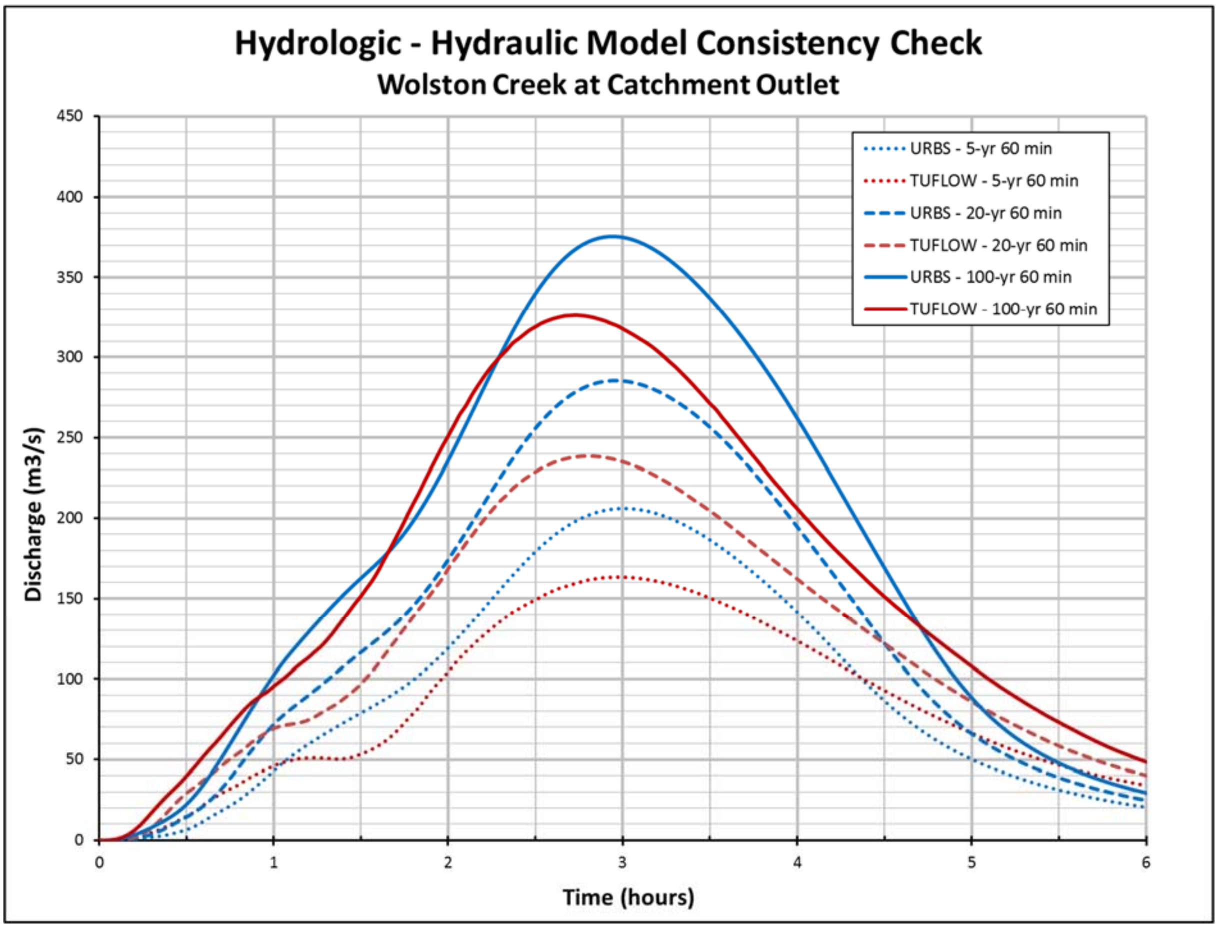
Hydrologic - Hydraulic Model Consistency Check
Wolston Creek at Wacol Station Road (May 2009)
Wolston Creek (Wacol Station Road) - TUFLOW
Wolston Creek (Wacol Station Road) - URBS
Discharge (m3/s)
0
50
100
150
200
250
19/05/2009 12:00
20/05/2009 0:00
20/05/2009 12:00
21/05/2009 0:00
21/05/2009 12:00
Time


Hydrologic - Hydraulic Model Consistency Check
Wolston Creek at Catchment Outlet (May 2009)
Wolston Creek (Catchment Outlet) - TUFLOW
Wolston Creek (Catchment Outlet) - URBS
Discharge (m3/s)
250
200
150
100
50
0
19/05/2009 12:00
20/05/2009 0:00
20/05/2009 12:00
21/05/2009 0:00
21/05/2009 12:00
Time

Design Events






Hydrologic - Hydraulic Model Consistency Check
Wolston Creek at Catchment Outlet
Discharge (m3/s)
Time (hours)
URBS - 5-yr 60 min
TUFLOW - 5-yr 60 min
URBS - 20-yr 60 min
TUFLOW - 20-yr 60 min
URBS - 100-yr 60 min
TUFLOW - 100-yr 60 min
0
50
100
150
200
250
300
350
400
450
1
2
3
4
5
6

Appendix E: URBS Ensemble Results – Design Events

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Notes on Table Content and Formatting

- The following tables indicate the ranking and discharge of all ten ensembles for each storm duration at the selected location within the catchment.
- The bold formatted rows indicate the critical storm duration for the selected location.
- The bold formatted columns indicate the median (Rank 5 / 6) peak discharge and corresponding ensemble number.
- The yellow highlighted peak discharge and ensemble number are those adopted from the simplified method as detailed in Section 6.3.4.
- The light pink highlighted peak discharge and ensemble number are those adopted from the simplified method for the storm duration(s) either side of the critical storm duration.

Sandy Creek at Campbell Avenue – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	0.5	44.89	45.04	45.16	45.28	**45.5**	**45.54**	45.6	45.67	45.72	45.79
		4	3	2	6	**5**	**9**	7	10	8	1
	1	52.77	54.32	55.04	55.88	**55.88**	**55.93**	55.95	56.58	57.35	57.36
		3	2	8	1	**4**	**5**	7	9	10	6
	1.5	54.97	56.58	57.35	57.59	**58**	**59.04**	59.08	61.3	63.03	63.14
		3	2	6	1	**8**	**7**	4	5	9	10
	2	**55.38**	**56.12**	**56.34**	**58.03**	**60.63**	**60.97**	**61.84**	**62.51**	**63.58**	**63.8**
		3	**2**	**1**	**6**	**4**	**8**	**7**	**9**	**10**	**5**
	3	52.58	52.87	53.74	55.49	**57.38**	**57.65**	62.32	63.21	63.58	64.72
		4	7	2	8	**1**	**6**	10	5	9	3
	4.5	45.51	45.59	49.01	50.96	**51.44**	**54.07**	55.2	55.67	58.21	66.37
		3	4	6	2	**5**	**7**	9	8	10	1
5	0.5	65.79	66.06	66.27	66.48	**66.84**	**66.9**	67	67.1	67.2	67.31
		4	3	2	6	**5**	**9**	7	10	8	1
	1	76.74	78.71	80.1	81.3	**81.42**	**81.47**	81.67	82.44	83.72	83.81
		3	2	8	4	**7**	**5**	1	9	10	6
	1.5	79.32	81.34	82.57	82.94	**83.5**	**85.28**	85.36	88.77	91.67	91.76
		3	2	6	1	**8**	**4**	7	5	9	10
	2	**79.2**	**80.54**	**81.16**	**83.56**	**87.15**	**87.85**	**89.06**	**90.27**	**91.97**	**92.14**
		3	**2**	**1**	**6**	**4**	**8**	**7**	**9**	**10**	**5**
	3	75.11	75.62	78.19	79.38	**82.79**	**83.08**	90.05	90.88	91.25	93.73
		4	7	2	8	**6**	**1**	10	5	9	3
	4.5	65.52	65.7	70.29	73.16	**73.81**	**77.54**	79.06	79.93	83.5	95.43
		3	4	6	2	**5**	**7**	9	8	10	1
10	0.5	80.3	80.62	80.67	80.98	**81**	**81.32**	81.69	81.77	81.8	81.85
		1	2	3	5	**4**	**6**	10	8	7	9
	1	92.15	95.56	96.86	96.93	**97.63**	**97.63**	100	100.79	102.07	104.84
		4	2	8	3	**5**	**9**	6	7	1	10
	1.5	99.37	100.83	101.02	102.14	**103.16**	**103.51**	106.68	107.59	110.3	110.56
		5	4	2	8	**7**	**6**	9	1	3	10
	2	**99.78**	**99.93**	**103.42**	**105.01**	**105.1**	**106.89**	**108.12**	**108.5**	**111.08**	**111.53**
		3	**4**	**6**	**5**	**9**	**7**	**10**	**8**	**2**	**1**
	3	92.97	94.46	95.51	97.71	**102.68**	**106.18**	107.31	109.2	110.69	113.88
		5	3	2	1	**4**	**8**	6	9	7	10
	4.5	76.72	81.16	84.26	88.26	**93.04**	**96.03**	99.26	99.31	107.91	110.42
		2	5	1	8	**7**	**9**	4	3	10	6

Sandy Creek at Campbell Avenue – Peak Discharge (m³/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
20	0.5	94.14	94.56	94.58	94.98	**95**	**95.4**	95.84	95.95	95.99	96.04
		1	2	3	5	**4**	**6**	10	8	7	9
	1	108.44	112.86	114.24	114.55	**115.28**	**115.39**	118.13	119.23	120.65	124.09
		4	2	8	3	**5**	**9**	6	7	1	10
	1.5	117.39	119.33	119.46	120.97	**122.1**	**122.54**	126.4	127.58	130.86	131.18
		5	4	2	8	**7**	**6**	9	1	3	10
	2	**118.33**	**118.37**	**122.41**	**124.32**	**124.63**	**126.88**	**128.23**	**128.74**	**131.81**	**132.42**
		3	**4**	**6**	**5**	**9**	**7**	**10**	**8**	**2**	**1**
	3	109.89	111.5	112.69	115.67	**121.15**	**125.64**	126.83	129.23	130.91	134.79
		5	3	2	1	**4**	**8**	6	9	7	10
	4.5	90.95	95.86	99.61	104.53	**110.16**	**113.8**	118.02	118.36	127.94	131.21
		2	5	1	8	**7**	**9**	4	3	10	6
50	0.5	111.78	113.07	113.88	114.16	**114.52**	**114.53**	114.84	115.37	115.53	115.63
		1	6	5	4	**10**	**7**	9	8	3	2
	1	136.26	137.69	137.95	138.24	**138.3**	**139.38**	142.03	142.54	143.94	144.09
		7	9	8	10	**4**	**5**	3	6	1	2
	1.5	144.19	145.01	146.12	147.64	**148**	**149.53**	155.01	155.53	156.03	157.69
		4	1	3	5	**7**	**8**	2	9	6	10
	2	**145.1**	**145.82**	**147.53**	**150.63**	**151.3**	**151.57**	**152.49**	**155.52**	**156.03**	**161.36**
		3	**5**	**7**	**4**	**8**	**2**	**6**	**1**	**9**	**10**
	3	123.33	126.47	129.2	129.44	**130.22**	**130.31**	133.79	149.57	150.13	153.53
		2	5	9	4	**6**	**7**	8	10	1	3
	4.5	110.77	119.29	120.2	121.33	**128.88**	**132.06**	132.38	132.47	139.43	159.43
		4	5	6	3	**9**	**7**	2	8	1	10
100	0.5	126.84	128.39	129.34	129.65	**130.08**	**130.08**	130.45	131.08	131.24	131.39
		1	6	5	4	**7**	**10**	9	8	3	2
	1	154.26	156.13	156.41	156.65	**156.79**	**158.06**	161.17	161.82	163.23	163.38
		7	9	8	10	**4**	**5**	3	6	1	2
	1.5	163.77	164.64	165.83	167.64	**168.12**	**169.92**	176.16	176.85	177.42	179.35
		4	1	3	5	**7**	**8**	2	9	6	10
	2	**165.17**	**165.97**	**168.1**	**171.72**	**172.46**	**172.89**	**173.95**	**177.33**	**177.97**	**184.07**
		3	**5**	**7**	**4**	**8**	**2**	**6**	**1**	**9**	**10**
	3	141.03	144.24	147.29	147.67	**148.64**	**148.76**	152.87	171.14	171.64	175.5
		2	5	9	4	**7**	**6**	8	10	1	3
	4.5	126.64	136.75	137.32	138.85	**147.59**	**151.23**	151.38	151.43	159.52	182.31
		4	5	6	3	**9**	**7**	8	2	1	10

Spinks Creek at Jubilee Avenue – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	**0.5**	**5.89**	**6.03**	**6.04**	**6.18**	**6.41**	**6.42**	**6.59**	**6.73**	**6.83**	**7.15**
		3	**2**	**6**	**4**	**8**	**5**	**9**	**7**	**10**	**1**
	1	5.51	5.59	5.77	5.96	**6.22**	**6.36**	6.56	6.75	7.03	7.2
		2	3	8	5	**4**	**7**	1	6	10	9
	1.5	4.51	4.87	4.95	5.16	**5.25**	**5.34**	5.71	6.78	6.81	7.14
		6	1	4	8	**3**	**7**	2	10	5	9
	2	4.13	4.48	4.57	4.79	**4.84**	**5.03**	5.19	5.39	5.58	6.54
		2	1	8	4	**6**	**3**	9	10	7	5
	3	3.55	3.75	4	4.23	**4.73**	**5.04**	5.95	5.97	6.13	7.19
		8	4	7	6	**9**	**5**	10	2	1	3
	4.5	3.28	3.83	3.95	4.01	**4.1**	**4.1**	4.1	4.64	5.06	5.38
		4	5	6	2	**7**	**8**	9	10	3	1
5	**0.5**	**8.9**	**9.14**	**9.15**	**9.4**	**9.8**	**9.8**	**10.11**	**10.37**	**10.54**	**11.1**
		3	**2**	**6**	**4**	**5**	**8**	**9**	**7**	**10**	**1**
	1	8.04	8.58	8.68	8.83	**9.19**	**9.39**	10.04	10.14	10.52	10.83
		2	3	8	5	**4**	**7**	1	6	10	9
	1.5	6.53	7.05	7.36	7.82	**7.84**	**8.12**	8.66	9.95	10.12	10.69
		6	1	4	8	**7**	**3**	2	10	5	9
	2	6.31	6.57	6.84	7.02	**7.24**	**7.34**	7.56	7.91	8.64	9.74
		2	8	1	6	**4**	**3**	9	10	7	5
	3	5.24	5.69	5.89	6.11	**6.84**	**7.26**	8.67	8.89	9.02	10.79
		8	4	7	6	**9**	**5**	10	2	1	3
	4.5	4.79	5.58	5.88	5.92	**5.95**	**5.95**	6.02	6.8	7.69	7.95
		4	5	6	7	**2**	**8**	9	10	3	1
10	**0.5**	**10.96**	**11.44**	**11.75**	**11.88**	**12.14**	**12.53**	**12.59**	**13.1**	**13.2**	**13.25**
		2	**1**	**5**	**6**	**4**	**8**	**3**	**7**	**9**	**10**
	1	9.11	9.86	9.92	10.18	**10.37**	**10.57**	11.7	11.73	13.85	15.01
		4	2	5	9	**8**	**3**	6	7	1	10
	1.5	8.14	8.59	8.83	9.23	**9.97**	**10.66**	10.67	11.59	11.84	11.96
		4	8	7	2	**9**	**5**	6	1	10	3
	2	8.09	8.82	8.91	9.31	**9.4**	**9.43**	9.55	10.57	10.64	11.56
		3	6	8	2	**10**	**9**	7	5	1	4
	3	7.5	7.51	7.76	7.79	**7.92**	**8.78**	8.89	9.22	9.97	12.29
		3	6	5	2	**8**	**7**	9	10	4	1
	4.5	4.42	5.58	5.75	5.86	**6.28**	**7.72**	8.16	9.05	9.79	11.6
		5	2	7	8	**1**	**10**	9	4	6	3

Spinks Creek at Jubilee Avenue – Peak Discharge (m³/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
20	**0.5**	**12.97**	**13.58**	**13.96**	**14.12**	**14.45**	**14.94**	**15.02**	**15.67**	**15.79**	**15.85**
		2	**1**	**5**	**6**	**4**	**8**	**3**	**7**	**9**	**10**
	1	10.95	11.76	11.84	12.18	**12.26**	**12.68**	13.87	14.04	16.58	18.05
		4	5	2	9	**8**	**3**	6	7	1	10
	1.5	9.93	10.15	10.44	11.12	**11.82**	**12.86**	12.87	13.94	14.15	14.33
		4	8	7	2	**9**	**5**	6	1	10	3
	2	9.67	10.57	10.57	11.02	**11.17**	**11.39**	11.43	12.6	12.71	14.08
		3	6	8	2	**10**	**9**	7	5	1	4
	3	8.88	9.02	9.25	9.37	**9.46**	**10.41**	10.53	10.91	11.97	14.87
		6	3	2	8	**5**	**7**	9	10	4	1
	4.5	5.2	6.77	6.82	6.96	**7.49**	**9.17**	9.76	10.77	11.74	14.04
		5	2	7	8	**1**	**10**	9	4	6	3
50	**0.5**	**15.92**	**16.42**	**16.87**	**17.2**	**17.54**	**17.87**	**18.1**	**18.4**	**18.8**	**20.07**
		6	**5**	**1**	**10**	**4**	**2**	**8**	**7**	**9**	**3**
	1	13.87	14.58	14.59	14.86	**15.37**	**15.68**	16.09	16.4	19.73	20.06
		8	10	5	7	**4**	**9**	6	3	2	1
	1.5	11.8	12.11	12.96	13.06	**13.94**	**15.26**	15.93	16.3	16.53	16.76
		7	1	4	8	**5**	**3**	6	2	9	10
	2	10.98	10.99	11.72	12	**12.99**	**13.22**	13.76	13.93	14.4	14.76
		7	8	2	4	**3**	**6**	1	9	10	5
	3	8.41	8.71	9.88	10.18	**10.91**	**11.09**	11.85	12.27	12.36	14.91
		7	9	5	2	**6**	**4**	3	8	1	10
	4.5	8.19	8.32	8.67	9.18	**9.31**	**9.36**	10.22	10.46	10.51	11.18
		8	3	2	7	**6**	**4**	9	1	5	10
100	**0.5**	**18.19**	**18.79**	**19.36**	**19.71**	**20.12**	**20.5**	**20.84**	**21.16**	**21.64**	**23.18**
		6	**5**	**1**	**10**	**4**	**2**	**8**	**7**	**9**	**3**
	1	15.7	16.57	16.61	16.87	**17.48**	**18.04**	18.45	18.73	22.56	22.96
		8	10	5	7	**4**	**9**	6	3	2	1
	1.5	13.38	13.88	14.77	14.86	**16.08**	**17.61**	18.14	18.57	18.82	19.11
		7	1	4	8	**5**	**3**	6	2	9	10
	2	12.49	12.53	13.38	13.85	**14.9**	**15.14**	15.75	15.9	16.45	17.03
		8	7	2	4	**3**	**6**	1	9	10	5
	3	9.63	9.96	11.33	11.88	**12.6**	**12.78**	13.75	14.19	14.2	17.21
		7	9	5	2	**6**	**4**	3	8	1	10
	4.5	9.36	9.57	9.96	10.51	**10.82**	**10.88**	11.75	12.04	12.06	12.81
		8	3	2	7	**4**	**6**	9	1	5	10

Scott Creek at Forest Lake Boulevard – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	0.5	2.91	3.03	3.06	3.15	3.45	3.52	3.58	3.6	3.73	4.27
		3	2	6	4	5	9	8	7	10	1
	1	2.47	2.78	2.8	2.83	2.93	3.1	3.25	3.35	3.38	3.46
		2	8	4	7	3	5	6	10	1	9
	1.5	2	2.24	2.32	2.4	2.64	2.88	3.07	3.16	3.33	3.44
		6	4	1	7	8	3	2	10	5	9
	2	2.12	2.13	2.21	2.21	2.23	2.32	2.35	2.41	3.09	3.1
		6	2	3	8	9	4	1	10	7	5
	3	1.59	1.76	1.79	1.81	1.96	2.08	2.55	2.7	2.72	3.51
		8	7	6	4	9	5	10	1	2	3
	4.5	1.44	1.69	1.74	1.78	1.87	1.88	1.94	2.09	2.43	2.59
		4	5	8	2	9	7	6	10	1	3
5	0.5	4.25	4.45	4.61	4.64	5.13	5.28	5.41	5.48	5.52	6.44
		3	2	4	6	5	9	7	8	10	1
	1	3.73	4.04	4.04	4.15	4.34	4.67	4.87	4.87	5.06	5.17
		2	7	8	4	3	5	6	10	9	1
	1.5	2.93	3.21	3.46	3.51	3.96	4.37	4.6	4.61	4.87	5.07
		6	4	7	1	8	3	2	10	5	9
	2	3.07	3.17	3.19	3.27	3.39	3.42	3.5	3.53	4.5	4.68
		6	9	2	3	8	4	10	1	5	7
	3	2.28	2.51	2.55	2.65	2.77	2.93	3.62	3.84	3.9	5.1
		8	7	6	4	9	5	10	1	2	3
	4.5	2.08	2.44	2.48	2.61	2.72	2.8	2.87	3.02	3.49	3.8
		4	5	8	2	9	7	6	10	1	3
10	0.5	5.42	5.7	5.98	6	6.07	6.1	6.87	6.92	6.94	7.15
		1	5	6	2	4	8	9	7	3	10
	1	4.57	4.72	4.76	4.88	4.98	5.04	5.26	5.45	6.83	7.19
		4	9	2	5	3	6	8	7	1	10
	1.5	3.65	3.94	4.11	4.25	4.4	4.86	5.1	5.24	5.4	5.6
		8	7	9	2	4	5	6	10	3	1
	2	3.72	3.73	3.76	3.89	3.97	4.37	4.54	4.59	4.67	5.95
		8	3	2	6	10	7	9	5	1	4
	3	2.98	3.22	3.25	3.36	3.59	3.68	3.75	3.91	4.61	5.72
		6	8	2	3	9	7	10	5	4	1
	4.5	1.72	2.27	2.57	2.66	3.17	3.53	3.61	3.71	4.27	5.42
		5	7	2	1	8	10	9	4	6	3

Scott Creek at Forest Lake Boulevard – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
20	**0.5**	**6.32**	**6.69**	**7.1**	**7.11**	**7.13**	**7.18**	**8.07**	**8.21**	**8.24**	**8.43**
		1	**5**	**4**	**6**	**8**	**2**	**9**	**7**	**3**	**10**
	1	5.46	5.58	5.64	5.88	**5.88**	**5.94**	6.3	6.45	8.1	8.51
		4	9	2	3	**5**	**6**	8	7	1	10
	1.5	4.42	4.69	4.84	5.05	**5.37**	**5.78**	6.07	6.2	6.44	6.69
		8	7	9	2	**4**	**5**	6	10	3	1
	2	4.4	4.44	4.48	4.63	**4.71**	**5.22**	5.44	5.44	5.57	7.16
		8	2	3	6	**10**	**7**	5	9	1	4
	3	3.49	3.79	3.83	3.97	**4.24**	**4.37**	4.41	4.68	5.48	6.79
		6	8	2	3	**9**	**7**	10	5	4	1
	4.5	2.02	2.67	3.07	3.15	**3.86**	**4.23**	4.29	4.37	5.07	6.45
		5	7	2	1	**8**	**10**	9	4	6	3
50	**0.5**	**7.49**	**7.94**	**8.09**	**8.47**	**8.64**	**8.74**	**9.15**	**9.21**	**9.7**	**11.03**
		5	**6**	**10**	**4**	**1**	**2**	**7**	**8**	**9**	**3**
	1	6.2	6.22	6.26	6.28	**7.23**	**7.27**	7.35	7.9	8.85	9.5
		10	7	8	5	**4**	**3**	9	6	2	1
	1.5	5.3	5.54	5.87	6.23	**6.67**	**6.75**	6.87	6.88	7.12	7.12
		1	4	7	8	**6**	**5**	9	2	3	10
	2	4.52	4.78	4.93	5.52	**5.71**	**5.73**	5.75	6.04	6.18	6.56
		7	8	2	3	**6**	**4**	9	1	10	5
	3	3.4	3.49	4.01	4.76	**4.95**	**4.95**	5.37	5.64	5.8	6.7
		7	9	5	4	**2**	**6**	1	3	8	10
	4.5	3.32	3.51	3.61	3.76	**4.05**	**4.2**	4.34	4.38	4.53	4.7
		8	2	3	7	**4**	**9**	5	6	1	10
100	**0.5**	**8.62**	**9.25**	**9.27**	**9.6**	**9.83**	**9.94**	**10.4**	**10.5**	**11.04**	**12.61**
		5	**6**	**10**	**4**	**1**	**2**	**7**	**8**	**9**	**3**
	1	7	7.03	7.11	7.21	**8.22**	**8.3**	8.37	9.05	10.02	10.84
		10	7	5	8	**3**	**4**	9	6	2	1
	1.5	6.08	6.29	6.77	7.24	**7.64**	**7.72**	7.79	7.8	8.09	8.11
		1	4	7	8	**6**	**5**	9	2	10	3
	2	5.15	5.47	5.68	6.28	**6.54**	**6.54**	6.57	6.92	7.04	7.47
		7	8	2	3	**6**	**9**	4	1	10	5
	3	3.91	3.98	4.57	5.45	**5.68**	**5.71**	6.15	6.5	6.69	7.69
		7	9	5	4	**6**	**2**	1	3	8	10
	4.5	3.8	4	4.15	4.3	**4.65**	**4.83**	4.96	5.04	5.21	5.38
		8	2	3	7	**4**	**9**	5	6	1	10

Bullockhead Creek at Centenary Motorway – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	0.5	46.95	47.87	48.06	48.42	**48.48**	**48.49**	48.51	48.6	48.77	49.22
		4	3	2	9	**5**	**7**	6	10	1	8
	1	**50.52**	**50.7**	**53.47**	**54.16**	**54.29**	**54.77**	**55.81**	**56.98**	**57.68**	**58.7**
		2	**3**	**9**	**8**	**7**	**4**	**5**	**10**	**1**	**6**
	1.5	42.8	43.79	45.56	47.91	**50.16**	**50.31**	52.3	52.58	58.33	59.86
		3	1	6	7	**8**	**4**	2	5	9	10
	2	39.94	40.28	43.62	44.16	**45.24**	**46.53**	48.04	51.92	53.51	56.29
		2	1	6	7	**8**	**4**	3	9	10	5
	3	35.72	36.01	40.03	43.51	**48.54**	**51.36**	53.49	53.73	54.46	62.78
		8	4	7	6	**9**	**5**	2	1	10	3
	4.5	33.48	37.46	38.21	38.84	**39.88**	**40.46**	42.67	43.1	44.3	56.01
		4	6	5	2	**7**	**3**	8	9	10	1
5	0.5	69.09	70.48	70.75	71.09	**71.19**	**71.23**	71.32	71.43	71.52	72.38
		4	3	2	9	**7**	**5**	10	6	1	8
	1	**73.87**	**74.51**	**77.95**	**79.29**	**79.51**	**80.42**	**81.85**	**83.47**	**84.71**	**86.24**
		2	**3**	**9**	**8**	**7**	**4**	**5**	**10**	**1**	**6**
	1.5	63.34	63.75	65.65	69.12	**72.86**	**73.51**	76.52	76.59	84.85	87.29
		3	1	6	7	**4**	**8**	5	2	9	10
	2	58.48	59.48	63.02	64.08	**65**	**67.8**	69.97	75.07	77.52	81.68
		2	1	6	7	**8**	**4**	3	9	10	5
	3	50.97	51.55	58.01	62.64	**69.84**	**74.1**	78.22	78.37	79.04	91.35
		8	4	7	6	**9**	**5**	2	1	10	3
	4.5	48.4	54.02	55.03	56.63	**57.42**	**59.19**	61.6	62.15	63.79	80.98
		4	6	5	2	**7**	**3**	8	9	10	1
10	0.5	83.96	85.02	85.88	86.2	**86.47**	**86.65**	86.8	86.88	87.02	87.43
		3	1	4	5	**10**	**7**	2	9	6	8
	1	**83.14**	**92.98**	**95.37**	**95.95**	**96.64**	**96.79**	**98.28**	**101.56**	**102.84**	**106.78**
		4	**2**	**8**	**3**	**5**	**9**	**6**	**1**	**7**	**10**
	1.5	76.51	78.11	80.07	85.37	**87.06**	**91.62**	94.3	97.75	101.03	102.79
		4	2	8	7	**5**	**6**	9	1	3	10
	2	69.02	79.82	83.75	86.2	**86.98**	**87.72**	88.36	91.21	92.09	95.2
		3	7	6	9	**10**	**8**	4	2	1	5
	3	61.25	65.97	73.49	78.21	**78.43**	**79.47**	86.59	86.67	89.1	91.42
		5	3	2	8	**6**	**4**	9	7	10	1
	4.5	50.57	54.31	58.8	60.66	**61.94**	**72.72**	82.8	83.43	95.13	97.51
		5	2	8	7	**1**	**9**	10	4	6	3

Bullockhead Creek at Centenary Motorway – Peak Discharge (m³/s) and Ensemble Ranking

ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
20	0.5	98.56	99.86	100.8	101.19	101.38	101.58	101.87	101.98	102.16	102.59
		3	1	4	5	10	7	9	2	6	8
	1	98.17	110.06	113.05	113.64	114.52	114.63	116.43	120.41	121.89	126.51
		4	2	8	3	5	9	6	1	7	10
	1.5	90.42	93.4	94.8	101.25	103.8	108.77	111.92	115.97	119.93	122.17
		4	2	8	7	5	6	9	1	3	10
	2	81.69	94.57	99.53	102.65	103.39	104.12	105.75	108.31	109.38	113.59
		3	7	6	9	10	8	4	2	1	5
	3	72.71	78.81	87.17	92.51	92.83	94.24	102.67	102.72	105.6	109.39
		5	3	2	8	6	4	9	7	10	1
	4.5	59.67	65.07	69.59	71.73	73.46	86.3	98.17	99.39	113.3	116.54
		5	2	8	7	1	9	10	4	6	3
50	0.5	117.82	120.82	121.3	121.38	121.43	121.64	122.04	122.13	123.07	124.07
		1	7	9	6	4	3	5	10	8	2
	1	125.76	134.37	134.45	135.52	137.27	137.43	137.59	139.88	143.02	146.31
		7	4	10	8	1	5	9	2	3	6
	1.5	105.6	116.58	120.77	122.62	130.43	134.22	139.49	140.05	143.41	145.02
		4	1	8	7	5	3	9	2	10	6
	2	105.43	106.73	109.41	110.91	112.33	115.48	121.64	121.73	128.5	131.73
		7	4	2	8	6	1	5	3	9	10
	3	83.72	91.13	91.94	93.04	96.34	96.51	103.09	104.2	111.9	127.58
		7	9	6	8	2	5	3	4	1	10
	4.5	81.42	84.96	85.14	86.03	88.49	90.84	93.93	98.73	102.03	108.44
		3	8	6	2	4	7	9	5	1	10
100	0.5	134.16	137.3	137.82	138.08	138.09	138.1	138.79	138.82	139.85	141
		1	7	9	4	3	6	5	10	8	2
	1	142.78	152.76	152.87	153.94	155.97	156.1	156.38	158.96	162.51	166.36
		7	10	4	8	1	5	9	2	3	6
	1.5	119.85	132.75	137.17	139.32	148.65	153.05	158.85	159.56	163.25	165.28
		4	1	8	7	5	3	9	2	10	6
	2	120.09	121.45	124.62	126.29	128.04	131.5	139.01	139.38	146.69	150.33
		7	4	2	8	6	1	3	5	9	10
	3	96.22	104.25	105.42	106.36	110.7	110.72	118.13	119.46	127.89	146.14
		7	9	6	8	5	2	3	4	1	10
	4.5	93.11	96.95	98.48	98.68	101.71	103.91	107.64	113.61	116.76	123.81
		3	8	6	2	4	7	9	5	1	10

Bullockhead Creek at Ipswich Motorway – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	0.5	50.54	51.01	51.16	51.4	**51.44**	**51.47**	51.52	51.56	51.64	51.87
		4	3	2	6	**9**	**5**	7	10	1	8
	1	**57.91**	**58.92**	**59.37**	**59.67**	**60.55**	**60.77**	**61.16**	**61.67**	**62.94**	**63.33**
		2	**9**	**3**	**7**	**8**	**4**	**5**	**10**	**1**	**6**
	1.5	50.3	55.48	56.49	57.26	**59.75**	**60.29**	61.56	62.12	63.27	65.94
		3	7	1	6	**5**	**4**	8	2	9	10
	2	49.67	49.92	52.03	54.77	**57.03**	**58.2**	60.08	60.19	60.5	64.92
		1	6	2	8	**7**	**3**	4	10	9	5
	3	42.7	45.27	49.91	51.02	**59.33**	**59.58**	61.7	61.73	63.8	70.37
		4	8	6	7	**9**	**2**	1	5	10	3
	4.5	41.53	43.56	45.1	45.37	**48.61**	**49.97**	51.11	51.82	53.91	67.49
		4	5	7	6	**3**	**2**	9	8	10	1
5	0.5	73.17	73.9	74.11	74.48	**74.51**	**74.56**	74.63	74.67	74.79	75.17
		4	3	2	6	**9**	**5**	7	10	1	8
	1	**83.75**	**84.91**	**86.06**	**86.17**	**87.63**	**87.93**	**88.47**	**89.09**	**91.22**	**91.69**
		2	**9**	**3**	**7**	**8**	**4**	**5**	**10**	**1**	**6**
	1.5	73.25	79.55	81.76	82.58	**85.8**	**86.9**	89.02	89.8	90.86	94.98
		3	7	1	6	**5**	**4**	8	2	9	10
	2	71.12	72.11	75.04	78.92	**82.66**	**83.85**	86.1	86.63	86.71	93.19
		6	1	2	8	**7**	**3**	10	4	9	5
	3	60.6	64.85	71.02	73.17	**84.77**	**86.05**	88.44	88.8	91.43	101.18
		4	8	6	7	**9**	**2**	5	1	10	3
	4.5	59.39	61.99	64.14	64.76	**70.29**	**72.03**	73.03	74.07	76.92	96.96
		4	5	7	6	**3**	**2**	9	8	10	1
10	0.5	88.78	88.95	89.61	89.79	**89.83**	**90.18**	90.21	90.27	90.36	90.65
		3	1	4	5	**2**	**10**	7	6	9	8
	1	99.55	104.16	104.61	105.28	**106.17**	**106.49**	106.87	108.1	109.86	112.27
		4	2	8	6	**5**	**9**	3	1	7	10
	1.5	**90.2**	**97**	**99.8**	**101.74**	**106.31**	**107.68**	**108.92**	**110.38**	**110.9**	**111.05**
		8	**4**	**2**	**7**	**5**	**9**	**6**	**1**	**3**	**10**
	2	79.94	87.98	98.44	99.92	**102.18**	**102.48**	102.5	103.98	106.35	111.89
		3	7	10	8	**6**	**4**	1	9	2	5
	3	75.21	86.74	91.98	94	**96.39**	**98.29**	99.08	101.34	102.8	103.98
		5	3	2	8	**1**	**6**	4	9	7	10
	4.5	66.37	67.9	68.35	74.81	**79.91**	**82.41**	96.31	98.4	110.03	110.13
		5	8	2	1	**7**	**9**	4	10	3	6

Bullockhead Creek at Ipswich Motorway – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
20	0.5	103.58	103.79	104.56	104.78	**104.84**	**105.23**	105.25	105.34	105.43	105.79
		3	1	4	5	**2**	**10**	7	6	9	8
	1	117.4	122.76	123.28	123.94	**125.14**	**125.51**	126	127.3	129.48	132.27
		4	2	8	6	**5**	**9**	3	1	7	10
	1.5	**106.3**	**114.97**	**118.37**	**120.31**	**126.04**	**127.35**	**128.93**	**130.53**	**131.06**	**131.24**
		8	**4**	**2**	**7**	**5**	**9**	**6**	**1**	**3**	**10**
	2	94.74	103.68	116.34	118.14	**120.98**	**121.17**	121.85	123.15	125.9	132.73
		3	7	10	8	**6**	**1**	4	9	2	5
	3	89.43	102.89	108.87	110.88	**114.52**	**116.06**	117.09	119.63	121.35	122.76
		5	3	2	8	**1**	**6**	4	9	7	10
	4.5	78.33	80.45	81.34	88.44	**94.56**	**97.36**	114.19	116.41	130.53	130.83
		5	8	2	1	**7**	**9**	4	10	6	3
50	0.5	122.06	124.48	125.05	125.1	**125.2**	**125.39**	125.56	125.78	126.4	126.88
		1	6	7	4	**5**	**9**	10	3	8	2
	1	140.48	145.95	146.86	148.72	**148.78**	**148.95**	149.24	149.28	153.48	155.12
		7	1	10	8	**2**	**4**	9	5	3	6
	1.5	**130.83**	**136.85**	**144.96**	**146.09**	**148.99**	**151.91**	**153.07**	**154.92**	**158.23**	**161.22**
		4	**8**	**7**	**1**	**9**	**5**	**2**	**10**	**3**	**6**
	2	122.97	127.14	129.22	132.43	**133.75**	**136.84**	142.54	148.2	148.26	151.22
		6	2	4	7	**1**	**8**	9	10	3	5
	3	101.79	108.33	114.52	115.01	**116.13**	**119.86**	126.59	127.38	134.03	151.06
		8	7	6	2	**9**	**5**	1	4	3	10
	4.5	101.02	101.48	103.82	108.58	**109.98**	**113.61**	115.57	120.6	120.92	135.37
		9	3	6	4	**8**	**2**	7	5	1	10
100	0.5	138.1	140.87	141.49	141.55	**141.68**	**141.88**	142.08	142.3	143.04	143.59
		1	6	7	4	**5**	**9**	10	3	8	2
	1	158.98	165.02	166.22	168.29	**168.38**	**168.65**	168.96	168.98	173.76	175.65
		7	1	10	2	**8**	**4**	9	5	3	6
	1.5	**148.79**	**155.22**	**164.6**	**165.98**	**168.91**	**172.51**	**173.66**	**175.71**	**179.86**	**183.07**
		4	**8**	**7**	**1**	**9**	**5**	**2**	**10**	**3**	**6**
	2	140.35	145.1	147.3	150.79	**152.5**	**155.91**	162.12	168.61	168.94	172.53
		6	2	4	7	**1**	**8**	9	10	3	5
	3	115.8	123.9	130.9	131.73	**132.51**	**137.07**	144.26	145.61	153.22	172.53
		8	7	6	2	**9**	**5**	1	4	3	10
	4.5	115.2	115.73	119.3	124.42	**125.47**	**129.92**	132.33	137.99	138.38	154.59
		9	3	6	4	**8**	**2**	7	1	5	10

Ric Nattrass Creek at Centenary Motorway – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	**0.5**	**19.81**	**20.25**	**20.27**	**20.36**	**21.76**	**22.08**	**22.14**	**22.47**	**22.78**	**23.59**
		3	**4**	**2**	**6**	**5**	**8**	**9**	**7**	**10**	**1**
	1	16.91	18.98	19.18	19.19	**19.69**	**19.94**	22.13	22.28	22.89	22.92
		2	8	3	5	**4**	**7**	6	1	9	10
	1.5	14.15	14.88	15.82	16.53	**17.49**	**18.18**	19.16	20.78	21.5	23.05
		6	1	4	7	**8**	**3**	2	5	10	9
	2	13.87	14.05	14.71	15.42	**15.45**	**15.95**	16.08	17.08	18.99	21
		8	2	6	3	**1**	**4**	9	10	7	5
	3	11.26	12.66	12.78	13.07	**14.61**	**15.46**	18.45	19.37	19.39	23.34
		8	4	7	6	**9**	**5**	10	1	2	3
	4.5	10.3	11.93	12.46	12.64	**12.78**	**13**	13.01	14.39	16.54	17.3
		4	5	6	7	**8**	**2**	9	10	3	1
5	**0.5**	**29.36**	**30.07**	**30.13**	**30.27**	**32.64**	**33.23**	**33.25**	**33.8**	**34.33**	**35.7**
		3	**4**	**2**	**6**	**5**	**8**	**9**	**7**	**10**	**1**
	1	24.14	27.83	28.46	28.73	**28.78**	**28.81**	32.47	33.46	33.58	33.69
		2	8	4	5	**3**	**7**	6	1	10	9
	1.5	20.41	22.47	22.9	23.82	**26.01**	**27.49**	28.42	30.21	31.13	33.86
		6	1	4	7	**8**	**3**	2	5	10	9
	2	20.59	20.92	21.07	21.94	**22.91**	**23.15**	23.46	24.64	28.64	30.6
		8	2	6	3	**9**	**1**	4	10	7	5
	3	16.2	18.39	18.62	18.74	**20.75**	**21.86**	26.38	27.91	28.23	34.15
		8	7	6	4	**9**	**5**	10	1	2	3
	4.5	14.77	17.15	18.06	18.23	**18.27**	**18.8**	18.82	20.72	24.51	25.01
		4	5	7	6	**8**	**9**	2	10	3	1
10	**0.5**	**35.52**	**36.44**	**38.19**	**38.75**	**38.76**	**39.8**	**40.83**	**42.17**	**42.47**	**42.5**
		2	**1**	**5**	**6**	**4**	**3**	**8**	**10**	**9**	**7**
	1	30.29	30.75	32.42	32.6	**32.85**	**34.45**	36.26	37.78	42.07	47.36
		4	5	2	8	**9**	**3**	6	7	1	10
	1.5	25.75	27.35	27.7	29.76	**29.78**	**33.76**	34.02	35.63	36.22	37.01
		8	7	4	9	**2**	**6**	5	1	10	3
	2	24.66	26.82	27.38	27.45	**27.96**	**28.95**	29.74	31.46	32.35	37.57
		3	8	6	2	**10**	**7**	9	5	1	4
	3	22.39	23.13	23.39	23.46	**25.21**	**26.6**	26.75	27.15	30.49	38.87
		6	2	8	3	**5**	**7**	9	10	4	1
	4.5	12.94	17.14	18.11	18.9	**19.21**	**23.76**	24.5	27.08	30.38	36.58
		5	7	2	1	**8**	**10**	9	4	6	3

Ric Nattrass Creek at Centenary Motorway – Peak Discharge (m³/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
20	**0.5**	**41.74**	**42.87**	**45.04**	**45.71**	**45.71**	**47.03**	**48.29**	**49.94**	**50.32**	**50.36**
		2	**1**	**5**	**4**	**6**	**3**	**8**	**10**	**9**	**7**
	1	36.21	36.75	38.69	38.98	**39.09**	**40.99**	42.72	44.85	49.81	56.37
		4	5	2	9	**8**	**3**	6	7	1	10
	1.5	30.31	32.6	33.55	35.01	**35.57**	**40.29**	40.62	42.41	42.88	43.95
		8	7	4	9	**2**	**6**	5	1	10	3
	2	29.34	31.68	32.31	32.54	**33.03**	**34.47**	35.59	37.17	38.4	45.27
		3	8	2	6	**10**	**7**	9	5	1	4
	3	26.31	27.25	27.53	27.92	**30.37**	**31.39**	31.52	31.95	36.37	46.54
		6	2	8	3	**5**	**7**	9	10	4	1
	4.5	15.23	20.18	21.69	22.39	**23.44**	**28.36**	29.13	32	36.12	43.8
		5	7	2	1	**8**	**10**	9	4	6	3
50	**0.5**	**49.59**	**50.68**	**52.04**	**54.58**	**54.85**	**57.27**	**58.18**	**58.25**	**58.32**	**62.06**
		6	**1**	**5**	**4**	**10**	**7**	**2**	**8**	**9**	**3**
	1	42.87	43.39	43.86	45.28	**46.19**	**49.64**	50.67	51.84	59.29	60.69
		8	10	7	5	**4**	**9**	3	6	2	1
	1.5	35.17	37.77	38.16	39.3	**43.44**	**46.88**	47.58	48.67	49.28	50.88
		7	1	4	8	**5**	**6**	2	3	9	10
	2	32.41	32.82	35.07	35.57	**38.7**	**39.57**	41.51	41.62	41.86	46.1
		7	8	2	4	**3**	**6**	1	9	10	5
	3	25.17	25.88	29.63	32.21	**32.89**	**33.64**	36.49	36.6	36.61	44.84
		7	9	5	2	**6**	**4**	8	1	3	10
	4.5	23.79	24.83	25.95	26.79	**28.61**	**30.41**	30.98	31.07	31.41	32.54
		8	3	2	7	**4**	**6**	9	5	1	10
100	**0.5**	**56.29**	**57.64**	**59.19**	**62.19**	**62.54**	**65.39**	**66.49**	**66.55**	**66.63**	**71.05**
		6	**1**	**5**	**4**	**10**	**7**	**2**	**8**	**9**	**3**
	1	48.61	48.97	49.55	51.3	**52.19**	**56.71**	57.45	59.16	67.37	69.09
		8	10	7	5	**4**	**9**	3	6	2	1
	1.5	40.67	43.01	43.4	44.59	**49.69**	**53.07**	53.95	55.74	55.91	57.8
		7	1	4	8	**5**	**6**	2	3	9	10
	2	36.87	37.48	39.94	40.71	**44.08**	**45.2**	47.35	47.43	47.62	52.8
		7	8	2	4	**3**	**6**	9	1	10	5
	3	28.66	29.47	33.79	37.21	**37.76**	**38.51**	41.9	42.06	42.2	51.45
		7	9	5	2	**6**	**4**	1	8	3	10
	4.5	27.13	28.48	29.65	30.59	**32.84**	**35.27**	35.53	35.88	36.02	37.2
		8	3	2	7	**4**	**6**	9	5	1	10

Wolston Creek at Catchment Outlet – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	0.5	115.92	116.02	116.07	116.13	**116.23**	**116.23**	116.27	116.29	116.33	116.33
		4	3	2	6	**5**	**9**	7	10	1	8
	1	145.57	146.35	147.37	147.44	**147.46**	**147.9**	147.99	148.29	148.53	149.1
		3	2	8	9	**7**	**5**	4	1	10	6
	1.5	147.86	157.72	157.92	158.86	**159.27**	**160.84**	161.2	162.3	163.52	165.8
		3	1	6	7	**2**	**8**	4	5	9	10
	2	**154.5**	**155.74**	**156.81**	**160.54**	**165.55**	**167.2**	**167.79**	**168.37**	**169.14**	**172.28**
		1	**6**	**2**	**3**	**8**	**7**	**4**	**9**	**10**	**5**
	3	144.34	154.17	154.41	156.71	**158.84**	**166.28**	172.97	174.49	177.74	179.32
		4	6	8	2	**7**	**1**	9	10	5	3
	4.5	131.6	136.83	138.58	140.88	**144.14**	**149.35**	151.85	157.54	163.41	181.78
		3	5	6	4	**7**	**9**	2	8	10	1
5	0.5	165.94	166.09	166.19	166.29	**166.48**	**166.5**	166.55	166.6	166.66	166.7
		4	3	2	6	**5**	**9**	7	10	8	1
	1	207.87	209.29	210.82	211.17	**211.3**	**211.74**	211.85	212.2	212.91	213.65
		3	2	8	7	**9**	**5**	4	1	10	6
	1.5	210.72	224.89	225.18	226.87	**226.93**	**229.35**	230.08	232.01	234.12	237.23
		3	1	6	7	**2**	**8**	4	5	9	10
	2	**219.88**	**221.76**	**223**	**228.52**	**235.76**	**238.14**	**238.86**	**240.01**	**241.4**	**245.84**
		1	**6**	**2**	**3**	**8**	**7**	**4**	**9**	**10**	**5**
	3	204.41	218.65	218.9	223.6	**226.32**	**236.82**	245.54	248.05	253.28	255.61
		4	6	8	2	**7**	**1**	9	10	5	3
	4.5	187.63	193.87	196.54	200.65	**204.11**	**211.91**	216.51	224.1	232.19	258.81
		3	5	6	4	**7**	**9**	2	8	10	1
10	0.5	199.95	200.11	200.15	200.31	**200.32**	**200.48**	200.67	200.72	200.74	200.76
		1	2	3	5	**4**	**6**	10	8	7	9
	1	249.51	253.18	254.22	254.44	**254.91**	**255.17**	255.87	257.35	258	259.98
		4	2	3	8	**9**	**5**	6	7	1	10
	1.5	269.45	271.39	271.8	273.5	**275.79**	**279.46**	281.86	282.95	284.19	284.85
		8	4	2	5	**7**	**6**	9	1	10	3
	2	263.62	274.53	278.74	283.94	**284.64**	**285.11**	285.55	289.4	292.89	294.4
		3	4	7	9	**6**	**10**	8	1	5	2
	3	**256.9**	**265.97**	**275.07**	**282.81**	**285.41**	**288.05**	**293.1**	**294.68**	**299.5**	**300.59**
		5	**1**	**3**	**2**	**4**	**8**	**9**	**6**	**7**	**10**
	4.5	224.11	227.03	231.32	234.7	**250.3**	**272.01**	276.1	285.37	285.88	308.01
		2	1	5	8	**9**	**7**	4	3	10	6

Wolston Creek at Catchment Outlet – Peak Discharge (m³/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
20	0.5	232.33	232.53	232.59	232.79	**232.8**	**233.01**	233.26	233.32	233.35	233.37
		1	2	3	5	**4**	**6**	10	8	7	9
	1	292.35	296.8	298.05	298.36	**298.93**	**299.24**	300.23	301.95	302.83	305.29
		4	2	3	8	**9**	**5**	6	7	1	10
	1.5	317.42	319.55	319.93	321.83	**324.8**	**329.07**	332.08	333.4	335.06	335.79
		8	4	2	5	**7**	**6**	9	1	10	3
	2	310.88	323.57	328.9	334.85	**335.78**	**336.39**	336.91	341.63	345.49	347.42
		3	4	7	9	**6**	**10**	8	1	5	2
	3	**303.06**	**313.04**	**324.36**	**333.67**	**335.98**	**339.3**	**345.25**	**347.02**	**352.86**	**353.98**
		5	**1**	**3**	**2**	**4**	**8**	**9**	**6**	**7**	**10**
	4.5	265	267.51	273.07	276.4	**295.04**	**321.07**	326.58	337.06	337.37	363.91
		2	1	5	8	**9**	**7**	4	10	3	6
50	0.5	276.07	276.77	277.24	277.42	**277.61**	**277.63**	277.81	278.1	278.19	278.24
		1	6	5	4	**10**	**7**	9	8	3	2
	1	354.28	356.65	356.9	356.95	**356.96**	**357.89**	359.48	360.06	360.7	360.94
		7	4	10	9	**8**	**5**	1	3	6	2
	1.5	378.28	388.22	389.81	391.49	**392.82**	**394.31**	395.77	400.21	401.88	403.47
		4	1	8	7	**5**	**3**	9	2	10	6
	2	**394.77**	**395.37**	**395.65**	**395.83**	**400.86**	**402.46**	**403.78**	**404.08**	**404.26**	**419.41**
		6	**7**	**2**	**4**	**8**	**9**	**1**	**5**	**3**	**10**
	3	349.08	354.25	371.96	374.42	**379.95**	**380.35**	389.42	391.84	407.22	421.78
		8	2	7	6	**5**	**9**	1	4	3	10
	4.5	337.02	337.52	338.79	353.74	**357.04**	**376.24**	378.39	383.06	389.64	427.25
		9	4	5	6	**3**	**7**	1	8	2	10
100	0.5	311.35	312.19	312.76	312.97	**313.2**	**313.23**	313.44	313.79	313.9	313.95
		1	6	5	4	**10**	**7**	9	8	3	2
	1	399.58	402.27	402.58	402.6	**402.61**	**403.72**	405.75	406.24	406.98	407.37
		7	4	10	9	**8**	**5**	1	3	6	2
	1.5	428.02	439.16	441.19	442.98	**444.44**	**446.02**	448.13	453.05	455.04	456.7
		4	1	8	7	**5**	**3**	9	2	10	6
	2	**448.38**	**448.87**	**449.33**	**449.45**	**455.09**	**457.08**	**458.54**	**458.66**	**458.99**	**476.41**
		6	**7**	**2**	**4**	**8**	**9**	**1**	**5**	**3**	**10**
	3	398.82	404.46	423.98	426.56	**433.3**	**433.7**	443.35	446.96	463.43	480.49
		8	2	7	6	**5**	**9**	1	4	3	10
	4.5	385.02	385.81	386.95	404.28	**407.44**	**429.62**	431.38	436.93	444.59	487.01
		9	4	5	6	**3**	**7**	1	8	2	10

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Appendix F: Design Events (Scenario 1) - Peak Flood Levels

The flood level data presented in this Appendix has been extracted (in part) from the results of a 2-dimensional flood model. Levels presented have been extracted generally at selected points along the centreline of the waterway with the intent of demonstrating general flood characteristics. The applicability of this data to locations on the floodplains adjacent should be determined by a suitably qualified professional. It is recommended for any detailed assessment of flood risk associated with the waterway that complete flood model results be accessed and interrogated.

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AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Wolston Creek						
0	1.18	1.18	1.18	1.18	1.18	1.18
100	1.26	1.33	1.41	1.49	1.56	1.64
200	1.38	1.54	1.71	1.87	2.00	2.15
300	1.51	1.75	2.01	2.22	2.40	2.60
400	1.72	2.07	2.38	2.63	2.83	3.03
500	2.04	2.48	2.83	3.10	3.32	3.55
600	2.37	2.89	3.30	3.63	3.87	4.13
700	2.66	3.23	3.70	4.05	4.32	4.59
800	2.89	3.51	4.01	4.38	4.67	4.95
900	3.09	3.73	4.27	4.66	4.95	5.23
1000	3.22	3.88	4.43	4.83	5.13	5.41
1100	3.32	4.00	4.56	4.96	5.26	5.55
1200	3.42	4.10	4.66	5.07	5.37	5.66
1300	3.52	4.20	4.76	5.17	5.47	5.77
1400	3.61	4.28	4.84	5.25	5.55	5.85
1500	3.68	4.36	4.91	5.32	5.63	5.93
1600	3.74	4.42	4.98	5.39	5.70	6.00
1700	3.80	4.48	5.04	5.46	5.77	6.07
1800	3.86	4.54	5.11	5.52	5.83	6.14
1900	3.94	4.62	5.18	5.59	5.90	6.21
2000	4.01	4.69	5.25	5.66	5.98	6.28
2100	4.07	4.75	5.30	5.72	6.03	6.34
2200	4.13	4.80	5.35	5.76	6.08	6.38
2300	4.18	4.85	5.41	5.81	6.13	6.44
2400	4.24	4.90	5.45	5.86	6.17	6.48
2500	4.30	4.94	5.48	5.88	6.19	6.49
Structure S1 – Wacol Station Road						
2600	4.76	5.57	6.03	6.29	6.50	6.73
2700	4.85	5.64	6.10	6.36	6.57	6.80
2800	4.94	5.71	6.16	6.43	6.64	6.87
2900	5.03	5.78	6.24	6.50	6.73	6.95
3000	5.10	5.85	6.31	6.59	6.82	7.06

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
3100	5.19	5.92	6.39	6.68	6.92	7.16
3200	5.28	6.00	6.46	6.76	7.00	7.24
3300	5.37	6.09	6.55	6.85	7.10	7.35
3400	5.46	6.16	6.63	6.93	7.18	7.43
3500	5.54	6.23	6.70	7.01	7.26	7.51
3600	5.58	6.26	6.73	7.04	7.29	7.54
3700	5.59	6.27	6.74	7.05	7.30	7.56
3800	5.61	6.29	6.76	7.07	7.32	7.57
3900	5.65	6.31	6.77	7.08	7.34	7.59
4000	5.71	6.34	6.79	7.09	7.35	7.59
4100	5.78	6.36	6.80	7.10	7.35	7.60
4205	5.89	6.39	6.81	7.11	7.36	7.60
Sandy Creek						
0	5.92	6.40	6.82	7.11	7.36	7.60
100	6.06	6.48	6.88	7.16	7.40	7.64
200	6.16	6.56	6.93	7.21	7.44	7.68
Structure S2 – Wolston Road						
300	6.33	6.74	7.13	7.43	7.68	7.95
400	6.55	6.93	7.27	7.55	7.78	8.04
500	6.78	7.11	7.41	7.67	7.89	8.13
600	7.02	7.34	7.60	7.83	8.03	8.26
700	7.23	7.53	7.77	7.99	8.17	8.39
800	7.35	7.66	7.89	8.10	8.28	8.48
900	7.51	7.82	8.04	8.24	8.41	8.61
1000	7.73	8.04	8.25	8.44	8.59	8.78
1100	7.99	8.28	8.49	8.67	8.81	8.98
1200	8.27	8.57	8.77	8.95	9.08	9.25
1300	8.53	8.84	9.05	9.23	9.36	9.52
1400	8.66	8.98	9.19	9.37	9.50	9.66
1500	8.87	9.19	9.41	9.59	9.71	9.88
1600	9.08	9.39	9.60	9.78	9.90	10.06
1700	9.28	9.58	9.78	9.95	10.06	10.22
1800	9.49	9.76	9.94	10.10	10.20	10.34

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
1900	9.69	9.94	10.10	10.24	10.33	10.46
2000	9.85	10.07	10.22	10.35	10.43	10.56
2100	10.08	10.29	10.42	10.54	10.62	10.73
2200	10.36	10.59	10.74	10.87	10.94	11.06
2300	10.63	10.88	11.04	11.18	11.25	11.37
2400	10.84	11.07	11.23	11.36	11.43	11.56
2500	11.11	11.34	11.49	11.62	11.69	11.81
2600	11.39	11.62	11.77	11.90	11.97	12.08
2700	11.66	11.90	12.05	12.16	12.23	12.33
2800	11.94	12.19	12.33	12.44	12.51	12.61
2900	12.23	12.50	12.65	12.76	12.82	12.92
Structure S3 – Ipswich Railway						
3000	12.46	12.77	12.94	13.07	13.15	13.31
3100	12.54	12.87	13.05	13.20	13.28	13.45
3186	12.62	12.96	13.15	13.30	13.39	13.56
Structure S4a – Ipswich Road						
Structure S4b – Ipswich Motorway						
3300	12.91	13.28	13.79	14.03	14.37	14.47
3400	13.23	13.62	14.02	14.27	14.69	14.85
3500	13.39	13.80	14.18	14.41	14.80	14.97
3600	13.50	13.93	14.30	14.54	14.90	15.07
3700	13.66	14.11	14.47	14.71	15.04	15.22
Structure S5 – Progress Road						
3800	14.19	14.67	15.31	15.65	16.00	16.20
3900	14.63	15.06	15.56	15.86	16.16	16.34
4000	14.98	15.38	15.77	16.03	16.29	16.46
Structure S6 – Inline Weir #1						
4100	15.72	16.09	16.32	16.50	16.68	16.80
4200	15.88	16.25	16.48	16.66	16.83	16.95
4300	16.00	16.38	16.62	16.80	16.98	17.11
4400	16.09	16.49	16.75	16.94	17.13	17.28
Structure S7 – Campbell Avenue						
4500	16.14	16.57	16.87	17.12	17.36	17.57

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
4600	16.24	16.68	16.98	17.22	17.47	17.68
Structure S8 – Inline Weir #2						
4700	17.85	18.13	18.30	18.47	18.64	18.80
4800	17.99	18.30	18.49	18.67	18.86	19.02
4900	18.10	18.44	18.65	18.84	19.04	19.21
5000	18.24	18.61	18.83	19.03	19.24	19.42
5100	18.42	18.81	19.03	19.23	19.45	19.63
5200	18.56	18.97	19.21	19.42	19.65	19.83
5300	18.71	19.14	19.38	19.61	19.84	20.03
Structure S9 – Formation Street						
5400	20.98	21.42	21.69	21.96	22.27	22.52
5500	21.22	21.62	21.87	22.13	22.42	22.65
5600	21.45	21.84	22.08	22.33	22.61	22.83
5700	21.72	22.09	22.33	22.56	22.82	23.03
5800	22.33	22.57	22.74	22.92	23.12	23.30
5900	23.08	23.28	23.39	23.51	23.65	23.77
6000	23.79	24.00	24.08	24.15	24.23	24.31
6100	24.06	24.27	24.38	24.47	24.56	24.65
6190	24.29	24.52	24.64	24.75	24.86	24.95
Tributary 3						
0	15.01	15.42	15.81	16.06	16.32	16.48
100	N/R	N/R	N/R	16.37	16.50	16.60
200	N/R	N/R	16.06	16.23	16.42	16.56
300	N/R	N/R	N/R	N/R	N/R	N/R
400	N/R	N/R	N/R	N/R	N/R	N/R
500	N/R	N/R	N/R	N/R	N/R	N/R
600	18.89	19.08	19.11	19.12	19.14	19.16
700	19.96	20.08	20.15	20.20	20.25	20.29
777	20.43	20.51	20.55	20.59	20.63	20.66
Structure S41 – Wilga Street						
900	22.46	22.61	22.67	22.71	22.76	22.78
1000	23.17	23.32	23.38	23.44	23.50	23.54
1048	23.49	23.63	23.69	23.76	23.84	23.89

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Bullockhead Creek						
0	5.92	6.40	6.82	7.11	7.36	7.60
100	6.05	6.48	6.87	7.15	7.39	7.63
200	6.15	6.55	6.92	7.20	7.43	7.67
300	6.42	6.77	7.10	7.35	7.58	7.81
400	6.61	6.94	7.23	7.48	7.70	7.91
500	6.88	7.18	7.42	7.64	7.86	8.05
600	7.27	7.52	7.71	7.89	8.08	8.25
Structure S10 – Spine Street						
700	7.76	8.06	8.26	8.43	8.63	8.79
800	8.10	8.42	8.62	8.80	9.00	9.15
900	8.43	8.75	8.95	9.12	9.31	9.45
1000	8.76	9.08	9.27	9.43	9.62	9.75
1100	9.04	9.37	9.57	9.73	9.91	10.04
1200	9.22	9.58	9.77	9.93	10.13	10.26
1300	9.34	9.69	9.89	10.06	10.25	10.38
1400	9.40	9.76	9.96	10.13	10.33	10.46
1500	9.47	9.83	10.04	10.22	10.41	10.55
Structure S11 – Ipswich Railway						
1600	10.28	10.93	11.33	11.77	12.20	12.54
Structure S12 – Sananda Street						
1700	10.36	10.95	11.35	11.79	12.21	12.54
1800	10.47	11.02	11.40	11.82	12.23	12.56
1900	10.59	11.10	11.47	11.87	12.27	12.59
2000	10.76	11.25	11.61	11.98	12.34	12.64
2100	10.95	11.41	11.76	12.10	12.42	12.70
2200	11.11	11.55	11.87	12.19	12.51	12.77
2300	11.33	11.71	12.00	12.29	12.60	12.84
2400	11.84	12.17	12.41	12.66	12.94	13.15
2500	12.55	12.91	13.12	13.32	13.57	13.72
2600	13.17	13.55	13.74	13.92	14.11	14.23
2700	13.58	13.92	14.09	14.26	14.43	14.54
2800	13.85	14.16	14.32	14.49	14.68	14.81

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Structure S13a – Ipswich Road						
Structure S13b – Ipswich Motorway						
2900	14.15	14.45	14.61	14.86	15.14	15.32
3000	14.80	15.06	15.19	15.35	15.62	15.79
3100	15.12	15.38	15.51	15.66	15.88	16.02
3200	15.44	15.68	15.82	15.96	16.15	16.27
3300	15.64	15.91	16.06	16.20	16.38	16.49
Structure S14 – Private Bridge						
3400	15.87	16.24	16.46	16.69	16.93	17.06
3500	16.13	16.52	16.74	16.95	17.16	17.29
3600	16.30	16.69	16.90	17.11	17.33	17.46
3700	17.14	17.38	17.51	17.66	17.85	17.96
Structure S15 – Boundary Road						
3800	17.88	18.18	18.37	18.57	18.76	18.91
3900	17.99	18.31	18.50	18.70	18.90	19.05
4000	18.24	18.54	18.72	18.91	19.09	19.23
4100	18.64	18.90	19.05	19.19	19.35	19.46
4200	18.96	19.24	19.39	19.53	19.68	19.78
Structure S16 – Bukulla Street						
4300	19.25	19.57	19.75	19.91	20.04	20.15
4400	19.45	19.77	19.95	20.12	20.27	20.38
4500	19.55	19.90	20.08	20.26	20.42	20.54
4600	20.11	20.36	20.50	20.63	20.76	20.88
4700	20.53	20.74	20.88	21.02	21.15	21.26
Structure S17 – Progress Road						
4800	20.74	21.05	21.28	21.56	22.15	22.38
4900	21.16	21.41	21.56	21.77	22.23	22.44
5000	21.92	22.16	22.28	22.40	22.62	22.76
5100	22.50	22.81	22.96	23.08	23.21	23.30
5200	22.83	23.17	23.33	23.49	23.65	23.75
5300	23.02	23.35	23.52	23.69	23.86	23.99
5400	23.21	23.54	23.70	23.87	24.05	24.18
5500	23.52	23.83	23.99	24.16	24.33	24.46

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Structure S18 – Coulson Street						
5600	24.20	24.65	24.79	24.96	25.10	25.22
5700	24.44	24.85	25.00	25.17	25.33	25.46
5800	24.72	25.07	25.22	25.38	25.55	25.67
5900	25.48	25.61	25.69	25.77	25.98	26.02
Structure S19a – Centenary Motorway						
Structure S19b – Springfield Railway						
6061	N/R	N/R	N/R	27.63	27.80	27.92
6100	N/R	27.52	27.70	27.88	28.08	28.22
6190	27.22	27.62	27.80	27.98	28.19	28.34
6300	27.35	27.72	27.90	28.08	28.29	28.44
6400	27.66	27.97	28.13	28.30	28.49	28.64
6500	27.97	28.23	28.36	28.52	28.70	28.84
6600	28.18	28.43	28.56	28.71	28.89	29.02
6700	28.43	28.69	28.81	28.96	29.13	29.26
6800	29.15	29.44	29.53	29.66	29.79	29.90
6900	30.52	30.73	30.77	30.85	30.93	31.00
7000	30.80	31.14	31.24	31.38	31.51	31.60
Structure S20 – Waterford Road Culvert						
7100	31.04	31.44	31.58	31.82	32.15	32.42
7200	31.19	31.56	31.71	31.94	32.24	32.50
7300	31.54	31.86	32.00	32.20	32.46	32.68
7400	N/R	32.31	32.42	32.58	32.78	32.95
7500	32.46	32.74	32.86	33.02	33.20	33.35
7600	33.05	33.29	33.39	33.55	33.71	33.84
7700	N/R	N/R	N/R	N/R	N/R	34.41
7800	34.44	34.70	34.81	34.97	35.11	35.21
7900	34.99	35.32	35.45	35.62	35.80	35.93
8000	35.45	35.80	35.92	36.08	36.24	36.36
8100	N/R	N/R	N/R	36.52	36.65	36.77
8200	36.39	36.76	36.89	37.01	37.14	37.25
8300	37.25	37.56	37.67	37.80	37.95	38.05
8400	37.88	38.14	38.22	38.36	38.52	38.63

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
8471	N/R	N/R	N/R	N/R	N/R	N/R
Ric Nattrass Creek						
0	10.58	11.10	11.46	11.86	12.26	12.59
100	11.19	11.35	11.61	11.92	12.30	12.62
200	11.91	12.12	12.19	12.27	12.39	12.66
300	12.08	12.29	12.36	12.45	12.58	12.69
Structure S27 – Wau Road						
400	12.48	12.81	12.92	13.03	13.17	13.26
Structure S28 – Kokoda Street						
500	12.75	13.37	13.52	13.64	13.78	13.87
Structure S29a – Ipswich Road + motorway off ramp						
Structure S29b – Ipswich Motorway						
619	13.29	13.71	13.87	13.96	14.15	14.30
700	13.47	13.82	13.96	14.05	14.24	14.40
800	14.37	14.53	14.60	14.68	14.84	14.98
Structure S30 – Bakery Road + motorway on ramp						
900	14.84	15.23	15.40	15.70	16.03	16.52
1000	15.26	15.58	15.72	15.93	16.22	16.60
1100	15.90	16.20	16.33	16.46	16.70	16.90
1200	N/R	N/R	N/R	N/R	N/R	N/R
Structure S31 – Boundary Road						
1300	18.53	19.18	19.52	19.83	20.08	20.19
1400	18.63	19.23	19.55	19.85	20.11	20.23
1500	18.84	19.32	19.61	19.89	20.15	20.28
1600	19.38	19.68	19.86	20.06	20.31	20.43
Structure S32a – Centenary Motorway						
Structure S32b – Springfield Railway						
Structure S32c – Centenary Motorway Footbridge						
1724	19.68	19.95	20.11	20.32	20.63	20.87
1800	20.22	20.55	20.70	20.88	21.00	21.19
1900	20.41	20.74	20.90	21.07	21.20	21.35
Structure S33 – Coca Cola Footbridge #2						
1988	20.56	20.86	21.01	21.17	21.30	21.44

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Structure S34 – Coca Cola Drop Structure #3						
Structure S35 – Coca Cola Drop Structure #2						
2100	22.83	22.92	22.97	23.02	23.08	23.13
2200	N/R	N/R	N/R	N/R	N/R	N/R
2300	24.08	24.29	24.40	24.52	24.65	24.74
Structure S36 – Coca Cola Footbridge #1						
2400	N/R	N/R	N/R	N/R	N/R	N/R
Structure S37 – Coca Cola Drop Structure #1						
Structure S38 – Coca Cola Spillway / Weir						
2500	N/R	28.13	28.30	28.46	28.61	28.72
2600	28.22	28.49	28.64	28.79	28.92	29.02
Structure S39 – Pine Road Culvert						
2716	N/R	31.32	31.52	31.63	31.73	31.79
2800	N/R	N/R	N/R	N/R	N/R	N/R
2900	35.27	35.38	35.43	35.47	35.54	35.58
3000	N/R	N/R	N/R	N/R	N/R	N/R
3100	41.10	41.22	41.28	41.33	41.39	41.43
Structure S40 – Progress Road Culvert						
3200	43.21	43.37	43.45	43.53	43.66	43.77
3300	46.90	47.02	47.06	47.12	47.20	47.26
3311	47.29	47.41	47.46	47.51	47.60	47.66
Tributary 1						
0	12.46	12.80	12.90	13.01	13.14	13.23
100	N/R	N/R	N/R	N/R	N/R	N/R
200	N/R	N/R	N/R	N/R	N/R	N/R
217	N/R	N/R	N/R	N/R	N/R	N/R
Scott Creek						
0	27.13	27.54	27.72	27.90	28.10	28.25
100	27.40	27.75	27.90	28.05	28.24	28.37
200	28.55	28.76	28.86	28.96	29.08	29.17
300	30.88	31.02	31.08	31.18	31.32	31.42
400	33.53	33.78	33.91	34.02	34.17	34.25
Structure S24 – Cardwell Street						

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
500	36.47	36.60	36.64	36.70	36.78	36.82
564	N/R	N/R	N/R	N/R	38.04	38.09
Forest Lake Boulevard						
700	42.50	42.77	42.86	42.99	43.21	43.42
Structure S25 – Signac Close Footbridge						
800	47.60	47.73	47.77	47.83	47.94	48.01
900	54.65	54.72	54.73	54.77	54.82	54.85
914	N/R	N/R	N/R	N/R	N/R	N/R
Spinks Creek						
0	37.53	37.60	37.67	37.77	37.90	38.00
100	38.57	38.70	38.79	38.87	38.97	39.04
200	40.11	40.26	40.34	40.40	40.47	40.52
Structure S21 – Roxwell Street						
300	43.00	43.26	43.41	43.59	43.77	43.93
400	43.37	43.62	43.76	43.91	44.07	44.21
500	44.88	45.05	45.10	45.17	45.23	45.27
Structure S22 – Jubilee Avenue						
600	N/R	N/R	N/R	N/R	N/R	N/R
700	47.24	47.44	47.55	47.64	47.74	47.82
800	N/R	N/R	N/R	N/R	49.16	49.20
900	50.16	50.19	50.24	50.28	50.32	50.36
1000	51.69	51.75	51.79	51.83	51.90	51.94
Structure S24 – Cardwell Street						
1100	53.56	53.63	53.67	53.68	53.73	53.77
Tributary 2						
0	20.39	20.72	20.89	21.06	21.19	21.34
100	20.41	20.74	20.91	21.08	21.22	21.36
203	20.43	20.76	20.94	21.10	21.25	21.39

N/R = no result, typically because the AMTD line does not intersect the flood surface

Appendix G: Design Events (Scenario 3) - Peak Flood Levels

The flood level data presented in this Appendix has been extracted (in part) from the results of a 2-dimensional flood model. Levels presented have been extracted generally at selected points along the centreline of the waterway with the intent of demonstrating general flood characteristics. The applicability of this data to locations on the floodplains adjacent should be determined by a suitably qualified professional. It is recommended for any detailed assessment of flood risk associated with the waterway that complete flood model results be accessed and interrogated.

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AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Wolston Creek						
0	1.18	1.18	1.18	1.18	1.18	1.18
100	1.26	1.33	1.41	1.49	1.56	1.64
200	1.37	1.53	1.70	1.85	1.99	2.14
300	1.50	1.74	1.98	2.20	2.38	2.58
400	1.71	2.05	2.35	2.60	2.81	3.02
500	2.02	2.46	2.80	3.08	3.30	3.53
600	2.35	2.87	3.28	3.61	3.87	4.13
700	2.63	3.21	3.68	4.04	4.33	4.62
800	2.86	3.49	3.99	4.38	4.68	4.98
900	3.06	3.72	4.25	4.66	4.97	5.26
1000	3.19	3.87	4.42	4.84	5.15	5.45
1100	3.29	3.99	4.55	4.98	5.29	5.59
1200	3.39	4.09	4.65	5.08	5.40	5.70
1300	3.50	4.19	4.75	5.18	5.50	5.81
1400	3.59	4.27	4.83	5.26	5.58	5.89
1500	3.66	4.35	4.91	5.34	5.66	5.97
1600	3.72	4.41	4.98	5.41	5.73	6.05
1700	3.79	4.48	5.04	5.47	5.80	6.12
1800	3.85	4.54	5.11	5.54	5.87	6.19
1900	3.92	4.61	5.18	5.61	5.94	6.26
2000	4.00	4.69	5.25	5.68	6.00	6.33
2100	4.06	4.74	5.31	5.74	6.06	6.38
2200	4.12	4.80	5.36	5.79	6.11	6.44
2300	4.18	4.85	5.41	5.84	6.17	6.49
2400	4.24	4.91	5.47	5.89	6.22	6.54
2500	4.32	4.97	5.51	5.92	6.24	6.56
Structure S1 – Wacol Station Road						
2600	4.73	5.55	6.01	6.29	6.52	6.77
2700	4.84	5.62	6.08	6.36	6.59	6.84
2800	4.94	5.70	6.15	6.44	6.67	6.91
2900	5.04	5.78	6.23	6.52	6.76	7.00
3000	5.15	5.86	6.32	6.62	6.87	7.11

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
3100	5.26	5.95	6.42	6.72	6.97	7.22
3200	5.38	6.04	6.50	6.81	7.06	7.31
3300	5.53	6.19	6.63	6.94	7.19	7.45
3400	5.63	6.27	6.72	7.03	7.28	7.54
3500	5.70	6.34	6.78	7.09	7.35	7.61
3600	5.73	6.36	6.81	7.12	7.38	7.63
3700	5.74	6.37	6.82	7.13	7.39	7.65
3800	5.76	6.38	6.83	7.15	7.41	7.66
3900	5.79	6.40	6.85	7.16	7.42	7.67
4000	5.83	6.42	6.86	7.17	7.43	7.68
4100	5.89	6.44	6.87	7.18	7.44	7.69
4205	5.98	6.47	6.89	7.19	7.44	7.69
Sandy Creek						
0	6.00	6.48	6.89	7.19	7.44	7.69
100	6.13	6.57	6.96	7.25	7.50	7.74
200	6.23	6.64	7.02	7.30	7.54	7.78
Structure S2 – Wolston Road						
300	6.39	6.82	7.21	7.51	7.77	8.03
400	6.60	6.98	7.33	7.62	7.86	8.11
500	6.81	7.14	7.45	7.72	7.95	8.19
600	7.05	7.36	7.63	7.87	8.09	8.31
700	7.25	7.55	7.79	8.02	8.22	8.43
800	7.37	7.67	7.91	8.12	8.32	8.52
900	7.52	7.82	8.05	8.26	8.44	8.64
1000	7.74	8.03	8.25	8.45	8.62	8.80
1100	7.99	8.27	8.49	8.67	8.83	9.00
1200	8.27	8.56	8.77	8.95	9.10	9.26
1300	8.54	8.83	9.04	9.22	9.37	9.52
1400	8.65	8.95	9.17	9.36	9.50	9.65
1500	8.85	9.16	9.38	9.56	9.71	9.86
1600	9.06	9.36	9.57	9.75	9.89	10.04
1700	9.27	9.55	9.75	9.93	10.05	10.20
1800	9.48	9.74	9.92	10.08	10.20	10.33

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
1900	9.69	9.92	10.09	10.23	10.34	10.46
2000	9.85	10.06	10.21	10.35	10.45	10.56
2100	10.09	10.29	10.43	10.55	10.64	10.74
2200	10.36	10.59	10.74	10.87	10.96	11.07
2300	10.63	10.88	11.04	11.18	11.28	11.38
2400	10.84	11.07	11.23	11.36	11.46	11.57
2500	11.12	11.34	11.50	11.63	11.72	11.83
2600	11.41	11.63	11.78	11.91	12.00	12.09
2700	11.68	11.91	12.06	12.18	12.26	12.35
2800	11.97	12.21	12.36	12.47	12.55	12.63
2900	12.29	12.55	12.70	12.81	12.88	12.97
Structure S3 – Ipswich Railway						
3000	12.53	12.83	12.99	13.12	13.22	13.36
3100	12.61	12.92	13.11	13.25	13.36	13.50
3186	12.69	13.02	13.21	13.37	13.49	13.63
Structure S4a – Ipswich Road						
Structure S4b – Ipswich Motorway						
3300	13.02	13.27	13.77	14.03	14.37	14.48
3400	13.32	13.69	14.06	14.34	14.75	14.92
3500	13.46	13.85	14.21	14.48	14.87	15.04
3600	13.56	13.97	14.33	14.61	14.98	15.17
3700	13.72	14.16	14.51	14.79	15.15	15.34
Structure S5 – Progress Road						
3800	14.24	14.71	15.34	15.75	16.24	16.65
3900	14.65	15.08	15.60	15.96	16.38	16.76
4000	14.97	15.38	15.81	16.14	16.51	16.85
Structure S6 – Inline Weir #1						
4100	15.75	16.14	16.38	16.59	16.83	17.10
4200	15.92	16.31	16.55	16.76	16.98	17.23
4300	16.04	16.44	16.69	16.91	17.13	17.37
4400	16.13	16.55	16.82	17.06	17.29	17.52
Structure S7 – Campbell Avenue						
4500	16.18	16.63	16.93	17.21	17.50	17.77

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
4600	16.29	16.74	17.03	17.32	17.60	17.87
Structure S8 – Inline Weir #2						
4700	17.85	18.13	18.32	18.51	18.70	18.88
4800	18.00	18.31	18.52	18.72	18.92	19.10
4900	18.11	18.46	18.68	18.89	19.10	19.30
5000	18.26	18.63	18.86	19.08	19.30	19.50
5100	18.43	18.82	19.07	19.30	19.52	19.72
5200	18.58	18.99	19.24	19.48	19.71	19.91
5300	18.72	19.14	19.41	19.65	19.90	20.11
Structure S9 – Formation Street						
5400	20.99	21.41	21.71	21.98	22.29	22.54
5500	21.25	21.63	21.91	22.17	22.45	22.70
5600	21.47	21.83	22.10	22.34	22.62	22.85
5700	21.73	22.06	22.31	22.54	22.80	23.02
5800	22.30	22.53	22.71	22.90	23.10	23.28
5900	23.09	23.28	23.41	23.54	23.69	23.82
6000	23.89	24.08	24.18	24.27	24.37	24.46
6100	24.20	24.43	24.56	24.69	24.81	24.91
6190	24.48	24.74	24.90	25.05	25.20	25.31
Tributary 3						
0	15.01	15.42	15.84	16.17	16.53	16.87
100	N/R	N/R	N/R	N/R	N/R	N/R
200	N/R	N/R	N/R	N/R	N/R	N/R
300	N/R	N/R	N/R	N/R	N/R	N/R
400	N/R	N/R	N/R	N/R	N/R	N/R
500	N/R	N/R	N/R	N/R	N/R	N/R
600	18.90	19.08	19.11	19.13	19.15	19.16
700	19.96	20.09	20.15	20.20	20.26	20.29
777	20.44	20.53	20.60	20.64	20.69	20.73
Structure S41 – Wilga Street						
900	22.47	22.65	22.72	22.76	22.81	22.84
1000	23.17	23.33	23.40	23.47	23.54	23.59
1048	23.49	23.63	23.70	23.78	23.86	23.93

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Bullockhead Creek						
0	6.00	6.48	6.89	7.19	7.44	7.69
100	6.10	6.55	6.94	7.23	7.48	7.73
200	6.19	6.61	6.99	7.28	7.52	7.76
300	6.44	6.80	7.15	7.41	7.66	7.89
400	6.63	6.96	7.27	7.52	7.76	7.98
500	6.89	7.18	7.45	7.68	7.90	8.11
600	7.30	7.55	7.76	7.95	8.15	8.33
Structure S10 – Spine Street						
700	7.79	8.07	8.28	8.47	8.67	8.84
800	8.11	8.41	8.63	8.81	9.02	9.18
900	8.44	8.75	8.95	9.13	9.33	9.48
1000	8.77	9.07	9.27	9.44	9.62	9.77
1100	9.05	9.36	9.56	9.72	9.91	10.05
1200	9.22	9.55	9.76	9.92	10.12	10.26
1300	9.34	9.68	9.88	10.05	10.25	10.39
1400	9.40	9.75	9.96	10.13	10.34	10.48
1500	9.47	9.83	10.05	10.23	10.44	10.59
Structure S11 – Ipswich Railway						
1600	10.25	10.86	11.25	11.69	12.14	12.49
Structure S12 – Sanananda Street						
1700	10.35	10.91	11.29	11.72	12.16	12.50
1800	10.47	10.98	11.34	11.76	12.19	12.52
1900	10.59	11.07	11.42	11.81	12.23	12.55
2000	10.76	11.23	11.57	11.94	12.31	12.62
2100	10.94	11.39	11.72	12.06	12.39	12.68
2200	11.09	11.52	11.84	12.17	12.48	12.75
2300	11.33	11.69	11.97	12.27	12.57	12.82
2400	11.87	12.19	12.42	12.67	12.94	13.15
2500	12.62	12.99	13.20	13.40	13.64	13.78
2600	13.26	13.66	13.85	14.02	14.22	14.31
2700	13.62	13.96	14.14	14.30	14.48	14.59
2800	13.86	14.18	14.35	14.51	14.72	14.84

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Structure S13a – Ipswich Road						
Structure S13b – Ipswich Motorway						
2900	14.14	14.44	14.61	14.84	15.12	15.30
3000	14.84	15.11	15.26	15.45	15.75	15.93
3100	15.16	15.42	15.57	15.73	15.98	16.14
3200	15.46	15.71	15.86	16.00	16.21	16.34
3300	15.67	15.95	16.10	16.25	16.45	16.57
Structure S14 – Private Bridge						
3400	15.93	16.31	16.51	16.71	16.95	17.08
3500	16.23	16.62	16.82	17.02	17.22	17.34
3600	16.38	16.75	16.95	17.14	17.35	17.48
3700	17.21	17.46	17.60	17.77	17.96	18.08
Structure S15 – Boundary Road						
3800	18.03	18.36	18.55	18.75	18.98	19.14
3900	18.13	18.47	18.66	18.87	19.09	19.26
4000	18.33	18.65	18.83	19.03	19.24	19.39
4100	18.65	18.92	19.08	19.24	19.43	19.56
4200	18.95	19.23	19.39	19.54	19.71	19.83
Structure S16 – Bukulla Street						
4300	19.27	19.58	19.75	19.92	20.07	20.18
4400	19.45	19.76	19.94	20.12	20.28	20.40
4500	19.55	19.88	20.07	20.25	20.42	20.55
4600	20.09	20.33	20.47	20.61	20.75	20.87
4700	20.54	20.73	20.86	21.00	21.13	21.25
Structure S17 – Progress Road						
4800	20.73	21.02	21.24	21.51	22.09	22.35
4900	21.15	21.41	21.55	21.75	22.19	22.43
5000	21.96	22.21	22.33	22.46	22.66	22.81
5100	22.55	22.88	23.03	23.17	23.30	23.40
5200	22.89	23.25	23.42	23.59	23.76	23.88
5300	23.06	23.41	23.58	23.77	23.94	24.07
5400	23.22	23.56	23.74	23.92	24.10	24.24
5500	23.52	23.84	24.01	24.20	24.37	24.51

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Structure S18 – Coulson Street						
5600	24.13	24.63	24.78	24.98	25.14	25.27
5700	24.41	24.82	24.97	25.17	25.34	25.47
5800	24.76	25.09	25.23	25.41	25.57	25.71
5900	25.82	26.07	26.19	26.36	26.49	26.59
Structure S19a – Centenary Motorway						
Structure S19b – Springfield Railway						
6061	N/R	N/R	N/R	27.64	27.81	27.94
6100	N/R	27.57	27.76	27.95	28.14	28.30
6190	27.26	27.68	27.86	28.06	28.26	28.42
6300	27.40	27.78	27.97	28.16	28.36	28.52
6400	27.72	28.03	28.18	28.36	28.55	28.70
6500	28.02	28.27	28.41	28.57	28.75	28.89
6600	28.22	28.47	28.59	28.76	28.93	29.07
6700	28.43	28.71	28.83	28.99	29.16	29.30
6800	29.15	29.45	29.55	29.68	29.82	29.94
6900	30.54	30.73	30.77	30.84	30.92	30.98
7000	30.81	31.17	31.28	31.43	31.56	31.66
Structure S20 – Waterford Road Culvert						
7100	31.05	31.46	31.61	31.84	32.21	32.50
7200	31.21	31.60	31.75	31.97	32.31	32.59
7300	31.57	31.91	32.05	32.25	32.54	32.77
7400	N/R	32.36	32.47	32.64	32.86	33.03
7500	32.47	32.78	32.91	33.06	33.28	33.42
7600	33.07	33.33	33.45	33.59	33.77	33.90
7700	N/R	N/R	N/R	N/R	N/R	34.42
7800	34.49	34.77	34.90	35.03	35.17	35.28
7900	35.06	35.41	35.54	35.70	35.89	36.02
8000	35.50	35.86	35.98	36.14	36.31	36.43
8100	N/R	N/R	N/R	36.53	36.69	36.81
8200	36.39	36.78	36.91	37.03	37.16	37.27
8300	37.26	37.58	37.69	37.84	37.99	38.10
8400	37.91	38.18	38.27	38.42	38.59	38.71

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
8471	N/R	N/R	N/R	N/R	N/R	N/R
Ric Nattrass Creek						
0	10.58	11.06	11.41	11.81	12.22	12.55
100	11.32	11.47	11.64	11.88	12.27	12.59
200	12.19	12.37	12.45	12.54	12.67	12.76
300	12.27	12.46	12.55	12.64	12.78	12.89
Structure S27 – Wau Road						
400	12.60	12.90	13.04	13.15	13.31	13.43
Structure S28 – Kokoda Street						
500	12.84	13.37	13.56	13.68	13.86	13.98
Structure S29a – Ipswich Road + motorway off ramp						
Structure S29b – Ipswich Motorway						
619	13.30	13.75	13.89	13.98	14.27	14.38
700	13.52	13.87	13.99	14.08	14.36	14.47
800	14.43	14.58	14.64	14.72	14.87	15.02
Structure S30 – Bakery Road + motorway on ramp						
900	14.87	15.24	15.38	15.58	16.12	16.54
1000	15.45	15.77	15.87	16.02	16.36	16.64
1100	15.98	16.31	16.43	16.58	16.84	16.99
1200	N/R	N/R	N/R	N/R	N/R	N/R
Structure S31 – Boundary Road						
1300	18.53	19.18	19.48	19.83	20.09	20.21
1400	18.70	19.23	19.51	19.85	20.11	20.24
1500	18.97	19.33	19.57	19.89	20.15	20.28
1600	19.45	19.75	19.89	20.06	20.30	20.43
Structure S32a – Centenary Motorway						
Structure S32b – Springfield Railway						
Structure S32c – Centenary Motorway Footbridge						
1724	19.69	19.99	20.18	20.32	20.62	20.87
1800	20.22	20.56	20.76	20.89	21.02	21.21
1900	20.41	20.75	20.93	21.09	21.22	21.37
Structure S33 – Coca Cola Footbridge #2						
1988	20.56	20.87	21.03	21.18	21.32	21.46

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Structure S34 – Coca Cola Drop Structure #3						
Structure S35 – Coca Cola Drop Structure #2						
2100	22.83	22.92	22.97	23.02	23.08	23.13
2200	N/R	N/R	N/R	N/R	N/R	N/R
2300	24.08	24.30	24.41	24.54	24.68	24.78
Structure S36 – Coca Cola Footbridge #1						
2400	N/R	N/R	N/R	N/R	N/R	N/R
Structure S37 – Coca Cola Drop Structure #1						
Structure S38 – Coca Cola Spillway / Weir						
2500	N/R	28.13	28.30	28.47	28.62	28.73
2600	28.23	28.50	28.66	28.82	28.97	29.08
Structure S39 – Pine Road Culvert						
2716	N/R	31.32	31.52	31.63	31.74	31.81
2800	N/R	N/R	N/R	N/R	N/R	N/R
2900	35.27	35.39	35.44	35.49	35.57	35.62
3000	N/R	N/R	N/R	N/R	N/R	N/R
3100	41.15	41.31	41.38	41.44	41.53	41.59
Structure S40 – Progress Road Culvert						
3200	43.21	43.37	43.45	43.53	43.66	43.77
3300	46.90	47.02	47.06	47.12	47.21	47.26
3311	47.29	47.41	47.46	47.51	47.60	47.66
Tributary 1						
0	12.59	12.89	13.03	13.14	13.30	13.41
100	N/R	N/R	N/R	N/R	N/R	N/R
200	N/R	N/R	N/R	N/R	N/R	N/R
217	N/R	N/R	N/R	N/R	N/R	N/R
Scott Creek						
0	27.15	27.59	27.78	27.97	28.17	28.33
100	27.43	27.80	27.95	28.11	28.30	28.43
200	28.57	28.76	28.82	28.93	29.06	29.17
300	30.89	31.04	31.09	31.19	31.32	31.41
400	33.55	33.76	33.90	34.01	34.17	34.25
Structure S24 – Cardwell Street						

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
500	36.47	36.61	36.65	36.70	36.79	36.83
564	N/R	N/R	N/R	N/R	38.05	38.10
Forest Lake Boulevard						
700	42.50	42.77	42.86	42.99	43.21	43.42
Structure S25 – Signac Close Footbridge						
800	47.60	47.73	47.77	47.83	47.94	48.01
900	54.65	54.72	54.73	54.77	54.82	54.85
914	N/R	N/R	N/R	N/R	N/R	N/R
Spinks Creek						
0	37.63	37.69	37.77	37.85	37.98	38.07
100	38.60	38.74	38.84	38.92	39.04	39.11
200	40.12	40.28	40.36	40.42	40.49	40.55
Structure S21 – Roxwell Street						
300	43.00	43.25	43.41	43.58	43.76	43.91
400	43.37	43.63	43.77	43.93	44.09	44.22
500	44.87	45.04	45.10	45.18	45.26	45.31
Structure S22 – Jubilee Avenue						
600	N/R	N/R	N/R	N/R	N/R	N/R
700	47.28	47.48	47.59	47.69	47.80	47.89
800	N/R	N/R	N/R	N/R	49.19	49.24
900	50.13	50.20	50.24	50.28	50.34	50.38
1000	51.68	51.75	51.79	51.83	51.90	51.94
Structure S24 – Cardwell Street						
1100	53.56	53.63	53.67	53.68	53.73	53.77
Tributary 2						
0	20.39	20.74	20.92	21.08	21.21	21.36
100	20.41	20.75	20.93	21.10	21.24	21.38
203	20.43	20.78	20.95	21.12	21.27	21.41

N/R = no result, typically because the AMTD line does not intersect the flood surface

Appendix H: Comparison of Flood Levels using the Simplified Ensemble Method and the Full Ensemble Method

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AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
Wolston Creek						
0	1.18	1.18	0.00	1.18	1.18	0.00
100	1.41	1.42	0.00	1.64	1.65	-0.01
200	1.71	1.71	0.00	2.15	2.17	-0.01
300	2.01	2.01	0.00	2.60	2.61	-0.02
400	2.38	2.38	0.00	3.03	3.05	-0.01
500	2.83	2.83	0.00	3.55	3.56	-0.01
600	3.30	3.31	0.00	4.13	4.14	-0.01
700	3.70	3.70	0.00	4.59	4.61	-0.02
800	4.01	4.01	0.00	4.95	4.96	-0.02
900	4.27	4.27	0.00	5.23	5.24	-0.01
1000	4.43	4.43	0.00	5.41	5.43	-0.01
1100	4.56	4.56	0.00	5.55	5.56	-0.01
1200	4.66	4.66	0.00	5.66	5.67	-0.01
1300	4.76	4.76	0.00	5.77	5.78	-0.01
1400	4.84	4.84	0.00	5.85	5.86	-0.01
1500	4.91	4.92	0.00	5.93	5.94	-0.01
1600	4.98	4.98	0.00	6.00	6.02	-0.01
1700	5.04	5.05	0.00	6.07	6.09	-0.01
1800	5.11	5.11	0.00	6.14	6.15	-0.01
1900	5.18	5.18	0.00	6.21	6.22	-0.01
2000	5.25	5.25	0.00	6.28	6.29	-0.01
2100	5.30	5.31	0.00	6.34	6.34	0.00
2200	5.35	5.36	0.00	6.38	6.39	0.00
2300	5.41	5.41	0.00	6.44	6.44	0.00
2400	5.45	5.46	0.00	6.48	6.48	0.00
2500	5.48	5.48	0.00	6.49	6.49	0.00
Structure S1 – Wacol Station Road						
2600	6.03	6.03	0.00	6.73	6.73	0.00
2700	6.10	6.10	0.00	6.80	6.79	0.00
2800	6.16	6.17	0.00	6.87	6.86	0.00
2900	6.24	6.24	0.00	6.95	6.95	0.00
3000	6.31	6.31	0.00	7.06	7.06	0.00

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
3100	6.39	6.39	0.00	7.16	7.16	0.00
3200	6.46	6.47	0.00	7.24	7.24	0.00
3300	6.55	6.56	0.00	7.35	7.35	0.00
3400	6.63	6.63	0.00	7.43	7.43	0.00
3500	6.70	6.71	0.00	7.51	7.51	0.00
3600	6.73	6.73	0.00	7.54	7.54	0.00
3700	6.74	6.74	0.00	7.56	7.55	0.00
3800	6.76	6.76	0.00	7.57	7.57	0.00
3900	6.77	6.78	0.00	7.59	7.59	0.00
4000	6.79	6.79	0.00	7.59	7.59	0.00
4100	6.80	6.80	0.00	7.60	7.60	0.00
4205	6.81	6.82	0.00	7.60	7.60	0.00
Sandy Creek						
0	6.82	6.82	0.00	7.60	7.60	0.00
100	6.88	6.88	0.00	7.64	7.64	0.00
200	6.93	6.93	0.00	7.68	7.68	0.00
Structure S2 – Wolston Road						
300	7.13	7.13	0.00	7.95	7.95	0.00
400	7.27	7.27	0.00	8.04	8.04	0.00
500	7.41	7.41	0.00	8.13	8.13	0.00
600	7.60	7.60	0.00	8.26	8.26	0.00
700	7.77	7.77	0.00	8.39	8.39	0.00
800	7.89	7.89	0.00	8.48	8.48	0.00
900	8.04	8.04	0.00	8.61	8.61	0.00
1000	8.25	8.24	0.01	8.78	8.78	0.00
1100	8.49	8.48	0.01	8.98	8.98	0.00
1200	8.77	8.77	0.01	9.25	9.25	0.00
1300	9.05	9.04	0.01	9.52	9.52	0.00
1400	9.19	9.18	0.01	9.66	9.66	0.00
1500	9.41	9.40	0.01	9.88	9.88	0.00
1600	9.60	9.60	0.01	10.06	10.06	0.00
1700	9.78	9.78	0.01	10.22	10.22	0.00
1800	9.94	9.94	0.01	10.34	10.34	0.00

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
1900	10.10	10.09	0.01	10.46	10.46	0.00
2000	10.22	10.22	0.01	10.56	10.56	0.00
2100	10.42	10.42	0.01	10.73	10.73	0.00
2200	10.74	10.73	0.01	11.06	11.06	0.00
2300	11.04	11.04	0.01	11.37	11.37	0.00
2400	11.23	11.22	0.01	11.56	11.55	0.00
2500	11.49	11.48	0.01	11.81	11.81	0.00
2600	11.77	11.77	0.01	12.08	12.07	0.00
2700	12.05	12.04	0.01	12.33	12.33	0.00
2800	12.33	12.32	0.01	12.61	12.60	0.00
2900	12.65	12.64	0.01	12.92	12.92	0.01
Structure S3 – Ipswich Railway						
3000	12.94	12.92	0.02	13.31	13.30	0.01
3100	13.05	13.03	0.02	13.45	13.43	0.01
3186	13.15	13.13	0.02	13.56	13.54	0.01
Structure S4a – Ipswich Road						
Structure S4b – Ipswich Motorway						
3300	13.79	13.71	0.08	14.47	14.46	0.01
3400	14.02	13.94	0.08	14.85	14.83	0.02
3500	14.18	14.09	0.09	14.97	14.95	0.02
3600	14.30	14.21	0.09	15.07	15.06	0.02
3700	14.47	14.39	0.08	15.22	15.20	0.02
Structure S5 – Progress Road						
3800	15.31	15.24	0.07	16.20	16.19	0.01
3900	15.56	15.50	0.06	16.34	16.33	0.01
4000	15.77	15.73	0.05	16.46	16.45	0.01
Structure S6 – Inline Weir #1						
4100	16.32	16.29	0.03	16.80	16.80	0.00
4200	16.48	16.45	0.03	16.95	16.95	0.00
4300	16.62	16.59	0.03	17.11	17.11	0.00
4400	16.75	16.71	0.04	17.28	17.28	0.00
Structure S7 – Campbell Avenue						
4500	16.87	16.83	0.05	17.57	17.57	0.00

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
4600	16.98	16.93	0.05	17.68	17.68	0.00
Structure S8 – Inline Weir #2						
4700	18.30	18.27	0.03	18.80	18.80	0.00
4800	18.49	18.46	0.03	19.02	19.03	0.00
4900	18.65	18.62	0.03	19.21	19.22	0.00
5000	18.83	18.80	0.03	19.42	19.42	0.00
5100	19.03	19.00	0.03	19.63	19.63	0.00
5200	19.21	19.18	0.03	19.83	19.83	0.00
5300	19.38	19.35	0.03	20.03	20.03	0.00
Structure S9 – Formation Street						
5400	21.69	21.66	0.03	22.52	22.52	0.00
5500	21.87	21.84	0.03	22.65	22.65	0.00
5600	22.08	22.05	0.03	22.83	22.83	0.00
5700	22.33	22.30	0.03	23.03	23.03	0.00
5800	22.74	22.72	0.02	23.30	23.30	0.00
5900	23.39	23.38	0.01	23.77	23.77	0.00
6000	24.08	24.07	0.01	24.31	24.31	0.00
6100	24.38	24.37	0.01	24.65	24.65	0.00
6190	24.64	24.63	0.01	24.95	24.95	0.00
Tributary 3						
0	15.81	15.76	0.05	16.48	16.47	0.01
100	N/R	N/R	N/R	16.60	16.60	0.01
200	16.06	16.02	0.04	16.56	16.55	0.01
300	N/R	N/R	N/R	N/R	N/R	N/R
400	N/R	N/R	N/R	N/R	N/R	N/R
500	N/R	N/R	N/R	N/R	N/R	N/R
600	19.11	19.10	0.00	19.16	19.16	0.01
700	20.15	20.14	0.01	20.29	20.28	0.01
777	20.55	20.55	0.01	20.66	20.66	0.01
Structure S41 – Wilga Street						
900	22.67	22.66	0.00	22.78	22.77	0.01
1000	23.38	23.37	0.00	23.54	23.54	0.01
1048	23.69	23.69	0.00	23.89	23.88	0.01

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
Bullockhead Creek						
0	6.82	6.82	0.00	7.60	7.60	0.00
100	6.87	6.87	0.00	7.63	7.63	0.00
200	6.92	6.93	0.00	7.67	7.67	0.00
300	7.10	7.10	0.00	7.81	7.80	0.00
400	7.23	7.24	0.00	7.91	7.91	0.00
500	7.42	7.43	-0.01	8.05	8.05	0.00
600	7.71	7.72	0.00	8.25	8.25	0.00
Structure S10 – Spine Street						
700	8.26	8.26	0.00	8.79	8.78	0.00
800	8.62	8.63	0.00	9.15	9.15	0.00
900	8.95	8.95	0.00	9.45	9.45	0.00
1000	9.27	9.27	0.00	9.75	9.75	0.00
1100	9.57	9.57	0.00	10.04	10.04	0.00
1200	9.77	9.77	0.00	10.26	10.26	0.00
1300	9.89	9.89	0.00	10.38	10.38	0.00
1400	9.96	9.96	0.00	10.46	10.46	0.00
1500	10.04	10.04	0.00	10.55	10.55	0.00
Structure S11 – Ipswich Railway						
1600	11.33	11.34	0.00	12.54	12.53	0.00
Structure S12 – Sananandа Street						
1700	11.35	11.35	0.00	12.54	12.54	0.00
1800	11.40	11.40	0.00	12.56	12.56	0.00
1900	11.47	11.47	0.00	12.59	12.59	0.00
2000	11.61	11.61	0.00	12.64	12.64	0.00
2100	11.76	11.76	0.00	12.70	12.70	0.00
2200	11.87	11.87	0.00	12.77	12.77	0.00
2300	12.00	12.00	0.00	12.84	12.85	0.00
2400	12.41	12.42	-0.01	13.15	13.15	0.00
2500	13.12	13.14	-0.02	13.72	13.72	0.00
2600	13.74	13.76	-0.02	14.23	14.22	0.01
2700	14.09	14.11	-0.02	14.54	14.54	0.00
2800	14.32	14.34	-0.02	14.81	14.80	0.00

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
Structure S13a – Ipswich Road						
Structure S13b – Ipswich Motorway						
2900	14.61	14.64	-0.03	15.32	15.32	0.00
3000	15.19	15.21	-0.02	15.79	15.79	0.00
3100	15.51	15.53	-0.02	16.02	16.02	0.00
3200	15.82	15.84	-0.02	16.27	16.27	0.00
3300	16.06	16.07	-0.02	16.49	16.49	0.00
Structure S14 – Private Bridge						
3400	16.46	16.48	-0.02	17.06	17.06	0.00
3500	16.74	16.76	-0.02	17.29	17.29	0.00
3600	16.90	16.92	-0.02	17.46	17.46	0.00
3700	17.51	17.52	-0.01	17.96	17.96	0.00
Structure S15 – Boundary Road						
3800	18.37	18.38	-0.01	18.91	18.91	0.00
3900	18.50	18.51	-0.01	19.05	19.05	0.00
4000	18.72	18.73	-0.01	19.23	19.23	0.00
4100	19.05	19.05	-0.01	19.46	19.46	0.00
4200	19.39	19.39	0.00	19.78	19.79	0.00
Structure S16 – Bukulla Street						
4300	19.75	19.75	0.00	20.15	20.16	-0.01
4400	19.95	19.95	0.00	20.38	20.39	-0.01
4500	20.08	20.08	0.00	20.54	20.55	-0.01
4600	20.50	20.50	0.00	20.88	20.89	-0.01
4700	20.88	20.88	0.00	21.26	21.26	0.00
Structure S17 – Progress Road						
4800	21.28	21.28	0.00	22.38	22.37	0.01
4900	21.56	21.56	0.00	22.44	22.43	0.01
5000	22.28	22.28	0.00	22.76	22.76	0.00
5100	22.96	22.96	0.00	23.30	23.30	0.00
5200	23.33	23.33	0.00	23.75	23.75	0.00
5300	23.52	23.52	0.00	23.99	23.98	0.00
5400	23.70	23.71	0.00	24.18	24.18	0.00
5500	23.99	23.99	0.00	24.46	24.46	0.00

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
Structure S18 – Coulson Street						
5600	24.79	24.79	0.00	25.22	25.22	0.00
5700	25.00	25.00	0.00	25.46	25.46	0.00
5800	25.22	25.22	0.00	25.67	25.67	0.00
5900	25.69	25.69	0.00	26.02	26.02	0.00
Structure S19a – Centenary Motorway						
Structure S19b – Springfield Railway						
6061	N/R	N/R	N/R	27.92	27.92	0.00
6100	27.70	27.70	0.00	28.22	28.22	0.00
6190	27.80	27.80	0.00	28.34	28.33	0.00
6300	27.90	27.90	0.00	28.44	28.43	0.00
6400	28.13	28.13	0.00	28.64	28.63	0.00
6500	28.36	28.36	0.00	28.84	28.83	0.00
6600	28.56	28.56	0.00	29.02	29.02	0.00
6700	28.81	28.81	0.00	29.26	29.25	0.01
6800	29.53	29.53	0.00	29.90	29.89	0.01
6900	30.77	30.78	0.00	31.00	30.99	0.00
7000	31.24	31.24	0.00	31.60	31.59	0.01
Structure S20 – Waterford Road Culvert						
7100	31.58	31.58	0.00	32.42	32.40	0.02
7200	31.71	31.71	0.00	32.50	32.49	0.02
7300	32.00	32.00	0.00	32.68	32.67	0.02
7400	32.42	32.42	0.00	32.95	32.94	0.01
7500	32.86	32.86	0.00	33.35	33.34	0.01
7600	33.39	33.39	0.00	33.84	33.83	0.01
7700	N/R	N/R	N/R	34.41	34.40	0.01
7800	34.81	34.81	0.00	35.21	35.19	0.02
7900	35.45	35.45	0.00	35.93	35.91	0.02
8000	35.92	35.90	0.01	36.36	36.34	0.02
8100	N/R	N/R	N/R	36.77	36.75	0.02
8200	36.89	36.87	0.02	37.25	37.23	0.02
8300	37.67	37.65	0.02	38.05	38.04	0.02
8400	38.22	38.20	0.02	38.63	38.62	0.02

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
8471	N/R	N/R	N/R	N/R	N/R	N/R
Ric Nattrass Creek						
0	11.46	11.46	0.00	12.59	12.58	0.00
100	11.61	11.60	0.01	12.62	12.62	0.00
200	12.19	12.19	0.00	12.66	12.65	0.00
300	12.36	12.36	0.00	12.69	12.69	0.00
Structure S27 – Wau Road						
400	12.92	12.92	0.00	13.26	13.26	0.00
Structure S28 – Kokoda Street						
500	13.52	13.52	0.00	13.87	13.87	0.00
Structure S29a – Ipswich Road + motorway off ramp						
Structure S29b – Ipswich Motorway						
619	13.87	13.88	-0.01	14.30	14.30	0.00
700	13.96	13.97	-0.01	14.40	14.39	0.00
800	14.60	14.61	0.00	14.98	14.94	0.05
Structure S30 – Bakery Road + motorway on ramp						
900	15.40	15.40	0.01	16.52	16.23	0.29
1000	15.72	15.71	0.01	16.60	16.40	0.20
1100	16.33	16.32	0.01	16.90	16.84	0.05
1200	N/R	N/R	N/R	N/R	N/R	N/R
Structure S31 – Boundary Road						
1300	19.52	19.48	0.04	20.19	20.17	0.02
1400	19.55	19.51	0.04	20.23	20.21	0.02
1500	19.61	19.57	0.04	20.28	20.26	0.02
1600	19.86	19.84	0.02	20.43	20.41	0.02
Structure S32a – Centenary Motorway						
Structure S32b – Springfield Railway						
Structure S32c – Centenary Motorway Footbridge						
1724	20.11	20.10	0.01	20.87	20.82	0.04
1800	20.70	20.68	0.02	21.19	21.15	0.03
1900	20.90	20.87	0.03	21.35	21.32	0.03
Structure S33 – Coca Cola Footbridge #2						
1988	21.01	20.98	0.03	21.44	21.41	0.03

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
Structure S34 – Coca Cola Drop Structure #3						
Structure S35 – Coca Cola Drop Structure #2						
2100	22.97	22.96	0.01	23.13	23.11	0.01
2200	N/R	N/R	N/R	N/R	N/R	N/R
2300	24.40	24.37	0.03	24.74	24.71	0.03
Structure S36 – Coca Cola Footbridge #1						
2400	N/R	N/R	N/R	N/R	N/R	N/R
Structure S37 – Coca Cola Drop Structure #1						
Structure S38 – Coca Cola Spillway / Weir						
2500	28.30	28.26	0.05	28.72	28.69	0.03
2600	28.64	28.61	0.04	29.02	28.99	0.03
Structure S39 – Pine Road Culvert						
2716	31.52	31.48	0.03	31.79	31.77	0.02
2800	N/R	N/R	N/R	N/R	N/R	N/R
2900	35.43	35.42	0.00	35.58	35.57	0.02
3000	N/R	N/R	N/R	N/R	N/R	N/R
3100	41.28	41.27	0.00	41.43	41.42	0.01
Structure S40 – Progress Road Culvert						
3200	43.45	43.45	0.00	43.77	43.72	0.05
3300	47.06	47.06	0.00	47.26	47.24	0.02
3311	47.46	47.46	0.00	47.66	47.64	0.02
Tributary 1						
0	12.90	12.90	0.00	13.23	13.23	0.00
100	N/R	N/R	N/R	N/R	N/R	N/R
200	N/R	N/R	N/R	N/R	N/R	N/R
217	N/R	N/R	N/R	N/R	N/R	N/R
Scott Creek						
0	27.72	27.72	0.00	28.25	28.25	0.00
100	27.90	27.91	0.00	28.37	28.37	0.00
200	28.86	28.83	0.02	29.17	29.16	0.01
300	31.08	31.07	0.00	31.42	31.40	0.02
400	33.91	33.88	0.02	34.25	34.21	0.04
Structure S24 – Cardwell Street						

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
500	36.64	36.64	0.00	36.82	36.80	0.01
564	N/R	N/R	N/R	38.09	38.07	0.02
Forest Lake Boulevard						
700	42.86	42.85	0.01	43.42	43.31	0.11
Structure S25 – Signac Close Footbridge						
800	47.77	47.77	0.00	48.01	47.98	0.03
900	54.73	54.74	-0.01	54.85	54.84	0.01
914	N/R	N/R	N/R	N/R	N/R	N/R
Spinks Creek						
0	37.67	37.66	0.01	38.00	37.98	0.02
100	38.79	38.77	0.01	39.04	39.03	0.01
200	40.34	40.33	0.01	40.52	40.51	0.01
Structure S21 – Roxwell Street						
300	43.41	43.39	0.03	43.93	43.89	0.03
400	43.76	43.74	0.02	44.21	44.18	0.03
500	45.10	45.08	0.02	45.27	45.26	0.01
Structure S22 – Jubilee Avenue						
600	N/R	N/R	N/R	N/R	N/R	N/R
700	47.55	47.53	0.02	47.82	47.81	0.01
800	N/R	N/R	N/R	49.20	49.19	0.01
900	50.24	50.24	0.00	50.36	50.35	0.01
1000	51.79	51.79	0.00	51.94	51.93	0.01
Structure S24 – Cardwell Street						
1100	53.67	53.67	0.00	53.77	53.76	0.01
Tributary 2						
0	20.89	20.86	0.03	21.34	21.31	0.03
100	20.91	20.88	0.03	21.36	21.33	0.03
203	20.94	20.91	0.03	21.39	21.36	0.03

Appendix I: URBS Ensemble Results – Rare Events

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Notes on Table Content and Formatting

- The following tables indicate the ranking and discharge of all ten ensembles for each storm duration at the selected location within the catchment.
- The bold formatted rows indicate the critical storm duration for the selected location.
- The bold formatted columns indicate the median (Rank 5 / 6) peak discharge and corresponding ensemble number.
- The yellow highlighted peak discharge and ensemble number are those adopted from the simplified method as detailed in Section 7.4.3.
- The light pink highlighted peak discharge and ensemble number are those adopted from the simplified method for the storm duration(s) either side of the critical storm duration.

Sandy Creek at Campbell Avenue – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	0.5	141.01	142.81	143.89	144.24	**144.72**	**144.73**	145.14	145.86	146.04	146.22
		1	6	5	4	**7**	**10**	9	8	3	2
	1	172.91	175.29	175.57	175.77	**175.95**	**177.45**	181.02	181.84	183.23	183.38
		7	9	8	10	**4**	**5**	3	6	1	2
	1.5	184.71	185.64	186.88	189	**189.66**	**191.74**	198.78	199.67	200.3	202.54
		4	1	3	5	**7**	**8**	2	9	6	10
	2	**186.86**	**187.72**	**190.32**	**194.52**	**195.33**	**195.96**	**197.17**	**200.92**	**201.7**	**208.64**
		3	**5**	**7**	**4**	**8**	**2**	**6**	**1**	**9**	**10**
	3	160.56	163.8	167.19	167.74	**168.79**	**169.19**	173.9	194.96	195.33	199.71
		2	5	9	4	**7**	**6**	8	10	1	3
	4.5	144.19	156.05	156.24	158.22	**168.28**	**172.25**	172.43	172.49	181.72	207.57
		4	5	6	3	**9**	**8**	7	2	1	10
500	0.5	160.61	162.75	164.03	164.41	**164.97**	**165**	165.46	166.33	166.51	166.76
		1	6	5	4	**7**	**10**	9	8	3	2
	1	198.21	201.4	201.63	201.77	**201.98**	**203.83**	208.02	209.09	210.4	210.54
		7	9	8	10	**4**	**5**	3	6	1	2
	1.5	213.05	214.06	215.32	217.88	**218.83**	**221.28**	229.39	230.57	231.28	233.93
		4	1	3	5	**7**	**8**	2	9	6	10
	2	**216.83**	**217.77**	**221.04**	**226.06**	**226.99**	**227.92**	**229.33**	**233.55**	**234.57**	**242.66**
		3	**5**	**7**	**4**	**8**	**2**	**6**	**1**	**9**	**10**
	3	187.13	190.33	194.16	195	**196.12**	**196.94**	202.45	227.35	227.53	232.6
		2	5	9	4	**7**	**6**	8	10	1	3
	4.5	168.26	182.12	182.52	184.76	**196.67**	**200.81**	201.35	201.49	212.14	242.14
		4	6	5	3	**9**	**8**	2	7	1	10
2000	0.5	191.2	193.94	195.51	195.95	**196.62**	**196.7**	197.22	198.33	198.52	198.88
		1	6	5	4	**7**	**10**	9	8	3	2
	1	238.69	243.34	243.45	243.55	**243.67**	**246.18**	251.34	252.88	253.92	254.04
		7	9	8	10	**4**	**5**	3	6	1	2
	1.5	259.56	260.67	261.87	265.18	**266.72**	**269.77**	279.57	281.28	282.1	285.47
		4	1	3	5	**7**	**8**	2	9	6	10
	2	**266.13**	**267.23**	**271.68**	**278.1**	**279.2**	**280.69**	**282.42**	**287.37**	**288.84**	**298.81**
		3	**5**	**7**	**4**	**8**	**2**	**6**	**1**	**9**	**10**
	3	232.01	235	239.55	240.96	**242.12**	**243.74**	250.61	281.81	281.97	288.14
		2	5	9	4	**7**	**6**	8	1	10	3
	4.5	209.04	225.9	227.36	229.72	**244.82**	**249.11**	250.22	250.79	263.64	300.6
		4	6	5	3	**9**	**8**	2	7	1	10

Spinks Creek at Jubilee Avenue – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	**0.5**	**20.34**	**21.03**	**21.72**	**22.1**	**22.57**	**23.03**	**23.44**	**23.79**	**24.34**	**26.15**
		6	**5**	**1**	**10**	**4**	**2**	**8**	**7**	**9**	**3**
	1	17.68	18.63	18.71	18.94	**19.66**	**20.52**	20.9	21.15	25.5	25.99
		8	10	5	7	**4**	**9**	6	3	2	1
	1.5	15.07	15.78	16.71	16.79	**18.39**	**20.15**	20.5	21	21.28	21.62
		7	1	4	8	**5**	**3**	6	2	9	10
	2	14.1	14.21	15.17	15.86	**16.96**	**17.23**	17.93	18.03	18.67	19.5
		8	7	2	4	**3**	**6**	1	9	10	5
	3	10.96	11.34	12.93	13.76	**14.48**	**14.64**	15.86	16.24	16.32	19.75
		7	9	5	2	**6**	**4**	3	1	8	10
	4.5	10.66	10.96	11.38	11.98	**12.44**	**12.65**	13.45	13.78	13.8	14.62
		8	3	2	7	**4**	**6**	9	5	1	10
500	**0.5**	**23.32**	**24.13**	**25**	**25.41**	**25.98**	**26.58**	**27.1**	**27.45**	**28.13**	**30.32**
		6	**5**	**1**	**10**	**4**	**2**	**8**	**7**	**9**	**3**
	1	20.39	21.43	21.58	21.75	**22.62**	**23.91**	24.26	24.45	29.51	30.13
		8	10	5	7	**4**	**9**	6	3	2	1
	1.5	17.33	18.35	19.36	19.41	**21.55**	**23.62**	23.69	24.3	24.59	25.05
		7	1	4	8	**5**	**3**	6	2	9	10
	2	16.33	16.54	17.66	18.66	**19.82**	**20.13**	20.96	20.98	21.75	22.94
		8	7	2	4	**3**	**6**	1	9	10	5
	3	12.77	13.2	15.1	16.36	**17.05**	**17.18**	18.77	19.03	19.27	23.24
		7	9	5	2	**6**	**4**	3	1	8	10
	4.5	12.44	12.88	13.32	14	**14.67**	**15.11**	15.79	16.13	16.22	17.11
		8	3	2	7	**4**	**6**	9	5	1	10
2000	**0.5**	**27.97**	**28.98**	**30.17**	**30.61**	**31.36**	**32.22**	**32.88**	**33.23**	**34.12**	**36.93**
		6	**5**	**1**	**10**	**4**	**2**	**8**	**7**	**9**	**3**
	1	24.71	25.89	26.22	26.26	**27.33**	**29.41**	29.68	29.75	35.99	36.83
		8	10	5	7	**4**	**9**	6	3	2	1
	1.5	21.78	22.58	23.72	23.73	**26.82**	**28.9**	29.39	29.7	30.03	30.7
		7	1	8	4	**5**	**6**	3	2	9	10
	2	20.32	20.37	21.77	23.34	**24.52**	**24.95**	25.83	26.01	26.83	28.63
		8	7	2	4	**3**	**6**	9	1	10	5
	3	15.79	16.34	18.75	20.83	**21.43**	**21.48**	23.76	23.77	24.33	29.16
		7	9	5	2	**6**	**4**	3	1	8	10
	4.5	15.45	16.16	16.61	17.42	**18.46**	**19.34**	19.76	20.1	20.37	21.36
		8	3	2	7	**4**	**6**	9	5	1	10

Scott Creek at Forest Lake Boulevard – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	**0.5**	**9.7**	**10.38**	**10.5**	**10.65**	**10.96**	**11.06**	**11.56**	**11.71**	**12.3**	**14.1**
		5	**10**	**6**	**4**	**1**	**2**	**7**	**8**	**9**	**3**
	1	7.85	7.88	7.97	8.2	**9.2**	**9.41**	9.45	10.27	11.24	12.25
		10	7	5	8	**3**	**4**	9	6	2	1
	1.5	6.92	7.1	7.74	8.34	**8.68**	**8.76**	8.77	8.78	9.11	9.17
		1	4	7	8	**6**	**5**	9	2	10	3
	2	5.83	6.22	6.5	7.09	**7.4**	**7.43**	7.49	7.88	7.97	8.46
		7	8	2	3	**9**	**6**	4	1	10	5
	3	4.46	4.52	5.18	6.2	**6.5**	**6.55**	7.02	7.46	7.67	8.79
		7	9	5	4	**6**	**2**	1	3	8	10
	4.5	4.33	4.55	4.75	4.9	**5.3**	**5.55**	5.74	5.77	5.96	6.14
		8	2	3	7	**4**	**9**	5	6	1	10
500	**0.5**	**11.21**	**11.92**	**12.11**	**12.28**	**12.52**	**12.61**	**13.17**	**13.38**	**14.05**	**16.17**
		5	**10**	**4**	**6**	**1**	**2**	**7**	**8**	**9**	**3**
	1	9.02	9.03	9.13	9.56	**10.53**	**10.91**	10.93	11.92	12.88	14.16
		10	7	5	8	**3**	**9**	4	6	2	1
	1.5	8.06	8.19	9.07	9.87	**10.09**	**10.09**	10.11	10.17	10.5	10.59
		1	4	7	8	**6**	**9**	2	5	10	3
	2	6.79	7.27	7.63	8.22	**8.59**	**8.69**	8.76	9.2	9.27	9.81
		7	8	2	3	**9**	**6**	4	1	10	5
	3	5.22	5.24	6	7.22	**7.61**	**7.69**	8.2	8.78	9.02	10.28
		7	9	5	4	**6**	**2**	1	3	8	10
	4.5	5.05	5.29	5.58	5.72	**6.2**	**6.54**	6.77	6.83	6.99	7.19
		8	2	3	7	**4**	**9**	6	5	1	10
2000	**0.5**	**13.61**	**14.34**	**14.37**	**14.96**	**15.02**	**15.14**	**15.68**	**15.99**	**16.77**	**19.42**
		5	**10**	**4**	**1**	**2**	**6**	**7**	**8**	**9**	**3**
	1	10.87	10.87	10.99	11.78	**12.64**	**13.25**	13.39	14.6	15.51	17.27
		7	10	5	8	**3**	**9**	4	6	2	1
	1.5	9.95	9.99	11.26	12.26	**12.29**	**12.42**	12.43	12.5	12.76	12.92
		1	4	7	9	**2**	**6**	8	5	10	3
	2	8.41	8.99	9.51	10.07	**10.54**	**10.76**	10.87	11.4	11.41	12.04
		7	8	2	3	**9**	**6**	4	10	1	5
	3	6.46	6.48	7.38	8.93	**9.51**	**9.63**	10.19	11.01	11.31	12.8
		9	7	5	4	**6**	**2**	1	3	8	10
	4.5	6.28	6.54	6.99	7.12	**7.72**	**8.25**	8.55	8.7	8.74	8.97
		8	2	3	7	**4**	**9**	6	5	1	10

Bullockhead Creek at Centenary Motorway – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	0.5	149.58	152.84	153.41	153.57	**153.79**	**153.89**	154.56	154.58	155.66	156.95
		1	7	9	3	**4**	**6**	10	5	8	2
	1	**160.48**	**171.8**	**172.13**	**173.07**	**175.43**	**175.51**	**175.9**	**178.81**	**182.78**	**187.2**
		7	**10**	**4**	**8**	**1**	**5**	**9**	**2**	**3**	**6**
	1.5	135.09	150.09	154.72	157.17	**168.18**	**173.26**	179.6	180.46	184.51	187.01
		4	1	8	7	**5**	**3**	9	2	10	6
	2	135.91	137.31	141.05	142.9	**145.01**	**148.78**	157.72	158.66	166.38	170.45
		7	4	2	8	**6**	**1**	3	5	9	10
	3	110.06	118.71	120.29	121.05	**126.37**	**126.63**	134.9	136.3	145.49	166.62
		7	9	6	8	**5**	**2**	3	4	1	10
	4.5	105.99	110.16	112.68	113.34	**116.38**	**118.33**	122.81	130.12	133.02	140.74
		3	8	2	6	**4**	**7**	9	5	1	10
500	0.5	171	174.4	174.99	175	**175.56**	**175.77**	176.36	176.49	177.56	179.04
		1	7	3	9	**4**	**6**	10	5	8	2
	1	**184.6**	**197.74**	**198.4**	**199.13**	**201.93**	**201.95**	**202.51**	**205.86**	**210.41**	**215.58**
		7	**10**	**4**	**8**	**5**	**1**	**9**	**2**	**3**	**6**
	1.5	155.7	173.62	178.46	181.34	**194.7**	**200.71**	207.75	208.84	213.32	216.52
		4	1	8	7	**5**	**3**	9	2	10	6
	2	157.77	159.18	163.73	165.82	**168.46**	**172.63**	183.63	185.45	193.64	198.29
		7	4	2	8	**6**	**1**	3	5	9	10
	3	128.93	138.35	140.52	141.01	**147.7**	**148.36**	157.73	159.22	169.36	194.45
		7	9	6	8	**5**	**2**	3	4	1	10
	4.5	123.63	128.36	131.89	133.89	**136.53**	**138.07**	143.61	152.87	155.27	163.87
		3	8	2	6	**4**	**7**	9	5	1	10
2000	0.5	204.62	208.21	208.48	208.87	**209.7**	**210.1**	210.52	210.81	211.86	213.64
		1	7	3	9	**4**	**6**	10	5	8	2
	1	223.41	239.48	240.78	241.03	**244.39**	**244.66**	245.35	249.41	254.85	261.3
		7	10	4	8	**5**	**1**	9	2	3	6
	1.5	**189.5**	**212.34**	**217.37**	**220.98**	**238.36**	**245.94**	**254.03**	**255.54**	**260.66**	**265.13**
		4	**1**	**8**	**7**	**5**	**3**	**9**	**2**	**10**	**6**
	2	193.76	195.14	201.04	203.54	**207.09**	**211.86**	226.42	229.89	238.66	244.22
		7	4	2	8	**6**	**1**	3	5	9	10
	3	160.95	171.46	174.7	174.72	**183.78**	**185.2**	196.33	197.96	209.54	241.44
		7	9	6	8	**5**	**2**	3	4	1	10
	4.5	153.39	159.15	164.47	169.06	**170.79**	**171.43**	178.87	191.64	192.91	202.87
		3	8	2	6	**4**	**7**	9	5	1	10

Bullockhead Creek at Ipswich Motorway – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	0.5	153.17	156.28	156.94	157.02	**157.17**	**157.37**	157.6	157.83	158.67	159.29
		1	6	7	4	**5**	**9**	10	3	8	2
	1	178.16	184.76	186.29	188.49	**188.77**	**189.09**	189.4	189.42	194.79	196.94
		7	1	10	2	**8**	**4**	5	9	3	6
	1.5	**168.05**	**174.9**	**185.62**	**187.26**	**190.18**	**194.54**	**195.67**	**197.91**	**203.02**	**206.44**
		4	**8**	**7**	**1**	**9**	**5**	**2**	**10**	**3**	**6**
	2	159.18	164.53	166.84	170.65	**172.78**	**176.51**	183.24	190.63	191.29	195.58
		6	2	4	7	**1**	**8**	9	10	3	5
	3	131.16	141.08	148.95	150.17	**150.53**	**156.04**	163.67	165.69	174.36	196.18
		8	7	6	2	**9**	**5**	1	4	3	10
	4.5	130.81	131.44	136.47	141.95	**142.55**	**147.94**	150.9	156.8	158.08	175.79
		9	3	6	4	**8**	**2**	7	1	5	10
500	0.5	173.98	177.55	178.25	178.37	**178.56**	**178.75**	179.04	179.27	180.26	180.98
		1	6	7	4	**5**	**9**	10	3	8	2
	1	204.22	211.53	213.54	215.92	**216.46**	**216.85**	217.13	217.2	223.35	225.84
		7	1	10	2	**8**	**4**	5	9	3	6
	1.5	**194.16**	**201.58**	**214.09**	**216.08**	**218.91**	**224.35**	**225.42**	**227.91**	**234.38**	**238.06**
		4	**8**	**7**	**1**	**9**	**5**	**2**	**10**	**3**	**6**
	2	185.28	191.43	193.87	198.12	**200.86**	**205.01**	212.4	221.04	222.19	227.49
		6	2	4	7	**1**	**8**	9	10	3	5
	3	151.92	164.44	173.46	174.98	**175.26**	**181.83**	189.95	192.96	203.08	228.27
		8	7	6	9	**2**	**5**	1	4	3	10
	4.5	152.13	152.88	160.1	165.87	**165.99**	**172.62**	176.38	182.51	185.16	204.8
		9	3	6	8	**4**	**2**	7	1	5	10
2000	0.5	206.46	210.75	211.52	211.68	**211.93**	**212.11**	212.48	212.70	213.94	214.80
		1	6	7	4	**5**	**9**	10	3	8	2
	1	245.99	254.38	257.22	259.82	**260.85**	**261.37**	261.57	261.74	269.13	272.19
		7	1	10	2	**8**	**4**	5	9	3	6
	1.5	**237.11**	**245.47**	**260.82**	**263.42**	**265.95**	**273.26**	**274.18**	**277.06**	**285.91**	**289.94**
		4	**8**	**7**	**1**	**9**	**5**	**2**	**10**	**3**	**6**
	2	228.41	235.85	238.45	243.44	**247.20**	**252.01**	260.34	271.08	273.12	280.15
		6	2	4	7	**1**	**8**	9	10	3	5
	3	186.71	203.90	214.81	216.12	**217.65**	**225.35**	234.10	238.95	251.51	282.34
		8	7	6	9	**2**	**5**	1	4	3	10
	4.5	188.08	189.01	200.32	205.20	**206.73**	**214.38**	219.62	225.87	231.17	253.81
		9	3	6	8	**4**	**2**	7	1	5	10

Ric Nattrass Creek at Centenary Motorway – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	**0.5**	**62.58**	**64.2**	**65.93**	**69.36**	**69.79**	**73.05**	**74.35**	**74.41**	**74.47**	**79.59**
		6	**1**	**5**	**4**	**10**	**7**	**2**	**8**	**9**	**3**
	1	54.66	54.74	55.44	57.55	**58.38**	**64.1**	64.45	66.81	75.8	77.83
		8	10	7	5	**4**	**9**	3	6	2	1
	1.5	46.64	48.61	49.02	51.32	**56.4**	**59.66**	60.76	62.99	63.32	65.21
		7	1	4	8	**5**	**6**	2	9	3	10
	2	41.68	42.53	45.21	46.26	**49.87**	**51.3**	53.53	53.84	53.86	60.04
		7	8	2	4	**3**	**6**	9	10	1	5
	3	32.59	33.41	38.36	42.77	**43.15**	**43.87**	47.75	48.25	48.39	58.75
		7	9	5	2	**6**	**4**	1	8	3	10
	4.5	30.83	32.54	33.73	34.78	**37.52**	**40.57**	40.68	41.13	41.21	42.36
		8	3	2	7	**4**	**9**	6	1	5	10
500	**0.5**	**71.26**	**73.27**	**75.23**	**79.27**	**79.8**	**83.65**	**85.25**	**85.33**	**85.34**	**91.49**
		6	**1**	**5**	**4**	**10**	**7**	**2**	**9**	**8**	**3**
	1	62.52	63.14	63.42	66.02	**66.73**	**73.93**	74.16	77.28	87.26	89.77
		10	8	7	5	**4**	**3**	9	6	2	1
	1.5	54.83	56.17	56.67	60.6	**65.54**	**68.53**	69.97	72.55	73.65	75.22
		7	1	4	8	**5**	**6**	2	9	3	10
	2	48.34	49.61	52.62	53.96	**57.85**	**59.79**	62.07	62.44	62.81	70.07
		7	8	2	4	**3**	**6**	9	10	1	5
	3	38.01	38.75	44.53	50.36	**50.52**	**51.17**	55.73	56.73	56.9	68.74
		7	9	5	2	**6**	**4**	1	8	3	10
	4.5	35.9	38.14	39.31	40.57	**43.94**	**47.5**	48.17	48.18	48.54	49.46
		8	3	2	7	**4**	**9**	6	1	5	10
2000	**0.5**	**84.73**	**87.42**	**89.73**	**94.73**	**95.51**	**100.32**	**102.4**	**102.42**	**102.44**	**110.19**
		6	**1**	**5**	**4**	**10**	**7**	**9**	**2**	**8**	**3**
	1	74.9	76.21	77.08	79.58	**81.9**	**89.06**	90.38	94.27	105.66	109.04
		10	7	8	5	**4**	**3**	9	6	2	1
	1.5	68.52	68.68	69.29	76.17	**80.56**	**83.02**	85.06	88.2	90.66	91.66
		7	1	4	8	**5**	**6**	2	9	3	10
	2	59.38	61.33	65.91	66.7	**70.95**	**73.85**	76.15	76.61	77.7	86.62
		7	8	2	4	**3**	**6**	9	10	1	5
	3	47.3	47.73	54.9	63.03	**63.29**	**63.47**	69.28	71.31	71.37	85.67
		7	9	5	6	**2**	**4**	1	8	3	10
	4.5	44.5	47.72	48.74	50.39	**54.83**	**59.22**	60.17	60.98	61	61.53
		8	3	2	7	**4**	**9**	1	6	5	10

Wolston Creek at Catchment Outlet – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
200	0.5	344.43	345.4	346.06	346.3	346.58	346.61	346.85	347.26	347.39	347.45
		1	6	5	4	10	7	9	8	3	2
	1	446.37	449.38	449.75	449.77	449.77	451.07	453.57	453.95	454.79	455.35
		7	4	9	8	10	5	1	3	6	2
	1.5	481.03	493.43	495.97	497.84	499.44	501.09	503.96	509.38	511.72	513.43
		4	1	8	7	5	3	9	2	10	6
	2	506.15	506.48	507.16	507.21	513.48	515.92	517.41	517.51	517.93	537.81
		6	7	2	4	8	9	5	1	3	10
	3	453.59	459.7	481.18	483.83	491.96	492.37	502.57	507.58	525.13	545.04
		8	2	7	6	5	9	1	4	3	10
	4.5	437.97	439.11	440.06	460.08	463.01	488.5	489.76	496.29	505.17	552.81
		9	4	5	6	3	7	1	8	2	10
500	0.5	389.99	391.15	391.94	392.23	392.56	392.59	392.89	393.37	393.53	393.61
		1	6	5	4	10	7	9	8	3	2
	1	509.66	513.12	513.55	513.57	513.62	515.13	518.31	518.53	519.51	520.3
		7	4	9	8	10	5	1	3	6	2
	1.5	552.52	566.58	569.85	571.81	573.6	575.31	579.27	585.34	588.18	589.92
		4	1	8	7	5	3	9	2	10	6
	2	585.8	585.86	586.83	586.89	593.94	597.01	598.34	598.8	599.12	622.43
		6	7	4	2	8	9	5	1	3	10
	3	527.91	534.6	558.7	561.4	571.42	571.87	582.71	589.73	608.58	632.45
		8	2	7	6	5	9	1	4	3	10
	4.5	510.37	512.04	512.65	536.44	538.95	569.03	569.47	577.4	587.95	642.66
		9	4	5	6	3	7	1	8	2	10
2000	0.5	424.66	426.56	427.19	427.2	427.28	427.56	427.6	427.99	428.42	428.78
		1	6	5	4	7	9	10	3	8	2
	1	540.96	546.39	547.22	547.44	547.47	547.61	548.53	550.37	552.55	553.88
		7	10	1	4	8	9	5	2	3	6
	1.5	584.08	599.57	600.86	604.07	608.36	608.44	612.23	615.36	617.31	622.19
		4	8	1	7	5	9	3	2	10	6
	2	622.91	624.52	625.7	627.73	633.45	634.46	635.71	641.6	642.28	655.84
		6	2	4	7	8	1	9	5	3	10
	3	603.58	623.36	624.1	627.37	636.83	637.93	641.59	655.61	661.08	685.7
		8	2	7	6	9	1	5	4	3	10
	4.5	607.98	608.02	609.34	613.67	617.3	636.96	640.23	657.98	670.77	702.82
		6	4	5	9	3	1	7	8	2	10

Appendix J: Rare Events (Scenario 1) - Peak Flood Levels

The flood level data presented in this Appendix has been extracted (in part) from the results of a 2-dimensional flood model. Levels presented have been extracted generally at selected points along the centreline of the waterway with the intent of demonstrating general flood characteristics. The applicability of this data to locations on the floodplains adjacent should be determined by a suitably qualified professional. It is recommended for any detailed assessment of flood risk associated with the waterway that complete flood model results be accessed and interrogated.

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AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
Wolston Creek			
0	1.69	1.69	1.69
100	2.09	2.19	2.35
200	2.55	2.73	3.02
300	2.97	3.20	3.55
400	3.37	3.63	4.01
500	3.86	4.14	4.55
600	4.47	4.78	5.23
700	4.92	5.23	5.67
800	5.27	5.57	6.01
900	5.55	5.86	6.32
1000	5.73	6.06	6.52
1100	5.87	6.20	6.68
1200	5.99	6.33	6.81
1300	6.10	6.44	6.92
1400	6.18	6.52	7.01
1500	6.26	6.61	7.11
1600	6.34	6.69	7.19
1700	6.41	6.76	7.27
1800	6.48	6.83	7.34
1900	6.55	6.91	7.42
2000	6.62	6.98	7.49
2100	6.67	7.03	7.54
2200	6.71	7.07	7.58
2300	6.76	7.12	7.63
2400	6.81	7.17	7.68
2500	6.82	7.18	7.68
Structure S1 – Wacol Station Road			
2600	6.98	7.30	7.77
2700	7.04	7.35	7.80
2800	7.11	7.41	7.86
2900	7.19	7.49	7.94
3000	7.30	7.61	8.07

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
3100	7.40	7.72	8.18
3200	7.48	7.80	8.26
3300	7.58	7.90	8.36
3400	7.67	7.99	8.45
3500	7.75	8.06	8.53
3600	7.78	8.09	8.56
3700	7.79	8.11	8.58
3800	7.81	8.13	8.59
3900	7.82	8.14	8.60
4000	7.83	8.14	8.60
4100	7.83	8.14	8.60
4205	7.83	8.14	8.60
Sandy Creek			
0	7.83	8.14	8.60
100	7.87	8.17	8.63
200	7.90	8.20	8.65
Structure S2 – Wolston Road			
300	8.19	8.51	9.01
400	8.27	8.58	9.07
500	8.35	8.65	9.12
600	8.47	8.75	9.20
700	8.59	8.85	9.28
800	8.68	8.93	9.34
900	8.79	9.03	9.42
1000	8.95	9.18	9.55
1100	9.14	9.36	9.69
1200	9.41	9.61	9.91
1300	9.67	9.86	10.14
1400	9.81	10.00	10.26
1500	10.02	10.20	10.47
1600	10.20	10.37	10.63
1700	10.35	10.52	10.76
1800	10.47	10.62	10.86

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
1900	10.58	10.73	10.95
2000	10.67	10.81	11.02
2100	10.83	10.96	11.16
2200	11.16	11.29	11.47
2300	11.47	11.60	11.78
2400	11.66	11.78	11.97
2500	11.91	12.03	12.21
2600	12.17	12.28	12.46
2700	12.42	12.53	12.69
2800	12.69	12.79	12.94
2900	13.00	13.10	13.25
Structure S3 – Ipswich Railway			
3000	13.43	13.61	13.91
3100	13.57	13.75	14.05
3186	13.68	13.86	14.15
Structure S4a – Ipswich Road			
Structure S4b – Ipswich Motorway			
3300	14.77	15.10	15.65
3400	15.07	15.40	15.83
3500	15.18	15.50	15.91
3600	15.28	15.59	15.97
3700	15.41	15.70	16.05
Structure S5 – Progress Road			
3800	16.39	16.63	16.85
3900	16.52	16.74	16.95
4000	16.62	16.83	17.03
Structure S6 – Inline Weir #1			
4100	16.93	17.08	17.27
4200	17.08	17.22	17.40
4300	17.24	17.38	17.56
4400	17.42	17.57	17.76
Structure S7 – Campbell Avenue			
4500	17.76	17.95	18.13

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
4600	17.87	18.05	18.24
Structure S8 – Inline Weir #2			
4700	18.95	19.10	19.30
4800	19.18	19.33	19.53
4900	19.37	19.54	19.74
5000	19.58	19.75	19.95
5100	19.80	19.97	20.18
5200	20.00	20.18	20.38
5300	20.20	20.38	20.57
Structure S9 – Formation Street			
5400	22.84	23.15	23.43
5500	22.95	23.25	23.52
5600	23.10	23.39	23.66
5700	23.26	23.54	23.82
5800	23.49	23.74	24.01
5900	23.92	24.10	24.34
6000	24.40	24.53	24.74
6100	24.75	24.87	25.05
6190	25.05	25.17	25.33
Tributary 3			
0	16.64	16.84	17.04
100	16.73	16.90	17.10
200	16.71	16.89	17.09
300	N/R	N/R	17.11
400	N/R	N/R	N/R
500	N/R	N/R	N/R
600	19.25	19.29	19.32
700	20.31	20.36	20.41
777	20.69	20.72	20.73
Structure S41 – Wilga Street			
900	22.80	22.83	22.88
1000	23.57	23.61	23.67
1048	23.92	23.97	24.03

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
Bullockhead Creek			
0	7.83	8.14	8.60
100	7.86	8.16	8.62
200	7.89	8.19	8.64
300	8.02	8.30	8.74
400	8.12	8.38	8.81
500	8.24	8.49	8.90
600	8.42	8.65	9.01
Structure S10 – Spine Street			
700	8.95	9.14	9.47
800	9.30	9.49	9.77
900	9.59	9.77	10.05
1000	9.88	10.05	10.31
1100	10.17	10.33	10.58
1200	10.39	10.55	10.79
1300	10.51	10.66	10.90
1400	10.58	10.74	10.97
1500	10.67	10.83	11.06
Structure S11 – Ipswich Railway			
1600	12.89	13.32	13.99
Structure S12 – Sananda Street			
1700	12.89	13.32	13.99
1800	12.91	13.34	14.00
1900	12.93	13.35	14.01
2000	12.97	13.38	14.03
2100	13.01	13.40	14.04
2200	13.05	13.44	14.06
2300	13.11	13.49	14.09
2400	13.36	13.67	14.20
2500	13.86	14.06	14.42
2600	14.32	14.44	14.68
2700	14.65	14.78	15.02
2800	14.93	15.08	15.32

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
Structure S13a – Ipswich Road			
Structure S13b – Ipswich Motorway			
2900	15.54	15.73	16.07
3000	16.00	16.25	16.65
3100	16.20	16.42	16.79
3200	16.41	16.60	16.93
3300	16.62	16.78	17.09
Structure S14 – Private Bridge			
3400	17.18	17.32	17.53
3500	17.40	17.54	17.75
3600	17.58	17.73	17.96
3700	18.07	18.22	18.45
Structure S15 – Boundary Road			
3800	19.07	19.26	19.56
3900	19.20	19.39	19.70
4000	19.37	19.56	19.85
4100	19.59	19.75	20.01
4200	19.90	20.04	20.28
Structure S16 – Bukulla Street			
4300	20.25	20.39	20.60
4400	20.50	20.65	20.89
4500	20.67	20.83	21.08
4600	21.00	21.15	21.39
4700	21.38	21.52	21.76
Structure S17 – Progress Road			
4800	22.58	22.79	23.05
4900	22.63	22.84	23.08
5000	22.89	23.04	23.25
5100	23.39	23.49	23.67
5200	23.86	23.99	24.19
5300	24.10	24.25	24.48
5400	24.30	24.46	24.70
5500	24.59	24.75	25.00

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
Structure S18 – Coulson Street			
5600	25.33	25.51	25.76
5700	25.58	25.76	26.03
5800	25.79	25.97	26.24
5900	26.07	26.28	26.36
Structure S19a – Centenary Motorway			
Structure S19b – Springfield Railway			
6061	28.04	28.19	28.41
6100	28.36	28.55	28.87
6190	28.48	28.68	28.99
6300	28.58	28.78	29.09
6400	28.77	28.97	29.27
6500	28.97	29.16	29.45
6600	29.15	29.34	29.62
6700	29.39	29.57	29.85
6800	30.01	30.16	30.39
6900	31.06	31.15	31.28
7000	31.68	31.79	31.95
Structure S20 – Waterford Road Culvert			
7100	32.69	32.94	33.21
7200	32.76	33.00	33.28
7300	32.90	33.14	33.41
7400	33.12	33.33	33.59
7500	33.50	33.68	33.94
7600	33.96	34.11	34.33
7700	34.46	34.54	34.70
7800	35.30	35.41	35.58
7900	36.04	36.19	36.39
8000	36.47	36.61	36.81
8100	36.88	37.02	37.21
8200	37.35	37.47	37.66
8300	38.15	38.27	38.45
8400	38.73	38.84	38.99

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
8471	N/R	N/R	39.95
Ric Nattrass Creek			
0	12.93	13.35	14.01
100	12.95	13.37	14.02
200	12.97	13.39	14.03
300	12.99	13.39	14.03
Structure S27 – Wau Road			
400	13.33	13.42	14.04
Structure S28 – Kokoda Street			
500	13.96	14.04	14.15
Structure S29a – Ipswich Road + motorway off ramp			
Structure S29b – Ipswich Motorway			
619	14.44	14.60	14.85
700	14.54	14.69	14.93
800	15.05	15.16	15.32
Structure S30 – Bakery Road + motorway on ramp			
900	16.56	16.84	17.37
1000	16.70	16.96	17.45
1100	17.04	17.25	17.63
1200	N/R	N/R	N/R
Structure S31 – Boundary Road			
1300	20.32	20.43	20.57
1400	20.36	20.47	20.63
1500	20.41	20.54	20.70
1600	20.58	20.70	20.88
Structure S32a – Centenary Motorway			
Structure S32b – Springfield Railway			
Structure S32c – Centenary Motorway Footbridge			
1724	21.01	21.21	21.55
1800	21.40	21.52	21.81
1900	21.65	21.74	21.93
Structure S33 – Coca Cola Footbridge #2			
1988	22.29	22.34	22.41

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
Structure S34 – Coca Cola Drop Structure #3			
Structure S35 – Coca Cola Drop Structure #2			
2100	23.26	23.29	23.33
2200	N/R	N/R	N/R
2300	24.91	24.95	25.07
Structure S36 – Coca Cola Footbridge #1			
2400	N/R	N/R	N/R
Structure S37 – Coca Cola Drop Structure #1			
Structure S38 – Coca Cola Spillway / Weir			
2500	28.82	28.93	29.06
2600	29.11	29.20	29.32
Structure S39 – Pine Road Culvert			
2716	31.83	31.90	31.98
2800	N/R	N/R	N/R
2900	35.61	35.66	35.73
3000	38.35	38.37	38.41
3100	41.46	41.50	41.59
Structure S40 – Progress Road Culvert			
3200	43.85	44.02	44.19
3300	47.29	47.35	47.44
3311	47.69	47.75	47.83
Tributary 1			
0	13.30	13.42	14.04
100	N/R	N/R	N/R
200	N/R	N/R	N/R
217	N/R	N/R	N/R
Scott Creek			
0	28.39	28.58	28.90
100	28.49	28.65	28.94
200	29.25	29.34	29.46
300	31.49	31.57	31.70
400	34.31	34.38	34.49
Structure S24 – Cardwell Street			

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
500	36.85	36.89	36.96
564	38.13	38.19	38.25
Forest Lake Boulevard			
700	43.64	44.04	45.13
Structure S25 – Signac Close Footbridge			
800	48.03	48.10	48.26
900	54.87	54.90	55.02
914	N/R	N/R	N/R
Spinks Creek			
0	38.09	38.20	38.39
100	39.12	39.20	39.36
200	40.56	40.61	40.73
Structure S21 – Roxwell Street			
300	44.06	44.22	44.39
400	44.33	44.46	44.64
500	45.34	45.39	45.52
Structure S22 – Jubilee Avenue			
600	N/R	N/R	N/R
700	47.89	47.98	48.10
800	49.24	49.29	49.35
900	50.38	50.42	50.47
1000	51.97	52.02	52.11
Structure S24 – Cardwell Street			
1100	53.80	53.85	53.93
Tributary 2			
0	21.60	21.67	21.92
100	21.62	21.67	21.94
203	21.63	21.70	21.96

N/R = no result, typically because the AMTD line does not intersect the flood surface

Appendix K: Rare Events (Scenario 3) - Peak Flood Levels

The flood level data presented in this Appendix has been extracted (in part) from the results of a 2-dimensional flood model. Levels presented have been extracted generally at selected points along the centreline of the waterway with the intent of demonstrating general flood characteristics. The applicability of this data to locations on the floodplains adjacent should be determined by a suitably qualified professional. It is recommended for any detailed assessment of flood risk associated with the waterway that complete flood model results be accessed and interrogated.

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AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
Wolston Creek			
0	1.18	1.69	1.69
100	1.64	2.09	2.19
200	2.14	2.55	2.73
300	2.58	2.96	3.20
400	3.02	3.36	3.63
500	3.53	3.86	4.14
600	4.13	4.48	4.81
700	4.62	4.96	5.28
800	4.98	5.32	5.63
900	5.26	5.60	5.92
1000	5.45	5.79	6.12
1100	5.59	5.93	6.28
1200	5.70	6.05	6.40
1300	5.81	6.16	6.51
1400	5.89	6.24	6.60
1500	5.97	6.33	6.68
1600	6.05	6.41	6.77
1700	6.12	6.48	6.84
1800	6.19	6.55	6.92
1900	6.26	6.61	6.98
2000	6.33	6.68	7.05
2100	6.38	6.74	7.11
2200	6.44	6.79	7.16
2300	6.49	6.84	7.21
2400	6.54	6.89	7.26
2500	6.56	6.90	7.27
Structure S1 – Wacol Station Road			
2600	6.77	7.05	7.38
2700	6.84	7.10	7.43
2800	6.91	7.17	7.49
2900	7.00	7.26	7.57
3000	7.11	7.38	7.70

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
3100	7.22	7.48	7.81
3200	7.31	7.57	7.89
3300	7.45	7.70	8.01
3400	7.54	7.78	8.10
3500	7.61	7.86	8.17
3600	7.63	7.88	8.20
3700	7.65	7.90	8.21
3800	7.66	7.91	8.23
3900	7.67	7.92	8.23
4000	7.68	7.93	8.24
4100	7.69	7.93	8.24
4205	7.69	7.94	8.24
Sandy Creek			
0	7.69	7.94	8.24
100	7.74	7.98	8.28
200	7.78	8.02	8.32
Structure S2 – Wolston Road			
300	8.03	8.28	8.59
400	8.11	8.35	8.65
500	8.19	8.42	8.71
600	8.31	8.53	8.80
700	8.43	8.63	8.89
800	8.52	8.72	8.97
900	8.64	8.82	9.06
1000	8.80	8.98	9.20
1100	9.00	9.16	9.37
1200	9.26	9.42	9.60
1300	9.52	9.67	9.84
1400	9.65	9.80	9.97
1500	9.86	10.00	10.17
1600	10.04	10.18	10.33
1700	10.20	10.33	10.48
1800	10.33	10.45	10.59

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
1900	10.46	10.57	10.70
2000	10.56	10.66	10.79
2100	10.74	10.84	10.96
2200	11.07	11.17	11.28
2300	11.38	11.48	11.59
2400	11.57	11.67	11.78
2500	11.83	11.93	12.03
2600	12.09	12.19	12.29
2700	12.35	12.44	12.53
2800	12.63	12.71	12.80
2900	12.97	13.05	13.15
Structure S3 – Ipswich Railway			
3000	13.36	13.48	13.65
3100	13.50	13.63	13.80
3186	13.63	13.76	13.91
Structure S4a – Ipswich Road			
Structure S4b – Ipswich Motorway			
3300	14.48	14.80	14.96
3400	14.92	15.19	15.36
3500	15.04	15.31	15.47
3600	15.17	15.43	15.60
3700	15.34	15.60	15.76
Structure S5 – Progress Road			
3800	16.65	16.97	17.14
3900	16.76	17.07	17.24
4000	16.85	17.15	17.33
Structure S6 – Inline Weir #1			
4100	17.10	17.37	17.55
4200	17.23	17.48	17.67
4300	17.37	17.61	17.81
4400	17.52	17.76	17.97
Structure S7 – Campbell Avenue			
4500	17.77	18.01	18.21

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
4600	17.87	18.10	18.31
Structure S8 – Inline Weir #2			
4700	18.88	19.04	19.24
4800	19.10	19.27	19.47
4900	19.30	19.47	19.67
5000	19.50	19.68	19.88
5100	19.72	19.90	20.10
5200	19.91	20.10	20.30
5300	20.11	20.31	20.50
Structure S9 – Formation Street			
5400	22.54	22.85	23.16
5500	22.70	22.99	23.28
5600	22.85	23.12	23.41
5700	23.02	23.27	23.54
5800	23.28	23.49	23.73
5900	23.82	23.97	24.16
6000	24.46	24.56	24.70
6100	24.91	25.01	25.14
6190	25.31	25.41	25.53
Tributary 3			
0	16.87	17.17	17.34
100	N/R	N/R	17.40
200	N/R	N/R	17.38
300	N/R	N/R	N/R
400	N/R	N/R	N/R
500	N/R	N/R	N/R
600	19.16	19.25	19.29
700	20.29	20.32	20.36
777	20.73	20.75	20.80
Structure S41 – Wilga Street			
900	22.84	22.86	22.90
1000	23.59	23.63	23.68
1048	23.93	23.98	24.04

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
Bullockhead Creek			
0	7.69	7.94	8.24
100	7.73	7.97	8.27
200	7.76	8.00	8.30
300	7.89	8.12	8.40
400	7.98	8.20	8.48
500	8.11	8.32	8.58
600	8.33	8.52	8.76
Structure S10 – Spine Street			
700	8.84	9.01	9.22
800	9.18	9.34	9.54
900	9.48	9.63	9.82
1000	9.77	9.91	10.08
1100	10.05	10.19	10.36
1200	10.26	10.40	10.57
1300	10.39	10.53	10.69
1400	10.48	10.62	10.79
1500	10.59	10.73	10.90
Structure S11 – Ipswich Railway			
1600	12.49	12.84	13.29
Structure S12 – Sananda Street			
1700	12.50	12.86	13.30
1800	12.52	12.88	13.31
1900	12.55	12.90	13.33
2000	12.62	12.94	13.36
2100	12.68	12.99	13.39
2200	12.75	13.05	13.43
2300	12.82	13.11	13.48
2400	13.15	13.36	13.68
2500	13.78	13.91	14.09
2600	14.31	14.39	14.50
2700	14.59	14.69	14.82
2800	14.84	14.96	15.11

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
Structure S13a – Ipswich Road			
Structure S13b – Ipswich Motorway			
2900	15.30	15.52	15.72
3000	15.93	16.13	16.40
3100	16.14	16.31	16.55
3200	16.34	16.49	16.70
3300	16.57	16.70	16.88
Structure S14 – Private Bridge			
3400	17.08	17.20	17.35
3500	17.34	17.46	17.60
3600	17.48	17.60	17.76
3700	18.08	18.21	18.36
Structure S15 – Boundary Road			
3800	19.14	19.31	19.50
3900	19.26	19.43	19.62
4000	19.39	19.56	19.75
4100	19.56	19.71	19.89
4200	19.83	19.95	20.12
Structure S16 – Bukulla Street			
4300	20.18	20.29	20.43
4400	20.40	20.52	20.68
4500	20.55	20.68	20.85
4600	20.87	20.99	21.15
4700	21.25	21.36	21.51
Structure S17 – Progress Road			
4800	22.35	22.56	22.78
4900	22.43	22.62	22.84
5000	22.81	22.93	23.09
5100	23.40	23.48	23.60
5200	23.88	23.98	24.12
5300	24.07	24.19	24.34
5400	24.24	24.36	24.52
5500	24.51	24.63	24.79

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
Structure S18 – Coulson Street			
5600	25.27	25.38	25.53
5700	25.47	25.59	25.75
5800	25.71	25.82	25.99
5900	26.59	26.68	26.82
Structure S19a – Centenary Motorway			
Structure S19b – Springfield Railway			
6061	27.94	28.03	28.18
6100	28.30	28.42	28.62
6190	28.42	28.55	28.74
6300	28.52	28.65	28.85
6400	28.70	28.83	29.03
6500	28.89	29.02	29.21
6600	29.07	29.19	29.39
6700	29.30	29.42	29.61
6800	29.94	30.04	30.21
6900	30.98	31.04	31.14
7000	31.66	31.74	31.86
Structure S20 – Waterford Road Culvert			
7100	32.50	32.80	33.04
7200	32.59	32.87	33.11
7300	32.77	33.02	33.25
7400	33.03	33.23	33.44
7500	33.42	33.58	33.78
7600	33.90	34.03	34.19
7700	34.42	34.48	34.56
7800	35.28	35.37	35.49
7900	36.02	36.14	36.28
8000	36.43	36.54	36.68
8100	36.81	36.92	37.07
8200	37.27	37.37	37.51
8300	38.10	38.20	38.32
8400	38.71	38.80	38.92

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
8471	N/R	N/R	N/R
Ric Nattrass Creek			
0	12.55	12.90	13.33
100	12.59	12.92	13.35
200	12.76	12.97	13.37
300	12.89	12.99	13.38
Structure S27 – Wau Road			
400	13.43	13.51	13.62
Structure S28 – Kokoda Street			
500	13.98	14.07	14.17
Structure S29a – Ipswich Road + motorway off ramp			
Structure S29b – Ipswich Motorway			
619	14.38	14.51	14.77
700	14.47	14.60	14.84
800	15.02	15.09	15.22
Structure S30 – Bakery Road + motorway on ramp			
900	16.54	16.64	16.91
1000	16.64	16.78	17.03
1100	16.99	17.13	17.32
1200	N/R	N/R	N/R
Structure S31 – Boundary Road			
1300	20.21	20.34	20.45
1400	20.24	20.37	20.49
1500	20.28	20.42	20.54
1600	20.43	20.57	20.71
Structure S32a – Centenary Motorway			
Structure S32b – Springfield Railway			
Structure S32c – Centenary Motorway Footbridge			
1724	20.87	20.99	21.20
1800	21.21	21.42	21.54
1900	21.37	21.65	21.71
Structure S33 – Coca Cola Footbridge #2			
1988	21.46	22.26	22.37

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
Structure S34 – Coca Cola Drop Structure #3			
Structure S35 – Coca Cola Drop Structure #2			
2100	23.13	23.25	23.28
2200	N/R	N/R	N/R
2300	24.78	24.93	24.99
Structure S36 – Coca Cola Footbridge #1			
2400	N/R	N/R	N/R
Structure S37 – Coca Cola Drop Structure #1			
Structure S38 – Coca Cola Spillway / Weir			
2500	28.73	28.82	28.92
2600	29.08	29.15	29.25
Structure S39 – Pine Road Culvert			
2716	31.81	31.84	31.90
2800	N/R	N/R	N/R
2900	35.62	35.65	35.70
3000	N/R	38.35	38.37
3100	41.59	41.62	41.69
Structure S40 – Progress Road Culvert			
3200	43.77	43.85	44.02
3300	47.26	47.29	47.35
3311	47.66	47.69	47.75
Tributary 1			
0	13.41	13.49	13.60
100	N/R	N/R	N/R
200	N/R	N/R	N/R
217	N/R	N/R	N/R
Scott Creek			
0	28.33	28.45	28.65
100	28.43	28.54	28.73
200	29.17	29.25	29.35
300	31.41	31.48	31.57
400	34.25	34.32	34.40
Structure S24 – Cardwell Street			

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
500	36.83	36.86	36.91
564	38.10	38.13	38.19
Forest Lake Boulevard			
700	43.42	43.64	44.04
Structure S25 – Signac Close Footbridge			
800	48.01	48.03	48.10
900	54.85	54.87	54.90
914	N/R	N/R	N/R
Spinks Creek			
0	38.07	38.15	38.28
100	39.11	39.18	39.28
200	40.55	40.59	40.66
Structure S21 – Roxwell Street			
300	43.91	44.05	44.22
400	44.22	44.34	44.50
500	45.31	45.37	45.46
Structure S22 – Jubilee Avenue			
600	N/R	N/R	N/R
700	47.89	47.97	48.06
800	49.24	49.29	49.34
900	50.38	50.40	50.43
1000	51.94	51.96	52.02
Structure S24 – Cardwell Street			
1100	53.77	53.80	53.85
Tributary 2			
0	21.36	21.60	21.66
100	21.38	21.61	21.69
203	21.41	21.64	21.72

N/R = no result, typically because the AMTD line does not intersect the flood surface

Appendix L: Rating Curves

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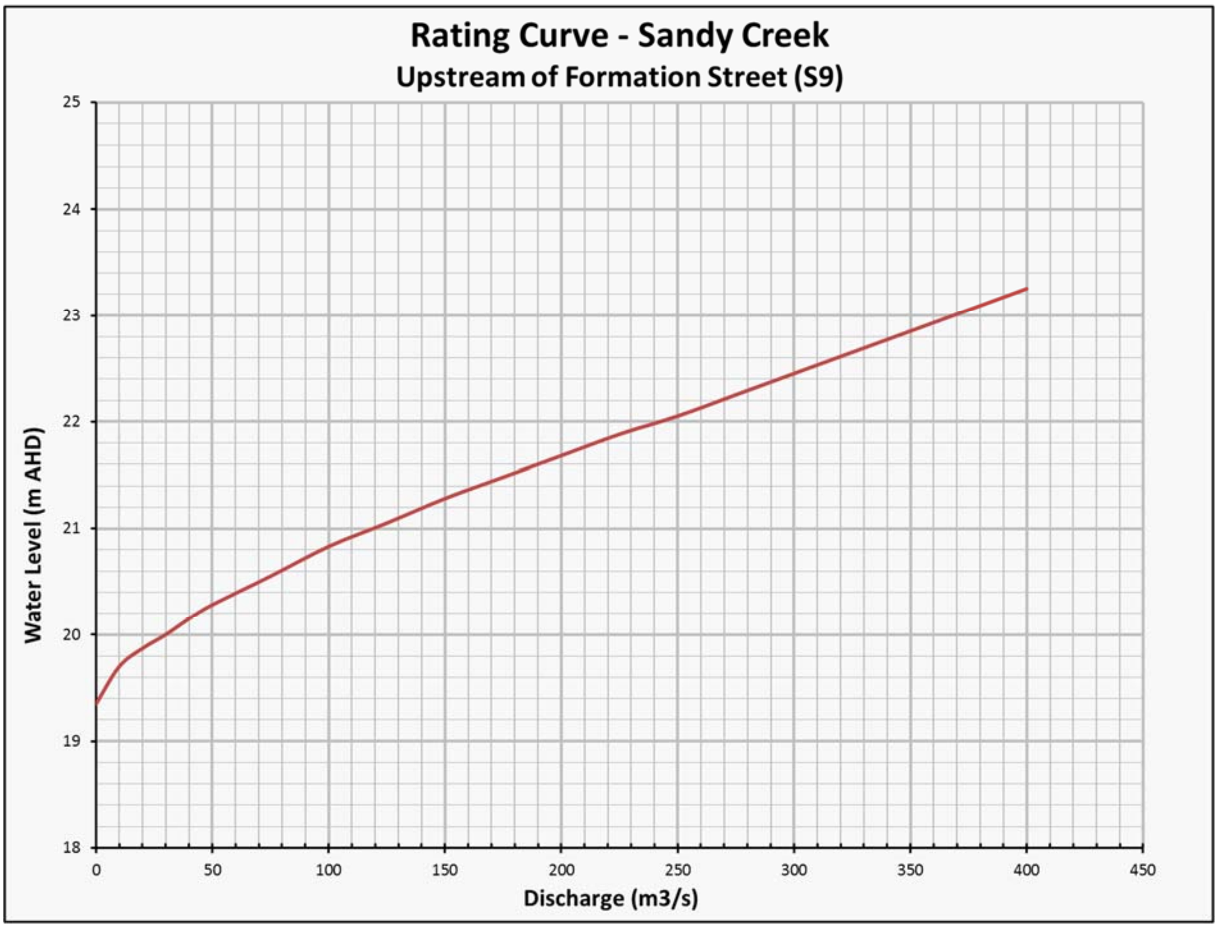
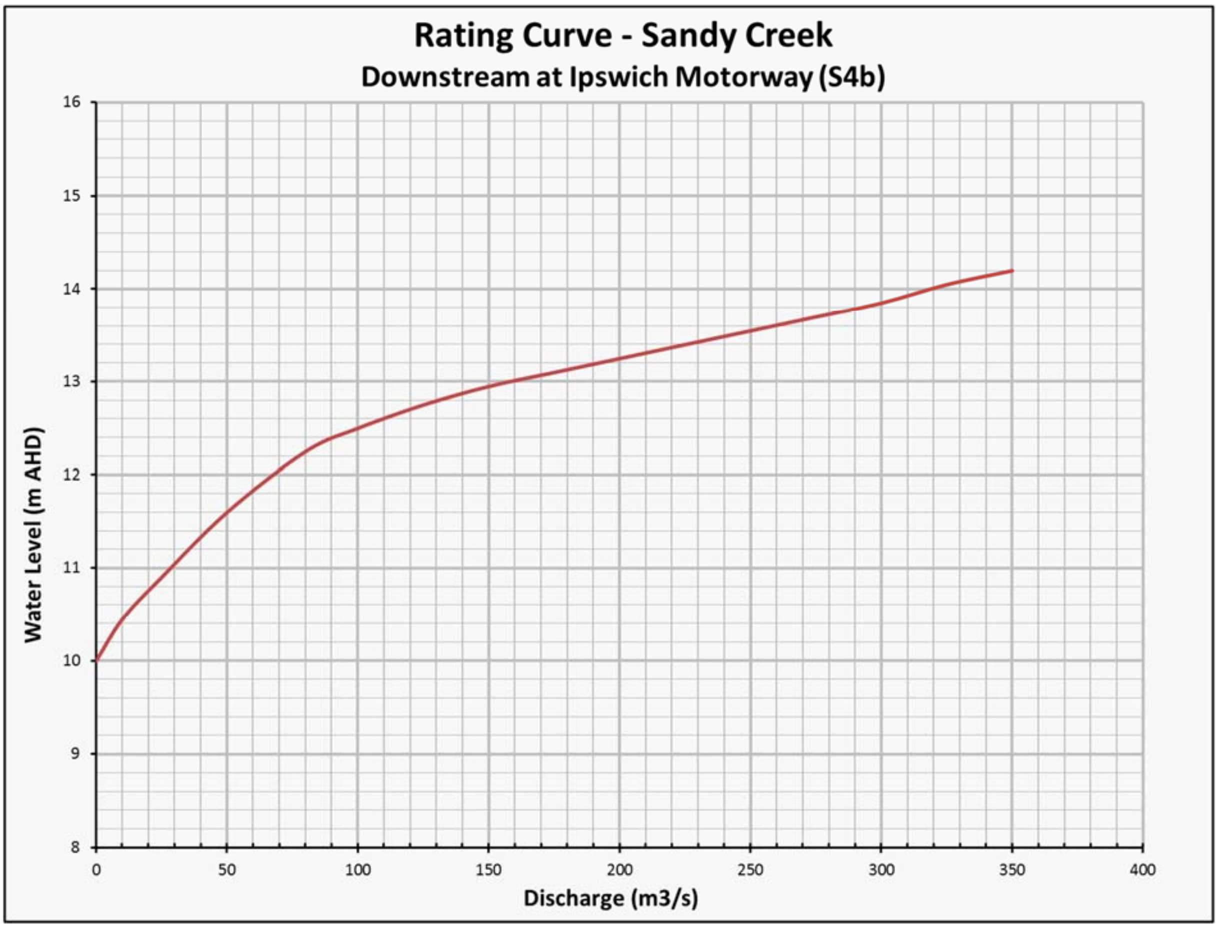
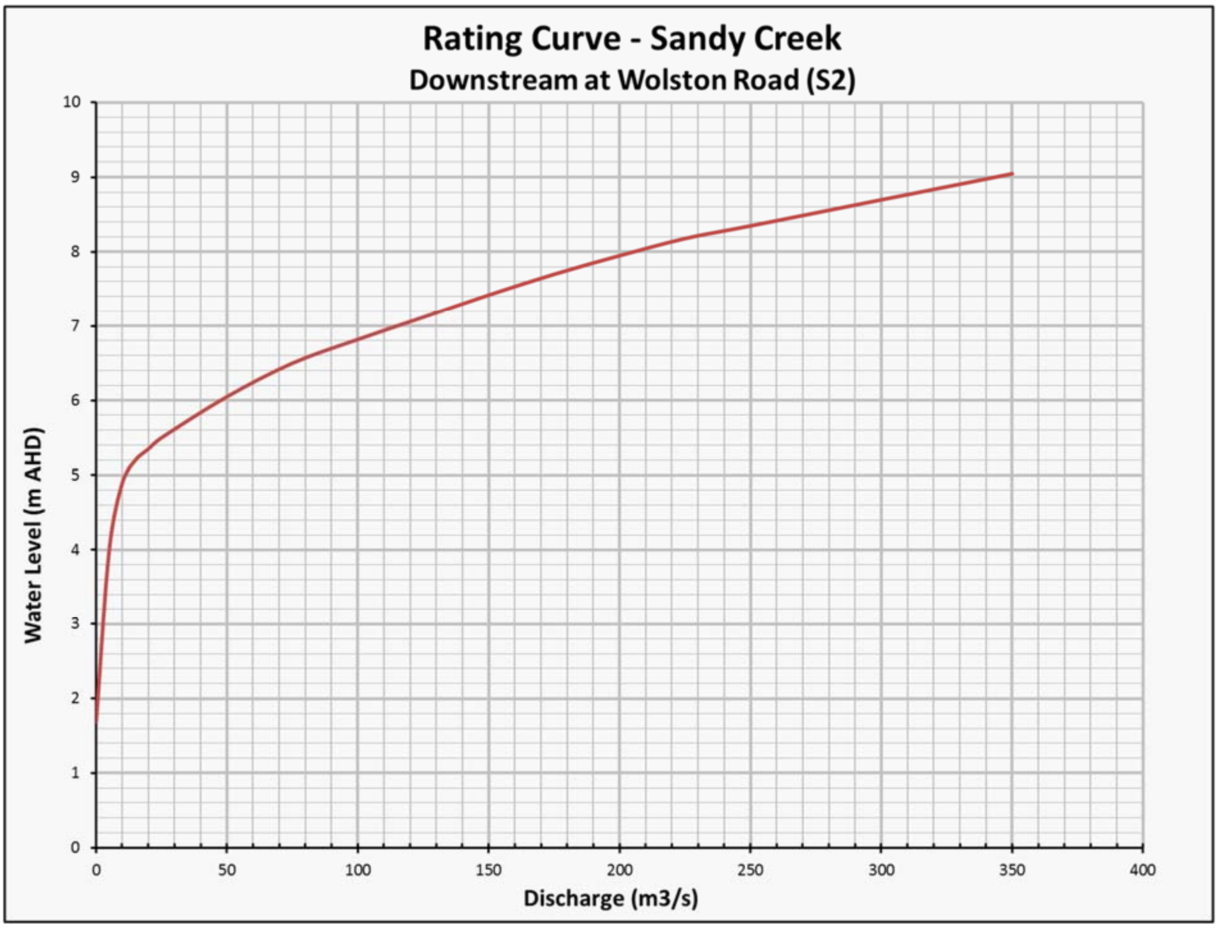
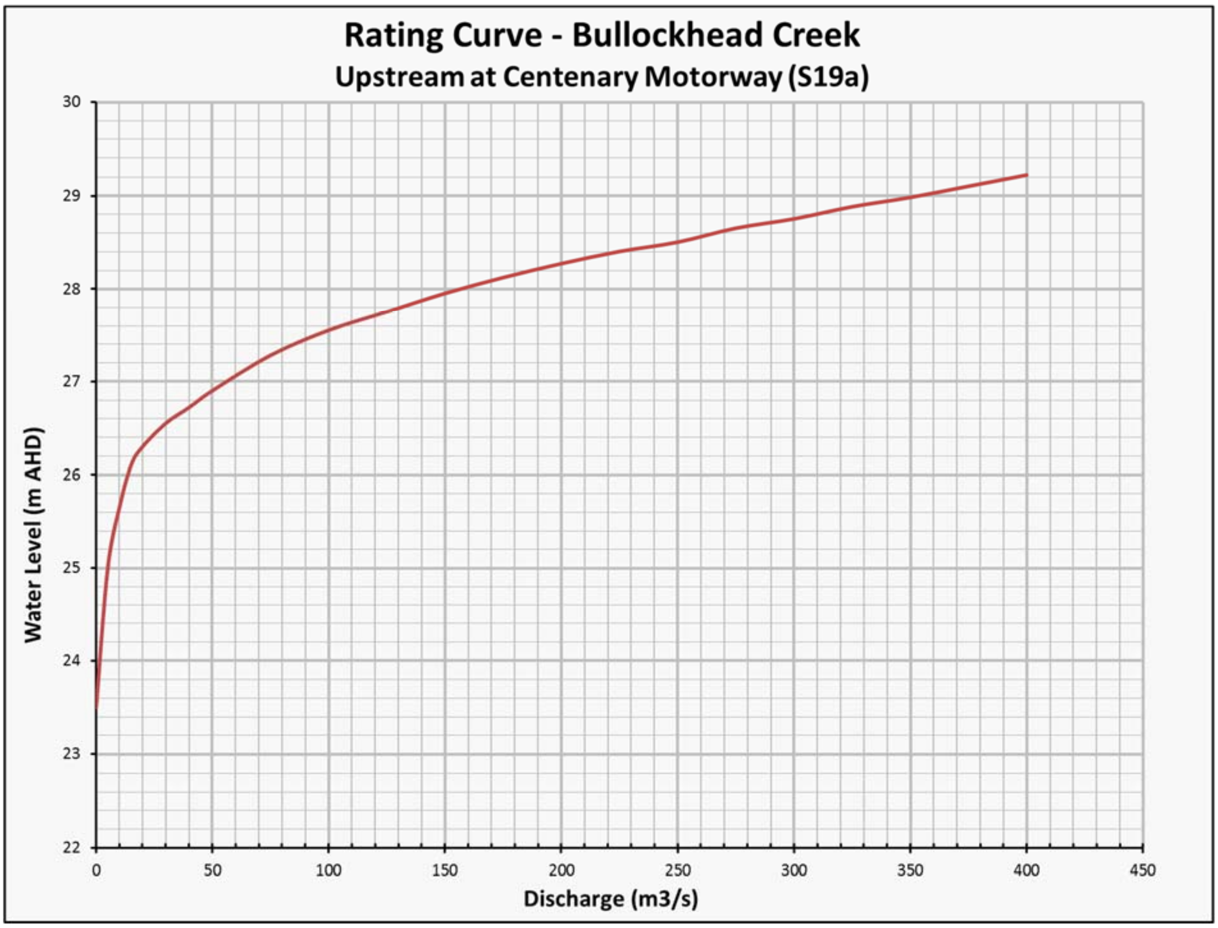

Rating Curve - Sandy Creek
Upstream of Formation Street (S9)
Water Level (m AHD)
25
24
23
22
21
20
19
18
0
50
100
150
200
250
300
350
400
450
Discharge (m3/s)

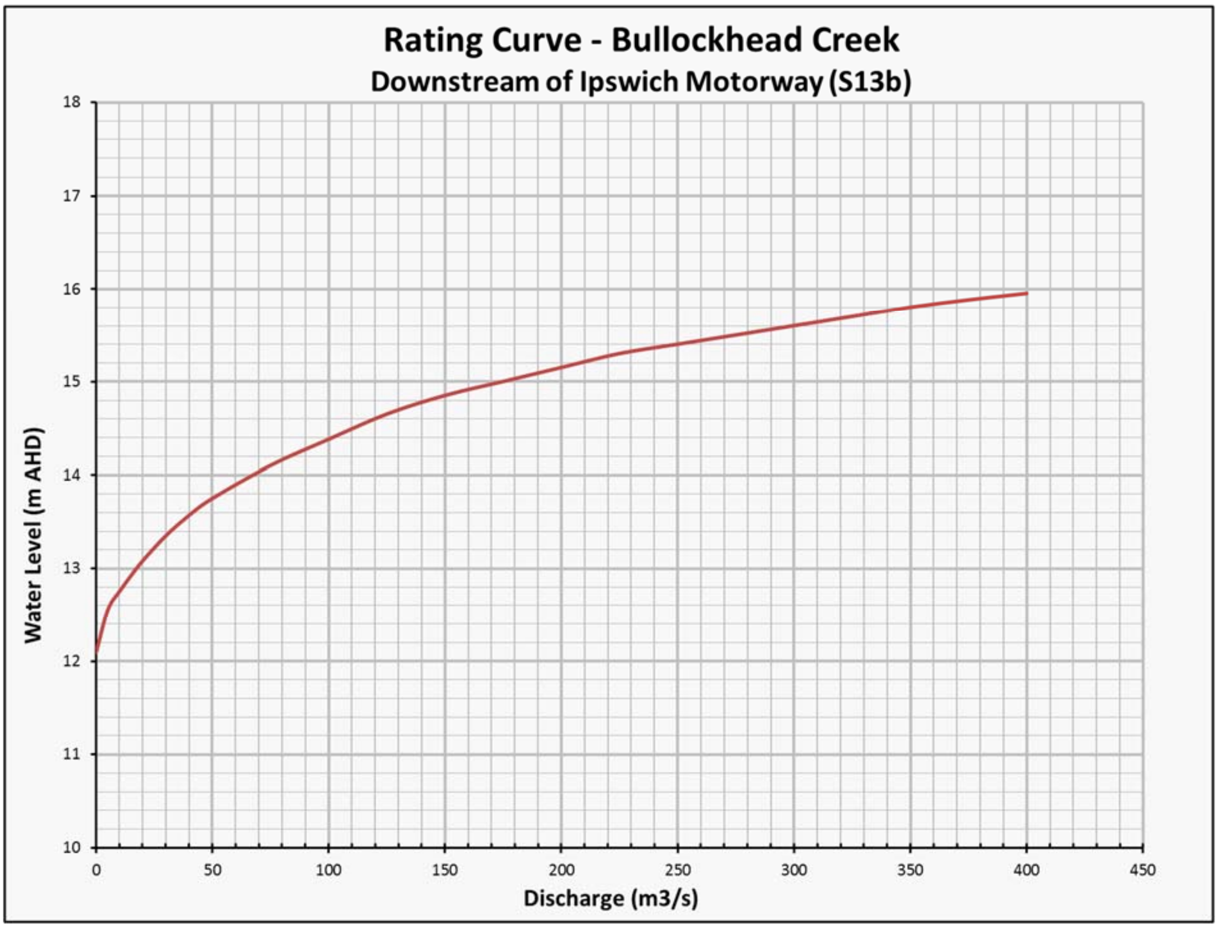

Rating Curve - Sandy Creek
Downstream at Ipswich Motorway (S4b)
Water Level (m AHD)
16
15
14
13
12
11
10
9
8
0
50
100
150
200
250
300
350
400
Discharge (m3/s)



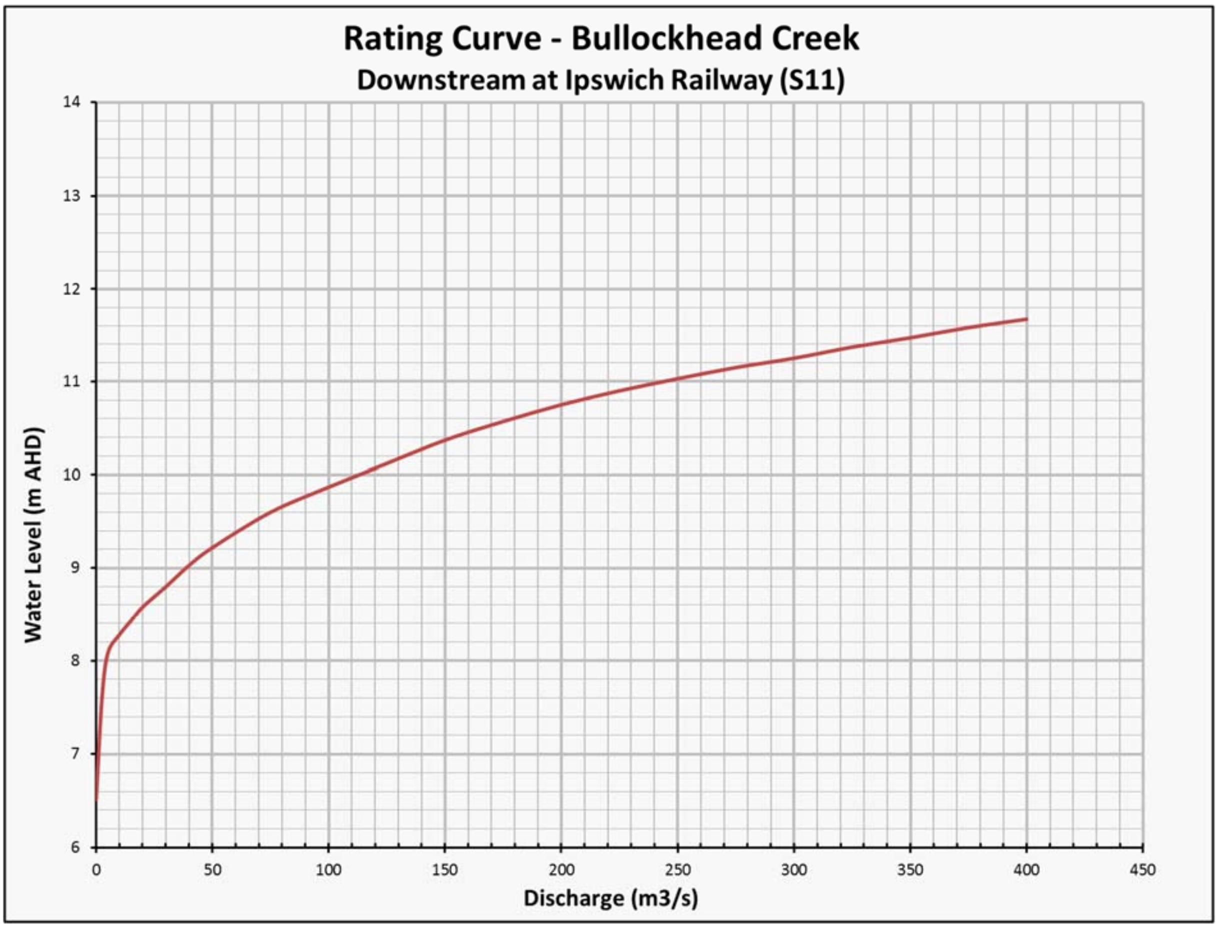
Rating Curve - Sandy Creek
Downstream at Wolston Road (S2)
Water Level (m AHD)
Discharge (m3/s)
0
1
2
3
4
5
6
7
8
9
10
0
50
100
150
200
250
300
350
400



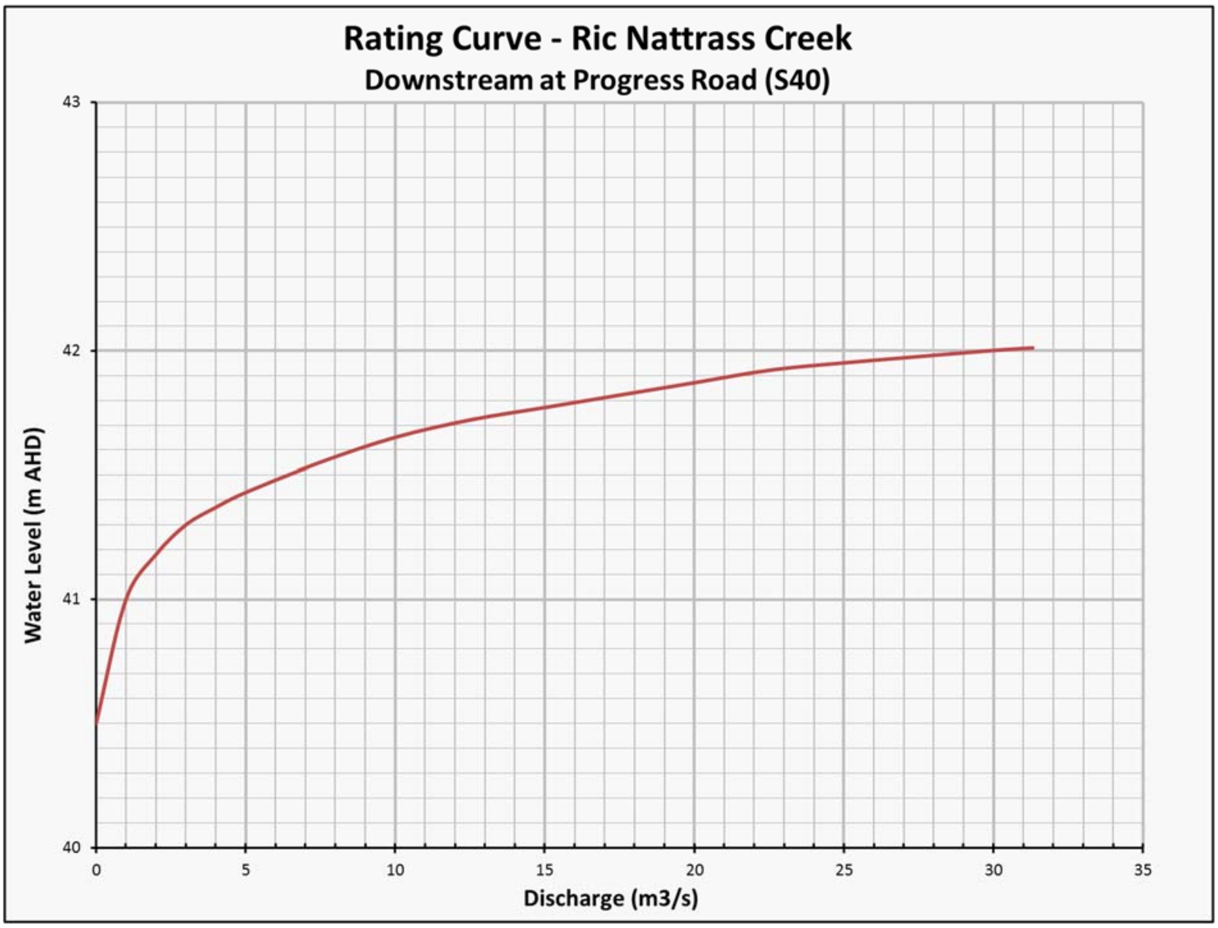
Rating Curve - Bullockhead Creek
Upstream at Centenary Motorway (S19a)
Water Level (m AHD)
Discharge (m3/s)
22
23
24
25
26
27
28
29
30
0
50
100
150
200
250
300
350
400
450



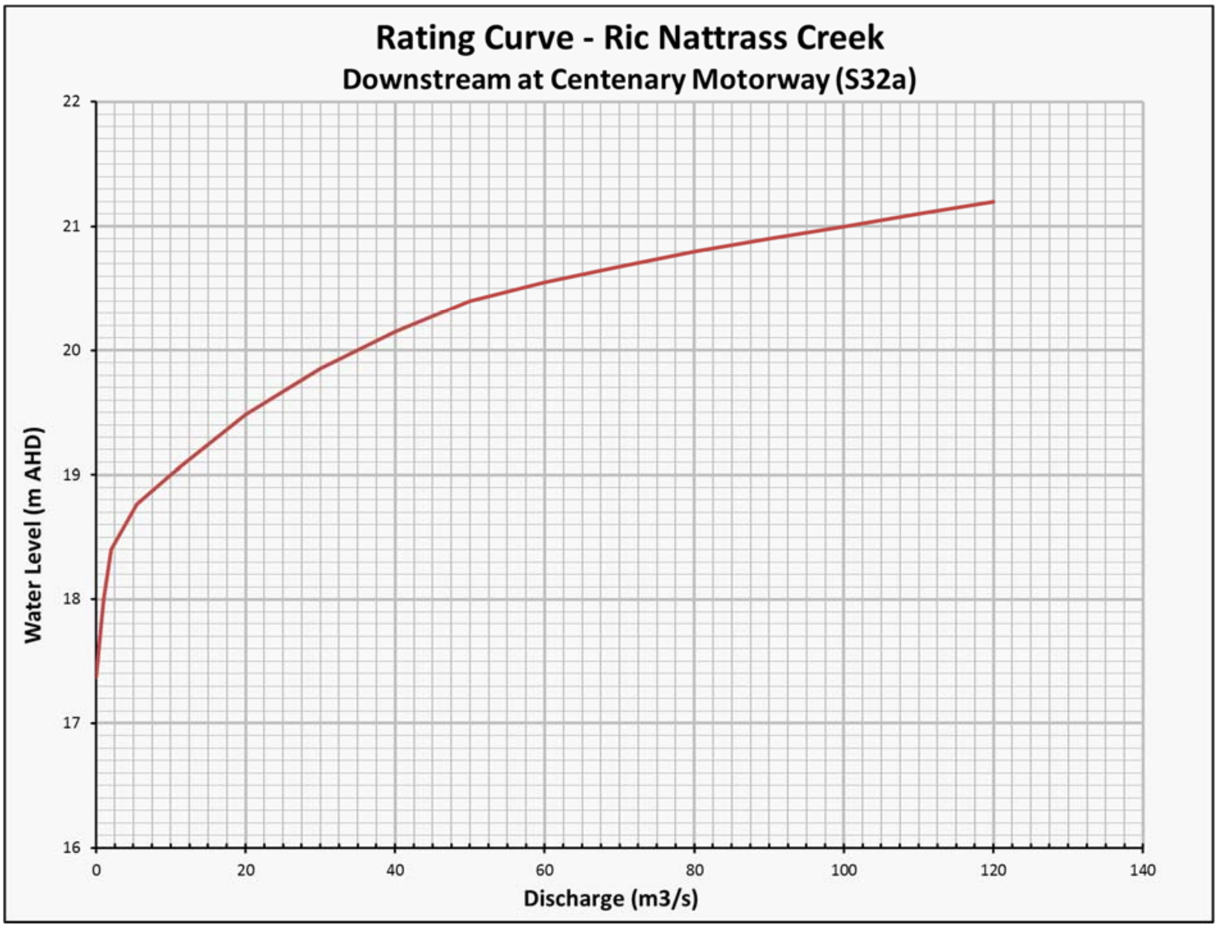
Rating Curve - Bullockhead Creek
Downstream of Ipswich Motorway (S13b)
Water Level (m AHD)
Discharge (m3/s)
18
17
16
15
14
13
12
11
10
0
50
100
150
200
250
300
350
400
450



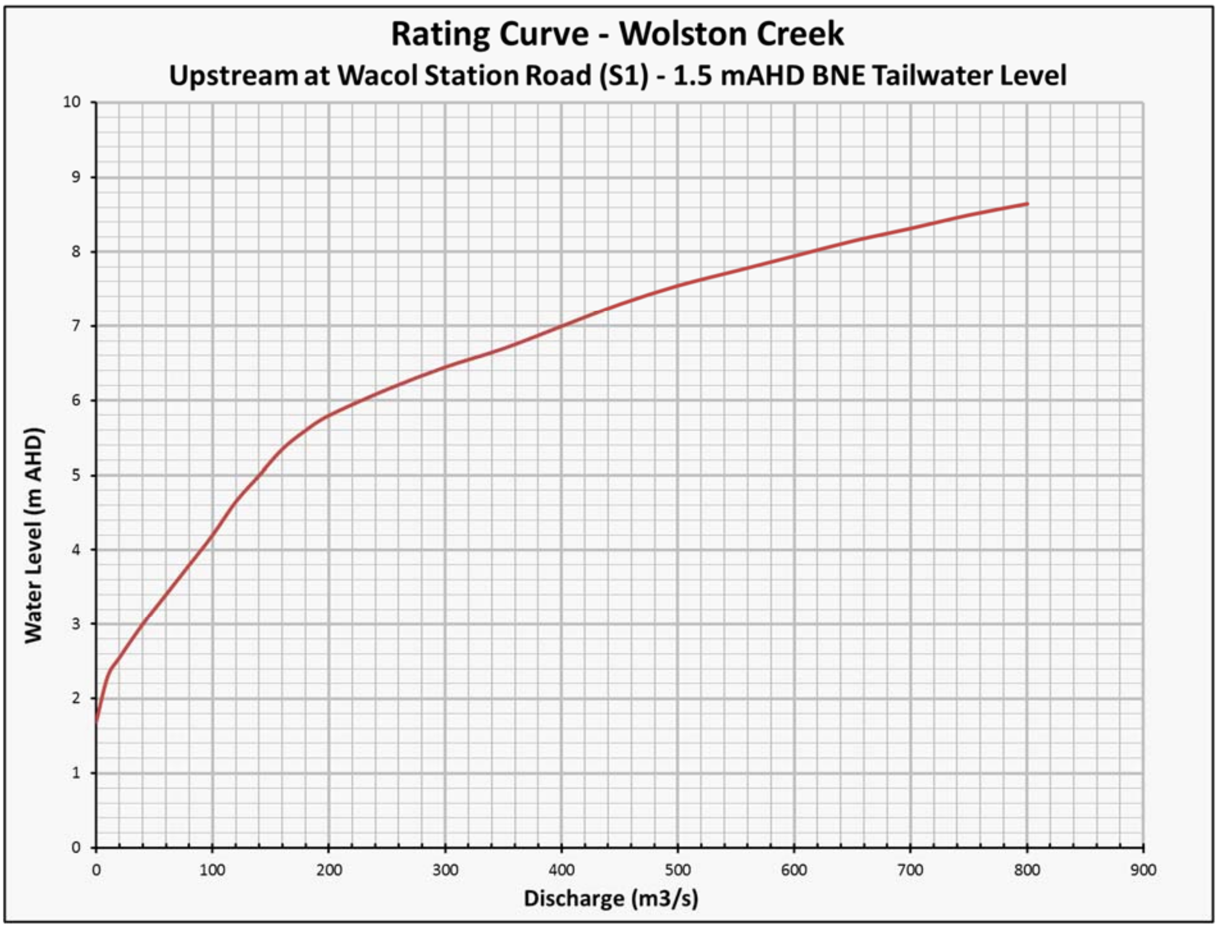
Rating Curve - Bullockhead Creek
Downstream at Ipswich Railway (S11)
Water Level (m AHD)
Discharge (m3/s)
14
13
12
11
10
9
8
7
6
0
50
100
150
200
250
300
350
400
450



Rating Curve - Ric Nattrass Creek
Downstream at Progress Road (S40)
Water Level (m AHD)
Discharge (m3/s)
43
42
41
40
0
5
10
15
20
25
30
35



Rating Curve - Ric Nattrass Creek
Downstream at Centenary Motorway (S32a)
Water Level (m AHD)
Discharge (m3/s)
22
21
20
19
18
17
16
0
20
40
60
80
100
120
140


Rating Curve - Wolston Creek
Upstream at Wacol Station Road (S1) - 1.5 mAHD BNE Tailwater Level
Water Level (m AHD)
Discharge (m3/s)
0
1
2
3
4
5
6
7
8
9
10
0
100
200
300
400
500
600
700
800
900

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Appendix M: Hydraulic Structure Reference Sheets

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Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Wacol Station Road Bridge

BCC Asset ID	B1900	Tributary Name	Wolston Creek
Owner	BCC	AMTD (m)	2560
Year of Construction	1985	Coordinates (GDA94)	E 492361 N 6950745
Year of Significant Modification	Currently being upgraded	Hydraulic Model ID	S1
Source of Structure Information	1996 HSRS + creek survey (2017)	Flood Model Representation	1d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\1 Wacol Station Road		

Structure Description		2 span concrete road bridge	
Bridges		**Culverts**	
Number of Spans	2	Number of Barrels	N/A
Number of Piers in Waterway	1	Dimensions (m)	N/A
Pier shape and Width (m)	0.45 Octagonal	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	-0.28	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 9.1	
Span Length (m)		17.64	
Lowest Level of Deck Soffit (m AHD)		3.53	
Lowest Level of Weir/Road (m AHD) (not including handrail)		4.5	
Average Handrail Height (m)		~ 0.7 (Armco)	

Image Description	Looking Downstream
Date	25th August 2016
Source	BCC Asset Management Records

Image Description	Looking Upstream
Date	25th August 2016
Source	BCC Asset Management Records

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				< 2-yr ARI (50 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	567.8	161.8	7.75	7.68	0.07	3.58	N/A	3
0.2	478.3	163.6	7.23	7.12	0.11	3.63	N/A	2
1	380.1	165.2	6.71	6.50	0.21	3.66	N/A	2
2	336.6	164.0	6.48	6.19	0.29	3.63	N/A	2
5	287.0	162.8	6.20	5.78	0.42	3.61	N/A	2
10	238.2	163.3	5.93	5.38	0.55	3.62	N/A	2
20	190.8	159.5	5.55	4.95	0.60	3.54	N/A	2
50	133.6	133.3	4.70	4.31	0.39	2.95	N/A	2

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Wolston Road Bridge

BCC Asset ID	B9784	Tributary Name	Sandy Creek
Owner	BCC	AMTD (m)	260
Year of Construction	2009	Coordinates (GDA94)	E 493177, N 6950475
Year of Significant Modification	Former bridge replaced in 2009	Hydraulic Model ID	S2
Source of Structure Information	2017 Detailed Survey	Flood Model Representation	1d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\2 Wolston Road - Sandy		

Structure Description		Single span concrete road bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	N/A	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	2.67	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 11.5	
Span Length (m)		23.9	
Lowest Level of Deck Soffit (m AHD)		9.62	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 11.01	
Average Handrail Height (m)		~ 0.85	

Image Description	Looking Downstream
Date	June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Image Description	Looking Upstream
Date	June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	290.8	290.8	8.90	8.62	0.28	3.46	0	2
0.2	247.4	247.4	8.45	8.21	0.24	3.38	0	2
1	196.9	196.9	7.88	7.70	0.18	3.28	0	2
2	172.6	172.6	7.62	7.47	0.15	3.21	0	2
5	155.2	155.2	7.31	7.19	0.12	2.99	0	2
10	132.2	132.2	7.00	6.91	0.09	2.90	0	2
20	108.2	108.2	6.61	6.55	0.06	2.96	0	1.5
50	76.2	76.2	6.25	6.23	0.02	3.01	0	2

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Ipswich Railway Bridge

BCC Asset ID	N/A	Tributary Name	Sandy Creek
Owner	Queensland Rail	AMTD (m)	2980
Year of Construction	Unknown	Coordinates (GDA94)	E 492874, N 6948909
Year of Significant Modification	N/A	Hydraulic Model ID	S3
Source of Structure Information	1996 HSRS + 2014 ALS	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\3 Ipswich Rail - Sandy		

Structure Description		Multi-cell box culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	8
Number of Piers in Waterway	N/A	Dimensions (m)	3.05 x 3.05
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	9.98
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	9.95
Structure Length (m) (in direction of flow)		~ 9.8	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		14.02	
Average Handrail Height (m)		N/A	

Image Description	N/A
Date	Pre 1996
Source	1996 HSRS

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	275.8	275.8	13.89	13.47	0.42	3.71	0	2
0.2	232.8	232.8	13.59	13.32	0.27	3.23	0	2
1	185.7	185.7	13.28	13.14	0.14	2.63	0	2
2	159.6	159.6	13.12	13.03	0.09	2.30	0	2
5	147.2	147.2	13.04	12.98	0.06	2.15	0	2
10	127.1	127.1	12.91	12.87	0.04	1.90	0	2
20	103.6	103.6	12.75	12.72	0.03	1.61	0	1.5
50	72.4	72.4	12.44	12.43	0.01	1.24	0	2

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Ipswich Motorway Bridges

BCC Asset ID	N/A	Tributary Name	Sandy Creek
Owner	DTMR	AMTD (m)	3200-3300
Year of Construction	Circa 2010	Coordinates (GDA94)	E 495086, N 6956468
Year of Significant Modification	N/A	Hydraulic Model ID	S4A & S4B
Source of Structure Information	DTMR design drawings	Flood Model Representation	2d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\4 Ipswich Motorway - Sandy		

Structure Description		L403 (Off Ramp) - Single span concrete bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	N/A	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 11.2	
Span Length (m)		25.05	
Lowest Level of Deck Soffit (m AHD)		15.64	
Lowest Level of Weir/Road (m AHD) (not including handrail)		18.01 (top of concrete barrier)	
Average Handrail Height (m)		N/A	

Structure Description		M104 (Outbound) - Single span concrete bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	N/A	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 22.4	
Span Length (m)		25.01	
Lowest Level of Deck Soffit (m AHD)		15.54	
Lowest Level of Weir/Road (m AHD) (not including handrail)		17.90 (top of concrete barrier)	
Average Handrail Height (m)		N/A	

Structure Description		M103 (Inbound) - Single span concrete bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	N/A	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 27.5	
Span Length (m)		25.02	
Lowest Level of Deck Soffit (m AHD)		15.76	
Lowest Level of Weir/Road (m AHD) (not including handrail)		18.12 (top of concrete barrier)	
Average Handrail Height (m)		N/A	

Structure Description		L402 (Ipswich Road) - Single span concrete bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	N/A	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 12	
Span Length (m)		25.05	
Lowest Level of Deck Soffit (m AHD)		15.22	
Lowest Level of Weir/Road (m AHD) (not including handrail)		17.58 (top of the barrier)	
Average Handrail Height (m)		N/A	

Structure Description		Pedestrian Bridge - Single span concrete bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	N/A	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 3.7	
Span Length (m)		24.7	
Lowest Level of Deck Soffit (m AHD)		12.95	
Lowest Level of Weir/Road (m AHD) (not including handrail)		14.94	
Average Handrail Height (m)		1.18	

Image Description	Looking Downstream
Date	27th June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Image Description	Looking Upstream
Date	27th June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	279.3	279.3	15.70	14.16	1.54	N/A	0	2
0.2	224.7	224.7	15.17	13.86	1.31	N/A	0	2
1	179.5	179.5	14.54	13.56	0.98	N/A	0	2
2	156.5	156.5	14.42	13.39	1.03	N/A	0	2
5	140.8	140.8	14.08	13.30	0.78	N/A	0	2
10	123.8	123.8	13.84	13.15	0.69	N/A	0	2
20	100.7	100.7	13.35	12.96	0.39	N/A	0	1.5
50	70.2	70.2	12.96	12.62	0.34	N/A	0	2

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Progress Road Bridge

BCC Asset ID	N/A	Tributary Name	Sandy Creek
Owner	DTMR	AMTD (m)	3725
Year of Construction	1991	Coordinates (GDA94)	E 492871, N 6948263
Year of Significant Modification	A footbridge has been added in 2016	Hydraulic Model ID	S5
Source of Structure Information	DTMR design drawings + creek survey (2017)	Flood Model Representation	1d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\5 Progress Road - Sandy		

Structure Description		Single span concrete bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	N/A	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	11.16	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 17.3	
Span Length (m)		23.9	
Lowest Level of Deck Soffit (m AHD)		14.27	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 15.75	
Average Handrail Height (m)		~ 1.3	

Image Description	Looking Downstream
Date	24th October 2017
Source	2017 site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				20-yr ARI (5 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	211.9	157.2	16.81	16.08	0.73	3.39	N/A	2
0.2	192.9	154.7	16.58	15.75	0.84	3.34	N/A	2
1	162.8	152.2	16.12	15.27	0.85	3.28	N/A	2
2	151.8	147.1	15.91	15.11	0.80	3.17	N/A	2
5	138.8	138.8	15.52	14.79	0.72	3.01	0	2
10	120.5	120.5	15.14	14.55	0.59	2.73	0	2
20	99.4	99.4	14.37	14.20	0.17	2.69	0	1.5
50	69.5	69.5	13.88	13.74	0.14	2.62	0	2

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Campbell Avenue Culvert

BCC Asset ID	C0081B	Tributary Name	Sandy Creek
Owner	BCC	AMTD (m)	4450
Year of Construction	1968	Coordinates (GDA94)	E 492713, N 6947592
Year of Significant Modification	Between 2007 and 2009 structure's downstream end has changed	Hydraulic Model ID	S7
Source of Structure Information	1996 HSRS + 2014 ALS	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\7 Campbell Avenue - Sandy		

Structure Description		Dual Carriageway multi-cell rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	6
Number of Piers in Waterway	N/A	Dimensions (m)	~ 3.05w x 2.7h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	13.49
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	13.61
Structure Length (m) (in direction of flow)		26.75	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 16.7	
Average Handrail Height (m)		~ 1	

Image Description	Looking Downstream
Date	24th October 2017
Source	2017 site inspection undertaken for flood study

Image Description	Looking Upstream
Date	24th October 2017
Source	2017 site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				20-yr ARI (5 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	246.9	183.5	18.11	17.79	0.32	3.72	N/A	2
0.2	211.9	179.8	17.92	17.61	0.31	3.64	N/A	2
1	168.9	158.3	17.55	17.32	0.23	3.20	N/A	2
2	148.7	143.9	17.34	17.16	0.18	2.91	N/A	2
5	126.4	126.4	17.09	16.97	0.12	2.56	0	2
10	107.1	107.1	16.85	16.78	0.07	2.17	0	2
20	87.4	87.4	16.55	16.51	0.04	1.77	0	1.5
50	60.2	60.2	16.12	16.11	0.01	1.34	0	2

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Formation Street Culvert

BCC Asset ID	C0080B	Tributary Name	Sandy Creek
Owner	BCC	AMTD (m)	5350
Year of Construction	1971	Coordinates (GDA94)	E 492790, N 6946715
Year of Significant Modification	N/A	Hydraulic Model ID	S9
Source of Structure Information	1996 HSRS + 2014 ALS	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\9 Formation Road - Sandy		

Structure Description		Multi-cell rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	6
Number of Piers in Waterway	N/A	Dimensions (m)	~ 3.05w x 2.78h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	19.35
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	19.34
Structure Length (m) (in direction of flow)		17.47	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 22.50	
Average Handrail Height (m)		0.98	

Image Description	Looking Downstream
Date	16th February 2010
Source	BCC Asset Management Records

Image Description	Looking Upstream
Date	24th October 2017
Source	2017 site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				100-yr ARI (1 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	240.0	208.7	23.40	20.66	2.74	6.84	N/A	2
0.2	197.2	193.4	23.12	20.47	2.65	5.07	N/A	2
1	155.6	155.6	22.48	20.12	2.36	4.53	0	2
2	137.1	137.1	22.23	19.93	2.30	4.34	0	2
5	115.5	115.5	21.92	19.69	2.23	4.10	0	2
10	97.4	97.4	21.64	19.45	2.19	3.87	0	2
20	80.3	80.3	21.37	19.21	2.16	3.63	0	1.5
50	54.8	54.8	20.91	18.77	2.14	3.20	0	2

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Spine Street Bridge

BCC Asset ID	B1111	Tributary Name	Bullockhead Creek
Owner	BCC	AMTD (m)	670
Year of Construction	1997	Coordinates (GDA94)	E 494631, N 6957622
Year of Significant Modification	N/A	Hydraulic Model ID	S10
Source of Structure Information	2017 survey	Flood Model Representation	2d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\10 Spine Street - Bullockhead		

Structure Description		Three Span Road Bridge	
Bridges		**Culverts**	
Number of Spans	3	Number of Barrels	N/A
Number of Piers in Waterway	2	Dimensions (m)	N/A
Pier shape and Width (m)	Cylinder, 0.75	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	~5	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 13.6	
Span Length (m)		~50	
Lowest Level of Deck Soffit (m AHD)		10.45	
Lowest Level of Weir/Road (m AHD) (not including handrail)		11.48	
Average Handrail Height (m)		1.02	

Image Description	Underneath the bridge
Date	30th May 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	293.1	293.1	9.33	9.22	0.11	N/A	0	2
0.2	249.5	249.5	9.00	8.89	0.11	N/A	0	2
1	201.3	201.3	8.64	8.53	0.11	N/A	0	2
2	181.0	181.0	8.49	8.38	0.11	N/A	0	2
5	153.3	153.3	8.28	8.18	0.10	N/A	0	2
10	131.0	131.0	8.11	8.01	0.09	N/A	0	2
20	107.9	107.9	7.92	7.84	0.09	N/A	0	2
50	75.3	75.3	7.64	7.57	0.08	N/A	0	2

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Ipswich Railway Culverts and Bridge

BCC Asset ID	N/A	Tributary Name	Bullockhead Creek
Owner	Queensland Rail	AMTD (m)	1560
Year of Construction	Unknown	Coordinates (GDA94)	E 494208, N 6950366
Year of Significant Modification	N/A	Hydraulic Model ID	S11
Source of Structure Information	1996 HSRS + 2014 ALS	Flood Model Representation	1d culvert / 2d weir 2d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\11 Railway1 - Bullockhead		

Structure Description		Multi-pipe Culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	6
Number of Piers in Waterway	N/A	Dimensions (m)	1.8 dia
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	6.68
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	6.52
Structure Length (m) (in direction of flow)		25.45	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 14.6	
Average Handrail Height (m)		N/A	

Structure Description		Single Span Bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	N/A	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	9.05	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~8.2	
Span Length (m)		9.34	
Lowest Level of Deck Soffit (m AHD)		~13.83	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~14.65	
Average Handrail Height (m)		~1	

Image Description	Looking Downstream at the culverts
Date	6th March 2018
Source	2018 site inspection undertaken for flood study

Image Description	Looking Upstream at the culverts
Date	6th March 2018
Source	2018 site inspection undertaken for flood study

Image Description	Looking Downstream at the bridge
Date	6th March 2018
Source	2018 site inspection undertaken for flood study

Image Description	Looking Upstream at the bridge
Date	6th March 2018
Source	2018 site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Culvert (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Culvert Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	290.5	104.1	13.99	11.10	2.89	6.82	0	2
0.2	246.8	96.8	13.32	10.87	2.45	6.35	0	2
1	197.3	87.3	12.53	10.59	1.94	5.72	0	2
2	176.4	83.1	12.20	10.45	1.75	5.44	0	2
5	149.5	78.0	11.77	10.25	1.52	5.11	0	2
10	127.1	71.7	11.33	10.07	1.26	4.70	0	2
20	104.4	66.2	10.92	9.87	1.05	4.34	0	2
50	72.9	57.7	10.28	9.50	0.78	3.78	0	2

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Sananada Street Culvert

BCC Asset ID	C2468P	Tributary Name	Bullockhead Creek
Owner	BCC	AMTD (m)	1690
Year of Construction	Unknown	Coordinates (GDA94)	E 494220, N 6950250
Year of Significant Modification	N/A	Hydraulic Model ID	S12
Source of Structure Information	1996 HSRS	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\12 Sananada Street - Bullockhead		

Structure Description		Twin pipe culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	2
Number of Piers in Waterway	N/A	Dimensions (m)	1.5 dia
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	7.44
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	7.39
Structure Length (m) (in direction of flow)		10	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 9.32	
Average Handrail Height (m)		N/A	

Image Description	Looking Downstream
Date	Unknown
Source	1996 HSRS

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				< 2-yr ARI (50 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	284.7	13.8	14.00	13.99	0.01	3.90	N/A	2
0.2	242.7	13.8	13.33	13.32	0.01	3.92	N/A	2
1	194.0	13.9	12.55	12.54	0.01	3.94	N/A	2
2	173.2	13.9	12.21	12.21	0.01	3.94	N/A	2
5	148.0	13.9	11.79	11.78	0.01	3.94	N/A	2
10	125.9	13.9	11.36	11.35	0.01	3.94	N/A	2
20	102.7	13.9	10.96	10.94	0.02	3.95	N/A	2
50	71.3	14.3	10.37	10.31	0.06	4.06	N/A	2

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Ipswich Motorway Bridge

BCC Asset ID	N/A	Tributary Name	Bullockhead Creek
Owner	DTMR	AMTD (m)	2800-2900
Year of Construction	Circa 2010	Coordinates (GDA94)	E 493825, N 6949310
Year of Significant Modification	N/A	Hydraulic Model ID	S13A & S13B
Source of Structure Information	DTMR design drawings	Flood Model Representation	2d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\13 Ipswich Motorway - Bullockhead		

Structure Description		M101 (Inbound) – Two span concrete bridge	
Bridges		**Culverts**	
Number of Spans	2	Number of Barrels	N/A
Number of Piers in Waterway	1	Dimensions (m)	N/A
Pier shape and Width (m)	Rectangle, 0.9 x2	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	11.13	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~21.7	
Span Length (m)		~69	
Lowest Level of Deck Soffit (m AHD)		22.61	
Lowest Level of Weir/Road (m AHD) (not including handrail)		25.769 (top of concrete barrier)	
Average Handrail Height (m)		N/A	

Structure Description		M102 (Outbound) – Two span concrete bridge	
Bridges		**Culverts**	
Number of Spans	2	Number of Barrels	N/A
Number of Piers in Waterway	1	Dimensions (m)	N/A
Pier shape and Width (m)	Rectangle, 0.9 x2	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	11.13	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~32.5-46.5	
Span Length (m)		~69	
Lowest Level of Deck Soffit (m AHD)		21.23	
Lowest Level of Weir/Road (m AHD) (not including handrail)		24.428 (top of concrete barrier)	
Average Handrail Height (m)		N/A	

Structure Description		L401 (Ipswich Road) – Single Span Bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	N/A	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	12.09	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~15	
Span Length (m)		29.34	
Lowest Level of Deck Soffit (m AHD)		15.45	
Lowest Level of Weir/Road (m AHD) (not including handrail)		18.407 (top of concrete barrier)	
Average Handrail Height (m)		N/A	

Image Description	Looking Downstream – view through one of the spans
Date	5th June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Image Description	Looking Upstream – view through one of the spans
Date	2nd June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				Motorway Bridges: > 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	282.4	282.4	16.18	15.33	0.85	N/A	N/A	1.5
0.2	226.2	226.2	15.85	15.09	0.76	N/A	N/A	1.5
1	171.8	171.8	15.38	14.81	0.57	N/A	N/A	1.5
2	150.8	150.8	15.19	14.69	0.50	N/A	N/A	1.5
5	120.9	120.9	14.91	14.49	0.42	N/A	N/A	1.5
10	100.7	100.7	14.67	14.33	0.35	N/A	N/A	1.5
20	83.4	83.4	14.49	14.16	0.32	N/A	N/A	1.5
50	57.4	57.4	14.18	13.86	0.32	N/A	N/A	1.5

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Army Barracks Bridge

BCC Asset ID	N/A	Tributary Name	Bullockhead Creek
Owner	Private	AMTD (m)	3370
Year of Construction	Unknown	Coordinates (GDA94)	E 493912, N 6948852
Year of Significant Modification	N/A	Hydraulic Model ID	S14
Source of Structure Information	1996 Survey	Flood Model Representation	1d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\14 Army Barracks - Bullockhead		

Structure Description		Three span private bridge	
Bridges		**Culverts**	
Number of Spans	3	Number of Barrels	N/A
Number of Piers in Waterway	2	Dimensions (m)	N/A
Pier shape and Width (m)	cylinder	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	12.07	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		6.69	
Span Length (m)		19.15	
Lowest Level of Deck Soffit (m AHD)		16.08	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 16.90	
Average Handrail Height (m)		~ 1m	

Image Description	Looking Downstream
Date	5th June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				50-yr ARI (2 % AEP) – Bridge deck 5-yr ARI (20 % AEP) – Approach Road				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	277.2	137.5	17.47	17.20	0.27	3.32	N/A	1.5
0.2	222.3	135.3	17.25	16.92	0.33	3.27	N/A	1.5
1	168.5	130.8	16.99	16.64	0.35	3.16	N/A	1.5
2	147.8	126.9	16.85	16.53	0.32	3.07	N/A	1.5
5	119.4	114.7	16.59	16.34	0.24	2.77	N/A	1.5
10	99.2	99.2	16.35	16.20	0.15	2.40	N/A	1.5
20	82.6	82.6	16.15	16.05	0.11	2.05	N/A	1.5
50	57.0	57.0	15.79	15.77	0.02	1.62	N/A	1.5

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Boundary Road

BCC Asset ID	B9389	Tributary Name	Bullockhead Creek
Owner	BCC	AMTD (m)	3700
Year of Construction	2016	Coordinates (GDA94)	E 493813, N 6948562
Year of Significant Modification	N/A	Hydraulic Model ID	S15
Source of Structure Information	Design drawings	Flood Model Representation	2d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\15 Boundary - Bullockhead		

Structure Description		Five Span Road Bridge	
Bridges		**Culverts**	
Number of Spans	5	Number of Barrels	N/A
Number of Piers in Waterway	4	Dimensions (m)	N/A
Pier shape and Width (m)	Cylinder, 1.2m	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	15.72	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 15.5	
Span Length (m)		~98	
Lowest Level of Deck Soffit (m AHD)		19.28	
Lowest Level of Weir/Road (m AHD) (not including handrail)		20.72	
Average Handrail Height (m)		~1.3	

Image Description	Looking Downstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	277.2	277.2	18.66	18.53	0.13	N/A	0	1.5
0.2	222.3	222.3	18.37	18.29	0.08	N/A	0	1.5
1	168.5	168.5	18.11	18.04	0.07	N/A	0	1.5
2	147.8	147.8	18.00	17.93	0.07	N/A	0	1.5
5	119.4	119.4	17.87	17.75	0.12	N/A	0	1.5
10	98.8	98.8	17.76	17.62	0.13	N/A	0	1.5
20	82.1	82.1	17.65	17.51	0.14	N/A	0	1.5
50	55.2	55.2	17.43	17.29	0.14	N/A	0	1.5

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Progress Road Culvert

BCC Asset ID	C0082B	Tributary Name	Bullockhead Creek
Owner	BCC	AMTD (m)	4770
Year of Construction	1973	Coordinates (GDA94)	E 494034, N 6947652
Year of Significant Modification	N/A	Hydraulic Model ID	S17
Source of Structure Information	1996 survey	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\17 Progress Road - Bullockhead		

Structure Description		Multi-cell rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	5
Number of Piers in Waterway	N/A	Dimensions (m)	2.74w x 2.34h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	18.11
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	18.06
Structure Length (m) (in direction of flow)		10.09	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 21.5	
Average Handrail Height (m)		Varies in height	

Image Description	Looking Downstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Image Description	Looking Upstream
Date	14th October 2015
Source	BCC Asset Management Records

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				20-yr ARI (5 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	265.0	159.2	23.04	22.00	1.04	8.27	N/A	1
0.2	212.9	154.1	22.78	21.76	1.02	8.01	N/A	1
1	162.3	143.9	22.37	21.49	0.88	7.48	N/A	1
2	142.5	136.0	22.13	21.38	0.75	5.66	N/A	1
5	120.6	120.6	21.52	21.24	0.28	3.76	0	1
10	100.4	100.4	21.23	21.09	0.14	3.13	0	1
20	82.4	82.4	20.99	20.93	0.06	2.57	0	1
50	55.3	55.3	20.68	20.67	0.01	1.72	0	1

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Coulson Street Culvert

BCC Asset ID	C0329B	Tributary Name	Bullockhead Creek
Owner	BCC	AMTD (m)	5580
Year of Construction	Unknown	Coordinates (GDA94)	E 494263, N 6946919
Year of Significant Modification	N/A	Hydraulic Model ID	S18
Source of Structure Information	1996 HSRS + 2014 ALS	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\18 Coulson Street - Bullockhead		

Structure Description		Multi-cell rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	5
Number of Piers in Waterway	N/A	Dimensions (m)	2.13w x 1.35h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	21.32
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	21.29
Structure Length (m) (in direction of flow)		22.1	
Span Length (m)		Unknown	
Lowest Level of Deck Soffit (m AHD)		22.67	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~23.5	
Average Handrail Height (m)		0.7 armco	

Image Description	Looking Downstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Image Description	Looking upstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				< 2-yr ARI (50 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	248.8	62.1	25.76	25.26	0.50	5.20	N/A	1
0.2	200.8	62.6	25.51	25.01	0.50	5.25	N/A	1
1	153.4	61.6	25.22	24.71	0.51	5.30	N/A	1
2	135.7	61.1	25.10	24.58	0.52	5.33	N/A	1
5	113.6	60.4	24.95	24.41	0.54	4.20	N/A	1
10	94.4	59.5	24.79	24.24	0.55	4.14	N/A	1
20	79.1	58.6	24.65	24.09	0.56	4.07	N/A	1
50	53.3	51.6	24.20	23.73	0.47	3.59	N/A	1

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Centenary Motorway + Railway Bridge

BCC Asset ID	N/A	Tributary Name	Bullockhead Creek
Owner	DMTR/QR	AMTD (m)	5925-6050
Year of Construction	Railway ~2013 Centenary ~2010	Coordinates (GDA94)	E 494488, N 6946605
Year of Significant Modification	N/A	Hydraulic Model ID	S19A & S19B
Source of Structure Information	Design drawings	Flood Model Representation	2d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\19A Centenary Motorway - Bullockhead G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\19B Railway2 - Bullockhead		

Structure Description		Three Span Railway Bridge	
Bridges		**Culverts**	
Number of Spans	3	Number of Barrels	N/A
Number of Piers in Waterway	2	Dimensions (m)	N/A
Pier shape and Width (m)	Cylinder, 1.2	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	23.4	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 11	
Span Length (m)		85.9	
Lowest Level of Deck Soffit (m AHD)		30.53	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 33	
Average Handrail Height (m)		There are noise walls	

Structure Description		Three Span Motorway Bridge	
Bridges		**Culverts**	
Number of Spans	3	Number of Barrels	N/A
Number of Piers in Waterway	2	Dimensions (m)	N/A
Pier shape and Width (m)	Cylinder, 1.2	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	23.81	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 38.5	
Span Length (m)		~84.8	
Lowest Level of Deck Soffit (m AHD)		30.0	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 33.60 (including concrete barrier)	
Average Handrail Height (m)		N/A	

Image Description	Looking Upstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Image Description	Looking Downstream
Date	6th June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	248.4	248.4	28.49	27.36	1.13	N/A	0	1
0.2	198.7	198.7	28.27	27.11	1.16	N/A	0	1
1	151.3	151.3	27.96	26.76	1.20	N/A	0	1
2	133.8	133.8	27.83	26.65	1.18	N/A	0	1
5	112.3	112.3	27.62	26.52	1.11	N/A	0	1
10	93.4	93.4	27.48	26.40	1.08	N/A	0	1
20	78.8	78.8	27.30	26.28	1.02	N/A	0	1
50	54.7	54.7	26.89	26.06	0.82	N/A	0	1

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Waterford Road Culvert

BCC Asset ID	C0083B	Tributary Name	Bullockhead Creek
Owner	BCC	AMTD (m)	7040
Year of Construction	1975	Coordinates (GDA94)	E 494810, N 6945761
Year of Significant Modification	N/A	Hydraulic Model ID	S20
Source of Structure Information	1996 HSRS + 2014 ALS	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\20 Waterford Road - Bullockhead		

Structure Description		Multi-cell rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	4
Number of Piers in Waterway	N/A	Dimensions (m)	3.04w x 2.4h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	28.97
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	28.96
Structure Length (m) (in direction of flow)		10.06	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 33	
Average Handrail Height (m)		1.2m	

Image Description	Looking Downstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Image Description	Looking Upstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				20-yr ARI (5 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	182.7	128.2	33.14	32.14	1.00	7.32	N/A	1
0.2	148.8	121.9	32.88	31.97	0.91	6.96	N/A	1
1	113.8	108.2	32.35	31.76	0.59	6.18	N/A	1
2	99.8	98.8	32.07	31.66	0.41	4.70	N/A	1
5	83.2	83.2	31.73	31.52	0.21	3.37	0	1
10	69.1	69.1	31.49	31.38	0.11	2.80	0	1
20	59.8	59.8	31.35	31.27	0.08	2.46	0	1
50	40.4	40.4	30.96	30.92	0.04	1.87	0	1

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Roxwell Street Culvert

BCC Asset ID	C1383B	Tributary Name	Bullockhead Creek
Owner	BCC	AMTD (m)	8475
Year of Construction	Unknown	Coordinates (GDA94)	E 494422, N 6944565
Year of Significant Modification	N/A	Hydraulic Model ID	S26
Source of Structure Information	2017 survey	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\26 Roxwell Street - Bullockhead		

Structure Description		Multi-cell slabbed linked rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	5
Number of Piers in Waterway	N/A	Dimensions (m)	3/2.4w x 1.8h + 2/2.4w x 2h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	37.19
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	37.12
Structure Length (m) (in direction of flow)		~ 13.7	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 40.33	
Average Handrail Height (m)		0.6m concrete barrier + 0.7m Armco	

Image Description	Looking Downstream
Date	23rd June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Image Description	Looking Upstream
Date	23rd June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Link to Flood Model Results	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				100-yr ARI (1 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	109.2	93.4	40.75	39.55	1.20	7.0	N/A	0.5
0.2	89.3	85.0	40.34	39.40	0.94	6.4	N/A	0.5
1	68.6	68.6	39.65	39.20	0.45	5.2	0	0.5
2	59.6	59.6	39.43	39.11	0.32	3.8	0	0.5
5	48.8	48.8	39.22	38.99	0.23	2.7	0	0.5
10	40.9	40.9	39.04	38.89	0.15	2.3	0	0.5
20	33.2	33.2	38.89	38.78	0.11	1.9	0	1
50	22.1	22.1	38.66	38.61	0.05	1.7	0	1

[1] *Flow underneath the road and only for 1D structures*

[2] *Measured at centre-span of bridge or at centre of culvert*

[3] *This is afflux at peak water level*

[4] *(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5] *(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6] *Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7] *Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Cardwell Street Culvert

BCC Asset ID	C0322B	Tributary Name	Scott Creek
Owner	BCC	AMTD (m)	420
Year of Construction	1995	Coordinates (GDA94)	E 494914, N 6946550
Year of Significant Modification	N/A	Hydraulic Model ID	S24
Source of Structure Information	Design Drawings	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\24 Cardwell Street - Scott Creek		

Structure Description		Single cell rectangular culvert with low flow	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	1
Number of Piers in Waterway	N/A	Dimensions (m)	3.6w x 2.4h with low flow channel
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	~ 33.85
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	~ 33.65
Structure Length (m) (in direction of flow)		~ 6.5	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 37.5	
Average Handrail Height (m)		1	

Image Description	Looking Downstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Looking Upstream	Looking Upstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj17\170300_Wolston_Creek_Flood_Study\Flood Management\Calculations\Flood Management\Tuflow\results\S1_DES
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	13.3	13.3	35.89	34.60	1.29	3.65	0	0.5
0.2	11.8	11.8	35.75	34.52	1.23	3.53	0	0.5
1	9.8	9.9	35.56	34.39	1.17	3.35	0	0.5
2	8.9	8.9	35.47	34.31	1.16	3.26	0	0.5
5	7.1	7.1	35.28	34.15	1.13	3.06	0	0.5
10	6.1	6.1	35.16	34.05	1.11	2.93	0	0.5
20	5.1	5.1	35.05	33.91	1.14	2.80	0	0.5
50	3.5	3.5	34.84	33.65	1.19	2.54	0	0.5

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Signac Close Timber Pedestrian Bridge

BCC Asset ID	PB030	Tributary Name	Scott Creek
Owner	BCC	AMTD (m)	750
Year of Construction	N/A	Coordinates (GDA94)	E 495231, N 6946573
Year of Significant Modification	N/A	Hydraulic Model ID	S25
Source of Structure Information	Field measurements	Flood Model Representation	1d bridge / 1d weir
Link to Data Source	N/A		

Structure Description		Timber pedestrian bridge	
Bridges		**Culverts**	
Number of Spans	3	Number of Barrels	N/A
Number of Piers in Waterway	2	Dimensions (m)	N/A
Pier shape and Width (m)	Cylinder	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	43.32	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 2.4	
Span Length (m)		~12.2	
Lowest Level of Deck Soffit (m AHD)		~47.9	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 48.3	
Average Handrail Height (m)		1.2	

Image Description	Looking in the downstream direction
Date	24th October 2017
Source	Site inspection undertaken for flood study

Image Description	Looking in the upstream direction
Date	24th October 2017
Source	Site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj17\170300_Wolston_Creek_Flood_Study\Flood Management\Calculations\Flood Management\Tuflow\results\S1_DES
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)	> 2000-yr ARI (0.05 % AEP)

AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	15.2	15.2	45.27	45.14	0.13	6.2	0	0.5
0.2	12.6	12.6	44.34	44.07	0.27	4.9	0	0.5
1	10.3	10.3	44.24	43.98	0.26	4.7	0	0.5
2	9.1	9.1	44.17	43.92	0.25	4.6	0	0.5
5	7.1	7.1	44.05	43.81	0.24	4.3	0	0.5
10	6.1	6.1	43.98	43.75	0.23	4.2	0	0.5
20	5.4	5.4	43.94	43.71	0.23	4.1	0	0.5
50	3.5	3.5	43.79	43.58	0.21	3.7	0	0.5

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Woodvale Crescent Culverts

BCC Asset ID	C2317B	Tributary Name	Spinks Creek
Owner	BCC	AMTD (m)	1060
Year of Construction	2004	Coordinates (GDA94)	E 495076, N 6943821
Year of Significant Modification	N/A	Hydraulic Model ID	S23
Source of Structure Information	Design Drawings	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\23 Woodvale Cres - Spinks		

Structure Description		Two cell rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	2
Number of Piers in Waterway	N/A	Dimensions (m)	2.7w x 1.2h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	52.2
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	52.15
Structure Length (m) (in direction of flow)		13.2	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		54.55	
Average Handrail Height (m)		N/A	

Image Description	Looking Downstream – Inlet Structure
Date	24th October 2017
Source	Site inspection undertaken for flood study

Image Description	Looking Upstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj17\170300_Wolston_Creek_Flood_Study\Flood Management\Calculations\Flood Management\Tuflow\results\S1_DES
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	14.3	14.3	53.76	52.97	0.79	2.77	0	0.5
0.2	11.9	11.9	53.53	52.87	0.66	2.67	0	0.5
1	9.3	9.3	53.33	52.78	0.55	2.47	0	0.5
2	8.1	8.1	53.23	52.73	0.50	2.36	0	0.5
5	6.7	6.7	53.11	52.66	0.45	2.23	0	0.5
10	5.6	5.6	53.01	52.61	0.40	2.10	0	0.5
20	4.4	4.4	52.88	52.58	0.30	1.94	0	0.5
50	2.9	2.9	52.71	52.49	0.22	1.74	0	0.5

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Roxwell Street Culvert

BCC Asset ID	C2307B	Tributary Name	Spinks Creek
Owner	BCC	AMTD (m)	280
Year of Construction	Circa 2001	Coordinates (GDA94)	E 494731, N 6944503
Year of Significant Modification	N/A	Hydraulic Model ID	S21
Source of Structure Information	Site measurements + 2014 ALS	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\21 Roxwell Street - Spinks		

Structure Description		Multi-cell rectangular culvert with inlet control weirs	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	3
Number of Piers in Waterway	N/A	Dimensions (m)	1 / 2.4w x 2.4h 2 / 2.4w x 1.8h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	~ 41.06 (v-notch) ~ 42.46 (rect. weir)
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	~ 40.68 (low flow) ~ 41.24
Structure Length (m) (in direction of flow)		~ 18	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 43.9	
Average Handrail Height (m)		Armco (0.7) + tubular handrail	

Image Description	Looking Downstream – Inlet Structure
Date	24th October 2017
Source	Site inspection undertaken for flood study

Image Description	Looking Upstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj17\170300_Wolston_Creek_Flood_Study\Flood Management\Calculations\Flood Management\Tuflow\results\S1_DES
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				100-yr ARI (1 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	34.2	30.6	44.39	41.73	2.66	4.0	N/A	0.5
0.2	28.8	27.8	44.22	41.67	2.55	3.9	N/A	0.5
1	22.7	22.7	43.92	41.59	2.33	3.6	0	0.5
2	20.0	20.0	43.77	41.56	2.21	3.5	0	0.5
5	16.1	16.1	43.59	41.50	2.09	3.3	0	0.5
10	13.7	13.7	43.41	41.47	1.94	3.1	0	0.5
20	11.0	11.0	43.26	41.39	1.87	3.0	0	0.5
50	7.0	7.0	42.99	41.23	1.76	2.7	0	1

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Progress Road Culverts

BCC Asset ID	C0239B	Tributary Name	Ric Nattrass Creek
Owner	BCC	AMTD (m)	3130
Year of Construction	N/A	Coordinates (GDA94)	E 495082, N 6947413
Year of Significant Modification	N/A	Hydraulic Model ID	S40
Source of Structure Information	Design Drawings	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\40 Progress Road - Ric Nattrass Creek		

Structure Description		Multi-cell slab linked rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	3
Number of Piers in Waterway	N/A	Dimensions (m)	1.8w x 1.2h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	40.83
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	40.5
Structure Length (m) (in direction of flow)		37.2	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~43.13	
Average Handrail Height (m)		N/A	

Image Description	Looking Downstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Image Description	Looking Upstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj17\170300_Wolston_Creek_Flood_Study\Flood Management\Calculations\Flood Management\Tuflow\results\S1_DES
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				500-yr ARI (0.2 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	25.9	23.8	43.46	41.94	1.52	6.12	N/A	0.5
0.2	21.4	21.4	43.10	41.88	1.22	5.51	0	0.5
1	17.3	17.3	42.56	41.82	0.74	4.45	0	0.5
2	15.4	15.4	42.35	41.78	0.57	3.95	0	0.5
5	12.3	12.3	42.13	41.71	0.42	2.92	0	0.5
10	10.5	10.5	42.00	41.66	0.34	2.77	0	0.5
20	8.8	8.8	41.87	41.60	0.27	2.61	0	0.5
50	5.7	5.7	41.61	41.47	0.14	2.26	0	0.5

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Pine Road Culverts

BCC Asset ID	C7782B	Tributary Name	Ric Nattrass Creek
Owner	BCC	AMTD (m)	2695
Year of Construction	2014	Coordinates (GDA94)	E 495206, N 6947827
Year of Significant Modification	N/A	Hydraulic Model ID	S39
Source of Structure Information	Design Drawings	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\39 Pine Road - Ric Nattrass Creek		

Structure Description		Multi-cell rectangular culvert + downstream weir	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	2
Number of Piers in Waterway	N/A	Dimensions (m)	3w x 1.5h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	29.05
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	28.94
Structure Length (m) (in direction of flow)		26.4	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 31.36	
Average Handrail Height (m)		None – fence only	

Image Description	Looking Downstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Image Description	Looking Upstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj17\170300_Wolston_Creek_Flood_Study\Flood Management\Calculations\Flood Management\Tuflow\results\S1_DES
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				5-yr ARI (20 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	46.1	21.1	32.01	30.04	1.97	2.34	N/A	0.5
0.2	39.2	20.6	31.93	29.95	1.98	2.29	N/A	0.5
1	30.9	20.0	31.81	29.81	2.00	2.22	N/A	0.5
2	27.1	19.5	31.74	29.73	2.01	2.17	N/A	0.5
5	22.4	18.8	31.64	29.61	2.03	2.09	N/A	0.5
10	18.8	17.9	31.52	29.50	2.02	1.99	N/A	0.5
20	15.2	15.2	31.32	29.37	1.95	1.69	0	0.5
50	10.4	10.4	30.98	29.16	1.82	1.16	0	0.5

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Railway Line and Pedestrian Bridge

BCC Asset ID	N/A	Tributary Name	Ric Nattrass Creek
Owner	Queensland Rail	AMTD (m)	1700
Year of Construction	2010	Coordinates (GDA94)	E 494891, N 6948690
Year of Significant Modification	N/A	Hydraulic Model ID	S32B & S32C
Source of Structure Information	QR Design Drawings	Flood Model Representation	2d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\32A - 32C Centenary Motorway - Ric Nattrass Creek		

Structure Description		Two Span Pedestrian Bridge	
Bridges		**Culverts**	
Number of Spans	2	Number of Barrels	N/A
Number of Piers in Waterway	1	Dimensions (m)	N/A
Pier shape and Width (m)	Cylinder, 1.2	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	18.31	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~4	
Span Length (m)		~63.8	
Lowest Level of Deck Soffit (m AHD)		~21.8	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~23.6	
Average Handrail Height (m)		1.3	

Structure Description		Three Span Railway Bridge	
Bridges		**Culverts**	
Number of Spans	3	Number of Barrels	N/A
Number of Piers in Waterway	2	Dimensions (m)	N/A
Pier shape and Width (m)	Cylinder, 1.2	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	~18.13	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~10.7	
Span Length (m)		~80.8	
Lowest Level of Deck Soffit (m AHD)		~21.6	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~23.82	
Average Handrail Height (m)		1	

Image Description	Looking Downstream at Railway Bridge
Date	24th October 2017
Source	Site inspection undertaken for flood study

Link to Flood Model Results	G:\BI\CD\Proj17\170300_Wolston_Creek_Flood_Study\Flood Management\Calculations\Flood Management\Tuflow\results\S1_DES
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	93.2	93.2	21.63	21.47	0.16	N/A	0	0.5
0.2	82.3	82.3	21.27	21.11	0.16	N/A	0	0.5
1	60.7	60.7	20.86	20.65	0.21	N/A	0	0.5
2	54.2	54.2	20.66	20.48	0.17	N/A	0	0.5
5	44.5	44.5	20.41	20.17	0.24	N/A	0	0.5
10	37.2	37.2	20.14	19.95	0.19	N/A	0	0.5
20	30.5	30.5	19.95	19.77	0.19	N/A	0	0.5
50	20.4	20.4	19.67	19.43	0.23	N/A	0	0.5

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Centenary Motorway Culverts

BCC Asset ID	N/A	Tributary Name	Ric Nattrass Creek
Owner	DTMR	AMTD (m)	1645
Year of Construction	2010	Coordinates (GDA94)	E 494848, N 6948733
Year of Significant Modification	N/A	Hydraulic Model ID	S32A
Source of Structure Information	DTMR Design Drawings	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\32A - 32C Centenary Motorway - Ric Nattrass Creek\Culvert		

Structure Description		Multi-pipe culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	9
Number of Piers in Waterway	N/A	Dimensions (m)	1.95 dia
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	17.60
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	17.37
Structure Length (m) (in direction of flow)		~42	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		Varies	
Average Handrail Height (m)		~1.75 (including concrete barrier & chain wire)	

Link to Flood Model Results	G:\BI\CD\Proj17\170300_Wolston_Creek_Flood_Study\Flood Management\Calculations\Flood Management\Tuflow\results\S1_DES
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	92.8	92.8	21.50	20.90	0.60	3.46	0	0.5
0.2	78.7	78.7	21.14	20.72	0.42	2.93	0	0.5
1	59.7	59.7	20.68	20.45	0.23	2.22	0	0.5
2	53.9	53.9	20.51	20.33	0.18	2.04	0	0.5
5	44.2	44.2	20.20	20.08	0.12	1.65	0	0.5
10	36.9	36.9	19.98	19.89	0.09	1.37	0	0.5
20	30.3	30.3	19.79	19.73	0.06	1.13	0	0.5
50	20.4	20.4	19.47	19.44	0.03	0.95	0	0.5

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Boundary Road Culverts

BCC Asset ID	C0793P	Tributary Name	Ric Nattrass Creek
Owner	BCC	AMTD (m)	1260
Year of Construction	N/A	Coordinates (GDA94)	E 494602, N 6949014
Year of Significant Modification	N/A	Hydraulic Model ID	S31
Source of Structure Information	Design Drawings	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\31 Boundary Road - Ric Nattrass Creek		

Structure Description		Multi-pipe culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	4
Number of Piers in Waterway	N/A	Dimensions (m)	1.95 dia
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	16.55
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	16.37
Structure Length (m) (in direction of flow)		30	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		N/A	
Average Handrail Height (m)		N/A	

Image Description	Looking Upstream
Date	24th October 2017
Source	Site inspection undertaken for flood study

Image Description	Looking Downstream
Date	6th September 2017
Source	Asset Management Records

Link to Flood Model Results	G:\BI\CD\Proj17\170300_Wolston_Creek_Flood_Study\Flood Management\Calculations\Flood Management\Tuflow\results\S1_DES
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				10-yr ARI (10 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	129.5	64.3	20.56	18.35	2.21	5.38	N/A	0.5
0.2	106.6	60.1	20.41	18.14	2.27	5.04	N/A	0.5
1	78.8	56.4	20.18	17.88	2.30	4.73	N/A	0.5
2	67.9	54.6	20.07	17.78	2.29	4.57	N/A	0.5
5	51.8	50.4	19.82	17.58	2.24	4.22	N/A	0.5
10	45.2	45.2	19.51	17.45	2.06	3.78	0	0.5
20	38.5	38.5	19.17	17.33	1.84	3.69	0	1
50	27.4	27.4	18.51	17.07	1.44	3.34	0	1

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Bakery Road and Ipswich Motorway On Ramp

BCC Asset ID	N/A	Tributary Name	Ric Nattrass Creek
Owner	DTMR	AMTD (m)	2695
Year of Construction	2010	Coordinates (GDA94)	E 494348, N 6949317
Year of Significant Modification	N/A	Hydraulic Model ID	S30
Source of Structure Information	DTMR Design Drawings	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\30 Bakery Road - Ric Nattrass Creek		

Structure Description		Classic Arch Culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	1
Number of Piers in Waterway	N/A	Dimensions (m)	~15 width
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	12.8
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	12.36
Structure Length (m) (in direction of flow)		50.4	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		Varies	
Average Handrail Height (m)		Varies (concrete barrier, Armco, wire mesh fence)	

Structure Description		Multi-cell box culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	3
Number of Piers in Waterway	N/A	Dimensions (m)	1.5w x 1.5h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	12.82
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	12.41
Structure Length (m) (in direction of flow)		84	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		Varies	
Average Handrail Height (m)		Varies (concrete barrier, Armco, wire mesh fence)	

Image Description	Looking Downstream
Date	1st June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Image Description	Looking Upstream
Date	1st June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Link to Flood Model Results	G:\BI\CD\Proj17\170300_Wolston_Creek_Flood_Study\Flood Management\Calculations\Flood Management\Tuflow\results\S1_DES
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Box Culvert (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Box Culvert Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	125.7	33.5	17.36	15.33	2.04	4.97	0	0.5
0.2	107.2	30.5	16.83	15.17	1.66	4.52	0	0.5
1	85.3	29.2	16.52	14.99	1.53	4.32	0	0.5
2	68.1	25.2	15.96	14.85	1.11	3.73	0	0.5
5	52.4	23.4	15.68	14.68	1.01	3.47	0	0.5
10	46.8	20.9	15.38	14.61	0.78	3.17	0	0.5
20	40.6	19.5	15.20	14.54	0.67	3.12	0	1
50	28.9	16.0	14.81	14.38	0.44	3.13	0	1

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Ipswich Motorway Bridges

BCC Asset ID	N/A	Tributary Name	Ric Nattrass Creek
Owner	DTMR	AMTD (m)	530-615
Year of Construction	2010	Coordinates (GDA94)	E 494229, N 6949554
Year of Significant Modification	N/A	Hydraulic Model ID	S29A & S29B
Source of Structure Information	DTMR Design Drawings	Flood Model Representation	2d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\29A and 29B Ipswich Motorway - Ric Nattrass Creek		

Structure Description		M106 (Outbound) - Single span concrete bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	N/A	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	11.24	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		17.44	
Span Length (m)		19.9	
Lowest Level of Deck Soffit (m AHD)		15.26	
Lowest Level of Weir/Road (m AHD) (not including handrail)		17.41 (including 1.1m concrete barrier)	
Average Handrail Height (m)		N/A	

Structure Description		M105 (Inbound) - Single span concrete bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	N/A	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	11.47	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		17.44	
Span Length (m)		19.9	
Lowest Level of Deck Soffit (m AHD)		15.28	
Lowest Level of Weir/Road (m AHD) (not including handrail)		17.52 (including 1.1m concrete barrier)	
Average Handrail Height (m)		N/A	

Structure Description		L404 (Off ramp) - Single span concrete bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	N/A	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	11.44	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		12.78	
Span Length (m)		19.98	
Lowest Level of Deck Soffit (m AHD)		15.00	
Lowest Level of Weir/Road (m AHD) (not including handrail)		17.16 (including 1.1m concrete barrier)	
Average Handrail Height (m)		N/A	

Structure Description		L405 (Ipswich Rd) - Single span concrete bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	N/A	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	11.24	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		11.70	
Span Length (m)		21.49	
Lowest Level of Deck Soffit (m AHD)		15.49	
Lowest Level of Weir/Road (m AHD) (not including handrail)		17.62 (including 1.1m concrete barrier)	
Average Handrail Height (m)		N/A	

Image Description	Looking Downstream
Date	1st June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Image Description	Looking Upstream
Date	1st June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Link to Flood Model Results	G:\BI\CD\Proj17\170300_Wolston_Creek_Flood_Study\Flood Management\Calculations\Flood Management\Tuflow\results\S1_DES
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	130.6	130.6	14.85	14.21	0.64	N/A	0	0.5
0.2	109.4	109.4	14.60	14.09	0.51	N/A	0	0.5
1	80.9	80.9	14.30	13.91	0.39	N/A	0	1
2	69.5	69.5	14.14	13.81	0.33	N/A	0	1
5	54.5	54.5	13.96	13.66	0.30	N/A	0	1
10	47.9	47.9	13.87	13.54	0.33	N/A	0	1
20	45.3	45.3	13.71	13.40	0.32	N/A	0	1
50	30.4	30.4	13.29	12.81	0.49	N/A	0	1

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Kokoda Street Culverts

BCC Asset ID	C0337B	Tributary Name	Ric Nattrass Creek
Owner	BCC	AMTD (m)	465
Year of Construction	N/A	Coordinates (GDA94)	E 494182, N 6949649
Year of Significant Modification	2009	Hydraulic Model ID	S28
Source of Structure Information	Design Drawings	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\28 Kokoda Street - Ric Nattrass Creek\Culvert 1703 - Kokoda St		

Structure Description		Multi-cell rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	6+1
Number of Piers in Waterway	N/A	Dimensions (m)	2.1w x 0.9h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	11.12,10.82 (low flow culvert)
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	11.05,10.75 (low flow culvert)
Structure Length (m) (in direction of flow)		13.2	
Span Length (m)		16.95	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~12.90	
Average Handrail Height (m)		0.7 (Armco)	

Image Description	Looking Upstream
Date	1st June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Link to Flood Model Results	[G:\BI\CD\Proj17\170300_Wolston_Creek_Flood_Study\Flood Management\Calculations\Flood Management\Tuflow\results\S1_DES]
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				2-yr ARI (50 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	129.4	46.9	14.12	13.55	0.57	3.6	N/A	0.5
0.2	109.1	47.4	14.01	13.44	0.57	4.2	N/A	0.5
1	81.5	47.4	13.85	13.30	0.55	3.6	N/A	1
2	82.3	45.6	13.76	13.21	0.55	3.5	N/A	1
5	54.5	45.1	13.62	13.07	0.55	3.4	N/A	1
10	48.7	43.9	13.50	12.96	0.54	3.3	N/A	1
20	43.2	42.2	13.35	12.86	0.49	3.2	N/A	1
50	30.0	30.0	12.72	12.52	0.20	2.3	N/A	1

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Wolston Creek Flood Study

Wau Road Culverts

BCC Asset ID	C0338P	Tributary Name	Ric Nattrass Creek
Owner	BCC	AMTD (m)	350
Year of Construction	N/A	Coordinates (GDA94)	E 494144, N 6949758
Year of Significant Modification	2009	Hydraulic Model ID	S27
Source of Structure Information	Design Drawings	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj18\180355_Wolston_Crk_Flood_Study\Flood Management\Data\Structures\27 Wau Road - Ric Nattrass Creek\Culvert 1704 - Wau Rd		

Structure Description		Multi-cell rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	6+1
Number of Piers in Waterway	N/A	Dimensions (m)	2.1w x 0.9h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	10.33, 10.25 (low flow culvert)
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	10.19, 10.11 (low flow culvert)
Structure Length (m) (in direction of flow)		14.4	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Lowest Level of Weir/Road (m AHD) (not including handrail)		~ 12.05	
Average Handrail Height (m)		0.7 (Armco)	

Image Description	Looking Downstream
Date	2nd June 2017
Source	Photo has been taken as part of 2017 Creek's Survey

Link to Flood Model Results	G:\BI\CD\Proj17\170300_Wolston_Creek_Flood_Study\Flood Management\Calculations\Flood Management\Tuflow\results\S1_DES
Model Version Number	WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
Model Scenario	Scenario 1 Design (S1_DES)

Structure Flood Immunity (immunity of lowest point of weir above structure)				< 2-yr ARI (50 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (mm)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05*	116.7	46.9	14.04	14.04	0.00	3.6	N/A	2
0.2*	91.7	46.3	13.42	13.39	0.02	4.2	N/A	2
1	100.5	46.7	13.23	12.75	0.48	3.5	N/A	1
2	86.2	46.2	13.14	12.64	0.50	3.5	N/A	1
5	68.5	45.2	13.01	12.50	0.51	3.4	N/A	1
10	59.4	43.8	12.90	12.41	0.49	3.3	N/A	1
20	51.9	42.4	12.80	12.33	0.46	3.2	N/A	1
50	36.8	36.3	12.46	12.12	0.33	2.7	N/A	1

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

**Subject to backwater effects from Bullockhead Creek*

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Appendix N: External Peer Review Documentation

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Our Ref: L.B20679.009.Wolston_Creek.docx

22 June 2018

Brisbane City Council
City Projects Office
Green Square, Level 1
505 St Pauls Terrace
Fortitude Valley
Qld 4006

Attention: Hanieh Zolfaghari

Dear Hanieh

RE: WOLSTON CREEK FLOOD MODELLING PEER REVIEW

Background

BMT was commissioned by Council to undertake a peer review of the Wolston Creek flood modelling prepared as part of the Wolston Creek Flood Study. This letter documents the outcomes of BMT's review.

The review was undertaken in three stages: firstly the initial model design, then model calibration and finally the design event modelling was reviewed. At the commencement of these review stages, Council submitted the following data to BMT:

- Hydrologic models (URBS);
- Hydraulic models including model output files (TUFLOW);
- GIS data; and
- Preliminary flood study reporting.

Review responses were provided to Council via email, and Council provided suitable responses to all queries. Generally, no concerns with the models were identified.

Overview of the Modelling Approach

Hydrological models were developed using URBS. The structure of the URBS models and the sub-catchment parameters has been reviewed. The URBS model parameters have been appropriately applied and are within the standard values for URBS models. The design event rainfall IFD used in the URBS model is appropriate for the catchment. It is noted that ARR2016 was used to compute the design storm events. An ARF of one was applied as a simplification on the ARR2016 guidance. This will result in overestimated design rainfall depths. Given the challenges in applying ARR2016 for a catchment study such as this, this is considered an adequate compromise. However, future users of the model should note that the flows and flood levels are overestimated, especially in lower reaches, and the hydrology could be revisited for design of infrastructure within the catchment.

Hydraulic models of the creeks in the study area were developed using TUFLOW. A 5m computational grid cell size was used. The creeks were modelled in 1D and linked to the 2D model domain of the floodplain.

While all ensemble temporal patterns were simulated in the hydrology model, only a small selection of events were modelled in the hydraulic model. This was done to reduce the number of hydraulic model runs to within a more pragmatic number of simulations. A representative ensemble temporal pattern was adopted for each storm duration based on the peak flows estimated by the hydrology model. In localities where the adopted ensemble event did not produce the true median peak flow, the adopted design event peak flow tends to overestimate the true median peak flow by 2%. Thus, the adopted approach is considered suitable.

Model Performance

The model performance has been checked in relation to: mass balance error, negative depth warnings, and instability. The model performance is considered suitable. It is noted that Council has also assessed the model performance in relation to replication of historical events (calibration and verification) and bridge structures have been compared to equivalent HEC-RAS models. Generally, Council's acceptable tolerance for calibration is 0.15m variance for peak flood levels at stream gauges and 0.3m variance for peak flood levels at maximum height gauges. Council has achieved these tolerances in most instances.

Limitations of the Review

This review focussed on scrutinising the design and performance of the models developed by Council. The scope of the review does not extend to the underlying data used to develop the model or the broader flood study methodology and procedure. For example, the accuracy of the topographic data, land use mapping (based on Brisbane City Council's City Plan and refined using aerial imagery), structure details and historic flood data has not been explicitly checked. If supplied information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions may change. As a consequence, BMT provides no liability to the accuracy or the precision of the supplied data. All liability to do with the assumptions that rely on the accuracy or the precision of the supplied data rest with Brisbane City Council.

Conclusion

The flood modelling undertaken as part of the Wolston Creek Flood Study complies with current industry practice, and is considered suitable for the purposes of the study.

Yours Faithfully

Richard Sharpe RPEQ (18843)
Senior Flood Engineer
BMT

Appendix P: Modelling User Guide

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Wolston Creek Flood Study

Model User Guide

Prepared by Brisbane City Council's, City Projects Office

June 2018

BRISBANE CITY

Dedicated to a better Brisbane

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Table of Contents

For Information Only – Not Council Policy

List of Tables

1.0 Introduction

1.1 Wolston Creek Flood Study (2018)

This document is to be read in conjunction with the Wolston Creek Flood Study - Volume 1 (2018).

The Wolston Creek Flood Study (2018) incorporates the calibration and verification of the hydrologic and hydraulic models; design event modelling; extreme event modelling and sensitivity modelling. Hydrologic and hydraulic models have been developed using the URBS and TUFLOW modelling software respectively.

Calibration of the URBS and TUFLOW models was undertaken utilising three historical storms; namely May 2015, January 2013 and May 2009. Verification of the URBS and TUFLOW models utilised the March 2017 historical storm event.

Design and extreme flood magnitudes were estimated for the full range of events from 2-yr ARI (50 % AEP) to PMF. These analyses assumed hydrologic ultimate catchment development conditions in accordance with the current version of BCC City Plan.

Three waterway scenarios were considered, as follows:

- Scenario 1 – Existing Waterway Conditions: Based on the current waterway conditions. Some minor modifications were made to the TUFLOW model developed as part of the calibration / verification phase.
- Scenario 2 – Minimum Riparian Corridor (MRC): Includes an allowance for a riparian corridor along the edge of the channel.
- Scenario 3 – Ultimate Conditions: Includes an allowance for the minimum riparian corridor (as per Scenario 2) and also assumes development infill to the boundary of the “Modelled Flood Corridor” in order to simulate potential development.

A sensitivity analysis was undertaken to understand the impacts of climate variability for two planning horizons; namely 2050 and 2100 using both RCP4.5 and RCP8.5.

1.2 Scope of this Document

This document provides a guide to users of the URBS hydrologic and TUFLOW hydraulic models that were developed as part of the flood study.

2.0 Hydrologic and Hydraulic Models

2.1 Hydrologic Models

2.1.1 General

The URBS modelling has been undertaken using Version 6.34 (beta), with simulations performed using the URBS Control Centre Version 4.2.0 in lieu of a batch file.

The name and location of the URBS Control Centre project is as follows:

..\URBS\Wolston\2017\Wolston.prj

The URBS modelling has been separated into:

- Calibration / Verification, and
- Design / Extreme / Climate Variability

The following sections discuss each respectively.

2.1.2 Calibration Models

For the calibration / verification runs, a separate model for each of the historical events has been developed. These are discussed individually in the following sections:

Event 1 – March 2017

The name and location of the March 2017 event folder is as indicated below, with the URBS Control Centre settings indicated in
Figure 2.1.

..\URBS\Wolston\2017\Calibration\Mar_2017

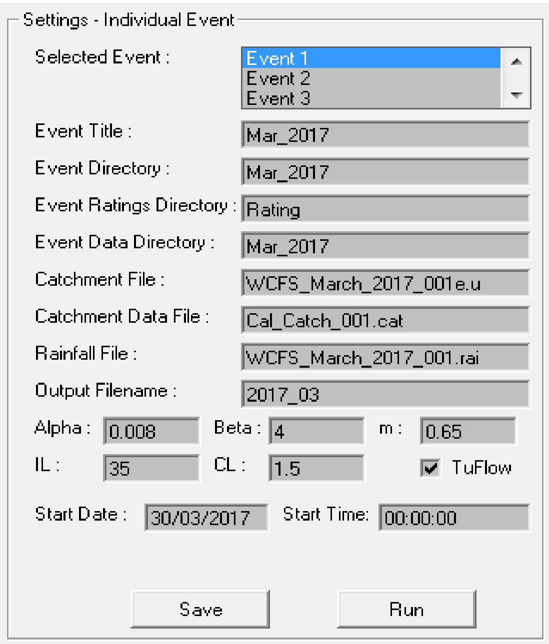

Figure 2.1: Event 1 (March 2017)

Event 2 – May 2015

The name and location of the May 2015 event folder is as indicated below, with the URBS Control Centre settings indicated in Figure 2.2.

..\URBS\Wolston\2017\Calibration\May_2015

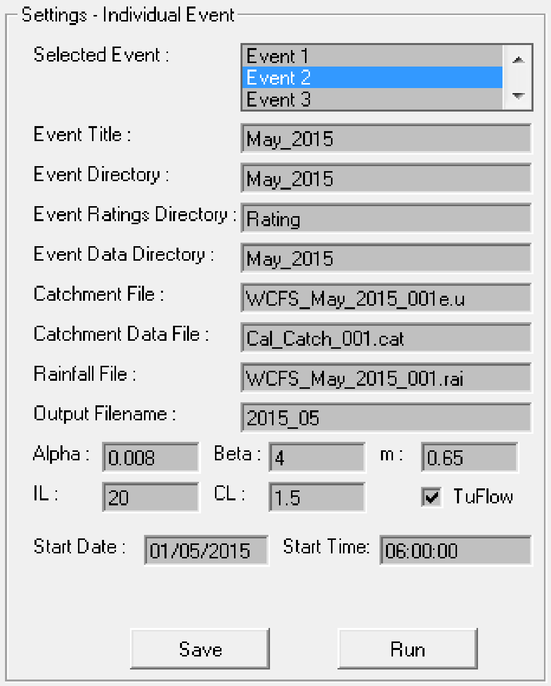

Figure 2.2: Event 2 (May 2015)

Event 3 – January 2013

The name and location of the January 2013 event folder is as indicated below, with the URBS Control Centre settings indicated in Figure 2.3.

..\URBS\Wolston\2017\Calibration\Jan_2013

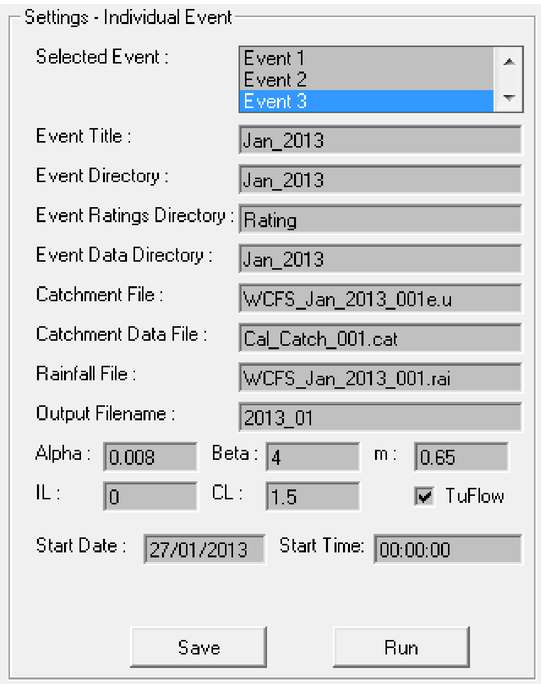

Figure 2.3: Event 3 (January 2013)

Event 4 – May 2009

The name and location of the May 2009 event folder is as indicated below, with the URBS Control Centre settings indicated in Figure 2.4.

..\URBS\Wolston\2017\Calibration\May_2009

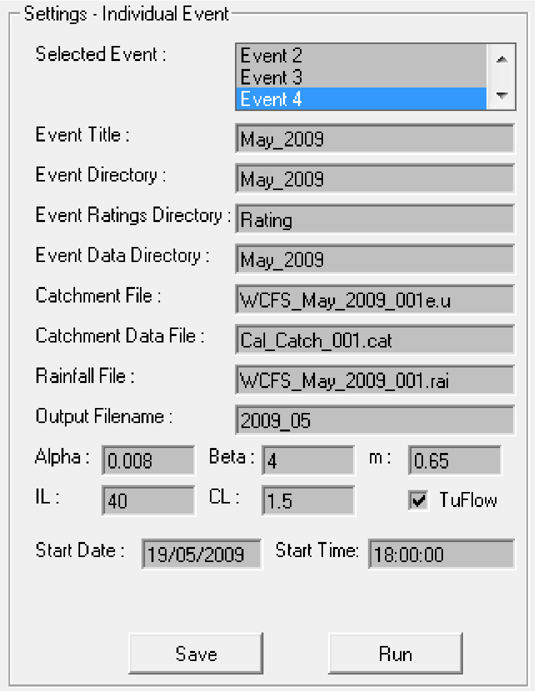

Figure 2.4: Event 4 (May 2009)

2.1.3 Design Model

For the design, extreme and climate variability events, one model has been developed. The name and location of the Design model folder is as indicated below, with the URBS Control Centre settings indicated in Figure 2.5.

- AR&R 2016: ..\URBS\Wolston\2017\Des16
- AR&R 1987: ..\URBS\Wolston\2017\Des87

For the Climate Variability runs, replace “IFD_2016.ifd” with those indicated below in order to generate the appropriate ARI files for the 100-yr to 500-yr ARI events:

- Climate Scenario 1 (2050) RCP4.5: IFD_2016_CC1_RCP4.5_6.7%_Centroid.ifd
- Climate Scenario 1 (2050) RCP8.5: IFD_2016_CC1_RCP8.5_8.8%_Centroid.ifd
- Climate Scenario 2 (2100) RCP4.5: IFD_2016_CC2_RCP4.5_9.2%_Centroid.ifd
- Climate Scenario 2 (2100) RCP8.5: IFD_2016_CC2_RCP8.5_21%_Centroid.ifd

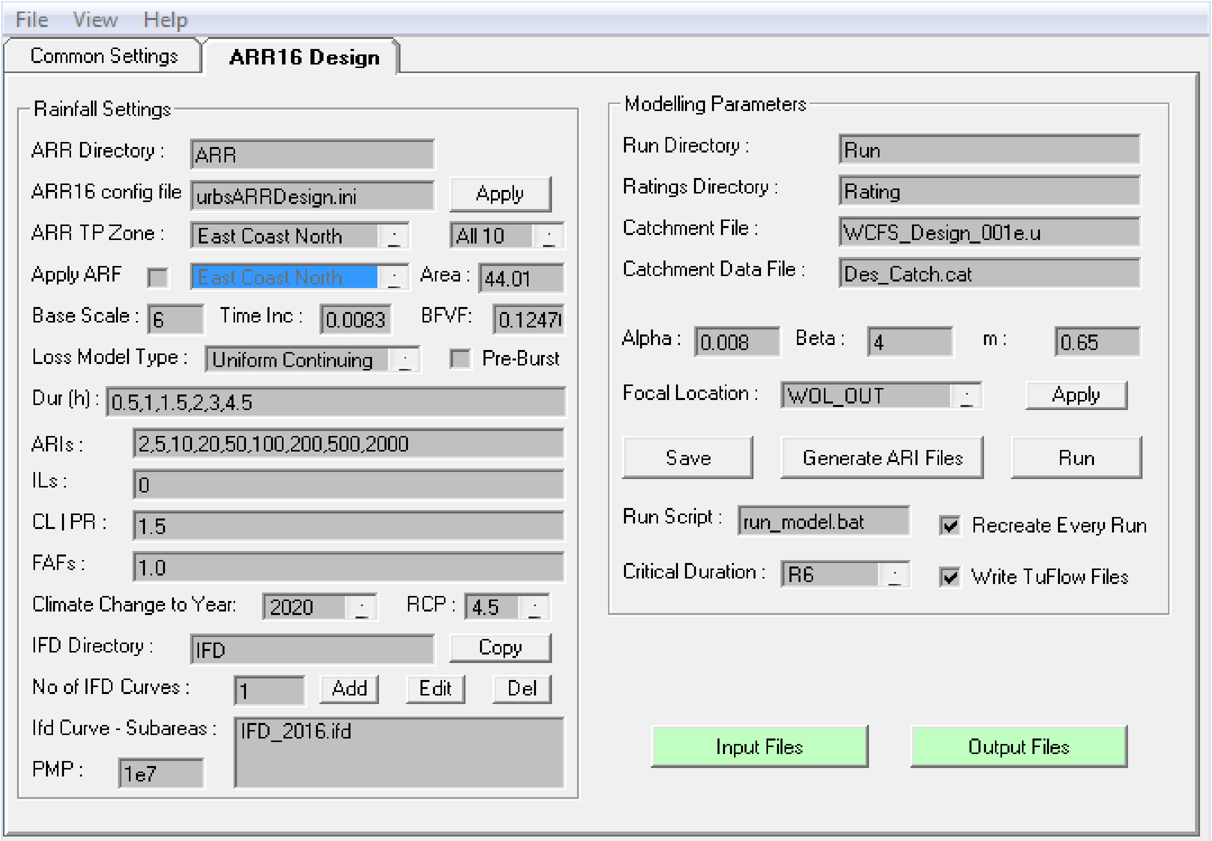

Figure 2.5: Design Run Settings – 2-yr to 2000-yr ARI

In order to run the PMF event, the URBS Control Centre settings are as per Figure 2.6.

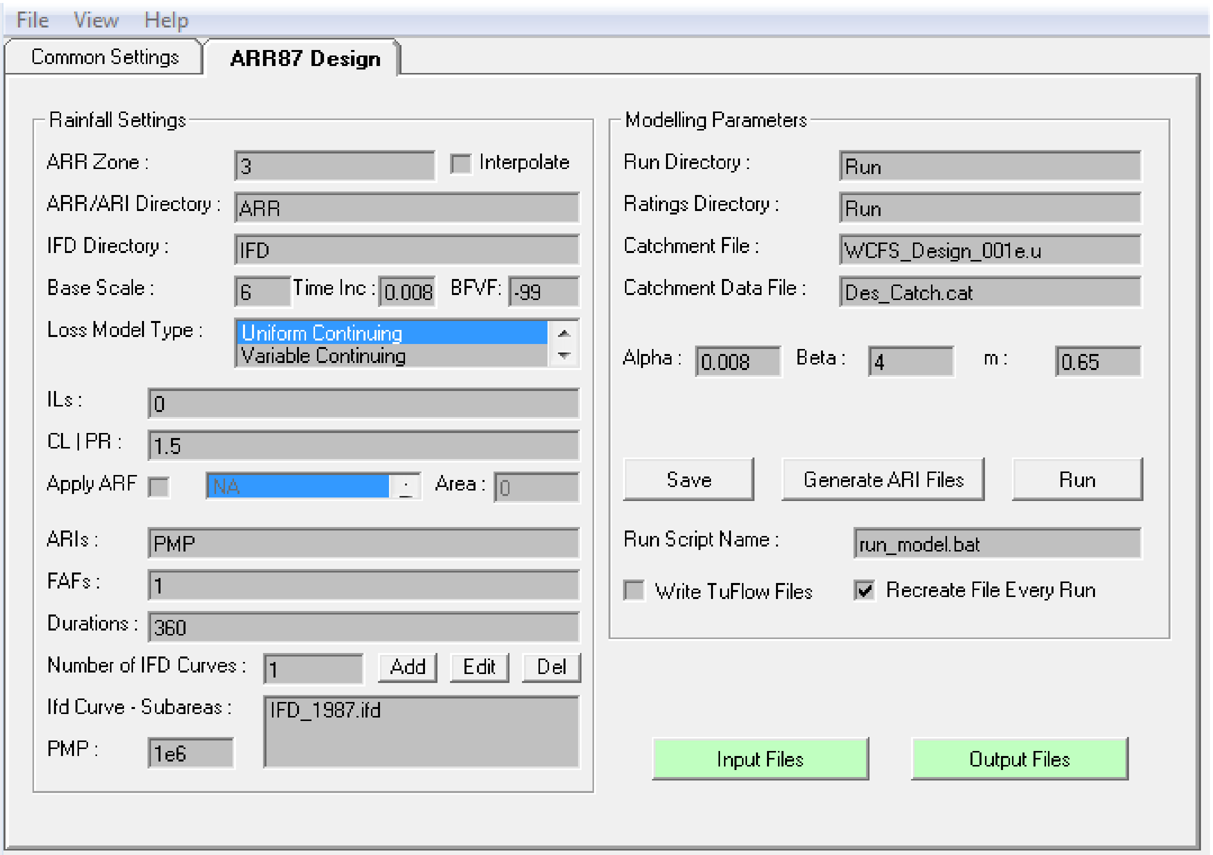

Figure 2.6: Design Run Settings – PMF

2.2 Hydraulic Models

2.2.1 General

TUFLOW modelling was undertaken using build: 2017-09-AC-iSP-w64.

The TUFLOW modelling was undertaken using a single TUFLOW Control File (TCF), which was named: WCFS_~s1~_~s1~_~e1~_~e2~_037.tcf. The ESTRY Control File (ECF) is embedded into the TCF.

This TCF can be used to simulate all of the model runs undertaken as part of the flood study. The model is run using the appropriate TUFLOW batch command based on the required scenario and events.

2.2.2 TUFLOW Calibration and Verification Models

TUFLOW simulations were undertaken for all four historical events. The model is essentially the same for each, apart from the boundary conditions. Table 2.1 indicates the scenario and event codes to be used inside the TUFLOW batch file.

Table 2.1 – TUFLOW Calibration and Verification Batch Codes

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)
Calibration – May 2015	CAL	CLA	2015	05
Calibration – January 2013	CAL	CLA	2013	01
Calibration – May 2009	CAL	CLA	2009	05
Verification – March 2017	CAL	CLA	2017	03

As an example, the batch file command for January 2013 simulation would be as follows:

tuflow_iSP_w64.exe -b -s1 CAL -s2 CLA -e1 2013 -e2 01 WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf

2.2.3 TUFLOW Design Event Models

TUFLOW simulations were undertaken for all Scenario 1, Scenario 2 and Scenario 3 design events up to and including the 100-yr ARI (1 % AEP) event. Table 2.2 to Table 2.4 indicate the scenario and event codes to be used inside the TUFLOW batch file.

Table 2.2 – TUFLOW Scenario 1 Design Event Batch Codes

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)
Design Events (Scenario 1)	S1_DES	CLA	002yE8	030m
			002yE5	060m
			002yE5	090m
			002yE8	120m
			002yE8	180m
			005yE8	030m
			005yE5	060m
			005yE5	090m
			005yE8	120m
			005yE8	180m
			010yE8	030m
			010yE5	060m
			010yE5	090m
			010yE8	120m
			010yE8	180m
			020yE8	030m
			020yE5	060m
			020yE5	090m
			020yE8	120m
			020yE8	180m
			050yE8	030m
			050yE5	060m
			050yE5	090m
			050yE8	120m
			050yE8	180m
			100yE8	030m
			100yE5	060m
			100yE5	090m
			100yE8	120m
			100yE8	180m

Table 2.3 – TUFLOW Scenario 2 Design Event Batch Codes

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)
Design Events (Scenario 2)	S2_DES	CLA	100yE8	030m
			100yE5	060m
			100yE5	090m
			100yE8	120m
			100yE8	180m

Table 2.4 – TUFLOW Scenario 3 Design Event Batch Codes

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)
Design Events (Scenario 3)	S3_DES	CLA	002yE8	030m
			002yE5	060m
			002yE5	090m
			002yE8	120m
			002yE8	180m
			005yE8	030m
			005yE5	060m
			005yE5	090m
			005yE8	120m
			005yE8	180m
			010yE8	030m
			010yE5	060m
			010yE5	090m
			010yE8	120m
			010yE8	180m
			020yE8	030m
			020yE5	060m
			020yE5	090m
			020yE8	120m
			020yE8	180m
			050yE8	030m
			050yE5	060m
			050yE5	090m
			050yE8	120m

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)
			050yE8	180m
			100yE8	030m
			100yE5	060m
			100yE5	090m
			100yE8	120m
			100yE8	180m

As an example, the batch file command for Scenario 1 100-yr ARI 60-minute simulation would be as follows:

```
tuflow_iSP_w64.exe -b -s1 S1_DES -s2 CLA -e1 100yE5 -e2 060m WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf
```

2.2.4 TUFLOW Rare and Extreme Event Models

TUFLOW simulations were undertaken for the Scenario 1 and Scenario 3 extreme events up to and including the PMF event. Table 2.5 and Table 2.6 indicate the scenario and event codes to be used inside the TUFLOW batch file.

Table 2.5 – TUFLOW Scenario 1 Rare and Extreme Event Batch Codes

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)
Rare and Extreme Events (Scenario 1)	S1_EXT	CLA	200yE2	030m
			200yE5	060m
			200yE5	090m
			200yE8	120m
			200yE9	180m
			500yE2	030m
			500yE5	060m
			500yE5	090m
			500yE8	120m
			500yE9	180m
			2000yE2	030m
			2000yE5	060m
			2000yE5	090m
			2000yE8	120m
			2000yE9	180m
			PMF	360m

As an example, the batch file command for Scenario 1 200-yr ARI 60-minute simulation would be as follows:

tuflow_iSP_w64.exe -b -s1 S1_EXT -s2 CLA -e1 200yE5 -e2 060m WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf

Similarly, the batch file command for Scenario 1 PMF simulation would be as follows:

tuflow_iSP_w64.exe -b -s1 S1_EXT -s2 CLA -e1 PMF -e2 360m WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf

Table 2.6 – TUFLOW Scenario 3 Rare and Extreme Event Batch Codes

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)
Rare and Extreme Events (Scenario 3)	S3_EXT	CLA	200yE2	030m
			200yE5	060m
			200yE5	090m
			200yE8	120m
			200yE9	180m
			500yE2	030m
			500yE5	060m
			500yE5	090m
			500yE8	120m
			500yE9	180m

As an example, the batch file command for Scenario 3 500-yr ARI 120-minute simulation would be as follows:

tuflow_iSP_w64.exe -b -s1 S3_EXT -s2 CLA -e1 500yE8 -e2 120m WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf

2.2.5 TUFLOW Sensitivity Analysis Models

TUFLOW climate sensitivity simulations were undertaken for climate variability. Table 2.7 indicates the scenario and event codes to be used inside the TUFLOW batch file.

As an example, the batch file command for Scenario 1 (2050) RCP4.5 100-yr 60-minute simulation would be as follows:

tuflow_iSP_w64.exe -b -s1 S1_CC -s2 CLA -e1 100yE5CC1a -e2 060m WCFS_~s1~_~s2~_~e1~_~e2~_037.tcf

Table 2.7 – TUFLOW Sensitivity Analysis Batch Codes

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)
Climate Variability (Scenario 1) Planning horizon 2050 RCP4.5	S1_CC	CLA	100yE8CC1a	030m
			100yE5CC1a	060m
			100yE5CC1a	090m
			100yE8CC1a	120m
			100yE8CC1a	180m
			200yE2CC1a	030m
			200yE5CC1a	060m
			200yE5CC1a	090m
			200yE8CC1a	120m
			200yE9CC1a	180m
Climate Variability (Scenario 1) Planning horizon 2050 RCP8.5	S1_CC	CLA	100yE8CC1b	030m
			100yE5CC1b	060m
			100yE5CC1b	090m
			100yE8CC1b	120m
			100yE8CC1b	180m
			200yE2CC1b	030m
			200yE5CC1b	060m
			200yE5CC1b	090m
			200yE8CC1b	120m
			200yE9CC1b	180m
Climate Variability (Scenario 1) Planning horizon 2100 RCP4.5	S1_CC	CLA	100yE8CC2a	030m
			100yE5CC2a	060m
			100yE5CC2a	090m
			100yE8CC2a	120m
			100yE8CC2a	180m
			200yE2CC2a	030m
			200yE5CC2a	060m
			200yE5CC2a	090m
			200yE8CC2a	120m
			200yE9CC2a	180m
			500yE2CC2a	030m
			500yE5CC2a	060m

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)
			500yE5CC2a	090m
			500yE8CC2a	120m
			500yE9CC2a	180m
Climate Variability (Scenario 1) Planning horizon 2100 RCP8.5	S1_CC	CLA	100yE8CC2b	030m
			100yE5CC2b	060m
			100yE5CC2b	090m
			100yE8CC2b	120m
			100yE8CC2b	180m
			200yE2CC2b	030m
			200yE5CC2b	060m
			200yE5CC2b	090m
			200yE8CC2b	120m
			200yE9CC2b	180m
			500yE2CC2b	030m
			500yE5CC2b	060m
			500yE5CC2b	090m
			500yE8CC2b	120m
			500yE9CC2b	180m
Climate Variability (Scenario 3) Planning horizon 2050 RCP4.5	S3_CC	CLA	100yE8CC1a	030m
			100yE5CC1a	060m
			100yE5CC1a	090m
			100yE8CC1a	120m
			100yE8CC1a	180m
Climate Variability (Scenario 3) Planning horizon 2050 RCP8.5	S3_CC	CLA	100yE8CC1b	030m
			100yE5CC1b	060m
			100yE5CC1b	090m
			100yE8CC1b	120m
			100yE8CC1b	180m
Climate Variability (Scenario 3) Planning horizon 2100 RCP4.5	S3_CC	CLA	100yE8CC2a	030m
			100yE5CC2a	060m
			100yE5CC2a	090m
			100yE8CC2a	120m

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)
			100yE8CC2a	180m
Climate Variability (Scenario 3) Planning horizon 2100 RCP8.5	S3_CC	CLA	100yE8CC2b	030m
			100yE5CC2b	060m
			100yE5CC2b	090m
			100yE8CC2b	120m
			100yE8CC2b	180m