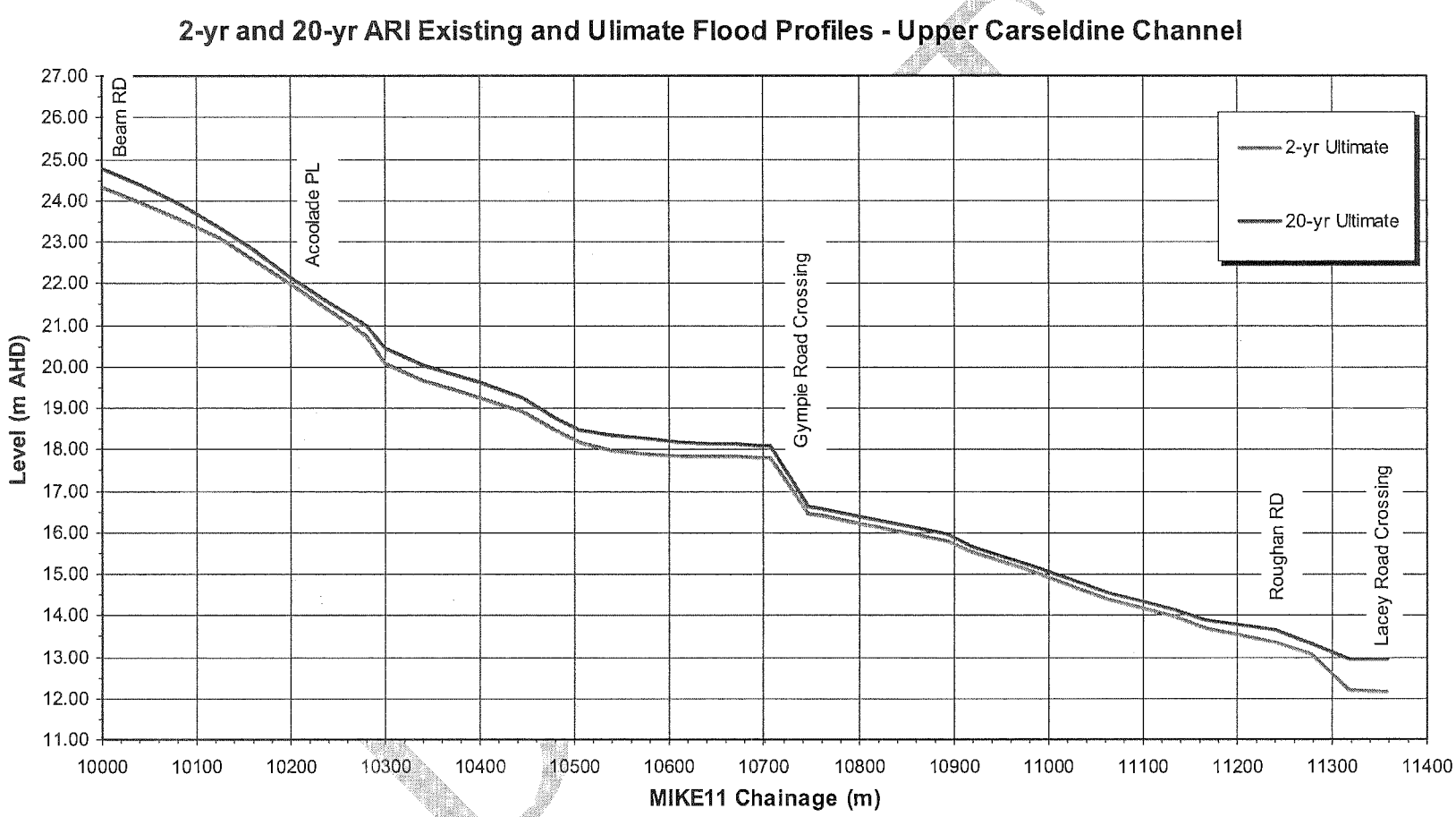
APPENDIX B: Flood Profile and Inundation Plots



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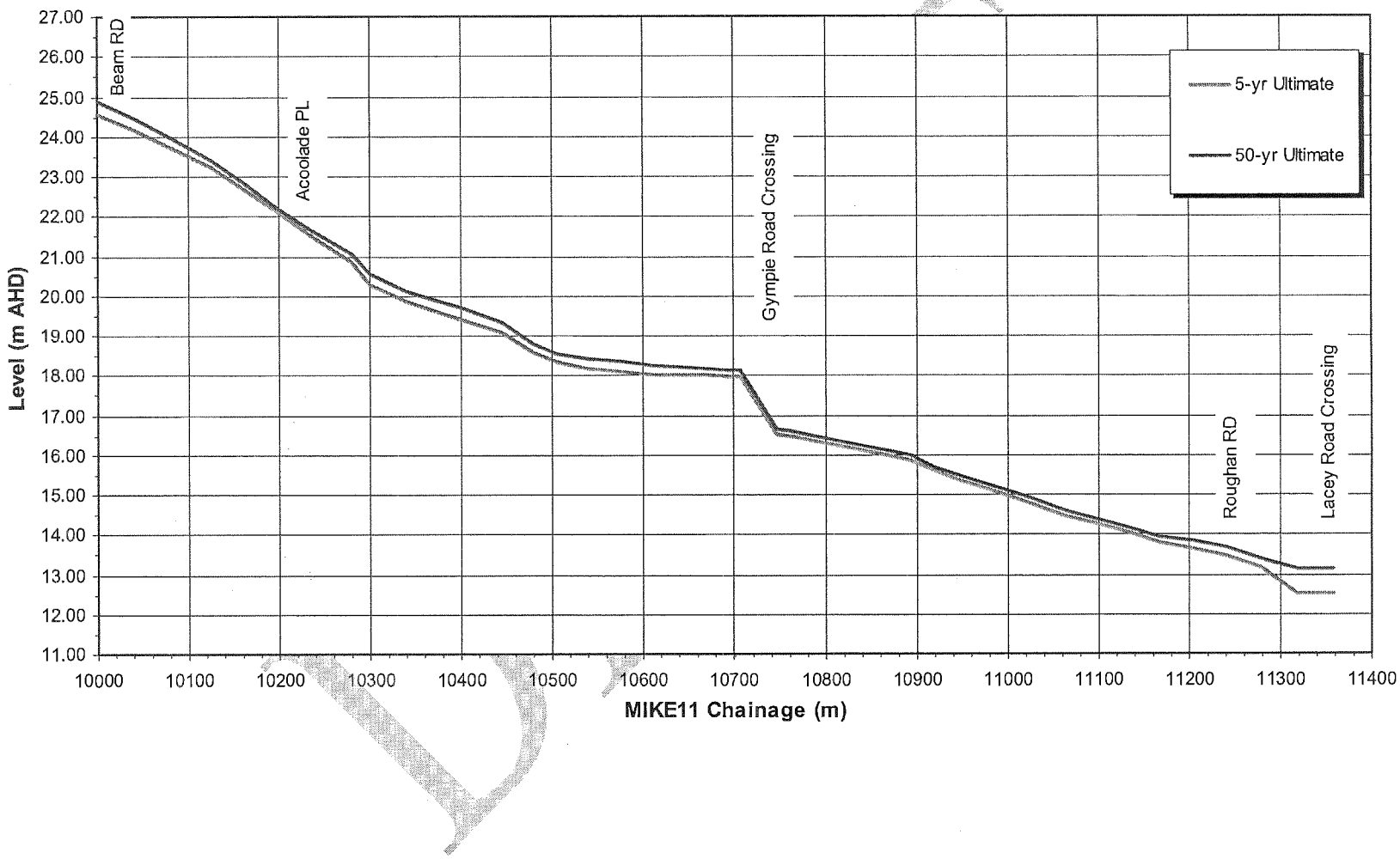
5-yr and 50-yr ARI Existing and Ulimate Flood Profiles - Upper Carseldine Channel



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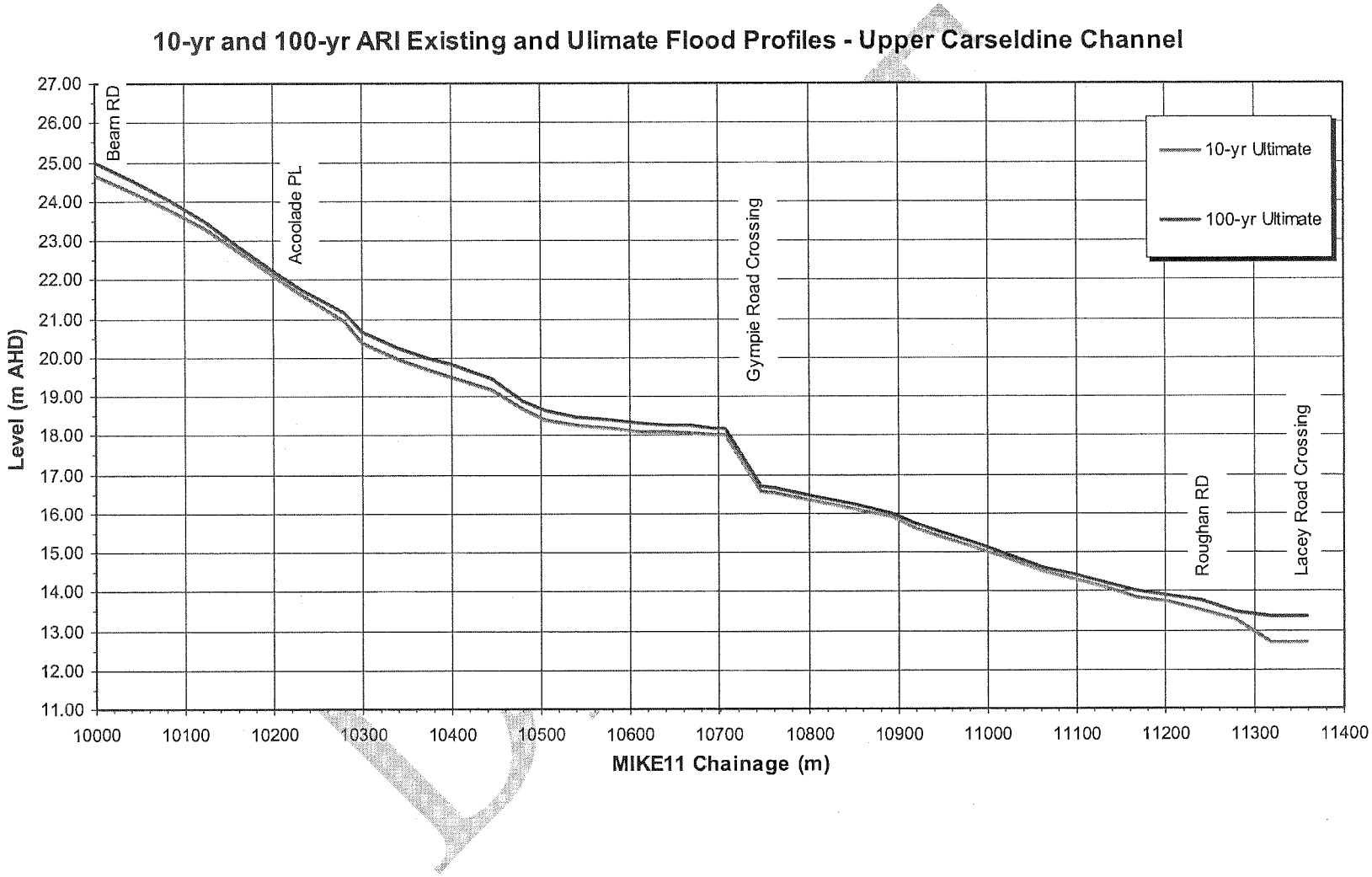
10-yr and 100-yr ARI Existing and Ulimate Flood Profiles - Upper Carseldine Channel
Level (m AHD)
MIKE11 Chainage (m)
27.00
26.00
25.00
24.00
23.00
22.00
21.00
20.00
19.00
18.00
17.00
16.00
15.00
14.00
13.00
12.00
11.00
10000
10100
10200
10300
10400
10500
10600
10700
10800
10900
11000
11100
11200
11300
11400
Beam RD
Acoolade PL
Gympie Road Crossing
Roughan RD
Lacey Road Crossing
10-yr Ultimate
100-yr Ultimate

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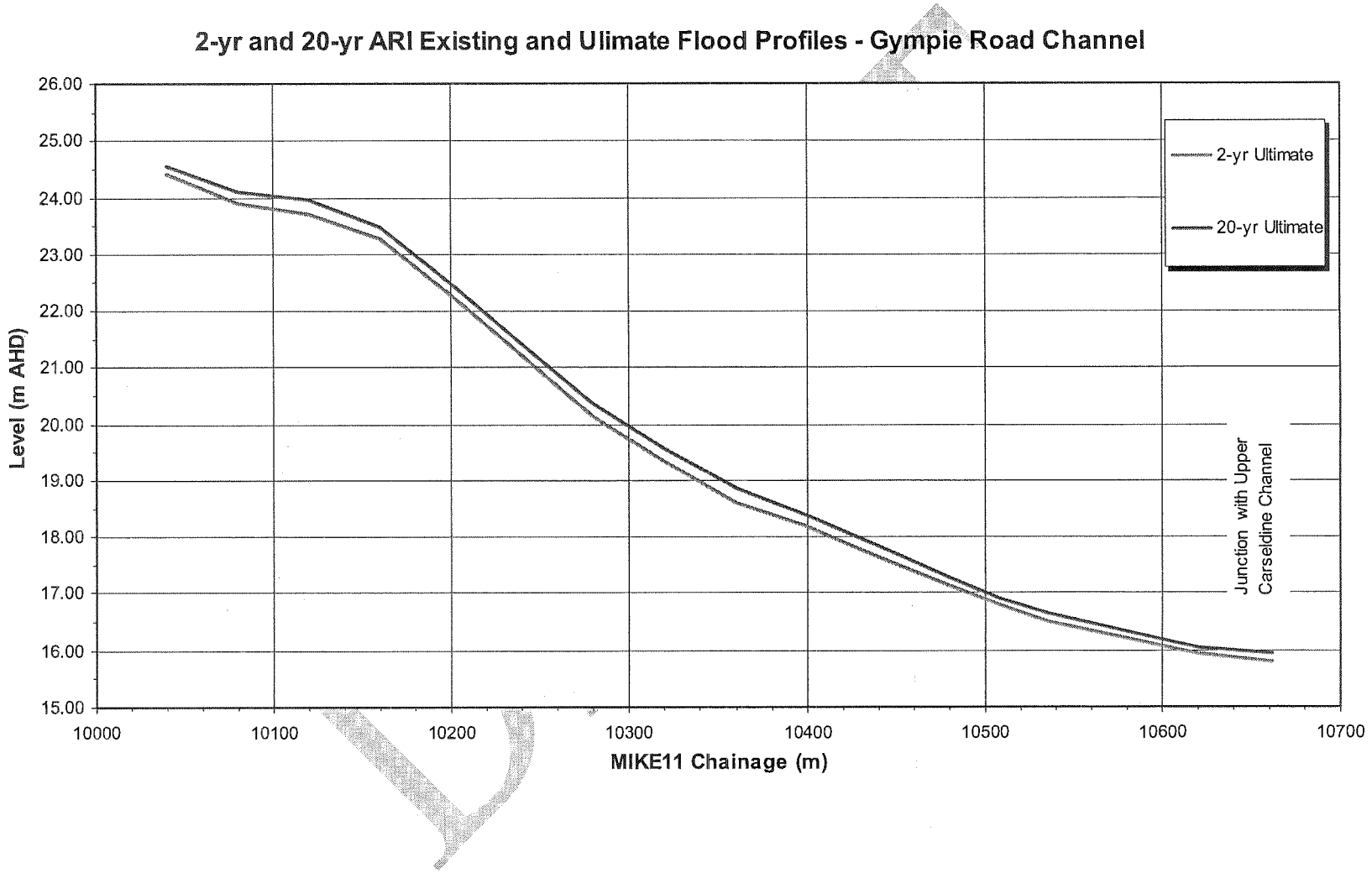

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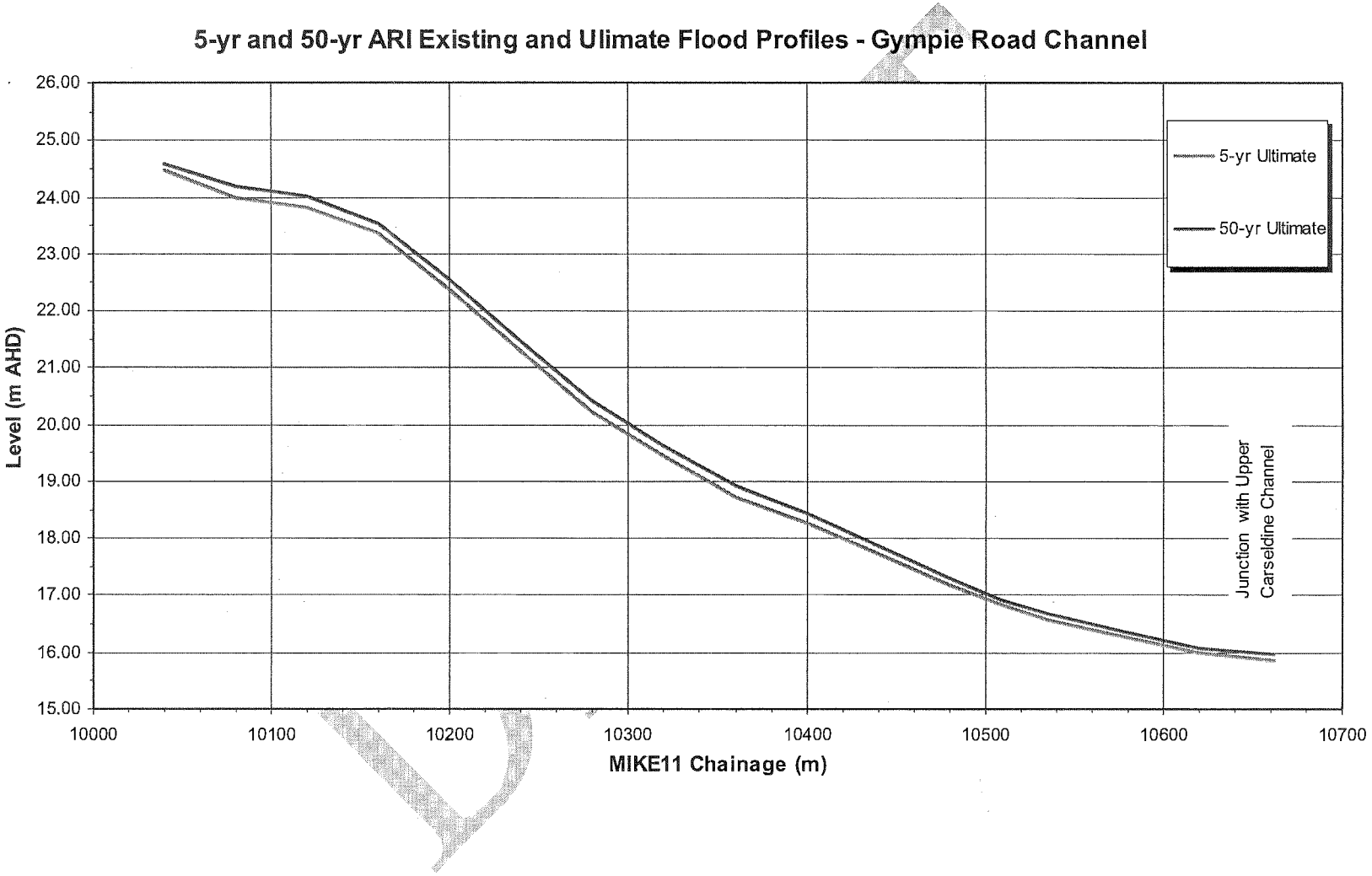

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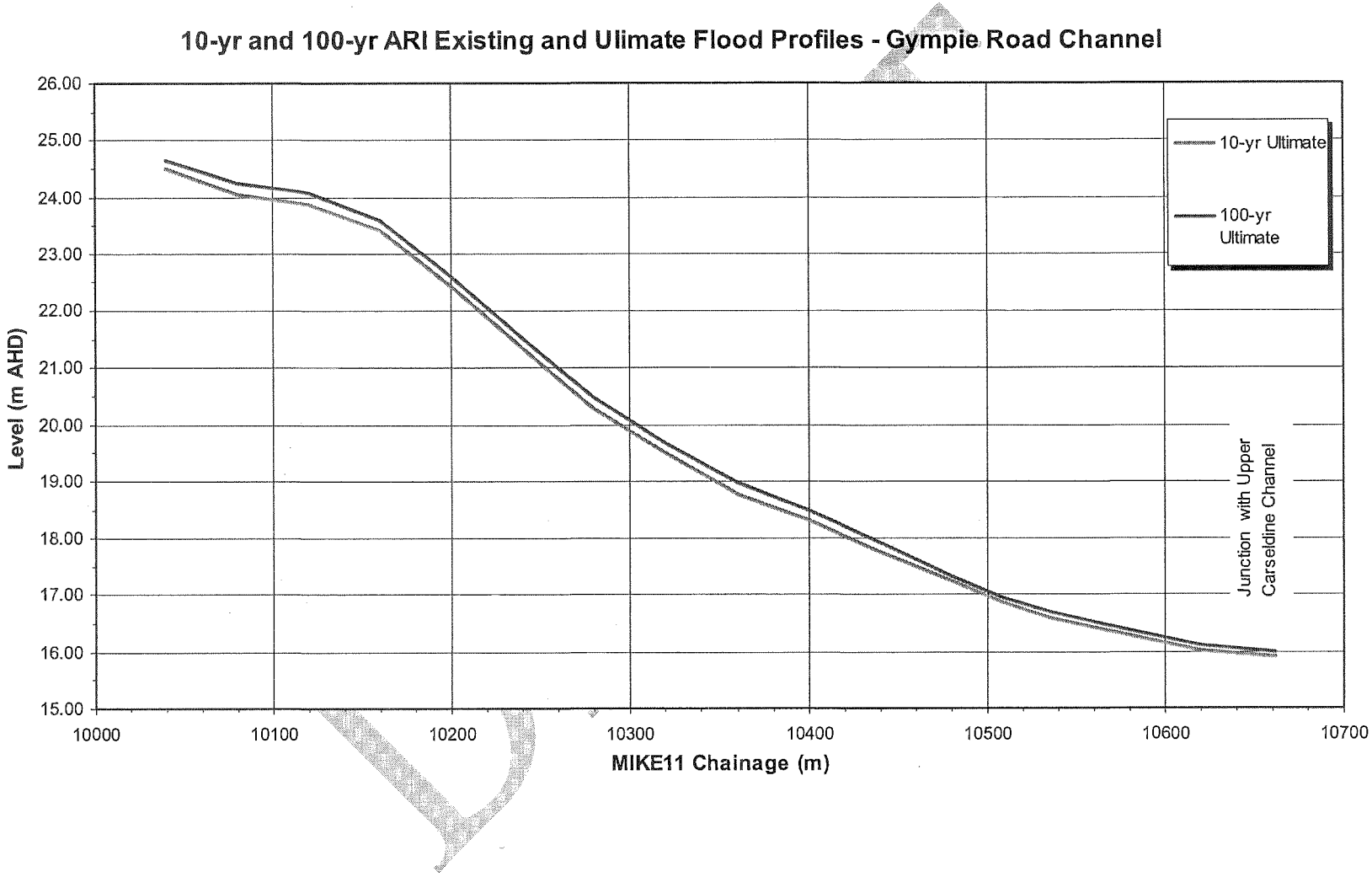

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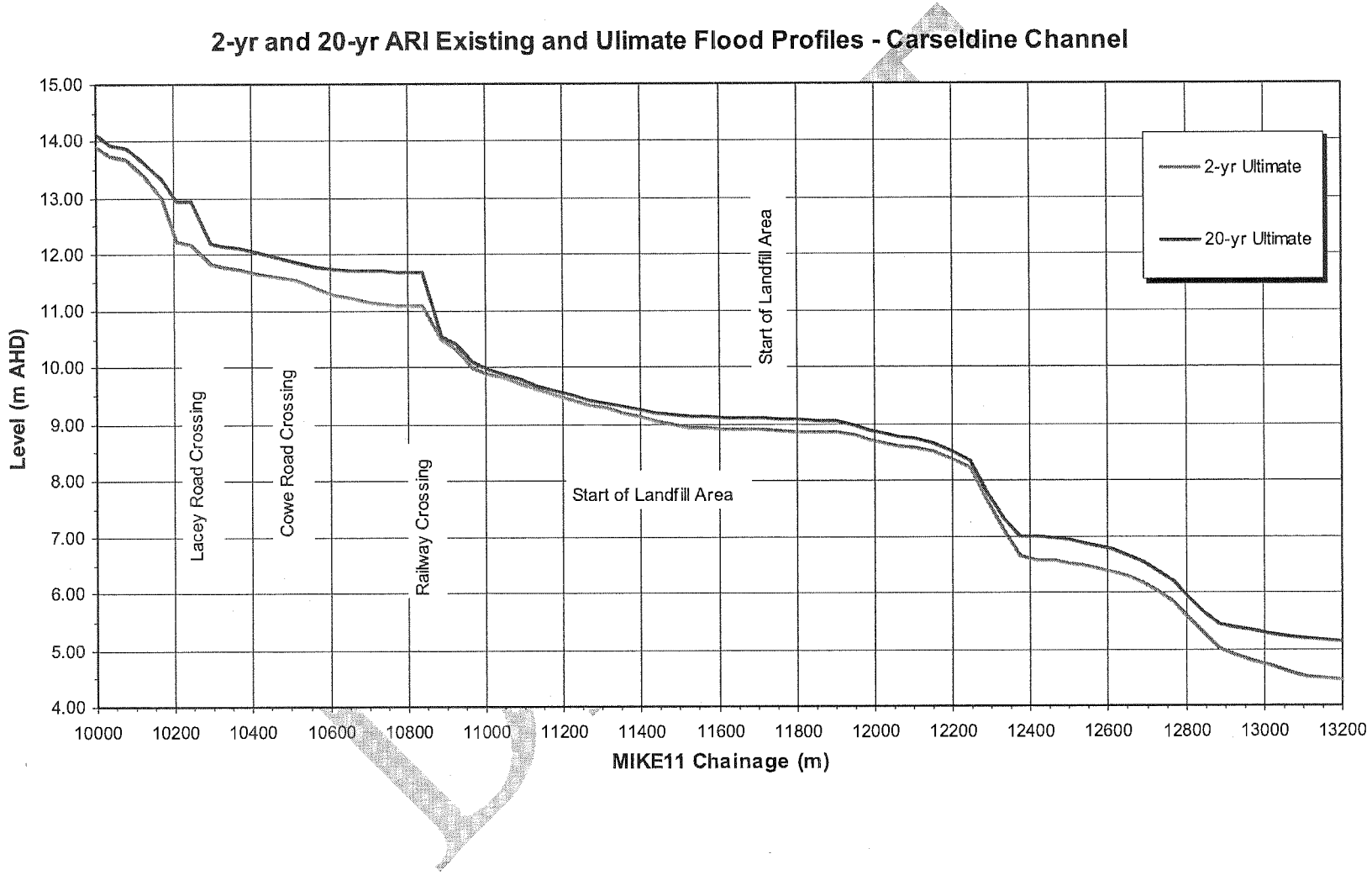
2-yr and 20-yr ARI Existing and Ulimate Flood Profiles - Carseldine Channel
Level (m AHD)
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
10000
10200
10400
10600
10800
11000
11200
11400
11600
11800
12000
12200
12400
12600
12800
13000
13200
MIKE11 Chainage (m)
2-yr Ultimate
20-yr Ultimate
Lacey Road Crossing
Cowe Road Crossing
Railway Crossing
Start of Landfill Area
Start of Landfill Area

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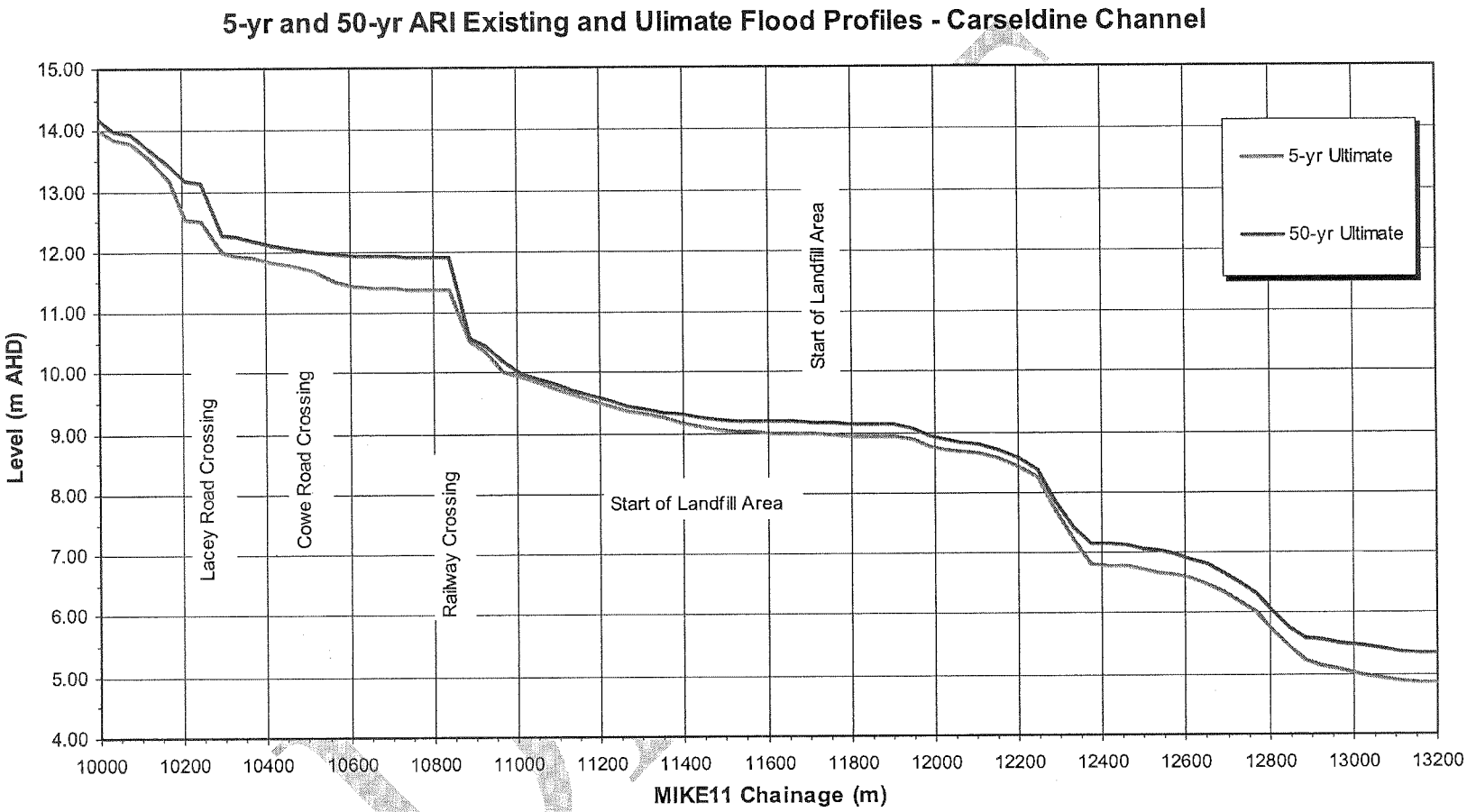

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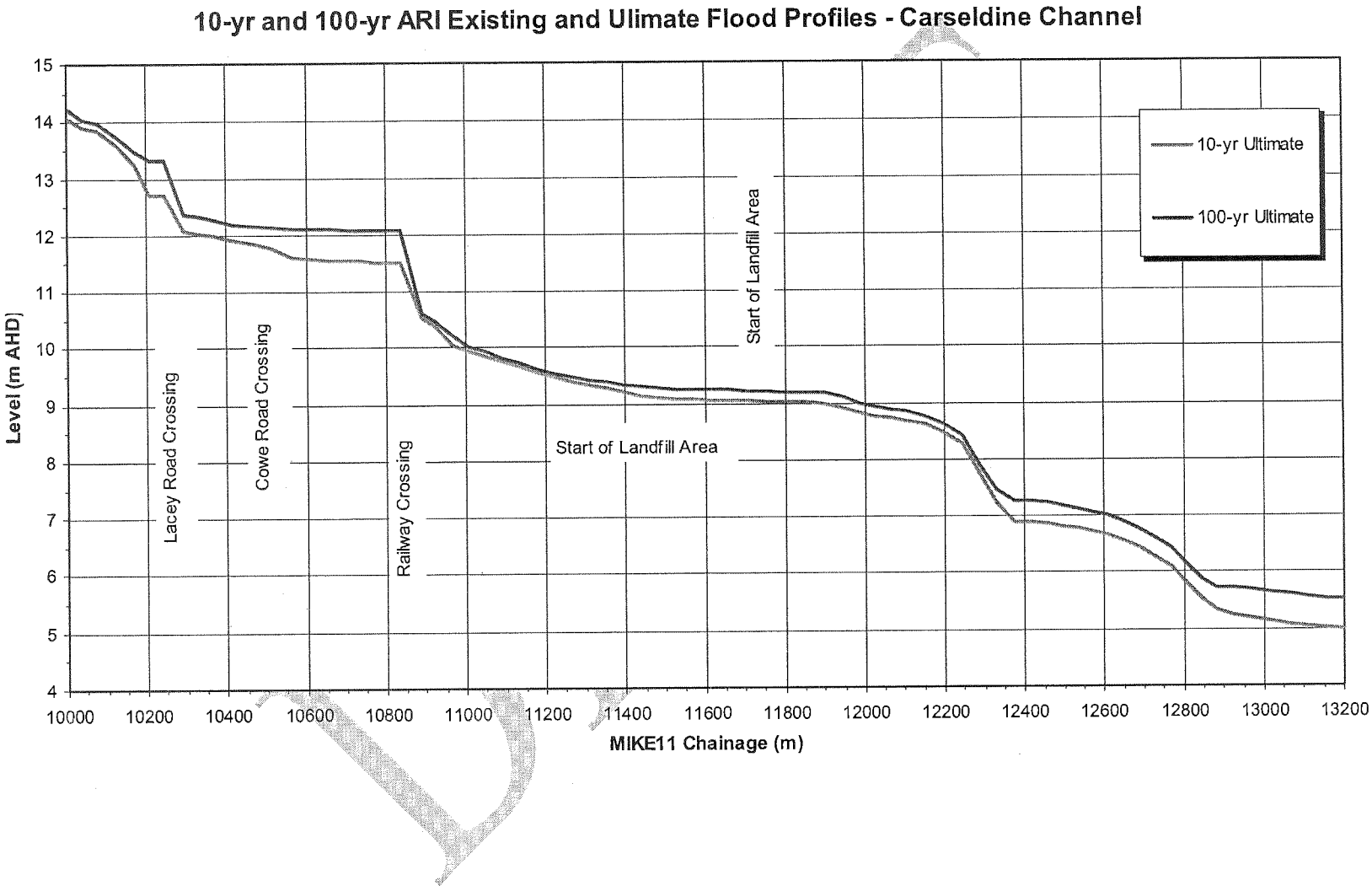

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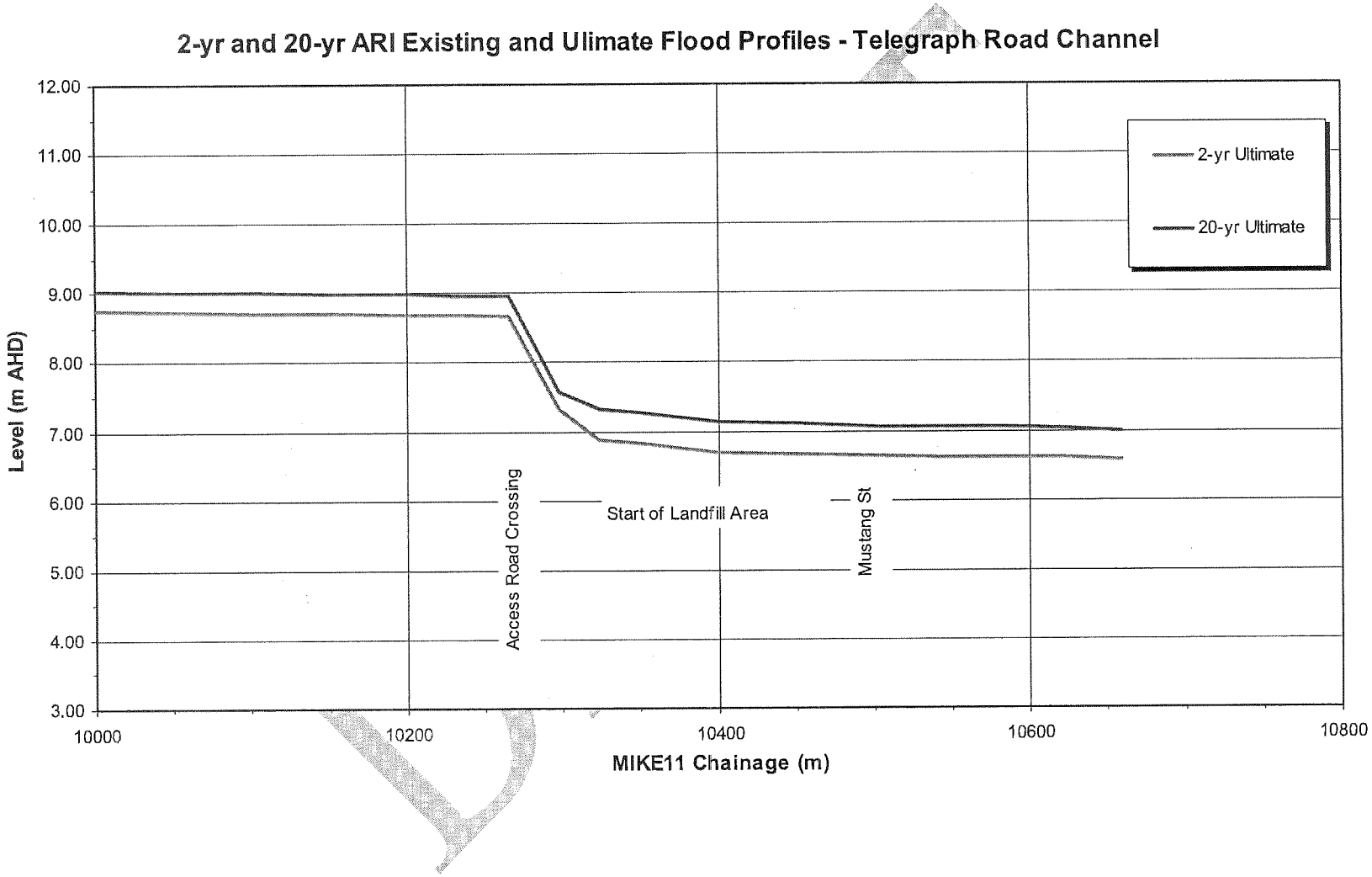

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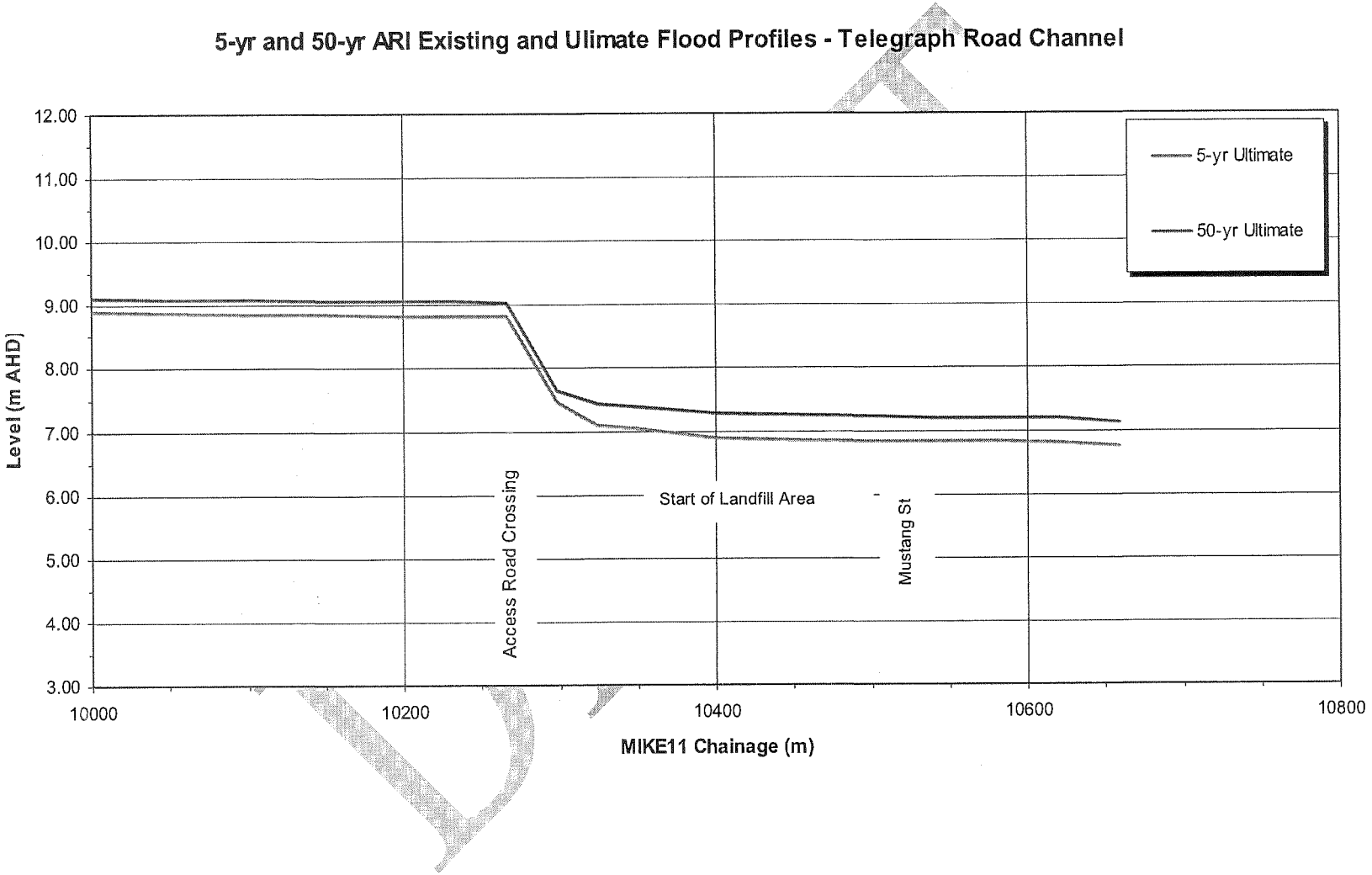

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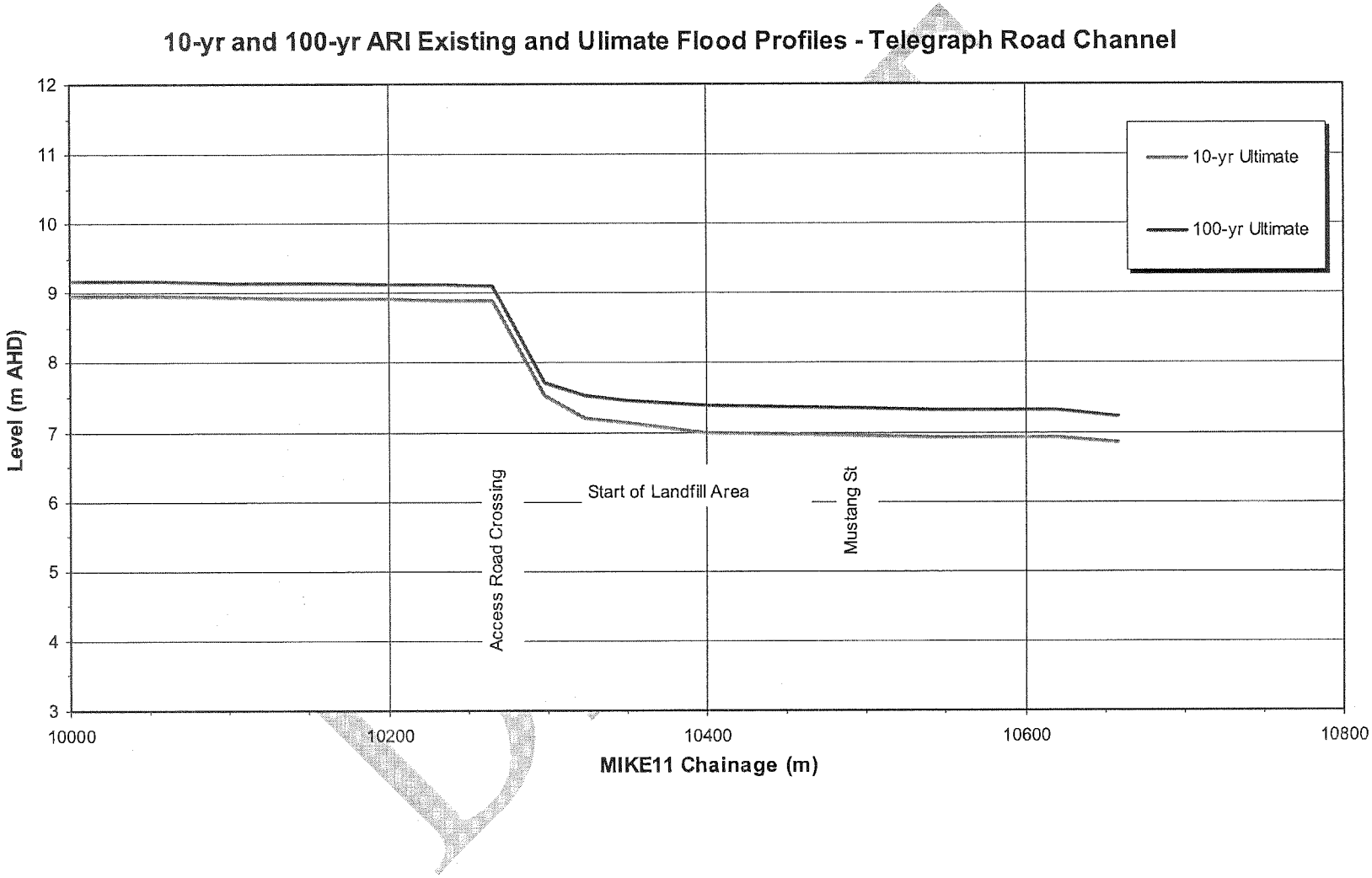

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APPENDIX C: Flood Inundation Map for the Carseldine Channel and associated tributaries

051461 Carseldine and Taigum Drainage Study



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APPENDIX D: Comparison of 100yr ARI Flood Levels

Reach	Chainage	AMTD	100-yr Flood Level (mAHD)			
			BCC Ultimate	WBM Ultimate	BCC Upgrade M	JWP Option A
Upper Cars	10000	4343	25.00	24.50	25.15	25.50
Upper Cars	10126	4217	23.47	23.30	23.45	23.53
Upper Cars	10233	4110	21.72	21.38	21.63	21.37
Upper Cars	10280	4084	21.12	21.03	21.27	20.96
Upper Cars	10300	4064	20.66	20.68	20.92	20.54
Upper Cars	10340	4024	20.22	20.29	20.51	20.17
Upper Cars	10400	3964	19.81	19.50	19.71	19.43
Upper Cars	10444	3920	19.44	19.10	19.31	19.06
Upper Cars	10480	3884	18.89	18.86	19.04	18.85
Upper Cars	10504	3860	18.61	18.62	18.78	18.65
Upper Cars	10540	3824	18.47	18.38	18.51	18.44
Upper Cars	10580	3784	18.39	18.14	18.25	18.24
Upper Cars	10640	3724	18.27	18.06	18.10	18.10
Upper Cars	10692	3672	18.19	17.98	17.95	17.97
Upper Cars	10707	3657	18.19	17.97	17.94	17.96
Gympie Road Culvert						
Upper Cars	10747	3617	16.70	17.00	17.00	16.96
Upper Cars	10761	3596	16.64	16.63	16.62	16.56
Upper Cars	10893	3464	16.01	15.97	15.97	15.91
Upper Cars	10946	3411	15.53	15.55	15.55	15.45
Upper Cars	11064	3293	14.61	14.57	14.56	14.54
Upper Cars	11167	3190	13.99	13.95	13.94	13.89
Upper Cars	11278	3079	13.49	13.79	13.77	13.43
Upper Cars	11359	2998	13.33	13.75	13.74	13.22
Gympie Rd	10040	596	24.63	25.27	24.91	24.86
Gympie Rd	10080	556	24.24	24.70	24.41	24.38
Gympie Rd	10120	516	24.08	24.13	23.91	23.89
Gympie Rd	10160	477	23.58	23.25	23.31	23.30
Gympie Rd	10200	437	22.59	22.38	22.70	22.70
Gympie Rd	10240	397	21.51	21.51	22.09	22.10
Gympie Rd	10280	356	20.47	20.88	21.30	21.30
Gympie Rd	10320	320	19.69	20.25	20.50	20.50
Gympie Rd	10360	279	18.96	19.50	19.75	19.74
Gympie Rd	10400	241	18.49	18.75	19.00	18.99
Gympie Rd	10440	200	17.92	18.00	18.25	18.23
Gympie Rd	10480	156	17.33	17.51	17.71	17.70
Gympie Rd	10536	110	16.69	16.54	16.63	16.63
Gympie Rd	10662	0	16.01	15.97	15.97	15.91
T'graph Rd	10000	N/A	9.09	N/A	N/A	N/A
T'graph Rd	10198	N/A	9.04	8.32	8.30	8.11
T'graph Rd	10266	N/A	9.03	8.00	7.93	7.55
Access Road Crossing						

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Reach	Chainage	AMTD	100-yr Flood Level (mAHD)			
			BCC Ultimate	WBM Ultimate	BCC Upgrade M	JWP Option A
T'graph Rd	10298	N/A	7.61	7.84	7.74	7.27
T'graph Rd	10350	N/A	7.45	7.52	7.36	6.72
T'graph Rd	10500	N/A	7.25	7.43	6.57	6.54
T'graph Rd	10659	N/A	7.08	7.42	6.40	6.23
Carseldine	10000	N/A	14.22	14.08	14.07	14.03
Carseldine	10078	N/A	13.97	13.93	13.93	13.87
Carseldine	10172	N/A	13.48	13.78	13.77	13.42
Carseldine	10243	2945	13.33	13.75	13.74	13.22
Lacey Road Culvert						
Carseldine	10293	2895	12.37	13.25	13.23	12.40
Carseldine	10364	2846	12.28	13.04	13.04	12.35
Carseldine	10414	2796	12.21	12.94	12.94	12.33
Carseldine	10464	2746	12.17	12.84	12.85	12.31
Carseldine	10514	2696	12.14	12.73	12.75	12.28
Carseldine	10564	2646	12.12	12.63	12.65	12.26
Carseldine	10654	2556	12.10	12.60	12.62	12.25
Carseldine	10705	2505	12.09	12.58	12.61	12.24
Carseldine	10768	2442	12.09	12.58	12.61	12.24
Carseldine	10837	2373	12.09	12.57	12.60	12.24
North Coast Railway						
Carseldine	10889	2321	10.59	10.83	10.83	10.76
Carseldine	10924	2286	10.46	10.69	10.69	10.58
Carseldine	11091	2119	9.82	10.26	10.26	9.96
Carseldine	11267	1943	9.47	9.79	9.77	9.56
Carseldine	11438	1772	9.25	9.63	9.39	9.25
Carseldine	11609	1601	9.17	9.60	9.19	9.00
Carseldine	11799	1411	9.13	9.57	8.80	8.70
Carseldine	11949	1261	9.02	9.39	8.01	7.85
Carseldine	12103	1107	8.79	9.04	7.47	7.32
Carseldine	12245	965	8.37	8.56	6.94	6.78
Carseldine	12460	750	7.08	7.42	6.40	6.23
Carseldine	12611	599	6.84	7.06	5.98	5.85
Carseldine	12769	441	6.28	6.32	5.73	5.66
Carseldine	12922	288	5.70	5.74	5.61	5.58
Carseldine	13066	144	5.60	5.70	5.55	5.54
Carseldine	13200	10	5.52	5.52	5.52	5.52

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101128 Albany Creek Flood Study

Water Resources Branch – BRISBANE INFRASTRUCTURE

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ALBANY CREEK

Project Owner: Water Resources Branch

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PART A – MODEL CALIBRATION

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this report is to describe the calibration of the Albany Creek Flood Model to the selected historical flood events in the catchment.

1.2 General

Albany Creek is located in the northern part of Brisbane. The catchment is split between the Brisbane City Council (BCC) and Moreton Bay Regional Council (MBRC) local government areas.

The total area of the catchment is approximately 888 hectares. The creek outlets into the South Pine River just downstream of Leitchs Crossing at Brendale.

The catchment takes in the suburbs ~~such as~~ of McDowall, Bridgeman Downs, Bunya, Albany Creek, and Arana Hills.

The upper reaches of the catchment are located in the Bunyaville Forest Reserve, upstream of Old Northern Road. Only a small part of the catchment upstream of Old Northern Road is developed – a small residential development in Arana Hills off Collins Road, and large-lot residential areas bounded by Old Northern Road and the Jinker Track.

Between Old Northern Road and Darien Street, the catchment is almost fully urbanised.

Between Darien Street and Albany Creek Road, there are some small areas of residential development along the western side of the catchment (near Keong Road). However, the majority of the catchment in this reach is undeveloped, containing the Darien Street Sports Fields, the Albany Creek Crematorium and Memorial Gardens, and the Albany Creek Road Reserve (including a pony club and park).

Downstream of Albany Creek Road, the catchment comprises residential development on the western side of the creek (in the MBRC area) and rural-residential development on the western side of the creek (in the BCC area).

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1.3 Study Elements

The Flood Study comprises two elements:

- a hydrologic model; and
- a hydraulic model.

BCC defined the study area for the hydraulic model to be downstream of Streisand Drive in McDowall, and Country Club Drive and Sunningdale Court in Albany Creek, as shown in Appendix A.

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2.0 AVAILABLE DATA

2.1 Hydrographic Data

2.1.1 Continuous Rainfall Gauges

Continuous rainfall data was provided for four gauges located in the vicinity of the Albany Creek catchment. This data is summarised in Table 2.1. The locations of the gauges are shown in Appendix A.

Table 2.1: Continuous Rainfall Data

Rain Gauge	Period of Record
C_R572	25/5/1994 – present
LCR566	1/7/1994 – present
A_R842	22/3/2005 – present
SPR959	19/2/2010 – present

2.1.2 Maximum Height Gauges (MHGs)

Three maximum height gauges (MHGs) are located along Albany Creek. Details of these gauges are listed in Table 2.2. The locations of the gauges are shown in Appendix A.

Table 2.2: Maximum Height Gauge Data

Maximum Height Gauge	Approximate Location	Period of Record
100	600 metres upstream of creek mouth	2/11/1981 – present
110	Just upstream of Albany Creek Road	5/5/1980 – present
120	Extension of Darien St, Bridgeman Downs	4/4/1988 – present

2.2 Topographic Data

The following topographic data was provided for the flood study:

- 0.25 metre contour data of the catchment in the Moreton Bay Regional Council local government area;
- 0.50 metre contour data of the catchment in the Brisbane City Council local government area; and
- Airborne Laser Scanning (ALS) survey data of the catchment.

No surveyed cross sections of the creek or hydraulic structures were provided for the flood study.

2.3 Hydraulic Structures

The flood study area comprises four hydraulic structures. The details of these structures are shown in Table 2.3.

Table 2.3: Hydraulic Structure Details

Location	Details
Galaxy Street, Bridgeman Downs	2/1800 mm RCPs
Peterson Place, Bridgeman Downs	8/1200 mm RCPs
Wendon Way, Bridgeman Downs	7/2.4 x 2.4 metre RCBCs
Albany Creek Road, Albany Creek	Bridge Structure

Bimap details of the three sets of culverts were provided by BCC.

Department of Main Roads' drawings of the bridge structure at Albany Creek Road were also provided by BCC.

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3.0 MODEL DESCRIPTIONS

3.1 Introduction

The models utilised for the Flood Study were:

- an XP-RAFTS hydrologic model; and
- a TUFLOW 1D/2D hydraulic model.

3.2 Hydrologic Model

The hydrologic modelling of the runoff in the Albany Creek catchment was carried out using XP-RAFTS. XP-RAFTS is an urban and rural runoff routing model used to calculate flood hydrographs from rainfall, catchment and channel inputs.

For the hydrologic model, the Albany Creek catchment was subdivided into 36 subareas. The subcatchment delineation is shown in Appendix A.

The fraction impervious of each subarea was determined for three scenarios:

- 1996 conditions (for the May 1996 calibration event), based on historical aerial photography;
- 2009/2010 conditions (for the May 2009 and October 2010 calibration events), based on current aerial photography; and
- ultimate catchment development (for the design flood events), based on current planning information from both the Moreton Bay Regional Council and Brisbane City Council.

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The average fraction impervious of the overall catchment for each scenario was:

- 1996 conditions – 18%;
- 2009/2010 conditions – 22%; and
- ultimate catchment development – 25%.

Approximately 40% of the Albany Creek catchment is located upstream of Old Northern Road. Albany Creek and its tributaries cross under Old Northern Road via culverts at three locations. At each crossing, the level of Old Northern Road is approximately six metres higher than the invert level of the creek at that point. Consequently, Old Northern Road forms a significant barrier to runoff from the upstream catchment in each tributary, acting like a detention basin for the catchment runoff.

Reword

The detention provided at the three culvert crossings at Old Northern Road was therefore included in the hydrologic model of the catchment. Modelling confirmed that Old Northern Road is not overtopped for floods up to and including the 1 in 100 year average recurrence interval (ARI) event.

Stage-storage curves for the storage area just upstream of Old Northern Road at each culvert crossing were determined based on the 0.25 metre contour data provided by MBRC. Culvert details were also provided by MBRC. A summary of the characteristics of each crossing is shown in Table 3.1.

Table 3.1: Old Northern Road Culvert Crossings

Approximate Location	Catchment Area (ha)	Culvert Details
The Boulevard, Albany Creek	204.6	3/1650 mm RCPs
Allamanda Crescent, Albany Creek	111.6	3/1650 mm RCPs
De Vito Place, McDowall	8.3	1200 mm RCP

To provide an understanding of the indicative response time of the catchment, the Bransby-Williams equation was used to estimate the time of concentration of the catchment. The characteristics of the catchment were calculated as follows:

- Stream Length = 8.5 km
- Catchment Area = 888 ha
- Equal Area Slope = 0.7%

Using the Bransby-Williams equation, the time of concentration of the catchment was calculated to be 270 minutes, or 4.5 hours. The Bransby-Williams equation is suitable for use in rural catchments, whereas the Albany Creek catchment contains large areas of urban development. However, this estimate of the time of concentration can be used as a reasonable indication of the response time of the catchment.

3.3 Hydraulic Model

The flood flow in Albany Creek was modelled using the combined 1-dimensional/2-dimensional unsteady flow software TUFLOW (2010-10-AC-iSP). TUFLOW models free-surface flows in one-dimensional links (such as open channels, pipes and culverts, bridges, etc) and two-dimensional domains.

4.0 CALIBRATION

4.1 Calibration Events

4.1.1 Hydrologic Model Calibration

Based on the available rainfall and maximum height gauge data, the following three events were selected for the calibration of the hydrologic and hydraulic models:

- May 1996;
- May 2009; and
- October 2010.

The cumulative rainfall from each event, including the rain in the week leading up to and following the peak of the event, are shown in Appendix A.

Intensity-Frequency-Duration (IFD) curves for each event are also shown in Appendix A. As discussed in Section 3.2, the time of concentration of the catchment is in the order of 4.5 hours.

No stream gauges are located within the Albany Creek catchment. Consequently, no direct calibration of the hydrologic model to recorded stream flows was possible. However, the flows calculated by the hydrologic model were input into the hydraulic model, for calibration to the recorded flood peaks.

As a further check of the hydrologic model, the peak design flows calculated by the hydrologic model were compared to the design flows determined from:

- the Rational Method; and
- the 1992 flood study of the catchment.

These results are discussed in Part B of the report.

For all calibration events, an initial loss of 0 mm was adopted, and a continuing loss rate of 0 mm/h and 2.5 mm/h was adopted in the impervious and pervious areas respectively.

For the three calibration events, the calculated flow hydrographs at the mouth of the creek are shown in Appendix A.

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4.1.2 Hydraulic Model Calibration

The peak flood levels calculated by the hydraulic model were compared to the recorded maximum height gauge (MHG) readings, for each flood event. The results are discussed in the following sections.

It should be noted that the ALS data does not accurately define the low flow paths in heavily vegetated areas, as the laser scanning cannot penetrate to the true ground level. Consequently, the "surveyed" ground level is typically 150-300 mm higher than the true ground level. This has a significant impact on the model results for small flood events, i.e. less than a 5 year event.

4.2 May 1996 Event

The May 1996 event was a relatively minor flood event. Based on the IFD curves of the recorded rainfall, the frequency of the event was in the order of 2 to 5 years.

A comparison of the recorded peak flood levels to the modelled peaks is shown in Table 4.1.

Table 4.1: Peak Flood Levels – May 1996 Event

Maximum Height Gauge	Recorded Peak Flood Level (mAHD)	Calculated Peak Flood Level (mAHD)	Difference (m)
100	10.32	10.47	+0.15
110	14.93	16.14	+1.21
120	25.05	25.24	+0.19

Good agreement was achieved at MHGs 100 and 120, with the differences less than 200 mm. A poor match was achieved at MHG 110. However, the recorded peak level at MHG 100 appears to be wrong, as discussed below.

110 ?

The magnitude of the May 1996 and May 2009 events are similar. Based on the IFD curves, both events had a frequency in the order of 2 to 5 years. The recorded peak flood levels in May 1996 were 180 mm and 90 mm higher than the recorded peak flood levels in May 2009 at MHGs 100 and 120 respectively. However, the recorded peak flood level in May 1996 at MHG 110 was 940 mm lower than that recorded in May 2009. It can therefore be concluded that the recorded level at MHG 110 in May 1996 is at least one metre too low.

need to check data

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4.3 May 2009 Event

The May 2009 event was similar in magnitude to the May 1996 event. Based on the IFD curves of the recorded rainfall, the frequency of the event was in the order of 2 to 5 years.

As discussed above, the recorded flood level at MHG 110 in May 1996 appears to be wrong. Thus, based on the recorded flood levels in May 2009, this event is the smallest of the three calibration events.

A comparison of the recorded peak flood levels to the modelled peaks is shown in Table 4.2.

Table 4.2: Peak Flood Levels – May 2009 Event

Maximum Height Gauge	Recorded Peak Flood Level (mAHD)	Calculated Peak Flood Level (mAHD)	Difference (m)
100	10.14	10.47	+0.33
110	15.87	16.15	+0.28
120	24.96	25.28	+0.32

Reasonable agreement was achieved at all three MHGs, with the differences less than 350 mm at all gauges. As discussed in Section 4.1.2, the accuracy of the ALS data has an impact on small flood events. The May 2009 event is the smallest of the three calibration events. Given this constraint, the calibration of the model to the recorded peak flood levels for this small flood event is considered to be acceptable.

4.4 October 2010 Event

The October 2010 event is the largest of the three calibration events. Based on the IFD curves of the recorded rainfall, the frequency of the event was in the order of 5 to 20 years.

A comparison of the recorded peak flood levels to the modelled peaks is shown in Table 4.3.

Table 4.3: Peak Flood Levels – October 2010 Event

Maximum Height Gauge	Recorded Peak Flood Level (mAHD)	Calculated Peak Flood Level (mAHD)	Difference (m)
100	10.94	10.78	-0.16
110	16.12	16.36	+0.24
120	25.15	25.45	+0.30

Good agreement was achieved at all MHGs, with the differences less than 300 mm.

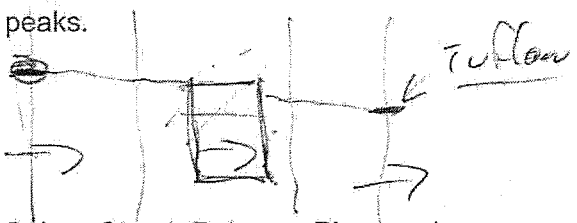
5.0 VERIFICATION

5.1 Verification Events

No verification events were modelled.

To check for consistency between the hydrologic and hydraulic models, the discharge hydrographs calculated at the mouth of Albany Creek were compared. The results for the three calibration events are shown in Appendix A.

These hydrographs demonstrate a high degree of consistency between the two models, both in terms of the magnitude and the timing of the of the flow peaks.



5.2 Structure Verification

The TUFLOW model included three sets of culverts – at Galaxy Street, Peterson Place and Wendon Way. The structure losses at these three crossings (as calculated by the TUFLOW model) were verified by checking the results with an independent hydraulic package, namely HEC-RAS (version 3.1.3). The results of both hydraulic models, for the three calibration events, are shown in Table 5.1.

Table 5.1: Structure Losses – Calibration Events

Calibration Event	Culvert Crossing	Upstream Level TUFLOW (mAHD)	Upstream Level HEC-RAS (mAHD)
May 1996	Galaxy Street	35.81[1]	35.88[1]
May 2009	Galaxy Street	35.83[1]	35.85[1]
October 2010	Galaxy Street	36.16[1]	36.22[1]
May 1996	Peterson Place	26.01[2]	26.00[2]
May 2009	Peterson Place	26.05[2]	26.02[2]
October 2010	Peterson Place	26.25[2]	26.29[2]
May 1996	Wendon Way	25.80[2]	25.80[2]
May 2009	Wendon Way	25.85[2]	25.86[2]
October 2010	Wendon Way	26.07[2]	26.07[2]

Notes: *1. Inlet Control*
2. Outlet Control

These results demonstrate that the structure losses calculated by the TUFLOW model are consistent with the results from the HEC-RAS model.

The structure losses at the crossing at Albany Creek Road were not verified. This was due to a number of factors, which made modelling the Albany Creek Road structure unrealistic in a 1-dimensional HEC-RAS model.

- Albany Creek Road is located at a tight bend in Albany Creek. A 1D model would not capture the bend losses which would occur in this area.
- The flood flow approaching Albany Creek Road is generally parallel to the road (from east to west). The flow departing the structure is almost parallel to the road (from west to east). Thus, it is practically impossible to determine a suitable cross section which accurately models the flood flow approaching or departing the structure.
- A significant amount of flood flow crosses over Albany Creek Road on the approach to the crossing, taking a considerable short cut compared to the flow which stays in the main channel of Albany Creek.
- The main channel of Albany Creek flows north-east, but a large overland flow path also exists downstream of Albany Creek Road. This overland flow path goes north and north-west.

It can therefore be seen that modelling of the Albany Creek Road structure is not suitable to a 1D model.

Given the excellent agreement between the TUFLOW model and HEC-RAS model at the other three crossings, it was considered that the TUFLOW model results were reliable.

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5.3 Sensitivity to Model Parameters

A sensitivity analysis was carried out, examining the effect of changing the tailwater level in South Pine River and the waterway Manning's n value along the waterway. These two analyses are discussed in Section 7.2 and Section 10.2.1 respectively.

5.4 Calibration and Verification Summary

The above results show that the model has achieved a good calibration, across all flood events. As discussed in Section 4.1.2, the accuracy of the ALS data has a significant impact on small flood events.

The model verification confirmed that the hydrologic and hydraulic models are producing consistent results. It also demonstrated the structure losses calculated by the TUFLOW model are consistent with the losses calculated by HEC-RAS. Thus, the structure losses are acceptable.

PART B – DESIGN EVENT MODELLING

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6.0 INTRODUCTION

The purpose of this part of the report is to describe the calculation of the design flood levels and discharges in Albany Creek, using the calibrated hydrologic and hydraulic models.

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7.0 MODEL DATA

7.1 Design Rainfall

Design rainfall for the RAFTS model was determined from:

- temporal patterns in accordance with Australian Rainfall and Runoff (AR&R); and
- rainfall intensities from Brisbane City Council's *Subdivision and Development Guidelines*.

For all design events, an initial loss of 0 mm was adopted, and a continuing loss rate of 0 mm/h and 2.5 mm/h was adopted in the impervious and pervious areas respectively.

7.2 Tailwater Conditions

Albany Creek outlets into the South Pine River at Brendale. Design flood levels in the South Pine River were obtained from the *South Pine River Catchment Management Plan* (John Wilson & Partners, 2004). The design flood levels (assuming ultimate catchment development) are shown in Table 7.1.

Table 7.1: South Pine River Peak Flood Levels at Albany Creek Mouth

Average Recurrence Interval	Flood Level (mAHD)
2 years	7.43
5 years	8.11
10 years	8.46
20 years	8.87
50 years	9.20
100 years	9.48

The catchment area of the South Pine River to the mouth of Albany Creek is approximately 190 km². It therefore has a time of concentration significantly longer than the time of concentration of Albany Creek. The *South Pine River Catchment Management Plan* did not provide any details regarding the time of concentration for the South Pine River catchment. For the purposes of this analysis, an indicative time of concentration of the South Pine River to Albany Creek of 12 hours was adopted.

A coincident flooding assessment was carried out, in accordance with QUDM Section 8.03.4(c). This assessment indicated the following coincident floods:

- Albany Creek Q100 + South Pine River Q1; and
- South Pine River Q100 + Albany Creek Q5.

A sensitivity analysis was carried out to determine the impact of the downstream tailwater level on flood levels in Albany Creek. The analysis showed that a change in the tailwater level of more than two metres (from 7.43 to 9.48 mAHD) only affected flood levels in the final 250 metres of the creek. Given this result, a uniform tailwater level in the South Pine River equivalent to the 100 year flood level (i.e. 9.48 mAHD) was adopted for all design flood events in Albany Creek.

7.3 Topographic and Structure Data

Airborne Laser Scanning (ALS) survey data of the study area, provided by BCC, was used to setup the TUFLOW model.

As discussed in Section 4.1.2, the ALS data does not accurately define low flow paths in heavily vegetated areas, because the laser scanning cannot penetrate to the true ground level. Consequently, the "surveyed" ground level is typically 150-300 mm higher than the true ground level. This has a significant impact on the model results for small flood events, i.e. less than a 5 year event.

Three culvert crossings are located within the study area. Bimap details of these culverts were provided by BCC. Details of these structures are shown in Table 2.3.

One bridge crossing, at Albany Creek Road, is located within the study area. Department of Main Roads' drawings (dated 1986) of this two-span bridge were provided by BCC. However, these drawings did not provide a large amount of detail regarding the waterway area under the bridge – only one small sketch figure. Site inspection also showed the waterway area to be significantly different to the sketch figure contained in the drawings. The bridge opening was therefore modelled based on the size of the waterway area observed during the site inspection.

No surveyed cross sections of the creek or hydraulic structures were provided for the flood study.

7.4 Land Use

The hydrologic modelling of the catchment for the design flood events adopted land uses assuming ultimate catchment development (based on current planning). Ultimate land use maps were provided for both the BCC and MBRC local government areas. The adopted fraction imperviousness in each subarea is shown in Appendix B.

8.0 DESIGN EVENT MODELLING

8.1 Australian Rainfall and Runoff

Design event modelling was carried out using the Australian Rainfall and Runoff temporal patterns.

The 2, 5, 10, 20, 50 and 100 year Average Recurrence Interval (ARI) flood events were modelled.

Storm durations from 15 minutes to 24 hours were initially modelled. However, the peak flood levels and discharges within the study area were produced by storms of 1 to 3 hours' duration.

8.2 Duration Independent Storm

Detail in appendix

The duration independent storm was also modelled. The 2, 5, 10, 20, 50 and 100 year Average Recurrence Interval (ARI) flood events were analysed, for comparison to the AR&R design flood events.

It is noted that the total depth of rainfall in the duration independent storm for each ARI event is typically factored down, based on the outcome of a flood frequency analysis. However, a flood frequency analysis was outside the scope of this flood study.

To be included.

May CC factors.

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9.0 HYDROLOGIC MODELLING

9.1 Comparison of Peak Discharges

The peak discharges calculated by the RAFTS hydrologic model were compared to the results from two independent sources: the Rational Method, and flows from the 1991 Albany Creek Flood Study.

As discussed in Section 3.2, Albany Creek (and its tributaries) cross under Old Northern Road via culverts at three locations. At each crossing, the level of Old Northern Road is approximately six metres higher than the invert level of the creek at that point. Consequently, Old Northern Road acts like a detention basin for the catchment runoff at the locations.

The Rational Method was therefore used to estimate the 100 year peak discharge to Old Northern Road in the two main catchments. The Rational Method cannot be used to calculate flows further downstream in the catchment, due to the flow attenuation which occurs at Old Northern Road.

The Bransby-Williams Method was used to calculate the time of concentration of the catchments. The results are shown in Table 9.1.

Table 9.1: Time of Concentration Calculations

Parameter	Catchments A – H	Catchments J – O
Area (ha)	204.6	111.6
Length (m)	3650	1930
Equal Area Slope (%)	1.3	1.6
Time of Concentration (min)	119	64

Times of concentration of 2 hours and 1 hour were therefore adopted for these two catchments respectively. The 100 year peak discharges from the catchments calculated using the Rational Method, compared to the results from RAFTS model, are shown in Table 9.2.

A comparison of the 100 year peak discharges from the 1991 Flood Study and the RAFTS model is also shown in Table 9.2.

Table 9.2: Comparison of 100 Year Peak Discharges

Location	100 Year Peak Discharge (m^3/s)		
	Rational Method	1991 Flood Study	RAFTS Model
Old Northern Rd (Catchment A – H)	34.8	26.4	41.4
Old Northern Rd (Catchment J – O)	28.6	-	33.1
Darien Street	-	73.4	73.0
Albany Creek Road	-	105.9	93.6
Mouth	-	113.8	108.3

These results show that the RAFTS model results are consistent with both the Rational Method results and the 1991 Flood Study.

9.2 Hydrologic Model Results

The 100 year peak discharges calculated by the RAFTS model are summarised in Table 9.3.

Table 9.3: RAFTS Model 100 Year Peak Discharges

Location (Subarea)	AR&R 100 Year Peak Discharge (m^3/s)	AR&R Storms Critical Storm Duration	DIS 100 Year Peak Discharge (m^3/s)
Old Northern Rd (H) – Upstream	41.4	1.5 hour	53.0
Old Northern Rd (H) – Downstream	31.8	1.5 hour	36.1
Country Club Drive(I)	33.1	2 hour	37.5
Old Northern Rd (O) – Upstream	33.1	1 hour	40.0
Old Northern Rd (O) – Downstream	28.4	1 hour	32.0
Sunningdale Court (P)	30.4	1 hour	34.6
Old Northern Rd (R) – Upstream	3.5	1 hour	3.9
Old Northern Rd (R) – Downstream	2.5	1 hour	2.8
Galaxy Street (T)	9.9	1 hour	12.4
Darien Street (W)	73.0	2 hour	85.4
Albany Creek Road (AD)	93.6	2 hour	120.2
Mouth (AJ)	108.3	2 hour	143.8

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A comparison of the 100 year peak discharges calculated by the RAFTS model and the TUFLOW model are summarised in Table 9.4. These results confirm that the two models are yielding consistent results. Consistent routing

Table 9.4: 100 Year Peak Discharges – RAFTS and TUFLOW

Location	RAFTS Peak Discharge (m^3/s)	TUFLOW Peak Discharge (m^3/s)
Galaxy Street	9.9	10.2
Darien Street	73.0	73.5
Albany Creek Road	93.6	92.2
Mouth	108.3	108.0

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10.0 HYDRAULIC MODELLING

10.1 Model Setup

For the flood study, a fine 4.0 metre grid was used to define flow in the 2-dimensional domain. 1-dimensional links were used to model the four hydraulic structures included within the study area defined by BCC.

The Manning's n roughness values used in the model are shown in Table 10.1.

Table 10.1: Manning's n Values

Land Use	Manning's n Value
Heavily Treed Areas	0.12
Riparian Vegetated Corridors	0.15
Residential Areas	0.20
Grassed Areas, Parks	0.035
Road Reserves	0.025

Inflows to the TUFLOW model were provided by the calibrated RAFTS model.

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10.2 Modelling Ultimate Waterway Conditions

10.2.1 Existing Waterway Corridors

The existing waterway corridors along Albany Creek are heavily vegetated. A Manning's n value of 0.12 was used in modelling. This value achieved good calibration with the recorded flood levels.

To examine the sensitivity of the model to changes in the Manning's n value, the 100 year 2 hour storm event (which produces the peak flood levels along most of the waterway within the study area) was re-run assuming a Manning's n value of 0.15 along the waterway (instead of the value used in the modelling of 0.12).

The results showed that increasing the Manning's n in all heavily vegetated areas (which constitutes the vast majority of the inundation extent) from 0.12 to 0.15 only causes an increase in flood level of up to 300 mm along the creek. A map showing the changes in flood level is contained in Appendix B.

no - only for planning purposes

10.2.2 Minimum Riparian Vegetated Corridor

Brisbane City Council proposes to provide a riparian vegetated corridor along Albany Creek with a minimum width of 15 metres from each side of the low flow bank with a Manning's n value of 0.15.

It is noted that apart from a small number of isolated locations (i.e. just upstream and just downstream of Wendon Way, just upstream and just downstream of Albany Creek Road), Albany Creek already provides a heavily vegetated corridor along the majority of its length.

As discussed in Section 10.2.1, increasing the Manning's n 0.15 for all heavily vegetated areas generally causes increases in flood levels of less than 300 mm.

Need to use our standard words.

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11.0 FINAL MODEL RESULTS

11.1 Flood Levels and Discharges

The most appropriate method for displaying results from a two dimensional model is through mapping. The area of inundation, flood depth, velocities and hazard levels are shown on Figures B1 – B96 for the full range of average recurrence intervals from the 2 year event through to the 100 year event.

In addition, point data has also been tabulated at a number of locations, including at the maximum height gauges and at all structures. The peak flood levels and discharges are detailed for all average recurrence intervals at a number of locations in Table 11.1 and Table 11.2.

Critical duration mapping has also been included in Appendix B. This mapping shows the critical duration for each ARI at all locations throughout the model.

Some mention of findings/conclusions.
eg. within bank
high flow through vegetated area
Q100 profile?
where are impacts/losses?

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Table 11.1: Peak Flood Levels (mAHD)

Location	100 yr ARI	50 yr ARI	20 yr ARI	10 yr ARI	5 yr ARI	2 yr ARI
2D Results						
MHG100	11.08	10.99	10.89	10.79	10.66	10.48
MHG110	16.51	16.47	16.41	16.36	16.29	16.14
MHG120	25.73	25.67	25.58	25.52	25.41	25.28
1D Results						
Albany Creek Road u/s	16.43	16.39	16.34	16.28	16.20	16.06
Albany Creek Road d/s	16.33	16.29	16.24	16.19	16.12	16.00
Galaxy Street u/s	36.73	36.61	36.48	36.36	36.28	36.11
Galaxy Street d/s	35.83	35.78	35.73	35.68	35.64	35.56
Peterson Place u/s	26.92	26.79	26.56	26.38	26.21	26.05
Peterson Place d/s	26.70	26.58	26.41	26.29	26.15	26.02
Wendon Way u/s	26.58	26.47	26.30	26.17	26.01	25.84
Wendon Way d/s	26.29	26.22	26.11	26.02	25.90	25.77

Note: Refer Figure for locations.

Ultimate conditions ?
with w.c.

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Table 11.2: Peak Flows (m^3/s)

Location	100 yr ARI	50 yr ARI	20 yr ARI	10 yr ARI	5 yr ARI	2 yr ARI
2D Results						
Outlet	108.28	98.90	81.04	66.69	52.20	37.29
Albany Creek Road u/s	81.65	73.37	62.22	52.48	42.59	31.62
Albany Creek Road d/s	92.24	83.24	69.93	58.44	47.47	34.63
Albany Creek Road overflow	47.07	38.38	25.89	16.23	7.85	1.41
Pony Club	80.21	71.60	61.01	51.91	42.12	31.24
Darlen Street	73.53	65.68	54.68	46.45	37.18	27.91
Wendon Way u/s	72.15	64.62	53.77	46.00	36.44	27.72
Wendon Way overflow	0.00	0.00	0.00	0.00	0.00	0.00
Peterson Place u/s	19.61	17.72	14.68	12.49	10.44	7.70
Peterson Place overflow	0.52	0.00	0.00	0.00	0.00	0.00
Albany Creek No 1	57.39	53.04	42.62	36.57	29.44	23.29
Albany Creek No 2	60.12	55.38	44.55	38.05	30.59	23.96
Albany Creek No 3	15.82	14.61	12.12	10.34	8.52	6.36
Galaxy Street u/s	10.16	9.05	7.76	6.52	5.71	4.27
Overland Flow path	0.00	0.00	0.00	0.00	0.00	0.00
Wendon Way u/s	72.15	64.62	53.77	46.00	36.44	27.72
1D Results						
Albany Creek structure 1	26.86	26.57	25.75	24.39	22.55	18.37
Albany Creek structure 2	18.70	18.67	18.53	17.99	17.24	14.95
Galaxy Street structure	9.96	8.88	7.63	6.42	5.62	4.22
Peterson Place structure	19.24	17.50	14.55	12.40	10.37	7.80
Wendon Way structure	72.07	64.57	53.64	45.67	36.41	27.61

Note: Refer Figure for locations.

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11.2 Flood Continuing

What does this title mean?

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12.0 REFERENCES

Brisbane City Council, 2008, Subdivision and Development Guidelines

Department of Natural Resources and Water, 2007, Queensland Urban Drainage Manual

Institution of Engineers Australia, Australian Rainfall and Runoff

John Wilson & Partners, 1991, Albany Creek Flood Study

John Wilson & Partners, 2004, South Pine River Catchment Management Plan

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PART C – USER GUIDELINES

No

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Appendix A Part A – Model Calibration

Figures

A1 Extent of Study

A2 Locations of Rainfall and Maximum Height Gauges

A3 RAFTS Model

A4 Cumulative Rainfall, May 1996

A5 Cumulative Rainfall, May 2009

A6 Cumulative Rainfall, October 2010

A7 IFD Chart, May 1996

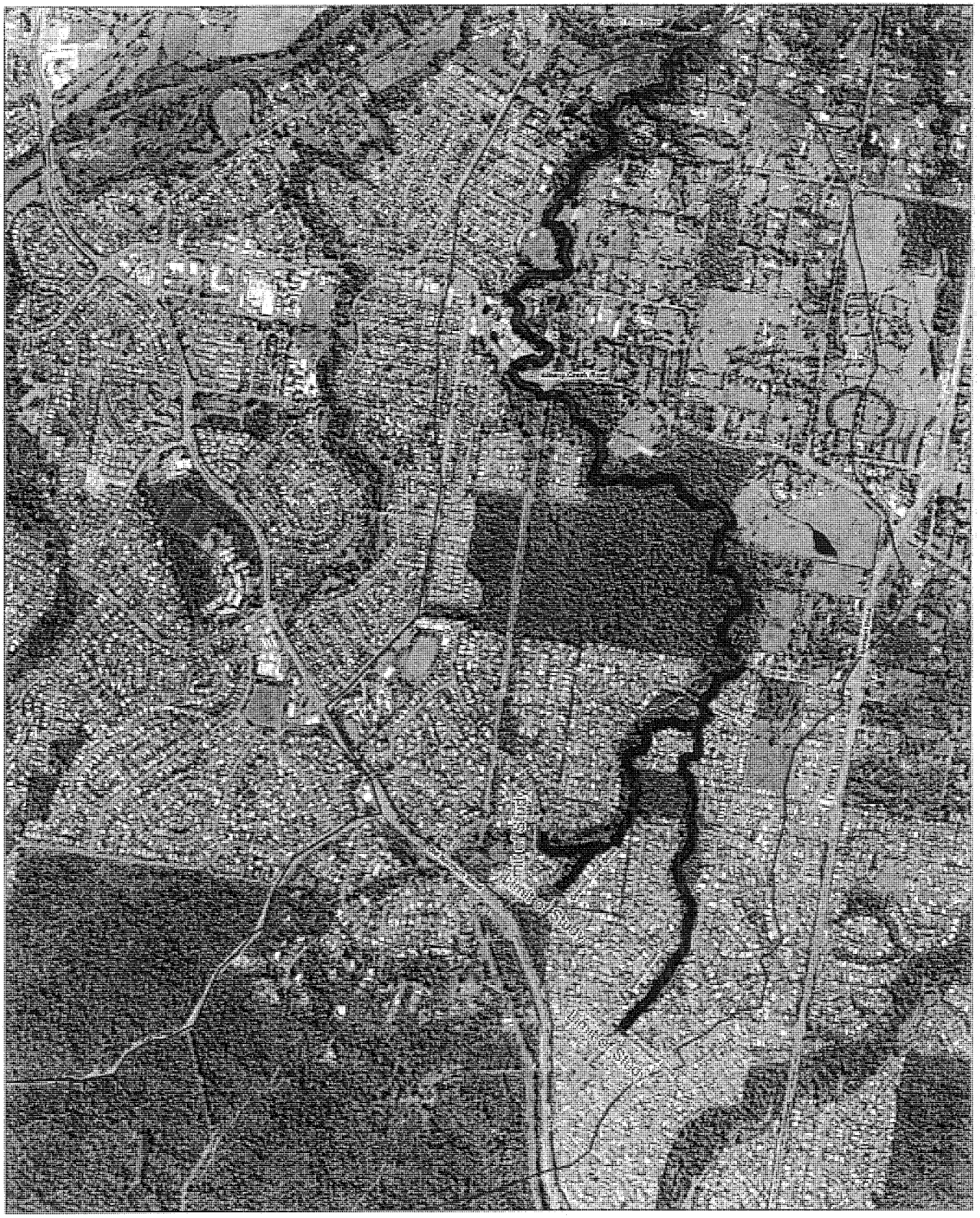
A8 IFD Chart, May 2009

A9 IFD Chart, October 2010

A10 RAFTS vs TUFLOW Hydrograph at Mouth, May 1996

A11 RAFTS vs TUFLOW Hydrograph at Mouth, May 2009

A12 RAFTS vs TUFLOW Hydrograph at Mouth, October 2010



Scale: 1:20,000

FIGURE A1
EXTENT OF STUDY

Project No: J11039

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File Path: [J11039MapInfo\Figure]

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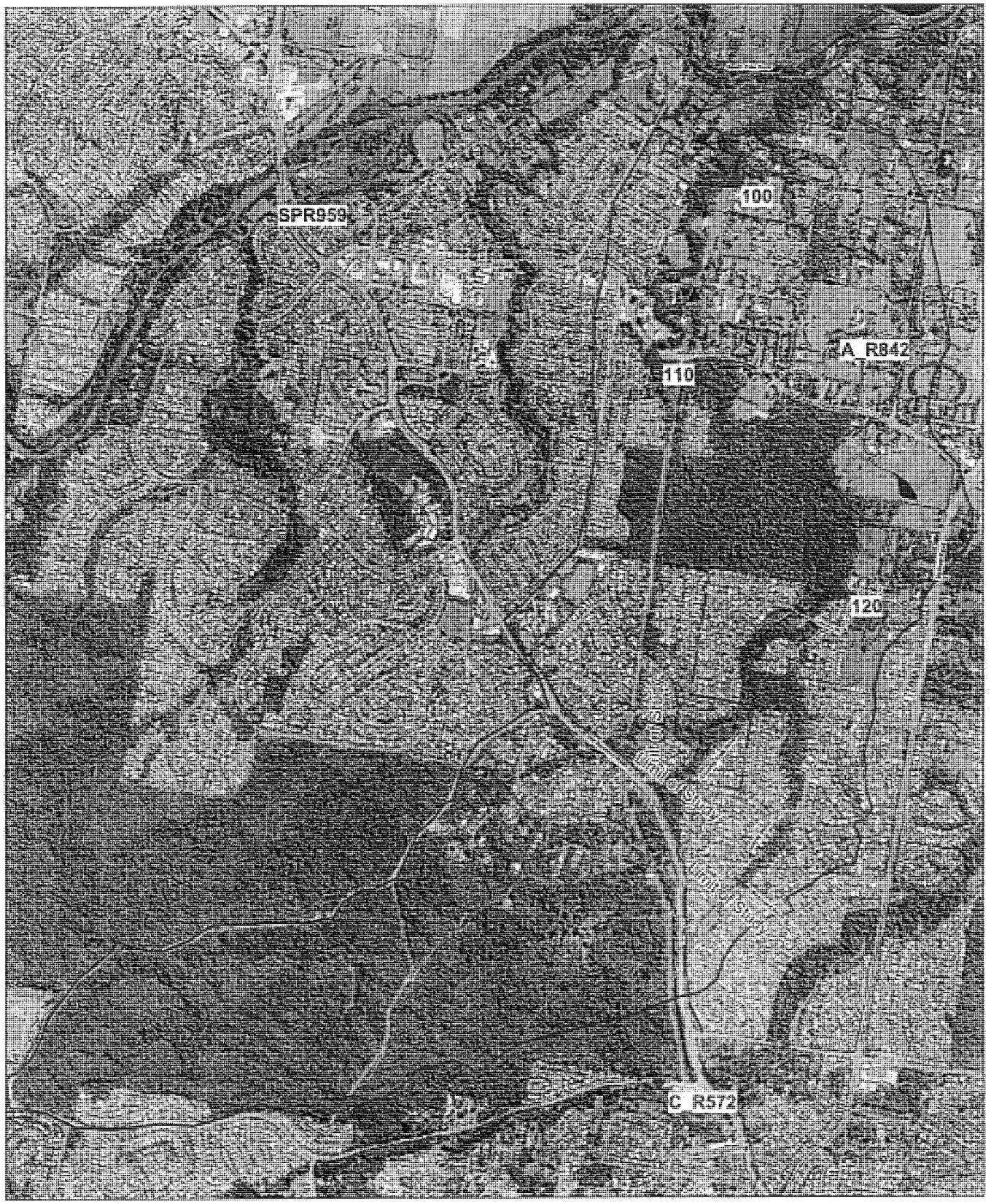

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Scale: 1:25,000

FIGURE A2
GAUGE LOCATIONS

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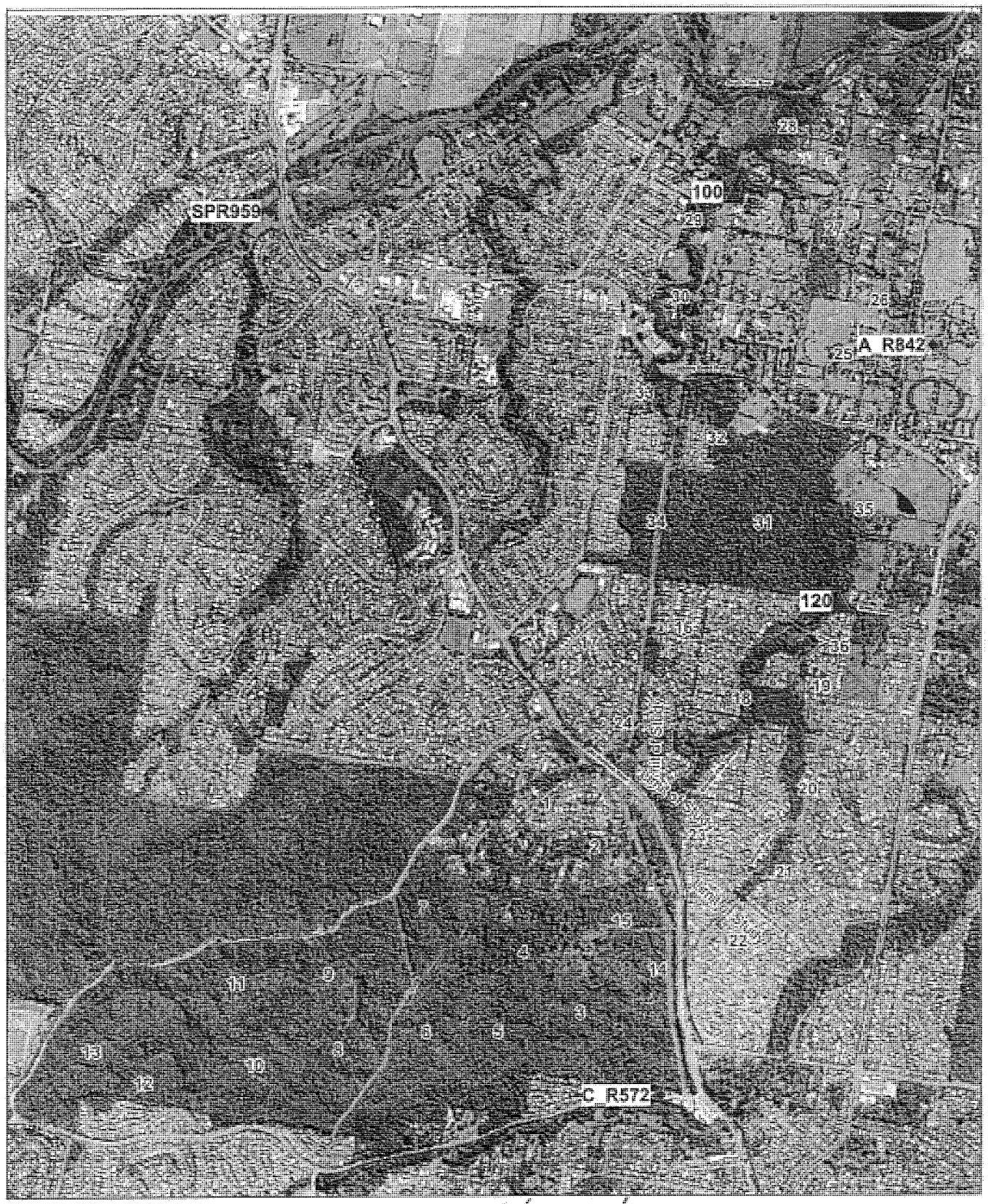
ALBANY CREEK FLOOD STUDY



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Subcatchments to be cleaner

Scale: 1:25,000

FIGURE A3
RAFTS MODEL

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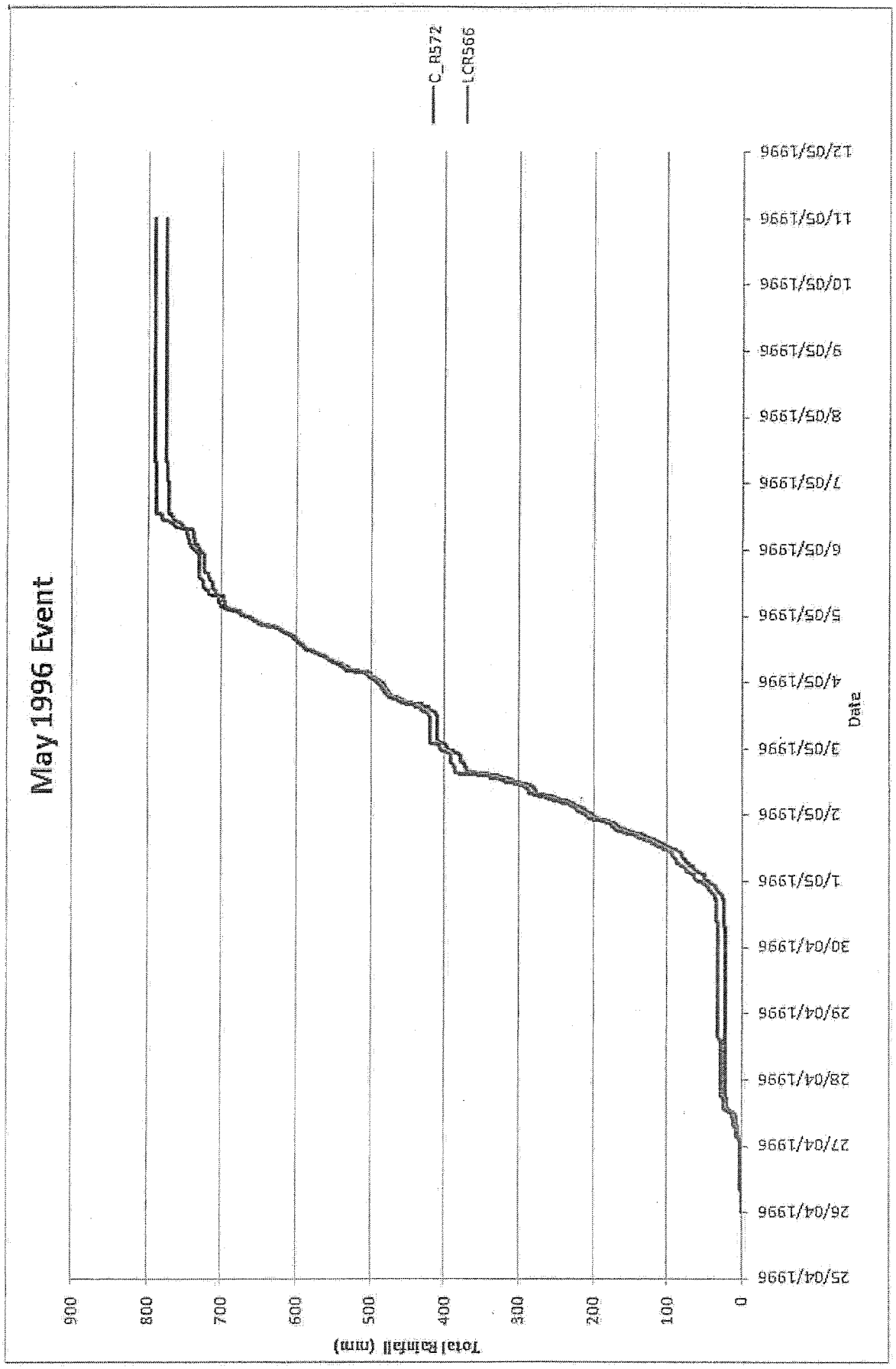
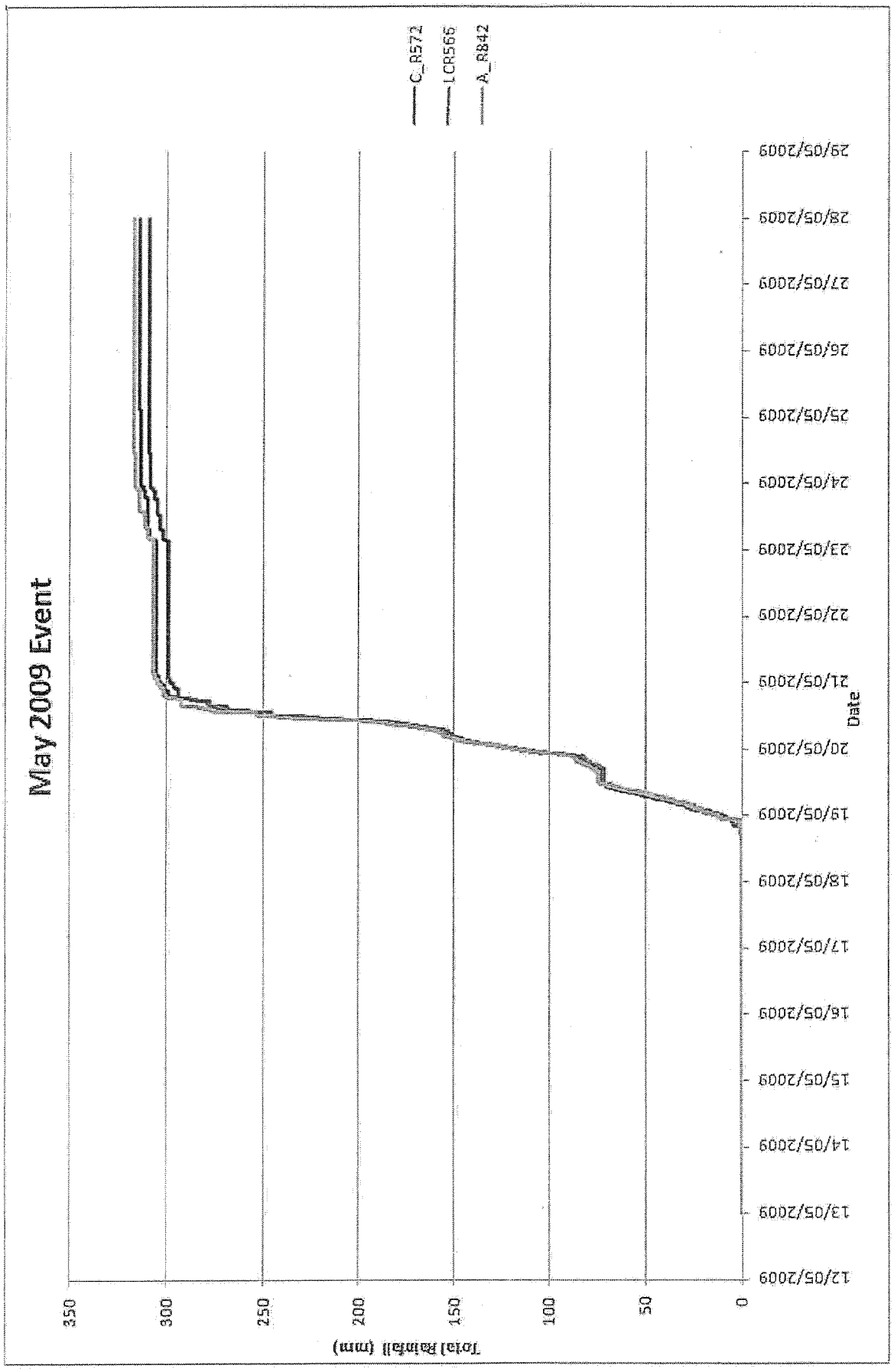
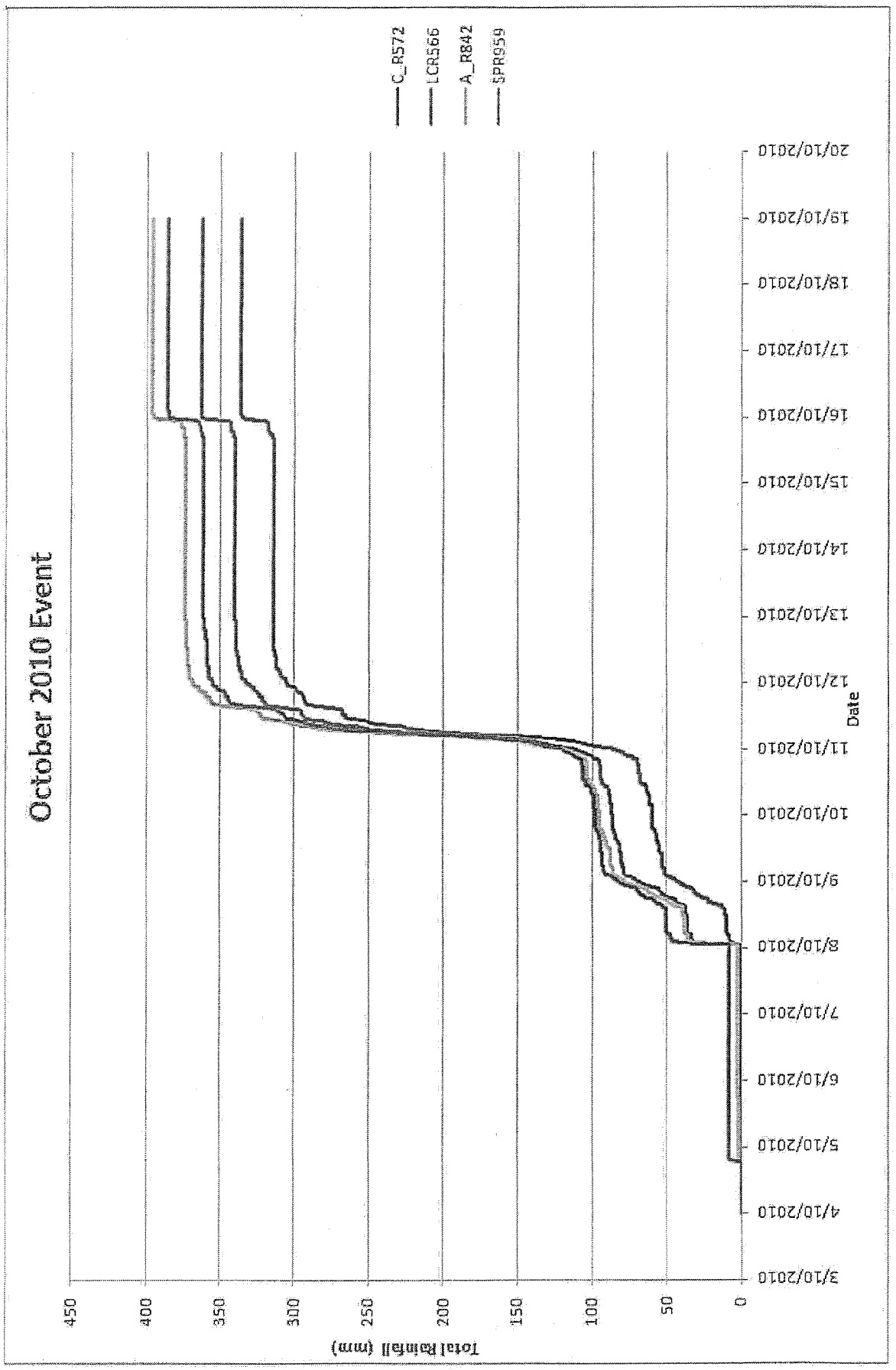

May 1996 Event
C_A572
LCR566
Total Rainfall (mm)
0
100
200
300
400
500
600
700
800
900
Date
25/04/1996
26/04/1996
27/04/1996
28/04/1996
29/04/1996
30/04/1996
1/05/1996
2/05/1996
3/05/1996
4/05/1996
5/05/1996
6/05/1996
7/05/1996
8/05/1996
9/05/1996
10/05/1996
11/05/1996
12/05/1996

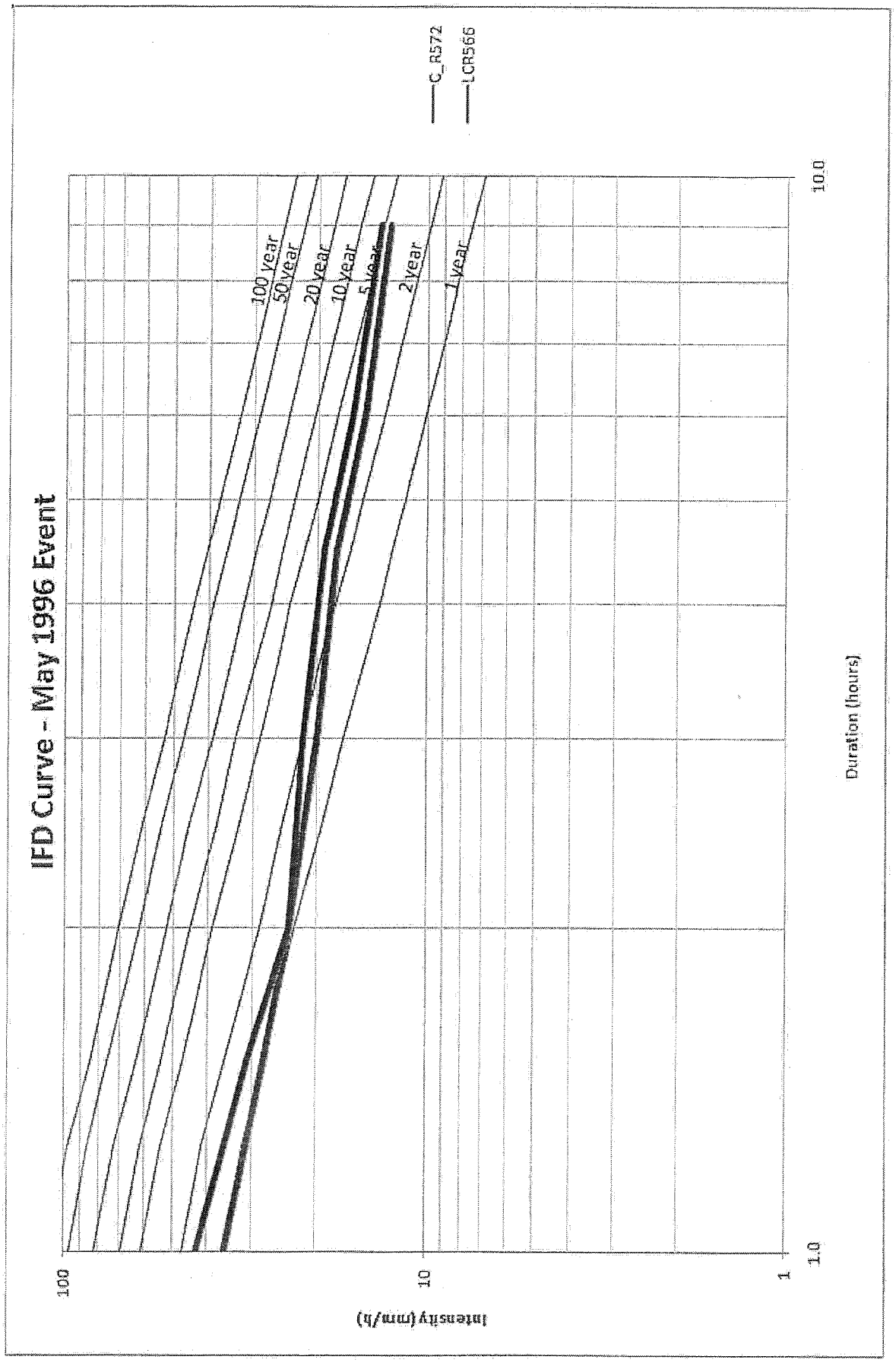
DRAFT


C_R572
LCR566
A_R842
May 2009 Event
Total Rainfall (mm)
350
300
250
200
150
100
50
0
Date
12/05/2009
13/05/2009
14/05/2009
15/05/2009
16/05/2009
17/05/2009
18/05/2009
19/05/2009
20/05/2009
21/05/2009
22/05/2009
23/05/2009
24/05/2009
25/05/2009
26/05/2009
27/05/2009
28/05/2009
29/05/2009

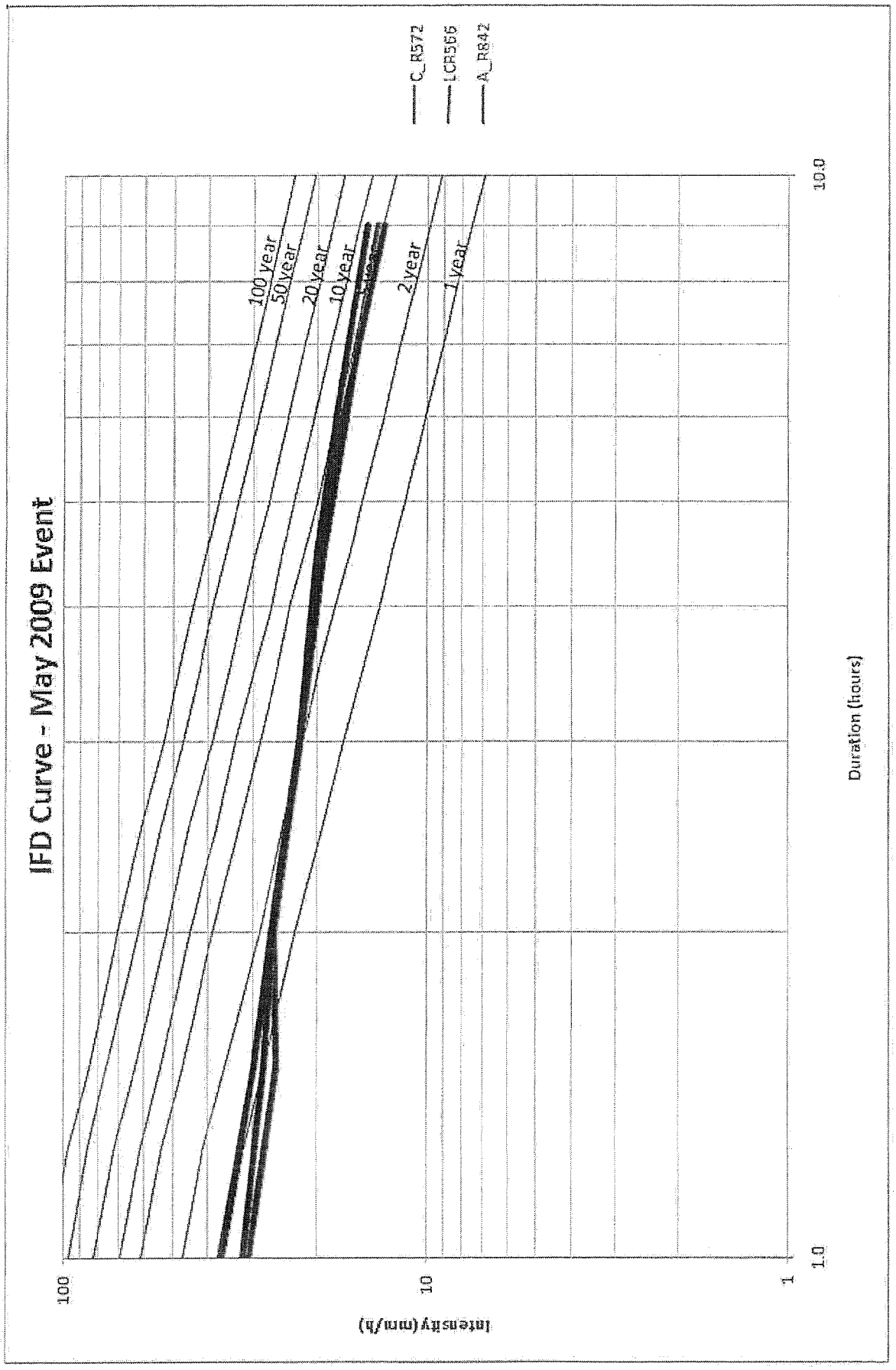
DRAFT


October 2010 Event
C_R572
LCR566
A_R842
SPR959
Total Rainfall (mm)
450
400
350
300
250
200
150
100
50
0
Date
3/10/2010
4/10/2010
5/10/2010
6/10/2010
7/10/2010
8/10/2010
9/10/2010
10/10/2010
11/10/2010
12/10/2010
13/10/2010
14/10/2010
15/10/2010
16/10/2010
17/10/2010
18/10/2010
19/10/2010
20/10/2010

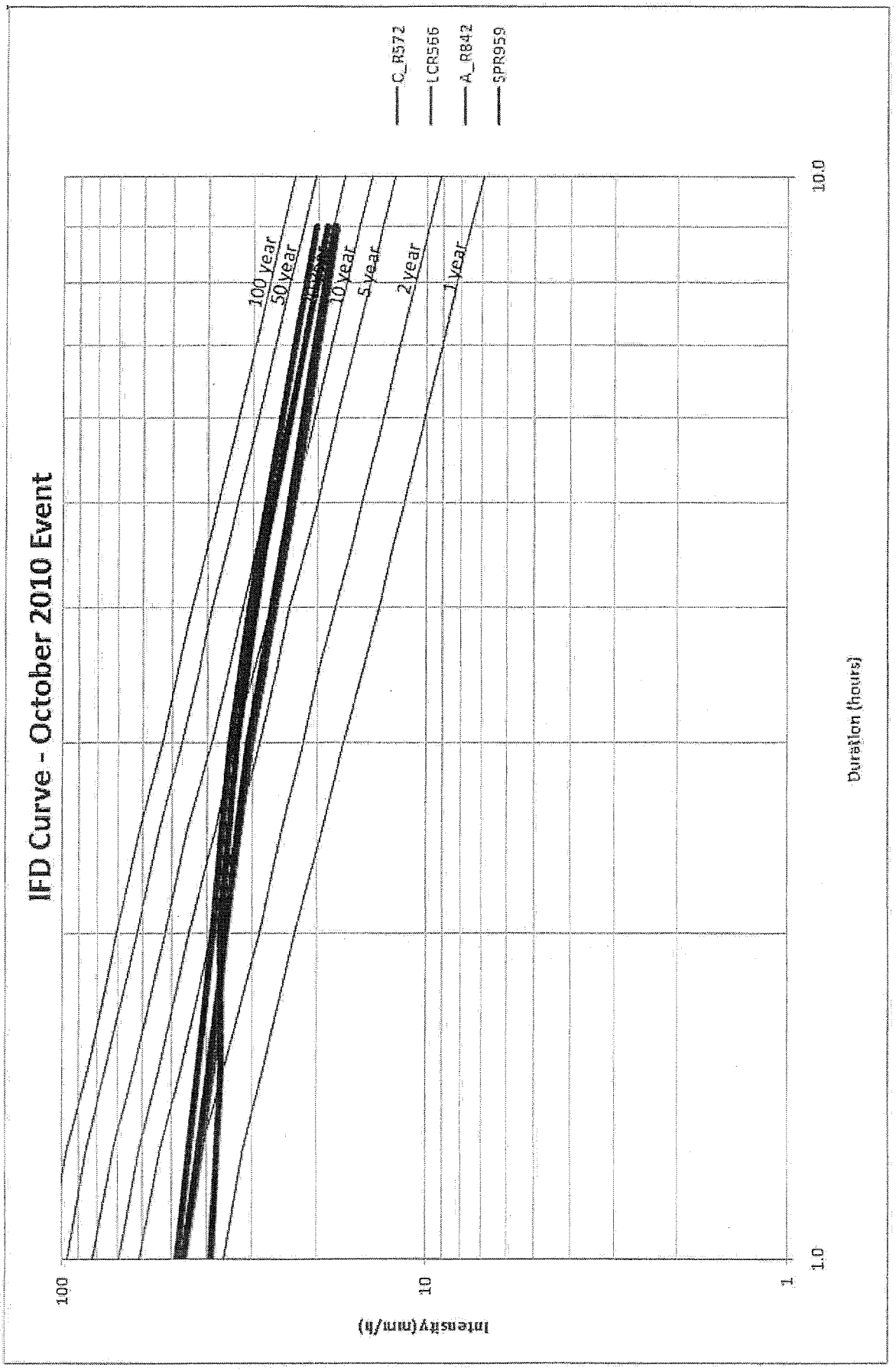
DRAFT


IFD Curve - May 1996 Event
C_R572
LCR566
100 year
50 year
20 year
10 year
5 year
2 year
1 year
100
10
1
Intensity (mm/h)
10.0
1.0
Duration (hours)

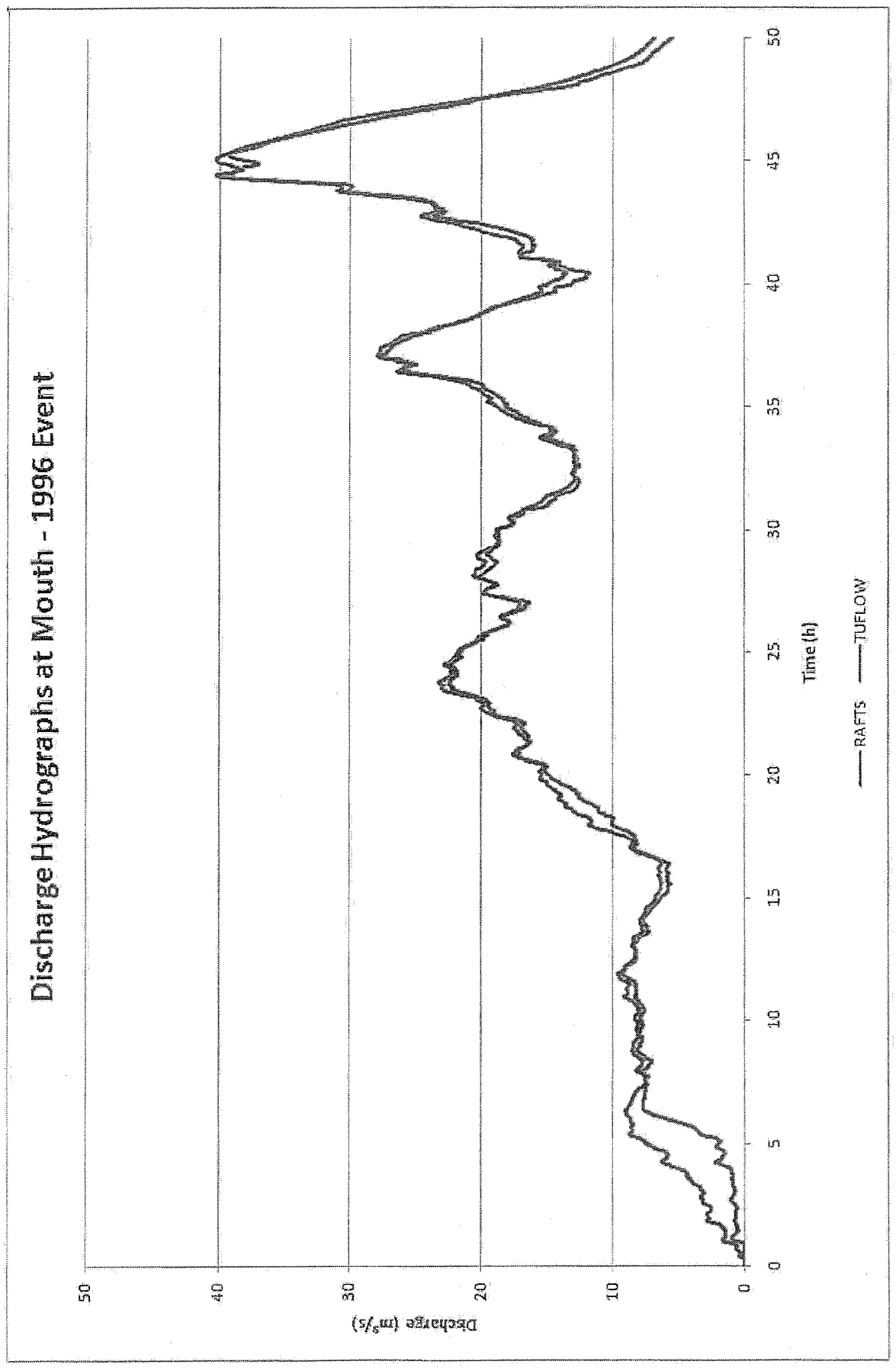
DRAFT


IFD Curve - May 2009 Event
C_R572
LCR566
A_R842
100 year
50 year
20 year
10 year
5 year
2 year
1 year
100
10
1
Intensity (mm/h)
10.0
1.0
Duration (hours)

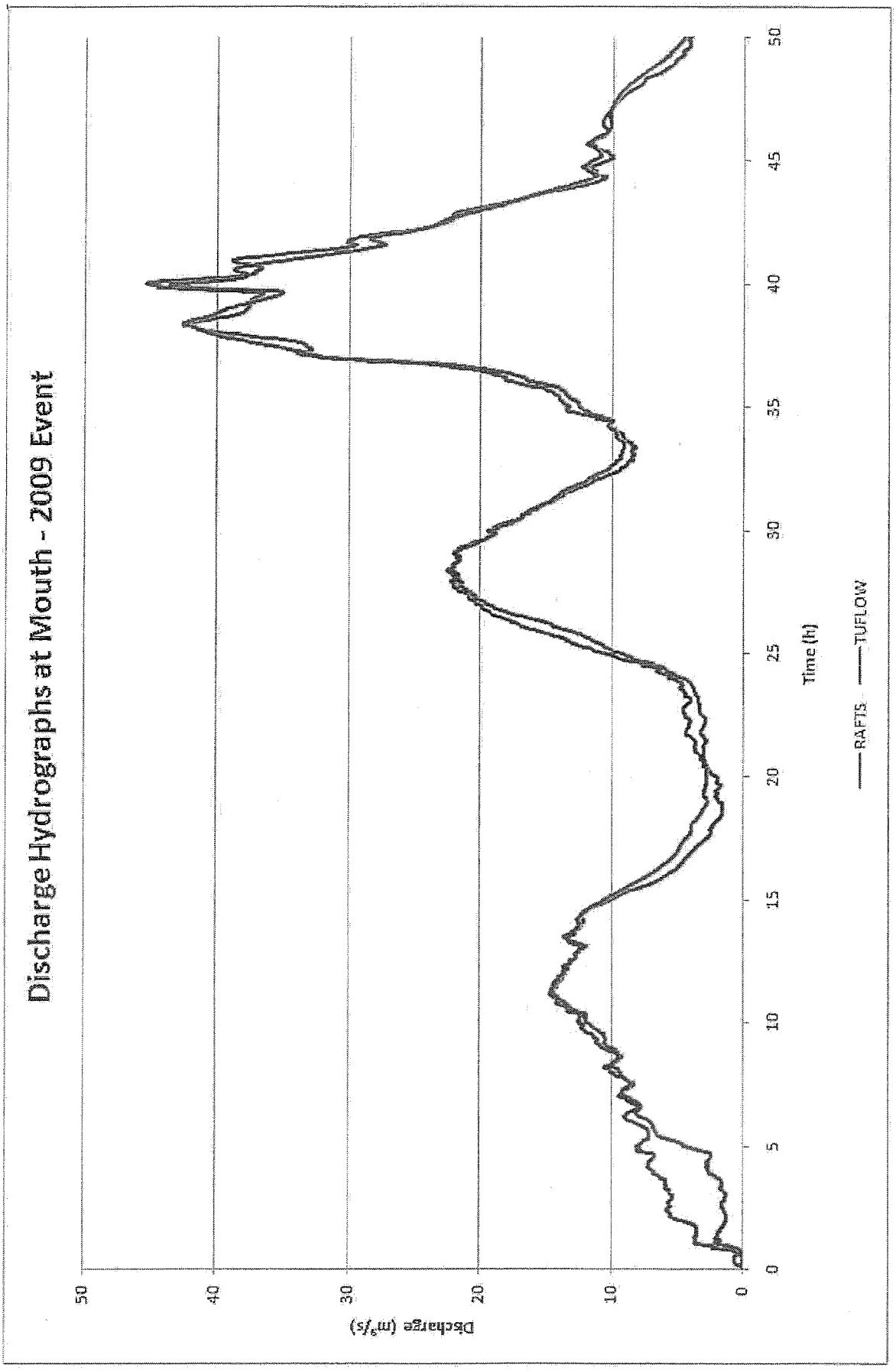
DRAFT


IFD Curve - October 2010 Event
C_R572
LCR566
A_R842
SPR959
100 year
50 year
10 year
5 year
2 year
1 year
100
10
1
Intensity (mm/h)
10.0
1.0
Duration (hours)

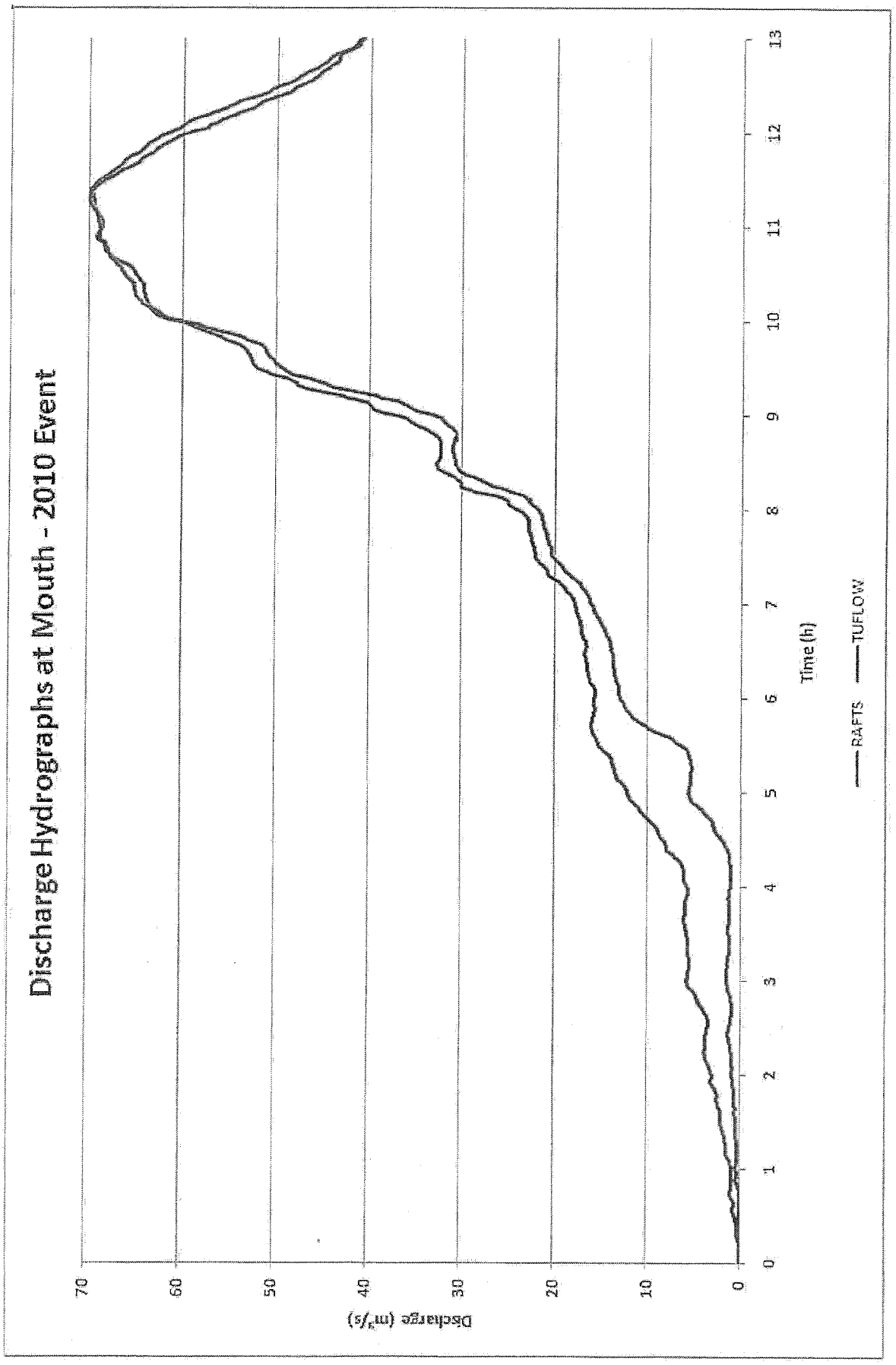
DRAFT


Discharge Hydrographs at Mouth - 1996 Event
Discharge (m³/s)
0
10
20
30
40
50
Time (h)
0
5
10
15
20
25
30
35
40
45
50
RAFTS
TUFLOW

DRAFT


Discharge Hydrographs at Mouth - 2009 Event
Discharge (m³/s)
0
10
20
30
40
50
Time (h)
0
5
10
15
20
25
30
35
40
45
50
RAFTS
TUFLOW

DRAFT



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Appendix B Part B – Design Event Modelling

Tables

B1 RAFTS Model Details

Figures

B1 100 yr ARI Inundation, Sheet 1 of 4

B2 100 yr ARI Inundation, Sheet 2 of 4

B3 100 yr ARI Inundation, Sheet 3 of 4

B4 100 yr ARI Inundation, Sheet 4 of 4

B5 100 yr ARI Flood Depth, Sheet 1 of 4

B6 100 yr ARI Flood Depth, Sheet 2 of 4

B7 100 yr ARI Flood Depth, Sheet 3 of 4

B8 100 yr ARI Flood Depth, Sheet 4 of 4

B9 100 yr ARI Velocity, Sheet 1 of 4

B10 100 yr ARI Velocity, Sheet 2 of 4

B11 100 yr ARI Velocity, Sheet 3 of 4

B12 100 yr ARI Velocity, Sheet 4 of 4

B13 100 yr ARI Hazard, Sheet 1 of 4

B14 100 yr ARI Hazard, Sheet 2 of 4

B15 100 yr ARI Hazard, Sheet 3 of 4

B16 100 yr ARI Hazard, Sheet 4 of 4

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B17 50 yr ARI Inundation, Sheet 1 of 4

B18 50 yr ARI Inundation, Sheet 2 of 4

B19 50 yr ARI Inundation, Sheet 3 of 4

B20 50 yr ARI Inundation, Sheet 4 of 4

B21 50 yr ARI Flood Depth, Sheet 1 of 4

B22 50 yr ARI Flood Depth, Sheet 2 of 4

B23 50 yr ARI Flood Depth, Sheet 3 of 4

B24 50 yr ARI Flood Depth, Sheet 4 of 4

B25 50 yr ARI Velocity, Sheet 1 of 4

B26 50 yr ARI Velocity, Sheet 2 of 4

B27 50 yr ARI Velocity, Sheet 3 of 4

B28 50 yr ARI Velocity, Sheet 4 of 4

B29 20 yr ARI Inundation, Sheet 1 of 4

B30 20 yr ARI Inundation, Sheet 2 of 4

B31 20 yr ARI Inundation, Sheet 3 of 4

B32 20 yr ARI Inundation, Sheet 4 of 4

B33 20 yr ARI Flood Depth, Sheet 1 of 4

B34 20 yr ARI Flood Depth, Sheet 2 of 4

B35 20 yr ARI Flood Depth, Sheet 3 of 4

B36 20 yr ARI Flood Depth, Sheet 4 of 4

B37 20 yr ARI Velocity, Sheet 1 of 4

DRAFT

B59 5 yr ARI Flood Depth, Sheet 3 of 4

B60 5 yr ARI Flood Depth, Sheet 4 of 4

B61 5 yr ARI Velocity, Sheet 1 of 4

B62 5 yr ARI Velocity, Sheet 2 of 4

B63 5 yr ARI Velocity, Sheet 3 of 4

B64 5 yr ARI Velocity, Sheet 4 of 4

B65 2 yr ARI Inundation, Sheet 1 of 4

B66 2 yr ARI Inundation, Sheet 2 of 4

B67 2 yr ARI Inundation, Sheet 3 of 4

B68 2 yr ARI Inundation, Sheet 4 of 4

B69 2 yr ARI Flood Depth, Sheet 1 of 4

B70 2 yr ARI Flood Depth, Sheet 2 of 4

B71 2 yr ARI Flood Depth, Sheet 3 of 4

B72 2 yr ARI Flood Depth, Sheet 4 of 4

B73 2 yr ARI Velocity, Sheet 1 of 4

B74 2 yr ARI Velocity, Sheet 2 of 4

B75 2 yr ARI Velocity, Sheet 3 of 4

B76 2 yr ARI Velocity, Sheet 4 of 4

B77 100 yr Critical Duration

B78 50 yr Critical Duration

B79 20 yr Critical Duration

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B80 10 yr Critical Duration

B81 5 yr Critical Duration

B82 2 yr Critical Duration

B83 Impact of Waterway Corridors

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ALBANY CREEK FLOOD STUDY



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FIGURE B1
100 YR ARI INUNDATION - Sheet 1 of 4

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16
16
17
16
16
16

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FIGURE B3
100 YR ARI INUNDATION - Sheet 3 of 4

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File Path: J:\J11039\Maps\MapInfo\Figure4

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ALBANY CREEK FLOOD STUDY

Cardno

BRISBANE CITY



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FIGURE B4
100 YR ARI INUNDATION - Sheet 4 of 4

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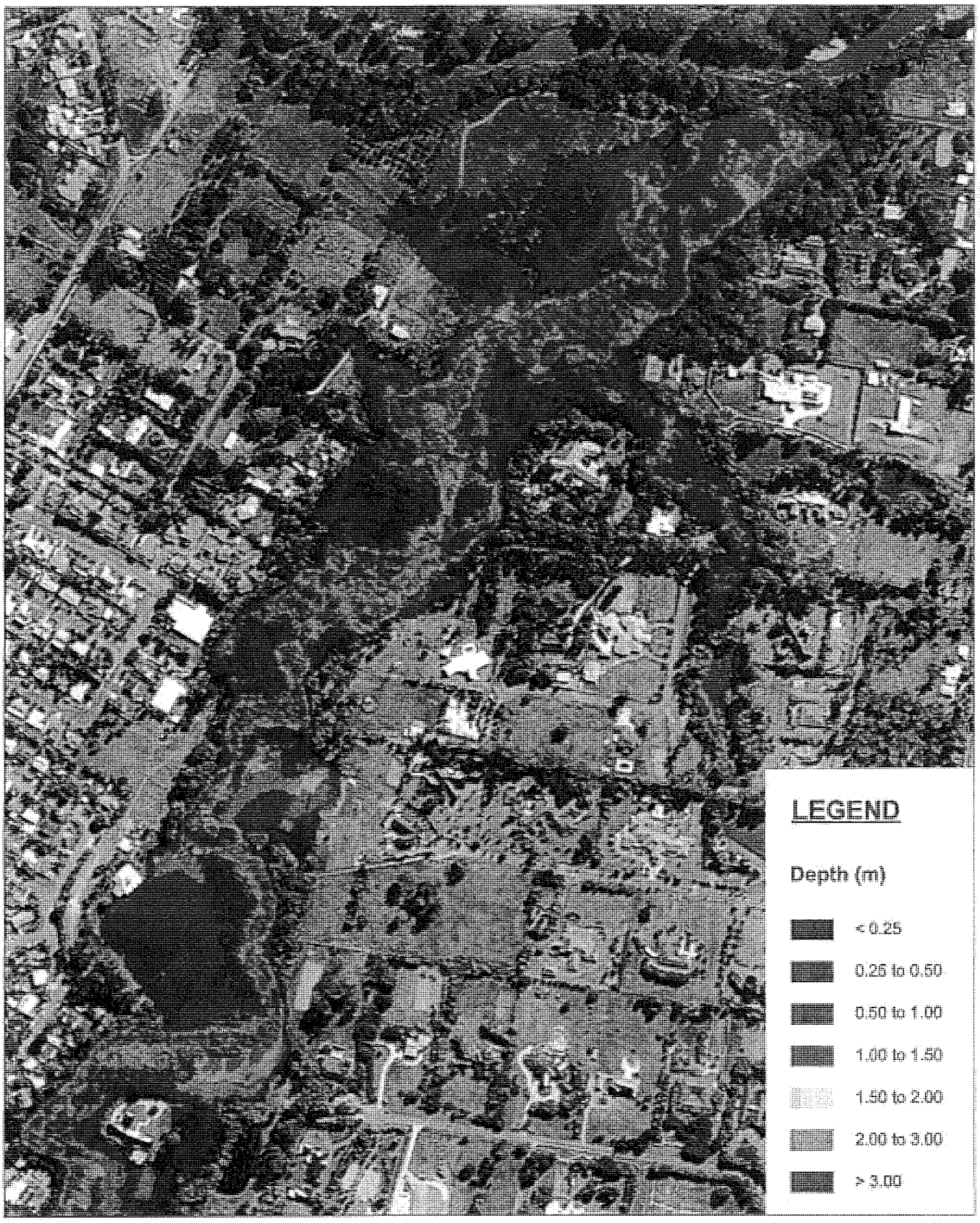

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FIGURE B5
100 YR ARI FLOOD DEPTH - Sheet 1 of 4

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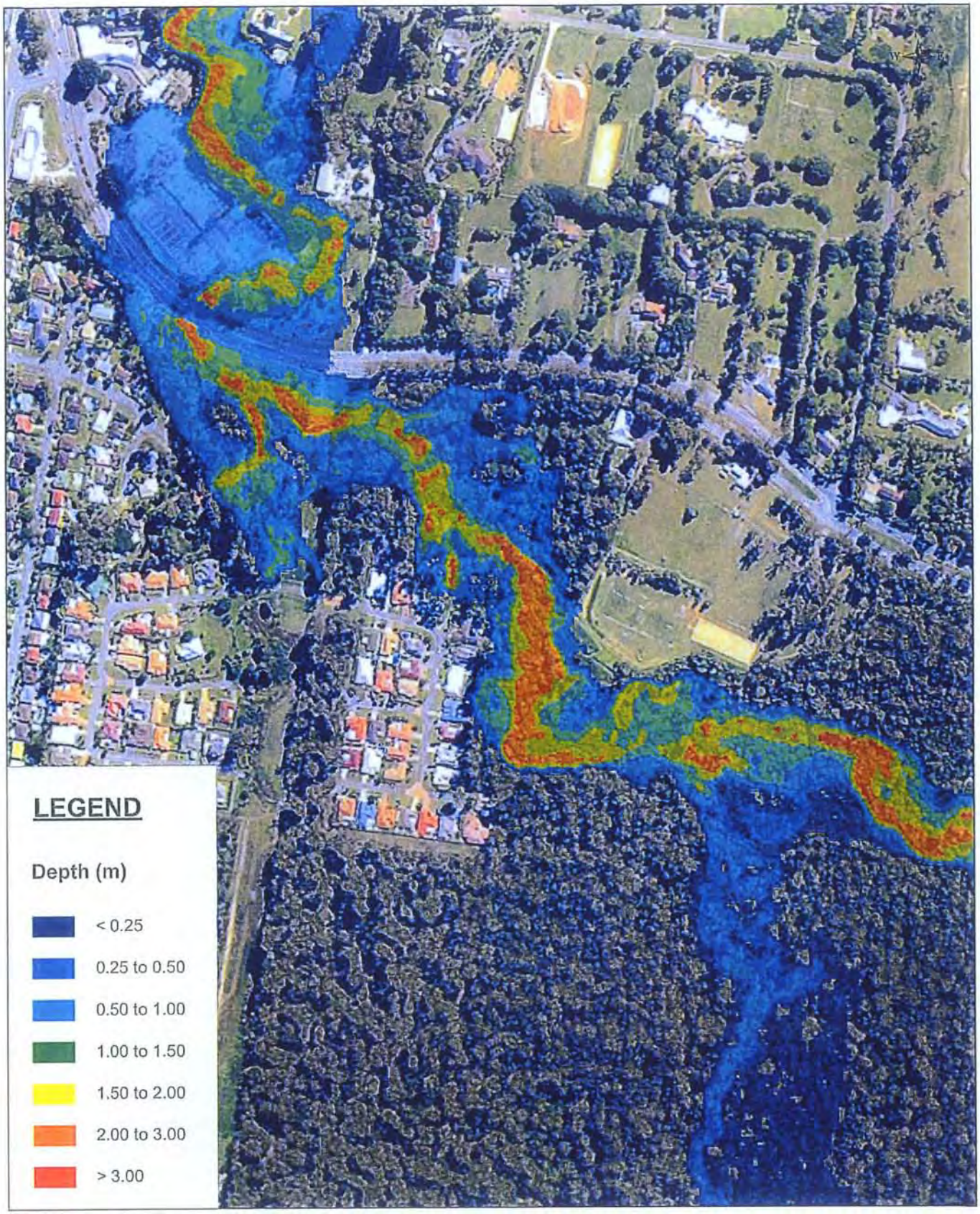

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FIGURE B6

100 YR ARI FLOOD DEPTH - Sheet 2 of 4

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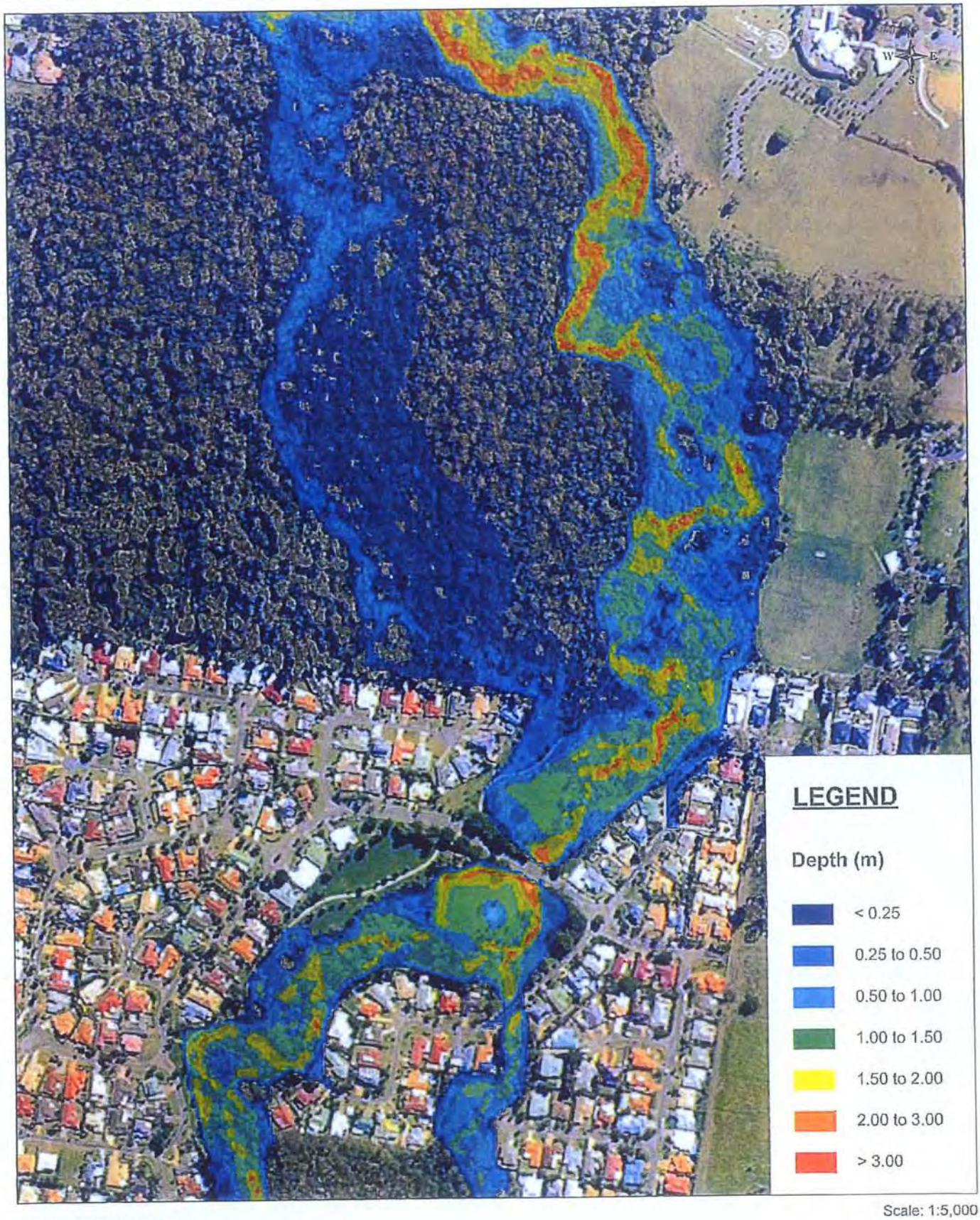

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FIGURE B7

100 YR ARI FLOOD DEPTH - Sheet 3 of 4

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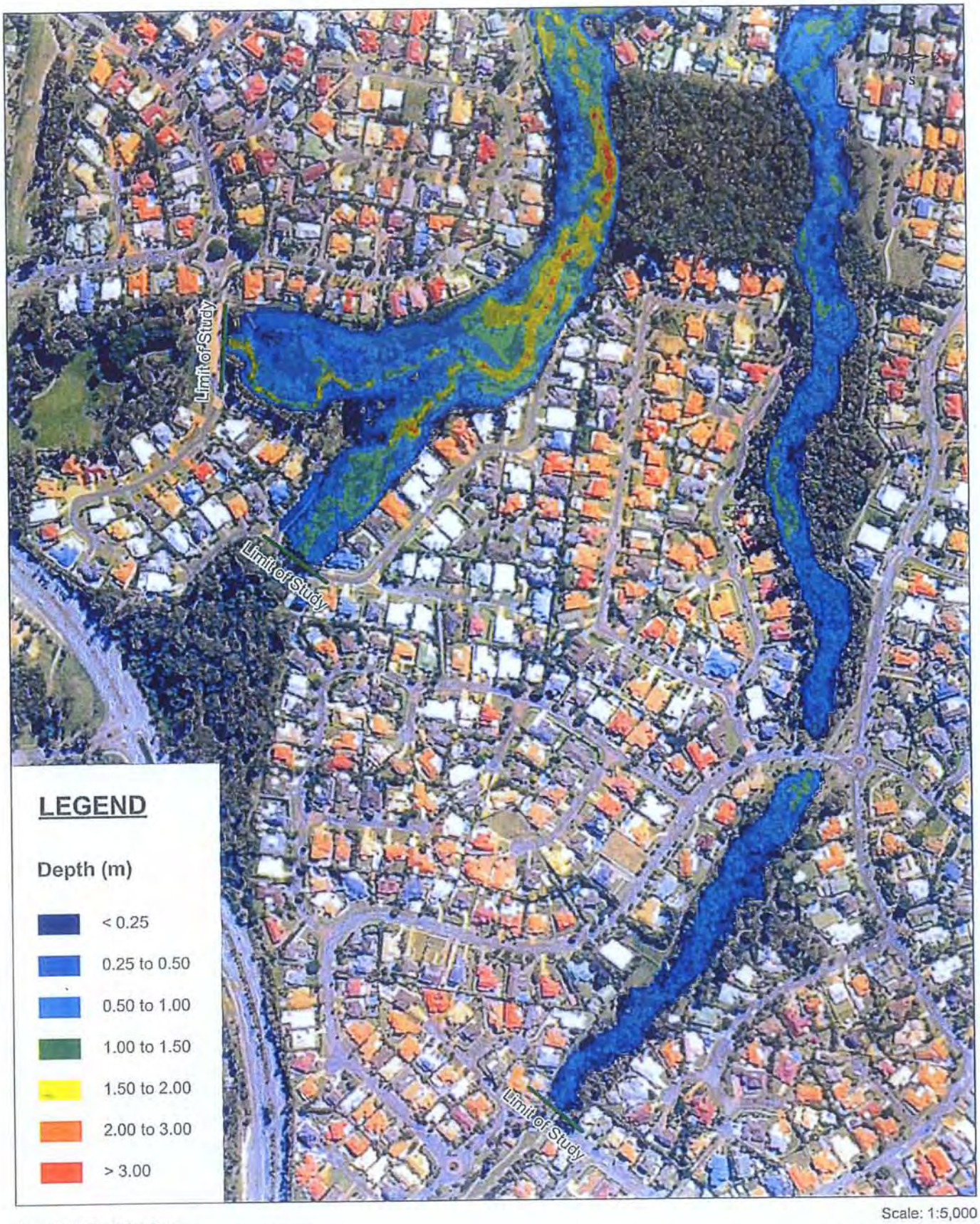

Scale: 1:5,000

FIGURE B8

100 YR ARI FLOOD DEPTH - Sheet 4 of 4

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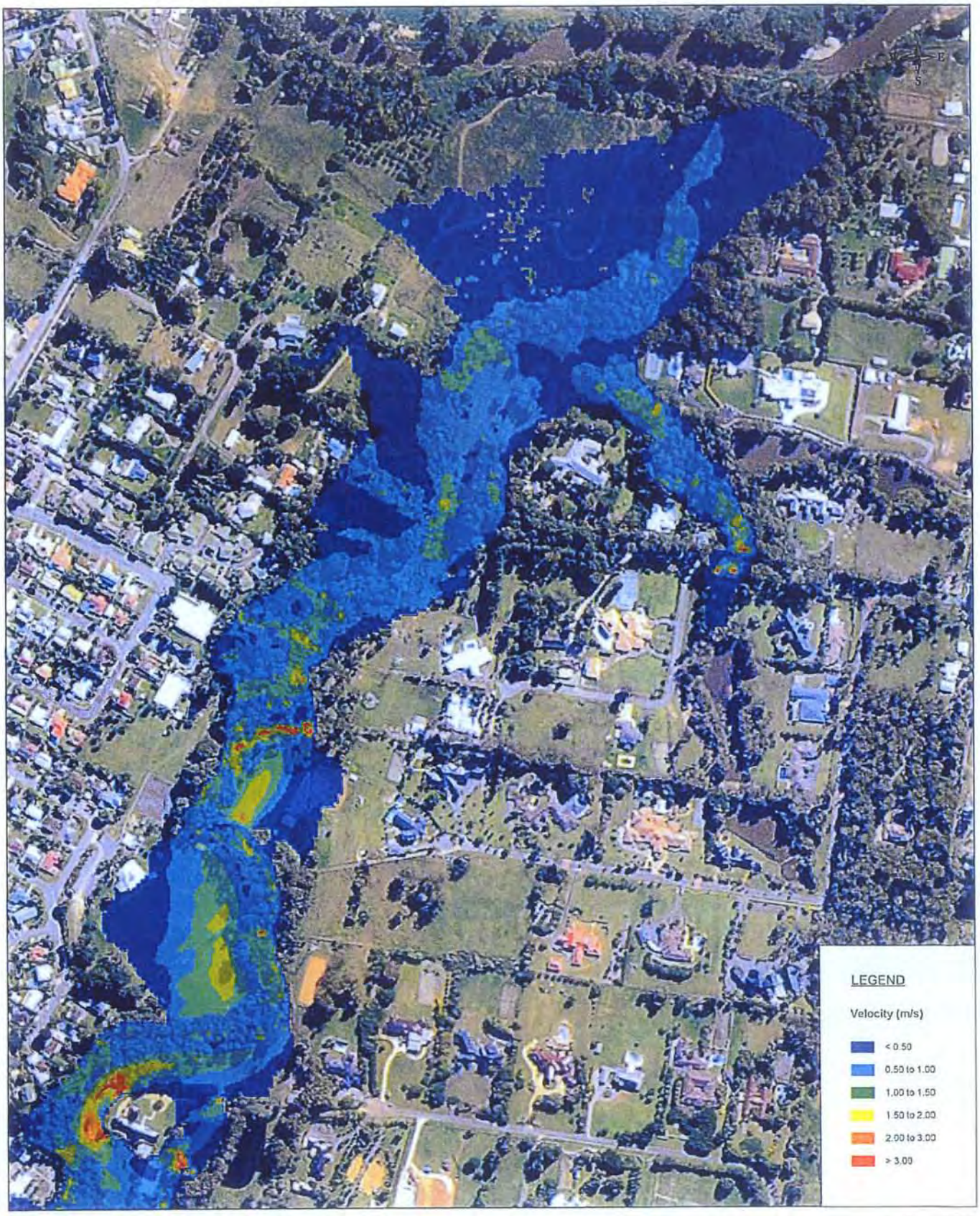

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FIGURE B9

100 YR ARI VELOCITY - Sheet 1 of 4

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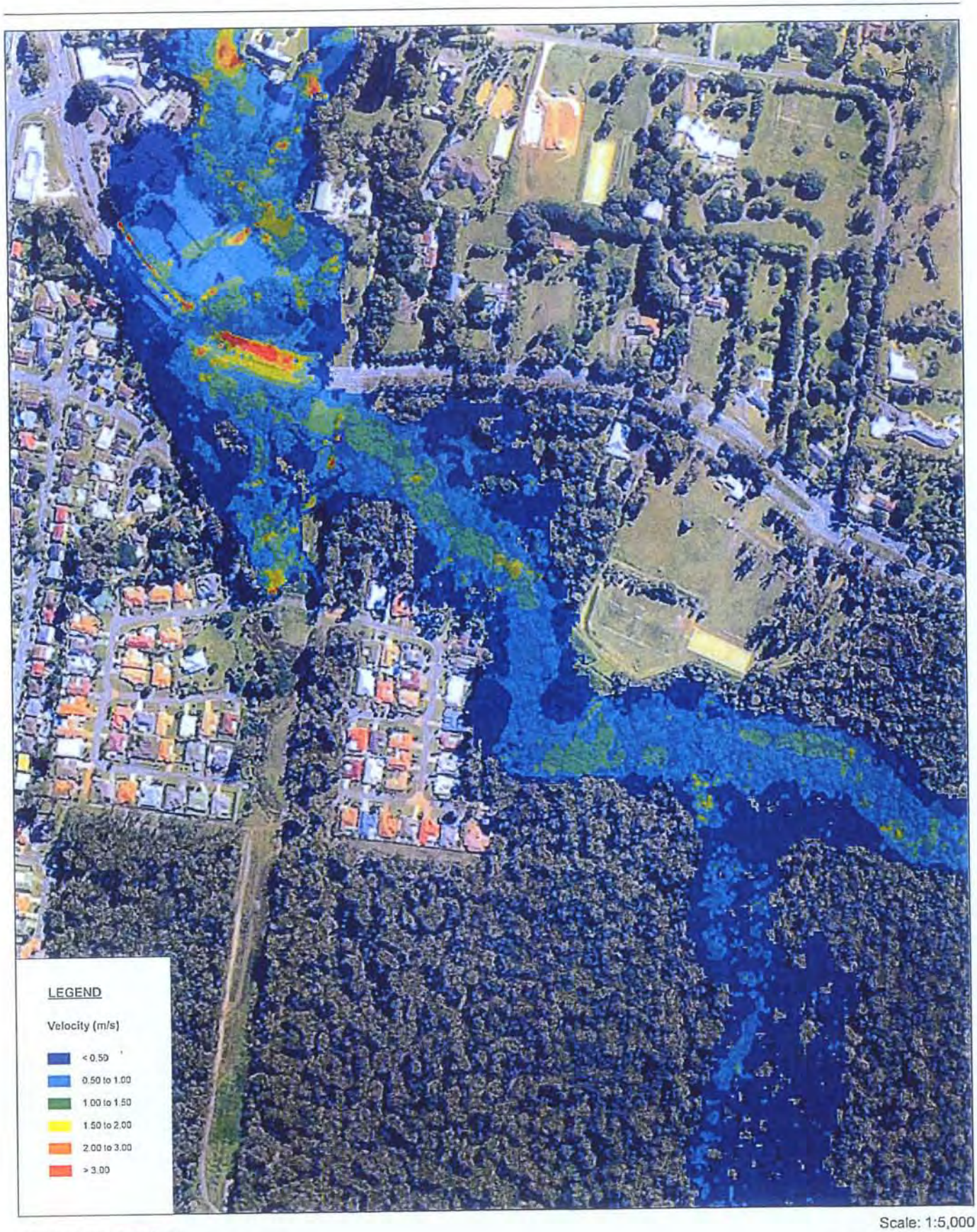

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FIGURE B10

100 YR ARI VELOCITY - Sheet 2 of 4

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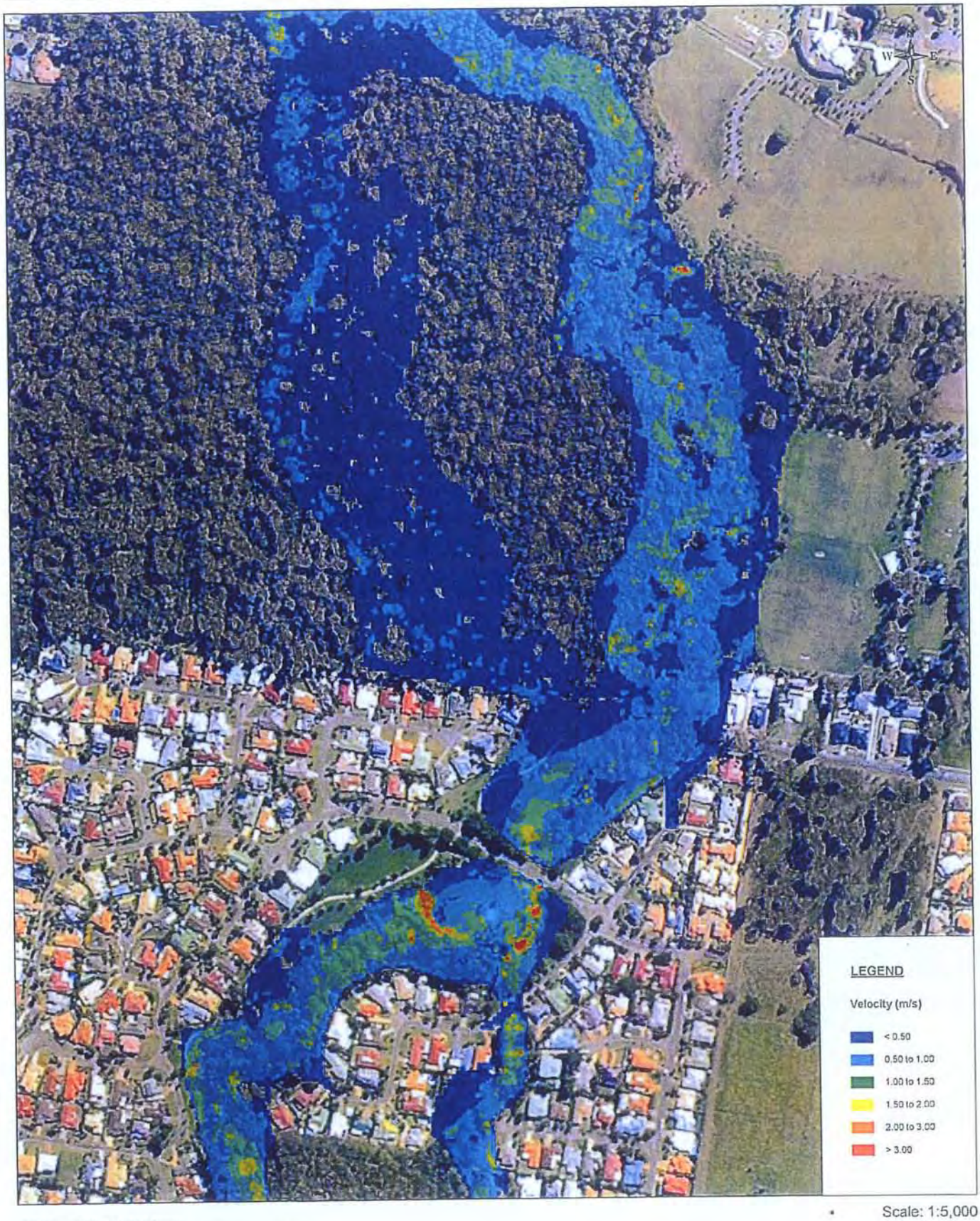

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FIGURE B11
100 YR ARI VELOCITY - Sheet 3 of 4

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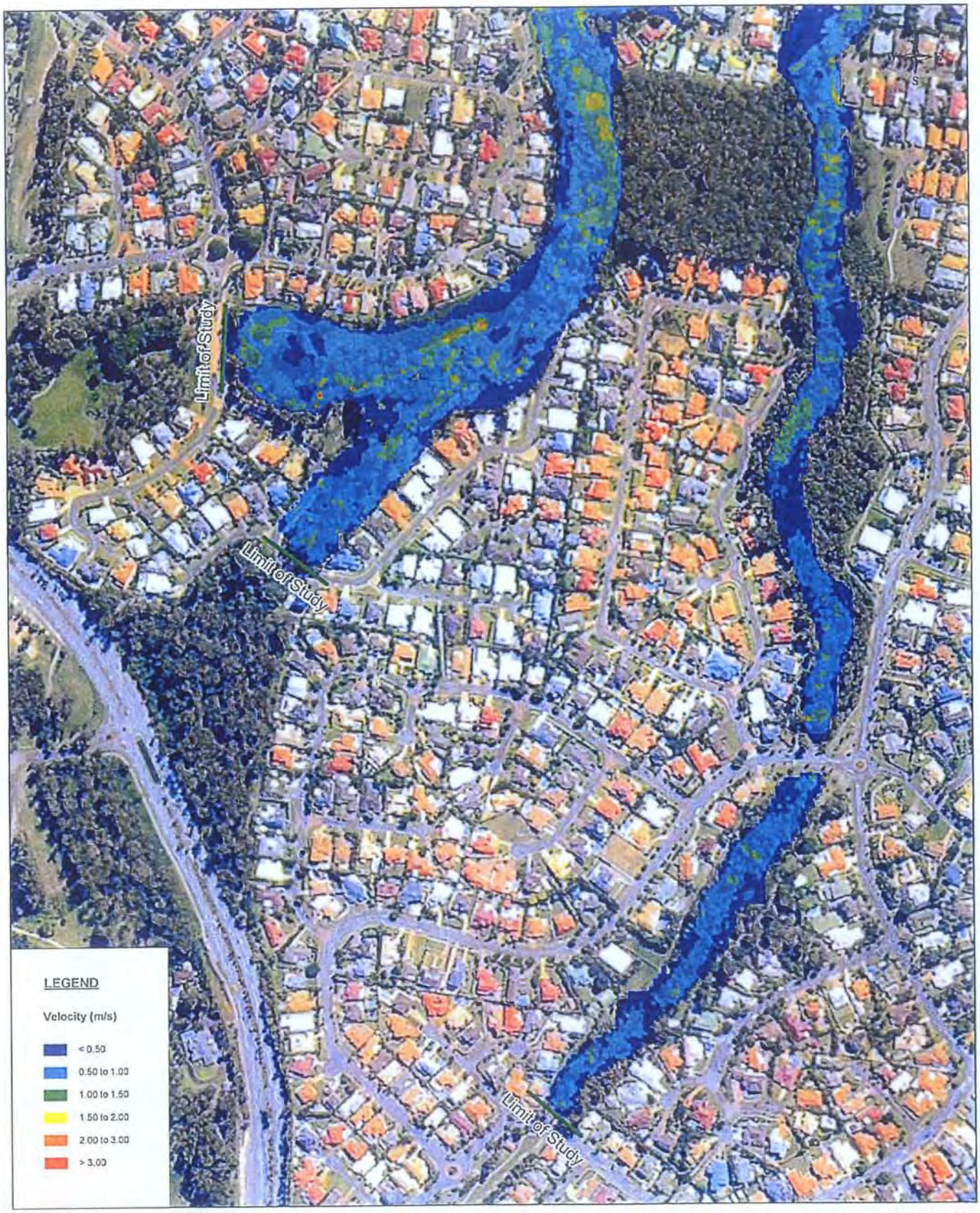

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FIGURE B12

100 YR ARI VELOCITY - Sheet 4 of 4

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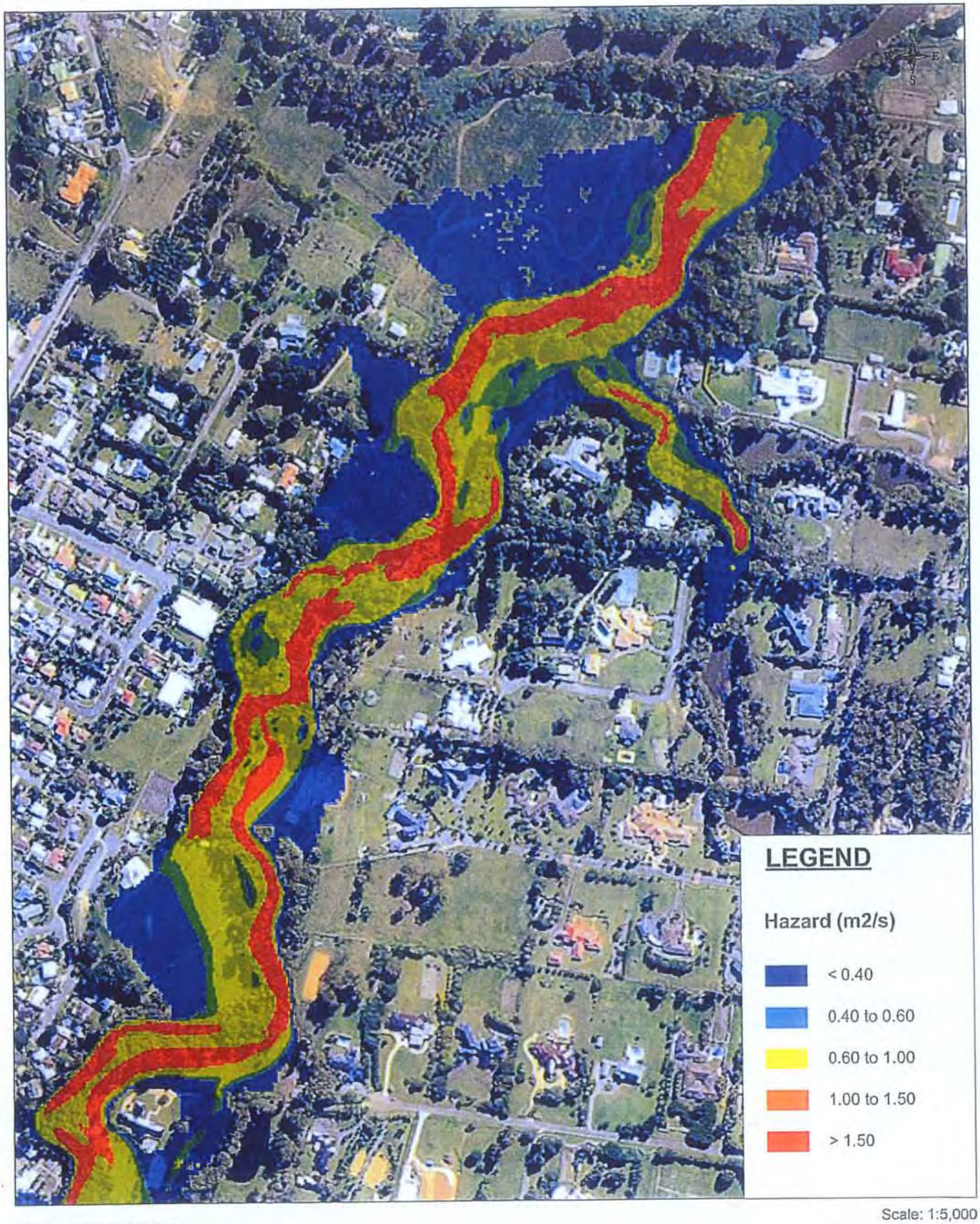

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Scale: 1:5,000

FIGURE B13

100 YR ARI HAZARD - Sheet 1 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

Print Date: 12-7-2011

BCC.079.0458

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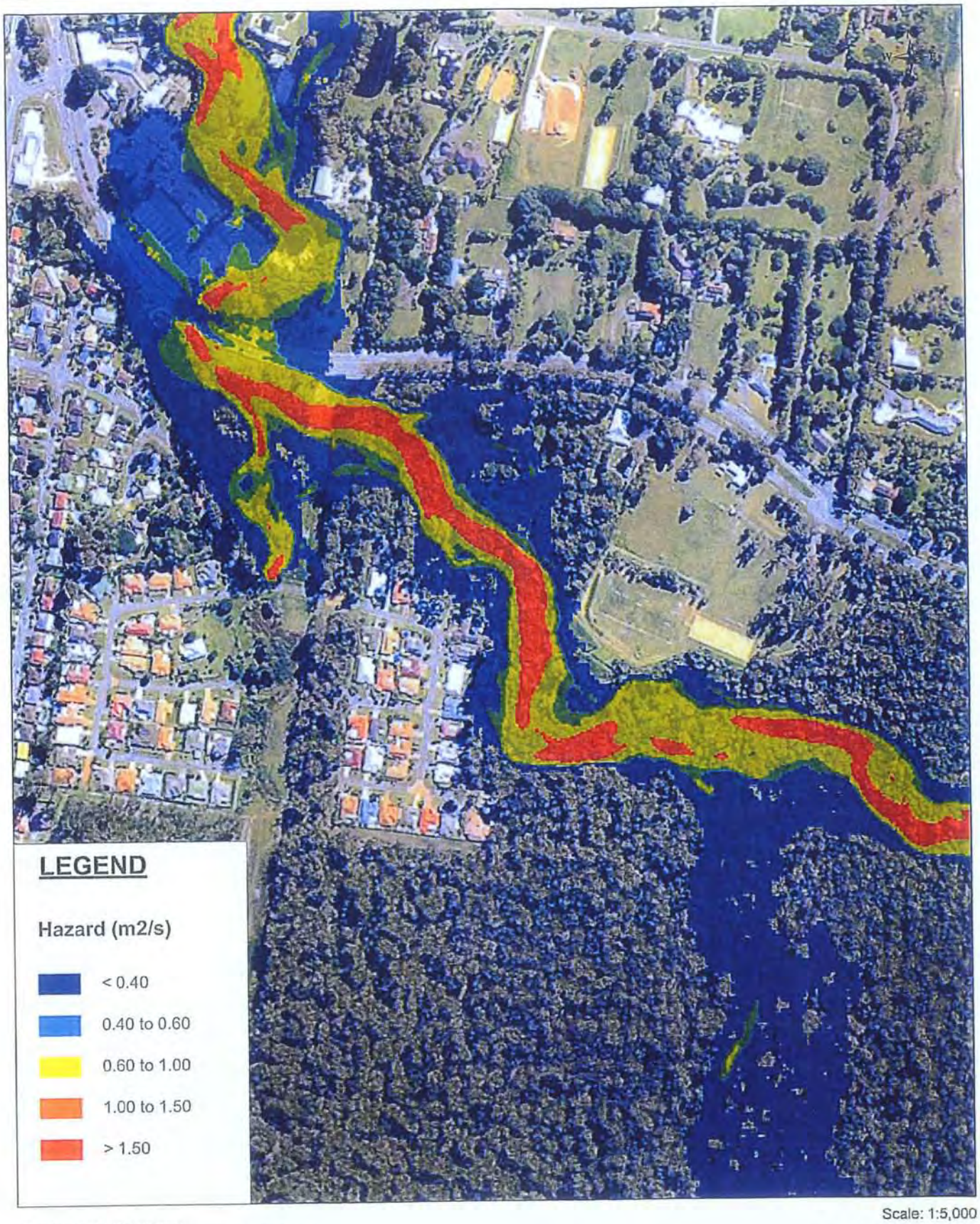
ALBANY CREEK FLOOD STUDY



Scale: 1:5,000

FIGURE B14
100 YR ARI HAZARD - Sheet 2 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

Print Date: 12-7-2011

BCC.079.0459

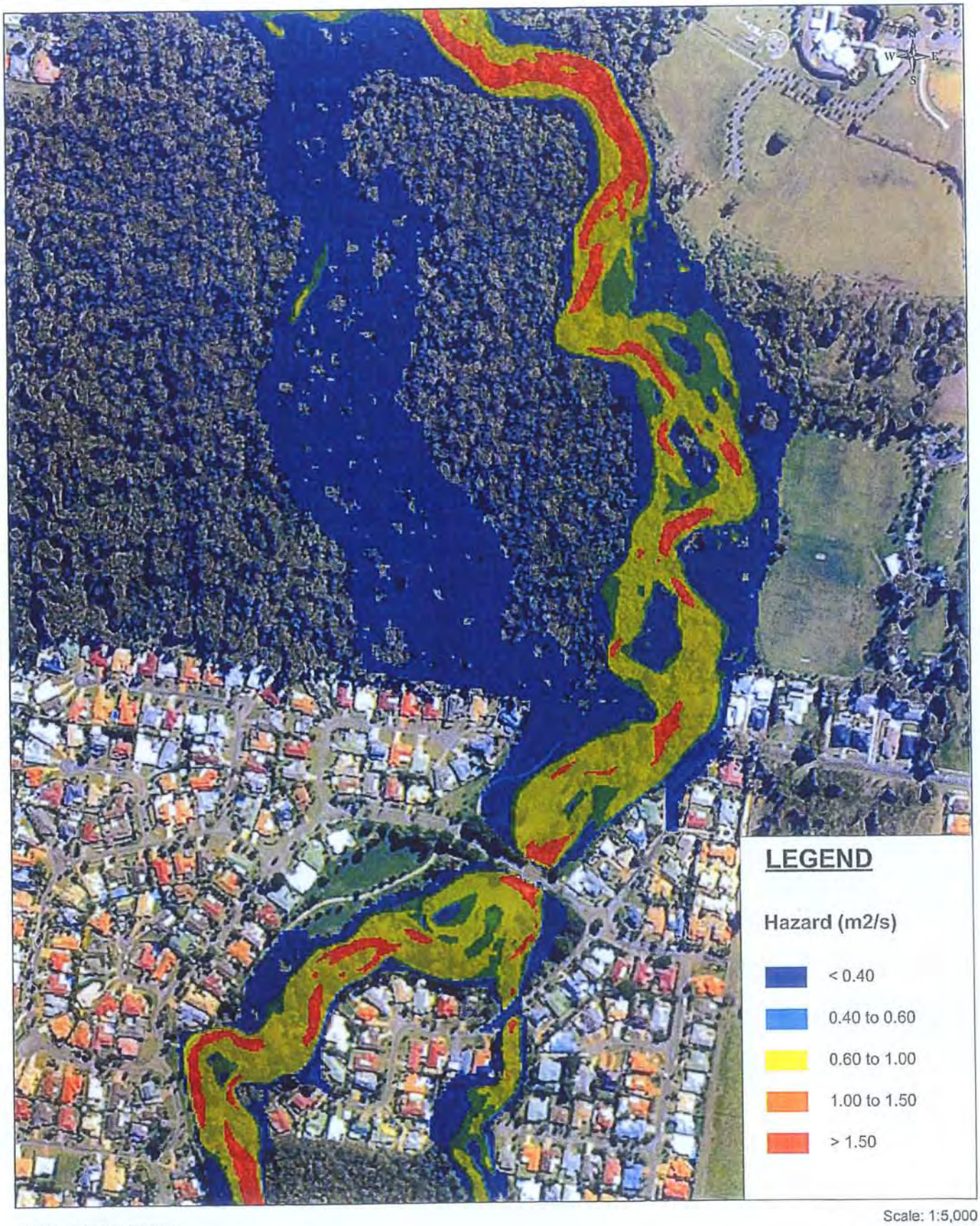


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FIGURE B15

100 YR ARI HAZARD - Sheet 3 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

Print Date: 12-7-2011

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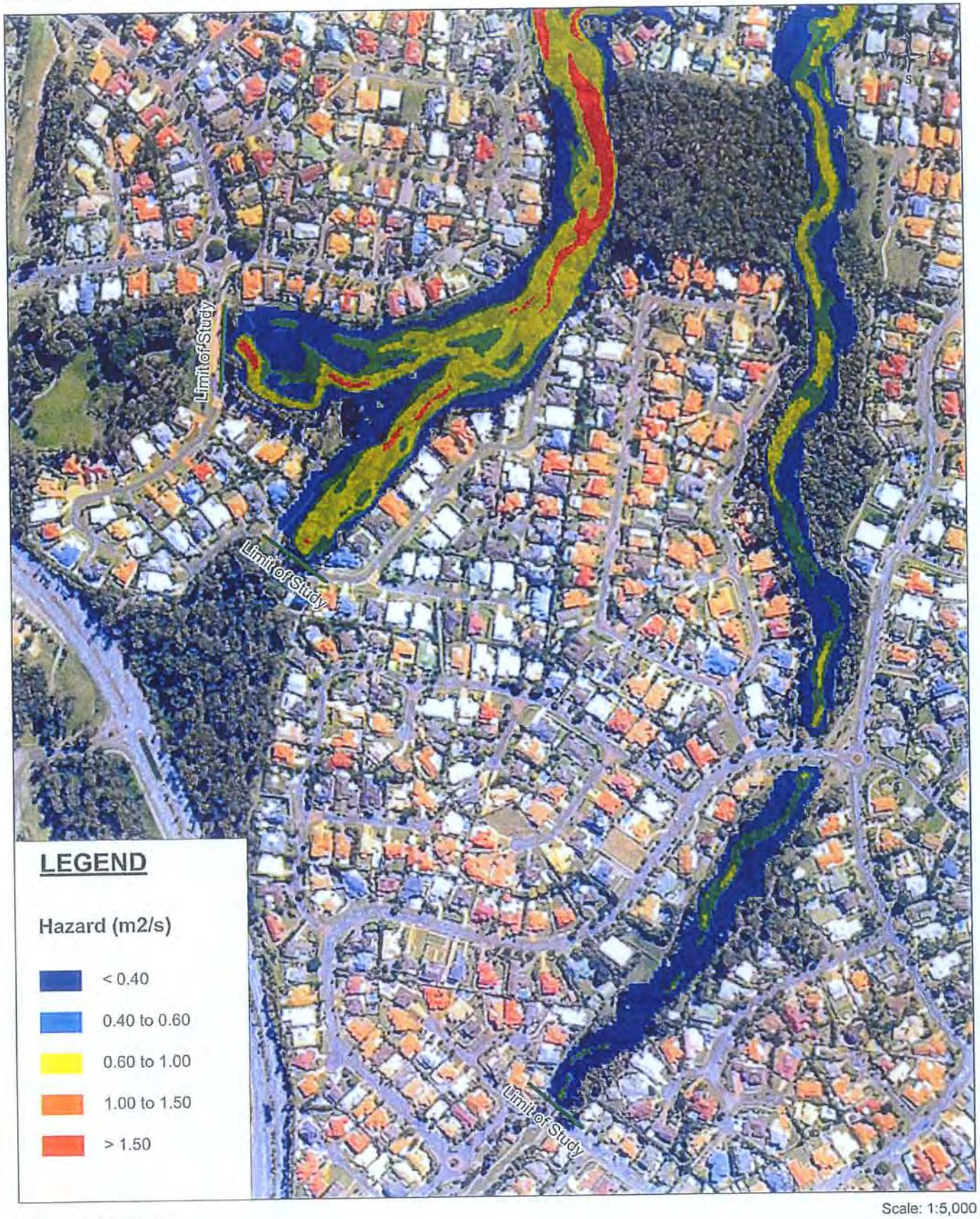

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FIGURE B16
100 YR ARI HAZARD - Sheet 4 of 4

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FIGURE B17

50 YR ARI INUNDATION - Sheet 1 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

Print Date: 12-7-2011

BCC.079.0462

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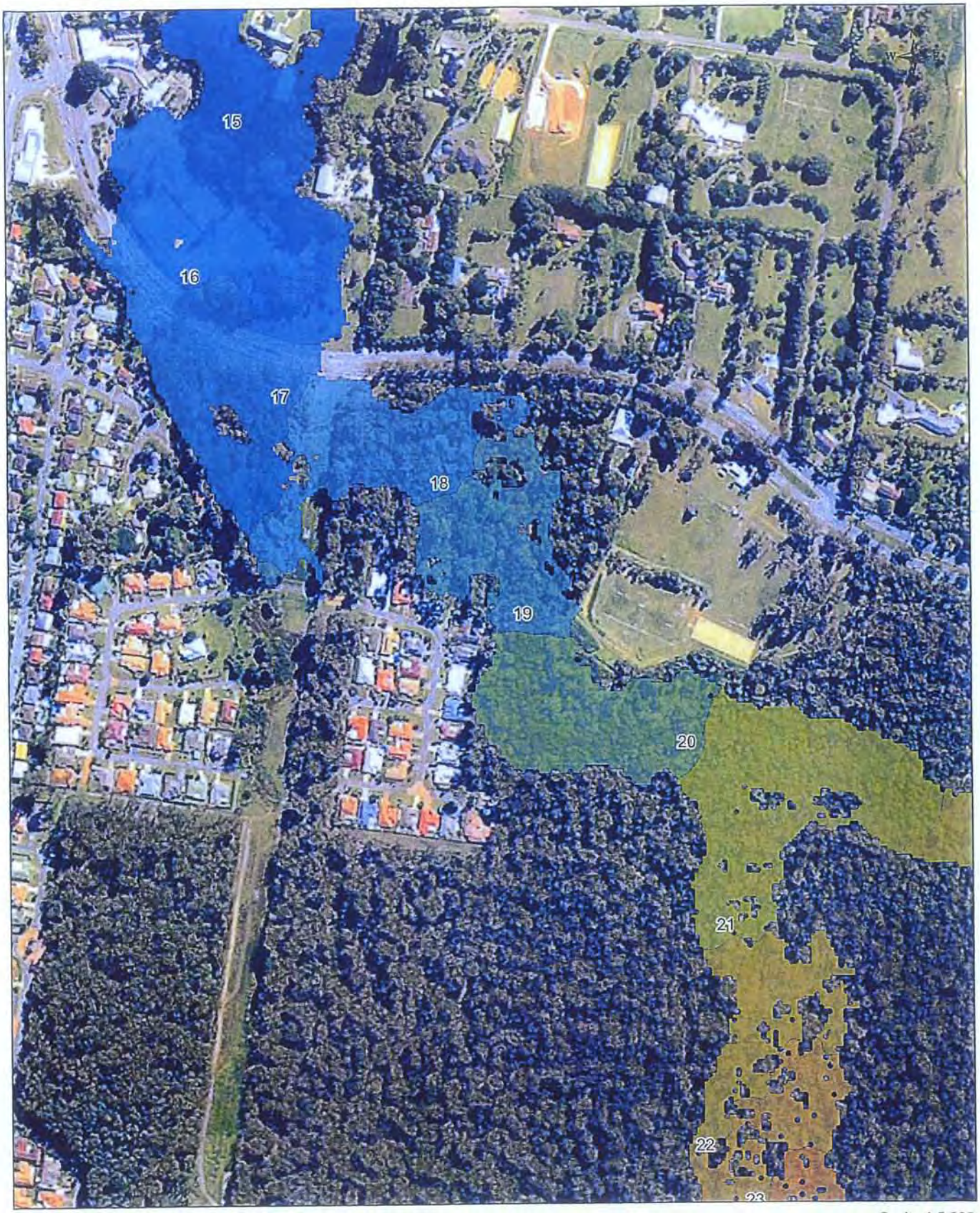

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FIGURE B18

50 YR ARI INUNDATION - Sheet 2 of 4

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FIGURE B19

50 YR ARI INUNDATION - Sheet 3 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

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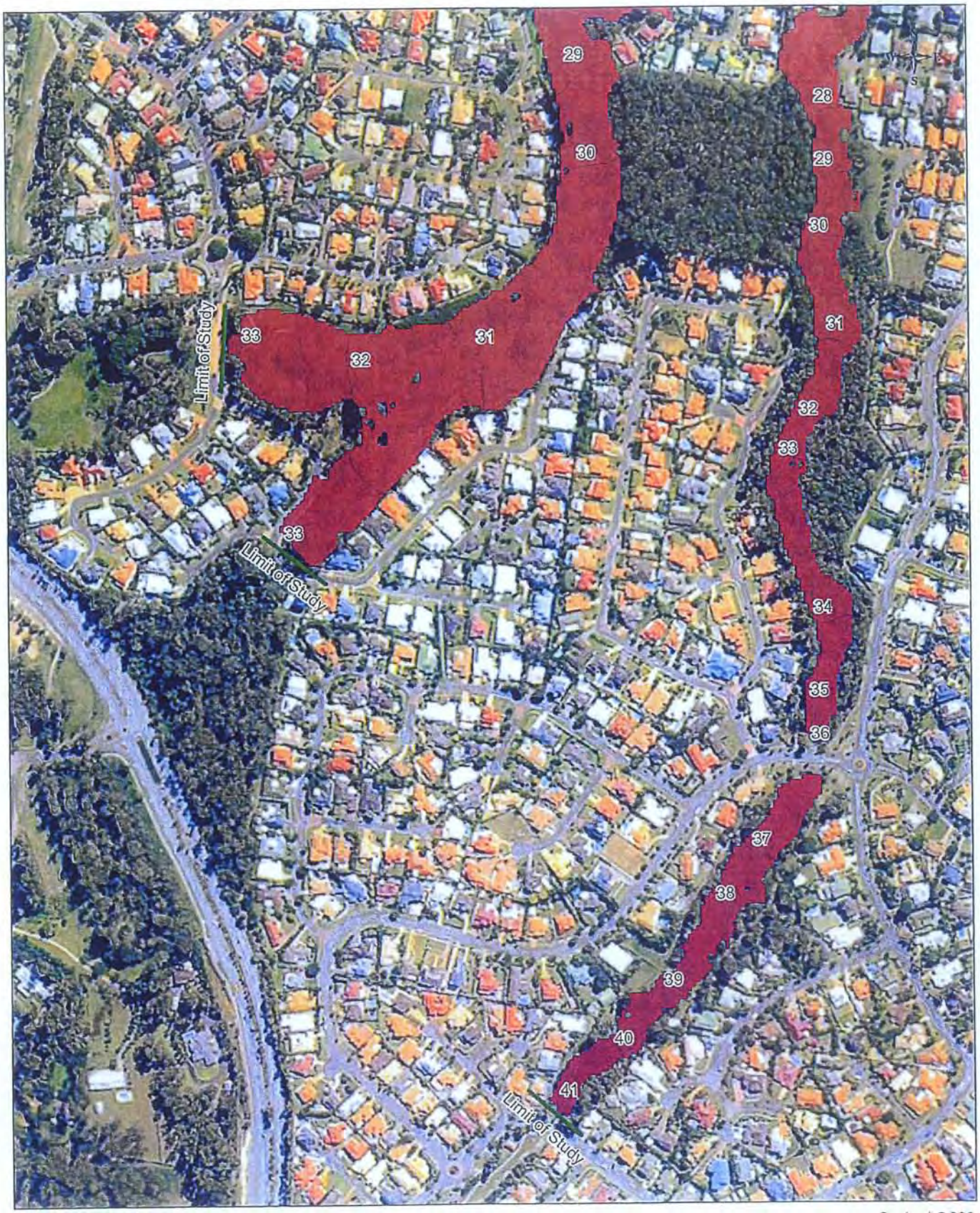

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FIGURE B20
50 YR ARI INUNDATION - Sheet 4 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

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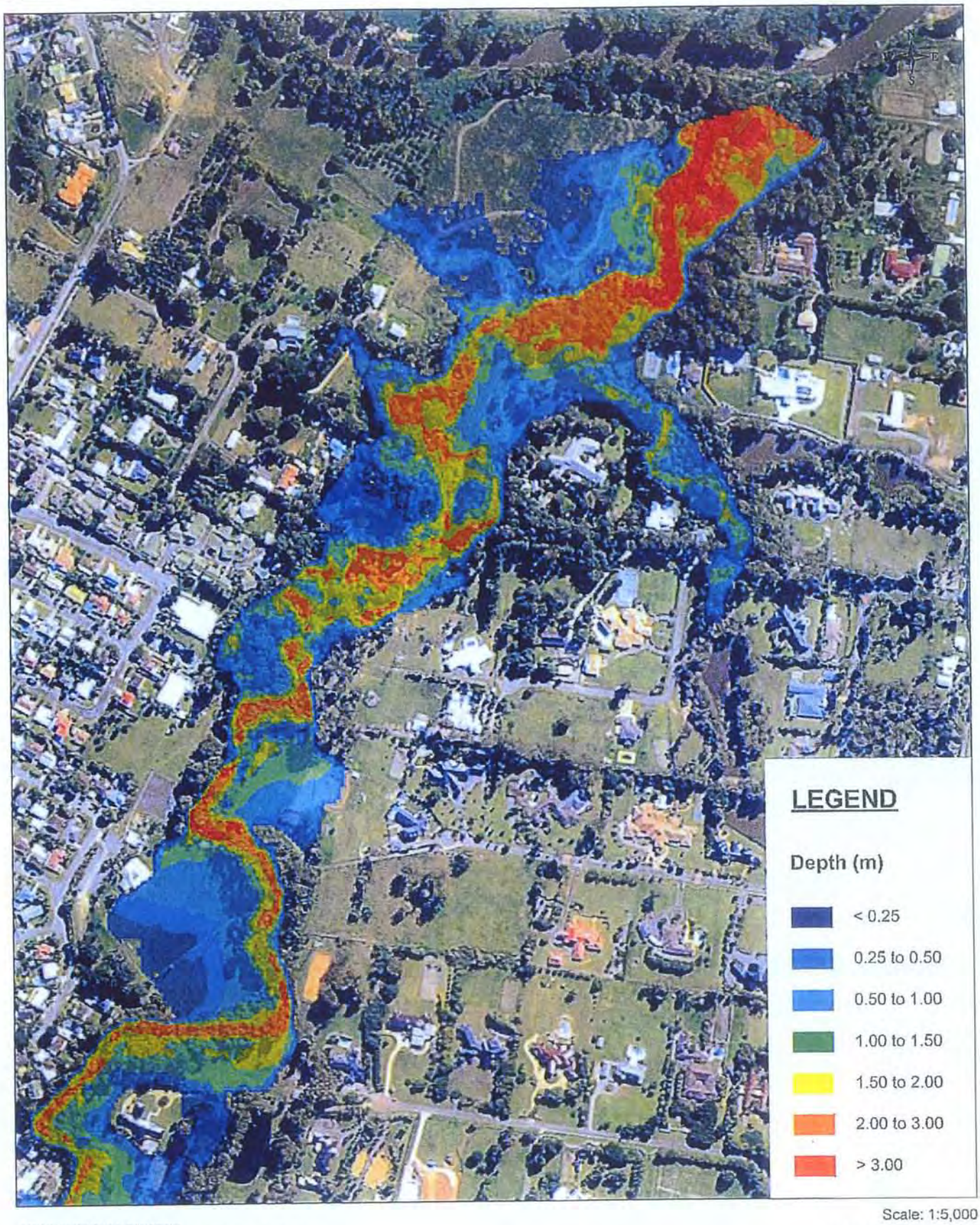

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FIGURE B21
50 YR ARI FLOOD DEPTH - Sheet 1 of 4

Project No: J11039

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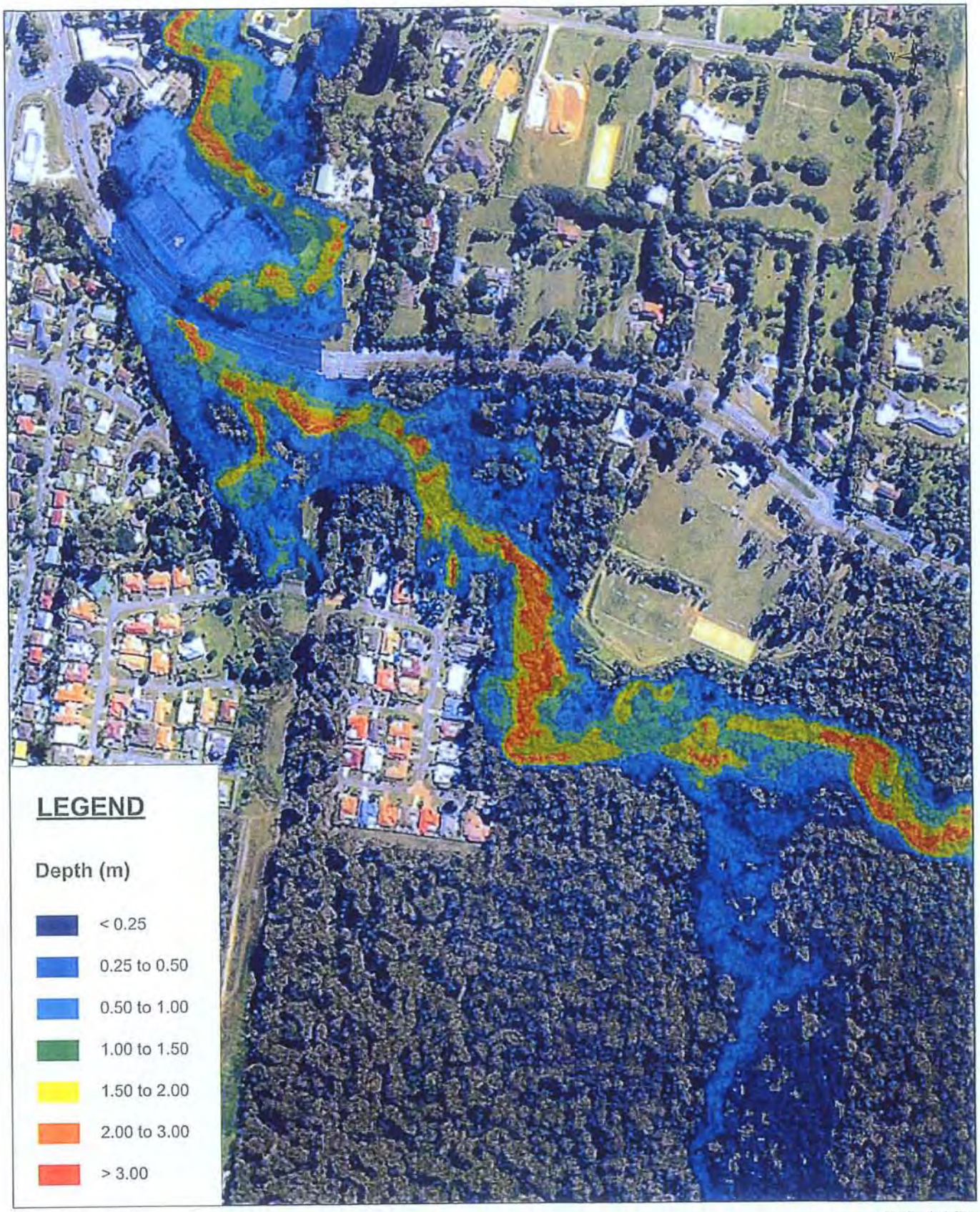

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FIGURE B22

50 YR ARI FLOOD DEPTH - Sheet 2 of 4

Project No: J11039

Rev: Orig Date: 08 July 2011

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Print Date: 12-7-2011

BCC.079.0467

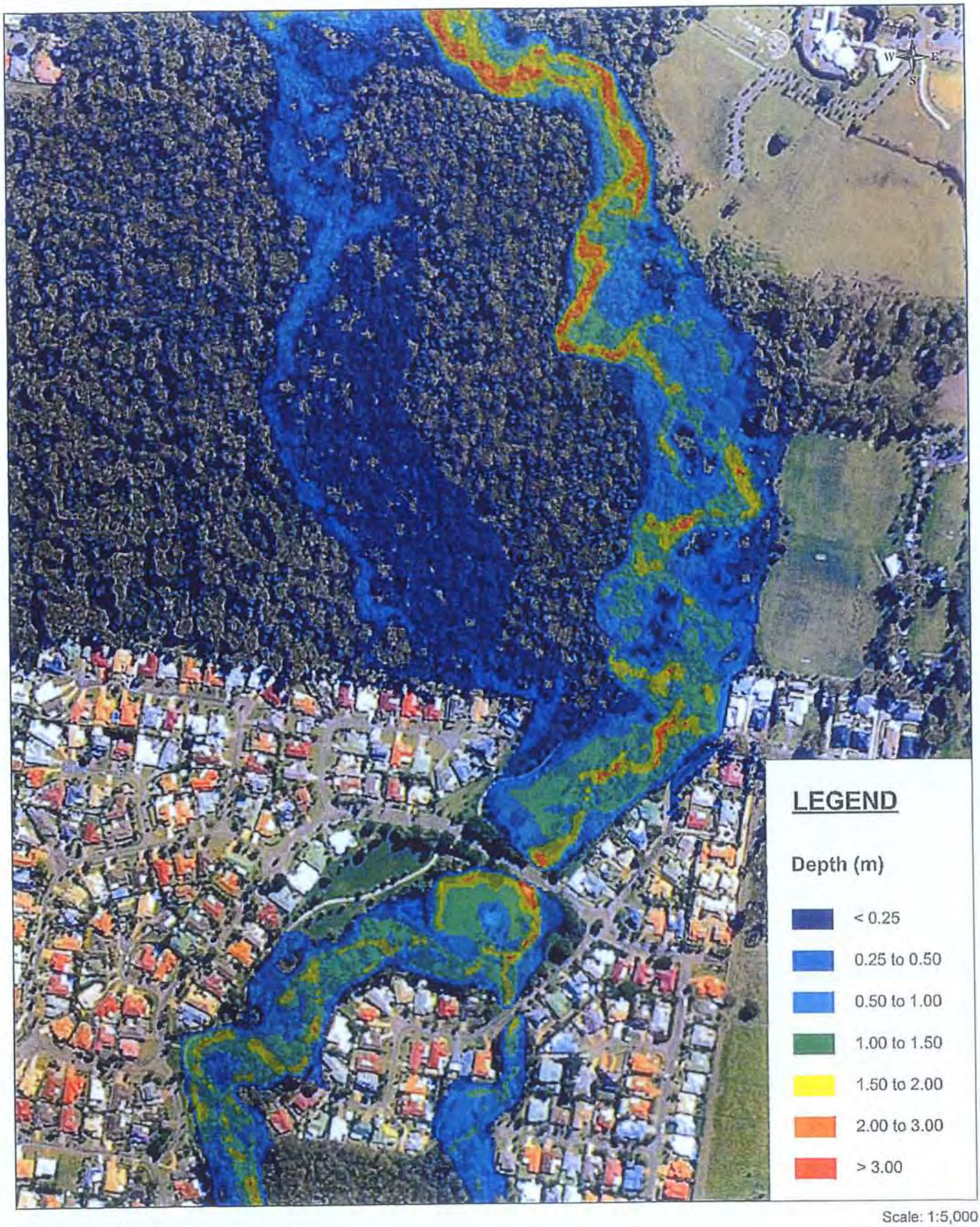

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FIGURE B23
50 YR ARI FLOOD DEPTH - Sheet 3 of 4

Project No: J11039

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File Path: J:\11039\Graphics\Figure B

Print Date: 12-7-2011

BCC.079.0468

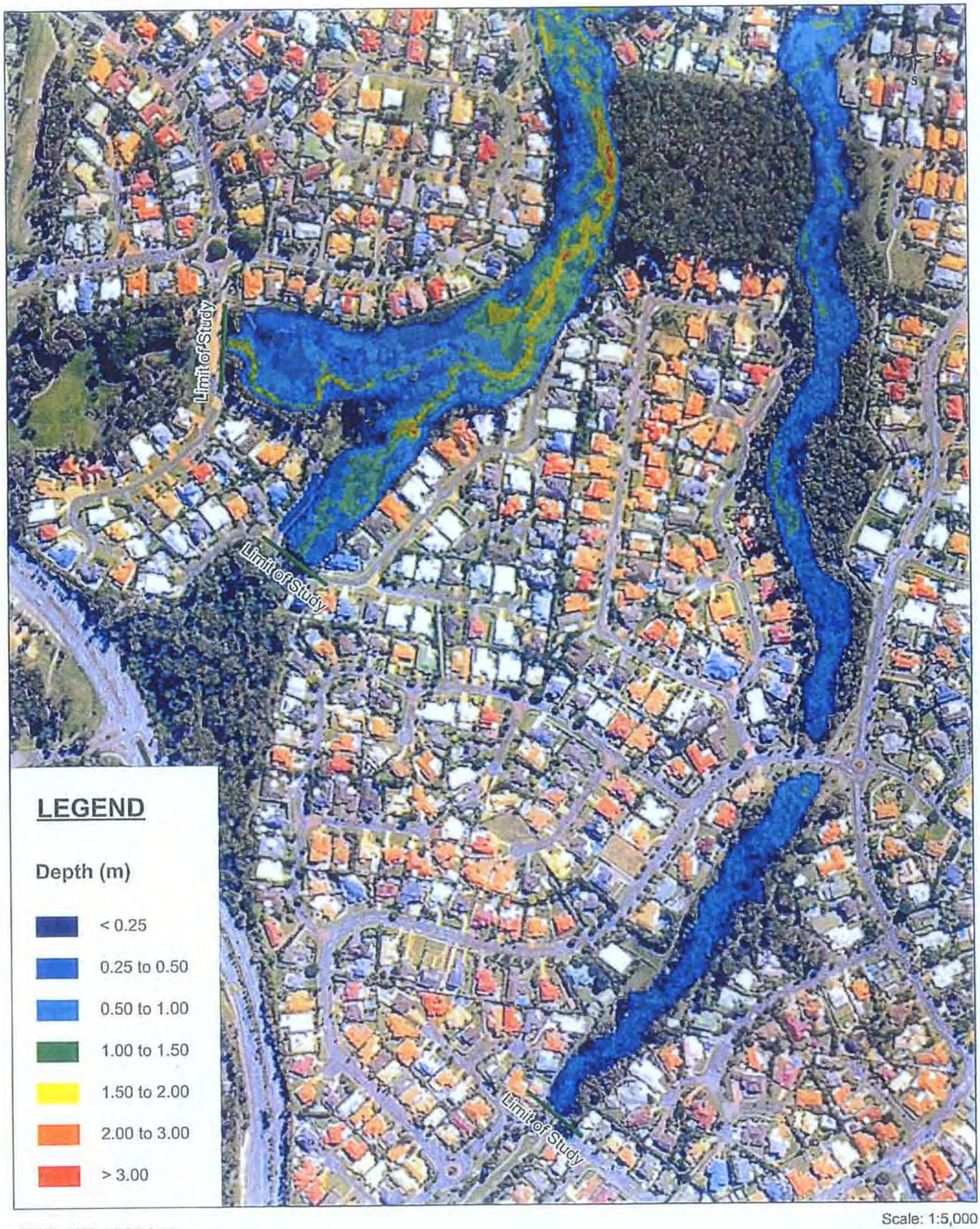

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FIGURE B24

50 YR ARI FLOOD DEPTH - Sheet 4 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

File Path: I:\J11039\GIS\Mxd\Figure B

Print Date: 12-7-2011

BCC.079.0469

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ALBANY CREEK FLOOD STUDY

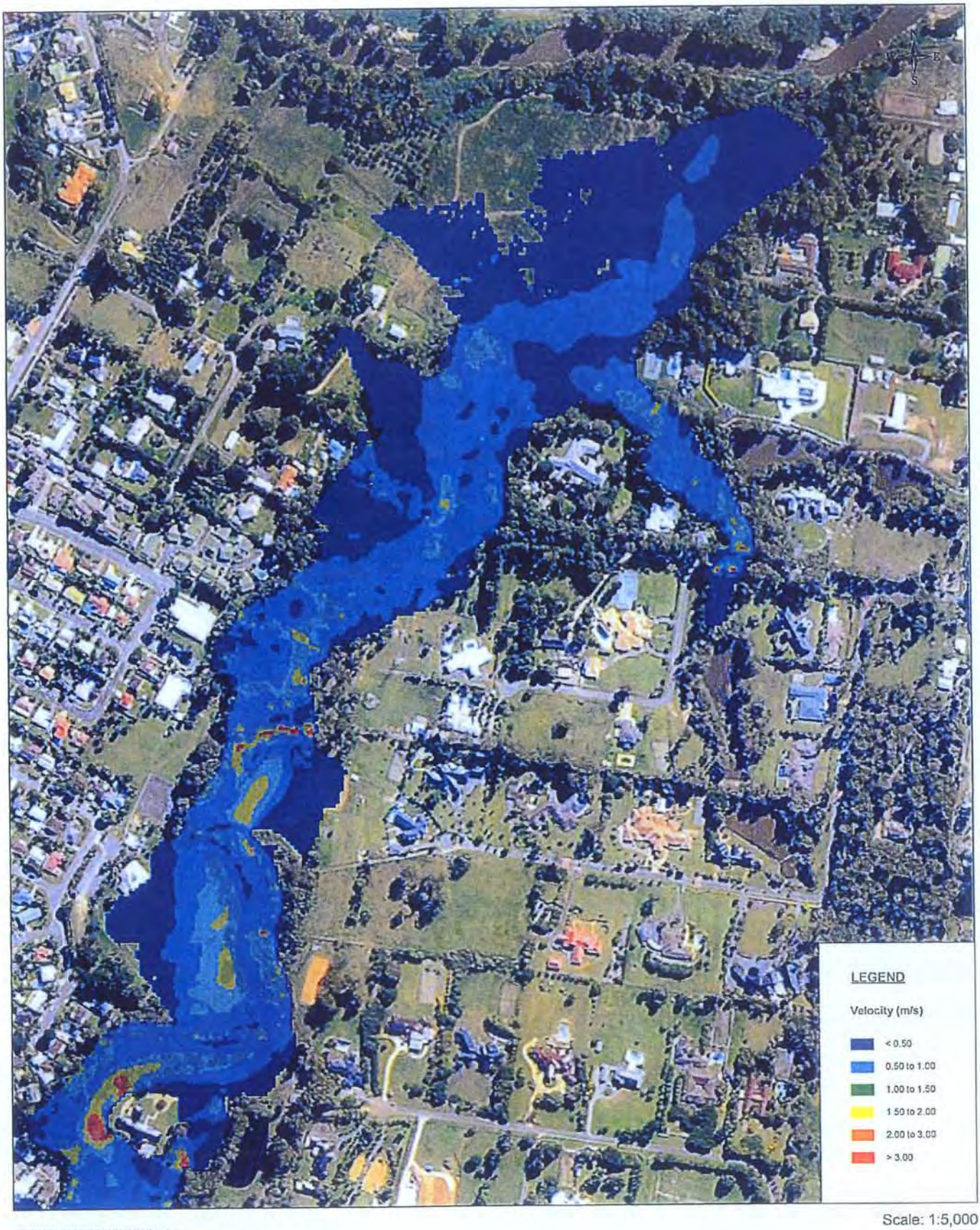

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FIGURE B25

50 YR ARI VELOCITY - Sheet 1 of 4

Project No: J11039

Water Resources Branch

Print Date: 12-7-2011

BCC.079.0470

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ALBANY CREEK FLOOD STUDY

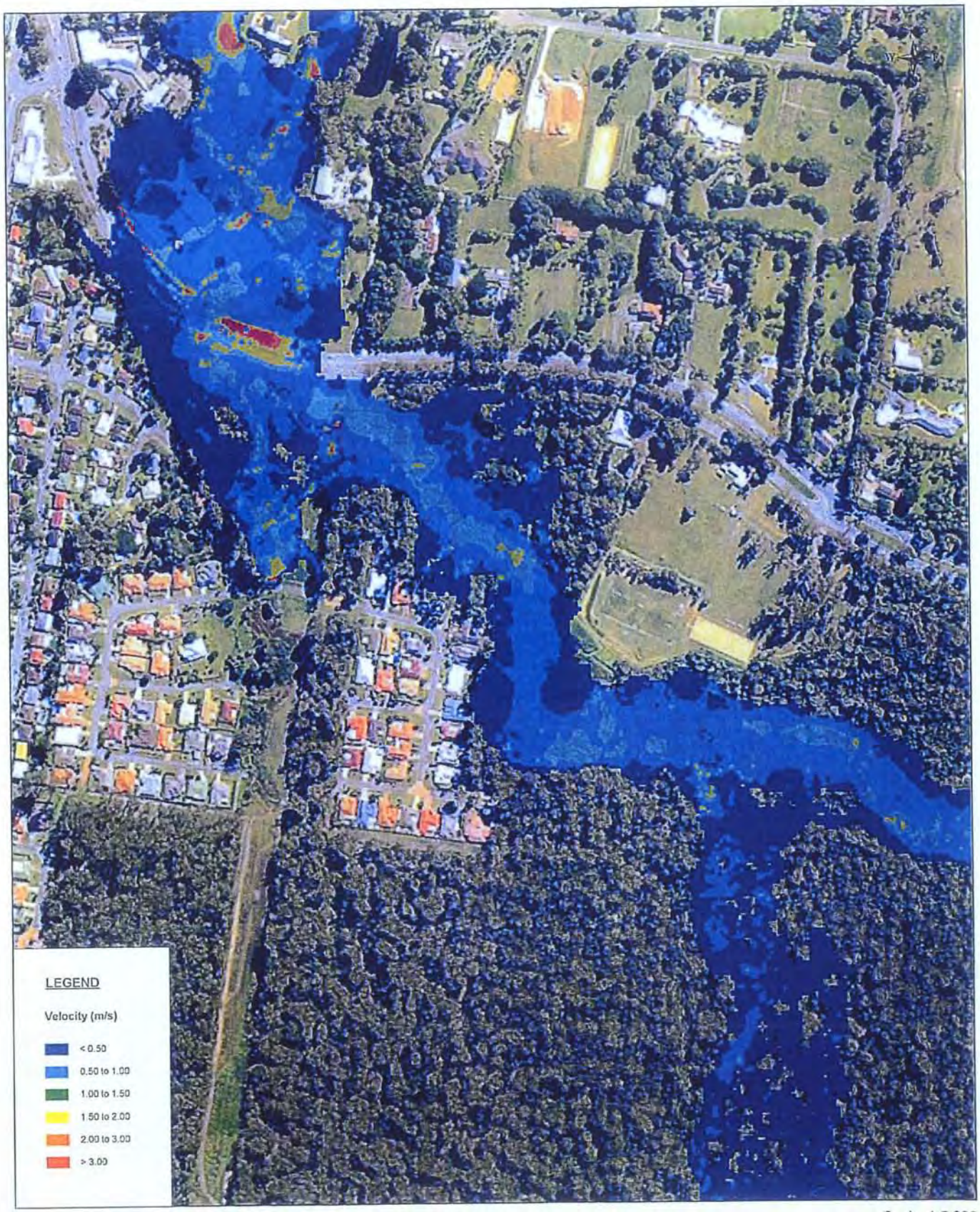

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FIGURE B26
50 YR ARI VELOCITY - Sheet 2 of 4

Project No: J11039

Water Resources Branch

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BCC.079.0471

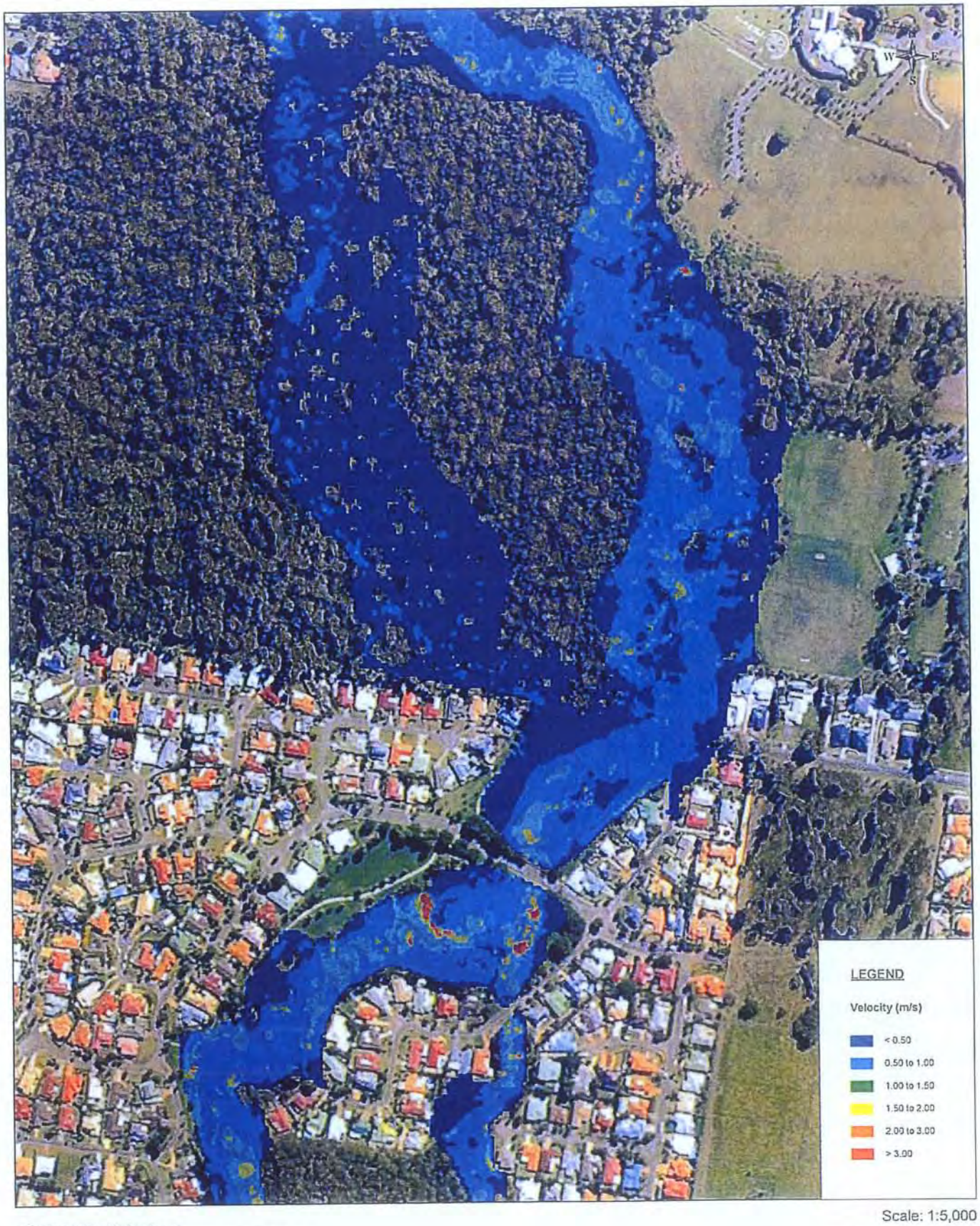

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FIGURE B27

50 YR ARI VELOCITY - Sheet 3 of 4

Project No: J11039

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File Path: J:\11039\GIS\Job\Figure\

Print Date: 12-7-2011

BCC.079.0472

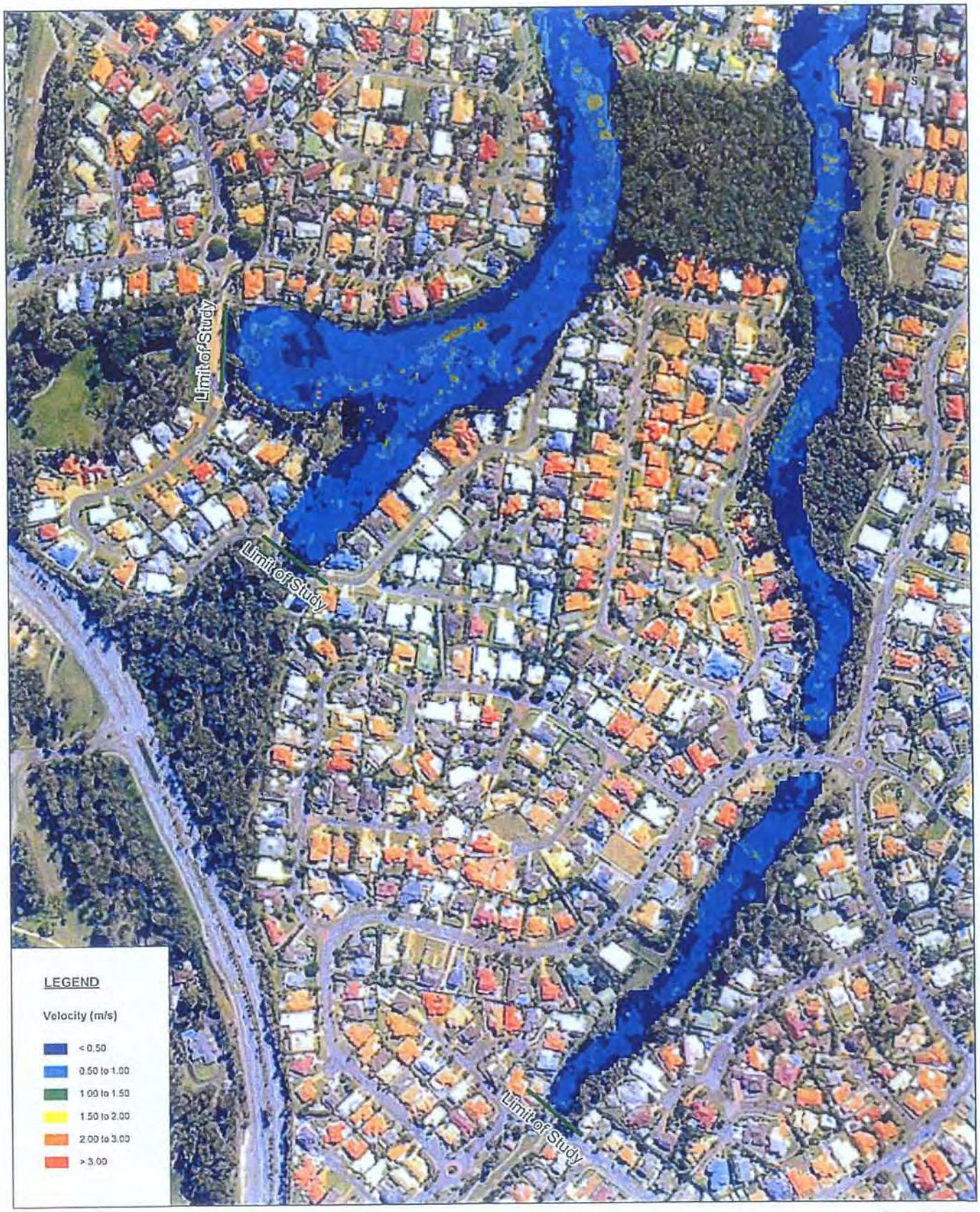

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FIGURE B28
50 YR ARI VELOCITY - Sheet 4 of 4

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BCC.079.0473

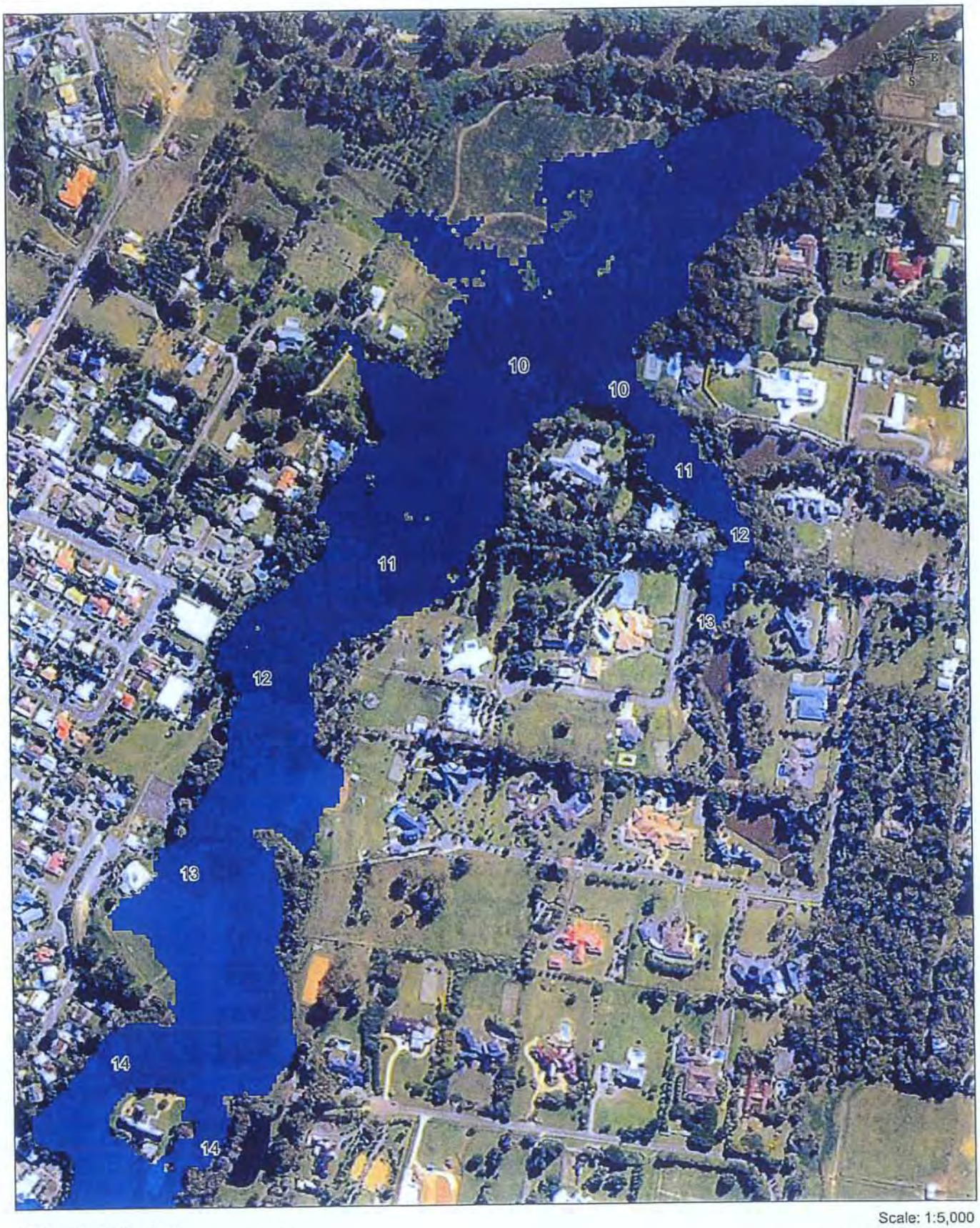

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FIGURE B29

20 YR ARI INUNDATION - Sheet 1 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

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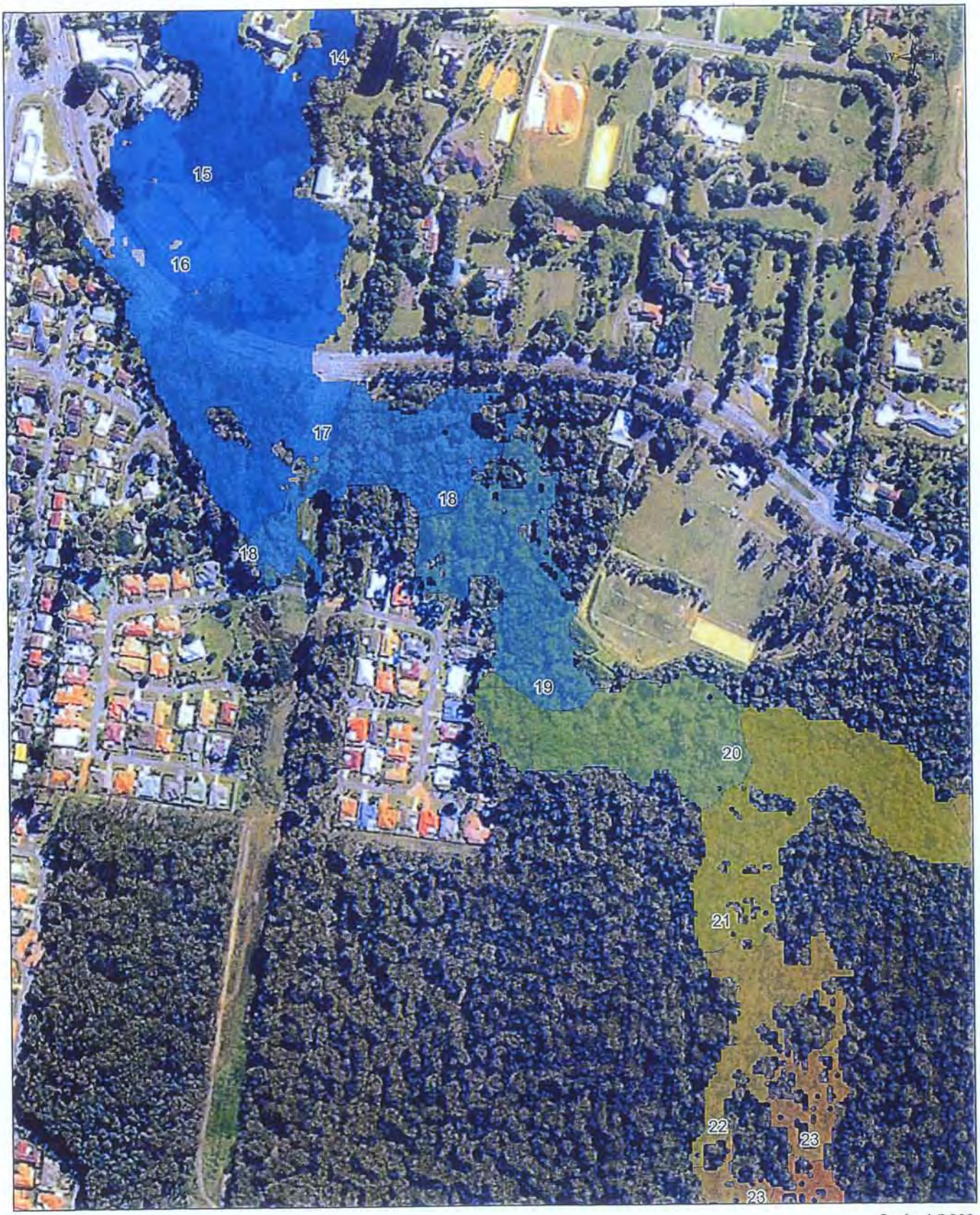

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FIGURE B30

20 YR ARI INUNDATION - Sheet 2 of 4

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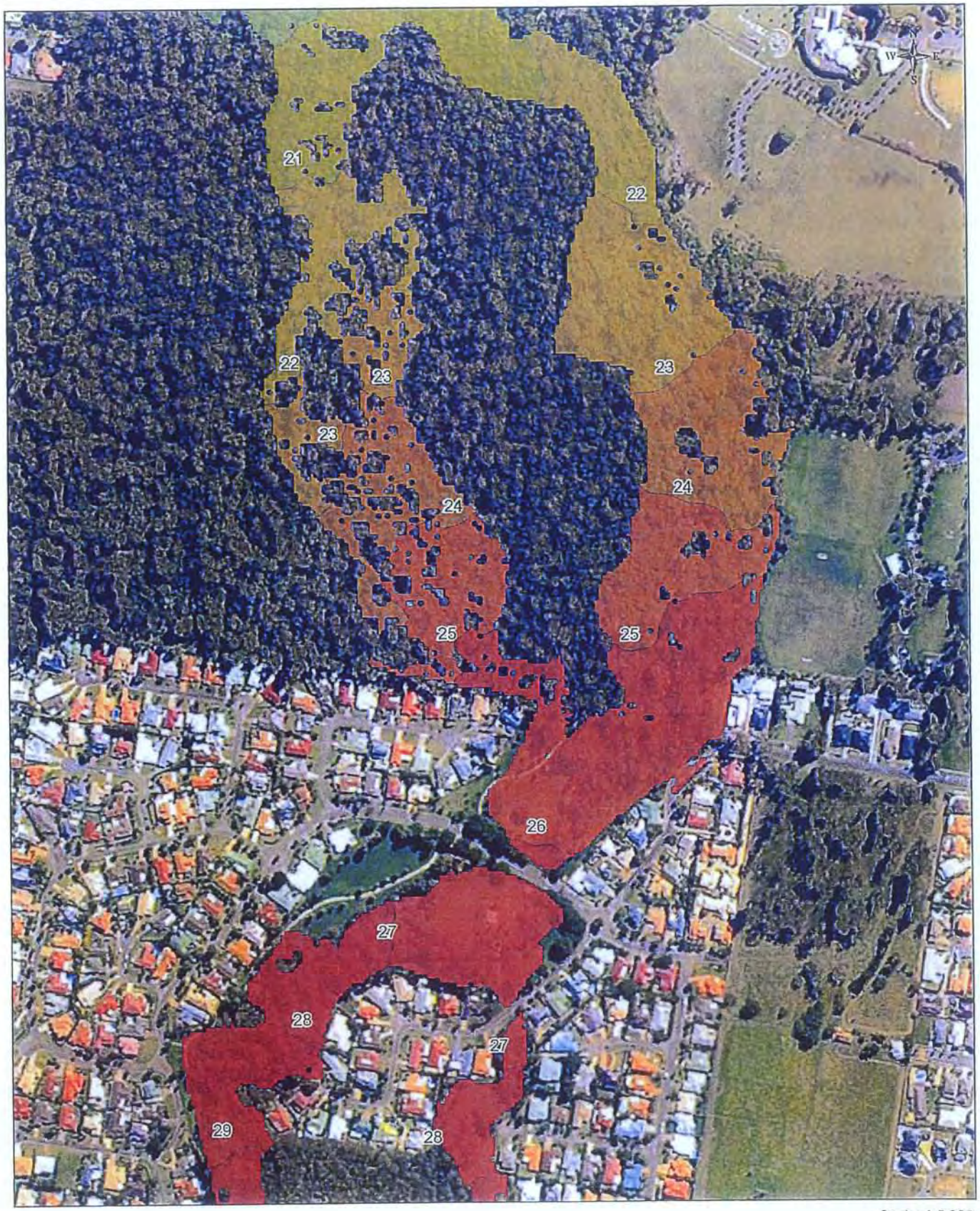

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FIGURE B31
20 YR ARI INUNDATION - Sheet 3 of 4

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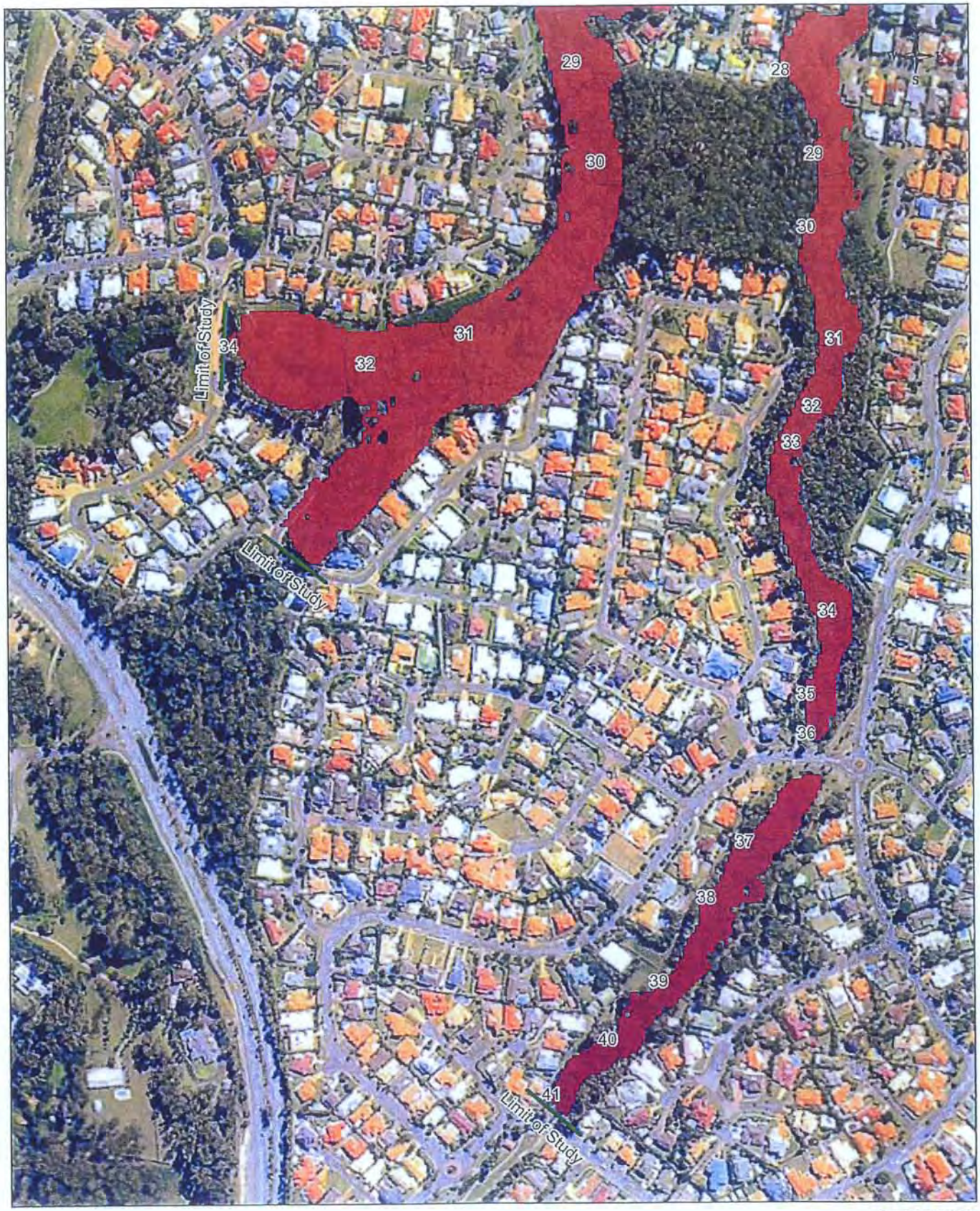

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FIGURE B32

20 YR ARI INUNDATION - Sheet 4 of 4

Rev: Orig Date: 06 July 2011

Project No: J11039

Water Resources Branch

File Path: J:\11039\GIS\MapFigures\

Print Date: 12-7-2011

BCC.079.0477

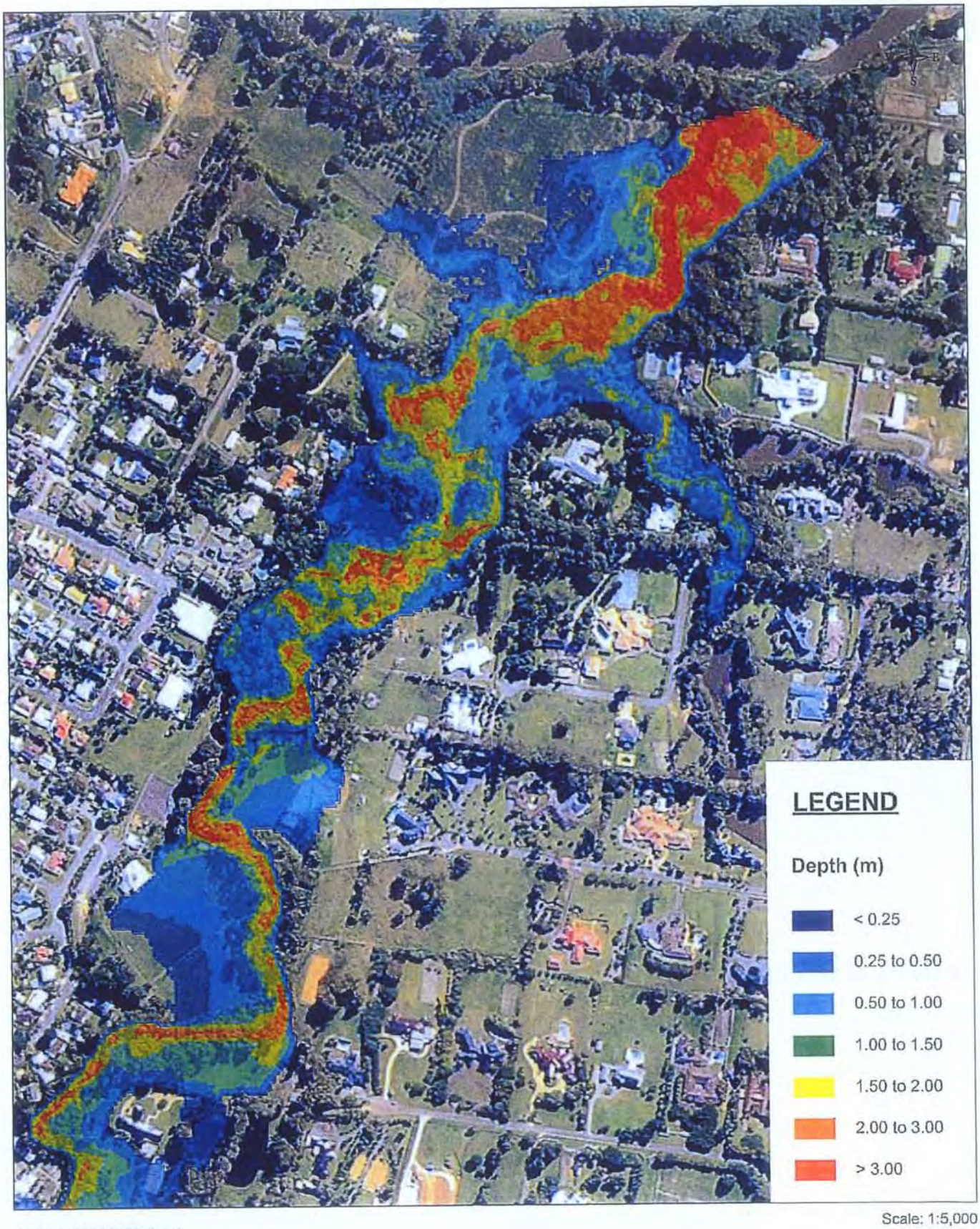

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FIGURE B33

20 YR ARI FLOOD DEPTH - Sheet 1 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

File Path: J:\11039\Graphics\Figures\

Print Date: 13-7-2011

BCC.079.0478

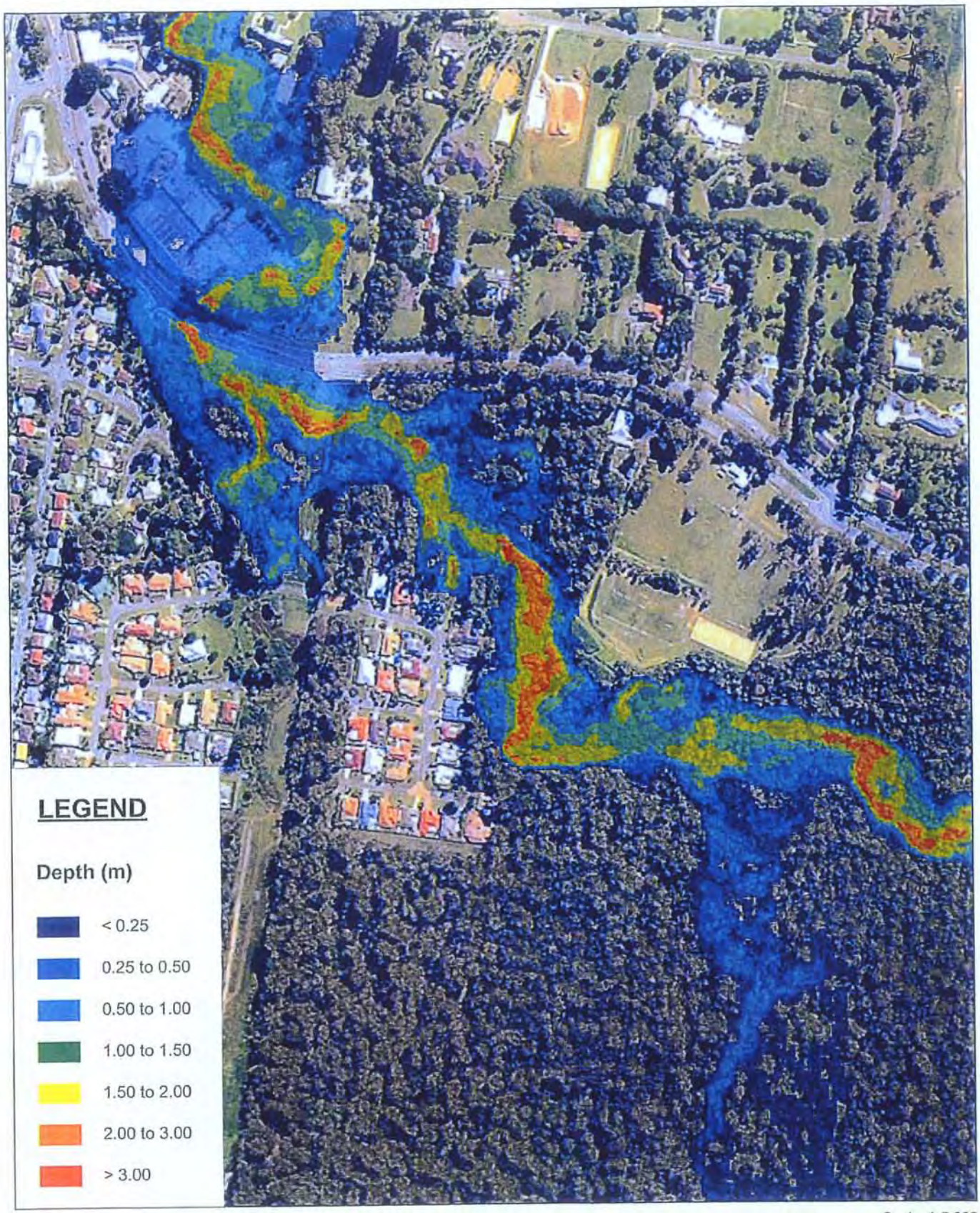

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FIGURE B34

20 YR ARI FLOOD DEPTH - Sheet 2 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

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Print Date: 13-7-2011

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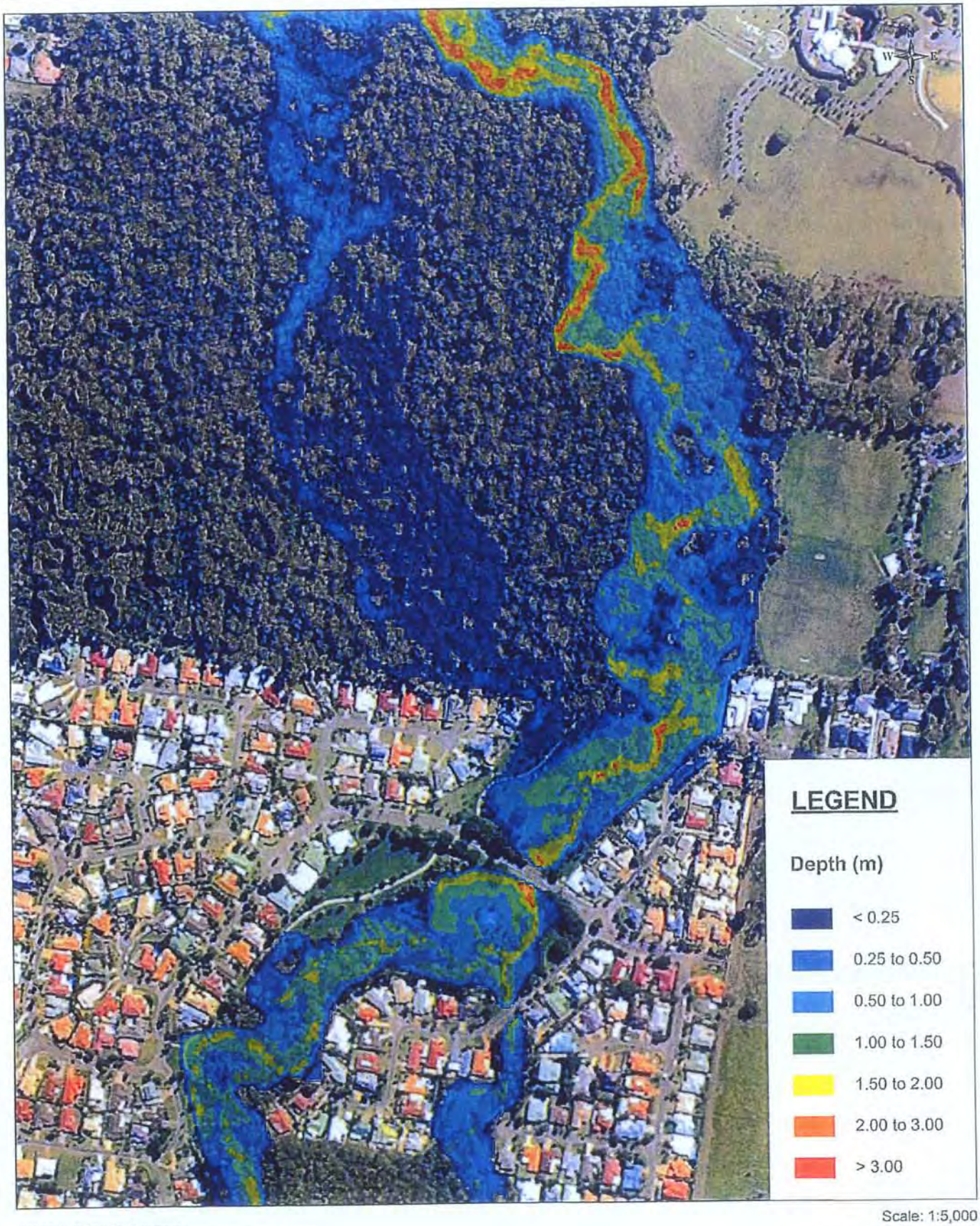

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FIGURE B35
20 YR ARI FLOOD DEPTH - Sheet 3 of 4

Project No: J11039

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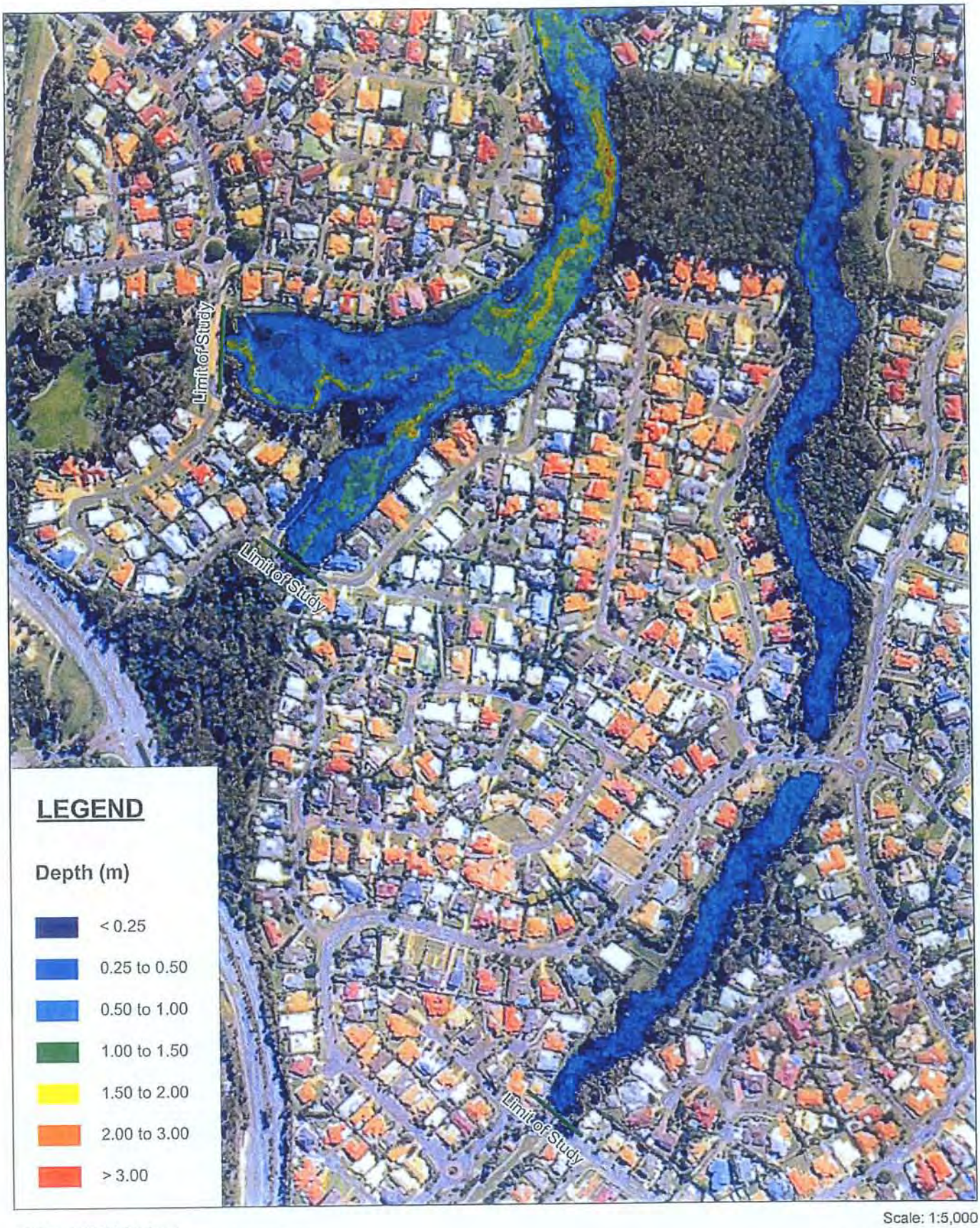
ALBANY CREEK FLOOD STUDY



Scale: 1:5,000

FIGURE B36

20 YR ARI FLOOD DEPTH - Sheet 4 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

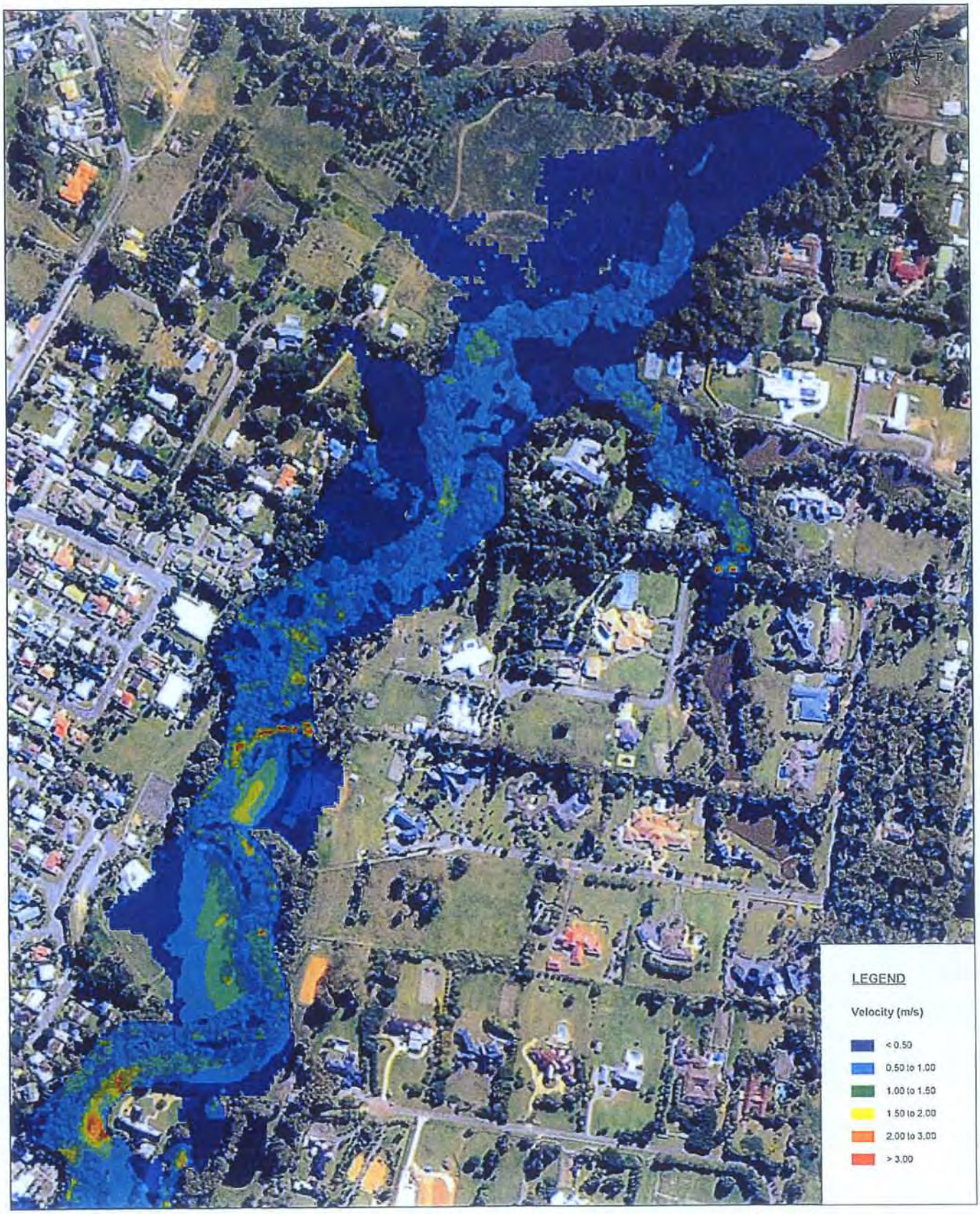
Water Resources Branch

Print Date: 10-7-2011

BCC.079.0481

DRAFT

ALBANY CREEK FLOOD STUDY



Scale: 1:5,000

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FIGURE B37
20 YR ARI VELOCITY - Sheet 1 of 4

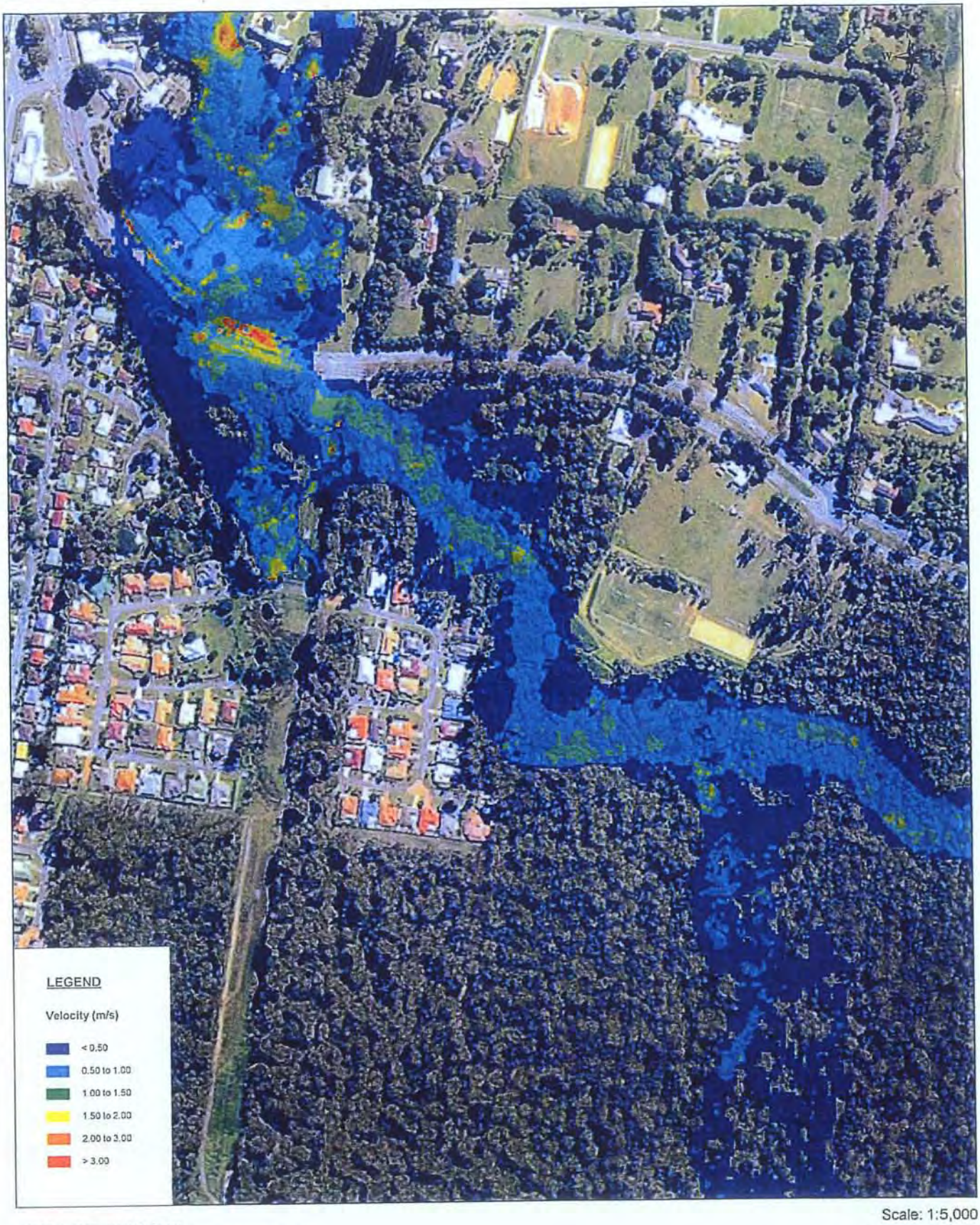
Rev: Orig Date: 06 July 2011

Project No: J11039

Water Resources Branch

Print Date: 13-7-2011

BCC.079.0482



Scale: 1:5,000

FIGURE B38
20 YR ARI VELOCITY - Sheet 2 of 4

Project No: J11039

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Rev: Orig Date: 06 July 2011

Water Resources Branch

File Path: [redacted]

Print Date: 13-7-2011

BCC.079.0483

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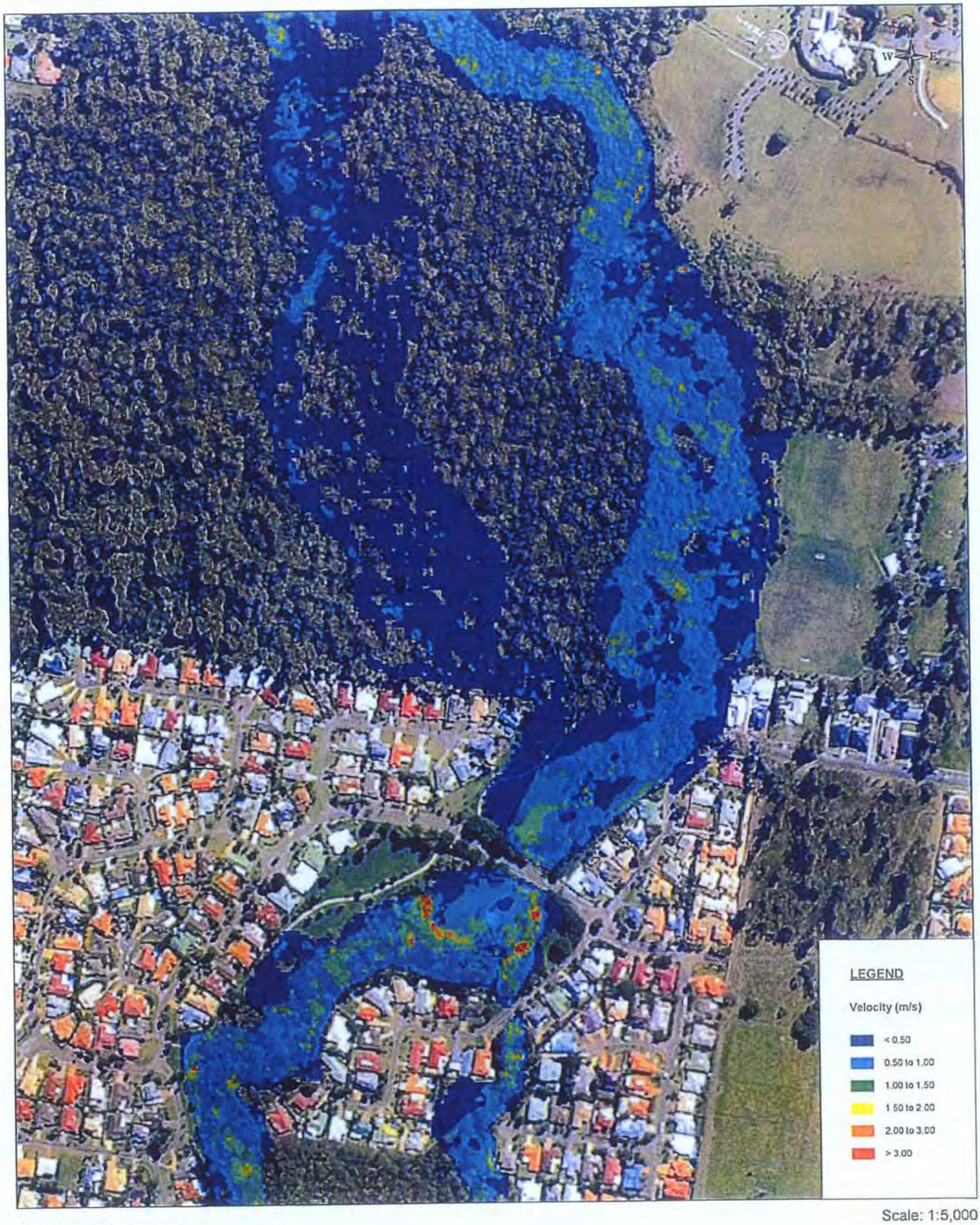
ALBANY CREEK FLOOD STUDY



Scale: 1:5,000

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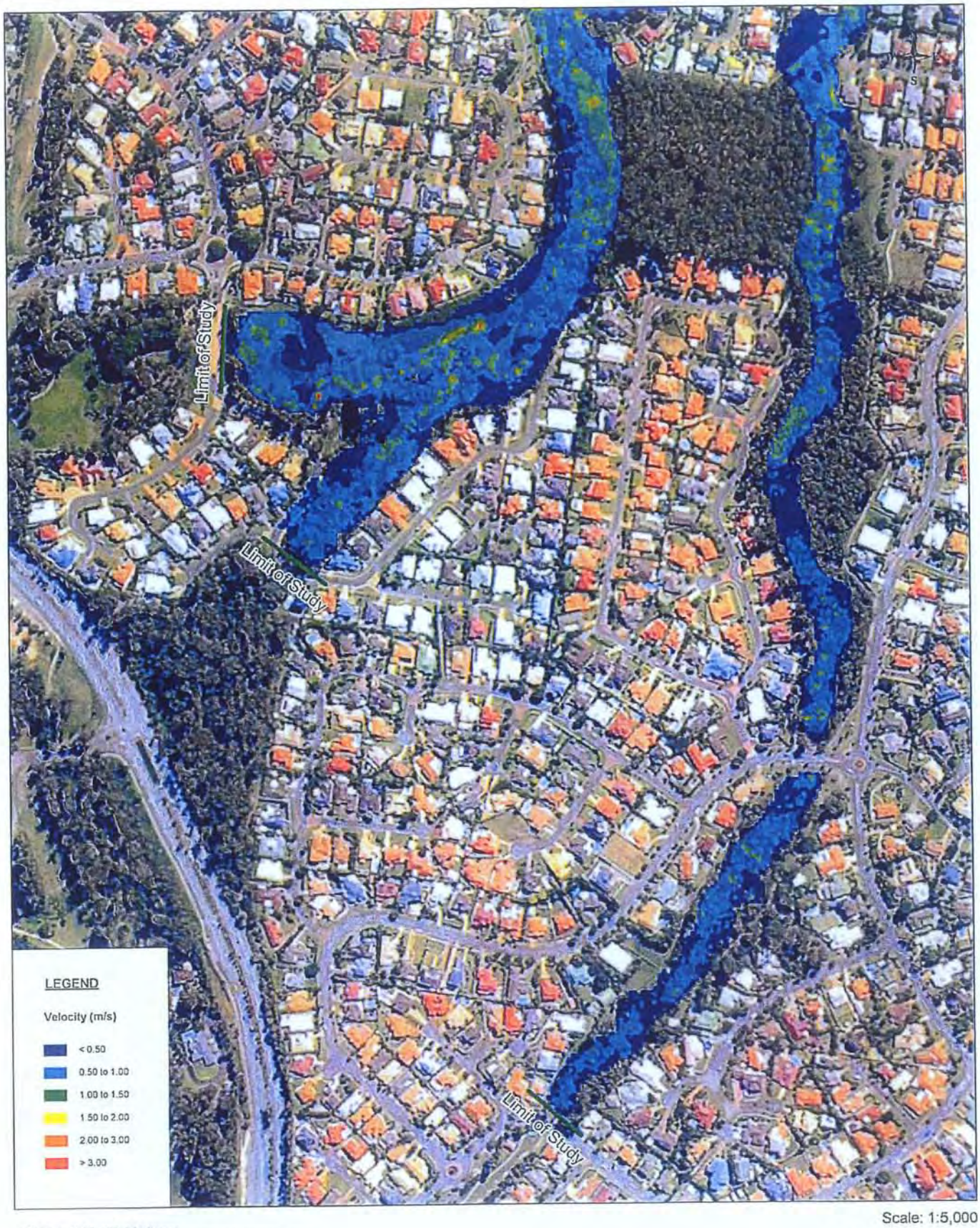
FIGURE B39
20 YR ARI VELOCITY - Sheet 3 of 4

Project No: J11039

Water Resources Branch

Print Date: 13-7-2011

BCC.079.0484



Scale: 1:5,000

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FIGURE B40

20 YR ARI VELOCITY - Sheet 4 of 4

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FIGURE B41

10 YR ARI INUNDATION - Sheet 1 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

File Path: J:\11039\GIS\Mxd\Figure4

Print Date: 18-7-2011

BCC.079.0486

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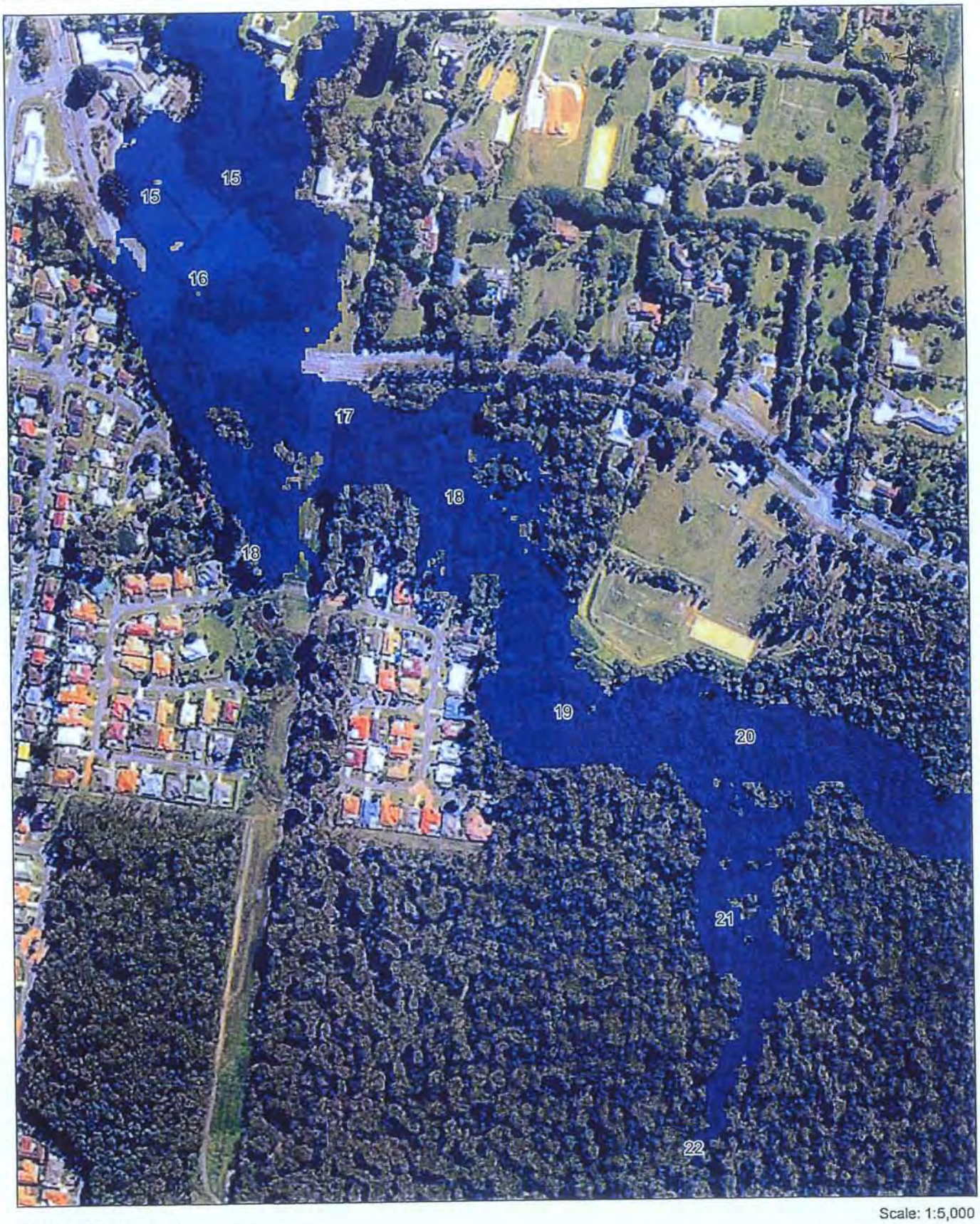
ALBANY CREEK FLOOD STUDY



Scale: 1:5,000

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FIGURE B42
10 YR ARI INUNDATION - Sheet 2 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

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FIGURE B43

10 YR ARI INUNDATION - Sheet 3 of 4

Rev: Orig Date: 06 July 2011

Project No: J11039

Water Resources Branch

Print Date: 13-7-2011

BCC.079.0488

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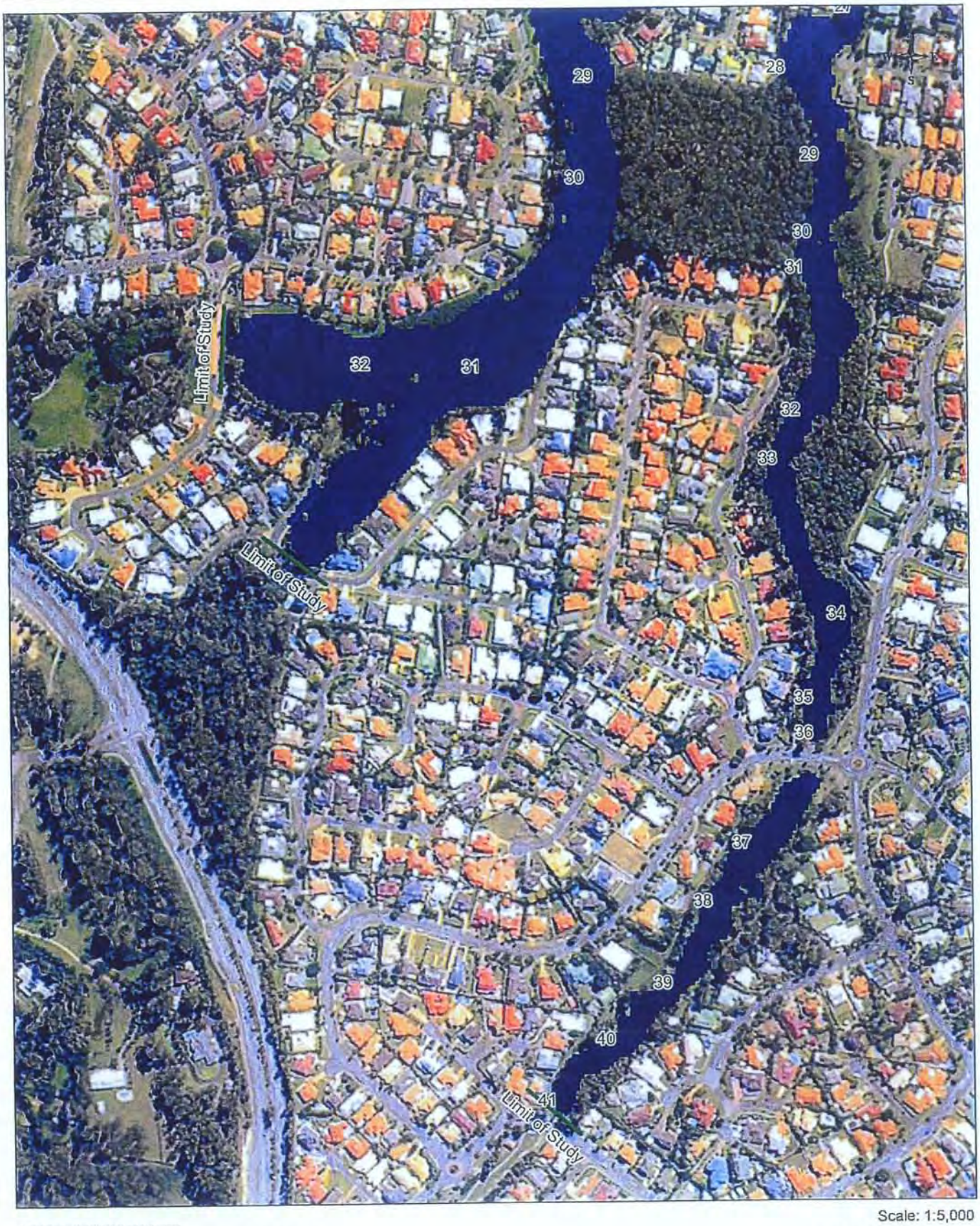
ALBANY CREEK FLOOD STUDY



Scale: 1:5,000

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FIGURE B44
10 YR ARI INUNDATION - Sheet 4 of 4

Project No: J11039

Water Resources Branch

Print Date: 13-7-2011

BCC.079.0489

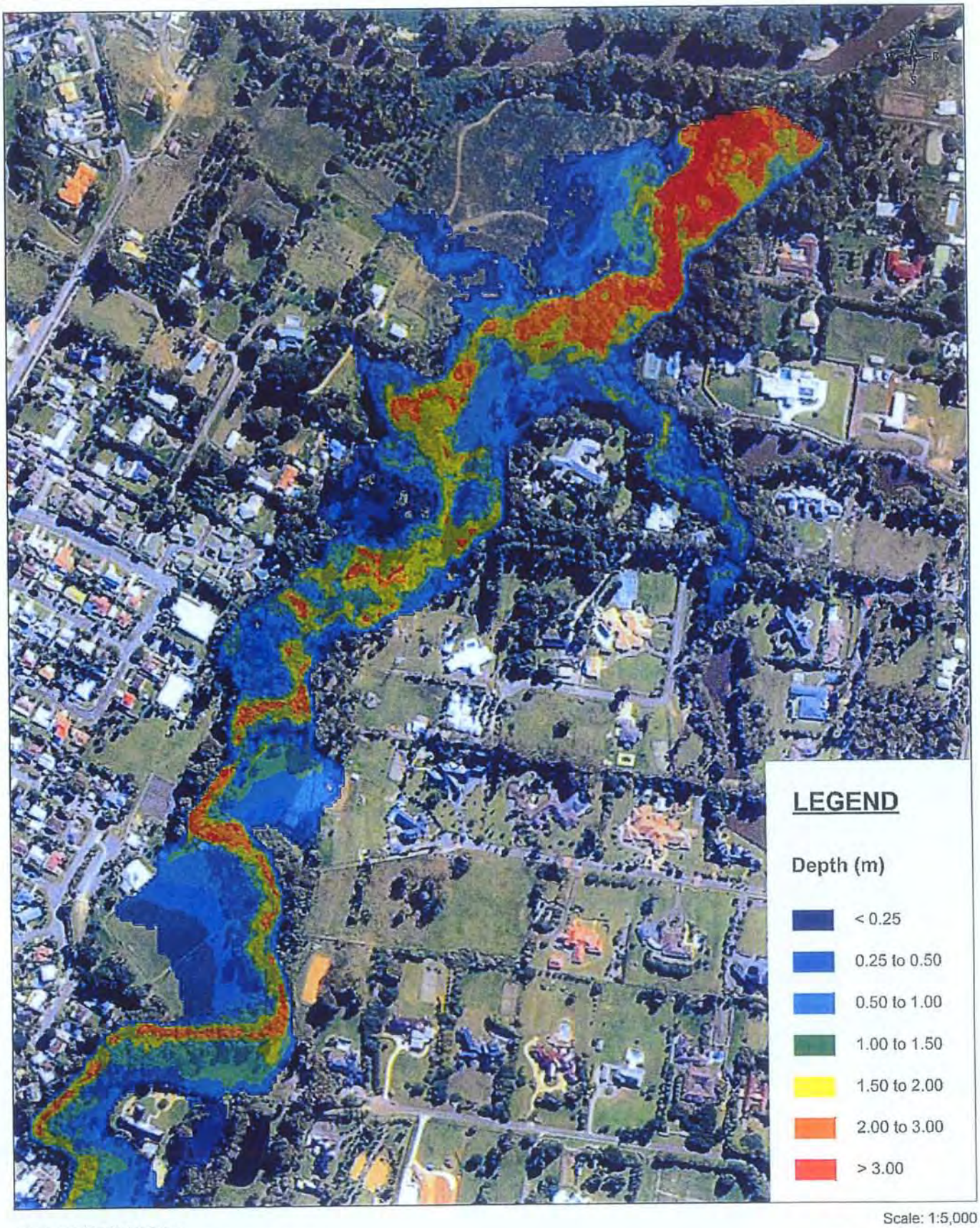

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FIGURE B45

10 YR ARI FLOOD DEPTH - Sheet 1 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

File Path: J:\11039\GIS\MXD\Figure B

Print Date: 13-7-2011

BCC.079.0490

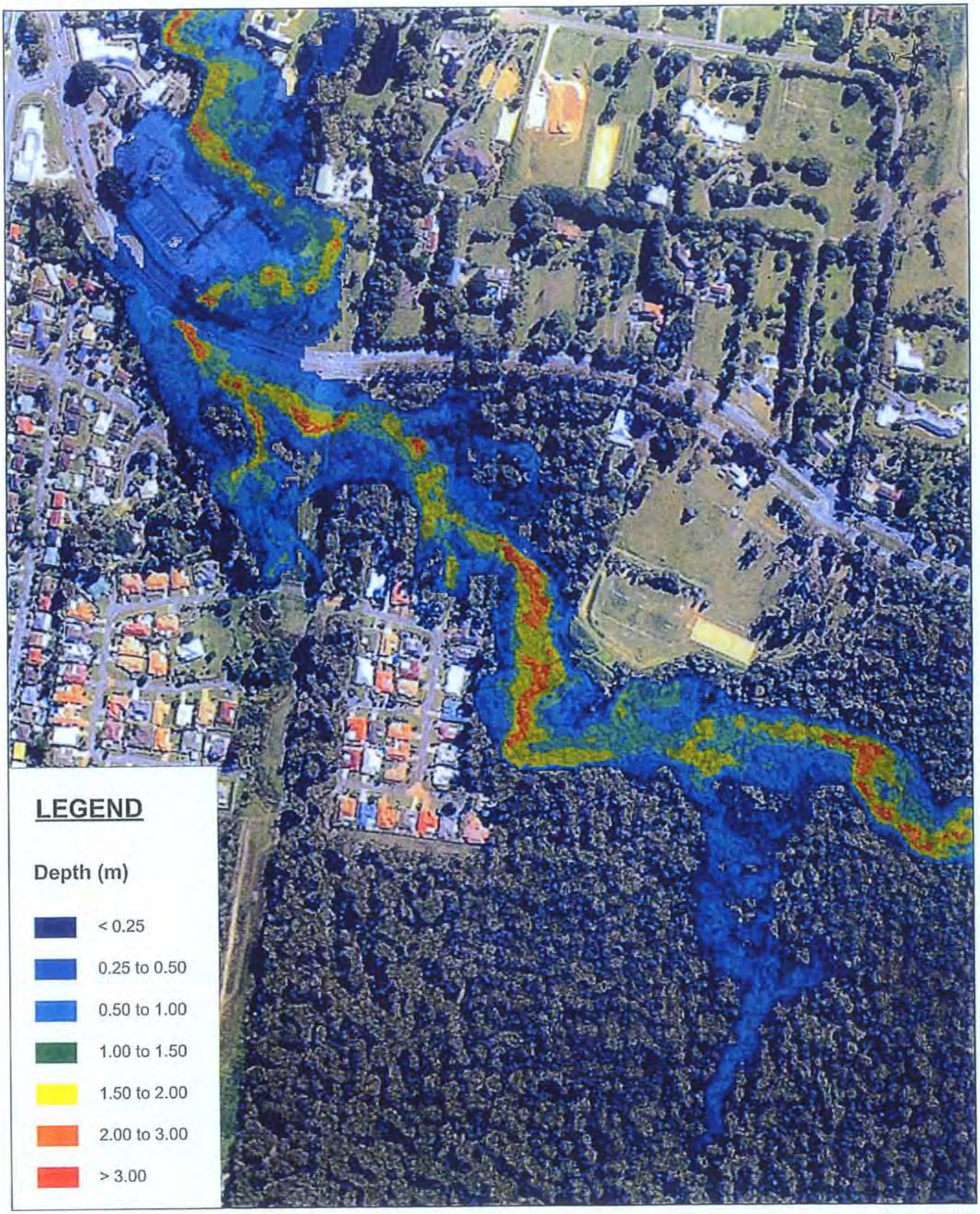

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FIGURE B46

10 YR ARI FLOOD DEPTH - Sheet 2 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

Print Date: 13-7-2011

BCC.079.0491

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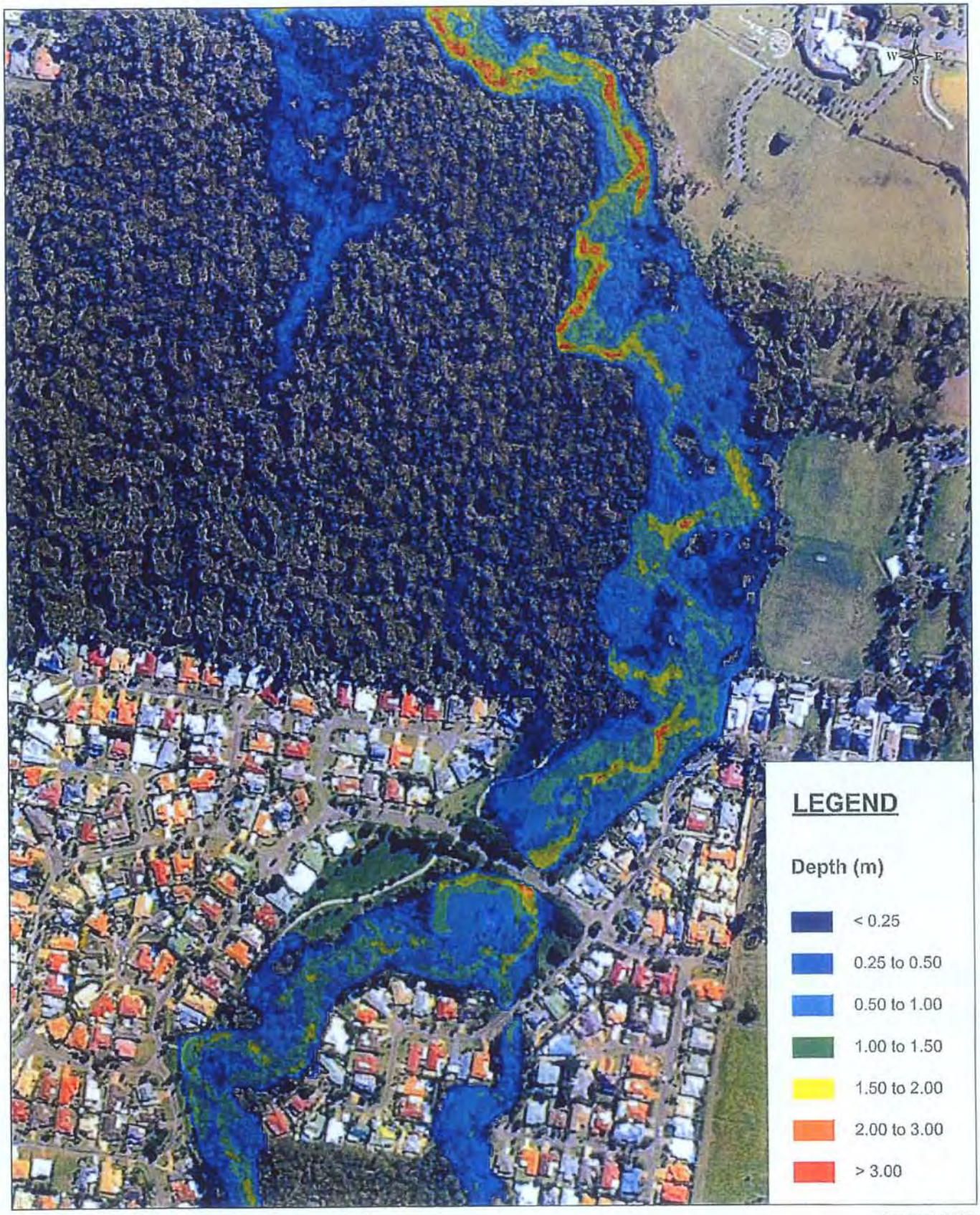
ALBANY CREEK FLOOD STUDY



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Rev: Orig Date: 06 July 2011

FIGURE B47
10 YR ARI FLOOD DEPTH - Sheet 3 of 4

Project No: J11039

Water Resources Branch

Print Date: 13-7-2011

File Path: [illegible]

BCC.079.0492

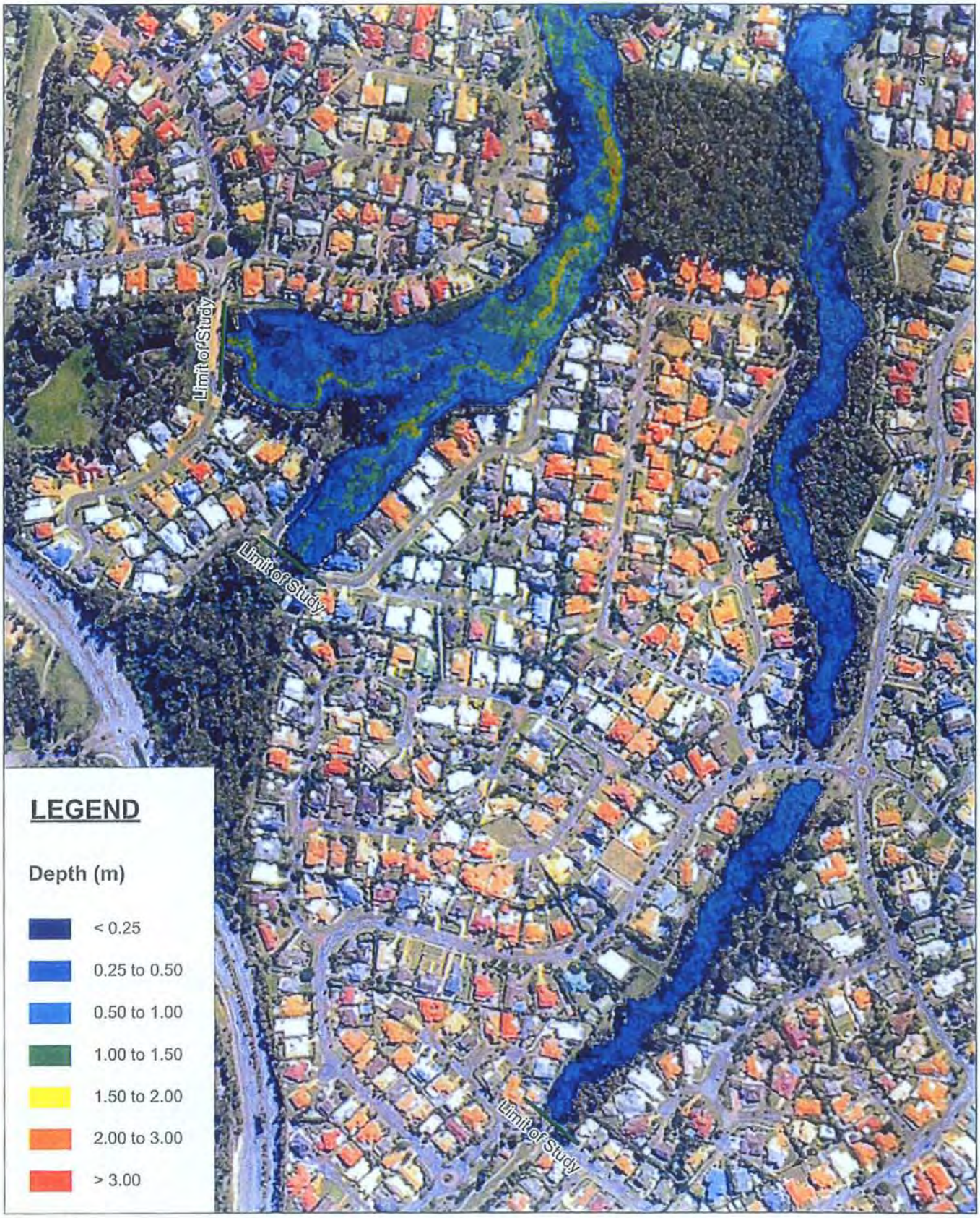

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FIGURE B48

10 YR ARI FLOOD DEPTH - Sheet 4 of 4

Rev: Orig Date: 06 July 2011

Project No: J11039

Water Resources Branch

Print Date: 13-7-2011

BCC.079.0493

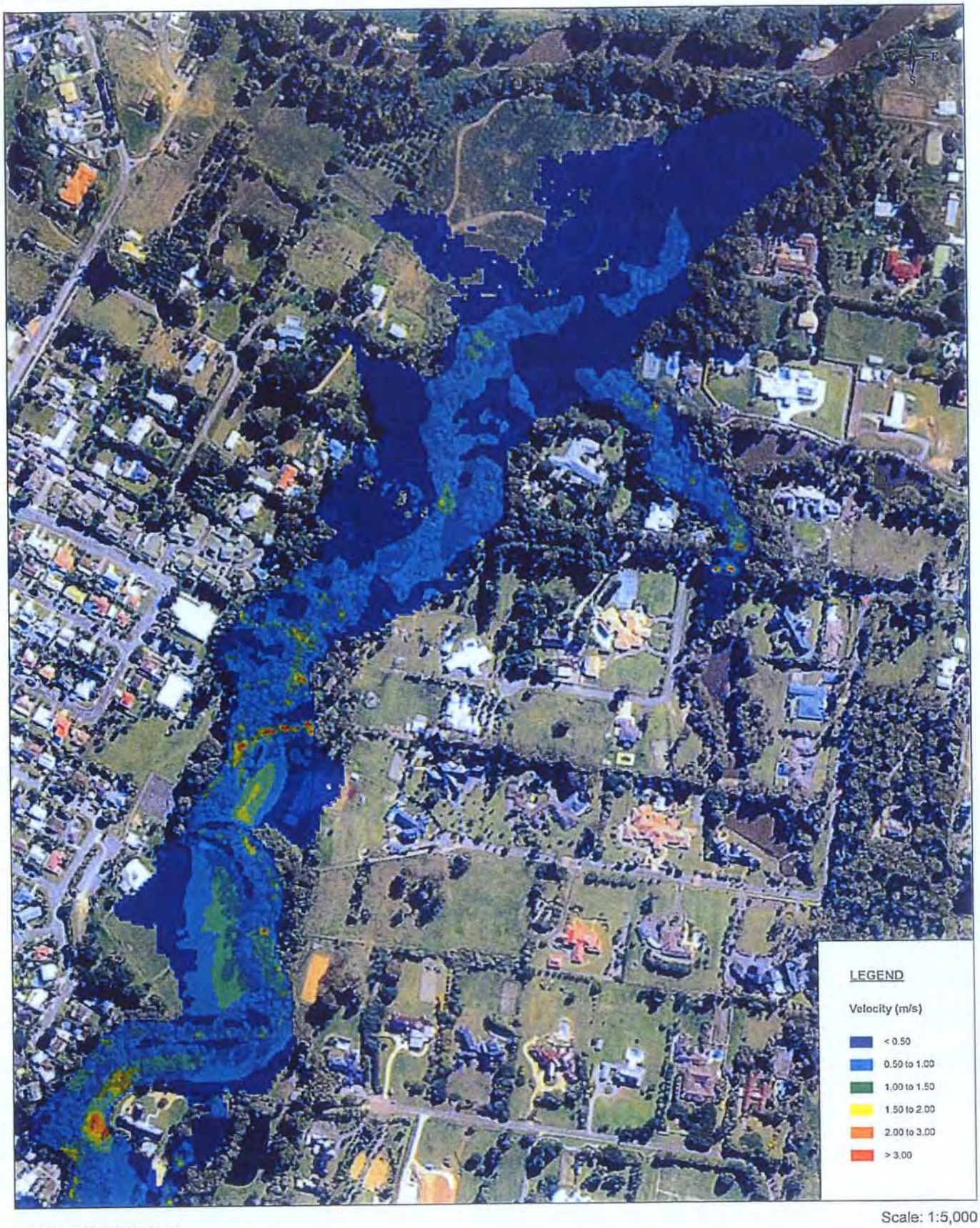

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FIGURE B49

10 YR ARI VELOCITY - Sheet 1 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

Print Date: 13-7-2011

File Path: [illegible]

BCC.079.0494

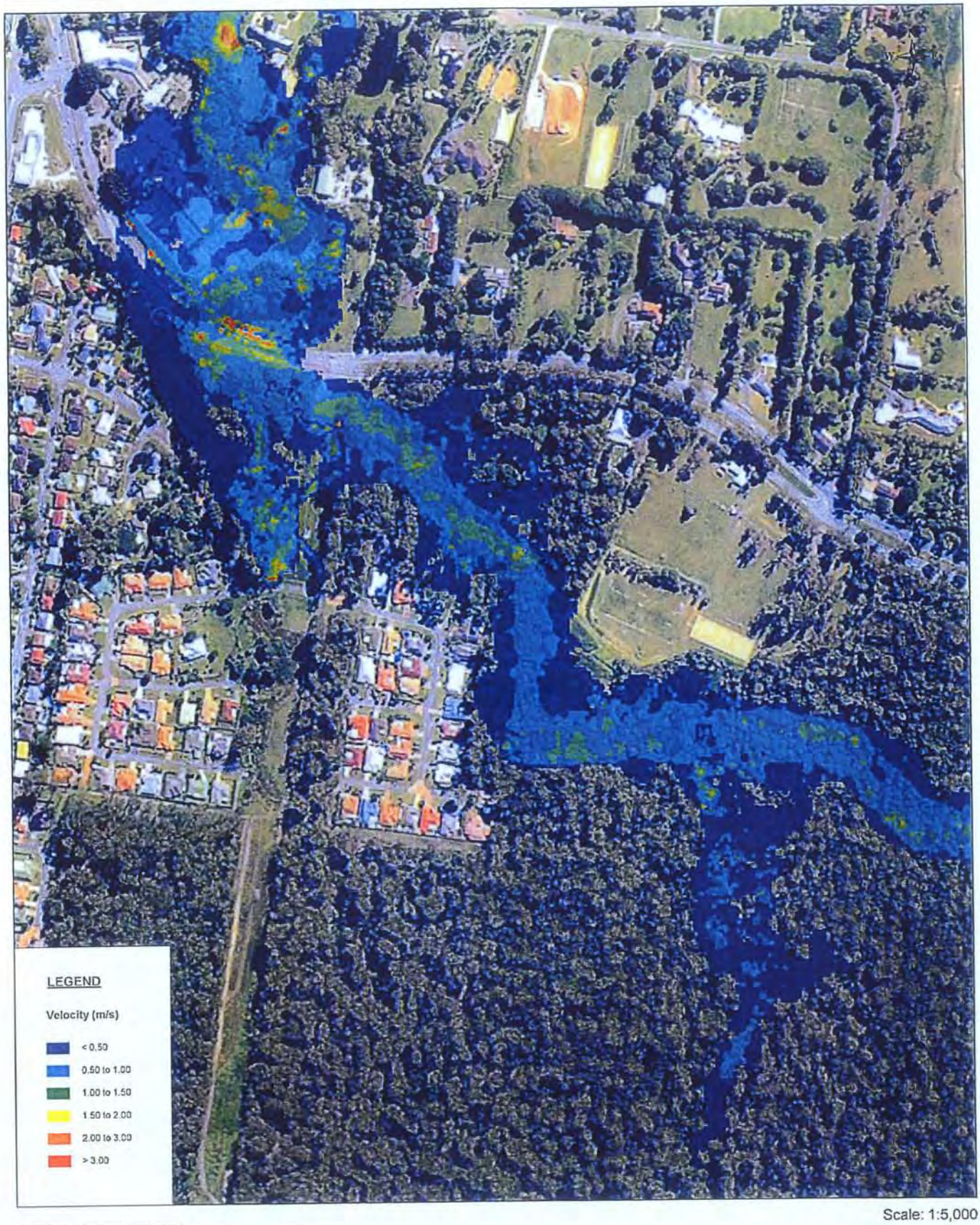

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FIGURE B50

10 YR ARI VELOCITY - Sheet 2 of 4

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

File Path: [illegible]

Print Date: 13-7-2011

BCC.079.0495

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ALBANY CREEK FLOOD STUDY

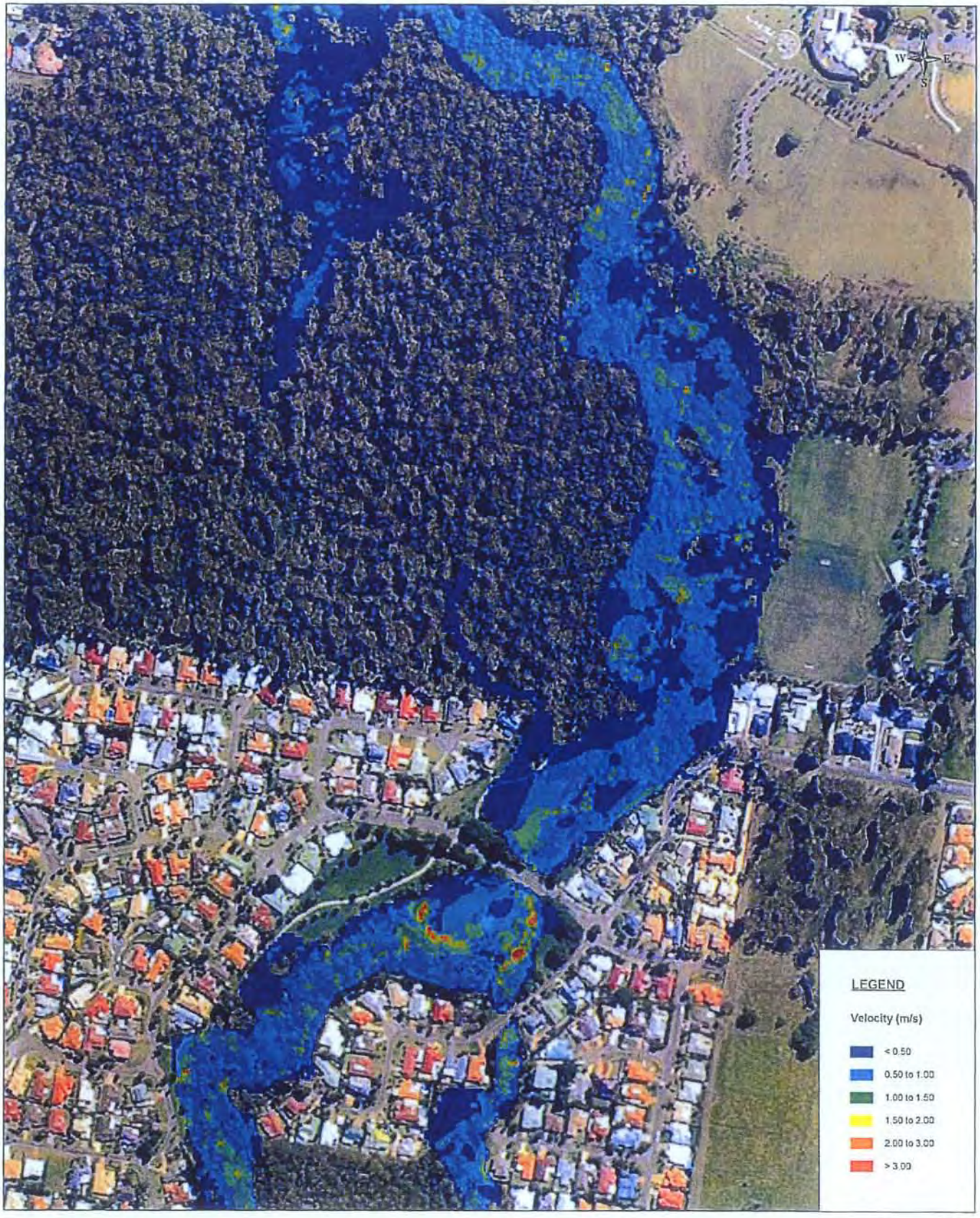

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FIGURE B51
10 YR ARI VELOCITY - Sheet 3 of 4

Rev: Orig Date: 06 July 2011

Project No: J11039

Water Resources Branch

Print Date: 13-7-2011

BCC.079.0496

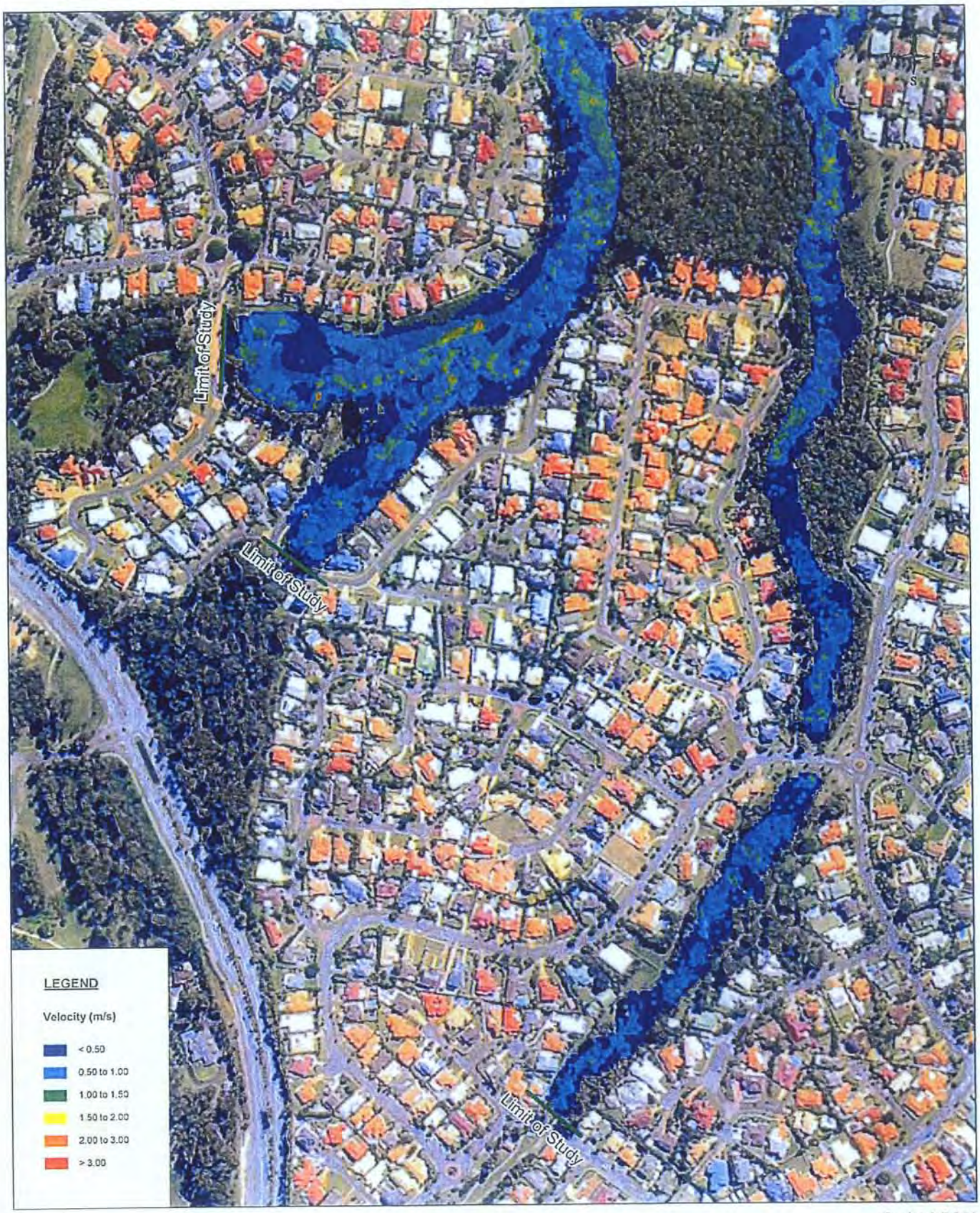

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FIGURE B52
10 YR ARI VELOCITY - Sheet 4 of 4

Project No: J11039

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Water Resources Branch

Print Date: 18-7-2011

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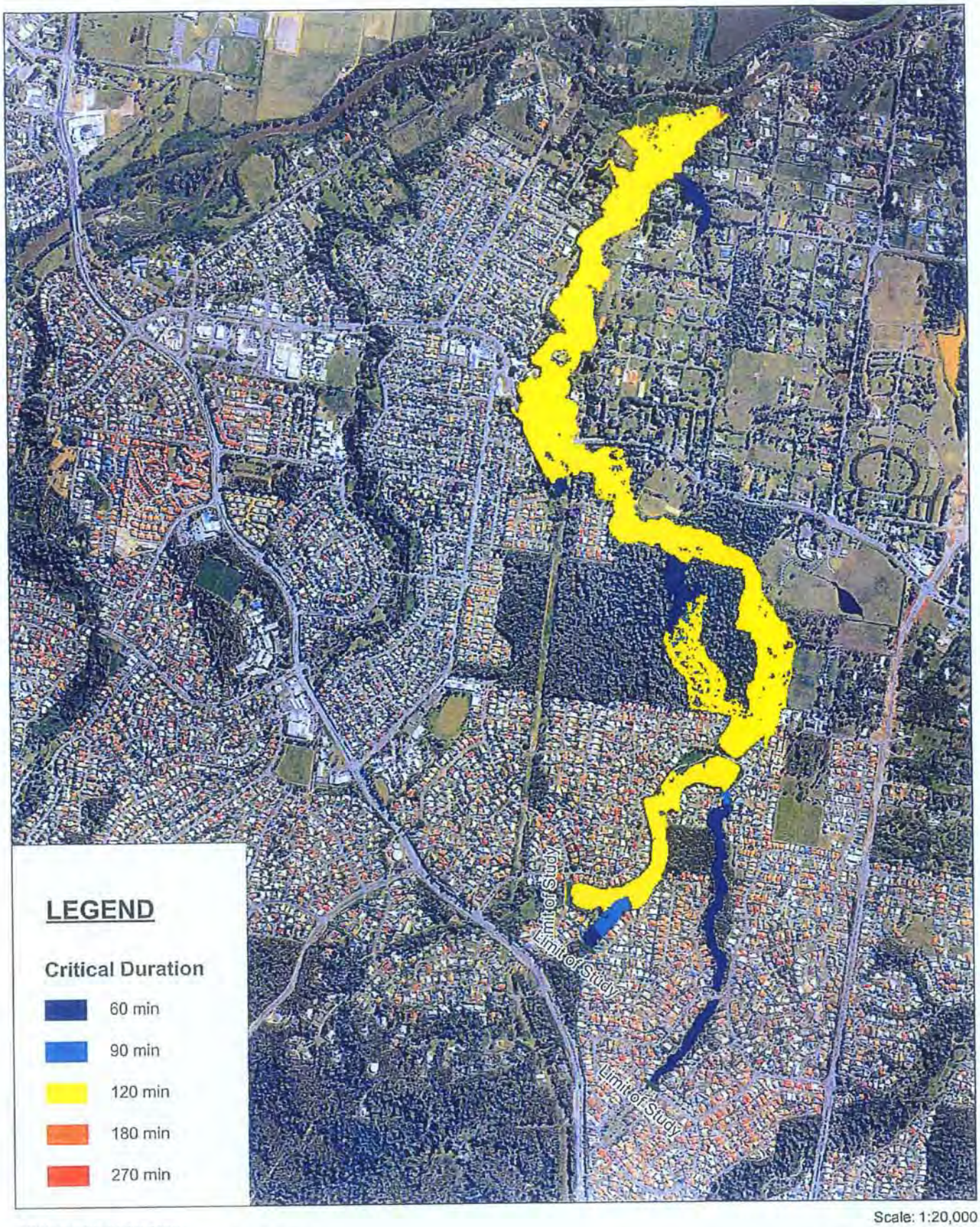

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FIGURE B77
100 YR ARI CRITICAL DURATION

Project No: J11039

Water Resources Branch

Print Date: 19-7-2011

BCC.079.0498

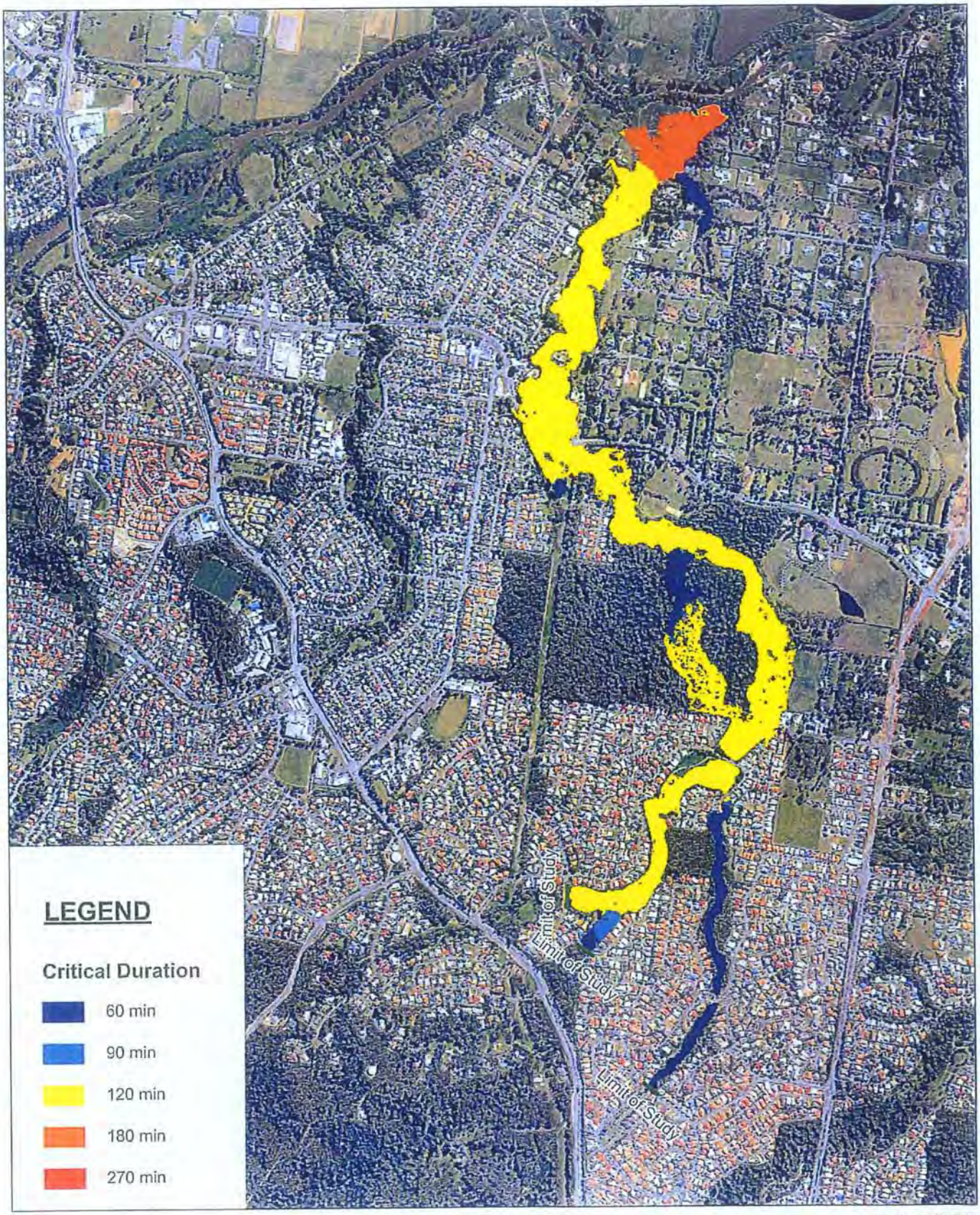

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FIGURE B78
50 YR ARI CRITICAL DURATION

Project No: J11039

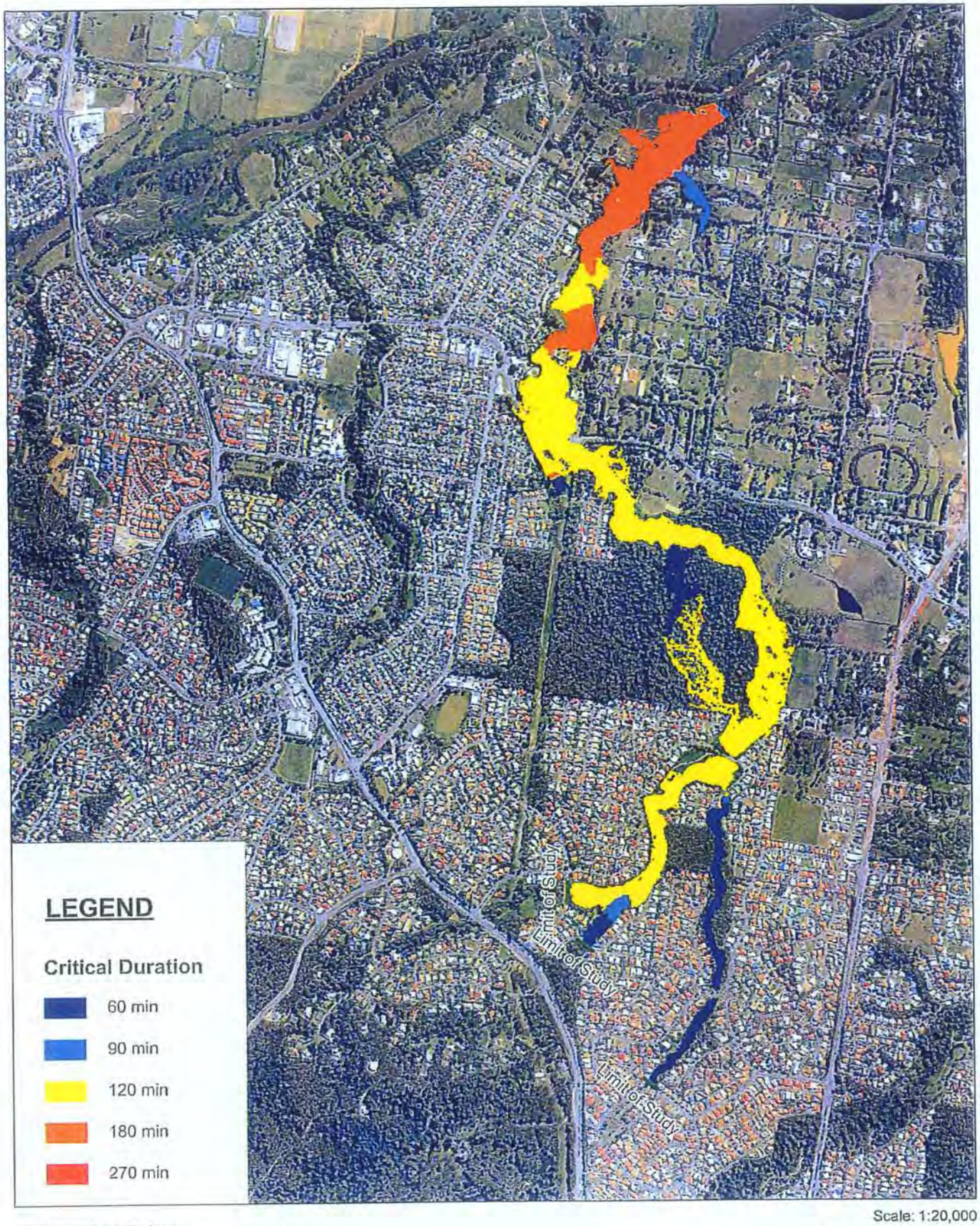
Rev: Orig Date: 06 July 2011

Water Resources Branch

File Path: [illegible]

Print Date: 13-7-2011

BCC.079.0499



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Rev: Orig Date: 06 July 2011

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FIGURE B79
20 YR ARI CRITICAL DURATION

Project No: J11039

Water Resources Branch

File Path: [illegible]

Print Date: 18-7-2011

BCC.079.0500

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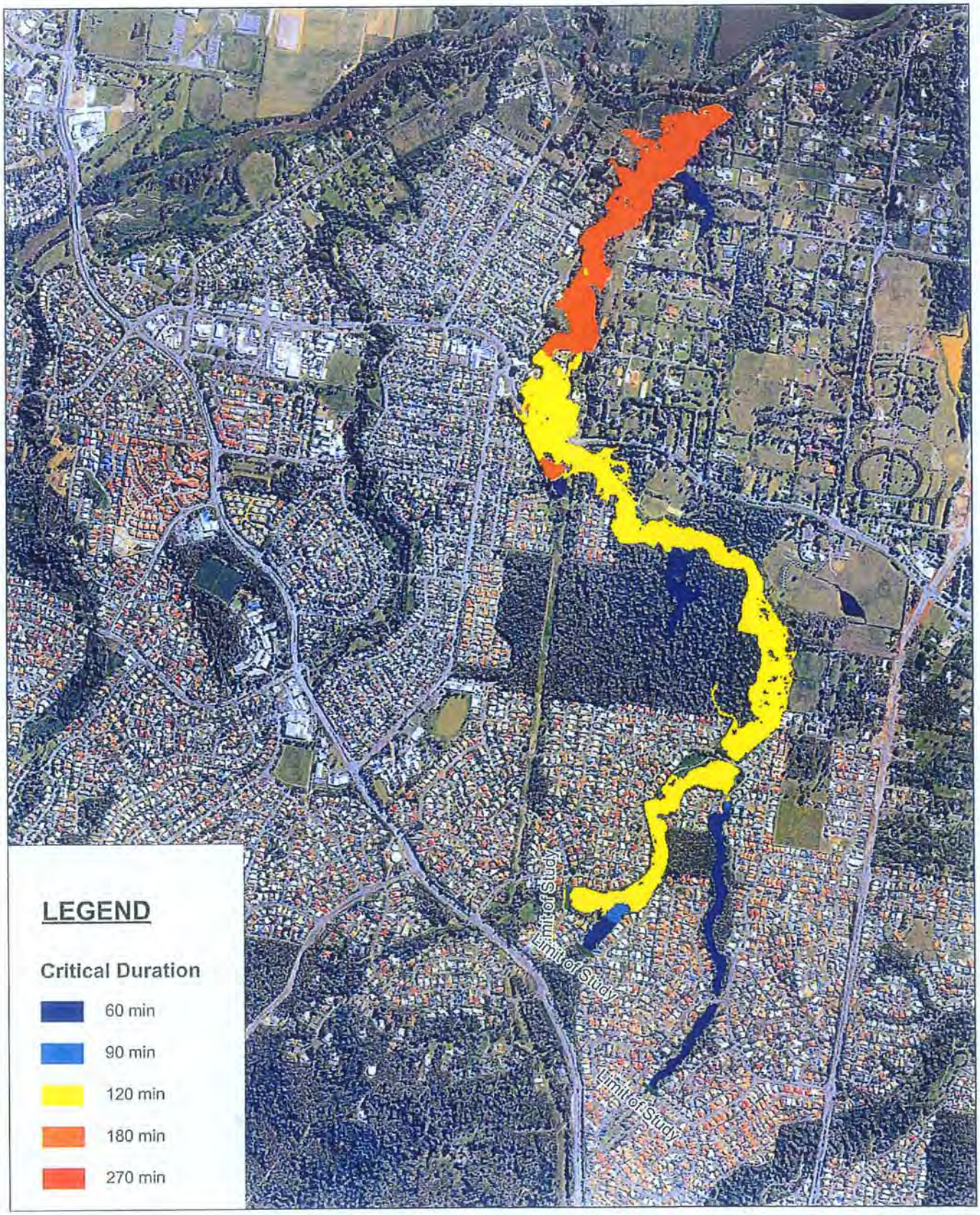

Scale: 1:20,000

FIGURE B80
10 YR ARI CRITICAL DURATION

Project No: J11039

Rev: Orig Date: 06 July 2011

Water Resources Branch

Print Date: 13-7-2011

BCC.079.0501

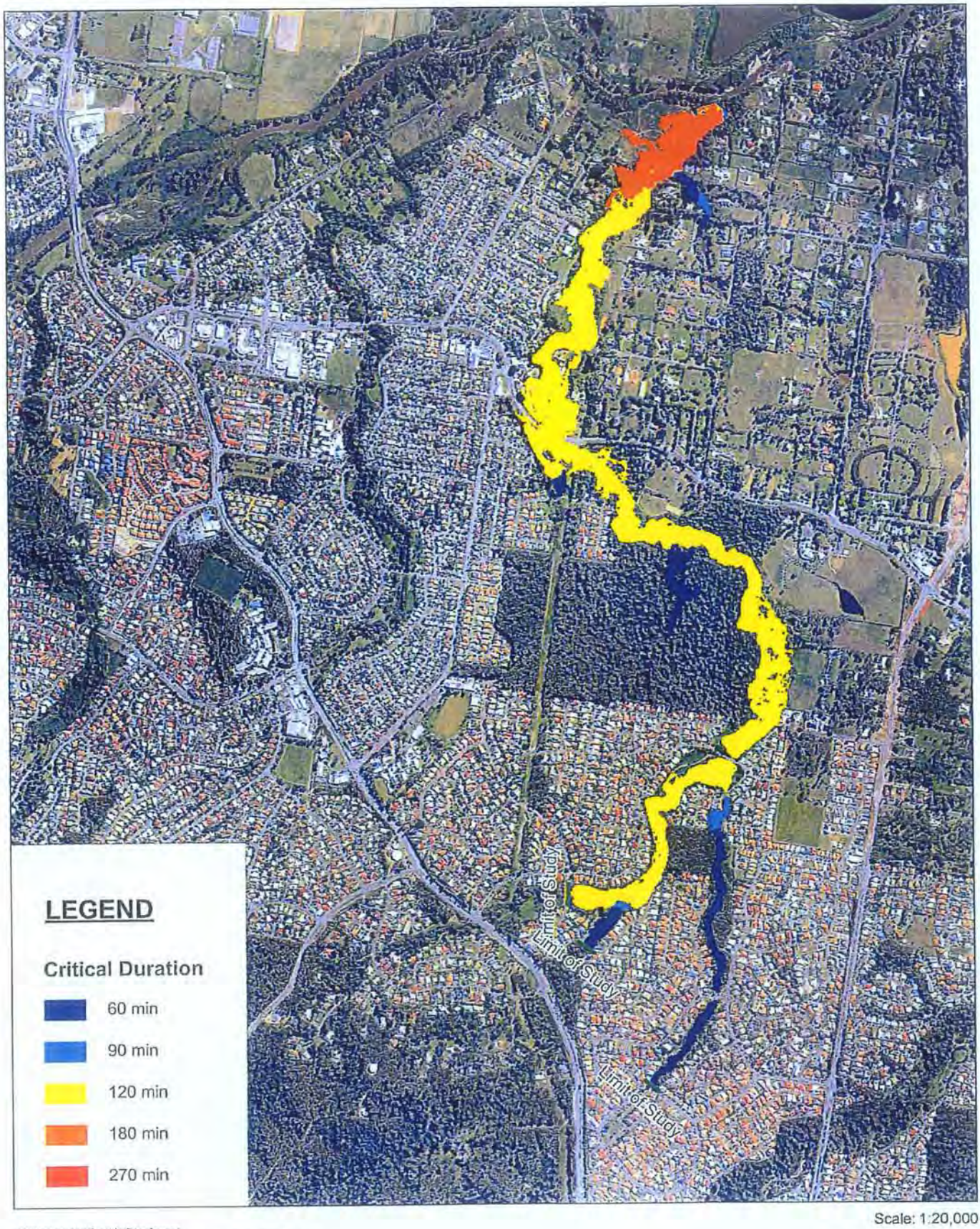

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FIGURE B81
5 YR ARI CRITICAL DURATION

Project No: J11039

Water Resources Branch

Print Date: 13-7-2011

File Path: J:\11039\GIS\MXD\Figure B

BCC.079.0502

DRAFT

ALBANY CREEK FLOOD STUDY

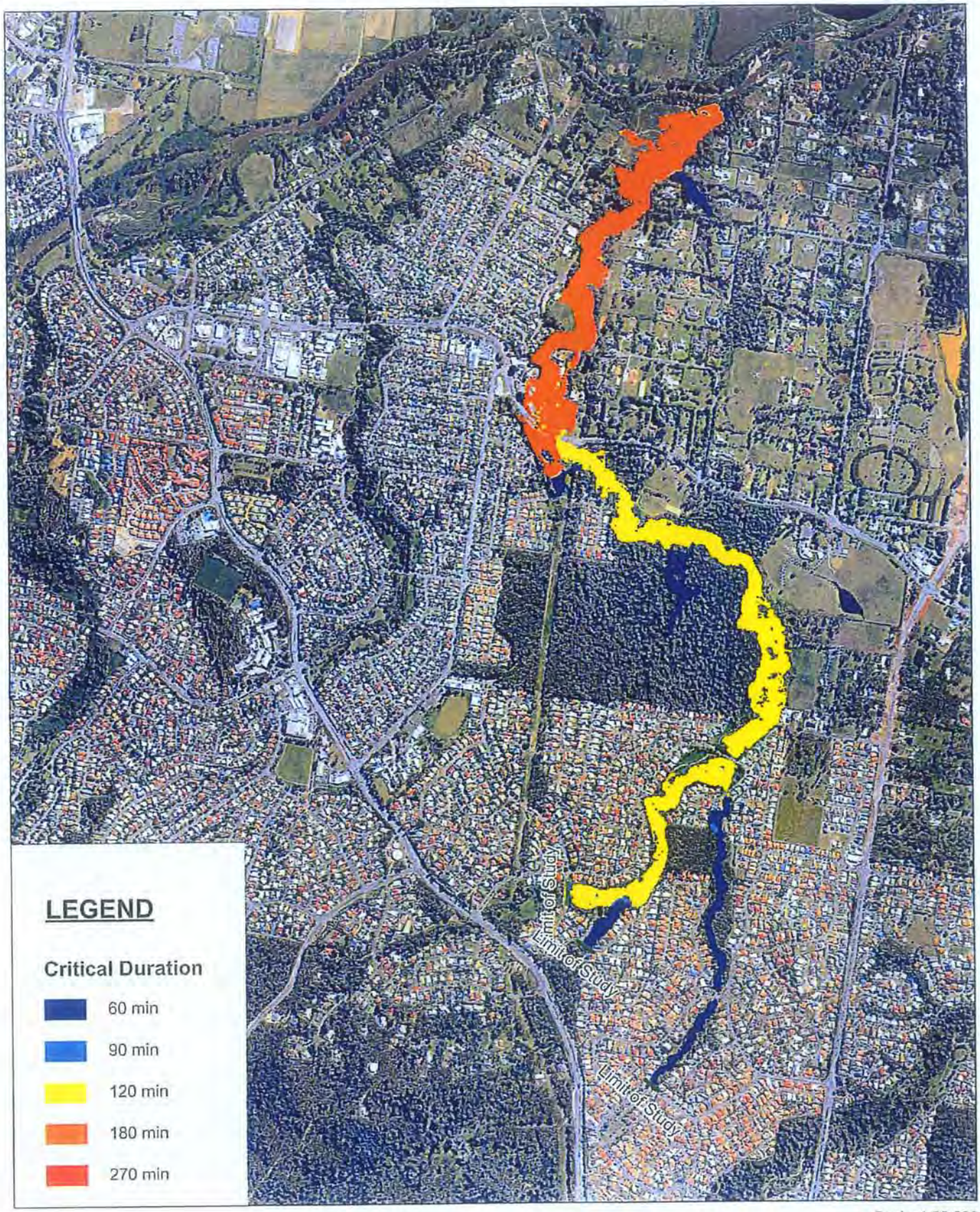

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FIGURE B82
2 YR ARI CRITICAL DURATION

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Water Resources Branch

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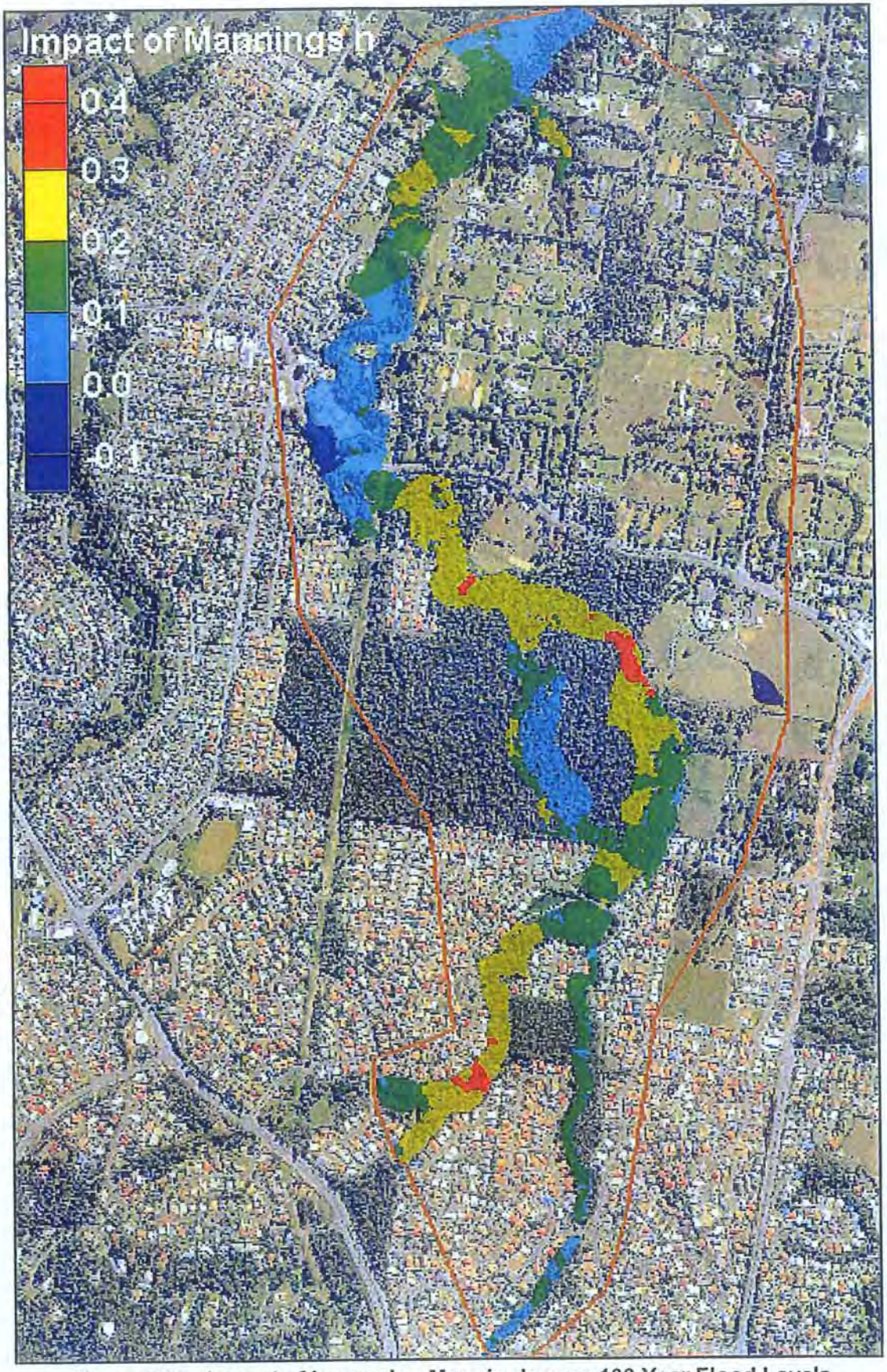

Figure B83 - Impact of Increasing Manning's n on 100 Year Flood Levels

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Perrin Creek Flooding Investigation

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February 2011

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Water Resources

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ACRONYMS AND ABBREVIATIONS

AHD	Australian Height Datum
ALS	Airborne Laser Survey
ARI	Average Recurrence Interval
BCC	Brisbane City Council
DEM	Digital Elevation Model
DHI	Danish Hydraulic Institute
FRL	Flood Regulation Line
HAT	Highest Astronomical Tide
IFD	Intensity Frequency Duration
MHG	Maximum Height Gauge
MHWS	Mean High Water Springs
MRC	Minimum Riparian Corridor
RCBC	Reinforced Concrete Box Culvert
RCP	Reinforced Concrete Pipe
QUDM	Queensland Urban Drainage Manual
WebBASX	Brisbane City Council database containing geographical data
WC	Waterway Corridor

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GLOSSARY

Term	Definitions
Hydrology	Hydrology is the study of the movement and distribution of water on ground surface
Hydraulic	Hydraulic is the physical science and technology of the behaviour of water in nature.
Hydrograph	Hydrograph is a graph showing changes in the flow discharge over a period of time
Manning 'n'	Manning 'n' is the resistance of the bed of a channel to the flow of water in it.
Head Loss	Head loss is the dissipated energy due to the friction and turbulence

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Executive Summary

Perrin Creek is located in the southern suburbs of Brisbane, encompassing a catchment area of approximately 8.5 km^2. The catchment lies within the suburbs of Morningside, Cannon Hill and Seven Hills and is currently comprised of low-density residential development in its upper and middle reaches, and light industry in its lower reaches. The creek discharges into the Brisbane River immediately downstream of the Cairncross Dockyards, Morningside.

The Perrin Creek catchment has undergone significant development in the last 20 years and since no recent modelling had been undertaken, it was necessary to develop a new model that could be used for development assessment.

A new hydrological model was developed for this study using XP RAFTS. The Perrin Creek catchment was divided into 33 sub-catchment areas, and sub-catchment data such as area, impervious percentage and channel slope were calculated and entered to the model. The model was run for design storm events based on temporal patterns in Australian Rainfall & Runoff (AR&R) and for design rainfall intensities based on the BCC supplement to the Queensland Urban Drainage Manual (QUDM). Discharge hydrographs calculated by the hydrologic model were extracted and used as inputs to the hydraulic model. The new hydrological model shall be used for any future works proposed within the Perrin Creek catchment.

Hydraulic modelling was undertaken using the Danish Hydraulic Institute's (DHI) MIKE 11 software, which had been used by a number of previous studies to model the watercourse. In November 2006, the DHI took the most recent model of the system (Option 14g), re-schematised it and improved its stability. This model was used as the basis for this study.

The model covered Perrin Creek from just downstream of Elwell Street to its confluence with the Brisbane River. The model included a number of minor tributaries, namely Branch 2 from the east and Branch 3 from the west. Another tributary, Branch 4, connects into Branch 2. Values of Manning's n roughness were estimated and input to the model. A model contained a total of 11 structures, including the pedestrian bridge north of Beelarong Street.

The revised hydraulic model is the most up-to-date model with a number of improvements included, such as updated Manning's *n* roughness parameters, incorporating the new channel profile and cross sections (Riverside Channel) reflecting the earthworks undertaken downstream of Lytton Road and modelling additional structures. The stability of the model has also been improved. The exact locations of cross sections and ground truthing of survey data used in the model have not been rigorously checked and should be considered when further revising the model. It should be noted that due to the earthworks undertaken by Port of Brisbane Corporation the main Perrin Creek branch downstream of Lytton Road has been eliminated from the hydraulic model. Further recommendations regarding the hydraulic model are detailed in Section 3.2.

Calibration of the hydrological and hydraulic models was not undertaken since only limited measured data for recent events was available, and the creek profile has also undergone significant changes

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during the last 10 years. It is strongly recommended that the model be calibrated once such information becomes available.

To allow for greater confidence in the head loss calculated at each structure, the system was also analysed using the steady state option in HEC-RAS. The models generally showed a satisfactory level of agreement, although some differences were noted in the reach upstream of Baringa Street.

The hydrologic and hydraulic models were used to determine flood levels, discharges and velocities in Perrin Creek and its tributaries for design events of 2, 5, 10, 20, 50 and 100 years ARI and storm durations of 30, 45, 60, 90, 120 and 180 minutes. The calculated values are presented in **Appendices D, E** and **F**.

The investigation found that the flood levels calculated in this study were generally lower than those of previous studies. Significantly higher levels were observed for the reaches between Elwell Street and Richmond Street due to blockages of the existing overland flow path. Downstream of Richmond Street to the start of new Riverside Channel the levels were generally lower due to lower flows from the hydrological model. Flood levels in new Riverside Channel to the mouth of Brisbane River were also higher due to the earthworks undertaken by Port of Brisbane Corporation at this location.

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1.0 Introduction

Perrin Creek has undergone significant development in the last 20 years. A number of hydraulic models have been developed to assess and assist in alleviating creek flooding. However, no recent modelling had been undertaken for the entire Perrin Creek catchment. This report describes the new 2007 hydrological model which was developed as a part of this study, improvements to the existing hydraulic model and the resulting updated new peak flood levels for Perrin Creek.

1.1 Study Objectives

The purpose of this study was to create a suitable model that can be used for development assessment within the Perrin Creek catchment. This required the review of previous studies and the updating and modification of the most suitable hydrologic and hydraulic models of Perrin Creek.

1.2 Study Scope

This study describes the new hydrological model, which was developed as part of this study and the existing hydraulic model which has been improved and updated to the most recent version of MIKE11 (MIKE11 v.2009). The Base Case, Minimum Riparian Corridor (MRC) and Waterway Corridor (MRC+WC) scenarios were modelled for design flood events having Average Recurrence Intervals (ARIs) of 2, 5, 10, 20, 50 and 100 years, and durations of 30, 45, 60, 90, 120 and 180 minutes. Results are compared with those calculated by the previous model which is shown in Appendix F.

1.3 Catchment Description

Perrin Creek is located in the southern suburbs of Brisbane, and has a catchment area of approximately 6 km^2. The catchment lies within the suburbs of Morningside, Cannon Hill and Seven Hills as shown in **Figure 1.1**. The creek discharges into the Brisbane River immediately downstream of the Cairncross Dockyards, Morningside as shown in **Figure 1.2**.

The catchment currently comprises low-density residential development in its upper and middle reaches, and light industry in its lower reaches. Some significant features in the catchment are shown in **Figure 1.2.** The catchment is almost entirely urbanised with only isolated pockets of possible future urban development situated within the region bounded by Lytton Road and Beelarong Street, Morningside. This region is low-lying and susceptible to regular inundation during wet periods according to the *Lytton Road (Perrin Creek) Flood Mitigation Investigation* (BCC 1999).

Perrin Creek is predominantly an overland system. Flow is conveyed underground for an isolated reach from Wynnum Road to Baringa Street, Morningside. Upstream of Wynnum Road, the open channel is largely concreted lined and heavily constrained by residential development on both sides of the creek. Downstream of Algoori Street, Morningside to Lytton Road, the creek has been excavated. Mangroves line the banks of this reach. The recently constructed open channel starts downstream of Lytton Road conveys the flow to the Brisbane River.

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There are two major tributaries feeding into the main branch of the Creek, defined as Branch 2 (East Branch) and Branch 3 (West Branch) as shown in **Figure 1.3**. Another branch, defined as Branch 4 (North Branch) feeds into Branch 2. Branch 3 and Branch 4 floodplains are mainly low lying and grassy. The degree of urban development on Branch 2 varies along its length, with the upstream section dominated by low lying grassy floodplains followed by light residential development, then heavily vegetated sections surrounding the banks of the Cannon Hill Anglican College.

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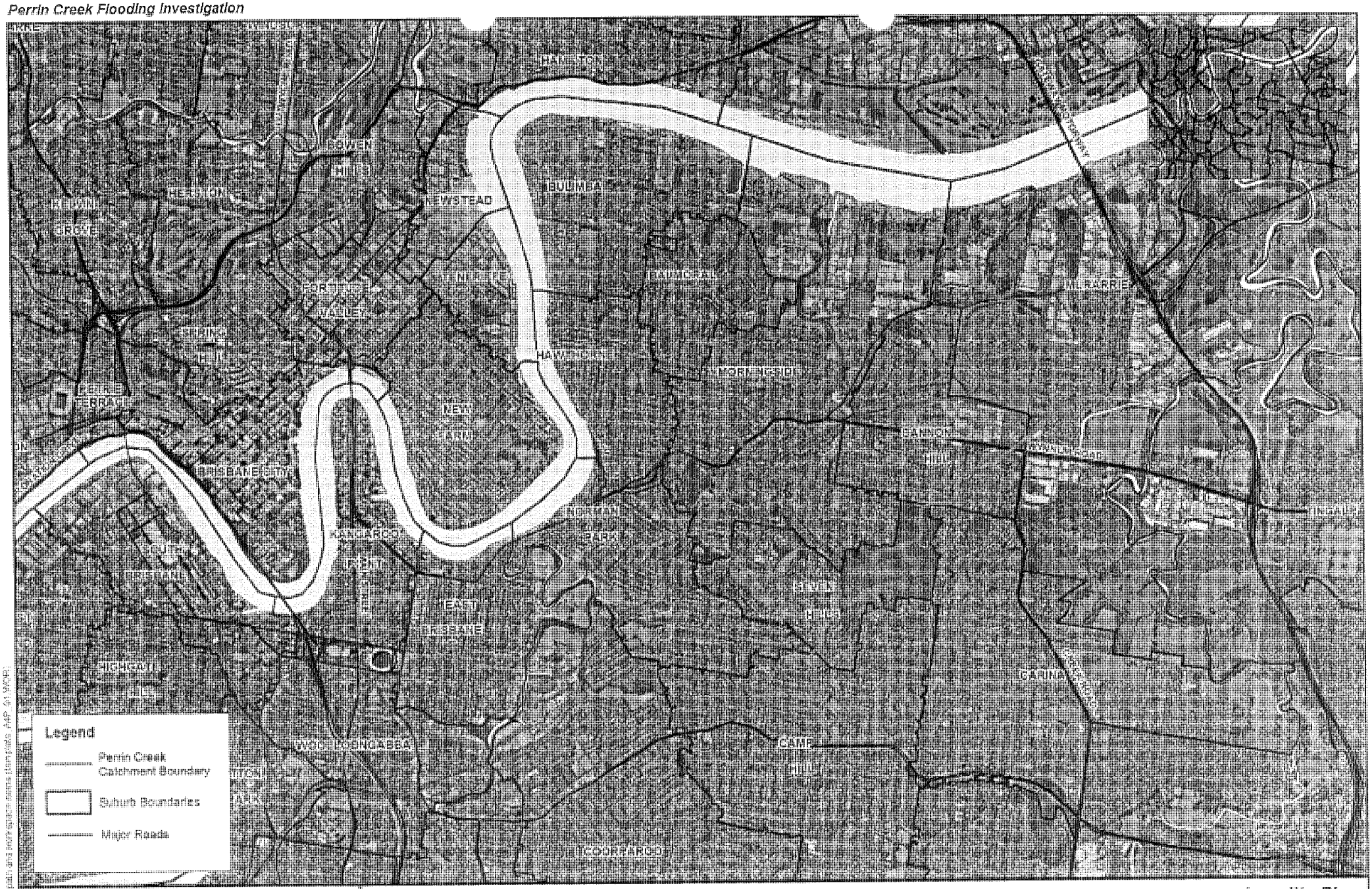

Locality Plan

Figure 1.1



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Perrin Creek Catchment Features

Figure 1.2



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Tributaries Feeding Into Perrin Creek

Figure 1.3

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1.4 Catchment History

Some of the drainage works, including the concrete lining of the sections between Richmond Road and Lang Street were undertaken in the 1950s and 1960s. The Colmslie Hotel and Colmslie Shopping Centre were completed in the mid 1980s. These resulted in the creek being piped from Wynnum Road to Baringa Street. Further extensions of the Colmslie Shopping Centre were completed in 2002–04. The section from Baringa Street to Lytton Road was further modified by the construction of a wider open channel in the late 1990s as part of residential development near Baringa Street, and industrial development on the eastern bank near Lytton Road. A tidal barrage was also completed just downstream of Algoori Street as part of this development.

The State Hockey Centre (located in Colmslie Reserve east of the Riverside Channel – see **Figure 1.2**) was built in the early 1990s over a breakout path to the Brisbane River, thus redirecting flows to the south. The Riverside Channel was built as part of Riverside Place, an industrial area constructed adjacent to Perrin Creek downstream of Lytton Road. This channel was not connected to the Creek previously due to environmental reasons, but could convey flow in times of flooding. Based on investigations conducted by Council in 2001, an additional span was added to the Lytton Road crossing in 2000–01 to provide a wider underflow area. With the recent changes to the lower reaches of Perrin Creek which has been made by Port of Brisbane in 2009, the Perrin Creek main branch has been filled downstream of Lytton Road and the flow is directed to the Brisbane River through recently formalised and mitigated Riverside Channel.

1.5 Model History

A number of models and options have been analysed in the past. The following is a list of five studies; a summary description of each is provided in **APPENDIX A**.

- *Colmslie Industrial Land – Hydraulic Analysis (2005)*
- *Perrin Creek Development and Model Review (2004)*
- *Upgrade Lytton Road (Perrin Creek) Flood Mitigation Investigation (2001)*
- *Lytton Road (Perrin Creek) Flood Mitigation Investigation (1999)*
- *Perrin Creek Master Drainage Plan (1992).*

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2.0 Study Data

2.1 Survey Data

This study used two types of survey data in the modelling process: Airborne Laser Scanning (ALS) and ground survey. No additional survey was undertaken as part of this study.

2.1.1 Airborne Laser Scanning (ALS)

Airborne Laser Scanning (ALS) is data collected by a laser scanner from a plane. AAM Hatch was commissioned to undertake ALS survey for the entire Brisbane area in 2002, providing the basis for ground level contours currently used in Council's mapping system. Weir sections and most of the overland flow sections were extracted from a five-metre Digital Elevation Model (DEM) derived from ALS data.

2.1.2 Ground Survey

Ground survey is considered the most appropriate and accurate method to determine ground levels. However, due to its high cost, it is not always conducted. The model incorporates survey and standard drawings from previous studies such as the Cardno Perrin Creek Re-alignment Project (2009), the GHD (1992) and the City Design (1999) reports. Perrin Creek bikeway survey which has been conducted in March 2009 has also been used to extract the information of pedestrian bridge north of Beelarong Street.

2.2 Calibration Data

There are only three Maximum Height Gauges (MHGs) and no stream gauging station in the Perrin Creek catchment. Only limited event data is available, the most recent being the December 1996 and March 2001 storm events. In addition, the creek profile has undergone significant changes in the last 10 years. Calibration of the model therefore was not considered in this report, but should be undertaken once appropriate data becomes available.

2.3 Design Plans

A summary of the data and plans used to code the structures into the hydraulic models is shown in **APPENDIX B**.

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3.0 Modelling Methodology

3.1 Hydrologic Modelling – XP RAFTS

3.1.1 General

A new hydrologic model was developed for this study using XP RAFTS, which is a widely accepted rainfall-runoff model for defining the hydrologic response of a catchment to a rainfall event. The catchment is modelled via a number of user-defined parameters that represent characteristics such as the imperviousness of the contributing catchment area, the channel and catchment slopes, and the available storage volumes.

3.1.2 Hydrological Model Setup

Rainfall

Storm events were based on the temporal patterns described in the *Australian Rainfall and Runoff – A Guide to Flood Estimation* (Pilgrim DH 1987). Rainfall intensities were derived from Intensity-Frequency- Duration (IFD) curves for Brisbane City as specified in the Brisbane City Council Supplement to the Queensland Urban Drainage Manual (QUDM). These storms were applied uniformly over the entire spatial extent of the catchment.

Catchment Characteristics

The Perrin Creek catchment was divided into 33 sub-catchment areas as shown in **Figure 3-1**. Sub-catchment boundaries were defined using contour and stormwater drainage information, with boundaries also being placed at major creek crossings whenever possible. A brief summary of the sub catchment characteristics such as areas pervious and impervious percentages is shown in **Table 3-1**. Channel slope and other relevant information related to the RAFTS model are listed in **APPENDIX C**.

The fraction impervious of subcatchments was determined in accordance with the Brisbane City Council Department of Works Supplement to QUDM (Brisbane City Council 1994, p.QUDM-BCC-2) and the Queensland Urban Drainage Manual (Neville Jones & Associates and Australian Water Engineering 1993, Table 5.04.1 and Table 5.04.2), with consideration of ultimate land use conditions as detailed in Brisbane City Council's City Plan 2000.

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Table 3-1: Sub-Catchment Area and Impervious Percentage

Sub-catchment Name	Catchment Area (ha)	Fraction Impervious
A	25.35	0.58
B	37.65	0.58
C	14.31	0.38
D	31.11	0.52
E	25.60	0.47
F	33.87	0.54
G	36.47	0.43
H	25.80	0.55
I	29.16	0.66
J	27.50	0.56
K	38.49	0.75
L	25.65	0.54
M	15.85	0.29
N	31.50	0.59
O	14.41	0.53
P	21.30	0.58
Q	32.43	0.72
R	14.84	0.59
S	7.30	0.65
T	29.02	0.57
U	17.37	0.56
V	50.05	0.57
W	32.77	0.61
X	22.56	0.89
Y	9.84	0.90
Z	22.11	0.28
AA	5.91	0.30
BB	34.33	0.66
CC	52.89	0.51
DD	14.83	0.41
EE	18.04	0.91
FF	32.07	0.83
GG	21.06	0.90

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3.2 Hydraulic Modelling – MIKE11

3.2.1 Background

A summary of previous studies relating to Perrin Creek is provided in Appendix G. These studies modelled the watercourse using the MIKE 11 software package, a one dimensional hydrodynamic simulation model developed and marketed by the Danish Hydraulic Institute (DHI).

In November 2006, the DHI carried out the "Perrin Creek MIKE 11 Model Upgrade Advice and Review". In this short study, the most recent model of the system (Option 14g) was re-schematised, its stability improved and recommendations were made for the model's further development. The findings of the DHI study are included in Appendix I of this report.

The model received from the DHI was improved and upgraded to Version 2009 of MIKE 11 and was used as the basis for this study.

3.2.2 Hydraulic Model Setup

Model Extent

The extent of the Perrin Creek hydraulic model is shown in **Figure 3-2**. The model covers Perrin Creek from just downstream of Elwell Street to its confluence with the Brisbane River. It includes the two main tributaries, namely Branch 2 to the east and Branch 3 to the west. Branch 2 begins upstream of Barrack Road, and Branch 3 immediately downstream of Algoori Street. Another tributary, Branch 4 to the north, connects into Branch 2. It should be noted that due to the earthworks undertaken by Port of Brisbane Corporation the main Perrin Creek branch downstream of Lytton Road has been eliminated from the hydraulic model.

Cross Sections

The revised DHI model cross sections have been updated to incorporate the recent changes to the Riverside Channel cross sections which have been made as a result of flood mitigation works undertaken by Port of Brisbane Corporation. These cross sections were extracted from the Cardno Perrin Creek Re-alignment Project design drawings and the planning line boundaries are based on council records. All other sections were also assessed to ensure that their extents were adequate. Where the cross section did not cover the waterway corridor, the cross section was extended using a 5m DEM. It should be noted that these cross sections have been examined against the cross sections extracted from hydrometric surveyed data conducted as part of Schedule 160 in 2007. This surveyed data includes a section of Perrin Creek located between Algoori Street and Lytton Road. It is noted that the surveyed cross sections are slightly shallower, however due to the initial depth set in the hydraulic model; the flood conveyance are not affected by applying the new surveyed data. As such, the existing cross sections in the model extracted from 5m DEM remains unchanged.

The sections were processed using the 'total area, hydraulic radius' method, and the conveyance curves checked to ensure that they were monotonically increasing.

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Hydraulic Roughness

The Manning's n values were estimated based on photos, aerial information and site visits. The present modelling technique allows the user to input the Manning's n values directly to the cross section files instead of defining a global value in the hydrodynamic file. This modelling technique was adopted for all cross sections in the model.

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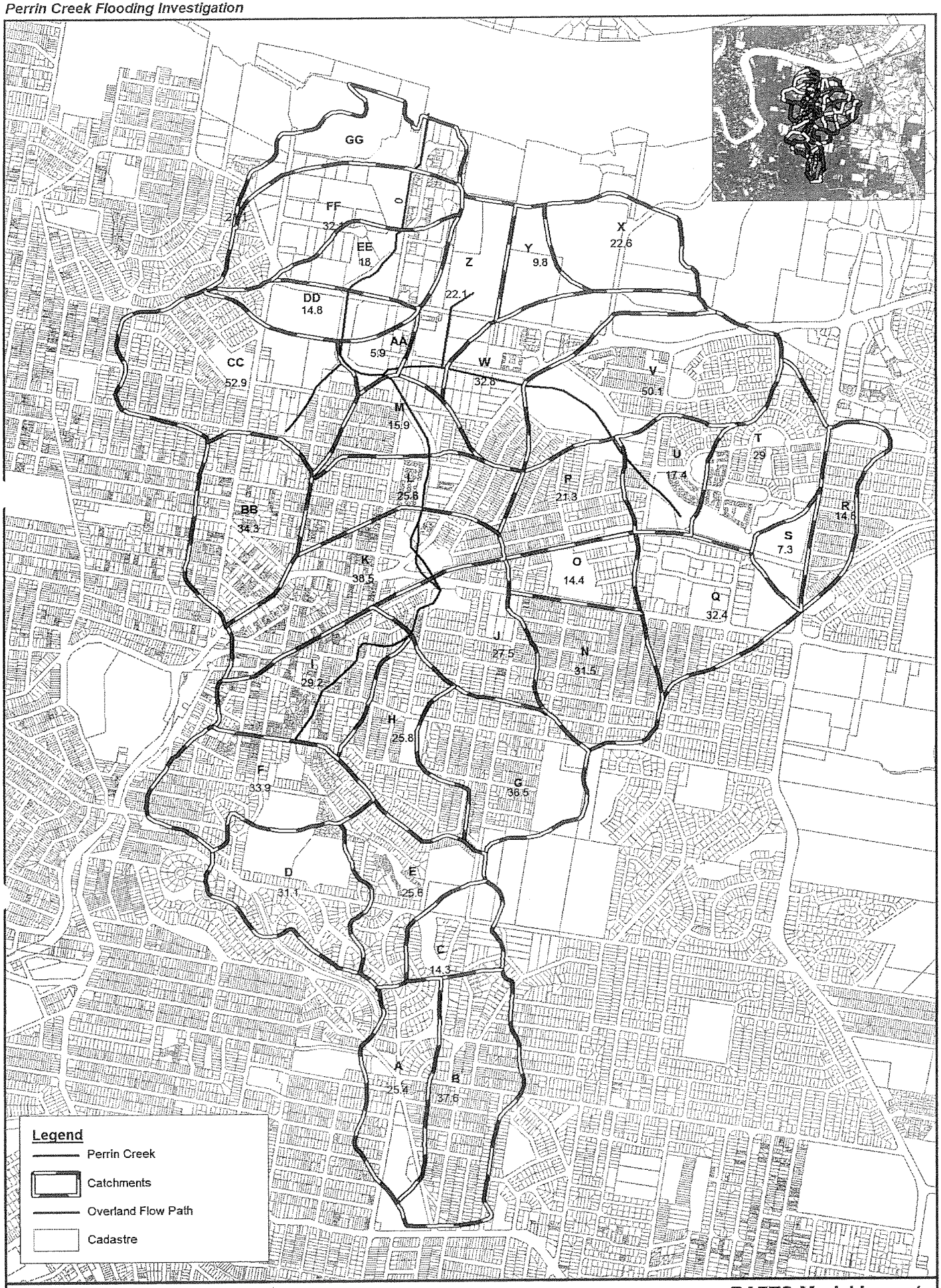

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RAFTS Model Layout

Figure 3.1

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Structures

A total of 11 structures were included in the model. **Table 3-2** is a summary of all the structures in the model. Weir sections were represented using a level-width relationship based on a 5 m DEM section extracted on top of the crossings. This estimated level-width relationship takes into account blockages such as buildings, handrails, guardrails and fences.

Table 3-2: Model Structures

Location	Model Branch & Chainage	Structure Type	Structure Dimensions
Richmond Rd	B1 Ch1685	Culvert/Weir	3/1650 RCP
Bridgewater Rd	B1 Ch2020	Culvert/Weir	3/3000x1800 RCBC
Lang St	B1 Ch2370	Culvert/Weir	3/3000x1800 RCBC
Wynnum Rd	B1 Ch2485	Culvert	5/3000x1800 RCBC
Baringa St	B1 Ch2905	Culvert/Weir	6/1650 RCP
Rock Gabion	B1 Ch3192	Weir	1000x1000x2000 long gabion wall
North of Beelarong St	B1 Ch3756	Bridge	6 spans (total width ~42 m)
Lytton Rd (East) (Upgraded in 2000)	B1 Ch4040	Bridge	3 spans (total width ~30 m)
Barrack Rd	B2 Ch272	Culvert/Weir	4/2400x1200 RCBC
Ivy St	B2 Ch510	Culvert/Weir	2/600 RCP
Junction Rd	B2 Ch1160	Culvert/Weir	6/1800 RPC

Model Boundaries

A total of 21 inflows were defined to accurately reflect the hydrologic behaviour of the creek. An inflow was defined for the upstream end of Perrin Creek, and the upstream end of Branch 2, Branch 3 and Branch 4. A further 17 inflows were defined to account for sub-catchments contained within the modelled area. The location of each inflow to the model is shown in **Figure 3-3**. A Mean High Water Spring (MHWS) level of 1.05 m AHD was used as the downstream boundary condition, to conservatively represent the Brisbane River tidal level.

Model Improvement

The revised DHI model has been updated and improved as part of this study. The adopted delta (in computation scheme) of 1 has been modified and the new delta value of 0.55 has been adopted. The time step has been decreased to 10 seconds and the initial depth for Branch 2 has been amended to allow for the additional storage within the system. Some abrupt drops in the bed profile have been smoothed to improve the model stability.

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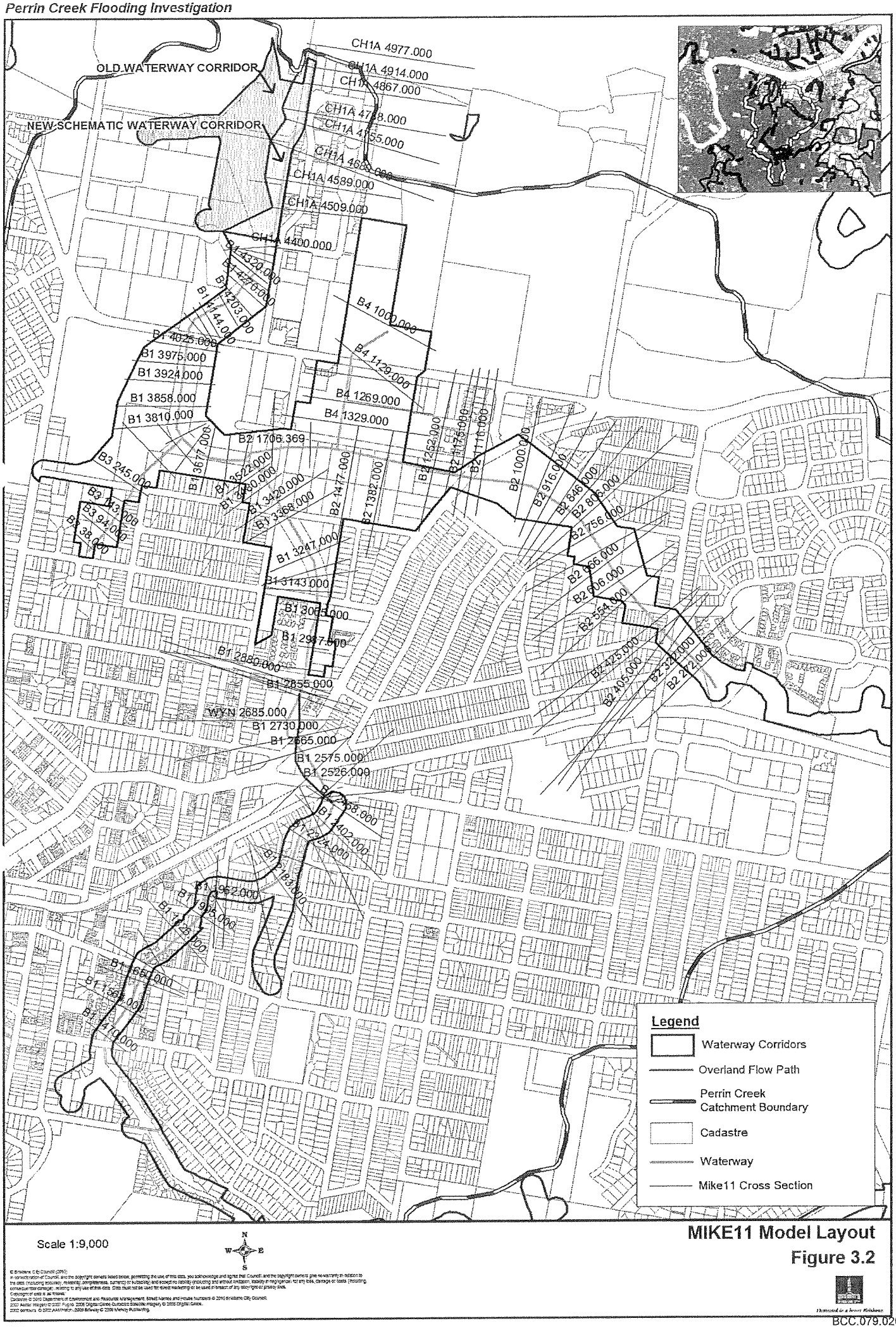

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MIKE11 Model Layout

Figure 3.2

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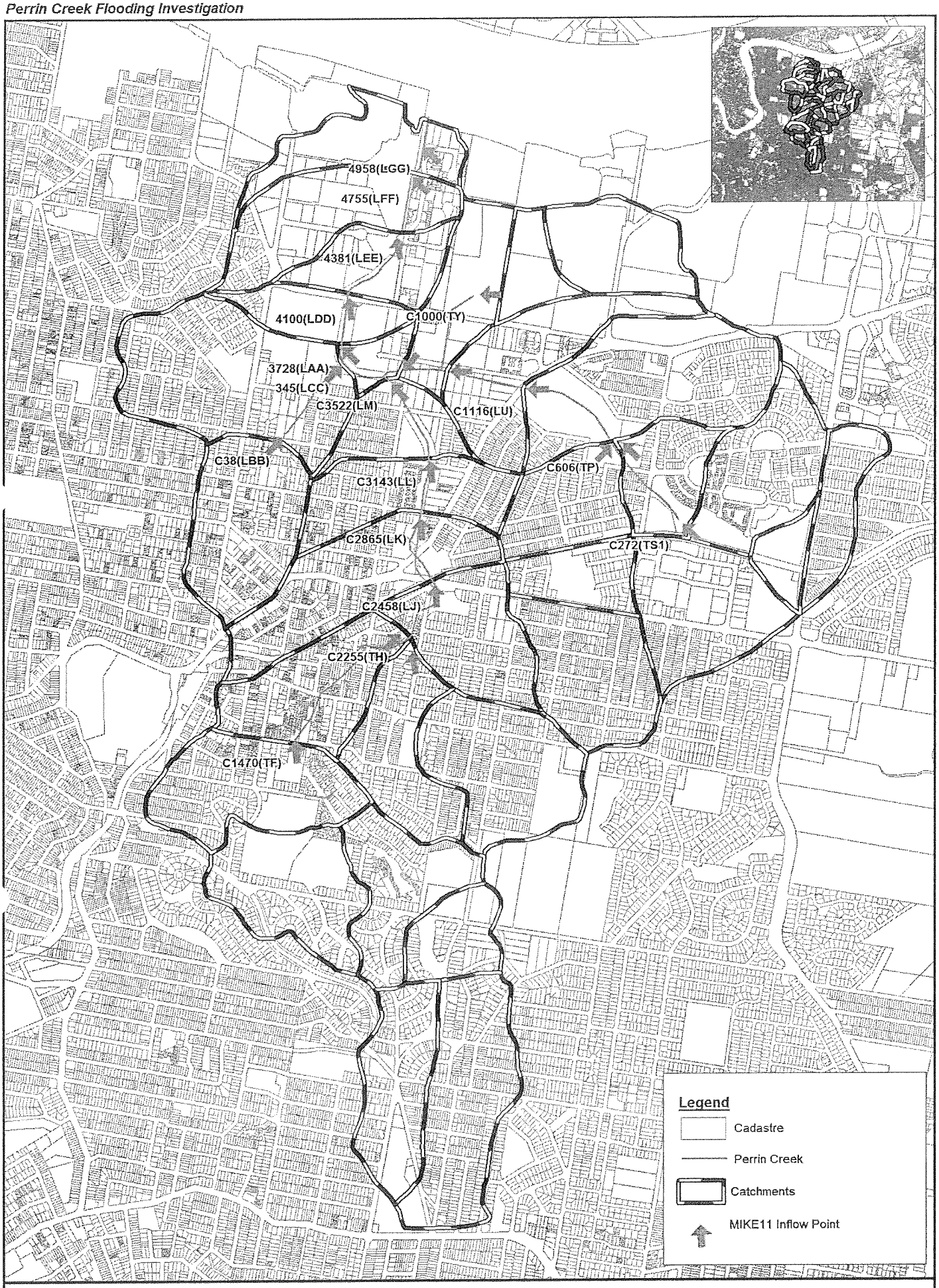

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MIKE11 Inflow Locations

Figure 3.3

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3.2.3 Scenarios Modelled

Base Case Model

The Base Case model (Option 14g as per Lawson and Treloar's 2004 study) was set up to compare flood levels with those of the MRC and of the MRC+WC scenarios. For each cross section, a single Manning's *n* roughness value was estimated for the channel, and an average value was adopted for the floodplain sections.

Minimum Riparian Corridor Model

The MRC is defined as a strip of vegetation that will grow away from the low flow bank if sufficient time is allowed. To model this, it is assumed that the 'vegetation' has a Manning's *n* value of 0.15 and will grow to a distance of 15 metres from each side of the low flow bank. Where the existing conditions have a Manning's *n* value greater than 0.15 (i.e. buildings), no changes to the Base Case model value have been made.

Minimum Riparian Corridor and Waterway Corridor Model

The Waterway Corridors (WC) serve as development control lines. They are determined based on creek hydraulics, creek ecology and environmental planning issues. The WC are used as planning line boundaries in which filling and/or development is restricted, with the objective of limiting impacts associated with flooding. The WC were introduced to the MRC model, and their location based on council records.

3.2.4 Design Event Analysis

The MIKE 11 model for Perrin Creek was run for the Base Case, MRC and MRC+WC scenarios for ARIs of 2, 5, 10, 20, 50 and 100 years, and durations of 30, 45, 60, 90, 120 and 180 minutes.

3.3 Hydraulic Modelling – HEC-RAS

3.3.1 General

To allow for greater confidence in the head loss calculated at each of the structures, the system was also analysed using HEC-RAS, another open channel flow model developed by the US Army Corps of Engineers. Version 4.1.0 (steady state option.) was used.

3.3.2 Hydraulic Model Setup

The cross sections, Manning's *n* roughness values and upstream and downstream boundary conditions used in the WC scenario of the MIKE11 model were applied to the HEC-RAS model. Results obtained for each structure and the differences in levels between the two models are shown in Section 4.3.

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4.0 Model Results

The hydrologic and hydraulic models were used to determine design flood levels, discharges and velocities for Perrin Creek and its tributaries. This report presents the results of the model runs for design events of 2, 5, 10, 20, 50 and 100 years ARI and storm durations of 30, 45, 60, 90, 120 and 180 minutes.

4.1 Hydrological Modelling Results – RAFTS

Design event modelling was based on ultimate catchment development conditions. The envelope of peak discharges for all durations is shown in **APPENDIX D.** A summary of peak discharges at key locations is given in **Table 4-1** below.

Table 4-1: RAFTS Peak Discharge at Key Point Locations

Location (Branch No)	2yr (m^3/s)	5yr (m^3/s)	10yr (m^3/s)	20yr (m^3/s)	50yr (m^3/s)	100yr (m^3/s)
Elwell Street (B1)	19.5	28.2	33.9	41.3	48.1	56.1
Wynnum Road (B1)	28.6	41.1	50.2	61.5	73.2	84.0
Barimga Street (B1)	30.4	43.3	53.4	65.7	78.9	89.8
Algoori Street (B1)	31.7	45.2	55.9	68.8	82.6	93.9
Lytton Road (B1)	47.8	72.4	89.1	111.9	139.0	163.6
Storage Basin (U/S Barrack) (B2)	7.4	10.0	11.7	13.7	15.0	17.1
Junction Road (B2)	15.2	22.4	27.0	33.4	39.5	45.8

4.2 Hydraulic Modelling Results – MIKE11

The Base Case model was modified to reflect MRC and MRC+WC scenario conditions and run for each storm event to determine the design flood levels and discharges.

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4.2.1 Results

A summary of the calculated peak water levels for the 100 year design event upstream and downstream of the hydraulic structures and at other selected sites is presented in **Table 4.2** below. A full listing of the calculated peak water levels and discharges is presented in **APPENDIX E.**

Table 4-2: MIKE11 Peak Water Levels at Key Locations – 100 Year Design Event

Perrin Creek Main Branch			
Locations	Base Case (m AHD)	MRC (m AHD)	MRC+WC (m AHD)
U/S Richmond St	10.74	10.74	10.99
D/S Richmond St	7.41	7.41	7.44
U/S Bridgewater	6.83	6.83	6.87
D/S Bridgewater	5.60	5.60	5.63
U/S Lang St	4.92	4.92	4.91
D/S Lang St	4.55	4.55	4.58
U/S Baringa St	3.48	3.48	3.49
D/S Baringa St	2.69	2.70	2.75
U/S Rock gabion (Tidal barge)	2.66	2.66	2.71
D/S Rock gabion (Tidal barge)	2.65	2.66	2.71
U/S Pedestrian Bridge	2.65	2.65	2.71
D/S Pedestrian Bridge	2.58	2.58	2.64
U/S Lytton Rd	2.56	2.56	2.62
D/S Lytton Rd	2.42	2.42	2.47
Perrin Creek Branch 2			
Locations	Base Case	MRC	MRC+WC
U/S Barrack Rd	3.74	3.74	3.76
D/S Barrack Rd	3.69	3.69	3.70
U/S Ivy St	3.66	3.66	3.66
D/S Ivy St	3.28	3.29	3.32
U/S Junction Rd	3.22	3.22	3.25
D/S Junction Rd	2.71	2.72	2.78

4.2.2 Comparison with Previous Study

Profile comparison with adopted levels from the *Lytton Road (Perrin Creek) Flood Mitigation Investigation* (BCC 1999) is provided in **APPENDIX F.**

In comparison with the 1999 study, it is noted that the levels calculated in this study are lower for the entire Perrin Creek main branch, except for the section upstream of Richmond Street and the enire Riverside Channel. The lower levels are due to lower flows from the new hydrological model. This pattern is similar for larger events such as 20, 50 and 100 years ARI. For smaller events such as 2, 5 and 10 years ARI, the levels from Elwell Street to Bridgewater Street are similar to the levels of the 1999 study.

Considerable differences in water levels were noted between Elwell Street and Richmond Street. The increase in level is due to multiple blockages such as fences (see **Figure 4-1**) over the weir section representing the road. Due to the re-alimentation of Perrin Creek and filling the portion of Perrin Creek downstream of Lytton Road the water levels increase in Riverside Channel.

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The change in the levels between Lang Street and Wynnum Road is due to the redevelopment of the culvert/pipe section under the Colmslie Shopping Centre, converted from a number of different culverts into a closed section in the hydraulic model.

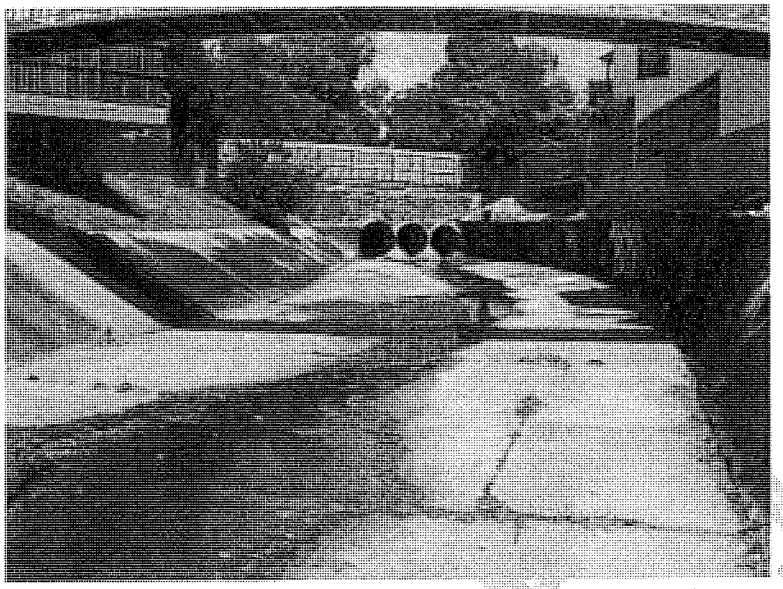

Figure 4-1: Looking Upstream Towards Richmond St – Fence Blockage

4.3 Hydraulic Modelling Results – HEC-RAS

Lytton Road and Baringa Street have been analysed using the steady state option in HEC-RAS.

Typically, at Lytton Road for the 100 year ARI event, the calculated peak flood levels were within 10–20 mm of those of the updated MIKE 11 model, with HEC-RAS slightly over predicting levels. There were noticeable differences between the HEC-RAS model and the MIKE 11 model in levels upstream of Baringa Street. (see **Table 4.3**). These differences were smaller for smaller events and higher for larger events.

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Table 4-3: Comparison of Results Between HEC-RAS and MIKE11 for Lytton Road Crossings

	Crit. Duration (min)	2yr	5yr	10yr	20yr	50yr	100yr
	120/180	1.80 (+0.02)	2.07 (+0.03)	2.24 (+0.07)	2.40 (+0.09)	2.59 (+0.11)	2.75 (+0.12)
	120/180	1.80 (+0.03)	2.07 (+0.03)	2.23 (+0.07)	2.40 (+0.09)	2.58 (+0.10)	2.74 (+0.12)
U/S Lytton Rd	120/180	1.79 (+0.02)	2.07 (+0.03)	2.23 (+0.07)	2.39 (+0.09)	2.58 (+0.10)	2.74 (+0.12)
D/S Lytton Rd	120/180	1.75 (+0.04)	2.01 (+0.05)	2.16 (+0.07)	2.29 (+0.07)	2.44 (+0.09)	2.56 (+0.09)
	120/180	1.68 (+0.01)	1.93 (-0.02)	2.07 (-0.01)	2.20 (-0.01)	2.34 (-0.01)	2.46 (-0.01)
	120/180	1.67 (0.00)	1.92 (0.00)	2.06 (0.00)	2.18 (0.00)	2.32 (0.00)	2.44 (0.00)

( ) – difference in levels from MIKE11 model

Comparison of Results Between HEC-RAS and MIKE11 for Baringa Street Crossings

	Crit. Duration (min)	2yr	5yr	10yr	20yr	50yr	100yr
	60/90	2.49 (-0.08)	2.94 (-0.10)	3.12 (-0.09)	3.22 (-0.11)	3.38 (-0.05)	3.49 (-0.01)
U/S Baringa St	60/90	2.48 (-0.07)	2.93 (-0.10)	3.12 (-0.08)	3.22 (-0.10)	3.38 (-0.04)	3.49 (0.00)
D/S Baringa St	90/120	2.01 (+0.01)	2.24 (+0.07)	2.38 (+0.09)	2.53 (+0.10)	2.70 (+0.10)	2.85 (+0.11)
	90/120	1.94 (0.00)	2.18 (+0.06)	2.32 (+0.07)	2.46 (+0.06)	2.65 (+0.05)	2.79 (+0.05)
	90/120	1.84 (0.00)	2.10 (0.00)	2.24 (0.00)	2.38 (0.00)	2.57 (0.00)	2.72 (0.00)

( ) – difference in levels from MIKE11 model

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5.0 Conclusions

The purpose of this study was to create a suitable model that could be used for development assessment within the Perrin Creek catchment. This was achieved by creating a new, hydrological model (RAFTS) and by reviewing and updating the existing hydraulic model (MIKE 11 Version 2009). The new hydrological model was run for 2, 5, 10, 20, 50 and 100 year ARI events and for storm durations of 30, 45, 60, 90, 120 and 180 minutes for the Base Case, MRC and MRC+WC scenarios.

Generally, the flood levels calculated in this study were lower than those of previous studies. Significantly higher levels were observed for the reaches between Elwell Street and Richmond Street for the larger design events due to blockages such as fences over of the existing overland flow path. Downstream of Richmond Street to Lytton Road the levels were generally lower due to lower flows from the hydrological model. In the main Perrin Creek from Lytton Road Bridge to the mouth of Brisbane River, the levels were slightly higher due to the re-alimentation of Perrin Creek and filling the portion of Perrin Creek downstream of Lytton Road the water levels increase in Riverside Channel.

The new hydrological model should be used for any future works proposed within the Perrin Creek catchment, although it needs to be stressed that the model has not been calibrated due to a lack of recorded flood level data. It is strongly recommended that the model be calibrated once such information becomes available.

The revised hydraulic model is the most up-to-date model with a number of improvements included such as incorporating the new channel profile and cross sections (Riverside Channel) reflecting the earthworks undertaken downstream of Lytton Road, checks on the cross section extents, incorporation of the MRC and WC lines, updating Manning's *n* roughness parameters, inflow locations, modelling additional structures and improving model stability. The exact locations of cross sections and ground truthing of survey data used in the model have not been rigorously checked and should be considered when further revising the model. Further recommendations regarding the hydraulic model are detailed in the following section.

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6.0 Recommendations

It is recommended that the following future works be conducted to the Perrin Creek hydraulic model.

- *Verify cross section locations.* Cross sections in the model should be revised where necessary to represent their correct locations for the whole of Perrin Creek—Wynnum Branch overland flow path through, and the pipes underneath, the Colmslie Shopping Centre.

- *Undertake survey for Branch 4.* The current model contains cross sections from a 5m DEM for Branch 4. Survey should be undertaken to better represent the waterway in this area.

- *Update minor crossings.* There were some crossings omitted from the updated model. It is suggested that these be included in the model after model cross section locations have been properly verified (see earlier point). The crossings omitted from the model are:
  a) Jersey Street Crossing – Branch 1
  b) Private crossings between Jersey Street and Richmond Road (x3) – Branch 1
  c) Lytton Rd crossings (in the vicinity of the State Hockey Centre) – Branch 4
  d) Col Gardner Dr (in the vicinity of the State Hockey Centre) – Branch 4

- *Undertake model calibration.* Limited calibration events are available for the Perrin Creek catchment. The models should be calibrated once data becomes available.

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References

Port of Brisbane Corporation 2009, *Perrin Creek Re-alignment Project design drawings*, Prepared by Cardno for Port of Brisbane Corporation, Brisbane

BCC 1992, *Perrin Creek Master Drainage Plan*, prepared by GHD for Brisbane City Council, Brisbane

BCC 1999, *Lytton Road (Perrin Creek) Flood Mitigation Investigation*, prepared by City Design, Brisbane City Council, Brisbane.

BCC 2001, *Upgrade Lytton Road (Perrin Creek) Flood Mitigation Investigation*, prepared by City Design, Brisbane City Council, Brisbane.

BCC 2004, *Perrin Creek Development and Model Review*, prepared by Lawson and Treloar for Brisbane City Council, Brisbane.

DPI, IMEA & BCC 1993, *Queensland Urban Drainage Manual* (QUDM), prepared by Neville Jones & Associates and Australian Water Engineering for Department of Primary Industries – Water Resources, Institute of Municipal Engineers Australia – Qld Division, and Brisbane City Council, Brisbane.

Neville Jones and Associates and Australian Water Engineering 1992, *Queensland Urban Drainage Manual*, prepared by Neville Jones and Associates and Australian Water Engineering, Australia.

Pilgrim DH (ed) 1987, *Australian Rainfall & Runoff - A Guide to Flood Estimation*, Institution of Engineers, Australia, Barton, ACT.

Port of Brisbane Corporation 2005, *Colmslie Industrial Land – Hydraulic Analysis*, prepared by Cardno MBK for Port of Brisbane Corporation, Brisbane.

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Appendix A: Review of past studies

Perrin Creek Master Drainage Plan (1992)

Council commissioned GHD to undertake the 1992 *Perrin Creek Master Drainage Study*. Its primary objective was to develop a calibrated hydraulic model of the Perrin Creek system to provide accurate information relating to floods within the catchment and analyse possible flood mitigation and/or drainage augmentation proposals. The study adopted ILSAX (V2.11) as the preferred hydrological model and MIKE11 (V2.1) as the preferred hydraulic model.

Calibration of the hydrological and hydraulic models was conducted by comparing recorded flood levels with those calculated by the MIKE11 model. Information available included maximum height gauge (MHG) data and spot level records from surveyed debris marks. The model was calibrated to the January 1974, April 1988 and February 1992 events. Good calibration was achieved for the February 1992 event, but not for the January 1974 and April 1988 events, probably due to the degree of siltation. Existing and ultimate catchment development were analysed for 10, 20, 50 and 100 year average recurrence interval (ARI) storm events. Note that this study predated major channel works in the lower catchment.

A number of flood mitigation options were also modelled, which included:

- Detention basins – These would reduce peak flows in the lower floodplain area, thereby reducing ponding levels upstream of Lytton Road bridge.
- Channel widening – Works would aim at increasing available conveyance. Limits of excavation were assumed to be Baringa Street and Junction Road (upstream) and Lytton Road (downstream).
- Lytton Road upgrading – This alternative would increase hydraulic capacity at the Lytton Road bridge to allow for increased flows caused by ultimate development and filling.
- Lytton Road upgrading and channel widening – A combination of flood mitigation measures was tested as it was concluded that a single flood mitigation measure would not provide sufficient reductions in flood levels.
- Re-establishment of secondary overland flowpath – This alternative would reduce peak flow at the Lytton Road bridge by re-establishing the pre-existing overland flow path at the Lytton Road culvert adjacent to the Colmslie Reserve.

A combination of floodplain excavation and either bridge upgrade works or establishment of the second overland flow path were found to reduce 100 year ARI flood levels to pre-existing levels. The overland flow path through Colmslie Reserve provided the most cost-effective method of reducing peak 100 year ARI flood levels. The Lytton Road bridge upgrade was considered to provide a degree of flood mitigation over a wide range of flows in conjunction with upstream and downstream channel works.

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Lytton Road (Perrin Creek) Flood Mitigation Investigation (1999)

City Design completed the *Lytton Road (Perrin Creek) Flood Mitigation Investigation* in 1999. The study included a detailed hydraulic analysis and presented recommendations for flood mitigation in the lower reaches of Perrin Creek. The aim was to reduce the flooding susceptibility of local residents and businesses situated in the Perrin Creek catchment, with particular emphasis on replacing the Lytton Road Bridge crossing. RAFTS (V5.1) and MIKE11 (V4.01) were adopted as the preferred hydrological and hydraulic models respectively.

The MIKE11 model was based on the hydraulic model developed as part of the *Perrin Creek Master Drainage Plan* (BCC 1992). A number of changes were incorporated into the model, relating largely to the representation of structures and the computation of channel conveyance and hydraulic radius. The model incorporated the excavated channel located between Baringa Street and Lytton Road.

Calibration was based on three historical events: January 1974, February 1992 and May 1996. The adopted calibration calculated water levels that were within approximately 100 mm of the recorded water level over the full range of calibration events. Design scenarios modelled included 2, 5, 10, 20, 50 and 100 year ARI events.

This study modelled a range of flood mitigation strategies, including:

- Option 1 - Lytton Road bridge upgrade
  - additional 9m span at the eastern side
  - removal of excess silt thereby lowering the invert
- Option 2 – Channel deweeding D/S Lytton Road
  - Lytton Road bridge upgrade
  - comprehensive deweeding program from Lytton Road to Brisbane River
- Option 3 – Linkage of Perrin Creek into Riverside Channel
  - Lytton Road bridge upgrade
  - introducing link between Perrin Creek and Riverside Channel
- Option 4 – Lowering of invert and linkage into Riverside Channel
  - Lytton Road bridge upgrade
  - excavation of the channel to –1.00m AHD
  - introducing link between Perrin Creek and Riverside Channel
- Option 5 – Construction of high flow channel
  - construction of high flow channel to extend from Lytton Road to Riverside Channel
  - introducing link between Perrin Creek and Riverside Channel.

Final recommendations included upgrading Lytton Road bridge with an extra 9m span on the eastern side, lowering the invert of the bridge to 0.07m AHD and provision of a high level link between Perrin Creek and Riverside Channel. The bridge upgrade was subsequently completed in 2000.

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Upgrade Lytton Road (Perrin Creek) Flood Mitigation Investigation (2001)

City Design completed the *Lytton Road (Perrin Creek) Flood Mitigation Investigation* in 2001. The study assessed the flood reduction benefits of a range of mitigation strategies for Perrin Creek downstream of the Lytton Road bridge. The investigation was conducted in two parts.

The MIKE11 modelling work undertaken by City Design in 1999 was used in this study. During the first stage of modelling, mitigation Options 6 to 9 were investigated. No results, conclusions or recommendations for these options were available.

During the second stage of modelling, a number of refinements were made to the model, including the addition of extra cross sections downstream of Lytton Road, the incorporation of separate cross sections for Perrin Creek and the Riverside Channel, and an improved link channel between Perrin Creek and Riverside Channel. Flood Regulation Lines (FRLs) were also included in the model. A range of flood mitigation strategies were modelled, all incorporating an upgraded 6m span on Lytton Road bridge. The options modelled are outlined below. The 100 year ARI storm event was the only scenario modelled.

- Option 10a
  - existing catchment conditions with no FRL
  - this option represented the existing creek configuration
- Option 10b
  - represented the existing creek configurations with FRL
  - formed the base case to which all subsequent cases were compared
- Option 11a
  - included a 40m wide high flow channel at Highest Astronomical Tide (HAT) from Lytton Road to the boundary of the Port of Brisbane Corporation land
- Option 11b
  - included a 40m wide high flow channel at HAT from Lytton Road to Riverside Channel
- Option 12a option included a 60m wide high flow channel from Lytton Road to the boundary of the Port of Brisbane Corporation land
- Option 12b
  - option included a 60m wide high flow channel at HAT from Lytton Road to Riverside Channel
- Option 13a
  - FRL introduced 30m from top of western bank of Perrin Creek extending from Lytton Road to the mouth
- Option 13b
  - FRL introduced 30m from top of bank on the western bank of Perrin Creek extending from Lytton Road to the mouth with a 60m high flow channel from Lytton Road to Riverside Channel.

Results are available for options 10a to 13b although no recommendations were included in the report.

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Perrin Creek Development and Model Review (2004)
Council's Development Assessment team commissioned Lawson and Treloar to review the hydraulic modelling work performed by Cardno MBK as part of a development proposal at 148 Baringa Street, Morningside. The work involved reviewing the reporting and overall methodology for the design proposal, a brief review of the hydrology and a review of the hydraulic analysis through spot checks.

The review highlighted several areas of the Perrin Creek model that required updating to current practices. The RAFTS model setup is unorthodox compared to the recommendation in the manual and general hydrologic modelling techniques. The MIKE11 review suggested changes to the road overland flow sections, model schematisation and processed data. It also recommended that the flowpaths from Wynnum Road to the Brisbane River would be more accurately schematised with a fine scale two-dimensional model with one-dimensional subsurface elements for the stormwater drainage from Wynnum Road to Baringa Street.

Colmslie Industrial Land – Hydraulic Analysis (2005)
The Port of Brisbane Corporation commissioned Cardno MBK to investigate flooding impacts associated with a proposed construction of industrial and commercial premises on land adjacent to Perrin Creek, between Lytton Road and Brisbane River.

The MIKE11 model for Perrin Creek was obtained from Brisbane City Council in 2003. A number of changes were made to Option 10b of the model, especially downstream of Lytton Road to better reflect the hydraulic behaviour of Perrin Creek. These changes included additional surveyed cross sections, an upgraded Lytton Road bridge structure, corrections to the inflow hydrographs and greater detail on the interaction of flow between Perrin Creek and Riverside Channel.

The extent of the proposed development extends to approximately 30m to the west of Perrin Creek. Most of the land at the southern end of the proposed development is located above the anticipated 100 year ARI flood level.

The impact of the development was assessed using MIKE11 V2001 SP1 hydraulic model. Recommendations to reduce the potential afflux caused by filling of the subject site included reducing the level of the overbank separating Riverside Channel from Perrin Creek by 0.2m, to a level of 1.6m AHD. Results showed that the proposed development would have no adverse impact on flood levels in Perrin Creek for any design event.

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Appendix B: Plans/Information

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Plans/Information included in the current model							
Structure	**Location**	**Structure Description**	**Size**	**U/S Invert (mAHD)**	**D/S Invert (mAHD)**	**Comments**	**Plan Number/Data Source**
Richmond Rd	B1 Ch1685	Culvert/Weir	3/1650 RCP	6.04	5.86		W2984
Bridgewater Rd	B1 Ch2020	Culvert/Weir	3/3000x1800 RCBC	4.88	4.7		W5939
Lang St	B1 Ch2370	Culvert/Weir	3/3000x1800 RCBC	2.32	2.26		W9382
Wynnum Rd	B1 Ch2485	Culvert	5/3000x1800 RCBC	-	-	Modelled as closed irregular cross sections	W6047
Baringa St	B1 Ch2905	Culvert/Weir	6/1650 RCP	1.76	1.63	Only superseded drawing available – assumed same heights	W3560 (Old Plan)
Rock Gabion	B1 Ch3192	Weir	1000x1000x2000 long gabion wall	-	-		WP3444/5m DEM
Lytton Rd (East)	B1 Ch4040	Bridge	3 spans (total length ~30m)	-	-		W11233
Barrack Rd	B2 Ch272	Culvert/Weir	4/2400x1200 RCBC	2.00	1.97		W3779
Ivy St	B2 Ch510	Culvert/Weir	2/600 RCP	1.90	1.88	No specific drawing, based on Barrack Rd plan	W3779 (Barrack Rd Plan)
Junction Rd	B2 Ch1160	Culvert/Weir	6/1800 RPC	1.76	1.63	Old model modified to represent 'W2331' drawing invert levels	W2331
For future reference – Has not been included in the current model							
Jersey Rd	B1	Bridge	-	-	-	Not included in the model – For future reference	W8450
Beelarong St	B3	Culvert/Weir	2/1350 RCP	0.88	0.87	Not included in the model – For future reference	W8452
Lytton Rd (East)	B4	Culvert/Weir	4/1350 RCP	0.62	0.48	Not included in the model – For future reference	W2985
Col Gardner Dr	B4	Culvert/Weir	3/1500x1200 RCBC	0.85	0.83	Not included in the model – For future reference	W5214

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Appendix C: RAFTS catchment characteristics

C-1 Adopted fraction impervious

The following table represents the fraction impervious for each City Plan group. The fraction impervious has been estimated using Queensland Urban Drainage Manual (QUDM).

Code	City Plan Group	Fraction Impervious based on QUDM	Area (ha)
CU2	Community Use Area Community Facilities	0.45	0.8
CU4	Community Use Area Education Purposes	0.30	35.1
CU5	Community Use Area Emergency Services	0.80	0.8
CU7	Community Use Area Railway	0.80	9.9
CU8	Community Use Area Utility Services	0.50	12.0
CN	Conservation	0.00	17.8
EC	Emerging Communities	0.60	6.9
GI	General Industry	0.90	106.1
LI	Light Industry	0.90	7.2
LR	Low Density Residential	0.45	267.6
LMR	Low-Medium Density Residential	0.60	99.2
MR	Medium Density Residential	0.65	0.8
MP4	Multi Purpose Centre Convenience Centre	0.90	2.1
MP3	Multi Purpose Centre Suburban Centre	0.90	6.8
PK	Park Land	0.00	30.2
RU	Rural	0.00	40.5
SP12	Special Purpose Centre Mixed Industry And Business	0.90	9.8
SR	Sport And Recreation	0.20	27.2
	Roads	1.00	170.9

C-2 Channel routing

The channel routing was calculated using the Muskingum-Cunge method. The 'mean channel slope' was estimated using contour information and the channel 'long section' estimated between two nodes. No 'mean lateral inflow width' was added to the model. On a few occasions a 'low-pipe flow' was used (i.e. between nodes x and z, and j to k). A cross section representing the reach was input using the 'section coordinate', and chosen from a representative section of the hydraulic model. The 'hydrograph lagging' was only used to connect to a Dummy node or where a detention basin is located. A value of zero was used for all hydrograph lags. A table of the data used in the modelling is shown in the model parameters section below.

C-3 Model parameters/data

Catchment Name	Catchment Area (ha)	Percentage Impervious (%)	Channel Length (m)	Channel Slope (%/100)	Catchment Slope (%)
A	25.35	0.58	1060	0.031	3.11
B	37.65	0.58	1225	0.032	3.18
C	14.31	0.38	300	0.012	4.13
D	31.11	0.52	770	0.037	3.64
E	25.60	0.47	570	0.009	2.70
F	33.87	0.54	440	0.007	2.52
G	36.47	0.43	770	0.058	5.71
H	25.80	0.55	445	0.016	3.24
I	29.16	0.66	790	0.006	1.43
J	27.50	0.56	320	0.002	1.76
K	38.49	0.75	390	0.004	2.19
L	25.65	0.54	255	0.003	1.68
M	15.85	0.29	410	0.000	0.83
N	31.50	0.59	685	0.050	4.96
O	14.41	0.53	285	0.012	1.73
P	21.30	0.58	520	0.007	0.42
Q	32.43	0.72	810	0.029	2.84
R	14.84	0.59	655	0.044	4.43
S	7.30	0.65	245	0.027	2.13
T	29.02	0.57	290	0.003	2.90
U	17.37	0.56	515	0.002	0.75
V	50.05	0.57	505	0.001	1.56
W	32.77	0.61	355	0.001	1.53
X	22.56	0.89	535	0.038	3.93
Y	9.84	0.90	320	0.003	2.46
Z	22.11	0.28	505	0.007	0.09
AA	5.91	0.30	315	0.000	0.58
BB	34.33	0.66	865	0.023	2.31
CC	52.89	0.51	505	0.004	1.70
DD	14.83	0.41	230	0.001	2.60
EE	18.04	0.91	370	0.001	0.45
FF	32.07	0.83	330	0.001	1.92
GG	21.06	0.90	250	0.001	0.64
Dummy1	0.00	0.00	0.001	0.001	0.001
Dummy2	0.00	0.00	0.001	0.001	0.001
Dummy3	0.00	0.00	0.001	0.001	0.001
Dummy4	0.00	0.00	0.001	0.001	0.001
Dummy5	0.00	0.00	0.001	0.001	0.001
Dummy6	0.00	0.00	0.001	0.001	0.001
Dummy7	0.00	0.00	0.001	0.001	0.001
Basin1A	0.00	0.00	0.001	0.001	0.001
Basin1B	0.00	0.00	0.001	0.001	0.001
TStorage1	0.00	0.00	0.001	0.001	0.001
TStorage2	0.00	0.00	0.001	0.001	0.001

An initial loss of 15 mm and a 0.2 proportional continuous loss have been used in the modelling for all nodes.

Appendix D: RAFTS model results

RAFTS model results

	RAFTS Results					
	100yr	50yr	20yr	10yr	5yr	2yr
A	11.1	9.6	8.5	7.2	6.2	4.4
B	16.1	14.0	12.4	10.5	9.0	6.4
C	31.7	27.3	23.7	19.9	16.7	12.0
D	12.8	11.1	9.7	8.1	7.0	5.0
E	47.1	40.5	34.9	28.6	23.9	16.7
F	56.1	48.1	41.3	33.9	28.2	19.5
I	62.5	53.7	45.8	37.5	31.2	21.4
G	14.1	12.1	10.5	8.7	7.3	5.2
H	23.9	20.5	17.8	14.8	12.4	9.0
J	84.0	73.2	61.5	50.2	41.1	28.6
K	89.8	78.9	65.7	53.4	43.3	30.4
L	93.9	82.6	68.8	55.9	45.2	31.7
M	95.1	83.5	69.3	56.1	45.4	31.8
X	13.6	11.9	10.9	9.3	8.1	5.9
Y	19.5	17.1	15.7	13.4	11.7	8.4
Z	18.6	15.9	14.0	11.8	10.2	7.3
N	14.7	12.7	11.2	9.3	8.0	5.8
O	19.1	16.6	14.5	12.0	10.1	7.3
P	22.7	19.6	17.1	14.3	12.3	8.8
Q	16.1	14.1	12.9	10.9	9.2	6.6
R	7.1	6.2	5.4	4.5	3.8	2.8
S	10.2	8.7	7.6	6.2	5.3	3.9
Basin1B	10.2	8.7	7.6	6.2	5.3	3.9
T	12.4	10.7	9.6	8.1	6.9	4.9
Basin1A	13.8	12.0	10.7	9.1	7.8	5.8
TStorage1	17.1	15.0	13.7	11.7	10.0	7.4
U	19.8	17.5	15.5	12.9	11.1	8.0
V	45.8	39.5	33.4	27.0	22.4	15.2
W	48.6	41.6	34.4	27.6	22.8	15.6
AA	147.9	124.8	99.7	79.7	64.6	41.7
BB	15.5	13.5	12.4	10.4	8.7	6.2
CC	24.5	20.3	16.9	13.7	11.4	7.5
DD	163.6	139.0	111.9	89.1	72.4	47.8
EE	165.6	140.9	113.7	90.4	73.6	48.8
FF	166.4	142.5	115.7	92.2	74.9	49.7
GG	166.4	143.1	117.0	93.2	75.6	50.3

Appendix E: MIKE11 model results

E-1 Envelope of Levels – Base Case Model

			Envelope of Levels - Base Case Model					
Chainage	Location	AMTD	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH1 1470.00	D/S Elwell St	3594	8.458	8.979	9.339	9.778	10.241	10.721
BRANCH1 1564.00		3500	8.114	8.958	9.359	9.812	10.27	10.738
BRANCH1 1650.00		3412	8.103	8.973	9.356	9.822	10.273	10.739
BRANCH1 1670.00	U/S Richmond St	3392	8.101	8.974	9.356	9.821	10.272	10.739
BRANCH1 1700.00	D/S Richmond St	3368	6.928	7.127	7.202	7.266	7.339	7.41
BRANCH1 1735.00		3330	6.734	6.936	7.017	7.086	7.164	7.239
BRANCH1 1825.00		3238	6.47	6.679	6.766	6.841	6.926	7.012
BRANCH1 1905.00		3160	6.228	6.464	6.561	6.648	6.746	6.856
BRANCH1 1962.00		3077	6.068	6.338	6.45	6.55	6.666	6.777
BRANCH1 1985.00		3054	6.036	6.32	6.433	6.533	6.645	6.752
BRANCH1 2005.00	U/S Bridgewater St	3035	6.087	6.389	6.507	6.609	6.722	6.827
BRANCH1 2035.00	D/S Bridgewater St	3010	5.148	5.331	5.415	5.486	5.548	5.604
BRANCH1 2123.00		2931	4.323	4.636	4.803	4.94	5.041	5.121
BRANCH1 2183.00		2875	4.179	4.587	4.765	4.906	5.018	5.105
BRANCH1 2255.00		2793	3.969	4.393	4.559	4.684	4.791	4.882
BRANCH1 2324.00		2707	3.894	4.389	4.573	4.709	4.82	4.911
BRANCH1 2350.00	U/S Lang St	2681	3.929	4.41	4.594	4.716	4.826	4.916
BRANCH1 2385.00	D/S Lang St	2645	3.875	4.248	4.336	4.413	4.484	4.548
BRANCH1 2402.00		2627	3.914	4.275	4.363	4.44	4.511	4.576
BRANCH1 2458.00		2565	3.869	4.255	4.341	4.417	4.487	4.551
BRANCH1 2468.00		2565	3.869	4.255	4.341	4.417	4.487	4.551
BRANCH1 2480.00		2541	3.858	4.212	4.301	4.377	4.448	4.517
BRANCH1 2510.00		2508	3.851	4.204	4.293	4.369	4.44	4.51
BRANCH1 2515.00		2503	3.85	4.203	4.291	4.368	4.439	4.509
BRANCH1 2526.00		2491	3.816	4.157	4.247	4.323	4.395	4.47
BRANCH1 2545.00		2470	3.757	4.078	4.171	4.246	4.318	4.405
BRANCH1 2565.00		2448	3.741	4.056	4.15	4.225	4.297	4.387
BRANCH1 2575.00		2437	3.45	3.675	3.761	3.822	3.887	4.023
BRANCH1 2665.00		2339	3.104	3.287	3.385	3.448	3.52	3.712
BRANCH1 2685.00		2317	2.794	3.14	3.31	3.417	3.514	3.585
BRANCH1 2720.00		2278	2.66	3.055	3.237	3.349	3.448	3.517
BRANCH1 2730.00		2267	2.621	3.031	3.225	3.341	3.444	3.516
BRANCH1 2855.00		2130	2.516	2.946	3.147	3.267	3.373	3.449
BRANCH1 2865.00		2120	2.548	2.989	3.189	3.307	3.411	3.481
BRANCH1 2865.00		2120	2.548	2.989	3.189	3.307	3.411	3.481
BRANCH1 2880.00	U/S Baringa St	2108	2.525	2.981	3.186	3.305	3.408	3.478
BRANCH1 2925.00	D/S Baringa St	2072	1.996	2.157	2.266	2.392	2.561	2.693
BRANCH1 2987.00		2017	1.928	2.093	2.223	2.365	2.538	2.682
BRANCH1 3065.00		1938	1.823	2.069	2.203	2.345	2.521	2.666
BRANCH1 3143.00		1841	1.809	2.064	2.198	2.34	2.518	2.663
BRANCH1 3165.00	U/S Rock Gabion	1792	1.802	2.06	2.194	2.336	2.515	2.66
BRANCH1 3205.00	D/S Rock Gabion	1776	1.799	2.053	2.187	2.329	2.509	2.654
BRANCH1 3247.00		1742	1.795	2.054	2.188	2.329	2.509	2.654
BRANCH1 3368.00		1626	1.795	2.053	2.188	2.33	2.509	2.654
BRANCH1 3420.00		1584	1.794	2.054	2.188	2.33	2.509	2.654
BRANCH1 3480.00		1519	1.794	2.053	2.187	2.329	2.509	2.654
BRANCH1 3522.00		1457	1.794	2.053	2.187	2.329	2.508	2.653
BRANCH1 3577.00		1391	1.793	2.053	2.187	2.329	2.508	2.653
BRANCH1 3577.00		1391	1.793	2.053	2.187	2.329	2.508	2.653
BRANCH1 3624.00		1341	1.793	2.052	2.186	2.328	2.507	2.652
BRANCH1 3677.00		1305	1.792	2.051	2.185	2.327	2.506	2.651
BRANCH1 3729.00	U/S Pedestrian Bridge	1269	1.792	2.051	2.186	2.327	2.506	2.651
BRANCH1 3774.00	D/S Pedestrian Bridge	1224	1.767	2.017	2.145	2.276	2.447	2.576
BRANCH1 3774.00		1224	1.767	2.017	2.145	2.276	2.447	2.576
BRANCH1 3810.00		1179	1.767	2.017	2.145	2.276	2.447	2.576
BRANCH1 3858.00		1127	1.764	2.014	2.142	2.273	2.443	2.572
BRANCH1 3924.00		1056	1.763	2.012	2.139	2.269	2.439	2.567
BRANCH1 3975.00		1011	1.76	2.009	2.136	2.266	2.435	2.563
BRANCH1 4025.00	U/S Lytton Rd	974	1.758	2.007	2.133	2.263	2.431	2.559
BRANCH1 4055.00	D/S Lytton Rd	938	1.697	1.936	2.052	2.175	2.315	2.415
BRANCH1 4057.00		932	1.667	1.919	2.04	2.166	2.308	2.407
BRANCH1 4100.00		898	1.665	1.898	2.017	2.141	2.281	2.38

			Envelope of Levels - Base Case Model					
Chainage	Location	AMTD	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH1 4123.00		880	1.568	1.845	1.977	2.109	2.282	2.352
BRANCH1 4144.00		862	1.524	1.776	1.93	2.071	2.217	2.317
BRANCH1 4203.00		810	1.553	1.774	1.886	2.029	2.17	2.266
BRANCH1 4237.00		772	1.467	1.684	1.788	1.888	2.018	2.11
BRANCH1 4270.00		735	1.402	1.577	1.659	1.761	1.948	2.112
BRANCH1 4293.00		709	1.33	1.529	1.683	1.806	1.976	2.103
BRANCH1 4304.00		697	1.299	1.497	1.634	1.774	1.944	2.073
BRANCH1 4320.00		679	1.359	1.526	1.649	1.772	1.935	2.061
BRANCH1 4322.00		677	1.358	1.522	1.645	1.769	1.931	2.056
BRANCH1 4337.00		660	1.333	1.494	1.616	1.739	1.905	2.034
BRANCH1 4364.00		630	1.314	1.448	1.553	1.663	1.827	1.956
BRANCH1 4381.00		609	1.298	1.427	1.529	1.636	1.789	1.915
BRANCH1 4400.00		582	1.284	1.377	1.466	1.559	1.691	1.796
CHANNEL1A 4400.00		577	1.284	1.377	1.466	1.559	1.691	1.796
CHANNEL1A 4420.00		557	1.27	1.387	1.48	1.576	1.714	1.825
CHANNEL1A 4509.00		468	1.245	1.351	1.437	1.525	1.652	1.754
CHANNEL1A 4589.00		388	1.222	1.318	1.397	1.478	1.596	1.689
CHANNEL1A 4680.00		297	1.196	1.28	1.351	1.421	1.531	1.614
CHANNEL1A 4755.00		222	1.118	1.136	1.157	1.195	1.273	1.34
CHANNEL1A 4788.00		189	1.132	1.14	1.174	1.212	1.28	1.334
CHANNEL1A 4867.00		110	1.111	1.105	1.112	1.133	1.173	1.209
CHANNEL1A 4914.00		63	1.13	1.09	1.13	1.098	1.122	1.145
CHANNEL1A 4977.00		0	1.05	1.05	1.05	1.05	1.05	1.05
BRANCH2 272.00		1472	3.472	3.603	3.66	3.742	3.797	3.851
BRANCH2 322.00		1422	3.448	3.567	3.611	3.657	3.701	3.76
BRANCH2 355.00		1388	3.445	3.565	3.605	3.649	3.692	3.75
BRANCH2 375.00	U/S Barrack St	1364	3.443	3.562	3.601	3.643	3.685	3.742
BRANCH2 405.00	D/S Barrack St	1330	3.437	3.553	3.588	3.62	3.649	3.686
BRANCH2 425.00		1312	3.434	3.548	3.578	3.606	3.63	3.662
BRANCH2 454.00		1290	3.434	3.548	3.579	3.607	3.632	3.663
BRANCH2 499.00	U/S Ivy St	1243	3.434	3.548	3.578	3.605	3.629	3.659
BRANCH2 520.00	D/S Ivy St	1221	2.63	2.818	2.919	3.029	3.183	3.284
BRANCH2 554.00		1186	2.625	2.817	2.918	3.028	3.181	3.282
BRANCH2 606.00		1087	2.61	2.805	2.907	3.019	3.174	3.276
BRANCH2 666.00		1065	2.607	2.801	2.903	3.015	3.17	3.272
BRANCH2 706.00		1050	2.606	2.8	2.902	3.013	3.168	3.271
BRANCH2 756.00		987	2.603	2.797	2.899	3.011	3.167	3.269
BRANCH2 806.00		935	2.598	2.792	2.894	3.006	3.162	3.265
BRANCH2 846.00		869	2.593	2.787	2.888	3	3.155	3.258
BRANCH2 881.00		830	2.589	2.782	2.884	2.995	3.15	3.253
BRANCH2 916.00		770	2.588	2.779	2.88	2.991	3.148	3.248
BRANCH2 954.00		730	2.582	2.774	2.874	2.986	3.14	3.243
BRANCH2 1000.00		690	2.577	2.768	2.869	2.98	3.135	3.238
BRANCH2 1118.00		577	2.568	2.758	2.858	2.97	3.124	3.228
BRANCH2 1145.00	U/S Junction Rd	562	2.562	2.752	2.852	2.962	3.118	3.219
BRANCH2 1175.00	D/S Junction Rd	548	2.018	2.2	2.304	2.421	2.578	2.709
BRANCH2 1205.00		539	1.985	2.175	2.282	2.401	2.562	2.694
BRANCH2 1252.00		490	1.938	2.134	2.247	2.374	2.54	2.677
BRANCH2 1382.00		370	1.868	2.079	2.206	2.343	2.518	2.661
BRANCH2 1477.00		260	1.838	2.069	2.199	2.339	2.515	2.659
BRANCH2 1600.00		140	1.815	2.06	2.193	2.333	2.511	2.655
BRANCH2 1600.00		140	1.815	2.06	2.193	2.333	2.511	2.655
BRANCH2 1706.00		34	1.794	2.053	2.187	2.329	2.508	2.653
BRANCH2 1706.37		34	1.793	2.053	2.187	2.329	2.508	2.653
BRANCH3 38.00		445	1.942	2.067	2.149	2.279	2.448	2.576
BRANCH3 94.00		390	1.781	2.019	2.147	2.278	2.447	2.576
BRANCH3 143.00		350	1.772	2.019	2.148	2.277	2.447	2.576
BRANCH3 194.00		300	1.77	2.018	2.148	2.277	2.447	2.576
BRANCH3 245.00		255	1.769	2.018	2.148	2.277	2.447	2.576
BRANCH3 345.00		145	1.768	2.018	2.145	2.276	2.447	2.576
BRANCH3 411.00		79	1.767	2.017	2.145	2.276	2.447	2.576
WYNNUM 2449.00	U/S Wynnum Rd	2584	3.889	4.255	4.341	4.417	4.487	4.551

			Envelope of Levels - Base Case Model					
Chainage	Location	AMTD	Q2	Q5	Q10	Q20	Q50	Q100
WYNNUM 2459.00		2574	3.81	4.245	4.331	4.404	4.471	4.533
WYNNUM 2480.00		2552	3.81	4.23	4.314	4.386	4.452	4.512
WYNNUM 2510.00		2522	4	4.187	4.281	4.355	4.422	4.483
WYNNUM 2535.00		2495	3.95	4.154	4.251	4.327	4.394	4.455
WYNNUM 2650.00		2377	3.9	4.047	4.138	4.208	4.268	4.323
WYNNUM 2685.00		2341	3.85	4.029	4.115	4.182	4.238	4.293
WYNNUM 2740.00		2272	3.85	4.001	4.068	4.127	4.171	4.22
WYNNUM 2750.00		2260	2.548	2.989	3.189	3.307	3.411	3.481
BRANCH4 1000.00		403	2.605	2.65	2.673	2.7	2.72	2.744
BRANCH4 1129.00		274	2.181	2.273	2.312	2.354	2.511	2.655
BRANCH4 1193.00		210	2.048	2.095	2.193	2.334	2.511	2.655
BRANCH4 1268.00		134	1.816	2.06	2.193	2.334	2.511	2.655
BRANCH4 1329.00		74	1.815	2.06	2.193	2.333	2.511	2.655
BRANCH4 1383.07		20	1.815	2.06	2.193	2.333	2.511	2.655

DRAFT

E-2 Envelope of Discharge – Base Case Model

		Envelope of Discharge - Base Case Model					
Chainage	Location	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH1 1517.00		19.377	27.763	33.449	40.647	47.433	55.176
BRANCH1 1607.00		18.878	26.421	31.707	38.378	43.142	48.303
BRANCH1 1660.00		18.643	25.228	28.491	31.532	33.56	36.173
BRANCH1 1685.00	Richmond St	18.614	25.105	27.626	29.767	32.39	34.94
BRANCH1 1717.50		18.611	25.098	27.621	29.764	32.389	34.937
BRANCH1 1780.00		18.606	25.076	27.605	29.755	32.384	34.929
BRANCH1 1865.00		18.565	25.017	27.561	29.733	32.363	34.902
BRANCH1 1933.50		18.506	24.942	27.503	29.707	32.329	34.83
BRANCH1 1973.50		18.455	24.894	27.465	29.691	32.312	34.811
BRANCH1 1995.00		18.432	24.871	27.45	29.685	32.307	34.804
BRANCH1 2020.00	Bridgewater St	18.391	24.815	27.406	29.656	32.287	34.779
BRANCH1 2079.00		18.38	24.783	27.378	29.667	32.308	34.817
BRANCH1 2153.00		18.271	24.532	27.302	29.734	32.476	35.045
BRANCH1 2219.00		18.039	24.336	27.306	29.696	32.893	35.499
BRANCH1 2289.50		25.68	35.157	39.843	46.765	51.01	56.864
BRANCH1 2337.00		25.336	34.472	39.246	44.724	50.55	55.523
BRANCH1 2370.00	Lang St	24.952	33.993	38.945	44.486	50.364	55.315
BRANCH1 2393.50		24.7	33.769	38.851	44.396	50.26	55.247
BRANCH1 2430.00		23.49	33.378	38.663	44.203	50.088	55.09
BRANCH1 2469.00		25.102	29.763	30.044	30.205	30.425	30.741
BRANCH1 2495.00		25.092	29.763	30.044	30.205	30.425	30.74
BRANCH1 2512.50		25.092	29.763	30.044	30.204	30.425	30.74
BRANCH1 2520.50		25.092	29.763	30.044	30.204	30.425	30.74
BRANCH1 2535.50		25.092	29.763	30.043	30.204	30.425	30.74
BRANCH1 2555.00		25.092	29.763	30.043	30.204	30.425	30.739
BRANCH1 2570.00		25.092	29.763	30.043	30.204	30.424	30.739
BRANCH1 2620.00		25.094	29.766	30.033	30.192	30.413	30.726
BRANCH1 2675.00		25.094	29.769	30.007	30.159	30.388	30.693
BRANCH1 2702.50		25.091	29.777	29.976	30.119	30.348	30.652
BRANCH1 2725.00		25.089	29.783	29.957	30.103	30.311	30.635
BRANCH1 2792.50		25.083	29.8	29.935	30.084	30.29	30.62
BRANCH1 2860.00		25.082	29.808	29.97	30.049	30.28	30.602
BRANCH1 2872.50		27.85	35.816	43.171	51.043	59.482	66.204
BRANCH1 2905.00	Baringa St	27.83	35.49	43.114	50.995	59.451	66.183
BRANCH1 2956.00		27.711	35.391	43.025	50.892	59.358	66.098
BRANCH1 3026.00		27.618	35.275	42.883	50.722	59.132	65.905
BRANCH1 3104.00		27.564	35.121	42.564	50.486	58.981	65.769
BRANCH1 3164.00		28.99	36.571	44.821	52.68	62.305	69.816
BRANCH1 3192.00	Rock Gabion	28.987	36.477	47.565	52.398	62.192	69.676
BRANCH1 3226.00		28.68	36.041	43.855	51.813	61.209	68.655
BRANCH1 3307.50		28	35.276	42.751	50.406	58.436	65.195
BRANCH1 3394.00		24.687	31.704	38.23	44.754	50.838	56.924
BRANCH1 3450.00		22.578	28.672	35.141	40.824	46.327	51.963
BRANCH1 3501.00		22.008	28.876	33.949	39.309	44.654	49.846
BRANCH1 3549.50		21.981	28.931	33.869	39.32	45.032	50.046
BRANCH1 3600.50		24.097	31.171	37.511	44.806	52.394	58.61
BRANCH1 3650.50		23.268	30.617	37.138	44.31	51.999	58.053
BRANCH1 3702.50		22.654	30.396	36.654	43.53	51.586	57.35
BRANCH1 3756.00	Pedestrian Bridge	22.358	30.487	36.623	43.359	51.726	57.538

		Envelope of Discharge - Base Case Model					
Chainage	Location	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH1 3792.00		24.704	33.306	39.34	45.789	54.804	62.331
BRANCH1 3834.00		24.666	32.935	38.729	45.027	54.336	61.617
BRANCH1 3891.00		24.645	32.56	38.152	44.354	53.753	60.846
BRANCH1 3949.50		24.643	32.38	38.064	44.255	53.246	60.712
BRANCH1 4000.00		24.643	32.256	37.973	44.186	52.901	60.623
BRANCH1 4040.00	Lytton Rd	24.643	32.238	37.948	44.159	52.876	60.622
BRANCH1 4056.00		24.643	32.237	37.941	44.142	52.888	60.628
BRANCH1 4078.50		24.644	32.241	37.935	44.122	52.908	60.644
BRANCH1 4111.50		25.091	32.757	38.527	44.769	53.647	61.374
BRANCH1 4133.50		25.092	32.753	38.519	44.77	53.633	61.364
BRANCH1 4173.50		25.093	32.757	38.51	44.743	53.615	61.357
BRANCH1 4220.00		25.094	32.756	38.506	44.728	53.607	61.361
BRANCH1 4253.50		25.096	32.76	38.507	44.728	53.606	61.367
BRANCH1 4281.50		25.097	32.762	38.508	44.726	53.615	61.41
BRANCH1 4298.50		25.098	32.767	38.513	44.73	53.641	61.449
BRANCH1 4312.00		25.099	32.77	38.521	44.735	53.678	61.483
BRANCH1 4321.00		25.101	32.775	38.528	44.74	53.709	61.509
BRANCH1 4329.50		25.103	32.779	38.535	44.748	53.739	61.534
BRANCH1 4350.50		25.108	32.794	38.558	44.771	53.809	61.598
BRANCH1 4372.50		25.11	32.804	38.564	44.783	53.844	61.634
BRANCH1 4390.50		25.619	33.323	39.163	45.46	54.52	62.268
CHANNEL1A 4410.00		25.62	33.324	39.164	45.461	54.522	62.272
CHANNEL1A 4464.50		25.623	33.33	39.17	45.468	54.534	62.299
CHANNEL1A 4549.00		25.628	33.34	39.182	45.484	54.555	62.339
CHANNEL1A 4634.50		25.634	33.354	39.201	45.506	54.608	62.389
CHANNEL1A 4717.50		25.639	33.375	39.227	45.533	54.678	62.458
CHANNEL1A 4771.50		26.54	34.415	40.489	46.66	56.012	63.75
CHANNEL1A 4827.50		26.542	34.418	40.495	46.667	56.019	63.767
CHANNEL1A 4890.50		27.216	35.301	41.563	47.765	57.502	65.079
CHANNEL1A 4945.50		27.217	35.303	41.566	47.768	57.503	65.08
BRANCH2 297.00		7.067	9.455	10.832	13.103	14.543	16.573
BRANCH2 338.50		6.857	9.227	10.435	12.19	13.258	15.303
BRANCH2 365.00		6.125	7.863	8.751	10.522	12.117	14.32
BRANCH2 390.00	Barrack St	5.502	6.844	7.92	9.634	11.656	13.841
BRANCH2 415.00		4.916	5.967	7.281	9.263	11.403	13.396
BRANCH2 439.50		4.321	5.65	7.202	9.161	11.23	13.23
BRANCH2 476.50		3.386	5.111	7.14	8.972	10.865	12.926
BRANCH2 510.00	Ivy St	3.199	5.013	7.082	8.896	10.584	12.571
BRANCH2 537.00		3.201	4.997	6.982	8.645	10.278	12.081
BRANCH2 580.00		3.21	4.881	6.316	7.684	9.168	10.634
BRANCH2 636.00		11.909	17.258	20.627	25.484	29.732	34.403
BRANCH2 686.00		11.289	16.372	19.727	24.052	28.067	32.479
BRANCH2 731.00		10.41	15.222	18.463	22.635	26.528	30.798
BRANCH2 781.00		9.497	14.013	17.038	20.997	24.548	28.513
BRANCH2 826.00		8.777	12.925	15.855	19.52	22.856	26.499
BRANCH2 863.50		8.207	12.092	14.852	18.31	21.475	24.787
BRANCH2 898.50		7.563	11.259	13.716	16.935	19.814	22.85
BRANCH2 935.00		6.854	10.283	12.545	15.334	17.851	20.575
BRANCH2 977.00		6.14	9.073	11.159	13.488	15.423	17.524

		Envelope of Discharge - Base Case Model					
Chainage	Location	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH2 1058.00	Junction Rd	5.648	8.081	9.626	11.42	14.211	15.99
BRANCH2 1130.50		7.338	10.862	12.961	15.384	19.033	21.577
BRANCH2 1160.00		7.335	10.861	12.958	15.383	19.029	21.57
BRANCH2 1190.00		7.33	10.835	12.91	15.315	18.927	21.446
BRANCH2 1228.50		7.31	10.783	12.832	15.215	18.772	21.265
BRANCH2 1317.00		7.241	10.593	12.572	14.752	17.956	20.395
BRANCH2 1429.50		7.184	10.277	12.176	14.419	17.304	19.264
BRANCH2 1538.50		6.084	11.505	13.582	15.685	19.261	21.498
BRANCH2 1653.00		9.397	13.348	16.019	19.562	24.369	30.115
BRANCH2 1706.18		27.047	27.047	27.047	27.047	27.047	30.98
BRANCH3 66.00		5.755	7.971	9.509	11.679	13.018	14.919
BRANCH3 118.50		5.086	7.376	8.807	10.84	12.147	13.92
BRANCH3 168.50		4.624	6.304	7.376	8.983	10.453	12.319
BRANCH3 219.50		4.626	6.2	7.119	8.629	9.979	11.776
BRANCH3 295.00		4.661	6.178	7.062	8.195	9.589	11.521
BRANCH3 378.00		10.07	13.221	15.038	17.767	20.268	23.495
WYNNUM 2454.00	Wynnum Rd	0	5.967	11.591	18.031	25.713	33.913
WYNNUM 2469.50		0	5.932	11.531	17.961	25.134	33.043
WYNNUM 2495.00		0	5.888	11.439	17.849	24.871	32.789
WYNNUM 2522.50		0	5.682	11.315	17.661	24.697	32.686
WYNNUM 2592.50		0	5.27	11.126	17.442	24.457	32.361
WYNNUM 2667.50		0	5.045	10.819	17.284	24.324	32.203
WYNNUM 2712.50		0	4.408	10.745	17.255	24.297	32.162
WYNNUM 2745.00		0	4.387	10.726	17.248	24.29	32.153
BRANCH4 1064.50		7.109	9.673	11.54	13.67	15.421	17.569
BRANCH4 1161.00		5.954	8.747	10.35	12.321	13.828	16.295
BRANCH4 1231.00		6.253	8.974	10.441	12.047	13.138	15.747
BRANCH4 1299.00		5.731	8.056	9.409	10.661	12.082	14.459
BRANCH4 1356.03		10.155	10.155	10.155	10.155	10.252	11.947

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E-3 Envelope of Levels – MRC Model

			Envelope of Levels - MRC Model					
Chainage	Location	AMTD	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH1 1470.00	D/S Elwell St	3594	8.458	8.879	9.339	9.778	10.241	10.721
BRANCH1 1564.00		3500	8.114	8.958	9.369	9.812	10.27	10.736
BRANCH1 1650.00		3412	8.103	8.973	9.388	9.822	10.273	10.739
BRANCH1 1670.00	U/S Richmond St	3392	8.101	8.974	9.386	9.821	10.272	10.739
BRANCH1 1700.00	D/S Richmond St	3366	6.928	7.127	7.202	7.288	7.339	7.41
BRANCH1 1735.00		3330	6.734	6.938	7.017	7.086	7.164	7.239
BRANCH1 1825.00		3238	6.47	6.679	6.768	6.841	6.926	7.012
BRANCH1 1905.00		3150	6.228	6.464	6.561	6.646	6.746	6.858
BRANCH1 1982.00		3077	6.088	6.338	6.45	6.55	6.666	6.777
BRANCH1 1985.00		3054	6.036	6.32	6.433	6.533	6.645	6.752
BRANCH1 2005.00	U/S Bridgewater St	3035	6.087	6.389	6.507	6.609	6.722	6.827
BRANCH1 2035.00	D/S Bridgewater St	3010	5.148	5.331	5.413	5.493	5.647	5.803
BRANCH1 2123.00		2931	4.322	4.635	4.795	4.932	5.037	5.12
BRANCH1 2183.00		2875	4.175	4.586	4.762	4.9	5.015	5.104
BRANCH1 2255.00		2793	3.965	4.392	4.558	4.693	4.79	4.881
BRANCH1 2324.00		2707	3.889	4.385	4.571	4.708	4.82	4.91
BRANCH1 2350.00	U/S Lang St	2681	3.923	4.407	4.583	4.716	4.828	4.915
BRANCH1 2385.00	D/S Lang St	2645	3.88	4.252	4.339	4.416	4.487	4.552
BRANCH1 2402.00		2627	3.916	4.278	4.365	4.442	4.514	4.579
BRANCH1 2458.00		2565	3.889	4.256	4.341	4.417	4.488	4.55
BRANCH1 2458.00		2565	3.889	4.256	4.341	4.417	4.488	4.55
BRANCH1 2480.00		2541	3.858	4.213	4.301	4.377	4.449	4.517
BRANCH1 2510.00		2508	3.852	4.205	4.293	4.369	4.44	4.51
BRANCH1 2515.00		2503	3.851	4.204	4.292	4.368	4.439	4.509
BRANCH1 2526.00		2491	3.816	4.168	4.247	4.323	4.394	4.471
BRANCH1 2545.00		2470	3.757	4.079	4.171	4.246	4.318	4.404
BRANCH1 2585.00		2448	3.741	4.057	4.15	4.226	4.297	4.387
BRANCH1 2575.00		2437	3.45	3.678	3.761	3.823	3.887	4.023
BRANCH1 2665.00		2339	3.104	3.287	3.385	3.448	3.52	3.719
BRANCH1 2685.00		2317	2.794	3.14	3.31	3.417	3.514	3.568
BRANCH1 2720.00		2278	2.661	3.054	3.237	3.349	3.448	3.506
BRANCH1 2730.00		2267	2.621	3.031	3.225	3.341	3.444	3.51
BRANCH1 2855.00		2130	2.516	2.946	3.147	3.267	3.374	3.449
BRANCH1 2865.00		2120	2.548	2.969	3.189	3.308	3.411	3.482
BRANCH1 2885.00		2120	2.548	2.969	3.189	3.308	3.411	3.482
BRANCH1 2880.00	U/S Baringa St	2108	2.525	2.961	3.188	3.305	3.408	3.478
BRANCH1 2925.00	D/S Baringa St	2072	1.996	2.158	2.267	2.395	2.566	2.697
BRANCH1 2987.00		2017	1.928	2.095	2.225	2.368	2.541	2.686
BRANCH1 3085.00		1938	1.823	2.071	2.205	2.347	2.524	2.669
BRANCH1 3143.00		1841	1.808	2.066	2.2	2.342	2.521	2.666
BRANCH1 3185.00	U/S Rock Gabion	1792	1.802	2.062	2.196	2.338	2.518	2.662
BRANCH1 3205.00	D/S Rock Gabion	1776	1.795	2.059	2.189	2.331	2.512	2.656
BRANCH1 3247.00		1742	1.795	2.056	2.19	2.332	2.512	2.657
BRANCH1 3368.00		1626	1.795	2.056	2.19	2.332	2.512	2.657
BRANCH1 3420.00		1584	1.795	2.056	2.19	2.332	2.512	2.657
BRANCH1 3480.00		1519	1.794	2.055	2.19	2.332	2.511	2.656
BRANCH1 3522.00		1457	1.794	2.055	2.189	2.332	2.511	2.656
BRANCH1 3577.00		1391	1.794	2.055	2.189	2.331	2.511	2.656
BRANCH1 3577.00		1391	1.794	2.055	2.189	2.331	2.511	2.656
BRANCH1 3624.00		1341	1.793	2.054	2.189	2.331	2.51	2.655
BRANCH1 3677.00		1305	1.792	2.053	2.187	2.33	2.509	2.654
BRANCH1 3728.00	U/S Pedestrian Bridge	1269	1.792	2.053	2.188	2.33	2.508	2.653
BRANCH1 3774.00	D/S Pedestrian Bridge	1224	1.787	2.019	2.147	2.279	2.449	2.579
BRANCH1 3774.00		1224	1.787	2.019	2.147	2.279	2.449	2.579
BRANCH1 3810.00		1179	1.787	2.019	2.147	2.279	2.448	2.579
BRANCH1 3858.00		1127	1.785	2.016	2.144	2.275	2.445	2.575
BRANCH1 3924.00		1056	1.783	2.014	2.141	2.272	2.441	2.571
BRANCH1 3975.00		1011	1.781	2.011	2.138	2.268	2.437	2.566
BRANCH1 4025.00	U/S Lytton Rd	974	1.759	2.009	2.135	2.265	2.433	2.562
BRANCH1 4055.00	D/S Lytton Rd	936	1.698	1.937	2.055	2.178	2.316	2.418
BRANCH1 4057.00		932	1.658	1.921	2.042	2.168	2.308	2.41
BRANCH1 4100.00		998	1.656	1.899	2.018	2.143	2.281	2.381

			Envelope of Levels - MRC Model					
Chainage	Location	AMTD	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH1 4123.00		880	1.57	1.847	1.98	2.112	2.254	2.355
BRANCH1 4144.00		862	1.525	1.779	1.933	2.074	2.218	2.32
BRANCH1 4203.00		810	1.554	1.776	1.897	2.031	2.17	2.268
BRANCH1 4237.00		772	1.488	1.668	1.788	1.889	2.018	2.112
BRANCH1 4270.00		735	1.402	1.578	1.68	1.783	1.947	2.112
BRANCH1 4293.00		709	1.33	1.53	1.665	1.807	1.974	2.101
BRANCH1 4304.00		697	1.299	1.487	1.635	1.775	1.943	2.072
BRANCH1 4320.00		679	1.358	1.626	1.649	1.773	1.933	2.059
BRANCH1 4322.00		677	1.355	1.622	1.645	1.769	1.929	2.056
BRANCH1 4337.00		660	1.333	1.493	1.615	1.739	1.903	2.032
BRANCH1 4364.00		630	1.313	1.447	1.562	1.683	1.824	1.954
BRANCH1 4381.00		606	1.298	1.427	1.528	1.636	1.787	1.913
BRANCH1 4400.00		582	1.283	1.378	1.464	1.559	1.689	1.794
CHANNEL1A 4400.00		577	1.283	1.376	1.464	1.559	1.689	1.794
CHANNEL1A 4420.00		557	1.27	1.388	1.479	1.576	1.712	1.823
CHANNEL1A 4509.00		466	1.245	1.351	1.438	1.524	1.65	1.752
CHANNEL1A 4589.00		388	1.221	1.317	1.395	1.476	1.594	1.687
CHANNEL1A 4680.00		297	1.195	1.279	1.35	1.42	1.529	1.612
CHANNEL1A 4755.00		222	1.118	1.138	1.155	1.194	1.271	1.338
CHANNEL1A 4788.00		189	1.133	1.14	1.174	1.212	1.279	1.333
CHANNEL1A 4857.00		110	1.111	1.105	1.112	1.133	1.172	1.205
CHANNEL1A 4914.00		63	1.131	1.092	1.092	1.098	1.122	1.144
CHANNEL1A 4977.00		0	1.05	1.05	1.05	1.05	1.05	1.05
BRANCH2 272.00		1472	3.476	3.619	3.7	3.765	3.822	3.879
BRANCH2 322.00		1422	3.447	3.569	3.614	3.662	3.708	3.769
BRANCH2 355.00		1388	3.445	3.565	3.606	3.649	3.693	3.751
BRANCH2 375.00	U/S Barrack St	1384	3.443	3.562	3.601	3.643	3.685	3.742
BRANCH2 405.00	D/S Barrack St	1330	3.437	3.553	3.588	3.621	3.649	3.686
BRANCH2 425.00		1312	3.434	3.549	3.578	3.606	3.63	3.662
BRANCH2 454.00		1290	3.434	3.549	3.579	3.607	3.632	3.664
BRANCH2 499.00	U/S Ivy St	1243	3.434	3.549	3.578	3.605	3.629	3.66
BRANCH2 520.00	D/S Ivy St	1221	2.64	2.827	2.929	3.04	3.193	3.294
BRANCH2 554.00		1186	2.635	2.826	2.928	3.038	3.191	3.292
BRANCH2 606.00		1087	2.62	2.815	2.917	3.029	3.183	3.285
BRANCH2 656.00		1055	2.614	2.807	2.909	3.021	3.176	3.278
BRANCH2 706.00		1050	2.61	2.803	2.905	3.017	3.172	3.275
BRANCH2 756.00		987	2.604	2.799	2.901	3.013	3.169	3.271
BRANCH2 806.00		935	2.598	2.793	2.895	3.007	3.163	3.266
BRANCH2 846.00		889	2.593	2.787	2.889	3.001	3.158	3.259
BRANCH2 881.00		830	2.59	2.783	2.884	2.996	3.151	3.254
BRANCH2 916.00		770	2.587	2.779	2.88	2.992	3.147	3.25
BRANCH2 954.00		730	2.582	2.774	2.875	2.987	3.142	3.245
BRANCH2 1000.00		690	2.577	2.769	2.87	2.981	3.136	3.24
BRANCH2 1116.00		577	2.567	2.759	2.859	2.971	3.128	3.229
BRANCH2 1145.00	U/S Junction Rd	562	2.562	2.752	2.852	2.963	3.117	3.22
BRANCH2 1175.00	D/S Junction Rd	546	2.023	2.214	2.32	2.438	2.593	2.722
BRANCH2 1205.00		539	1.99	2.189	2.297	2.417	2.576	2.706
BRANCH2 1252.00		490	1.943	2.148	2.26	2.386	2.551	2.686
BRANCH2 1382.00		370	1.862	2.066	2.213	2.35	2.525	2.667
BRANCH2 1477.00		260	1.842	2.076	2.206	2.345	2.521	2.664
BRANCH2 1600.00		140	1.819	2.065	2.197	2.338	2.515	2.659
BRANCH2 1600.00		140	1.819	2.065	2.197	2.338	2.515	2.659
BRANCH2 1706.00		34	1.794	2.055	2.189	2.331	2.511	2.656
BRANCH2 1706.37		34	1.794	2.055	2.189	2.331	2.511	2.656
BRANCH3 38.00		445	1.944	2.072	2.152	2.282	2.46	2.58
BRANCH3 94.00		390	1.792	2.022	2.149	2.28	2.449	2.58
BRANCH3 143.00		350	1.773	2.021	2.149	2.28	2.449	2.58
BRANCH3 194.00		300	1.771	2.021	2.148	2.28	2.449	2.58
BRANCH3 245.00		255	1.77	2.02	2.148	2.279	2.449	2.58
BRANCH3 345.00		145	1.768	2.02	2.148	2.279	2.449	2.579
BRANCH3 411.00		79	1.767	2.019	2.147	2.279	2.449	2.579
WYNNUM 2449.00	U/S Wynnum Rd	2584	3.689	4.256	4.341	4.417	4.486	4.55

			Envelope of Levels - MRC Model					
Chainage	Location	AMTD	Q2	Q5	Q10	Q20	Q50	Q100
WYNNUM 2459.00		2574	3.81	4.248	4.331	4.404	4.471	4.533
WYNNUM 2480.00		2552	3.81	4.231	4.314	4.386	4.452	4.512
WYNNUM 2510.00		2522	4	4.187	4.281	4.355	4.423	4.483
WYNNUM 2535.00		2496	3.95	4.154	4.251	4.327	4.394	4.455
WYNNUM 2650.00		2377	3.9	4.047	4.138	4.208	4.266	4.323
WYNNUM 2685.00		2341	3.85	4.028	4.115	4.183	4.238	4.293
WYNNUM 2740.00		2272	3.85	4.001	4.088	4.127	4.171	4.22
WYNNUM 2750.00		2260	2.548	2.989	3.189	3.308	3.411	3.482
BRANCH4 1000.00		403	2.606	2.65	2.672	2.698	2.717	2.74
BRANCH4 1129.00		274	2.182	2.276	2.317	2.362	2.516	2.659
BRANCH4 1193.00		210	2.046	2.084	2.198	2.338	2.516	2.659
BRANCH4 1269.00		134	1.819	2.065	2.197	2.338	2.516	2.659
BRANCH4 1329.00		74	1.819	2.065	2.197	2.338	2.516	2.659
BRANCH4 1383.07		20	1.819	2.065	2.197	2.338	2.515	2.659

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E-4 Envelope of Discharge – MRC Model

		Envelope of Discharge - MRC Model					
Chainage	Location	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH1 1517.00		19.377	27.763	33.449	40.647	47.433	55.176
BRANCH1 1607.00		18.878	26.421	31.707	38.376	43.142	48.303
BRANCH1 1660.00		18.643	25.228	28.491	31.532	33.56	36.173
BRANCH1 1685.00	Richmond St	18.614	25.105	27.626	29.767	32.39	34.94
BRANCH1 1717.50		18.611	25.098	27.621	29.764	32.389	34.937
BRANCH1 1780.00		18.606	25.076	27.605	29.755	32.384	34.929
BRANCH1 1865.00		18.565	25.017	27.561	29.733	32.363	34.902
BRANCH1 1933.50		18.506	24.942	27.503	29.707	32.329	34.83
BRANCH1 1973.50		18.455	24.894	27.465	29.691	32.312	34.811
BRANCH1 1995.00		18.432	24.871	27.45	29.685	32.307	34.804
BRANCH1 2020.00	Bridgewater St	18.391	24.815	27.406	29.656	32.287	34.779
BRANCH1 2079.00		18.38	24.781	27.381	29.667	32.308	34.819
BRANCH1 2153.00		18.273	24.538	27.308	29.739	32.483	35.058
BRANCH1 2219.00		18.04	24.351	27.312	29.907	32.91	35.519
BRANCH1 2289.50		25.679	35.192	39.892	46.872	51.073	56.789
BRANCH1 2337.00		25.34	34.501	39.279	44.729	50.557	55.528
BRANCH1 2370.00	Lang St	24.956	33.856	38.97	44.494	50.366	55.288
BRANCH1 2393.50		24.685	33.798	38.873	44.405	50.3	55.192
BRANCH1 2430.00		23.49	33.514	38.684	44.213	50.098	55.028
BRANCH1 2469.00		25.104	29.774	30.047	30.208	30.422	30.739
BRANCH1 2495.00		25.096	29.774	30.046	30.207	30.421	30.738
BRANCH1 2512.50		25.095	29.774	30.046	30.207	30.421	30.738
BRANCH1 2520.50		25.095	29.774	30.046	30.207	30.421	30.737
BRANCH1 2535.50		25.096	29.775	30.046	30.207	30.421	30.737
BRANCH1 2555.00		25.096	29.775	30.046	30.207	30.42	30.737
BRANCH1 2570.00		25.096	29.775	30.046	30.206	30.42	30.736
BRANCH1 2620.00		25.097	29.777	30.035	30.194	30.412	30.724
BRANCH1 2675.00		25.097	29.781	30.009	30.161	30.383	34.037
BRANCH1 2702.50		25.094	29.789	29.978	30.121	30.344	30.651
BRANCH1 2725.00		25.092	29.795	29.96	30.105	30.31	30.634
BRANCH1 2792.50		25.087	29.812	29.937	30.086	30.292	30.615
BRANCH1 2860.00		25.087	29.822	29.97	30.052	30.282	30.601
BRANCH1 2872.50		27.854	35.81	43.179	51.06	59.5	66.198
BRANCH1 2905.00	Baringa St	27.834	35.487	43.12	51.013	59.467	66.175
BRANCH1 2956.00		27.714	35.386	42.995	50.91	59.353	66.088
BRANCH1 3026.00		27.621	35.284	42.834	50.715	59.138	65.891
BRANCH1 3104.00		27.569	35.111	42.608	50.381	58.964	65.73
BRANCH1 3164.00		28.995	36.447	44.072	52.439	62.202	69.727
BRANCH1 3192.00	Rock Gabion	28.992	40.605	46.834	52.077	62.974	69.551
BRANCH1 3226.00		28.656	35.915	43.283	51.473	61.115	68.538
BRANCH1 3307.50		27.991	35.258	42.528	50.078	58.249	65.132
BRANCH1 3394.00		24.595	31.648	37.971	44.49	50.857	56.848
BRANCH1 3450.00		22.724	29.656	34.988	40.641	46.307	51.732
BRANCH1 3501.00		22.147	28.857	33.848	39.175	44.69	49.588
BRANCH1 3549.50		22.104	28.994	33.743	39.203	45.056	50.112
BRANCH1 3600.50		24.057	31.151	37.519	44.618	52.301	58.363
BRANCH1 3650.50		23.218	30.633	37.142	44.094	52.072	57.817
BRANCH1 3702.50		22.603	30.391	36.646	43.334	51.579	57.236
BRANCH1 3756.00	Pedestrian Bridge	22.378	30.451	36.592	43.161	51.592	57.429

		Envelope of Discharge - MRC Model					
Chainage	Location	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH1 3792.00		24.719	33.263	39.242	45.597	54.495	62.136
BRANCH1 3834.00		24.632	32.872	38.646	44.819	53.964	61.397
BRANCH1 3891.00		24.611	32.495	38.132	44.336	53.509	60.765
BRANCH1 3949.50		24.605	32.299	38.033	44.236	53.121	60.633
BRANCH1 4000.00		24.606	32.222	37.941	44.171	52.722	60.54
BRANCH1 4040.00	Lytton Rd	24.606	32.2	37.923	44.147	52.716	60.521
BRANCH1 4056.00		24.607	32.196	37.915	44.128	52.729	60.527
BRANCH1 4078.50		24.608	32.2	37.907	44.105	52.749	60.542
BRANCH1 4111.50		25.054	32.718	38.502	44.773	53.477	61.275
BRANCH1 4133.50		25.055	32.715	38.493	44.752	53.465	61.263
BRANCH1 4173.50		25.056	32.716	38.48	44.721	53.448	61.251
BRANCH1 4220.00		25.058	32.717	38.479	44.706	53.438	61.251
BRANCH1 4253.50		25.06	32.719	38.48	44.706	53.436	61.255
BRANCH1 4281.50		25.061	32.721	38.481	44.706	53.451	61.292
BRANCH1 4298.50		25.061	32.726	38.486	44.708	53.482	61.327
BRANCH1 4312.00		25.062	32.73	38.493	44.713	53.518	61.361
BRANCH1 4321.00		25.064	32.735	38.5	44.719	53.549	61.387
BRANCH1 4329.50		25.066	32.741	38.507	44.726	53.579	61.412
BRANCH1 4350.50		25.072	32.757	38.529	44.749	53.649	61.476
BRANCH1 4372.50		25.073	32.763	38.536	44.76	53.685	61.511
BRANCH1 4390.50		25.583	33.283	39.136	45.435	54.358	62.145
CHANNEL1A 4410.00		25.583	33.284	39.137	45.436	54.36	62.15
CHANNEL1A 4464.50		25.586	33.29	39.142	45.443	54.372	62.176
CHANNEL1A 4549.00		25.591	33.3	39.154	45.46	54.393	62.214
CHANNEL1A 4634.50		25.596	33.313	39.173	45.482	54.446	62.264
CHANNEL1A 4717.50		25.602	33.334	39.198	45.508	54.517	62.334
CHANNEL1A 4771.50		26.498	34.367	40.394	46.648	55.833	63.586
CHANNEL1A 4827.50		26.5	34.37	40.4	46.655	55.849	63.603
CHANNEL1A 4890.50		27.173	35.234	41.467	47.652	57.333	64.902
CHANNEL1A 4945.50		27.174	35.236	41.469	47.655	57.334	64.903
BRANCH2 297.00		7.082	9.457	10.78	13.026	14.492	16.481
BRANCH2 338.50		6.874	9.212	10.381	12.163	13.172	15.175
BRANCH2 365.00		6.108	7.858	8.717	10.416	12.075	14.211
BRANCH2 390.00	Barrack St	5.506	6.86	7.92	9.543	11.615	13.619
BRANCH2 415.00		4.908	5.974	7.284	9.242	11.343	13.351
BRANCH2 439.50		4.332	5.65	7.194	9.139	11.166	13.143
BRANCH2 476.50		3.368	5.111	7.134	8.957	10.829	12.843
BRANCH2 510.00	Ivy St	3.201	5.018	7.075	8.892	10.558	12.499
BRANCH2 537.00		3.209	4.992	6.903	8.58	10.08	11.865
BRANCH2 580.00		3.244	4.858	6.203	7.478	8.684	10.093
BRANCH2 636.00		11.769	17.11	20.393	25.3	29.703	34.29
BRANCH2 686.00		11.154	16.272	19.4	23.947	28.15	32.517
BRANCH2 731.00		10.299	15.165	18.278	22.637	26.668	30.888
BRANCH2 781.00		9.465	13.965	16.941	21.015	24.697	28.665
BRANCH2 826.00		8.814	12.892	15.812	19.568	23.004	26.661
BRANCH2 863.50		8.249	12.111	14.822	18.372	21.616	24.951
BRANCH2 898.50		7.619	11.285	13.729	16.998	19.951	23.008
BRANCH2 935.00		6.917	10.323	12.64	15.401	17.982	20.728
BRANCH2 977.00		6.204	9.122	11.259	13.617	15.554	17.664

		Envelope of Discharge - MRC Model					
Chainage	Location	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH2 1058.00	Junction Rd	5.663	8.097	9.647	11.454	14.248	16.029
BRANCH2 1130.50		7.346	10.872	12.975	15.405	19.06	21.609
BRANCH2 1160.00		7.343	10.871	12.973	15.403	19.056	21.603
BRANCH2 1190.00		7.338	10.842	12.922	15.335	18.954	21.48
BRANCH2 1228.50		7.315	10.787	12.842	15.232	18.797	21.294
BRANCH2 1317.00		7.242	10.61	12.565	14.749	17.955	20.407
BRANCH2 1429.50		7.186	10.282	12.18	14.407	17.256	19.269
BRANCH2 1538.50		8.08	11.499	13.583	15.629	19.184	21.409
BRANCH2 1653.00		9.394	13.364	16.013	19.43	24.476	29.977
BRANCH2 1706.18		32.687	31.16	31.16	31.16	31.16	31.16
BRANCH3 66.00		5.733	7.937	9.45	11.609	12.956	14.888
BRANCH3 118.50		4.962	7.28	8.746	10.712	12.071	13.868
BRANCH3 168.50		4.614	6.279	7.291	8.836	10.205	11.897
BRANCH3 219.50		4.623	6.196	7.082	8.422	9.675	11.422
BRANCH3 295.00		4.706	6.151	6.924	8.133	9.5	11.201
BRANCH3 378.00		10.091	12.943	15.016	17.769	20.112	23.067
WYNNUM 2454.00	Wynnum Rd	0	6.059	11.607	18.168	25.736	33.83
WYNNUM 2469.50		0	6.007	11.545	17.974	25.049	33.042
WYNNUM 2495.00		0	5.953	11.452	17.863	24.906	32.828
WYNNUM 2522.50		0	5.739	11.325	17.719	24.75	32.657
WYNNUM 2592.50		0	5.269	11.135	17.464	24.495	32.388
WYNNUM 2667.50		0	5.19	10.825	17.294	24.329	32.194
WYNNUM 2712.50		0	4.402	10.75	17.269	24.303	32.156
WYNNUM 2745.00		0	4.382	10.731	17.263	24.296	32.15
BRANCH4 1064.50		7.11	9.68	11.598	13.962	15.516	17.682
BRANCH4 1161.00		5.974	8.683	10.239	12.185	13.668	16.133
BRANCH4 1231.00		6.256	8.894	10.315	11.873	12.928	15.529
BRANCH4 1299.00		5.732	7.965	9.232	10.496	11.937	14.243
BRANCH4 1356.03		10.147	10.147	10.147	10.147	10.147	11.586

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E-5 Envelope of Levels – MRC+WC Model

			Envelope of Levels - MRC+WC Model					
Chainage	Location	AMTD	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH1 1470.00	D/S Elwell St	3594	8.458	8.979	9.343	9.637	10.38	10.983
BRANCH1 1564.00		3500	8.114	8.957	9.364	9.67	10.415	10.991
BRANCH1 1650.00		3412	8.102	8.973	9.393	9.682	10.421	10.994
BRANCH1 1670.00	U/S Richmond St	3392	8.101	8.973	9.391	9.86	10.419	10.993
BRANCH1 1700.00	D/S Richmond St	3366	6.931	7.127	7.202	7.275	7.361	7.444
BRANCH1 1735.00		3330	6.734	6.937	7.017	7.094	7.195	7.275
BRANCH1 1825.00		3238	6.489	6.677	6.764	6.847	6.946	7.048
BRANCH1 1905.00		3150	6.227	6.459	6.555	6.649	6.763	6.895
BRANCH1 1962.00		3077	6.065	6.329	6.439	6.551	6.693	6.81
BRANCH1 1985.00		3054	6.032	6.309	6.421	6.533	6.659	6.783
BRANCH1 2005.00	U/S Bridgewater St	3035	6.081	6.377	6.495	6.611	6.741	6.865
BRANCH1 2035.00	D/S Bridgewater St	3010	5.151	5.34	5.419	5.493	5.584	5.629
BRANCH1 2123.00		2931	4.33	4.658	4.812	4.947	5.057	5.148
BRANCH1 2183.00		2875	4.198	4.615	4.777	4.917	5.036	5.133
BRANCH1 2255.00		2793	3.996	4.416	4.569	4.697	4.81	4.907
BRANCH1 2324.00		2707	3.925	4.413	4.583	4.723	4.84	4.936
BRANCH1 2350.00	U/S Lang St	2681	3.958	4.419	4.578	4.711	4.822	4.914
BRANCH1 2385.00	D/S Lang St	2645	3.908	4.271	4.355	4.436	4.511	4.581
BRANCH1 2402.00		2627	3.943	4.306	4.391	4.473	4.549	4.621
BRANCH1 2458.00		2565	3.918	4.275	4.358	4.432	4.502	4.57
BRANCH1 2458.00		2565	3.918	4.275	4.356	4.432	4.502	4.57
BRANCH1 2480.00		2541	3.888	4.233	4.315	4.39	4.46	4.533
BRANCH1 2510.00		2508	3.881	4.225	4.307	4.382	4.452	4.526
BRANCH1 2515.00		2503	3.879	4.223	4.306	4.381	4.451	4.525
BRANCH1 2528.00		2491	3.844	4.177	4.261	4.336	4.406	4.487
BRANCH1 2545.00		2470	3.784	4.097	4.184	4.259	4.33	4.422
BRANCH1 2565.00		2448	3.788	4.078	4.164	4.238	4.31	4.404
BRANCH1 2575.00		2437	3.47	3.689	3.771	3.833	3.894	4.043
BRANCH1 2665.00		2339	3.12	3.312	3.394	3.459	3.525	3.735
BRANCH1 2685.00		2317	2.814	3.187	3.328	3.432	3.542	3.6
BRANCH1 2720.00		2278	2.682	3.106	3.256	3.364	3.469	3.533
BRANCH1 2730.00		2267	2.644	3.084	3.245	3.357	3.466	3.531
BRANCH1 2855.00		2130	2.538	3.002	3.188	3.284	3.39	3.468
BRANCH1 2865.00		2120	2.57	3.043	3.21	3.325	3.43	3.504
BRANCH1 2865.00		2120	2.57	3.043	3.21	3.325	3.43	3.504
BRANCH1 2880.00	U/S Baringa St	2106	2.546	3.032	3.203	3.317	3.421	3.493
BRANCH1 2925.00	D/S Baringa St	2072	2.004	2.171	2.288	2.427	2.599	2.745
BRANCH1 2987.00		2017	1.935	2.116	2.252	2.403	2.586	2.736
BRANCH1 3065.00		1938	1.836	2.098	2.236	2.382	2.57	2.721
BRANCH1 3143.00		1841	1.822	2.093	2.231	2.378	2.566	2.718
BRANCH1 3185.00	U/S Rock Gabion	1792	1.815	2.088	2.226	2.373	2.562	2.714
BRANCH1 3205.00	D/S Rock Gabion	1776	1.812	2.087	2.22	2.368	2.557	2.71
BRANCH1 3247.00		1742	1.808	2.084	2.221	2.369	2.558	2.711
BRANCH1 3368.00		1626	1.808	2.083	2.221	2.369	2.558	2.711
BRANCH1 3420.00		1584	1.808	2.083	2.221	2.369	2.558	2.71
BRANCH1 3480.00		1519	1.808	2.082	2.221	2.369	2.557	2.71
BRANCH1 3522.00		1457	1.807	2.082	2.22	2.368	2.557	2.709
BRANCH1 3577.00		1391	1.807	2.082	2.22	2.368	2.557	2.709
BRANCH1 3577.00		1391	1.807	2.082	2.22	2.368	2.557	2.709
BRANCH1 3624.00		1341	1.807	2.082	2.22	2.368	2.556	2.709
BRANCH1 3677.00		1305	1.806	2.08	2.218	2.366	2.555	2.707
BRANCH1 3728.00	U/S Pedestrian Bridge	1269	1.806	2.081	2.219	2.367	2.555	2.707
BRANCH1 3774.00	D/S Pedestrian Bridge	1224	1.781	2.046	2.174	2.318	2.493	2.635
BRANCH1 3774.00		1224	1.781	2.046	2.174	2.318	2.493	2.635
BRANCH1 3810.00		1179	1.78	2.045	2.174	2.318	2.493	2.636
BRANCH1 3858.00		1127	1.778	2.043	2.171	2.314	2.489	2.631
BRANCH1 3924.00		1056	1.777	2.04	2.168	2.311	2.485	2.627
BRANCH1 3975.00		1011	1.774	2.037	2.164	2.307	2.481	2.622
BRANCH1 4025.00	U/S Lytton Rd	974	1.772	2.035	2.162	2.304	2.477	2.618
BRANCH1 4056.00	D/S Lytton Rd	936	1.713	1.958	2.091	2.216	2.353	2.471
BRANCH1 4057.00		932	1.674	1.945	2.082	2.209	2.347	2.466
BRANCH1 4100.00		898	1.67	1.92	2.055	2.182	2.319	2.437

			Envelope of Levels - MRC+WC Model					
Chainage	Location	AMTD	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH1 4123.00		980	1.585	1.869	2.019	2.152	2.289	2.41
BRANCH1 4144.00		962	1.537	1.807	1.975	2.117	2.255	2.379
BRANCH1 4203.00		810	1.587	1.796	1.934	2.073	2.205	2.328
BRANCH1 4237.00		772	1.48	1.663	1.801	1.932	2.053	2.2
BRANCH1 4270.00		735	1.414	1.592	1.687	1.803	2.039	2.185
BRANCH1 4293.00		709	1.341	1.549	1.708	1.853	2.045	2.171
BRANCH1 4304.00		697	1.311	1.515	1.68	1.823	2.015	2.144
BRANCH1 4320.00		679	1.37	1.56	1.687	1.819	2.004	2.132
BRANCH1 4322.00		677	1.367	1.548	1.683	1.815	2.001	2.129
BRANCH1 4337.00		660	1.343	1.516	1.653	1.788	1.978	2.108
BRANCH1 4364.00		630	1.322	1.468	1.587	1.711	1.896	2.032
BRANCH1 4381.00		609	1.306	1.445	1.56	1.671	1.835	1.97
BRANCH1 4400.00		582	1.27	1.391	1.491	1.587	1.726	1.837
CHANNEL1A 4400.00		577	1.27	1.391	1.491	1.587	1.726	1.837
CHANNEL1A 4420.00		557	1.277	1.402	1.505	1.605	1.751	1.869
CHANNEL1A 4509.00		468	1.252	1.365	1.46	1.553	1.688	1.795
CHANNEL1A 4589.00		389	1.228	1.33	1.417	1.503	1.627	1.729
CHANNEL1A 4690.00		297	1.201	1.291	1.368	1.446	1.557	1.65
CHANNEL1A 4755.00		222	1.119	1.142	1.165	1.212	1.293	1.372
CHANNEL1A 4788.00		189	1.13	1.146	1.166	1.228	1.298	1.362
CHANNEL1A 4887.00		110	1.109	1.104	1.119	1.143	1.188	1.229
CHANNEL1A 4914.00		83	1.128	1.069	1.09	1.104	1.13	1.157
CHANNEL1A 4977.00		0	1.05	1.05	1.05	1.05	1.05	1.05
BRANCH2 272.00		1472	3.493	3.637	3.71	3.777	3.834	3.882
BRANCH2 322.00		1422	3.458	3.584	3.626	3.674	3.727	3.786
BRANCH2 355.00		1386	3.456	3.578	3.615	3.66	3.711	3.768
BRANCH2 375.00	U/S Barrack St	1364	3.454	3.574	3.61	3.653	3.703	3.759
BRANCH2 405.00	D/S Barrack St	1330	3.448	3.565	3.595	3.628	3.682	3.698
BRANCH2 425.00		1312	3.445	3.557	3.582	3.609	3.636	3.666
BRANCH2 454.00		1280	3.445	3.559	3.584	3.611	3.639	3.668
BRANCH2 499.00	U/S Ivy St	1243	3.445	3.557	3.582	3.608	3.636	3.664
BRANCH2 520.00	D/S Ivy St	1221	2.645	2.835	2.94	3.056	3.217	3.324
BRANCH2 554.00		1186	2.64	2.835	2.94	3.054	3.216	3.322
BRANCH2 608.00		1097	2.625	2.823	2.929	3.044	3.207	3.315
BRANCH2 668.00		1065	2.619	2.815	2.921	3.037	3.2	3.308
BRANCH2 708.00		1050	2.614	2.811	2.917	3.033	3.197	3.305
BRANCH2 758.00		987	2.609	2.807	2.912	3.029	3.193	3.302
BRANCH2 806.00		935	2.603	2.801	2.907	3.023	3.188	3.297
BRANCH2 846.00		969	2.598	2.795	2.9	3.016	3.181	3.29
BRANCH2 881.00		930	2.594	2.791	2.896	3.011	3.176	3.285
BRANCH2 916.00		770	2.591	2.787	2.892	3.007	3.171	3.281
BRANCH2 954.00		730	2.586	2.782	2.887	3.002	3.166	3.276
BRANCH2 1000.00		690	2.581	2.777	2.881	2.997	3.161	3.271
BRANCH2 1116.00		577	2.571	2.766	2.871	2.986	3.15	3.26
BRANCH2 1146.00	U/S Junction Rd	562	2.567	2.76	2.864	2.978	3.141	3.25
BRANCH2 1175.00	D/S Junction Rd	548	2.031	2.234	2.347	2.473	2.64	2.775
BRANCH2 1205.00		539	2	2.211	2.326	2.452	2.622	2.757
BRANCH2 1252.00		490	1.956	2.173	2.294	2.426	2.601	2.742
BRANCH2 1382.00		370	1.853	2.121	2.253	2.395	2.578	2.726
BRANCH2 1477.00		260	1.855	2.113	2.247	2.39	2.575	2.723
BRANCH2 1600.00		140	1.846	2.103	2.239	2.384	2.57	2.719
BRANCH2 1600.00		140	1.846	2.103	2.239	2.384	2.57	2.719
BRANCH2 1706.00		34	1.807	2.062	2.22	2.368	2.557	2.709
BRANCH2 1706.37		34	1.807	2.062	2.22	2.368	2.557	2.709
BRANCH3 38.00		445	1.943	2.074	2.18	2.322	2.496	2.637
BRANCH3 94.00		390	1.799	2.049	2.177	2.321	2.495	2.636
BRANCH3 143.00		350	1.798	2.048	2.176	2.32	2.495	2.636
BRANCH3 194.00		300	1.795	2.048	2.176	2.32	2.494	2.636
BRANCH3 245.00		255	1.794	2.047	2.176	2.319	2.494	2.636
BRANCH3 345.00		145	1.793	2.047	2.175	2.319	2.494	2.636
BRANCH3 411.00		79	1.781	2.046	2.174	2.318	2.493	2.635
WYNNUM 2449.00	U/S Wynnum Rd	2584	3.918	4.275	4.356	4.432	4.502	4.57

			Envelope of Levels - MRC+WC Model					
Chainage	Location	AMTD	Q2	Q5	Q10	Q20	Q50	Q100
WYNNUM 2459.00		2574	3.899	4.265	4.345	4.418	4.486	4.55
WYNNUM 2480.00		2552	3.847	4.248	4.329	4.399	4.466	4.529
WYNNUM 2510.00		2522	4	4.207	4.295	4.369	4.437	4.5
WYNNUM 2535.00		2496	3.95	4.175	4.265	4.34	4.409	4.472
WYNNUM 2650.00		2377	3.9	4.064	4.15	4.219	4.278	4.34
WYNNUM 2685.00		2341	3.85	4.045	4.126	4.193	4.25	4.309
WYNNUM 2740.00		2272	3.85	4.012	4.079	4.135	4.181	4.235
WYNNUM 2750.00		2260	2.57	3.043	3.21	3.325	3.43	3.504
BRANCH4 1000.00		403	2.623	2.668	2.691	2.718	2.738	2.761
BRANCH4 1129.00		274	2.181	2.282	2.326	2.385	2.57	2.719
BRANCH4 1193.00		210	2.046	2.104	2.24	2.385	2.57	2.719
BRANCH4 1269.00		134	1.646	2.103	2.239	2.384	2.57	2.719
BRANCH4 1329.00		74	1.646	2.103	2.239	2.384	2.57	2.719
BRANCH4 1383.07		20	1.646	2.103	2.239	2.384	2.57	2.719

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E-6 Envelope of Discharge – MRC+WC Model

		Envelope of Discharge - MRC+WC Model					
Chainage	Location	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH1 1517.00		19.377	27.76	33.454	40.534	47.183	54.799
BRANCH1 1607.00		18.877	26.418	31.769	38.116	42.54	47.219
BRANCH1 1660.00		18.644	25.229	28.414	31.591	33.711	36.62
BRANCH1 1685.00	Richmond St	18.615	25.111	27.675	30.159	33.279	36.329
BRANCH1 1717.50		18.612	25.104	27.67	30.156	33.277	36.325
BRANCH1 1780.00		18.608	25.086	27.654	30.146	33.271	36.314
BRANCH1 1865.00		18.57	25.034	27.613	30.122	33.249	36.277
BRANCH1 1933.50		18.518	24.969	27.562	30.091	33.209	36.196
BRANCH1 1973.50		18.474	24.929	27.528	30.074	33.192	36.181
BRANCH1 1995.00		18.457	24.91	27.516	30.068	33.187	36.175
BRANCH1 2020.00	Bridgewater St	18.429	24.869	27.483	30.047	33.174	36.165
BRANCH1 2079.00		18.413	24.84	27.467	30.064	33.195	36.207
BRANCH1 2153.00		18.282	24.656	27.441	30.165	33.317	36.469
BRANCH1 2219.00		17.954	24.464	27.486	30.401	33.748	36.976
BRANCH1 2289.50		25.531	35.489	40.347	45.888	51.87	57.69
BRANCH1 2337.00		25.124	34.775	39.864	45.479	51.668	57.162
BRANCH1 2370.00	Lang St	24.823	34.637	39.667	45.407	51.631	57.109
BRANCH1 2393.50		24.499	34.595	39.638	45.369	51.65	57.16
BRANCH1 2430.00		23.88	34.557	39.553	45.301	51.604	57.108
BRANCH1 2469.00		25.551	29.908	30.093	30.287	30.547	30.799
BRANCH1 2495.00		25.537	29.908	30.092	30.287	30.548	30.797
BRANCH1 2512.50		25.538	29.908	30.092	30.287	30.548	30.796
BRANCH1 2520.50		25.538	29.908	30.092	30.286	30.548	30.796
BRANCH1 2535.50		25.539	29.908	30.092	30.286	30.548	30.796
BRANCH1 2555.00		25.539	29.908	30.092	30.286	30.547	30.796
BRANCH1 2570.00		25.539	29.908	30.091	30.286	30.547	30.796
BRANCH1 2620.00		25.541	29.909	30.078	30.276	30.533	30.794
BRANCH1 2675.00		25.539	29.911	30.051	30.242	30.507	30.755
BRANCH1 2702.50		25.527	29.917	30.03	30.226	30.472	30.736
BRANCH1 2725.00		25.523	29.923	30.013	30.237	30.464	30.713
BRANCH1 2792.50		25.516	29.949	30.037	30.266	30.499	30.719
BRANCH1 2860.00		25.52	30.007	30.087	30.251	30.48	30.711
BRANCH1 2872.50		28.335	37.11	44.61	52.674	61.79	68.928
BRANCH1 2905.00	Baringa St	28.316	37.003	44.589	52.667	61.756	68.923
BRANCH1 2956.00		28.166	36.937	44.509	52.574	61.644	68.815
BRANCH1 3026.00		28.05	36.816	44.418	52.41	61.393	68.6
BRANCH1 3104.00		27.983	36.581	44.188	52.229	61.221	68.449
BRANCH1 3164.00		29.397	37.785	45.882	54.734	64.756	72.792
BRANCH1 3192.00	Rock Gabion	29.394	37.649	45.667	54.633	64.627	72.729
BRANCH1 3226.00		29.038	37.204	45.232	54.052	63.882	71.717
BRANCH1 3307.50		28.314	36.327	44.225	52.202	60.805	68.32
BRANCH1 3394.00		24.705	32.655	39.418	45.863	53.312	59.41
BRANCH1 3450.00		23.563	31.311	37.909	43.817	50.718	55.509
BRANCH1 3501.00		22.872	30.295	36.578	42.161	48.434	52.598
BRANCH1 3549.50		22.698	30.459	36.571	42.262	48.54	53.141
BRANCH1 3600.50		24.771	31.589	38.555	45.387	53.811	60.346
BRANCH1 3650.50		23.872	30.961	38.019	44.722	53.26	59.971
BRANCH1 3702.50		23.088	30.617	37.399	43.934	52.531	59.499
BRANCH1 3756.00	Pedestrian Bridge	22.874	30.514	37.106	43.912	52.275	59.643

		Envelope of Discharge - MRC+WC Model					
Chainage	Location	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH1 3792.00		25.399	33.748	40.141	46.047	56.639	65.129
BRANCH1 3834.00		25.224	33.319	39.864	47.617	55.81	64.651
BRANCH1 3891.00		25.045	33.208	39.723	47.173	55.655	64.106
BRANCH1 3949.50		24.915	33.168	39.677	46.687	55.539	63.609
BRANCH1 4000.00		24.904	33.148	39.635	46.589	55.453	63.258
BRANCH1 4040.00	Lytton Rd	24.919	33.129	39.614	46.32	55.402	63.125
BRANCH1 4056.00		24.93	33.122	39.588	46.197	55.368	63.087
BRANCH1 4078.50		24.943	33.109	39.548	45.966	55.317	63.03
BRANCH1 4111.50		25.363	33.649	40.176	46.646	56.167	64.028
BRANCH1 4133.50		25.365	33.639	40.138	46.505	56.125	63.983
BRANCH1 4173.50		25.367	33.623	40.076	46.294	56.061	63.919
BRANCH1 4220.00		25.371	33.617	40.047	46.223	56.005	63.887
BRANCH1 4253.50		25.372	33.618	40.047	46.226	55.99	63.893
BRANCH1 4281.50		25.374	33.62	40.047	46.23	55.943	63.912
BRANCH1 4298.50		25.375	33.622	40.047	46.24	55.933	63.93
BRANCH1 4312.00		25.376	33.624	40.05	46.251	55.936	63.949
BRANCH1 4321.00		25.378	33.626	40.054	46.261	55.941	63.966
BRANCH1 4329.50		25.381	33.629	40.059	46.271	55.952	63.988
BRANCH1 4350.50		25.398	33.639	40.078	46.3	55.993	64.054
BRANCH1 4372.50		25.405	33.644	40.085	46.326	56.033	64.113
BRANCH1 4390.50		25.91	34.201	40.73	47.048	56.818	64.922
CHANNEL1A 4410.00		25.911	34.202	40.731	47.05	56.82	64.924
CHANNEL1A 4464.50		25.915	34.208	40.737	47.058	56.831	64.943
CHANNEL1A 4549.00		25.922	34.218	40.749	47.073	56.852	64.972
CHANNEL1A 4634.50		25.929	34.231	40.763	47.09	56.901	65.036
CHANNEL1A 4717.50		25.938	34.249	40.785	47.111	56.975	65.115
CHANNEL1A 4771.50		26.929	35.237	41.899	48.479	58.205	66.592
CHANNEL1A 4827.50		26.933	35.242	41.905	48.485	58.218	66.61
CHANNEL1A 4880.50		27.637	35.947	42.628	49.5	59.238	67.879
CHANNEL1A 4945.50		27.638	35.948	42.63	49.502	59.239	67.882
BRANCH2 297.00		7.071	9.577	10.884	13.059	14.429	16.521
BRANCH2 338.50		6.899	9.344	10.3	12.039	13.089	15.265
BRANCH2 365.00		6.16	8.051	8.78	9.937	12.241	14.326
BRANCH2 390.00	Barrack St	5.741	7.052	7.816	9.62	11.765	13.753
BRANCH2 415.00		5.118	5.97	7.56	9.498	11.536	13.548
BRANCH2 439.50		4.454	5.838	7.548	9.468	11.465	13.462
BRANCH2 476.50		3.435	5.8	7.53	9.418	11.368	13.332
BRANCH2 510.00	Ivy St	3.347	5.766	7.519	9.389	11.305	13.221
BRANCH2 537.00		3.35	5.709	7.362	9.137	10.861	12.658
BRANCH2 580.00		3.362	5.388	6.653	8.204	9.715	11.403
BRANCH2 636.00		11.969	17.254	20.991	25.979	30.415	35.39
BRANCH2 686.00		11.318	16.414	19.886	24.584	28.812	33.462
BRANCH2 731.00		10.502	15.329	18.737	23.2	27.277	31.73
BRANCH2 781.00		9.697	14.153	17.338	21.459	25.199	29.281
BRANCH2 826.00		8.997	13.157	16.145	19.992	23.349	26.987
BRANCH2 863.50		8.416	12.361	15.101	18.671	21.813	25.053
BRANCH2 898.50		7.775	11.479	13.911	17.218	20.007	22.869
BRANCH2 935.00		7.042	10.458	12.652	15.512	17.901	20.349
BRANCH2 977.00		6.275	9.17	11.144	13.385	15.205	17.238



		Envelope of Discharge - MRC+WC Model					
Chainage	Location	Q2	Q5	Q10	Q20	Q50	Q100
BRANCH2 1058.00	Junction Rd	5.691	8.188	9.776	11.621	14.498	16.383
BRANCH2 1130.50		7.425	11.043	13.218	15.773	19.65	22.408
BRANCH2 1160.00		7.422	11.041	13.216	15.771	19.646	22.403
BRANCH2 1190.00		7.416	11.01	13.162	15.692	19.52	22.253
BRANCH2 1228.50		7.387	10.956	13.079	15.585	19.356	22.076
BRANCH2 1317.00		7.298	10.719	12.747	14.984	18.403	20.965
BRANCH2 1429.50		7.218	10.347	12.342	14.611	17.619	19.798
BRANCH2 1538.50		8.111	11.611	13.617	16.148	19.504	22.042
BRANCH2 1653.00		9.552	13.75	16.385	20.033	25.84	30.237
BRANCH2 1706.18		27.046	27.046	27.046	27.046	27.046	30.717
BRANCH3 66.00		5.75	7.905	9.427	11.549	12.878	14.828
BRANCH3 118.50		4.891	7.066	8.398	10.19	11.637	13.617
BRANCH3 168.50		4.661	6.372	7.56	9.211	10.732	12.725
BRANCH3 219.50		4.654	6.306	7.31	8.801	10.274	12.257
BRANCH3 295.00		4.666	6.291	7.366	8.616	9.555	11.049
BRANCH3 378.00		9.984	13.359	15.136	18.124	20.644	23.462
WYNNUM 2454.00	Wynnum Rd	0.057	7.273	12.779	19.709	27.82	36.538
WYNNUM 2469.50		0.025	7.228	12.702	19.424	26.979	35.623
WYNNUM 2495.00		0	7.172	12.589	19.3	26.762	35.322
WYNNUM 2522.50		0	6.916	12.436	19.132	26.587	35.187
WYNNUM 2592.50		0	6.406	12.206	18.826	26.256	34.901
WYNNUM 2667.50		0	5.577	11.82	18.577	25.975	34.662
WYNNUM 2712.50		0	5.424	11.736	18.535	25.922	34.609
WYNNUM 2745.00		0	5.399	11.714	18.527	25.915	34.597
BRANCH4 1064.50		7.156	9.819	11.708	13.971	15.487	17.834
BRANCH4 1161.00		5.922	8.658	10.107	12.4	14.227	16.314
BRANCH4 1231.00		6.203	8.851	10.217	12.45	14.058	15.617
BRANCH4 1299.00		5.745	7.944	9.238	10.989	12.381	14.402
BRANCH4 1356.03		10.158	10.158	10.158	10.158	11.004	11.736

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Appendix F: Profile Comparisons

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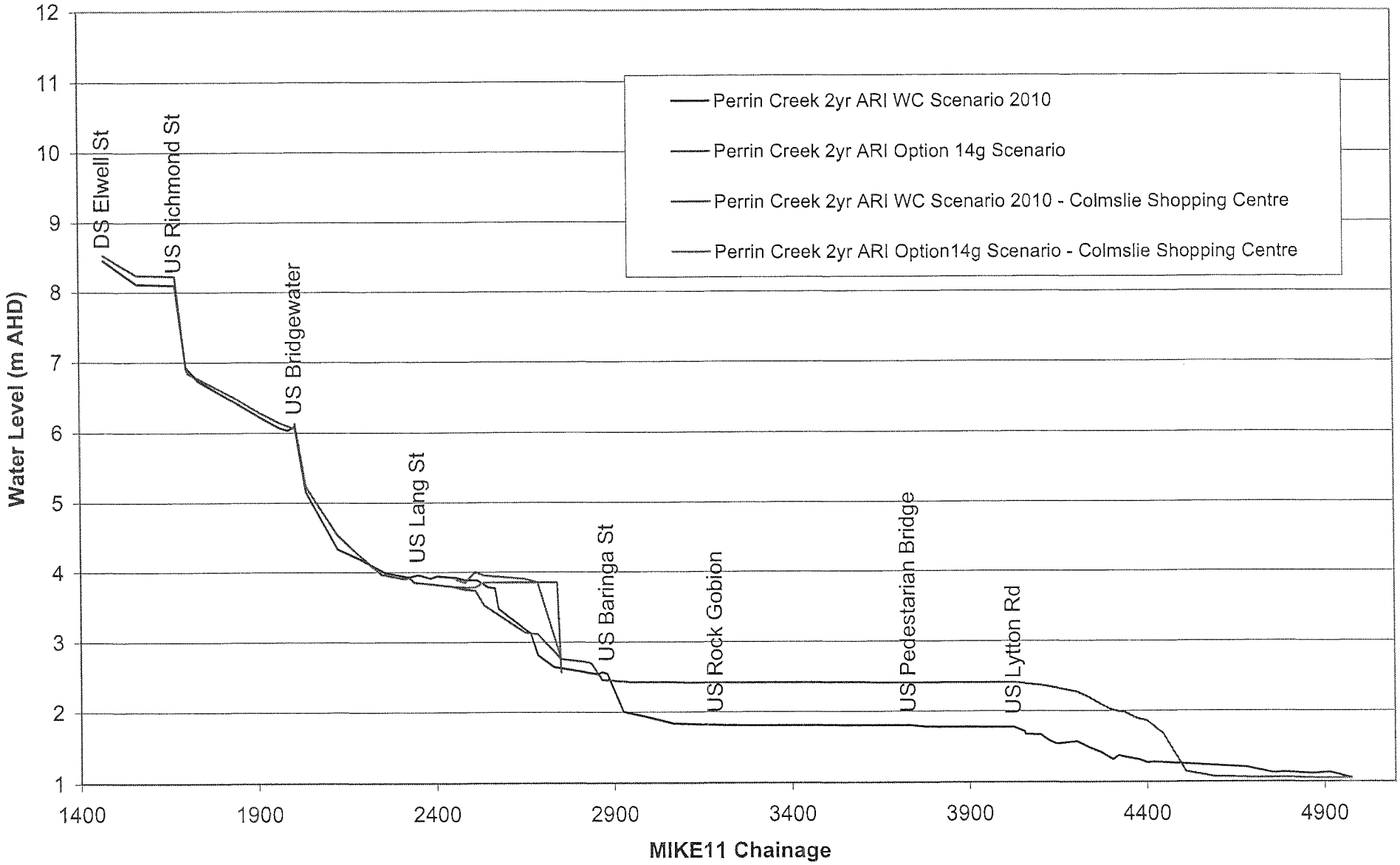
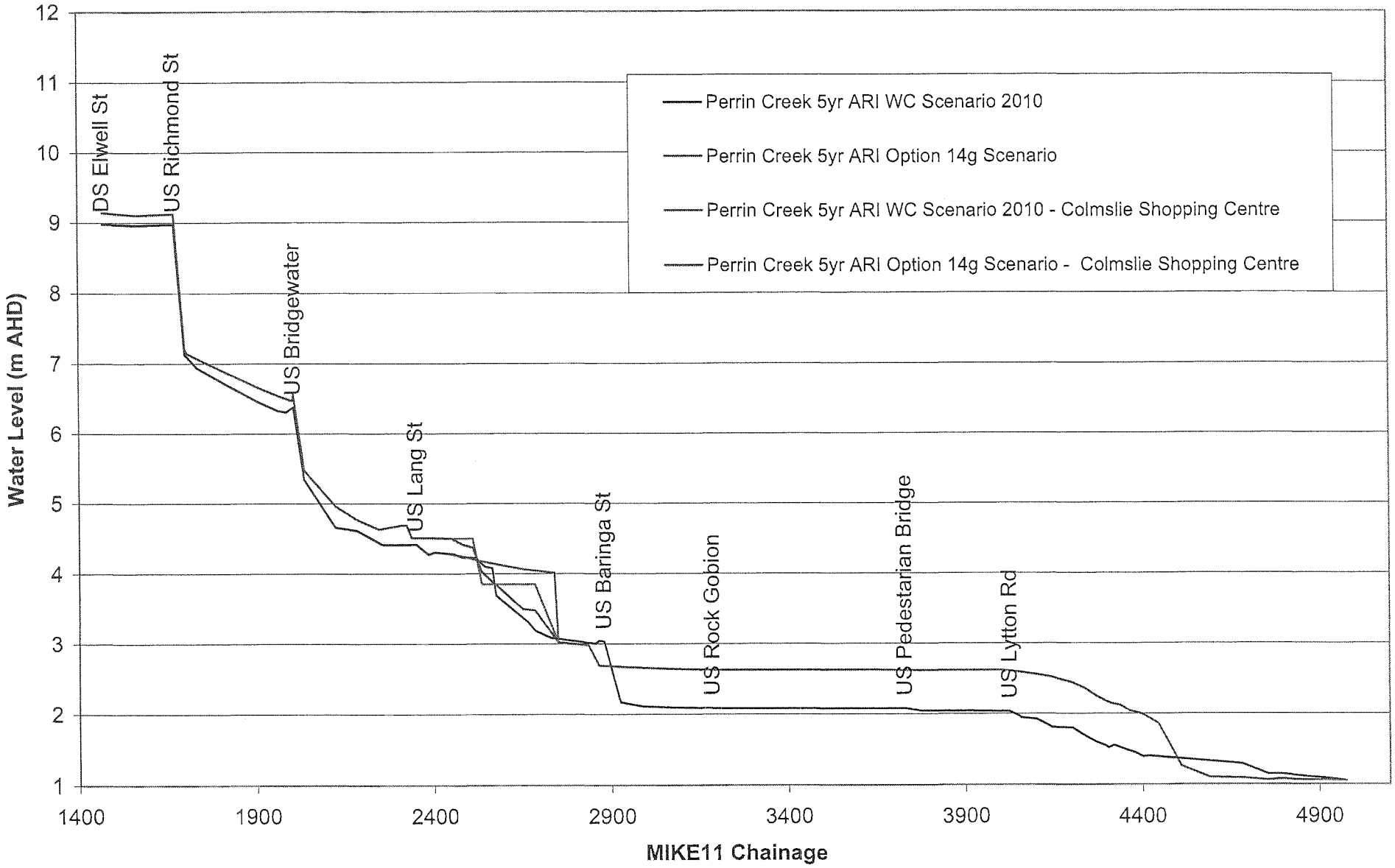
F-1

Perrin Creek 2010 vs Option14g - Main Branch (Branch1+Channel1A) (2yr ARI Envelope)



F-2

Perrin Creek 2010 vs Option14g - Main Branch (Branch1+Channel1A) (5yr ARI Envelope)



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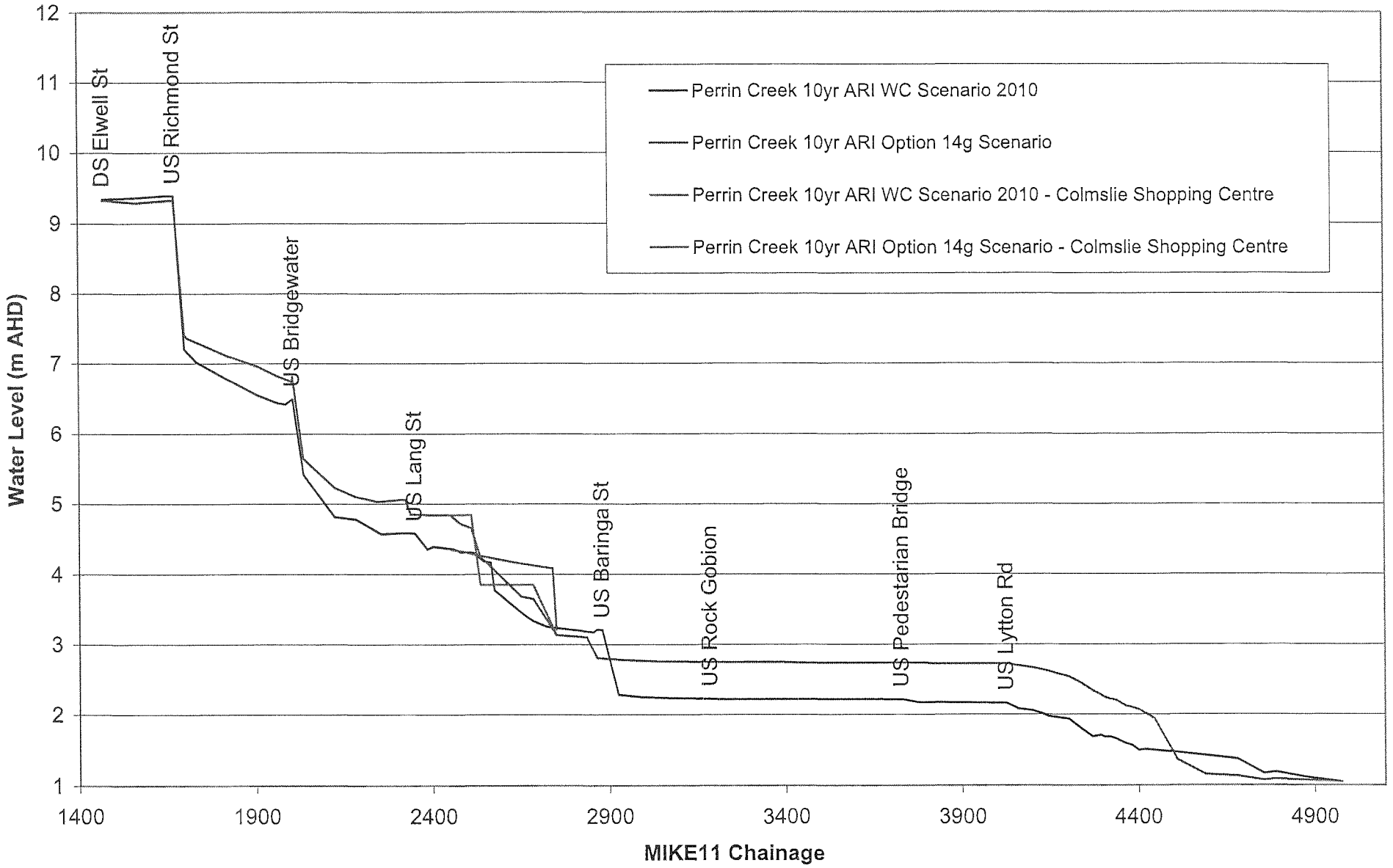
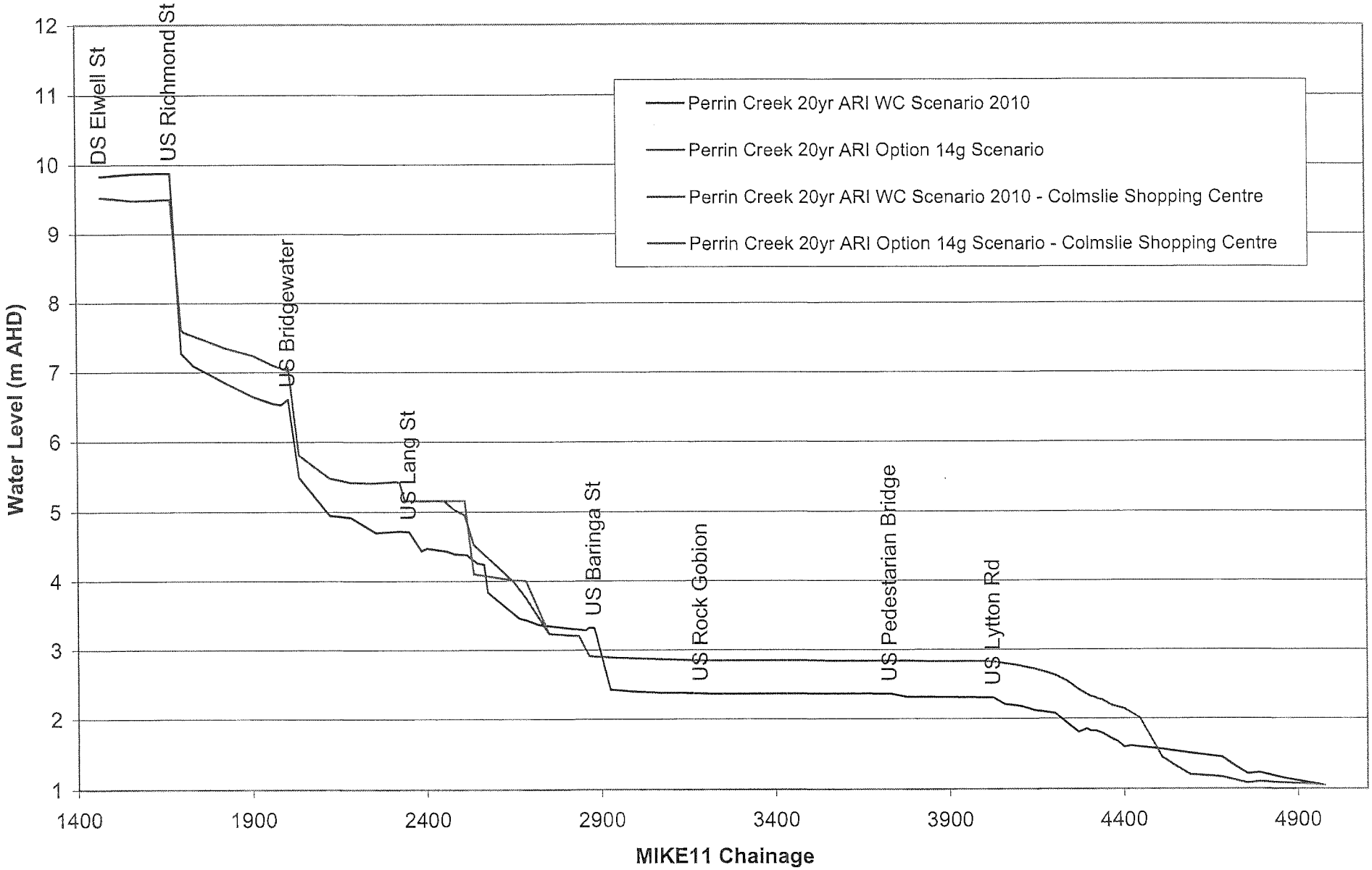
F-3

Perrin Creek 2010 vs Option14g - Main Branch (Branch1+Channel1A) (10yr ARI Envelope)



F- 4

Perrin Creek 2010 vs Option14g - Main Branch (Branch1+Channel1A) (20yr ARI Envelope)



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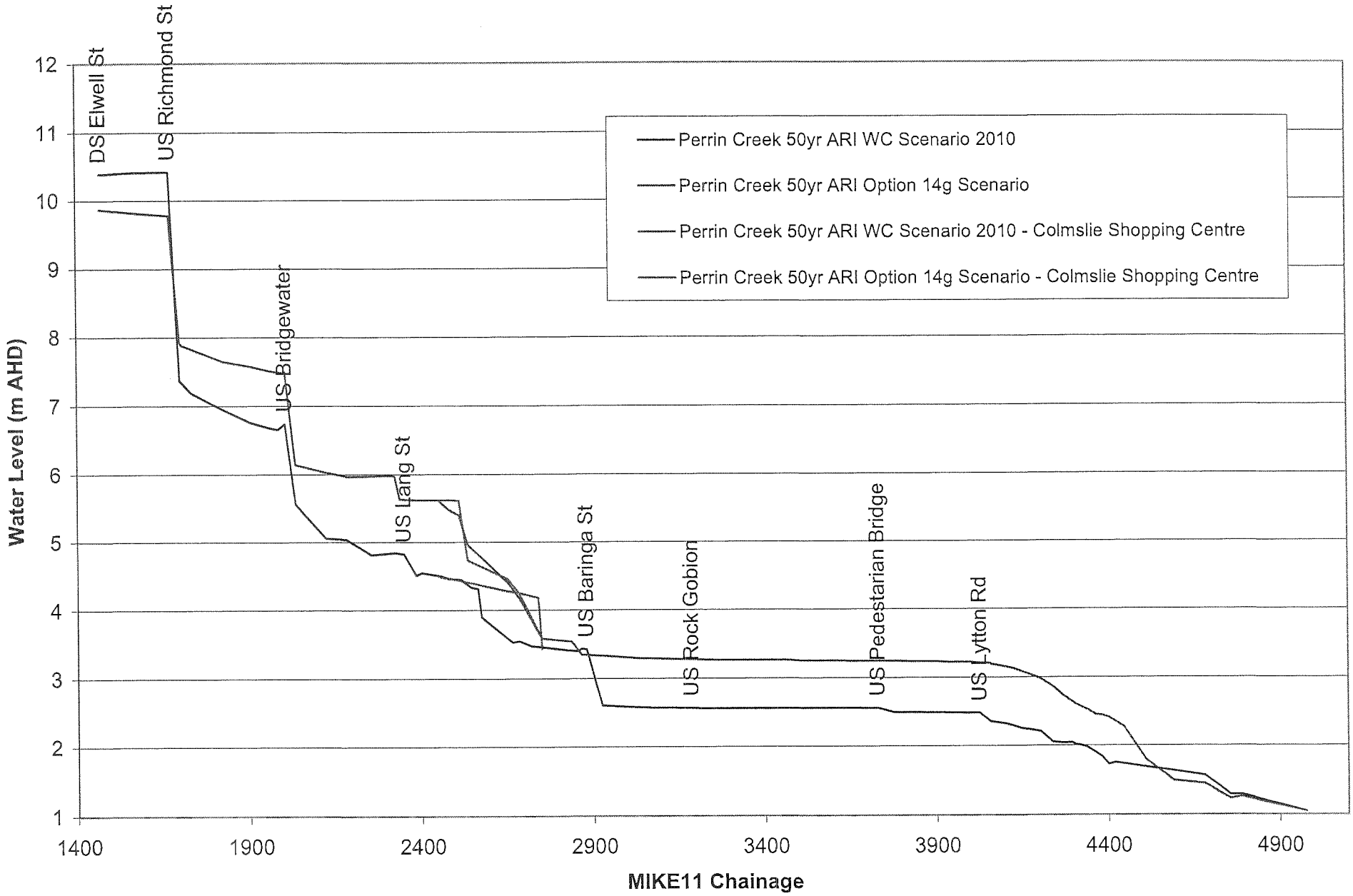
F- 5

Perrin Creek 2010 vs Option14g - Main Branch (Branch1+Channel1A) (50yr ARI Envelope)



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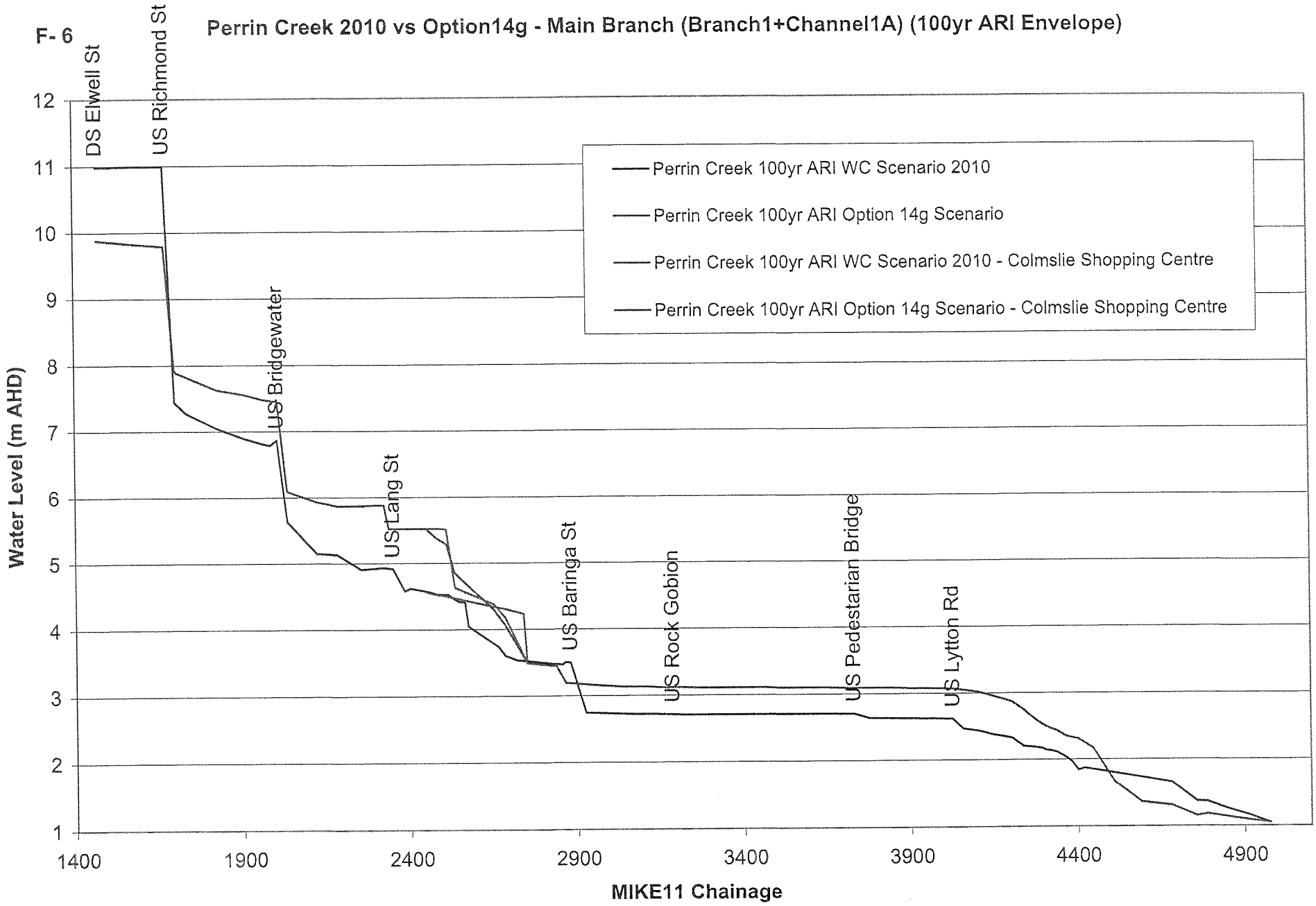

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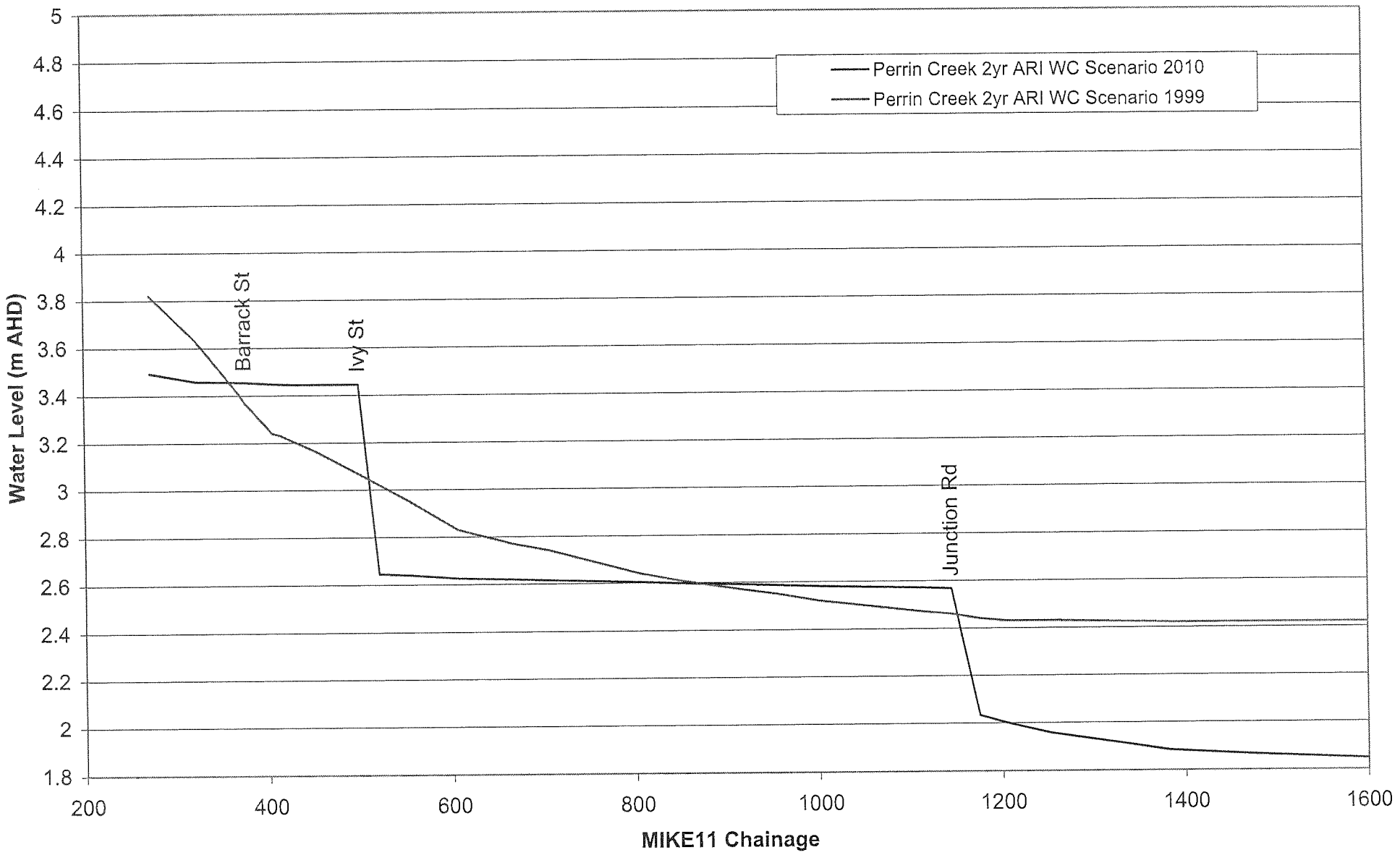
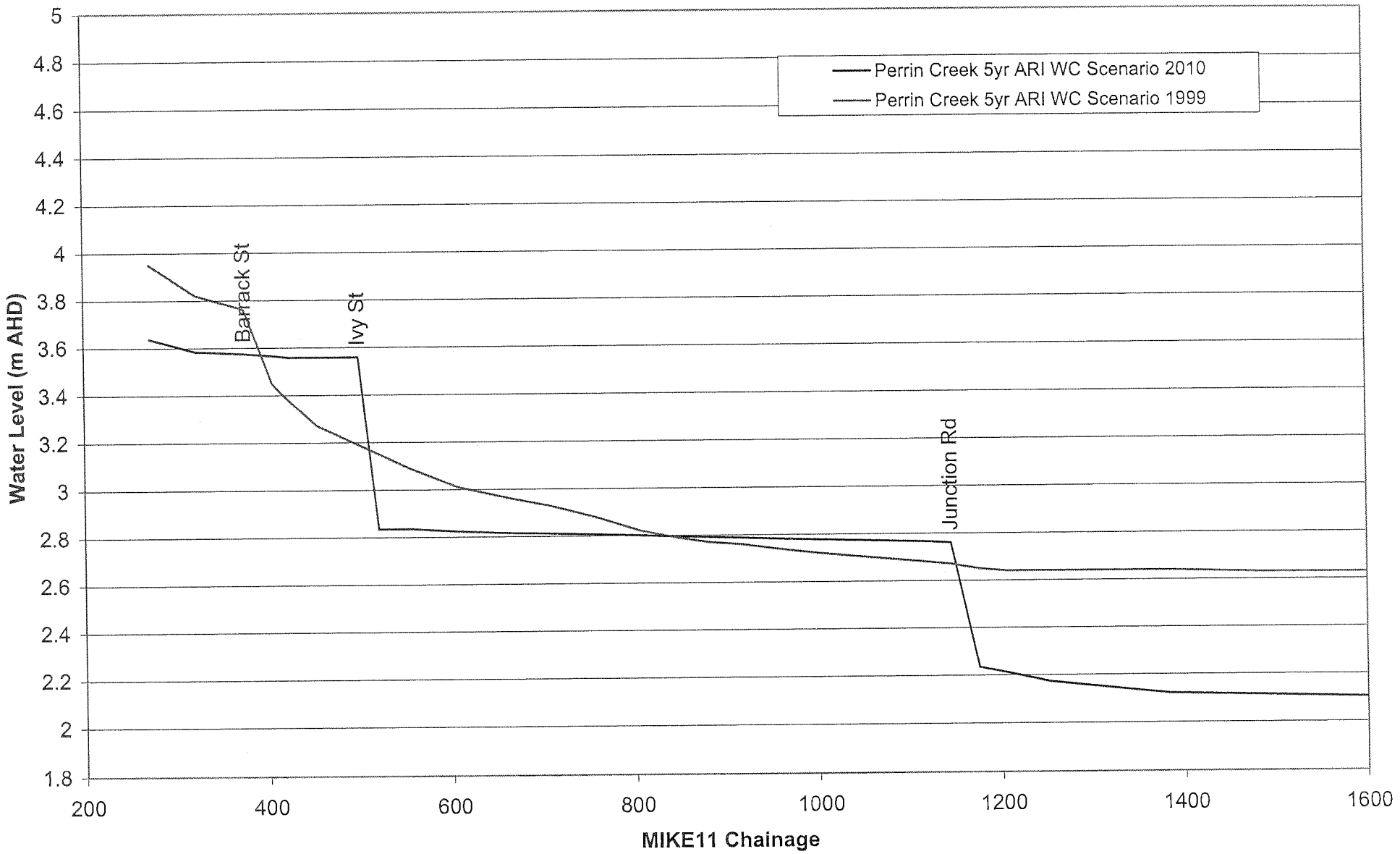
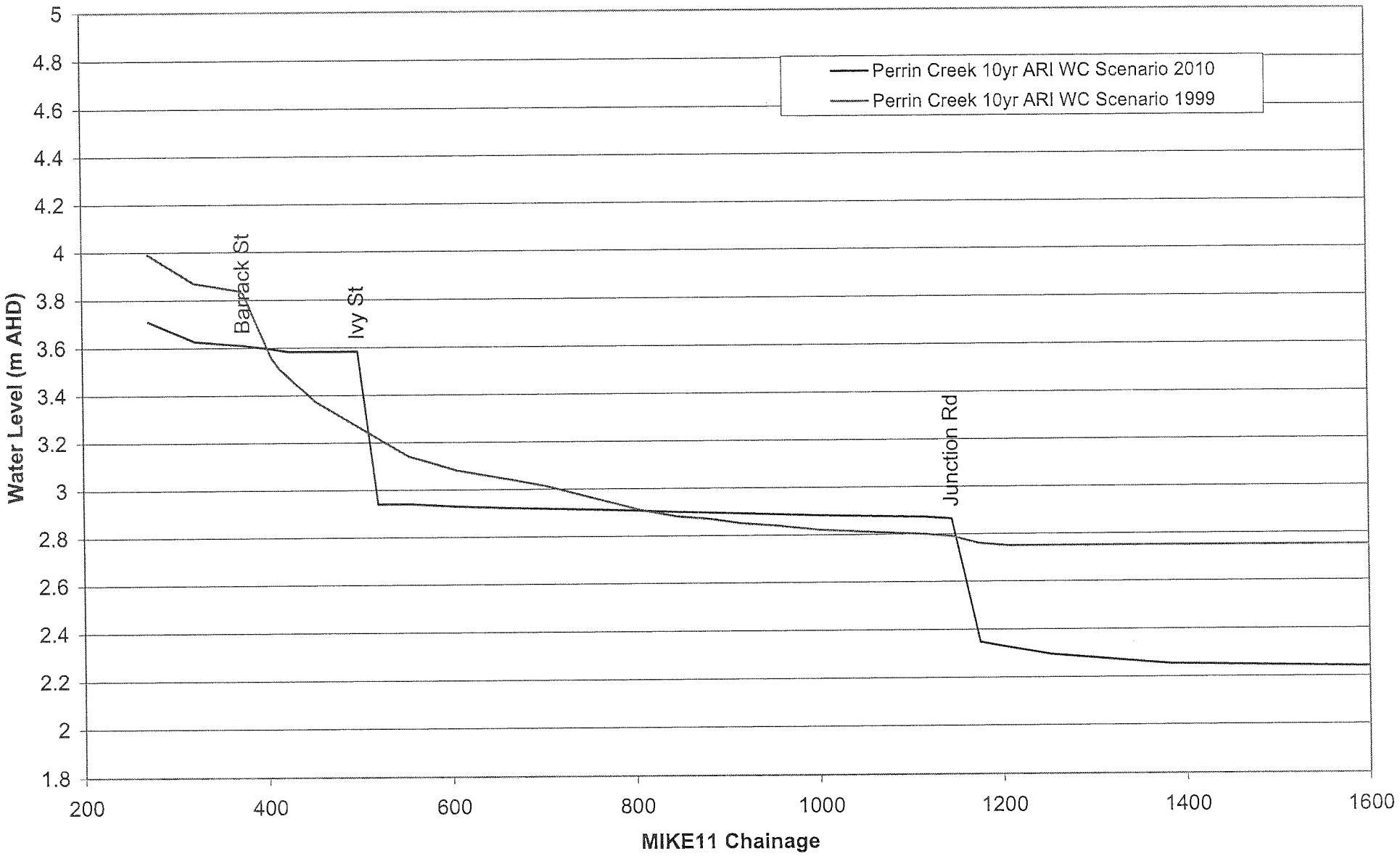
Perrin Creek 2010 vs Option14g - Branch 2 - 2yr ARI



Perrin Creek 2010 vs Option14g - Branch 2 - 5yr ARI

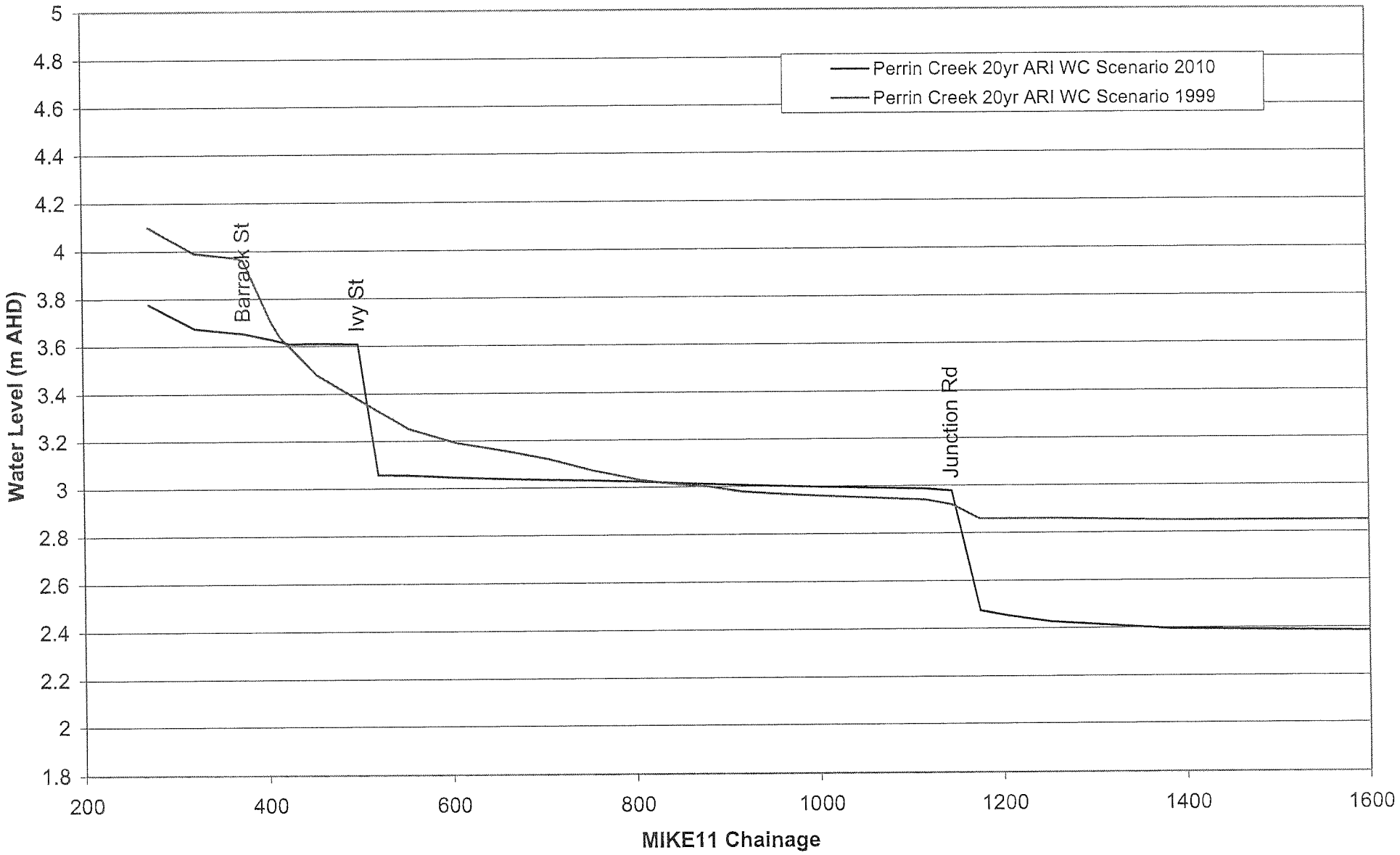


Perrin Creek 2010 vs Option14g - Branch 2 - 10yr ARI



F- 10

Perrin Creek 2010 vs Option14g - Branch 2 - 20yr ARI



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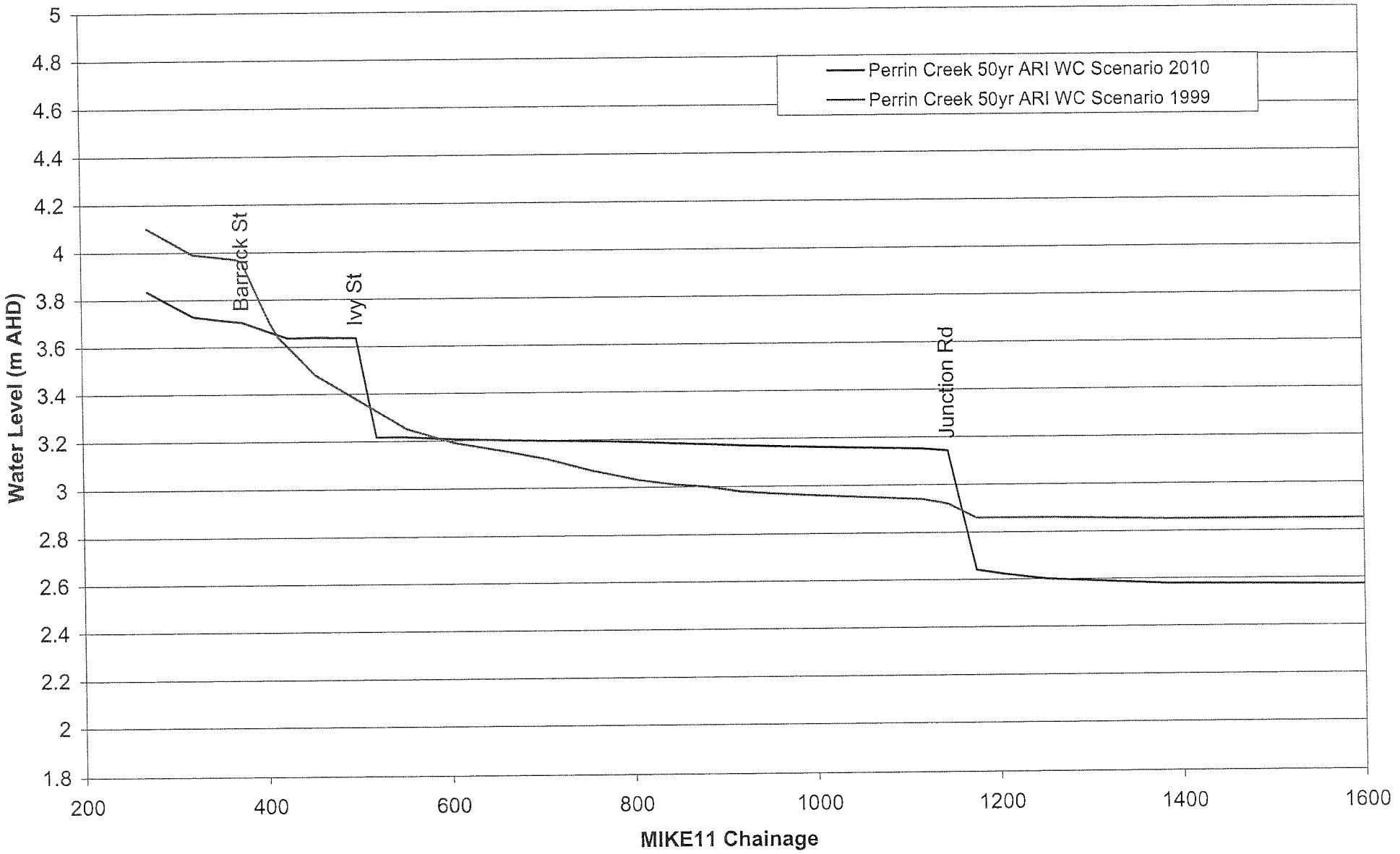
F- 11

Perrin Creek 2010 vs Option14g - Branch 2 - 50yr ARI



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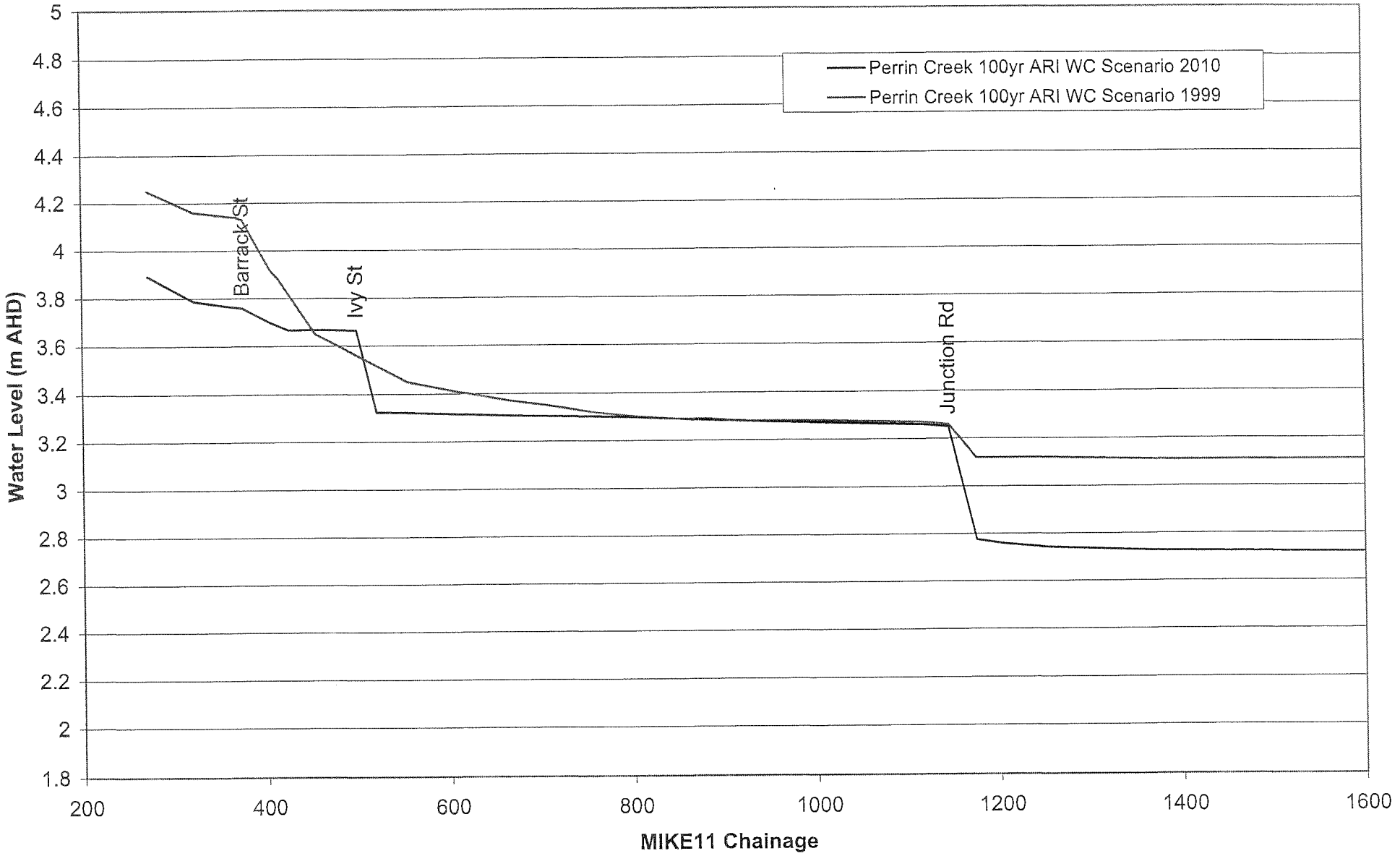
F-12

Perrin Creek 2010 vs Option14g - Branch 2 - 100yr ARI



Appendix G: Model Development

The Perrin Creek hydraulic model was first built in 1992 as part of the *Perrin Creek Master Drainage Plan* (BCC 1992). The model was revised as part of the *Lytton Road (Perrin Creek) Flood Mitigation Investigation* (BCC 1999) and recommendations resulted in the upgrade of Lytton Road bridge. Other mitigation options were subsequently analysed in the *Upgrade Lytton Road (Perrin Creek) Flood Mitigation Investigation* (BCC 2001).
In late 2003, Lawson and Treloar was commissioned to review Council's MIKE11 model. A model known as Option 14g was subsequently provided to Council.
In late 2006, Danish Hydraulic Institute (DHI) reviewed Option 14g and carried out significant changes to the model and recommended a few changes be made. The model reviewed by the DHI was adopted as the preferred hydraulic model for this study and updated accordingly. MIKE11 Version 2007 was used.

Over the course of this study a number of modifications were carried out to upgrade the Perrin Creek hydraulic model to achieve more confidence in predicting levels for the creek.
The following tasks were completed by the Timelines indicated below

April 2007

- Positioning of WC reviewed and updated where necessary
- Hydrologic model reviewed
- MIKE 11 model converted to Version 2005 SP4
- Instability issues related to conversion resolved
- Cross section extents in Mike 11 model extrapolated with the use of ALS survey data
- HEC RAS Validation for hydraulic structures completed.

November 2007

- Surveyed sections in hydraulic model reviewed
- New improved hydrological model built to reflect changes requested in variation
- Hydraulic model re-run to achieve new levels as a result of variance in input from new hydrology.

February 2011

- Main Perrin Creek branch downstream of Lytton Road at the junction of Perrin Creek and Riverside Channel to the mouth of Brisbane River has been eliminated from hydraulic model.
- The cross sections downstream of Lytton Road have been updated.
- Instability issues related to abrupt changes in bed profile resolved.
- The pedestrian bridge north of Beelarong Street has been added to the hydraulic model.
- The adopted delta of 1 has been replaced by 0.55.
- Time step has been decreased.

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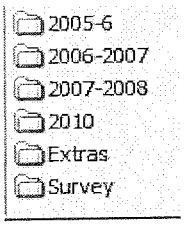
Appendix H: Model Handover Information

I-1 Directory Structure

The directory for the Perrin Creek Study is divided into three to differentiate three time periods over the course of the project life. The most recent of these is the 2007-2008 Folder which contains all of the most recent models results and final reports. The file structure for this subdivision is presented below:



The File Structure for all of the most recent results and reports are as follows:

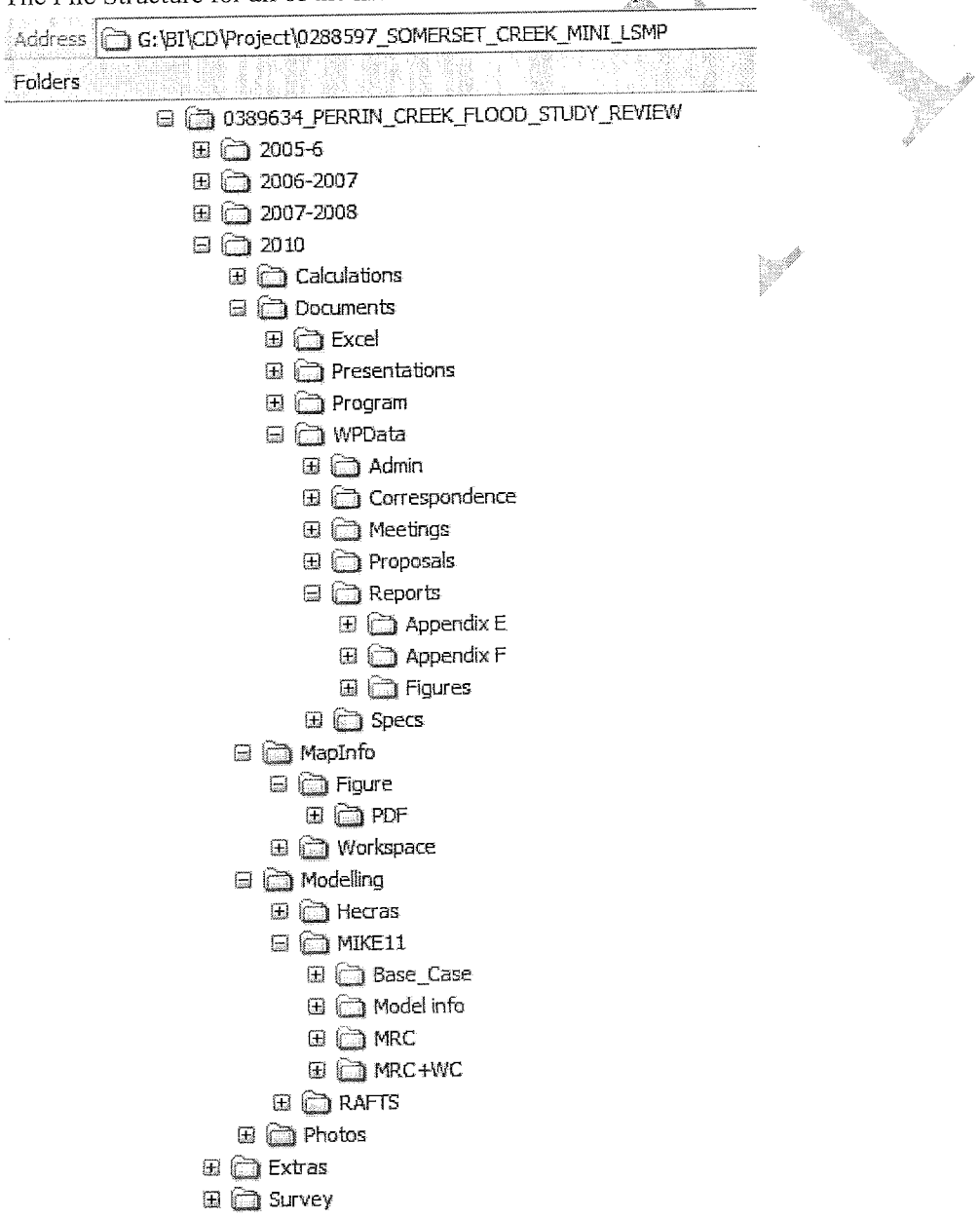


Figure I-1: Perrin Creek Flood Investigation Folder Structure

I-2 Modelling Nomenclature

2.1 RAFTS Design Run Modelling Nomenclature

A final 2007 RAFTS model has been used for the 2010 modelling, these files are located at: G:\BI\CD\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2010\Modelling\RAFTS

The run file and its associated parameter files have been titled:
"Ultimate_Perrin_Creek_2007"
The associated results files are named as follows:
"*year* yr *time* min"
e.g. The results file for the 100yr 60minute event is named
"100yr060min"
This convention follows for all rainfall event return periods and design storm durations.

Table I-1 below shows the naming convention for RAFTS files in a tabular format.

Table I-1: RAFTS files naming conventions

Base Case Model		
RAFTS Run files	Ultimate_Perrin_Creek_2007.**	G:\BI\CD\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2010\Modelling\RAFTS
RAFTS Local Results Files	XXXyrXXXmin.loc	
RAFTS Total Results Files	XXXyrXXXmin.tot	
RAFTS Output Results Files	XXXyrXXXmin.out	

Model Files and Runs Used in RAFTS modelling	
**	Represents the associated file type for all of the RAFTS run files.
RAFTS run file types "**"	".XP", ".dat", ".out", ".sy1", ".sy2", "xpt"
XXX_XXX	Represents all of the following model runs for the following ARI events and Storm Durations
"XXX_"	ARI Event
"_XXX"	Storm Duration
ARI Events used	2yr, 5yr, 10yr, 20yr, 50yr, 100yr.
ARI Events written as follows	002, 005, 010, 020, 050, 100
Storm Durations used	30min, 45min, 60min, 90min, 120min, 180min.
Storm Durations written as follows	030, 045, 060, 090, 120, 180

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2.2 Mike 11 Design Run Modelling Nomenclature

All Mike 11 design run modelling files for the 2010 modelling are located at:
G:\BI\CD\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2010\Modelling\MIKE11

Table I-2, below shows the naming convention for RAFTS files in a tabular format.

Table I-2: MIKE 11 files naming conventions

Base Case Model		
Simulation File	Perrin_Creek_Base_Case_XXX_XXX.sim11	G:\BI\CD\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2010\Modelling\MIKE11\Base_Case
Network File	Perrin_Creek_Base_Case.nwk11	
Cross Section File	Perrin_Creek_Base_Case.xns11	
Boundary File	XXXyrXXXmin.bnd11	
Hydrodynamic File	Perrin_Creek_Base_Case.HD11	
Results File	XXX_XXX_2010.RES11	
Time Steps	5/10 seconds	

MRC Model		
Simulation File	Perrin_Creek_MRC_XXX_XXX.sim11	G:\BI\CD\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2010\Modelling\MIKE11\MRC
Network File	Perrin_Creek_MRC.nwk11	
Cross Section File	Perrin_Creek_MRC.xns11	
Boundary File	XXXyrXXXmin.bnd11	
Hydrodynamic File	Perrin_Creek_MRC.HD11	
Results File	XXX_XXX_2010.RES11	
Time Steps	5/10 seconds	

MRC + WC Model		
Simulation File	Perrin_Creek_MRC+WC_XXX_XXX.sim11	G:\BI\CD\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2010\Modelling\MIKE11\MRC+WC
Network File	Perrin_Creek_MRC+WC.nwk11	
Cross Section File	Perrin_Creek_MRC+WC.xns11	
Boundary File	XXXyrXXXmin.bnd11	
Hydrodynamic File	Perrin_Creek_MRC+WC.HD11	
Results File	XXX_XXX_2010.RES11	
Time Steps	5/10 seconds	

Model Files and Runs used in Mike 11 modelling.	
XXX_XXX	Represents all of the following model runs for the following ARI events and Storm Durations
"XXX_"	ARI Event
"_XXX"	Storm Duration
ARI Events used	2yr, 5yr, 10yr, 20yr, 50yr, 100yr.
ARI Events written as follows	002, 005, 010, 020, 050, 100
Storm Durations used	30min, 45min, 60min, 90min, 120min, 180min.
Storm Durations written as follows	030, 045, 060, 090, 120, 180

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I-3 Results Files

I-3.1 Modelling Results Summaries

A summary of all the results from the 2010 modelling with comparisons to results from modelling completed in 1999 can be found in the files and locations as outlined in **Table I-3** below.

Table I-3: Results Summaries and Locations

Modelling Results Files		
RESULTS FILE	FILE NAME	LOCATION
Mike 11 Results Summary	W30389634-AA021Ahz_MIKE11_2010_vs_MIKE11_1999.xls	G:\BI\CD\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2010\Calculations\Mike11
Rafts Results Summary	Results.xls	G:\BI\CD\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2010\Calculations\Raft
HEC RAS structure check results summary	results.xls	G:\BI\CD\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2010\Calculations\Hecras

Refer to **Table I-4 Project Document Chain** in **Section I-4.3**.

I-4 Proposal and Reporting

I-4.1 Proposal

The proposal (variation) for the upgrade of the Perrin Creek modelling can be found at the following location:

G:\BI\CD\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2010\Documents\WPData\Proposals

I-4.3 Reporting

All reports and associated appendices for the finalisation of the study can be found at the following location:
G:\BI\CD\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2010\Documents\WPData\Reports

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Table I-4 Project Document Chain

Document Type	Document Title	Date	Directory Location
Proposal	PERRIN_CREEK_FLOOD_STUDY_REVIEW Final Proposal_Project Plan	26th October 2005	G:\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2005-6\Documents\Proposals\Final Proposal_Project Plan
Progress Report	W30389643_ST001Amr_sf p 2301_Status Report1	Nov 2005 to Mar 2006	G:\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2005-6\Documents\Reports\Progress_Status Reports
Progress Report	W30389634-ST002Bes_Progress Report	Dec 2006 to Apr 2007	G:\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2006-2007\Documents\Progress Reports
Memorandum	W30389634_PR001Dmr_Proposal Variation Perrin ck model Finalisation	25th October 2006	G:\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2005-6\Documents\Proposals\0607
Progress Report	W30389634-ST002Bes_Progress Report	Dec 2006 to Apr 2007	G:\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2006-2007\Documents\Progress Reports
Progress Report	W30389634-PR001Crles_PerrinCreek_November_2007	Sep 2007 to Nov 2007	G:\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2007-2008\Documents\Progress Report\Progress Report 15112007
Progress Report	W30389634_PR002Djc_PerrinCreek_January_2008	Jan 2008	G:\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2007-2008\Documents\Progress Report\Progress Report 15112007
Progress Report	W30389634-PR001Crljc_PerrinCreek_March_2008.doc	March 2008	G:\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2007-2008\Documents\Progress Report\Progress Report 26032008
Draft Report	W3060314-RE001Aes_Perrin_Creek_Investigation_rev4.doc	April 2008	G:\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2007-2008\Documents\Reports
Draft Report	W3060314-RE001Aes_Perrin_Creek_Investigation_FINAL_MK.doc	June 2009	G:\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_REVIEW\2007-2008\Documents\Reports
Variation	W30389634Bhz_Perrin Creek Flood Investigation.doc	September 2010	G:\BI\CD\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_RE

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			VIEW\2010\Documents\WPData\Proposals
Final Report	W3060314-RE002Ahz_Perrin_Creek_Investigation_Final.doc	February 2010	G:\BI\CD\Project\0389634_PERRIN_CREEK_FLOOD_STUDY_RE VIEW\2010\Documents\WPData\Reports

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Appendix I: DHI Memo – Perrin Creek MIKE 11 Model Upgrade Advice and Review

DRAFT

By Email

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Nerang QLD 4211
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Fax: +61 7 5527 4177
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Web: dhigroup.com

Brisbane City Council
City Design
Level 3 TC Beirne Building
315 Brunswick St Mall
Fortitude Valley, QLD 4006

ATT [redacted]
PH [redacted]

Init: SPS
Ref: 50437/BCCMR-1

Date: 17/11/2006

Dear [redacted]

PERRIN CREEK MIKE11 MODEL UPGRADE ADVICE AND REVIEW

We have completed a review of the Perrin Creek MIKE11 model and included a detailed description of the re-schematising and stabilising tasks completed below as well as recommendations for further development of the model.

Schematisation

The existing Perrin Ck MIKE11 model used a separate branch with a weir structure to model the flow overtopping the road bridges. The present modelling methodology incorporates the culvert and the weir at the same location on the same branch. We have updated the weirs in the model to follow this method and have removed the defunct branches from the network file. We also found that the existing weirs were only as wide as the actual bridge span. This may result in artificially high water levels and therefore we have updated the weir level width relationships to represent the full cross section above the weir crest level.

The connection chainage point of *Branch2* and *Branch3* to the main channe (*Branch1*) were found to conflict with the location indicated in the aerial photograph provided. We have updated these connections to match the aerial photograph and have also placed a cross section at the downstream end of *Branch2*.

Several cross sections appeared to be located at incorrect chainage positions on the model branches. We updated the cross section chainages based on the survey positions provided by council and have included details of the new chainages in Attachment A. We also found that several of the cross sections extended beyond the immediate floodplain and overlapped the same area of the floodplain that was modelled by neighbouring branches. These cross sections were modified by moving the bank markers accordingly. A large number of cross sections were found to have non-monotonically increasing conveyance curves. These were rectified by adjusting the left and right bank "high flow" markers to separate the channel from the floodplain in the conveyance calculation.

We redeveloped the culvert/pipe system under Wynnum Rd and the shopping centres to a closed cross section method within MIKE11 and incorporated energy loss structures at the junctions between different culvert/pipe sizes. The energy loss elements represent the turbulence loss that are assumed to occur under the road and shopping centres as the piped system transitions between various sizigns and configurations. It was not possible to verify these changes however they must be present in the system given the various pipe and culvert information.

We redeveloped the overland flow path between Wynnum Rd and the outlet of the culvert/pipe system. This was routed based our observations from the aerial photograph and the DTM provided by council. The weir levels for

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overflow into the overland flow system were based on those from the original model network and the cross section were taken from the DTM.

We found that the rock gabion located downstream of Baringa Street was represented incorrectly and was producing substantial model instability. We have separated the cross sections upstream and downstream and have represented the rock gabion with broad crested weir.

Stability

The primary issue with the stability of the existing model included:

1. Poor definition of conveyance curves in cross sections
2. Closely spaced cross sections producing high Courant number conditions.
3. Poorly defined structures and culverts
4. Poorly defined initial conditions

These issues were improved as described above and the model stability was dramatically increased. The model runs on a 30 second timestep with no stability issues.

Recommendations

Based on our re-development of the model we have several recommendations to confirm the model results.

- The values used in the level width relationship for the weir used to represent the rock gabion downstream of Baringa St were estimated based on the upstream cross section and site photos. This weir section should be surveyed or estimated from existing laser survey data sets
- The broad crested weir levels used in the various road bridge weirs should be cross checked with values from a DTM or similar available data.
- The routing and flow characteristics of the overland flow path from Wynnum Rd to Baringa St should be checked to ensure that this is accurate. This could be done with a 2D overland flow model. It is not possible to accurately define the overland flow characteristics of this area with a 1D model. We note that the majority of the 100 year flow passes overland through this area.
- In addition the weir level at the downstream end of the overland flow path branch should also be checked as the recent development of the shopping centre at this location may have changed levels significantly
- The weir levels used in the overflow branches between Branch1 and Channel1A should be redefined as discrepancies were found between the weir levels and the cross section data.

Should you have any further queries please don't hesitate to contact me on (07) 5502 2455.

Yours sincerely,
DHI Water and Environment Pty Ltd

[redacted]
State Manager

Enclosed: Attachment A - Specific Model Changes

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Attachment A
Specific Model Changes

BCC.079.0269

Table 1: Cross sections moved on Branch1

Original Chainage	New Chainage
1720	1735
2245	2255
2865	2925
2835	2880
2828	2865
2942	2987
3033	3065
3097	3143
3454	3420
3497	3480
3540	3522
3587	3577
3635	3624
3701	3677
3753	3728
3782	3774
3825	3810
3890	3858
3934	3924
3998	3975

Cross Sections with left and right bank markers added

2458
4364
4400
4420
4509
4680
4901
4911
5022

Trimmed Cross Sections

3411
3774
3728

Re-schematised Weirs

Barrack
Junction
Richmond
Bridgewater
Lang
Baringa

BCC.079.0270

Stable Swamp Creek Flood Study

Report A - Model Calibration

June 2010

DRAFT

Prepared by
Water and Environment
City Design

Prepared for
Water Resources
City Planning and Sustainability

Stable Swamp Creek Flood Study

Report A – Model Calibration

DRAFT

City Design
Floor 1 Green Square
505 St Pauls Terrace
Fortitude Valley QLD 4006

Document Control

G:\BI\CD\Proj06\060949_Stable_Swamp_Ck_Flood_Study\Documents\Draft_Flood Study_For Review\Report A - Calibration Report\StableSwampFloodStudy_ReportA_Calibration - FINAL.doc

Issue No.	Date of Issue	Prepared By (Author/s)		Edited and Proofread By		Reviewed By		Approved for Issue (Project Director)	
		Name	Initials	Name	Initials	Name	Initials	Name	Initials
Draft 1	February 2008	[redacted]							
Draft 13	May 2008								
Draft 15	2009								
Draft 18	March 2010								
Draft 19	June 2010								

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1 Introduction

1.1 Purpose

The purpose of the Stable Swamp Creek Flood Study was to determine flood levels across the Stable Swamp Creek catchment for range of storm events. These flood levels are to be used for setting development guideline levels for proposed development in the vicinity of the Stable Swamp Creek watercourse.

1.2 General

The Stable Swamp Creek catchment is located within the south-western suburbs of Brisbane, covering an area of approximately 27km^2. The catchment consists of several waterways, the four of principal interest being;

- Stable Swamp Creek;
- Shelleys Creek;
- Archerfield Channel; and
- A tributary of Stable Swamp Creek known as North Arm

Figure 1.1 illustrates the extent of the Stable Swamp Creek catchment.

Stable Swamp Creek winds through the suburbs of Sunnybank, Coopers Plains, and Salisbury before discharging into the downstream reaches of Oxley Creek at Rocklea. Stable Swamp Creek is a largely modified system. There are few natural sections of the creek remaining. Much of the floodplain has been filled for urban and industrial development and public open space usage.

Hydraulic structures are frequent, primarily for the many road crossings and include road, rail and footbridge crossings. The downstream reaches of Stable Swamp Creek are tidal and support mangroves and wetland areas. In these downstream reaches the floodplain is wide and interacts with the lower reaches of Oxley Creek.

Stable Swamp Creek North Arm originates in Coopers Plains upstream of the Beryl Roberts Basin and joins the main Stable Swamp Creek branch at Archerfield adjacent to the corner of Musgrave Rd and Deal Street.

Shelleys Creek drains the southern areas or furthest upper reaches of the catchment running south to north, including Sunnybank Hills and Calamvale before becoming Stable Swamp Creek at Beenleigh Road in Sunnybank. Shelleys Creek and Stable Swamp Creek are both largely urbanised catchments with some parkland and industrial zoning.

Shelleys Creek is steep, incised and largely constrained by residential development. The creek is in a relatively natural condition until Lang Street where it becomes canalised and concrete lined to the confluence of Stable Swamp Creek at Boundary Road Sunnybank.

The Archerfield Channel was constructed in the 1940's as part of the Archerfield Airport development and drains areas of Archerfield and Acacia Ridge also running south to north and discharges into Stable Swamp Creek between Colvin Street and Beaudesert Road in Salisbury.

South of Boundary Road Archerfield Channel passes through a series of detention basins before opening into a 1.5km long linear concrete lined channel north of Boundary Road. The catchment is largely industrial and undeveloped land is zoned for future industrial use.

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A further tributary of Stable Swamp Creek, South Arm, flows through Acacia Ridge and Archerfield before joining Stable Swamp Creek at Gay Street Sunnybank. South Arm flows through large areas of Queensland Rail property and is predominately piped underground therefore is not hydraulically modelled. However the South Arm catchment has been included in the hydrologic model and flows from the South Arm catchment are included in the hydraulic model.

The total catchment area of Stable Swamp Creek is 27km^2, the sub catchment area of Shelleys Creek is 3.3km^2 and that of Archerfield Channel is 3.1km^2. The total number of hydraulic structures on Stable Swamp Creek, Shelleys Creek and Archerfield Channel, is 23, 7 and 2 respectively.

1.3 Study Elements

The Stable Swamp Creek Flood Study consists of three elements;

1. Model set up and calibration
2. Design event modelling

Report A - Model Calibration

Hydrologic and hydraulic models were developed for the primary waterways within the catchment study area. The hydrologic model simulates catchment rainfall-runoff and, in a simplified approach, the movement of flood waters down the creeks. The hydraulic model simulates the movement of flood waters using advanced mathematics, thereby giving a more accurate representation of flood behaviour, particularly where downstream effects and hydraulic structures are influential.

Calibration is a process of model parameter adjustment by which flood levels generated by the model using recorded rainfall are compared with recorded flood level data for the event in question. When sufficient points are in agreement the model is considered to be "calibrated" to that event. By calibrating to a range of historical flood events the model can be used more confidently to represent the action of the catchment and to develop design event flood levels.

The model was calibrated to the January 1998, March 2001 and November 2004 events and verified to the May 1996 event.

This report, Report A – Model Calibration documents the data used in the RAFTS hydrologic and MIKE 11 hydraulic models, revisions and updates to the existing hydrologic and hydraulic models and the details of the amalgamation of these existing models to a new comprehensive model for the Stable Swamp Creek system.

Report B - Design Event Modelling

Following on from Report A, Report B – Design Event Modelling provides the results of the design event model simulations obtained using the calibrated hydrologic and hydraulic models. The 100, 50, 20, 10, 5 and 2 year ARI events have been modelled. Peak flood levels and peak flood discharges for all design events are tabulated in Appendix B of Report B.

As part of Report B, the impact of future development and the importance of the riparian (streamside) habitat on flood levels was also considered.

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Report C - Mitigation Options

An existing mitigation options report has been included with this flood study. The Stable Swamp Creek model has undergone refinement since assessment of the various mitigation options available for the Stable Swamp Creek watercourse and consideration of this fact should be taken where reviewing model results and proposed mitigation options in this report.

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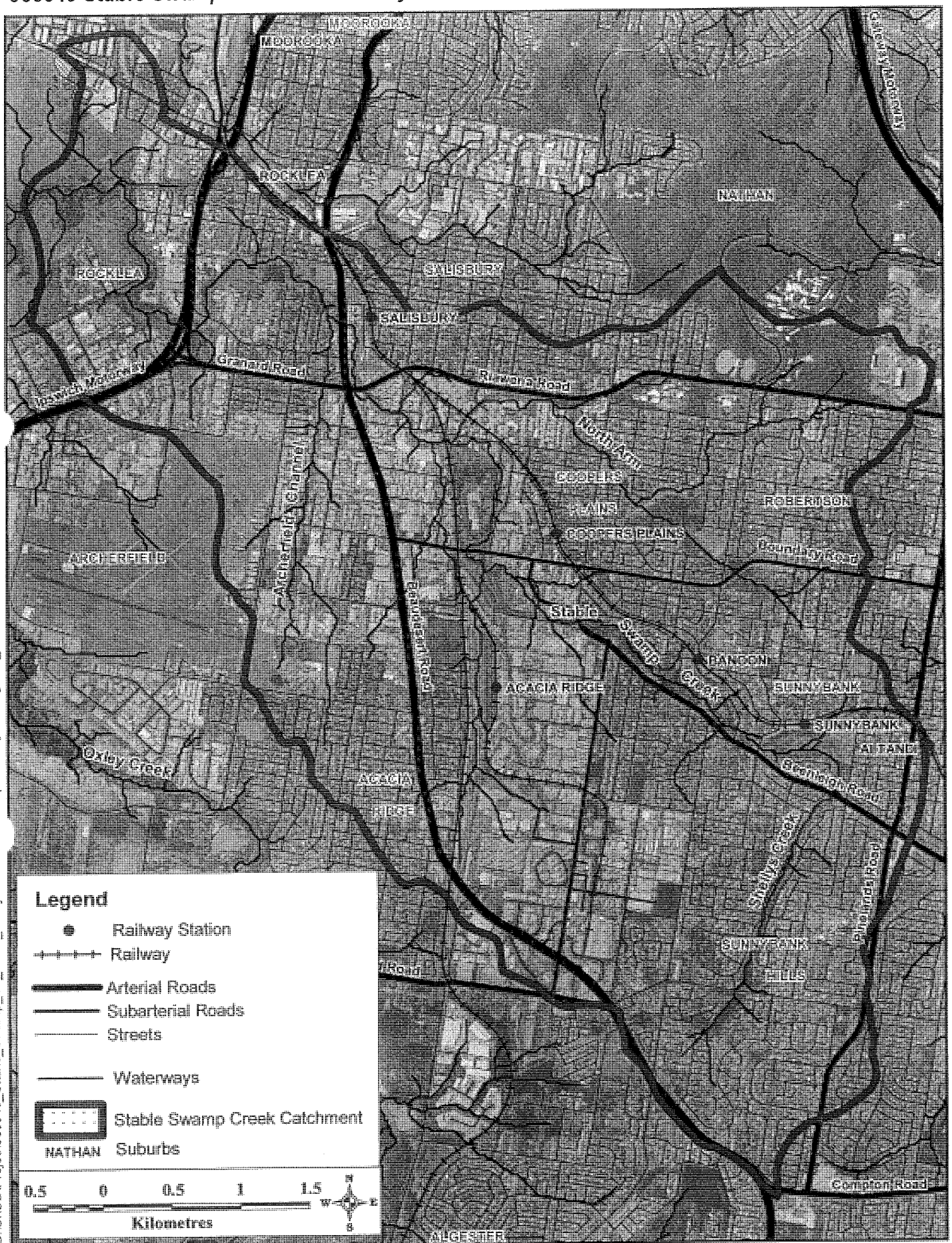

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Stable Swamp Creek Catchment

Figure 1.1

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2 Available Data

2.1 Hydrographic Data

2.1.1 Continuous Rainfall Gauges

Continuous rainfall gauges located in or near Stable Swamp Creek catchment are shown in Figure 2.1 and the available rainfall data summarised in Table 2.1. Historical rainfall data from these gauges were used for calibration and verification of the hydrological and hydraulic models as summarised in Table 2.1. Rainfall contours developed by Council's flood database FloodWise were used to determine the spatial distribution of total rainfall across the catchment. An explanation of the gauges selected for each calibration event is included in Section 4 Calibration.

Table 2.1 Available and Adopted Rainfall Data

Gauge	Location	Operation Period	Calibration Events			Verification Events	
			Jan 98	Mar 01	Nov 04	Mar 92	May 96
SSR130	Musgrave Road Coopers Plains	10/03/1994 to 12/05/2003	✔✔	✔✔	NA	NA	✔✔
OXR114	Calamvale Telstra Calamvale	16/02/1989 to now	✔	✔✔	✔✔	✔✔	✔✔
R_R747	Dulcie Street Mt Gravatt	08/01/2001 to now	✔	NA	✔✔	NA	NA
BMR138	Griffith University Mt Gravatt	16/02/1989 to now	✔	✔	✔	✔✔	✔✔
OXR126	Beaty Road Acacia Ridge	01/06/1989 to 12/05/2003	✔✔	✔	NA	✔✔	✔✔
OXR020	Corinda High School Corinda	25/05/1991 to now	✔✔	✔	✔	✔	✔✔

✔ Data available
✔✔ Data available and adopted for calibration
NA: No data available

2.1.2 Continuous Streamflow Gauges

Two continuous height stream gauges are located in the Stable Swamp Creek catchment area. Firstly, gauge SSE129 located at Musgrave Road, Coopers Plains on Stable Swamp Creek which is now non operational and replaced by SSA847 for future reference and secondly, OXA023 located at Corinda High School on the western side of Oxley Creek, see Figure 2.1.

Data from these two gauges was sourced from Council maintained records to verify the adoption of calibration and verification events used in previous studies and to identify new calibration events which may have occurred since the previous studies were completed.

The Coopers Plains Stable Swamp Creek gauge was used for the calibration of the hydrologic and hydraulic models and the determination of rating curves, and the Corinda High School Oxley Creek gauge for verifying downstream boundary conditions within Oxley Creek during calibration events. (see Table 2.2 and Figure 2.1).

At the Corinda High School Gauge OXA023, continuous height data was only available for the 1992, 2001 and 2004 calibration events. The data was considered to be unreliable for the other calibration events as the gauge was not functional during the May 1996 event and the January 1998 event.

Table 2.2 Details of continuous height recorders

Station	Owner	Period of Operation	Format of Data	MIKE 11 Chainage (m)
SSE129 - Musgrave Road – Coopers Plains (Stable Swamp Creek)	BCC	30/05/89 to now	Digital	5159
OXA023 - Corinda High School – Corinda (Oxley Creek)	BCC	22/05/1991 to now	Digital	NA

Table 2.3 Peak Water Levels at Continuous Gauges

Continuous Gauge	Calibration Events (m AHD)			Verification Events (m AHD)	MIKE 11 Chainage (m)
	Jan 98	Mar 01	Nov 04	May 96	
SSE129 - Musgrave Road – Coopers Plains (Stable Swamp Creek)	NA	8.24	7.68	6.94	5158
OXA023 - Corinda High School – Corinda (Oxley Creek)	NA	2.59	2.80	NA	NA

2.1.3 Maximum Height Gauges (MHG)

There are twenty five maximum height gauges (MHGs) within the greater Stable Swamp Creek catchment for which records are available from 1992 onwards. All except four gauges were used to source data for calibration purposes; two gauges located on Shelleys Creek branch, two on Archerfield Channel, three on North Arm and 14 on Stable Swamp Creek branch itself were used to source data for calibration purposes.

Four gauges, two on North Arm and two in Stable Swamp Creek were discarded as they were recently installed and have data available for events from 2006 onwards only. The location of each of the MHGs and their assigned MIKE 11 chainage is given in Table 2.4. Figure 2.2 illustrates the locations of the MHGs and Table 2.5 summarises peak flood levels recorded at each MHG for the calibration events.

It was also noted that:

- Gauges SS220 and SS190 for the November 2004 event and SS120 for the March 2001 event on Stable Swamp Creek are debris level readings only as the gauges were destroyed during this event.
- Gauge SS130 on Stable Swamp Creek and Gauge SS400 for the March 2001 event on Archerfield Channel were debris level readings as the water level overtopped the maximum height of the gauge.

Table 2.4 MHG Locations

Gauge Name	MIKE 11 Chainage (m)	Branch	Location Description
SS250	10948	Shelleys Creek	Kingman Street - Sunnybank Hills
SS240	11844	Shelleys Creek	Lang Street - Sunnybank Hills
SS230A	1430	Stable Swamp	Stones Road- Sunnybank Hills
SS220	3068	Stable Swamp	Cnr Beenleigh Road/Gay Street - Sunnybank Hills
SS210	3838	Stable Swamp	Gay Street - Sunnybank Hills
SS200	3921	Stable Swamp	Boundary Road (Culvert)-Coopers Plains
SS190	3996	Stable Swamp	Annie Street - Archerfield
SS180	4594	Stable Swamp	Edith Street - Archerfield
SS170	5380	Stable Swamp	Inter Alton Street/Musgrave Road - Archerfield
SS160	5570	Stable Swamp	Norbury Street- Archerfield
SS150	6324	Stable Swamp	Dollis Street- Archerfield
SS140	6560	Stable Swamp	Colvin Street- Archerfield
SS130	6978	Stable Swamp	Between Tramore Street/Leeds Street - Rocklea
SS120	7788	Stable Swamp	Marshall Road - Rocklea
SS110	8135	Stable Swamp	Ipswich Road - Rocklea
SS100	9135	Stable Swamp	Franklin Street - Rocklea
SS400	2224	Archerfield Channel	Marshall Road (Culvert) - Archerfield
SS410	1750	Archerfield Channel	Rodwell Street - Archerfield
SS300	1720	North Arm	Railway Bridge (TNT Depot)- Salisbury
SS310	850	North Arm	Between Burgess Street/Debra Street - Salisbury
SS320	312	North Arm	Cnr Musgrave Road / Orange Grove Road

Table 2.5 Maximum Flood Height Recordings from MHGs

Gauge Name	Peak Flood Level (m AHD)			
	Event Date			
	May 96	January 98	March 01	November 04
Shelleys Creek				
SS250	NA	NA	52.24	51.41
SS240	NA	NA	43.16	43.14
Stable Swamp				
SS230A	NA	NA	NA	33.3
SS220	17.75	NA	NA	17.45
SS210	15.37	15.97	15.87	15.16
SS200	NA	11.9	12.65	NA
SS190	10.79	NA	11.76	11.84
SS180	8.4	NA	10.02	9.33
SS170	6.58	7.35	8.12	7.38
SS160	6.27	6.97	7.78	6.98
SS150	5.53	5.91	6.61	6.13
SS140	5.15	5.26	6.23	5.77
SS130	4.98	4.99	5.95	5.42
SS120	4.88	4.82	5.54	5.10
SS110	4.71	4.55	5.10	5.04
SS100	4.49	3.13	3.85	3.71
Archerfield Channel				
SS400	NA	NA	6.31	5.92
SS410	NA	NA	7.12	6.79
North Arm				
SS300	NA	7.73	9.36	NA
SS310	NA	NA	12.77	NA
SS320	15.5	15.66	16.87	NA

NA - No data available
Level from nearby debris height
Gauge destroyed and level from debris
Level over top of inner gauge therefore level from debris

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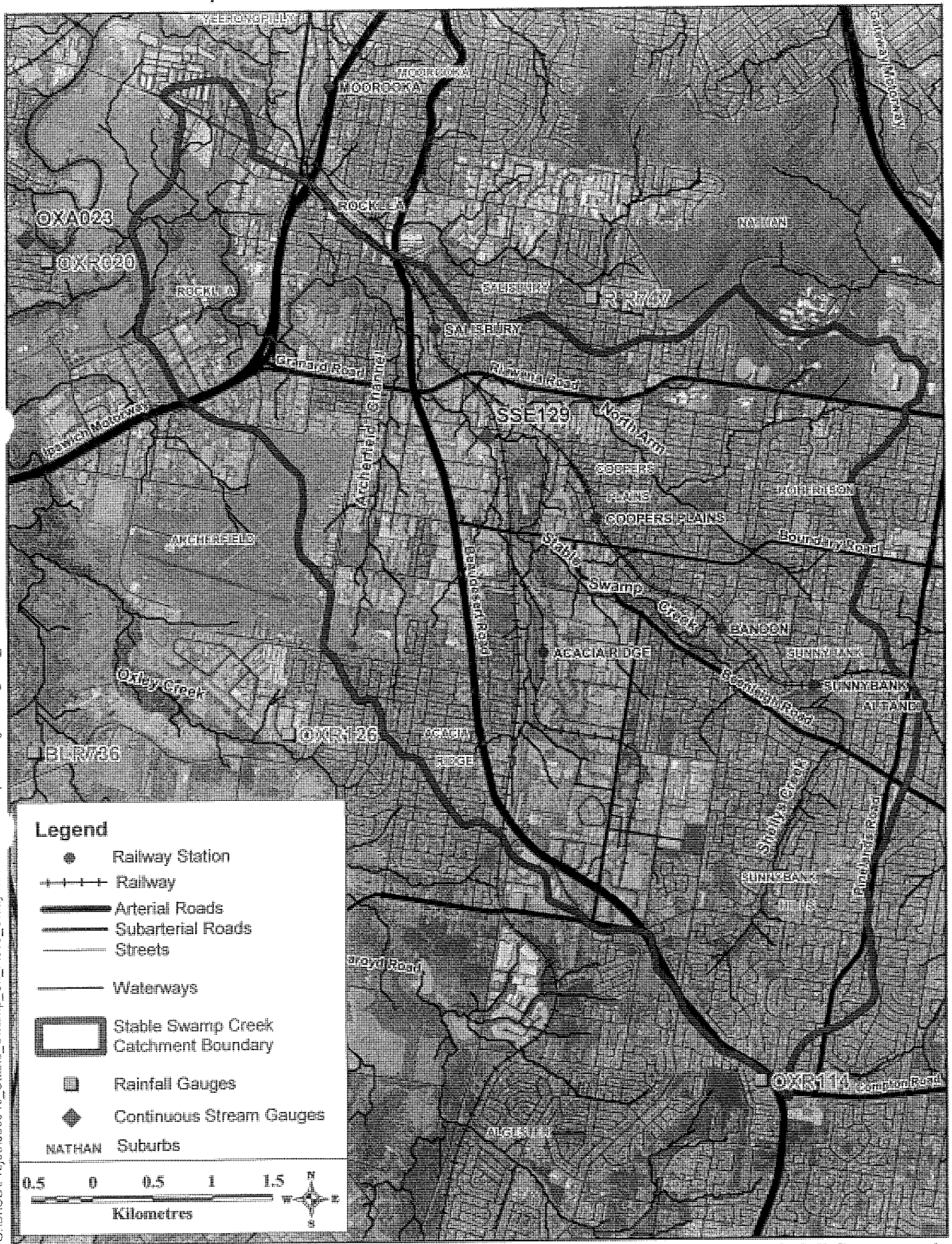

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Rainfall Gauge and Continuous Stream Gauge Locations

Figure 2.1

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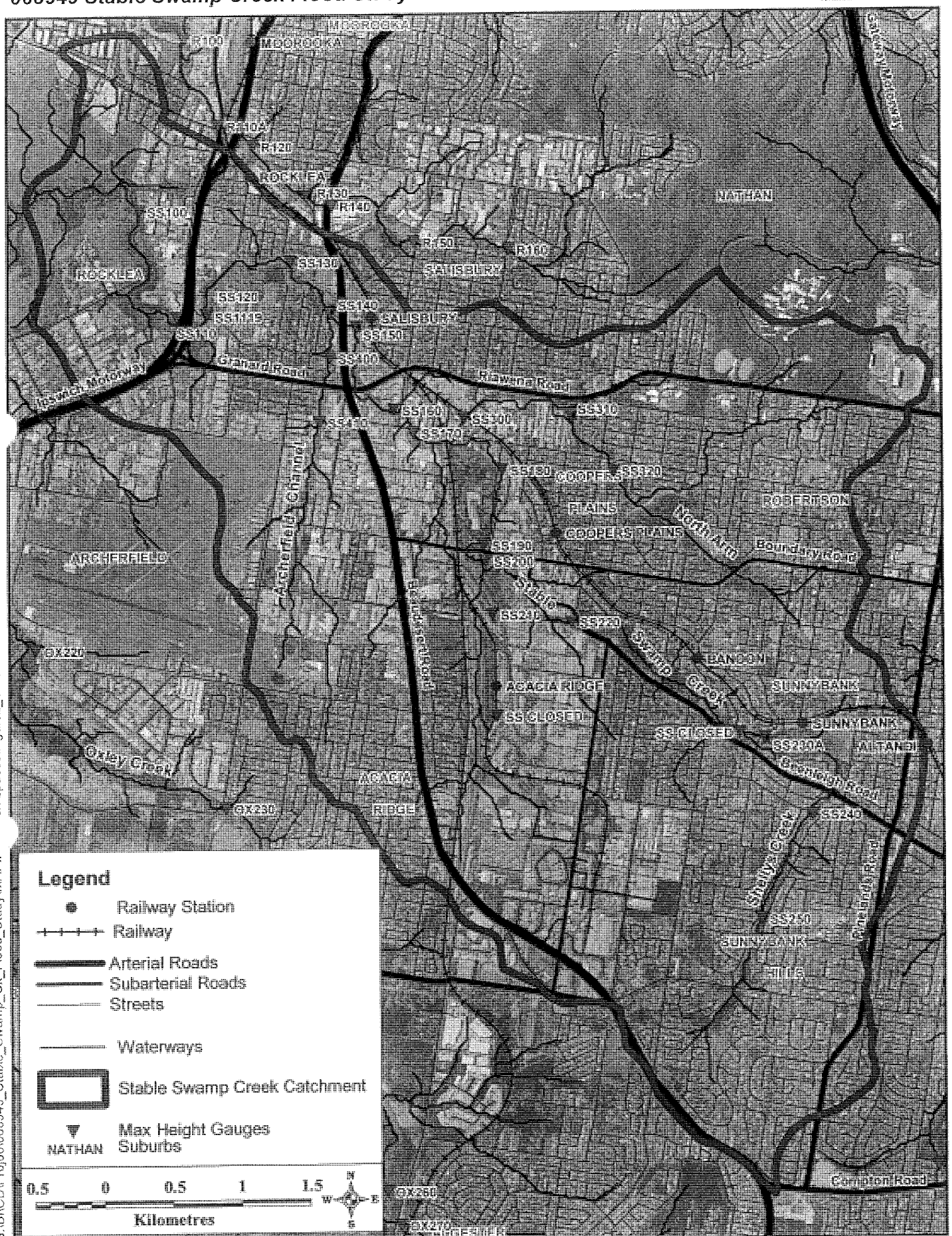

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Max Height Gauge Locations

Figure 2.2

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2.2 Topographic Data

2.2.1 Creek Cross Sections

Cross section data used to define waterway bathymetry in the MIKE 11 hydraulic model was sourced as follows;

- Stable Swamp Creek, including North Arm – Cross sections originated from detailed channel survey of Stable Swamp Creek conducted between November 1998 and March 1999.
- Archerfield Channel – Cross sections originate from the channel survey of Archerfield Drain conducted in May 1999.
- Shelleys Creek: Chainage 0 – 1709 sourced from Shelleys Creek survey undertaken in March 1999.
- Chainage 11766 – 10100 sourced from November 1998 – March 1999 survey.

Table A.4 in APPENDIX A2 documents the MIKE 11 cross sections.

New cross-section survey was taken at Keats Street in June 2006 to describe channel modification since the previous survey. Additional survey sections were also acquired for Beryl Roberts Basin in August 2006.

2.3 Hydraulic Structures

Three structures were identified as having been replaced or modified since being surveyed in 1998:

- A replacement footbridge at Colvin Street Rocklea;
- A replacement footbridge at Freney Street, Rocklea; and
- A replacement road bridge at Stones Road crossing Sunnybank.

Structure information in the MIKE 11 model was updated using the design drawings for the replacement structures. Structure information for all structures included in the MIKE 11 model is summarised in Table A.5 in Appendix A2 and also in the hydraulic structure reference sheets (HSRS) provided in Report B Design Modelling.

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3 Model Descriptions

3.1 Introduction

Hydrologic models simulate the catchment rainfall-runoff and, in a simplified approach, the movement of flood waters down the creeks. Hydraulic models simulate the movement of flood waters using more advanced mathematics, thereby giving a more accurate representation of flood behaviour, particularly where downstream effects and hydraulic structures are influential.

The hydrologic model was set up based on the RAFTS software version 6.3 (XP Software, 1996) and is described in Section 3.2.

The unsteady hydraulic model was developed based on MIKE 11 version 2009 (DHI, 2009). Unsteady models simulate the progression of a flood wave down the creek over time and therefore have the ability to simulate:

- the rise and fall of a flood;
- variations in downstream tidal effects;
- storage effects of floodplains; and
- overland flowpaths

The unsteady hydraulic model is described in Section 3.3.

3.2 Hydrologic Model

Sub-catchments are represented as nodes within the RAFTS to provide points within the model where total and localised flow hydrograph information can be extracted. The hydrologic model included a total of 88 sub-catchments or nodes to describe the 27km^2 catchment.

Of these sub-catchments, 20 were located in the Shelleys Creek catchment, 31 in Archerfield Channel, 12 in North Arm and 25 in Stable Swamp Creek. Sub-catchment boundaries were determined based on a review of existing catchment delineations and updated in accordance with the local topography using one metre IBIMAP contours and local drainage networks.

A further 33 "dummy" nodes were incorporated into the model to allow flow hydrographs to be derived for tributaries upstream of junctions.

Catchment area, land use (impervious and pervious), slope and roughness (PERN) values were used to define the sub-catchments. Figure 3.1 illustrates the model layout including sub-catchments.

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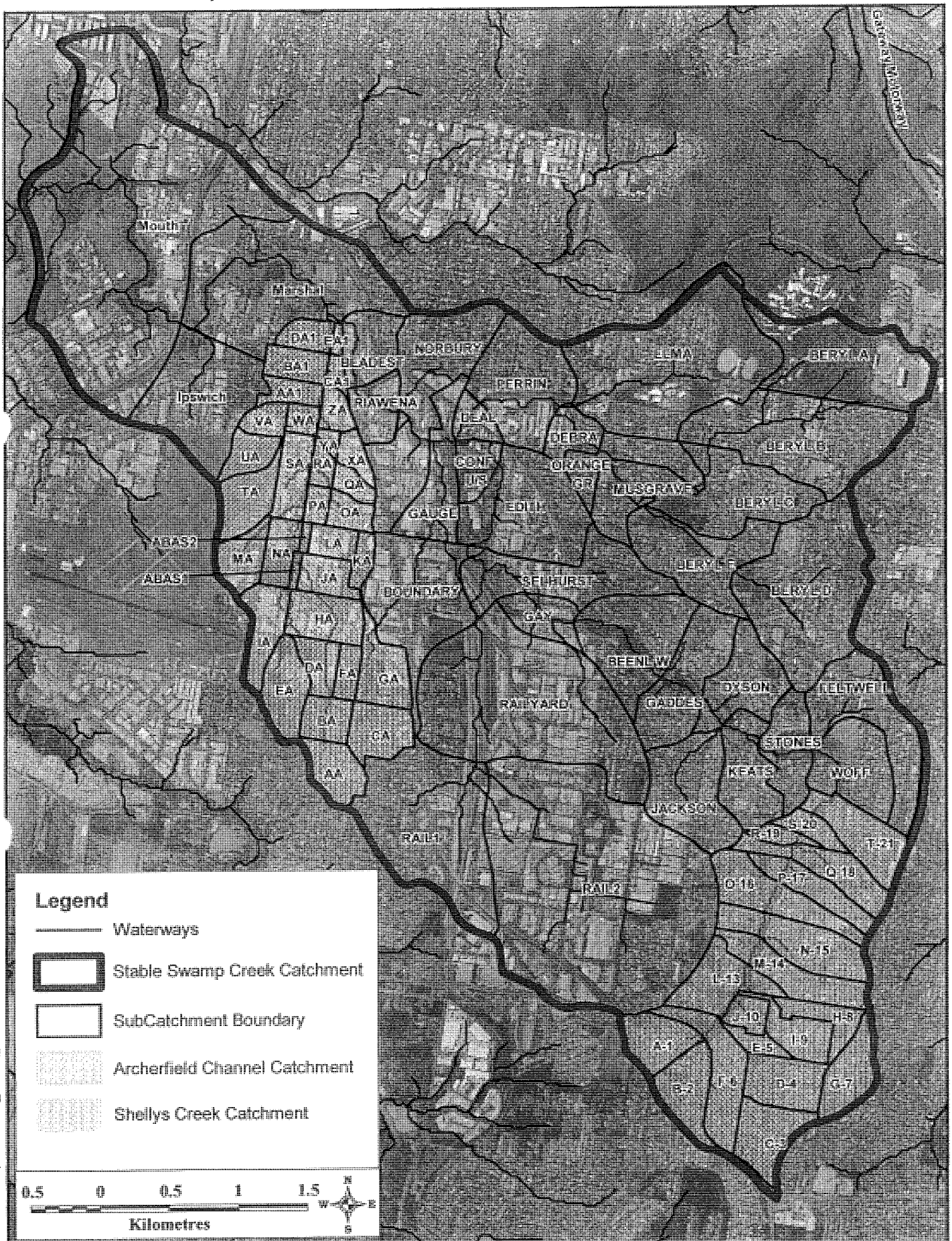

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Hydrologic Model Layout

Figure 3.1

BCC.079.0522

Table 3.1 shows the fraction impervious values adopted and Table A.1 in Appendix A1 summarises the sub-catchment properties.

Table 3.1 Adopted Fraction Impervious Values

Development Type		C10	Fraction Impervious
Commercial and Industrial		0.88	0.90
Residential B		0.88	0.90
Urban Residential A (Including Roads)	Lots greater than 750 m^2	0.77	0.35
	Lots 600 m^2 to 750 m^2	0.79	0.45
	Lots 450 m^2 to 600 m^2	0.81	0.55
	Lots 300 m^2 to 450 m^2	0.83	0.65
Rural Residential		0.74	0.20
Open Space and Parks etc		0.70	0.00

Note: The above table is an amalgam of the Brisbane City Council Department of Works Supplement to QUDM (Brisbane City Council 1994, p.QUDM-BCC-2) and the Queensland Urban Drainage Manual (QUDM) (Neville Jones & Associates and Australian Water Engineering, 1993, Tables 5.04.1 and 5.04.2). The Supplement lists the variation in 10 year event runoff coefficient for various land uses while QUDM relates runoff coefficient to fraction impervious.

RAFTS allows each sub-catchment to be divided into two sub-areas to reflect impervious and pervious portions. Due to the extent of catchment development, this approach was followed for all sub-catchments in the model.

The fraction impervious of sub-catchments was determined in accordance with the Brisbane City Council Department of Works Supplement to QUDM (Brisbane City Council 1994, p.QUDM-BCC-2) and the Queensland Urban Drainage Manual (QUDM) (Neville Jones & Associates and Australian Water Engineering 1993, Tables 5.04.2 and 5.04.1).

The determination of sub catchment size was made with consideration of ultimate land use conditions as detailed within Brisbane City Council's City Plan 2000. Where more detail was required, such as for the Beryl Roberts Park, impervious fractions were assigned based on aerial photography (2005 DigitalGlobe satellite imagery, BCC 2005). Table 3.2 broadly identifies the land use classification within Stable Swamp Creek catchment.

Table 3.2 Areas of land use – ultimate development scenario

Land Use Type	Total Area (ha)	% of Total Area
Open Space	525	19.6
Urban	1152	43.0
Commercial/ Industrial	1002	37.4
Total	2679	100.0

An average impervious value of 48% was obtained for the catchment.

The impervious fraction in the RAFTS software was set to zero for pervious areas and 100% for impervious areas. PERN values, which are a multiplication factor applied to the storage delay time coefficient "B" in the storage discharge relationship of the RAFTS hydrologic simulation at each to take into account the roughness of each subcatchment (Aitken, 1975) and were set to 0.05 and 0.025 for pervious and impervious subcatchments respectively

The drainage paths of the Stable Swamp Creek catchment were represented in the RAFTS model by a number of links, including channel routing links, lagging links and dummy lagging links (with zero lag time).

Creek cross sections are a requirement for and were applied to routing links and were sourced from channel surveys of Stable Swamp Creek, Shelleys Creek and Archerfield Channel. In the majority of cases, reaches in the RAFTS model extended across a number of surveyed cross sections. In each case, the cross section considered to be most representative of the reach was input to the RAFTS model.

Mannings 'n' values for each cross section were initially derived from those applied to the hydraulic model and then varied within reasonable limits as part of the calibration process. Dummy link lags were used to connect tributaries to the main drainage line and to allow for additional nodes required for hydrograph derivation purposes. In all cases, a zero lag time was assigned to dummy links.

Full details regarding each link used in the model (including length, slope, adopted cross section and Mannings 'n' values) are listed Table A.1 in Appendix A1.

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3.3 Hydraulic Model

The extent of the Stable Swamp Creek 2010 MIKE 11 calibration model as shown in Figures 3.2, Figure 3.3 and Figure 3.4, include the following features:

- Approx 260 cross sections
- 21 branches
- 38 broad crested weirs and 40 culverts to describe road/pedestrian crossings and pipe crossings within the model
- 48 lateral inflows to points within the model
- 6 inflows to the upstream end of branches

Branch Layout

The Stable Swamp Creek 2010 model consists of four main branches;

- Shelleys Creek (Chainage 10000 – 12165);
- Stable Swamp Creek (Chainage 737 – 10100);
- Archerfield Channel (Chainage 1010 – 2500); and
- North Arm (Chainage 0 – 1900)

There are also a number of smaller branches including;

- Riawena Road (Chainage 10000 – 10176) – A small tributary of North Arm.
- Three branches associated with Beryl Roberts Basin in Coopers Plains; one for the main basin and two tributaries that flow into the basin known as Beryl Roberts Main and Beryl Roberts Tributary.
- Six link channels associated with the potential overland flowpath immediately upstream of the confluence of Archerfield Channel and Stable Swamp Creek.
- Three link channels and two branches associated with the potential overland flowpath located in the area upstream of the railway crossing at Coopers Plains.

Branch descriptions are provided in Table A.3 in Appendix A2.

Model Cross Sections

Cross sections were sourced from new and existing survey and existing MIKE 11 hydraulic models. The cross section database in the MIKE 11 model references data origin, namely BCC survey or aerial laser survey (ALS) data.

All cross sections are processed using the total area, hydraulic radius option for a minimum of 60 equidistant points. Bank markers 1, 2 and 3 define the left extent, invert and right extent of the cross sections respectively.

Table A.4 in Appendix A2 lists cross-section chainages, their adopted middle thread (AMTD) equivalent distance from the mouth of the watercourse and the BCC survey reference. Any changes to the surveyed cross-sections are described in this table.

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Model Parameters

Mannings n values were reviewed based on site inspection and aerial photography and are largely retained unchanged from previous models.

The existing adopted models for this study employed a hotstart parameter file to define initial conditions. In earlier versions of the Mike11 software package this was required to enable the model to begin a simulation with no water in the system or to run "dry". In order to improve stability and reduce run times of the updated model, the hotstart parameter file was no longer used to define initial conditions for the Stable Swamp Creek 2010 model.

Hydraulic Structures

Each of the 38 crossings, road and footbridge, are modelled with a combination of culverts and weirs. As a part of the model updating process and to improve model stability, all weirs and culverts have been converted and arranged in a single branch, online assembly. A summary of hydraulic structures including chainage and a description is provided in Table A.5 in Appendix A2.

Model inflows

A total of 55 inflows were defined to reflect the hydrologic behaviour of the creek and minimise localised increases in flow due to concentrated local inflows. An inflow was defined for the upstream boundary of Shelleys Creek, Archerfield Channel, Riawena Road, Beryl Roberts Main Channel and Beryl Roberts Tributary.

A further 48 lateral inflows account for catchments contained within the modelled area. A dummy flow of $0.01m^3/s$ is included at the top of the Railway overland flow branch to improve model stability.

The location of each inflow is shown in Figures 3.2 – 3.4. A complete listing and description of inflows is provided in Table A.6 in Appendix A2.

Tailwater Conditions

Hourly level records for Oxley Creek at the Corinda High School Telemetry Gauge (OXA023) were obtained for calibration and verification events and were used to inform the downstream boundary condition at Oxley Creek.

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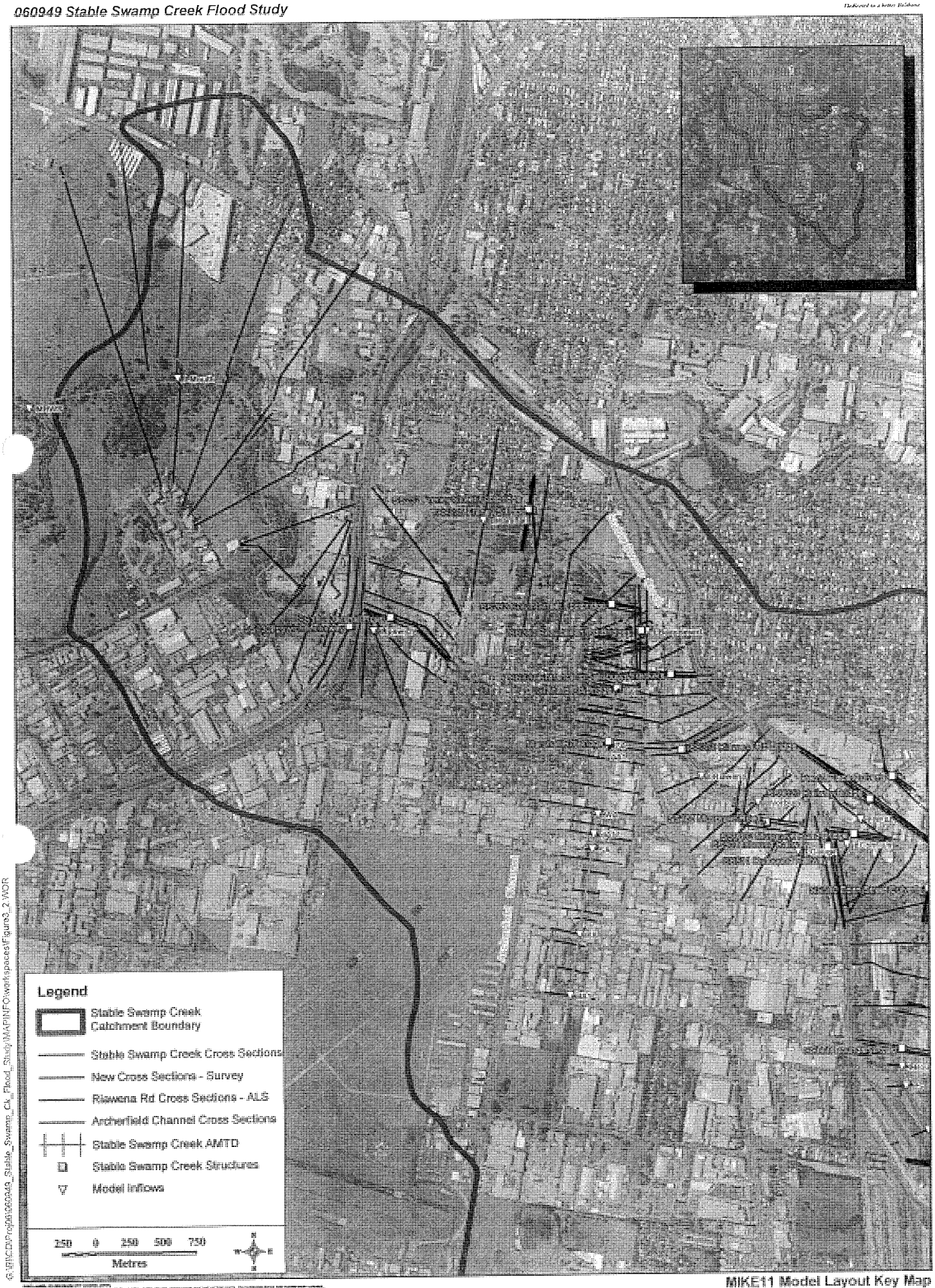

MIKE11 Model Layout Key Map

Figure 3.2

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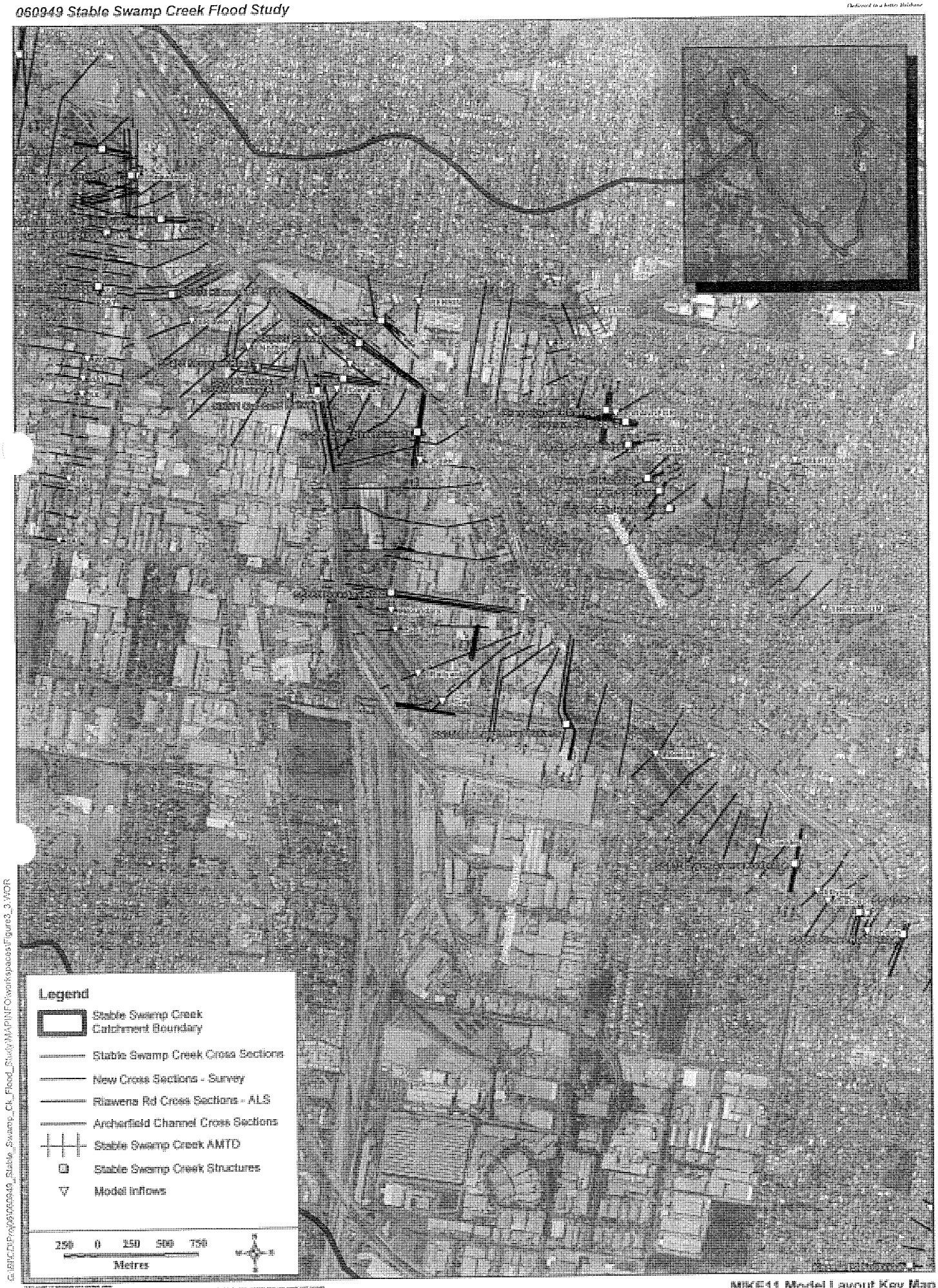

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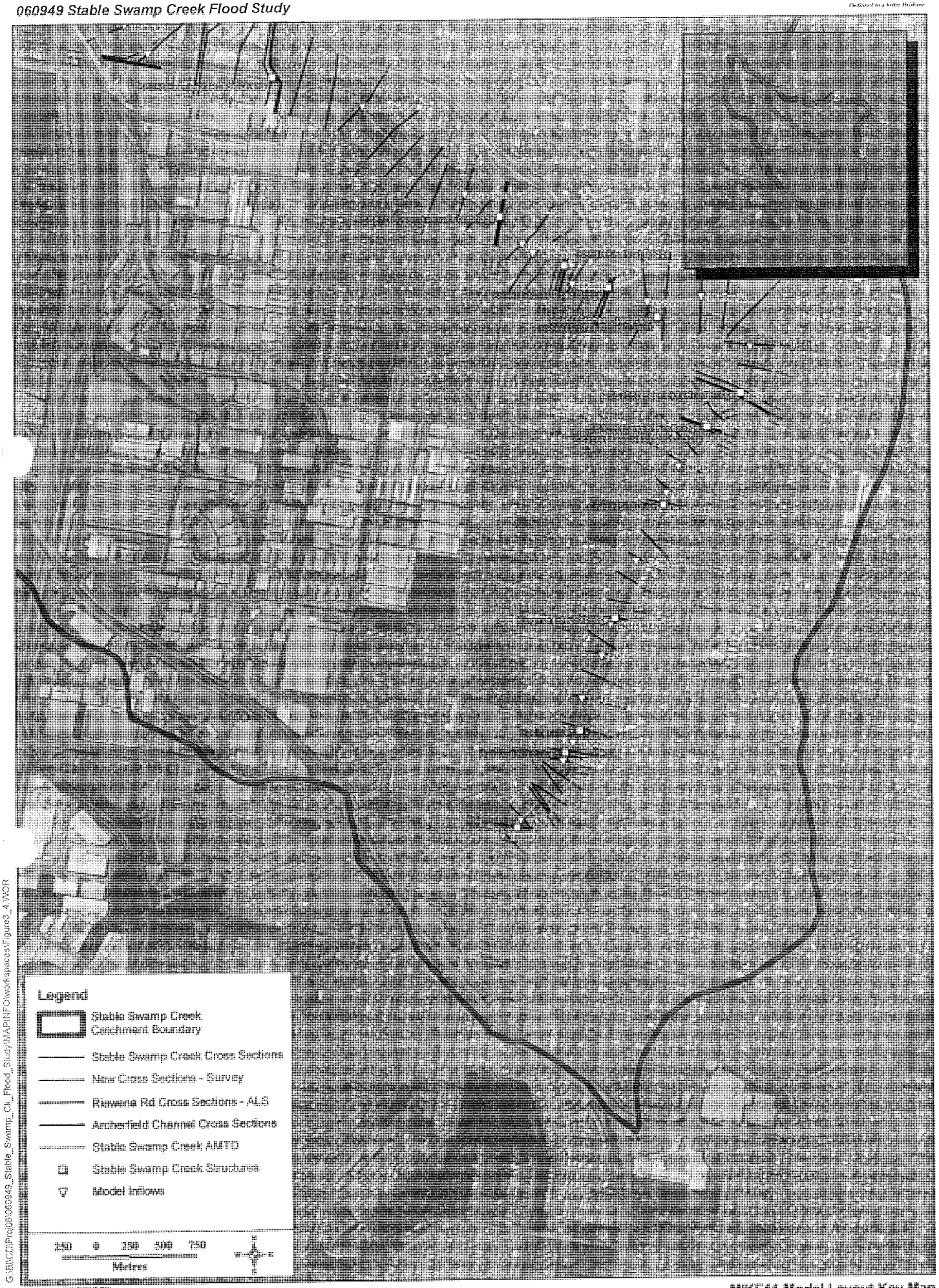
MIKE11 Model Layout Key Map

Figure 3.3



G:\BCC\Proj060\060949_Stable_Swamp_Ck_Flood_Study\MAPINFO\workspaces\Figure3_4.WOR

MIKE11 Model Layout Key Map

Figure 3.4

4 Calibration

4.1 Calibration Events

Calibration events were selected by considering the relative size of the event and the availability of data for each event. Events prior to 1984 were discarded as significant flood mitigation works were completed during 1983 – 1984 and survey data for the creek was collected in 1999.

Calibration Events

- January 1998
- March 2001
- November 2004

4.1.1 Hydrologic Model Calibration

Hydrologic model calibration was undertaken by comparing model generated flows to flows calculated using rating curves previously developed for the Musgrave Road stream gauge (SSE129). The RAFTS model parameter BX[1] was varied to improve the match of modelled flows to recorded events at the Musgrave Road stream gauge.

Initial and continuing losses were estimated based on the previous five days of rainfall for each historical event and adjusted to improve calibration with recorded data at the Musgrave Road gauge. The adopted losses are summarised in Table 4.1 and antecedent conditions for each event are discussed in further detail in Sections 4.2, 4.3 and 4.4. The calibration process demonstrated a BX value = 1 was most appropriate factor, where the BX value is a factor applied to the storage delay time coefficient (B) in the RAFTS simulation. The RAFTS default value of 0.285 was used for the storage non-linearity exponent "n".

Table 4.1 Initial and Continuing Loss Rates

Event	Initial Loss (mm)		Continuing Loss (mm/h)	
	Pervious	Impervious	Pervious	Impervious
January 1998	50	50	0	0
March 2001	50	50	0	0
November 2004	10	10	0	0
May 1996	10	10	0	0

4.1.2 Hydraulic Model Calibration

Channel, structure and floodplain modifications identified in Section 3.3 that occurred subsequent to calibration events were not included in the hydraulic modelling for the calibration and verification events.

Manning's n values were varied to improve the correlation of the modelled discharge and peak level with recorded data. Adopted manning's n values were not varied across calibration events and values chosen were chosen to represent the best calibration outcome with all events taken into consideration.

[1] The RAFTS parameter BX is a multiplication factor for the B parameter, where B = storage delay time coefficient

A summary of differences between the recorded and modelled flood levels at each of the MHGs is given in Table 4.2. Each event is analysed in more detail in the following sections.

Table 4.2 Difference between Recorded and Modelled Flood Levels

MHG	MIKE 11 Branch	MIKE 11 Chainage (m)	Calibration Events			Verification Events
			Jan 98 (m)	Mar 01 (m)	Nov 04 (m)	May 96 (m)
SS250	Shelleys Creek	10,948	-	-0.46	0.27	-
SS240	Shelleys Creek	11,844	0.39	0.34	0.29	-0.08
SS230A	Stable Swamp	1,430	-	-	0.21	-
SS220	Stable Swamp	3,068	-	-	0.28	-0.72
SS200	Stable Swamp	3,921	0.99	0.45	-	-
SS190	Stable Swamp	3,996	-	0.41	-0.03	0.20
SS180	Stable Swamp	4,594	-	-0.02	0.18	-0.28
SS170	Stable Swamp	5,380	0.09	-0.33	0.00	-0.12
SS160	Stable Swamp	5,570	0.11	-0.29	0.04	-0.15
SS150	Stable Swamp	6,324	0.06	-0.29	-0.12	-0.30
SS140	Stable Swamp	6,560	0.33	-0.12	-0.06	-0.14
SS130	Stable Swamp	6,978	0.29	-0.04	0.04	-0.47
SS120	Stable Swamp	7,788	0.15	0.14	0.10	-0.69
SS110	Stable Swamp	8,135	0.12	0.07	-0.22	-0.72
SS100	Stable Swamp	9,135	0.36	-0.03	-0.90	-1.39
SS400	Archerfield Channel	2,224	-	-0.06	-0.07	-
SS410	Archerfield Channel	1,750	-	-0.23	-0.06	-
SS300	North Arm	1,720	1.48	0.56	-	-
SS310	North Arm	850	-	0.70	-	-
SS320	North Arm	312	0.38	-0.13	-	-

- No level recorded
Blue Modelled result less than 150mm of recorded level
Red Modelled result greater than 150mm of recorded level
Green Modelled results within 150mm of recorded level

4.2 January 1998 event

The January 1998 event occurred on the 28th day of the month and was triggered by severe thunderstorms resulting in flash flooding in Brisbane's southern suburbs. The event was ranked by the Stable Swamp Creek Stormwater Management Plan (SMP) Flooding Technical Report (City Design, June 2000) as the second most severe event to be recorded in Stable Swamp Creek, after December 1978.

However recorded maximum height gauge readings indicate the event was less severe than the March 2001 and November 2004 events. Although the Musgrave Road stream gauge failed near the beginning of the event, 13 MHGs were operational.

Total rainfall and rainfall intensity was recorded at six rainfall stations as shown in Table 2.1. Rainfall gauge stations indicate there was zero recorded rainfall at all nearby gauges for at least five days prior to the event and the catchment could be therefore considered relatively dry and creek levels likely to be low. An initial loss of 50mm and 0mm continuous loss was adopted to allow a maximum amount of infiltration losses at the beginning of the event in consideration of the antecedent conditions.

Recorded and modelled peak flood levels for the January 1998 event are presented Table 4.3. Figure 4.1 shows a longitudinal profile comparing the January 1998 recorded peak flood levels vs. modelled peak flood level at each MHG location for the Stable Swamp Creek main branch and Figures 4.2.1, 4.2.2 and 4.2.3 provide similar profiles for Shelleys Creek, Archerfield Channel and North Arm respectively. Hydrograph calibration could not be undertaken for the Musgrave Road stream gauging station as the gauge failed early in the event, however the modelled peak level hydrograph at the gauge location is provided in Figure 4.3.

Sensitivity runs using BX = 3 and 50mm/hr initial loss, 0 mm/hr continuing loss in the RAFTS model resulted in a particularly good calibration for the 1998 event. However, a BX =1 was found to provide a significantly improved calibration for both the 2001 and 2004 events.

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Table 4.3 Recorded & Modelled Peak Flood Levels, January 1998

MIKE 11 Branch	MHG	Description	MIKE 11 Chainage (m)	Jan 98 Recorded Level (m)	Jan 98 Modelled Level[1] (m)	Difference (m)
Shelleys Creek	SS250	Kingman Street	10,948	-	52.04	-
Shelleys Creek	SS240	Lang Street	11,844	43.41	43.80	0.39
Stable Swamp	SS230A	Stones Road	1,430	-	33.82	-
Stable Swamp	SS220	Beenleigh Road	3,068	-	18.19	-
Stable Swamp	SS200	Boundary Road	3,921	11.90	12.89	0.99
Stable Swamp	SS190	Annie Street	3,996	-	12.04	-
Stable Swamp	SS180	Edith Street	4,594	-	9.67	-
Stable Swamp	SS170	Musgrave Road	5,380	7.35	7.44	0.09
Stable Swamp	SS160	Norbury Street	5,570	6.97	7.08	0.11
Stable Swamp	SS150	Dollis Id	6,324	5.91	5.97	0.06
Stable Swamp	SS140	Colvin Street	6,560	5.26	5.59	0.33
Stable Swamp	SS130	Tramore Street	6,978	4.99	5.28	0.29
Stable Swamp	SS120	Marshall Road	7,788	4.82	5.00	0.18
Stable Swamp	SS110	Ipswich Road	8,135	4.55	4.67	0.12
Stable Swamp	SS100	Franklin Street	9,135	3.13	3.49	0.36
Archerfield Channel	SS400	Marshall Road	2,224	-	5.82	-
Archerfield Channel	SS410	Rodwell Street	1,750	-	6.93	-
North Arm	*SS300*	*Railway Bridge*	*1,720*	*7.73*	*9.21*	*1.48*
North Arm	SS310	Burgess Street	850	-	12.54	-
North Arm	SS320	Orange Grove Road	312	15.66	16.04	0.49

1bx = 1 run4
Potentially Inaccurate Gauge – No record
StableSwamp07_1998_bx1_53.RES11
Red Modelled result greater than 150mm of recorded level
Green Modelled results within 150mm of recorded level

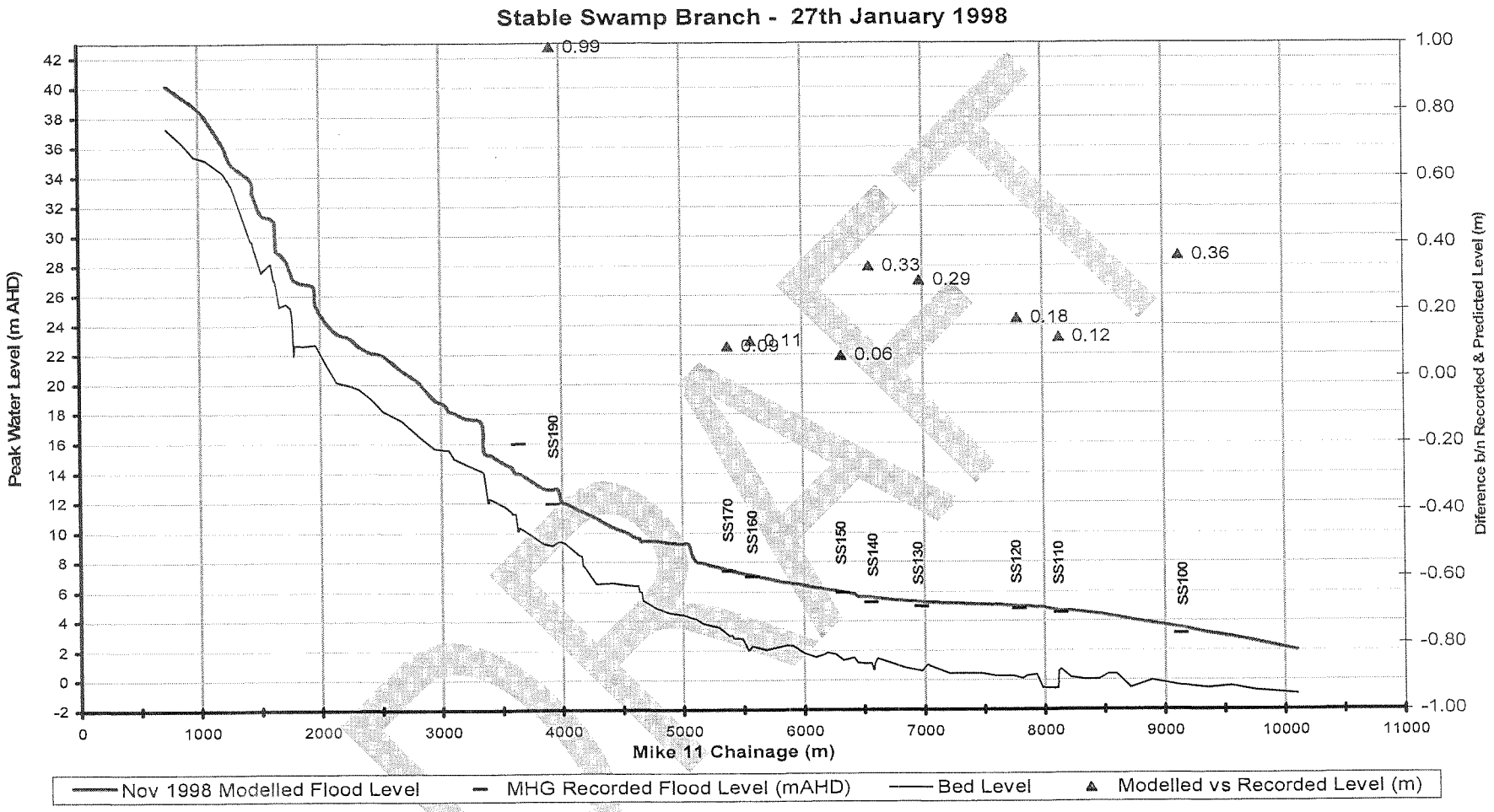

Figure 4.1 Stable Swamp Creek Calibration, January 1998

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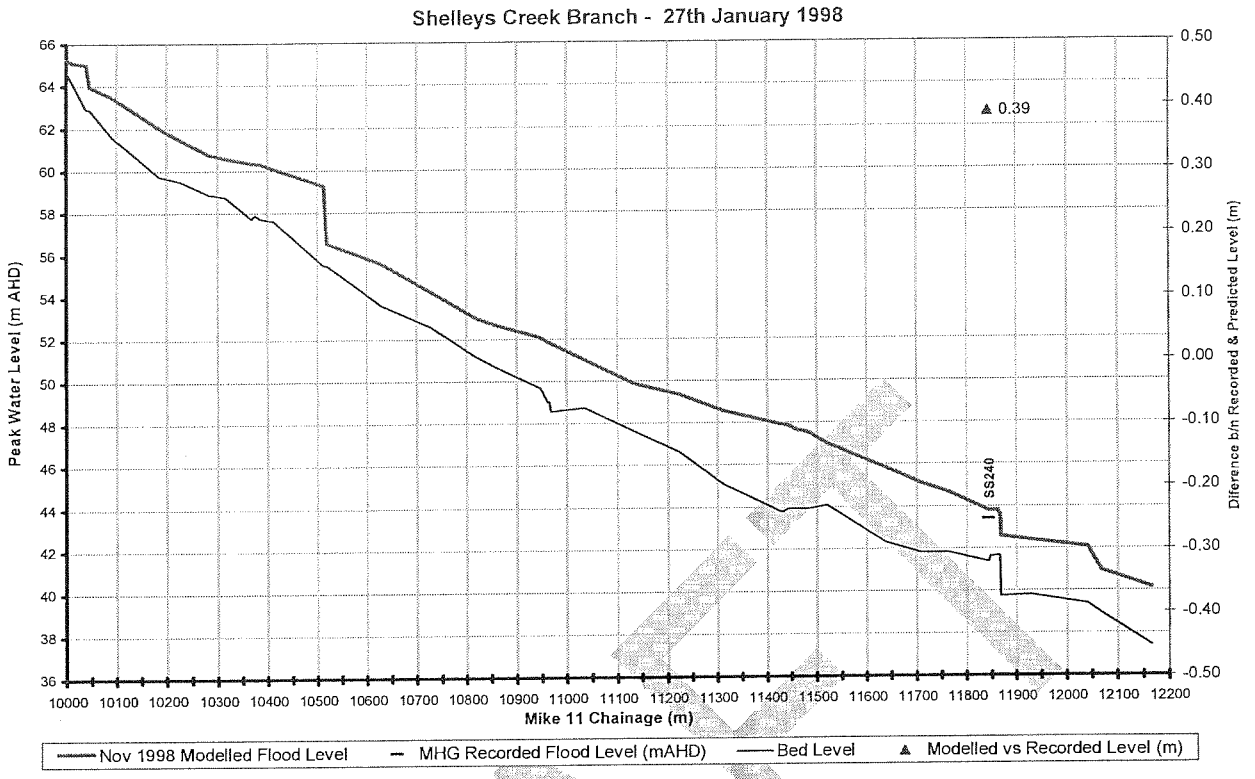

Figure 4.2.1 Shelleys Creek Calibration, January 1998

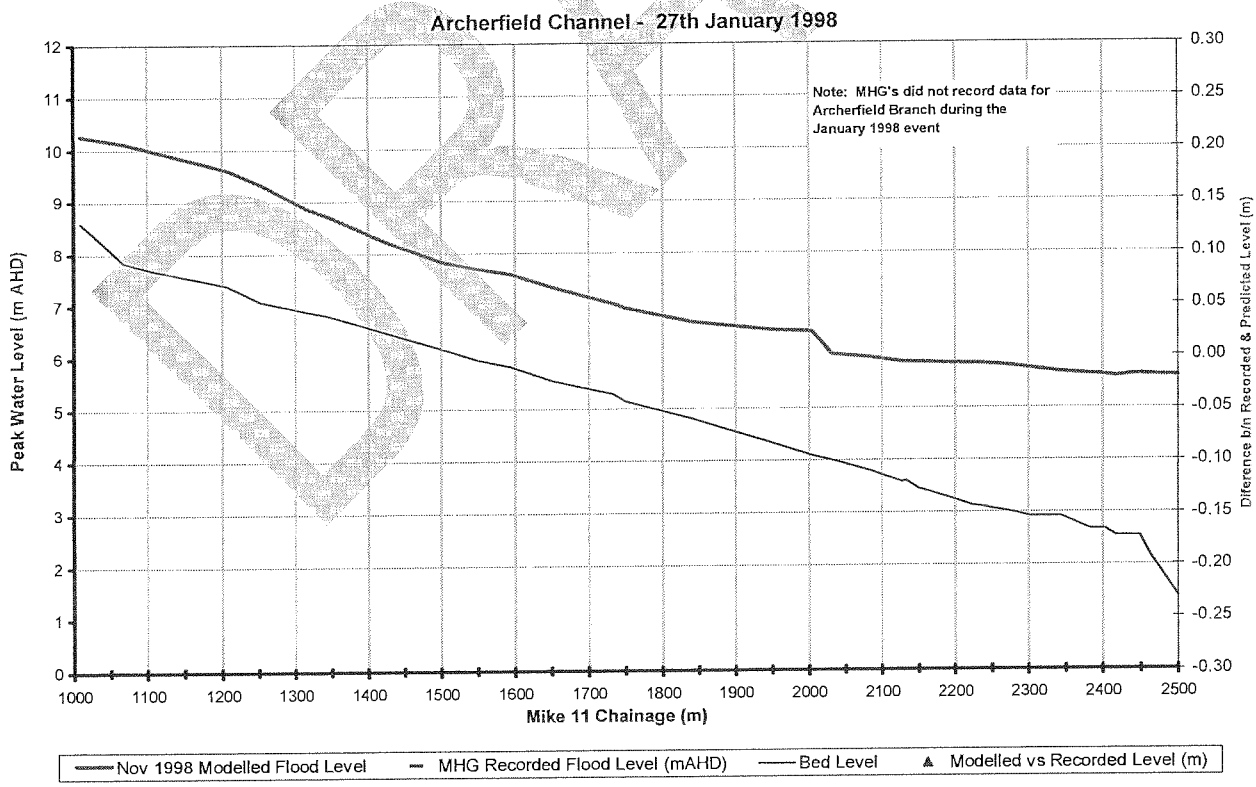

Figure 4.2.2 Archerfield Channel Calibration, January 1998

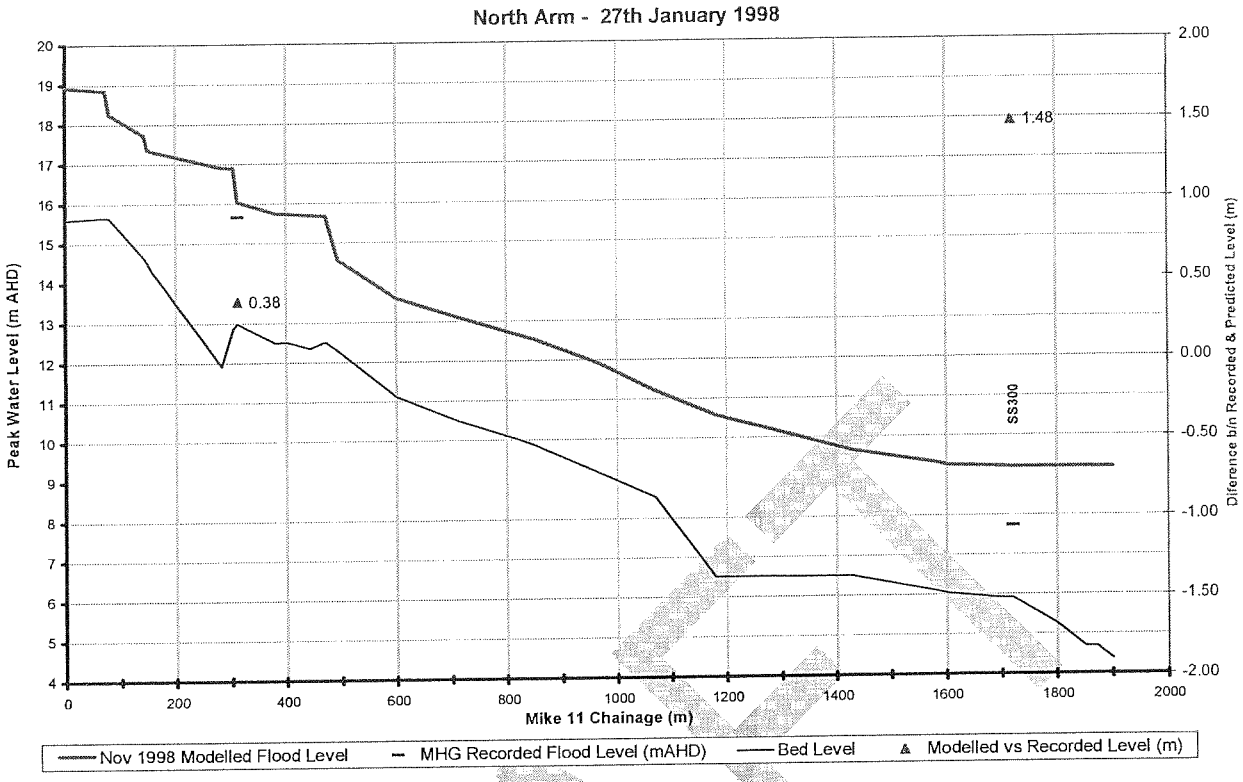

Figure 4.2.3 North Arm Calibration, January 1998

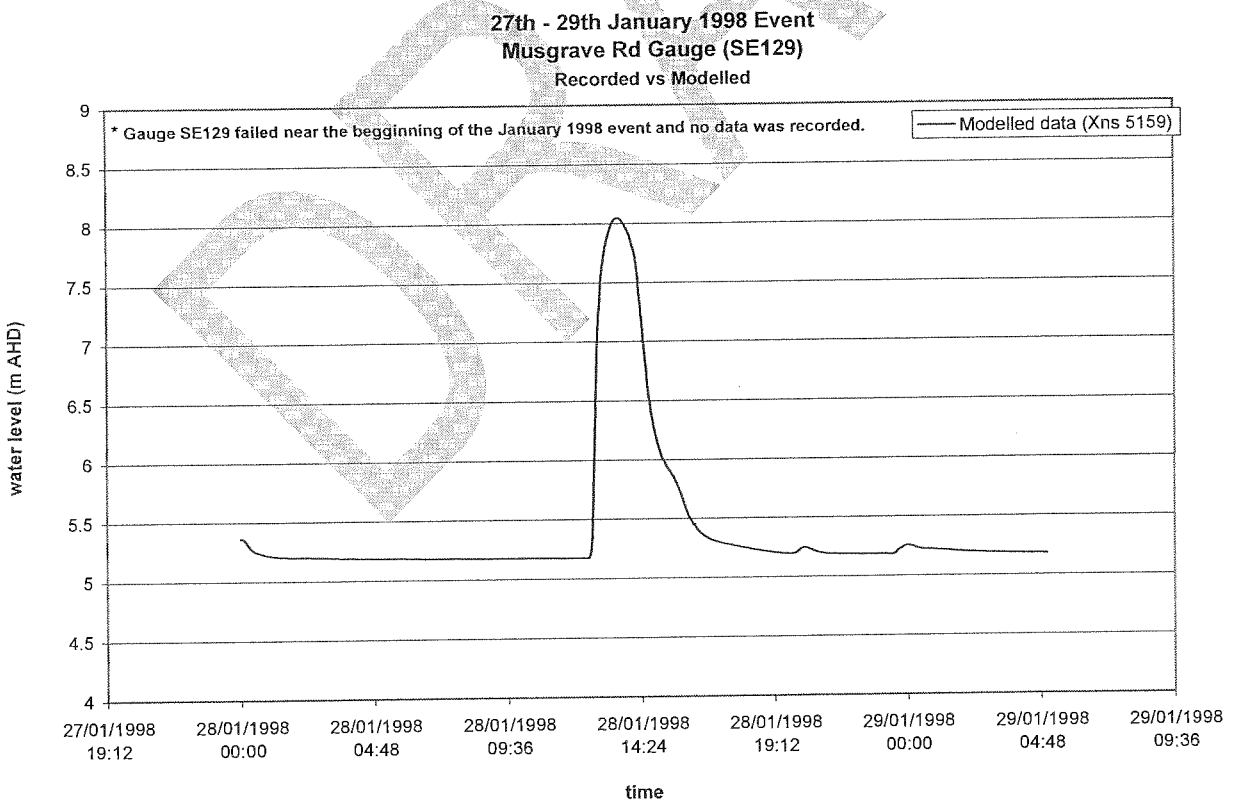

Figure 4.3 Modelled water levels – Musgrave Road Gauge, November 1998 event

4.3 March 2001

Occurring on the 9th March, this flash flood event was triggered by intense rainfall associated with a band of thunderstorms across South East Queensland. The stream gauge at Musgrave Road indicates this is the largest event recorded during the period of operation of this gauge and it is the largest event modelled as part of the calibration process. The event was well documented with the continuous stream gauge at Musgrave Road and 19 maximum height gauges recording peak flood levels.

Rainfall records from five rainfall stations are available for this event, refer to Table 2.1. Gauges SSR130 and OXR114 were selected as the source for rainfall data input for the event. Due to the rainfall distribution and similarity of the data recorded at the other nearby gauges with available data, it was considered satisfactory to apply the data from these two gauges only.

The rainfall distribution has OXR114 data applied to the Shelleys Creek branch downstream to the Woff node and the SSR130 gauge data was applied to the remainder of the catchment. Table A.2 in Appendix A1 summarises the rainfall distribution adopted for the event.

Almost no rainfall was recorded for the five days prior to the March 2001 rainfall event. Therefore it can be assumed that the antecedent conditions were a relatively dry catchment and low creek water levels and an initial loss of 50mm was adopted.

Recorded and modelled peak flood levels for the March 2001 event are presented Table 4.4. Figure 4.4 shows a longitudinal profile comparing the March 2001 recorded peak flood levels vs. modelled peak flood level at each MHG location for the Stable Swamp Creek main branch and Figures 4.5.1, 4.5.2 and 4.5.3 provide similar profiles for Shelleys Creek, Archerfield Channel and North Arm respectively. A comparison of the recorded vs. MIKE 11 modelled peak water level hydrograph at the Musgrave Road continuous stream gauge for the 2001 event is provided in Figure 4.6.

A reasonable match was achieved with recorded levels, particularly through the centre of the catchment. The MIKE 11 model suggests the Beryl Roberts Basin spillway would have been in operation during the 2001 event, with a modelled peak water level of approximately 22.3m AHD in the basin. BCC staff who witnessed the 2001 event confirmed the basin did overtop in 2001.

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Table 4.4 Recorded & Modelled Peak Flood Levels, March 2001

MIKE 11 Branch	MHG	Description	MIKE 11 Chainage (m)	March 2001 Modelled Level[1] (m AHD)	March 2001 Modelled Level[1] (m AHD)	Difference (m)
Shelleys Creek	SS250	Kingman Street	10,948	52.24	51.78	-0.46
Shelleys Creek	SS240	Lang Street	11,844	43.16	43.50	0.34
Stable Swamp	SS230A	Stones Road	1,430	-	33.73	
Stable Swamp	SS220	Beenleigh Road	3,068	-	18.29	
Stable Swamp	SS200	Boundary Road	3,921	12.65	13.10	0.45
Stable Swamp	SS190	Annie Street	3,996	11.76	12.17	0.41
Stable Swamp	SS180	Edith Street	4,594	10.02	10.00	-0.02
Stable Swamp	SS170	Musgrave Road	5,380	8.12	7.79	-0.33
Stable Swamp	SS160	Norbury Street	5,570	7.78	7.49	-0.29
Stable Swamp	SS150	Dollis Id	6,324	6.61	6.32	-0.29
Stable Swamp	SS140	Colvin Street	6,560	6.23	6.11	-0.12
Stable Swamp	*SS130*	*Tramore Street*	*6,978*	*5.95*	*5.91*	*-0.04*
Stable Swamp	*SS120*	Marshall Road	*7,788*	*5.54*	*5.68*	*0.14*
Stable Swamp	SS110	Ipswich Road	8,135	5.10	5.17	0.07
Stable Swamp	SS100	Franklin Street	9,135	3.85	3.89	-0.03
Archerfield Channel	*SS400*	*Marshall Road*	*2,224*	*6.31*	*6.25*	*-0.06*
Archerfield Channel	SS410	Rodwell Street	1,750	7.12	6.89	-0.23
North Arm	SS300	Railway Bridge	1,720	9.36	9.92	0.56
North Arm	SS310	Burgess Street	850	12.77	13.47	0.70
North Arm	SS320	Orange Grove Road	312	16.87	16.74	-0.13

1BX = 1
~Potentially Inaccurate Gauge – No record
StableSwamp07_2001_bx1_53.RES11
Blue Modelled result less than 150mm of recorded level
Red Modelled result greater than 150mm of recorded level
Green Modelled results within 150mm of recorded level

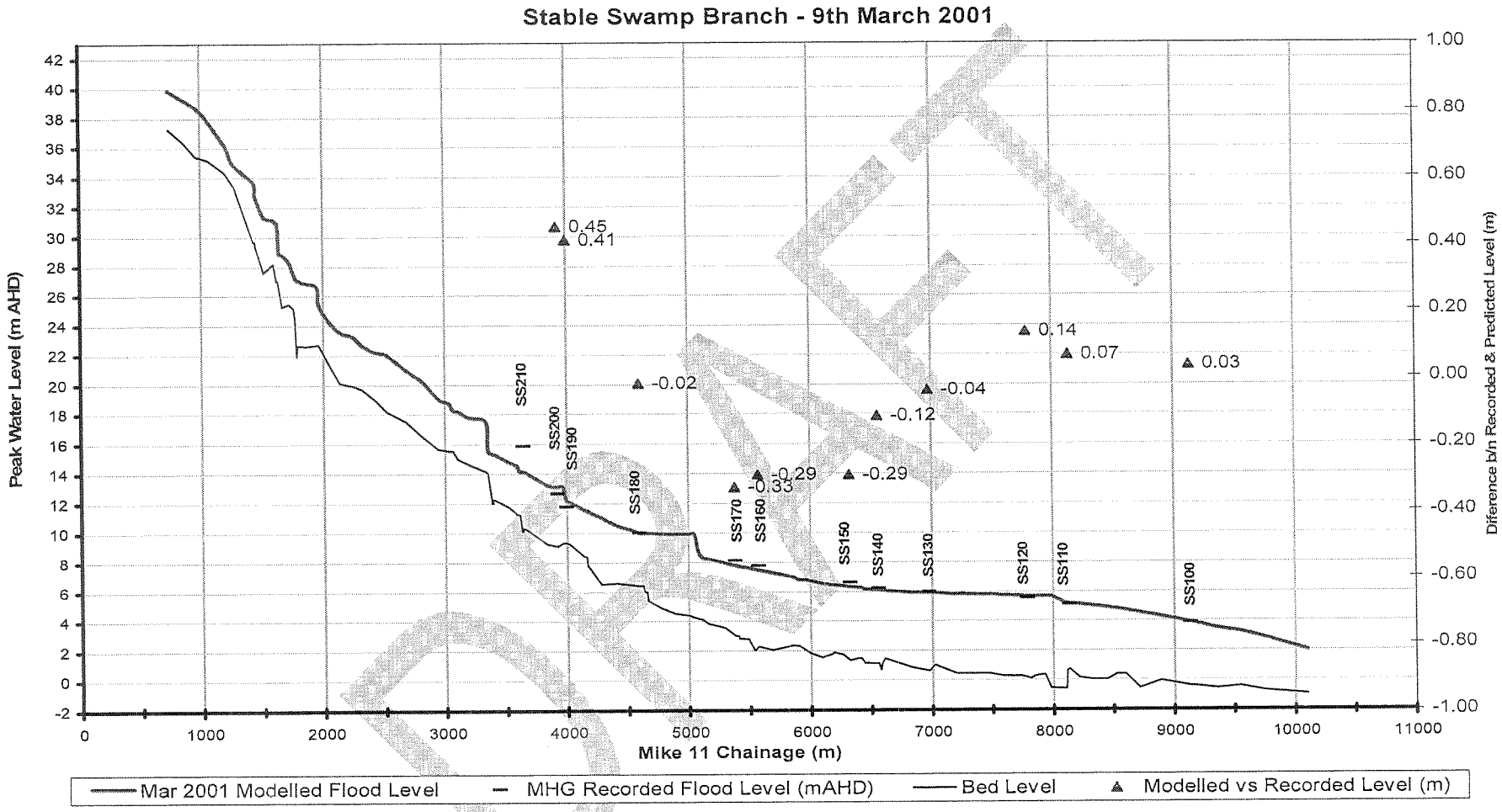

Figure 4.4 Stable Swamp Creek Calibration, March 2001

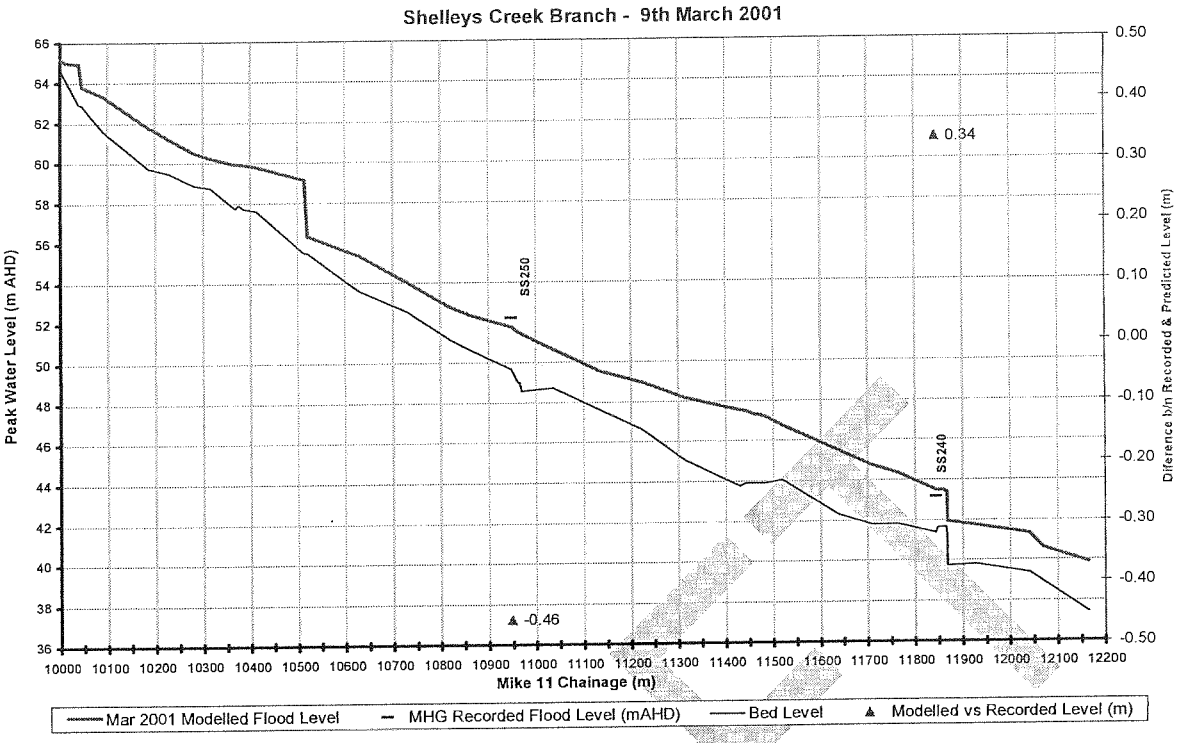

Figure 4.5.1 Shelleys Creek Calibration, March 2001

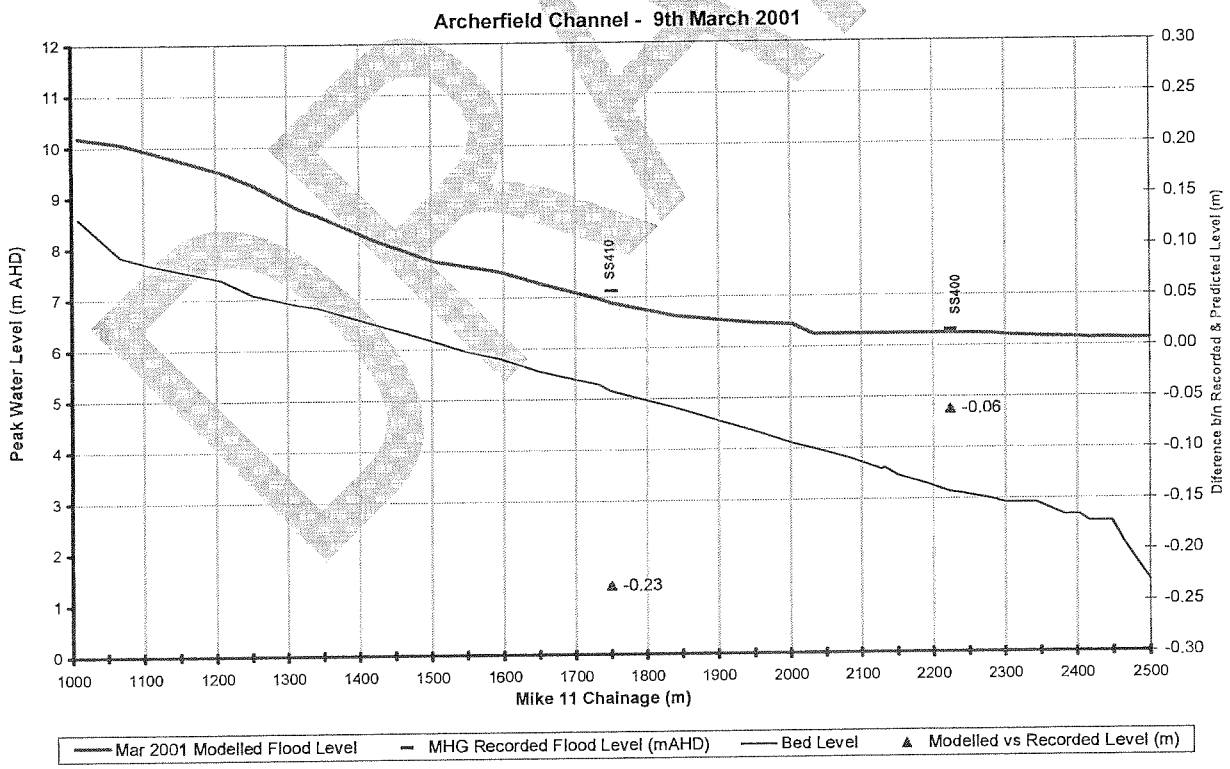

Figure 4.5.2 Archerfield Channel Calibration, March 2001

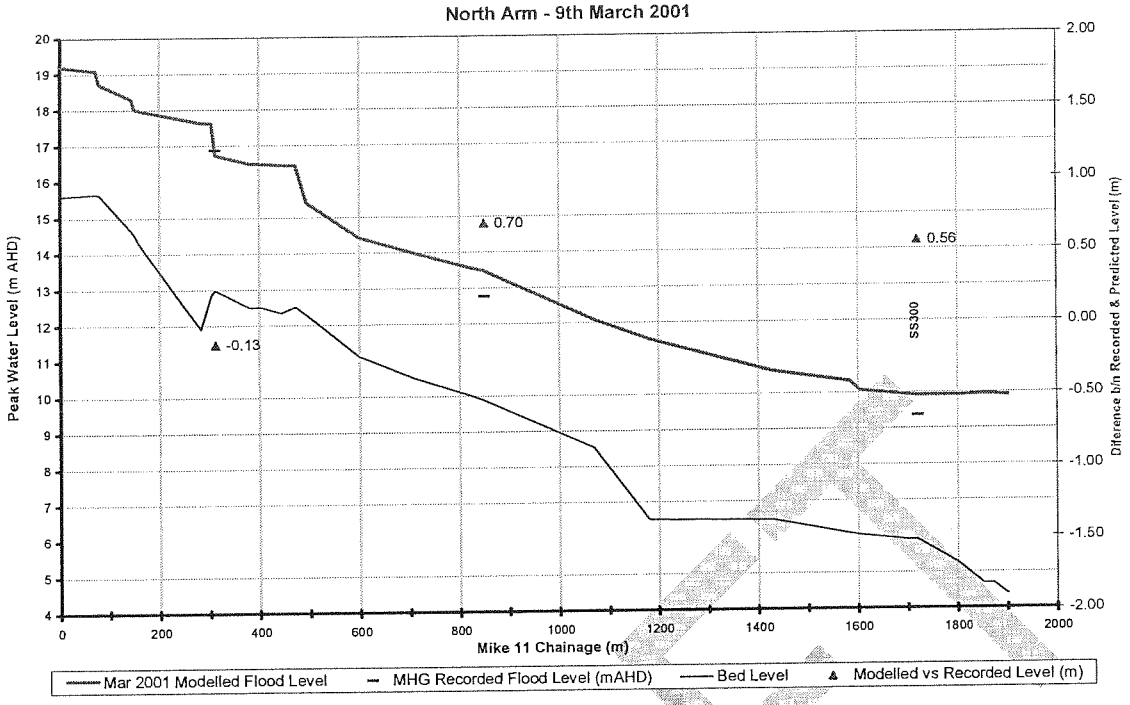

Figure 4.5.3 North Arm Calibration, March 2001

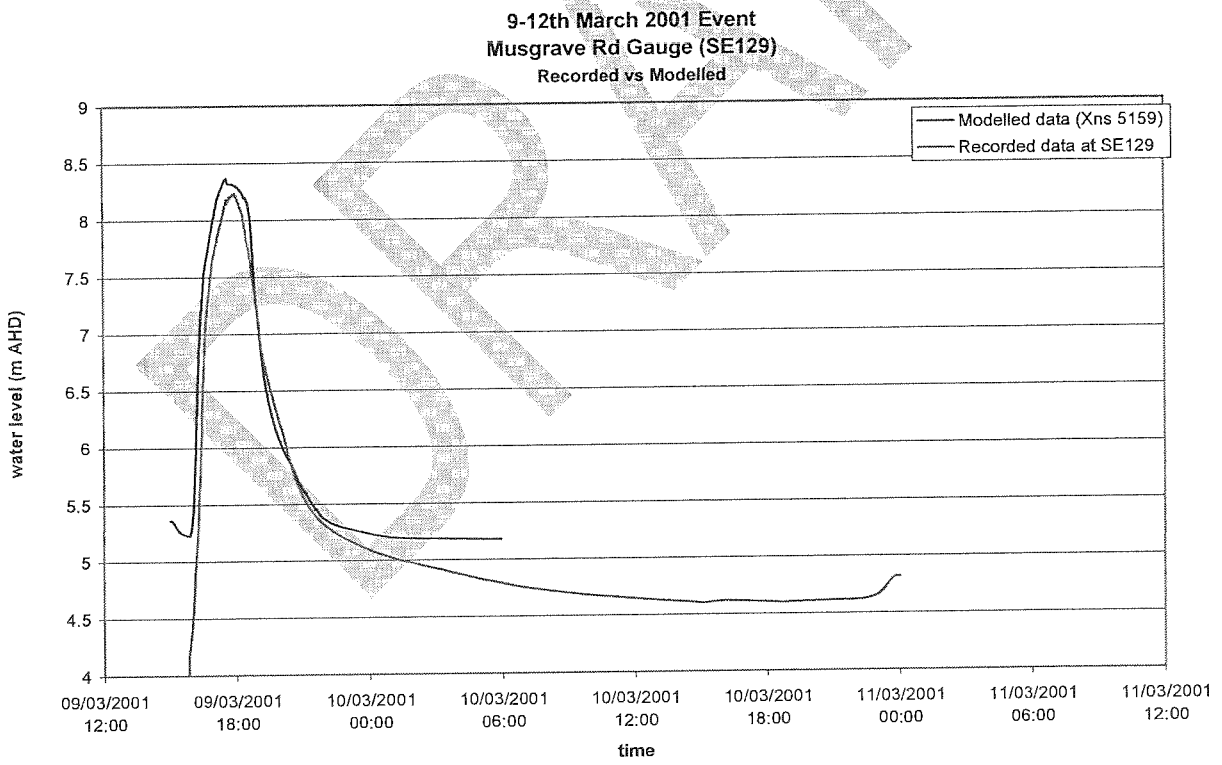

Figure 4.6 Recorded vs. modelled water levels – Musgrave Road Gauge, March 2001 event

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4.4 November 2004

This event occurred on the 7th November 2004 and along with the 2001 and 1998 events was one of the largest events in the last decade. Similar to the 1998 and 2001 events, flooding was caused by intense rainfall associated with a band of thunderstorms across South East Queensland. The continuous stream gauge at Musgrave Road and 16 maximum height gauges recorded peak flood levels.

Minor amounts of rainfall were recorded at nearby gauges within the five days prior to this event, enough to dampen the catchment and therefore initial losses of 10mm were adopted for this calibration event.

Rainfall records from four rainfall stations located within the vicinity of the catchment are available over this period. Continuous rainfall data from two rainfall gauges OXR114 and R_R747 was selected. As there was no available data for the SSR130 gauge, data from the nearby R_R747 gauge in Salisbury was considered to be a suitable substitute due to its proximity. As with the 2001 event, due to the rainfall distribution and similarity of the data recorded at the other nearby gauges, rainfall from these two gauges has been applied across the catchment.

As with the 2001 event, rainfall from the OXR114 gauge was applied to the Shelleys Creek branch. The remainder of the catchment utilised rainfall data from the R_R747 gauge, refer to Table A.2 in Appendix A1.

Recorded and modelled peak flood levels for the November 2004 event are presented Table 4.5. Figure 4.7 shows a longitudinal profile comparing the November 2004 recorded peak flood levels vs. modelled peak flood level at each MHG location for the Stable Swamp Creek main branch and Figures 4.8.1, 4.8.2 and 4.8.3 provide similar profiles for Shelleys Creek, Archerfield Channel and North Arm respectively. A comparison of the recorded vs. MIKE 11 modelled peak water level hydrograph at the Musgrave Road continuous stream gauge for the November 2004 event is provided in Figure 4.9.

A reasonable match was achieved with recorded levels, although flood levels in Shelleys Creek are over estimated. The MIKE 11 model suggests the Beryl Roberts Basin spillway would have been in operation during the 2004 event, with a modelled peak water level of approximately 22.2m AHD in the basin. BCC staff who witnessed the 2004 event confirmed the basin did overtop in 2004.

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Table 4.5 Recorded & Modelled Peak Flood Levels, November 2004

MIKE 11 Branch	MHG	Description	MIKE 11 Chainage (m)	November 2004 Recorded Level (m AHD)	November 2004 Modelled Level[1] (m AHD)	Difference (m)
Shelleys Creek	SS250	Kingman Street	10,948	51.41	51.68	0.27
Shelleys Creek	SS240	Lang Street	11,844	43.14	43.43	0.21
Stable Swamp	SS230A	Stones Road	1,430	33.30	33.51	0.28
Stable Swamp	*SS220*	*Beenleigh Road*	*3,068*	*17.45*	*17.73*	*-1.58*
Stable Swamp	SS200	Boundary Road	3,921	-	12.42	
Stable Swamp	*SS190*	*Annie Street*	*3,996*	*11.84*	*11.81*	*-0.03*
Stable Swamp	SS180	Edith Street	4,594	9.33	9.51	0.18
Stable Swamp	SS170	Musgrave Road	5,380	7.38	7.38	0.00
Stable Swamp	SS160	Norbury Street	5,570	6.98	7.02	0.04
Stable Swamp	SS150	Dollis Id	6,324	6.13	6.02	-0.12
Stable Swamp	SS140	Colvin Street	6,560	5.77	5.71	-0.06
Stable Swamp	SS130	Tramore Street	6,978	5.42	5.46	0.04
Stable Swamp	SS120	Marshall Road	7,788	5.10	5.20	0.10
Stable Swamp	SS110	Ipswich Road	8,135	5.04	4.82	-0.22
Stable Swamp	SS100	Franklin Street	9,135	3.71	3.62	-0.09
Archerfield Channel	SS400	Marshall Road	2,224	5.92	5.85	-0.07
Archerfield Channel	SS410	Rodwell Street	1,750	6.79	6.73	-0.06
North Arm	SS300	Railway Bridge	1,720	-	9.03	
North Arm	SS310	Burgess Street	850	-	12.61	
North Arm	SS320	Orange Grove Road	312	-	16.07	

1BX = 1
– No record
Potentially Inaccurate Gauge
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Blue Modelled result less than 150mm of recorded level
Red Modelled result greater than 150mm of recorded level
Green Modelled results within 150mm of recorded level

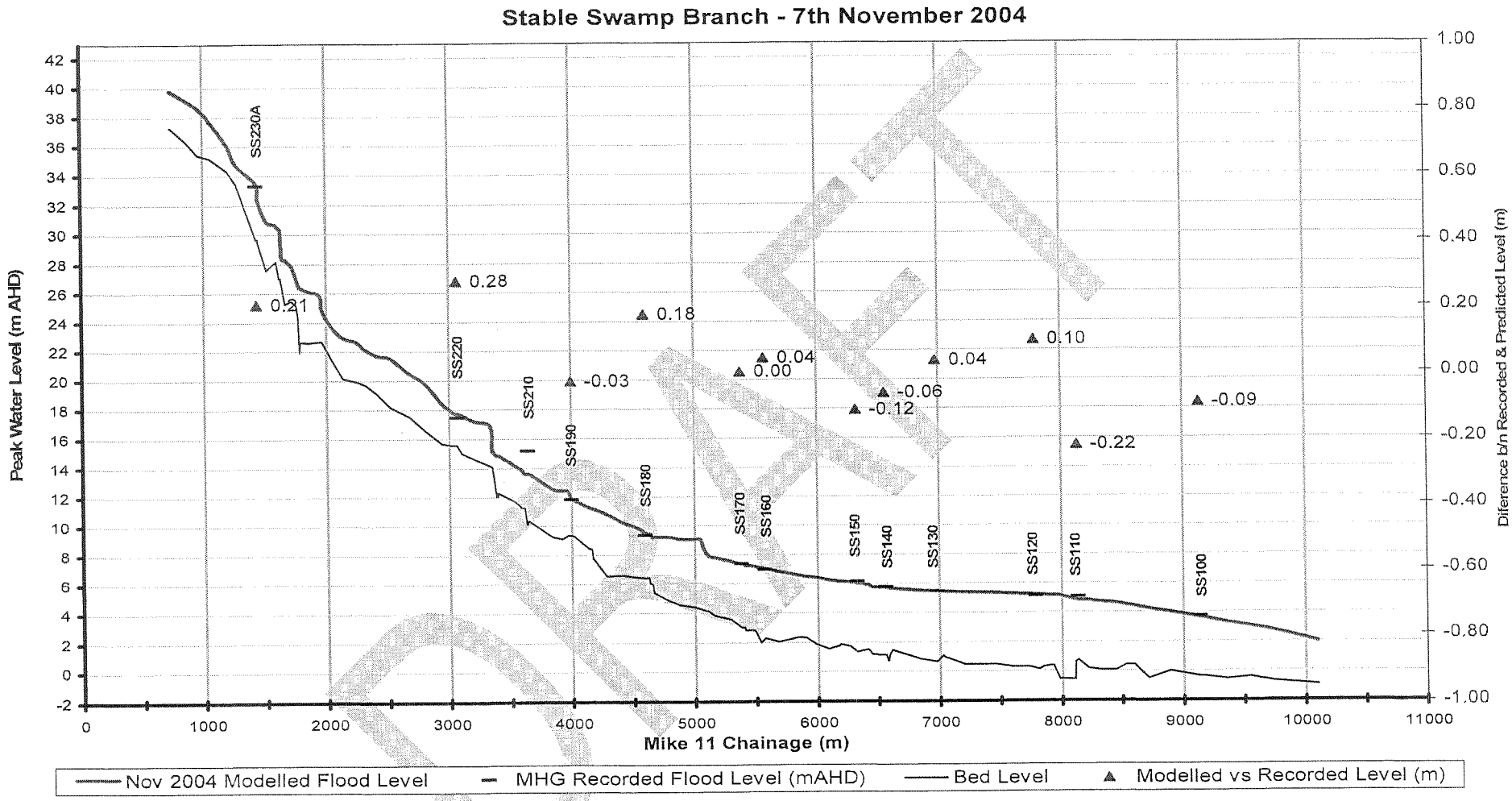

Figure 4.7 Stable Swamp Creek Calibration, November 2004

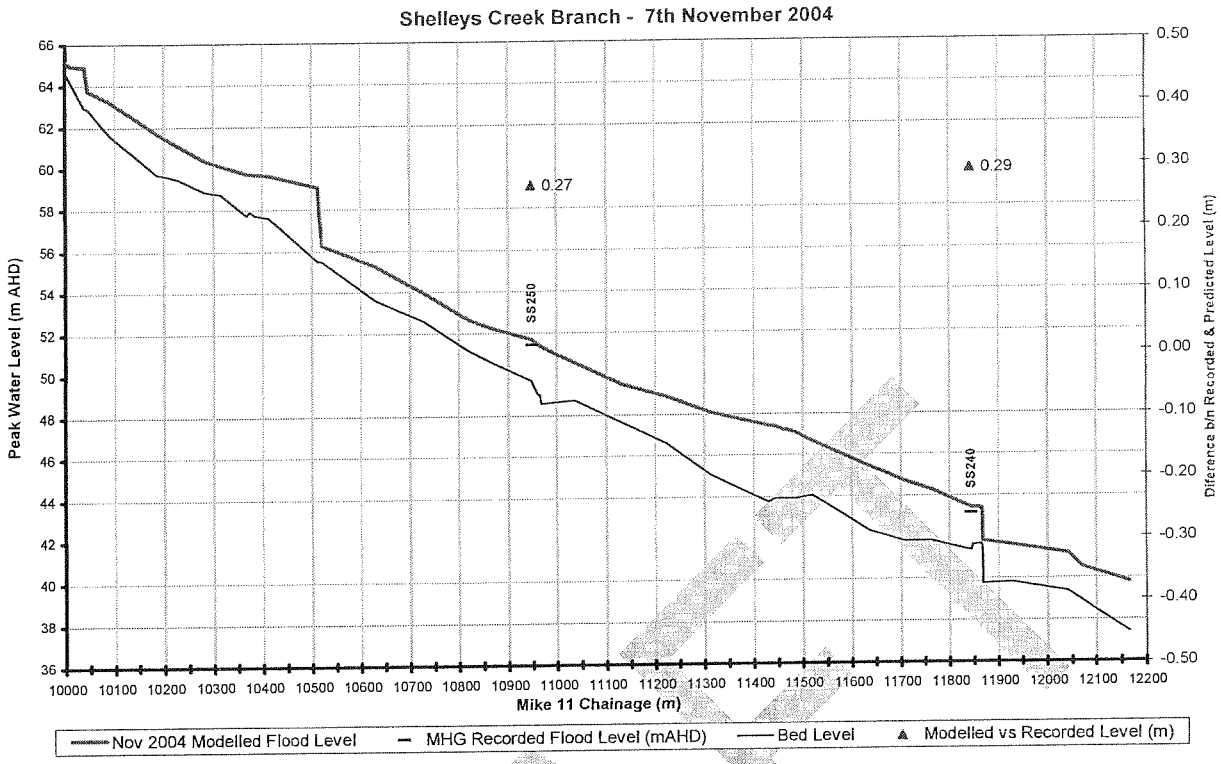

Figure 4.8.1 Shelleys Creek Calibration, November 2004

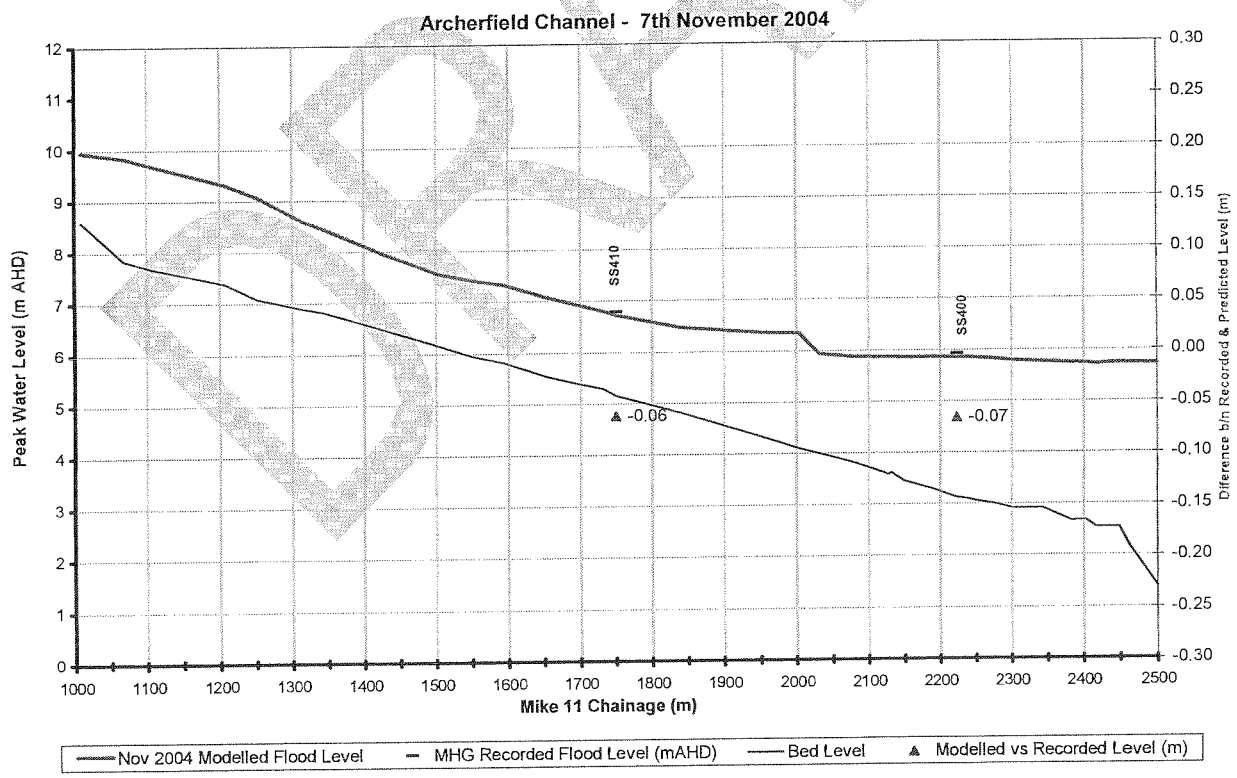

Figure 4.8.2 Archerfield Channel Calibration, November 2004

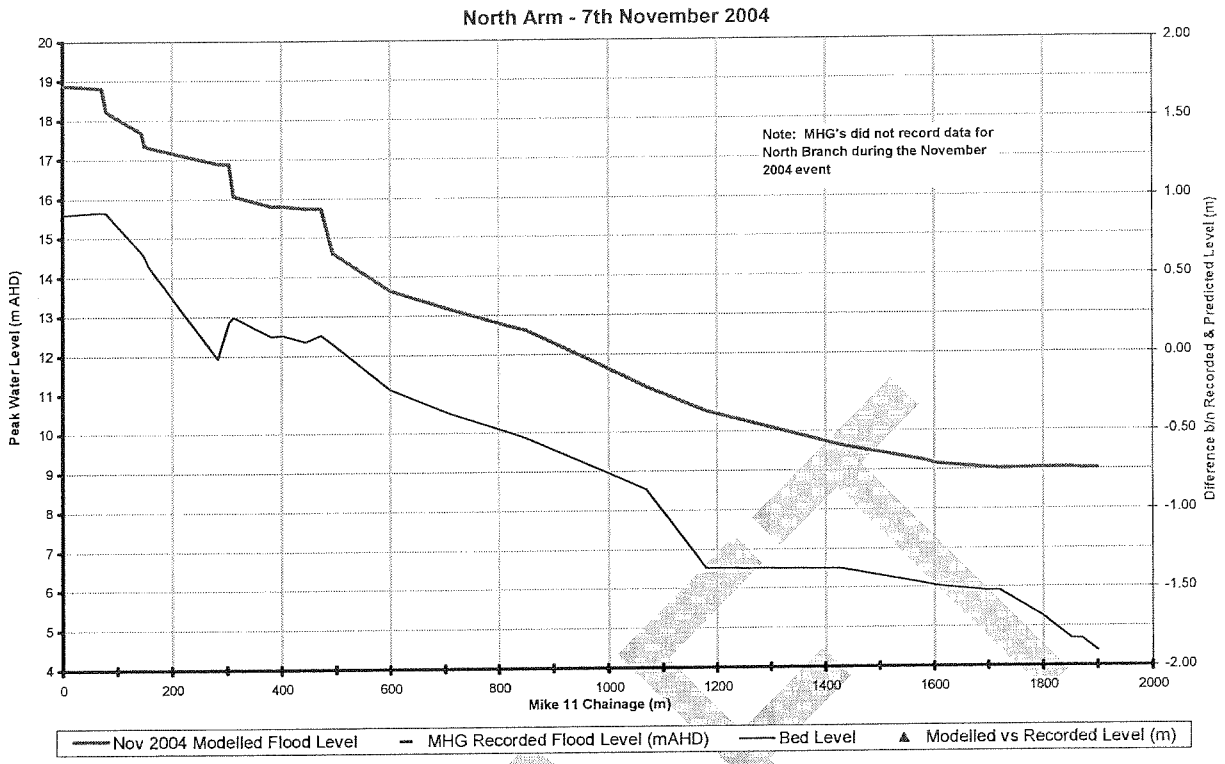

Figure 4.8.3 North Arm Calibration, November 2004

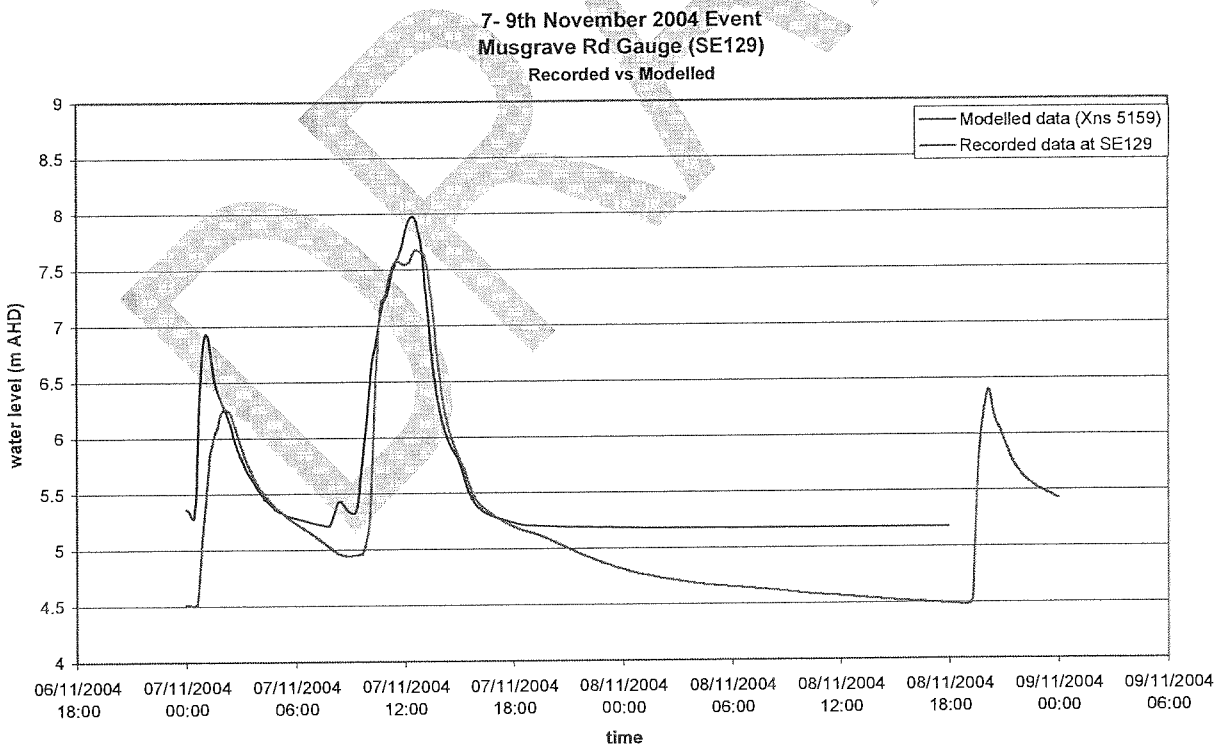

Figure 4.9 Recorded vs. modelled water levels – Musgrave Road Gauge – November 2004 event

5 Verification

5.1 Verification Events

Procedures used to select verification events are similar to those involved in the selection of the calibration events. Verification events provide a means of checking the adequacy of modelling parameters adopted for calibration.

5.2 May 1996

A smaller event in Stable Swamp Creek than the January 1998 and March 2001 events, the event occurred on the 5th May 1996 and was a relatively small with flows less than a third of the 2001 flows recorded at the Musgrave Road gauge.

Rainfall records from five rainfall gauges, located within the vicinity of the catchment, are available over this period. See Table 2.1 and Figure 2.1 for available gauge data and gauge locations. Gauges utilised include SSR130, OXR114, BMR138, OXR126, OXR020. Refer to Table A.2 in Appendix A1 for sub-catchment breakdown and rainfall gauge data application.

A significant amount of rainfall was recorded in the five days leading up to the event, therefore an initial loss of 10mm and a continuing loss rate 0mm/h was adopted in the RAFTS model for the May 1996 event.

Recorded and modelled peak flood levels for the May 1996 event are presented Table 5.1. Figure 5.1 shows a longitudinal profile comparing the May 1996 recorded peak flood levels vs. modelled peak flood level at each MHG location for the Stable Swamp Creek main branch and Figures 5.2.1, 5.2.2 and 5.2.3 provide similar profiles for Shelleys Creek, Archerfield Channel and North Arm respectively. A comparison of the recorded vs. MIKE 11 modelled peak water level hydrograph at the Musgrave Road continuous stream gauge for the May 1996 event is provided in Figure 5.3.

The majority of the modelled levels are within the 150mm tolerance recommended by BCC (BCC, 1997) with the exception of MHGs located in the downstream reaches of Stable Swamp Creek which are influenced by the flood level in Oxley Creek.

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Table 5.1 Recorded & Modelled Peak Flood Levels, May 1996

MIKE 11 Branch	MHG	Description	MIKE 11 Chainage (m)	May 1996 Recorded Level (m AHD)	May 1996 Modelled Level[1] (m AHD)	Difference (m)
Shelleys Creek	SS250	Kingman Street	10,948	-	50.97	
Shelleys Creek	SS240	Lang Street	11,844	43.06	42.98	-0.08
Stable Swamp	SS230A	Stones Road	1,430	-	32.64	
Stable Swamp	SS220	Beenleigh Road	3,068	17.75	17.03	-0.72
Stable Swamp	SS200	Boundary Road	3,921	-	11.12	
Stable Swamp	SS190	Annie Street	3,996	10.79	10.99	0.20
Stable Swamp	SS180	Edith Street	4,594	8.40	8.13	-0.28
Stable Swamp	SS170	Musgrave Road	5,380	6.58	6.46	-0.12
Stable Swamp	SS160	Norbury Street	5,570	6.27	6.12	-0.15
Stable Swamp	SS150	Dollis Id	6,324	5.53	5.23	-0.30
Stable Swamp	SS140	Colvin Street	6,560	5.15	5.01	-0.14
Stable Swamp	SS130	Tramore Street	6,978	4.98	4.51	-0.47
Stable Swamp	SS120	Marshall Road	7,788	4.88	4.19	-0.69
Stable Swamp	SS110	Ipswich Road	8,135	4.71	4.00	-0.72
Stable Swamp	SS100	Franklin Street	9,135	4.49	3.10	-1.39
Archerfield Channel	SS400	Marshall Road	2,224	-	5.09	
Archerfield Channel	SS410	Rodwell Street	1,750	-	6.30	
North Arm	SS300	Railway Bridge	1,720	-	7.33	
North Arm	SS310	Burgess Street	850	-	11.71	
North Arm	SS320	Orange Grove Road	312	-	14.67	-0.83

1BX = 1
Blue Modelled result less than 150mm of recorded level
Red Modelled result greater than 150mm of recorded level
Green Modelled results within 150mm of recorded level

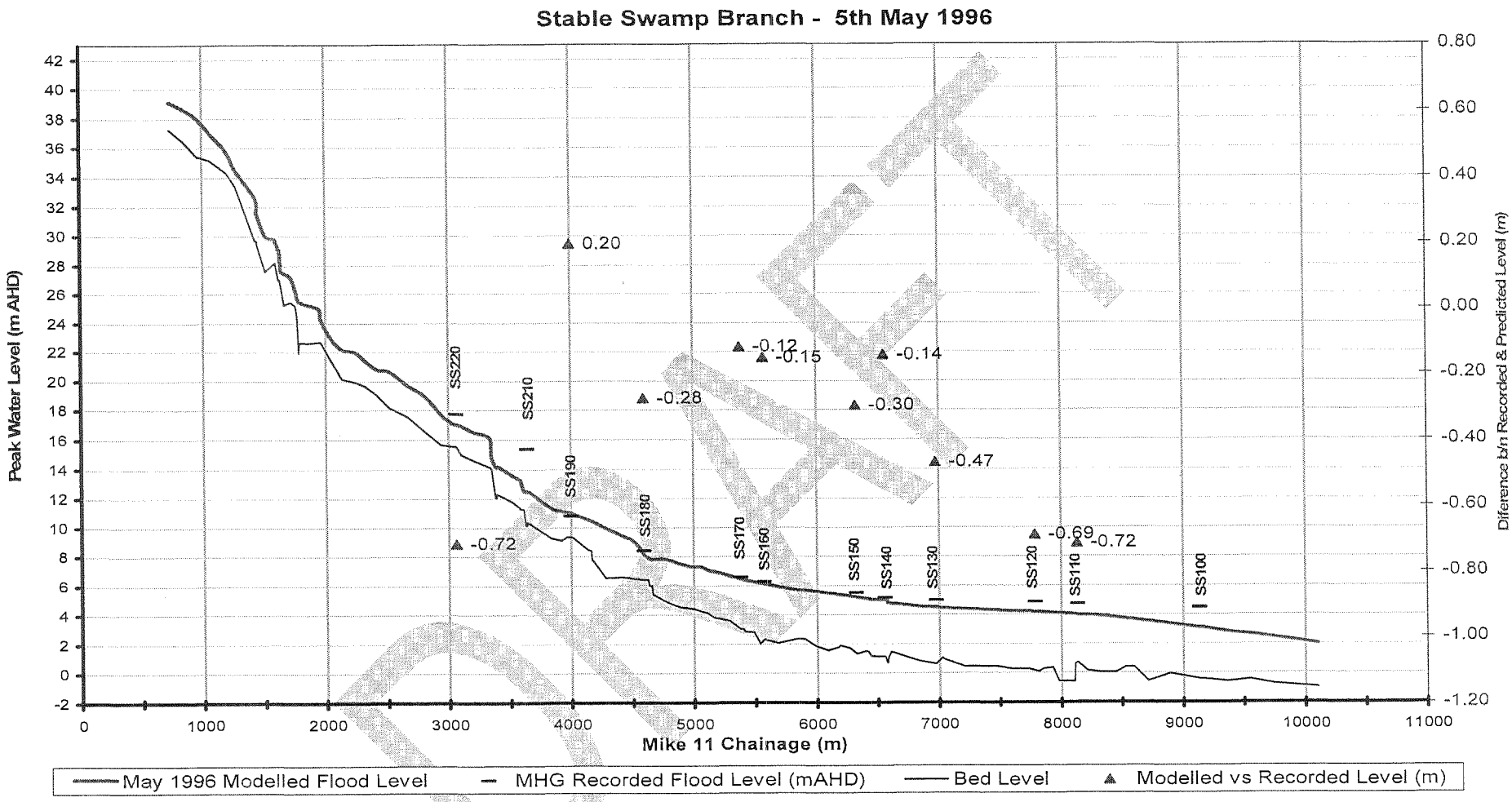

Figure 5.1 Stable Swamp Creek Verification, May 1996

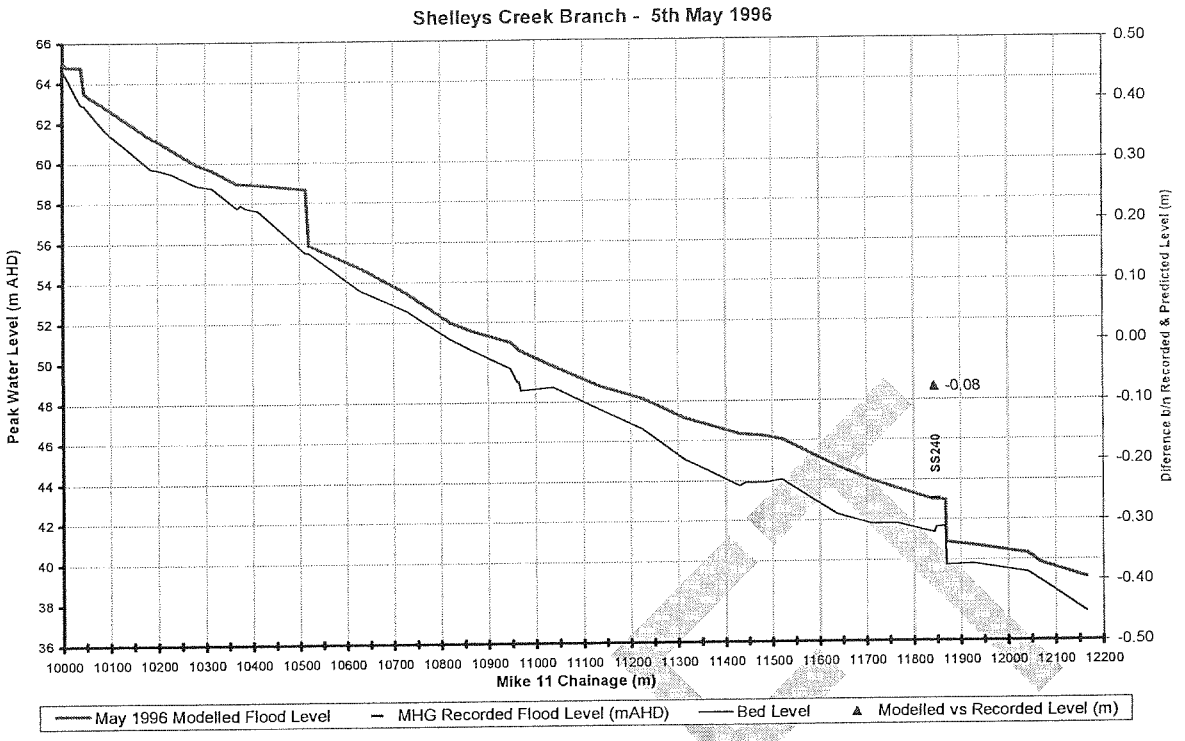

Figure 5.2.1 Shelleys Creek Verification, May 1996

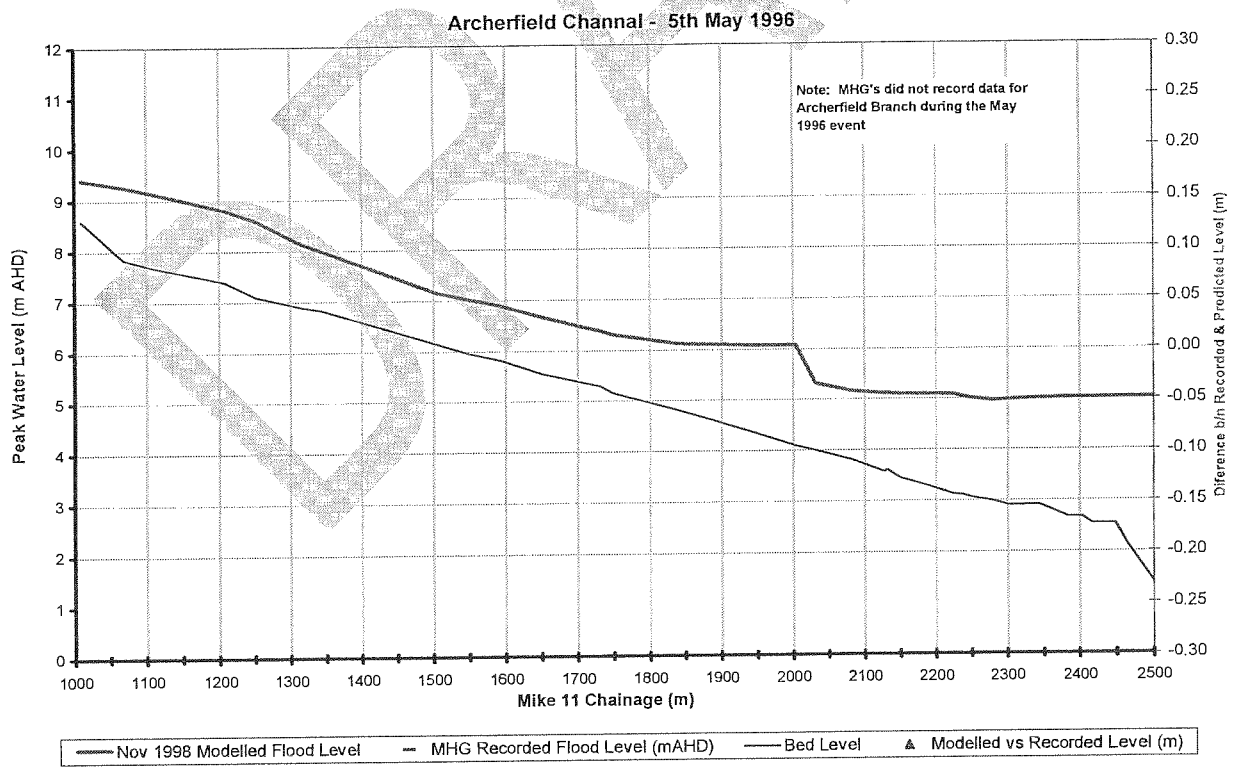

Figure 5.2.2 Archerfield Channel Verification, May 1996

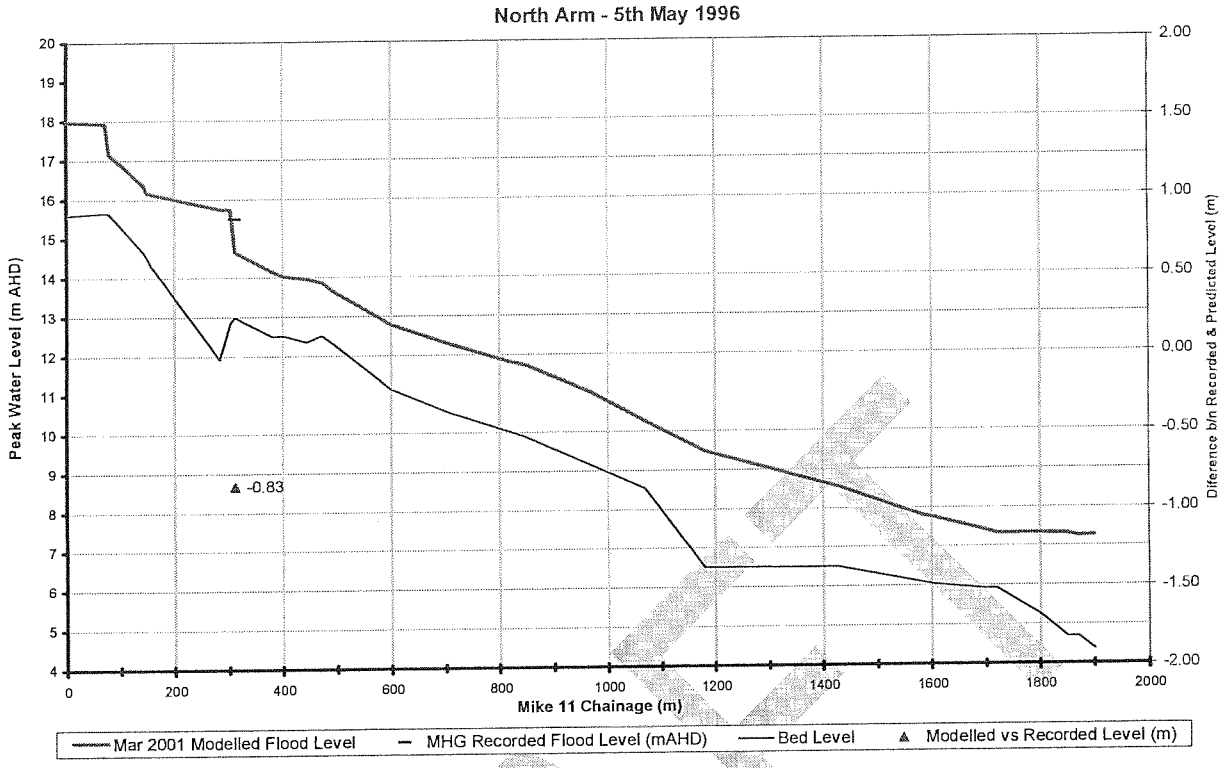

Figure 5.2.3 North Arm Verification, May 1996

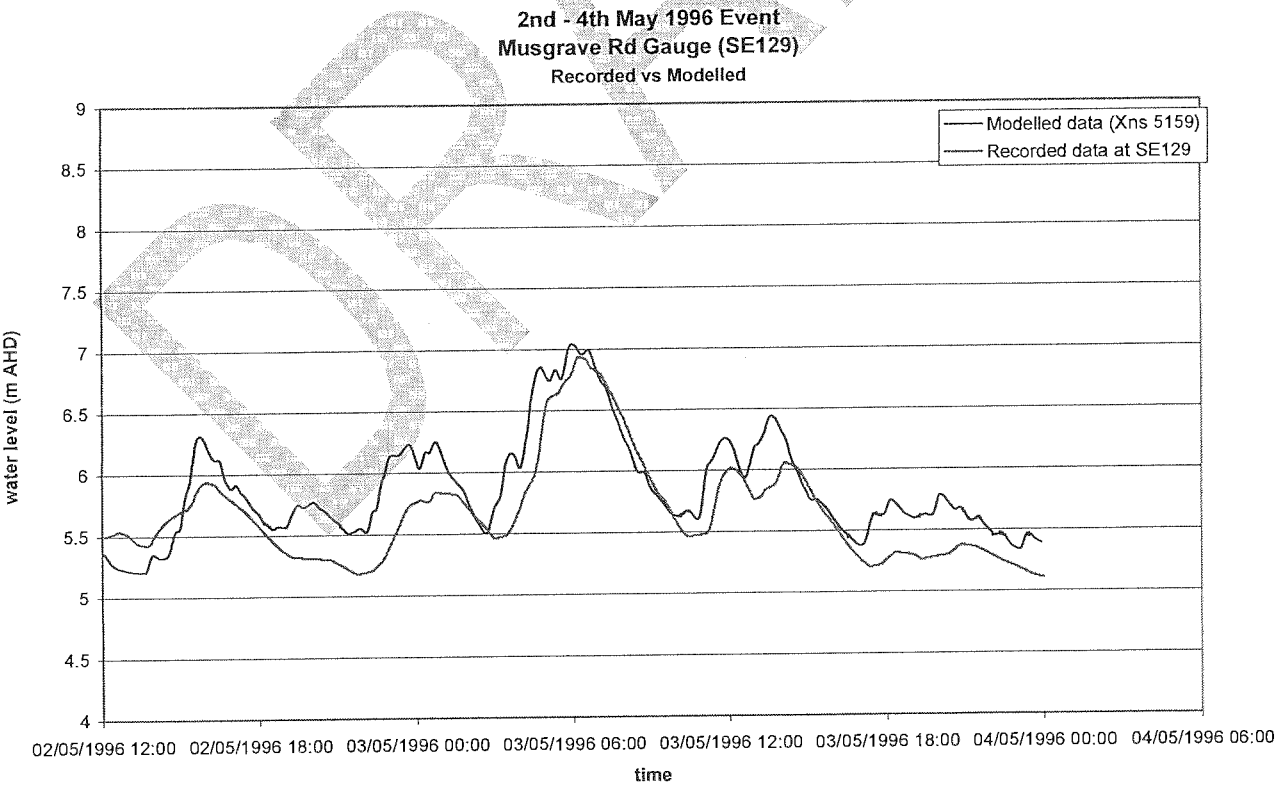

Figure 5.3 Recorded vs. modelled water levels – Musgrave Road Gauge, May 1996 event

5.3 Structure Verification

As MIKE 11 calculates headlosses at structures in a different manner to that commonly used, a validity check of headlosses at four key structures was undertaken as part of model verification. The selected structures include:

- Boundary Road Bridge,
- Beenleigh Road Bridge West,
- Beaudesert Road Bridge and;
- Beenleigh Railway Bridge.

The hydraulic modelling software package HEC RAS (US Army Corps of Engineers, 1995) was used to developed localised models at each structure. The headloss predicted by HEC RAS was then compared against losses calculated by the Stable Swamp Creek 2010 MIKE 11 model. Two calibration events, January 1998 and March 2001 were used for the assessment.

Brisbane City Council structural and bathymetrical survey data was used to setup the HEC RAS models. Inflows and tailwater conditions were taken from the MIKE 11 model at corresponding upstream and downstream cross sections. The HEC RAS models incorporated at least two sections upstream and downstream of the structure to ensure results captured inlet and outlet losses.

Results indicate a significant difference in the calculated headlosses when comparing MIKE 11 and HEC RAS. Headlosses were found to be significantly greater where using HEC RAS across all modelled structures. Furthermore, the results showed that the amount of headloss across each structure varied differently with the application of different flows for each calibration event.

Head losses calculated by MIKE 11 were found to decrease when a larger flow was applied to the model, in this case where the 2001 event flow was compared to the 1998 event. Contrasting this finding, HEC RAS appeared to increase the head loss across each structure where a larger flow was applied.

The inconsistency in findings is considered largely as a result of the approach to modelling structures in each model. The MIKE 11 model makes use of the surveyed deck cross section to define conveyance area across the structure. The HEC RAS structure models were constructed as a best representation of actual structure and therefore conveyance was limited to account for blockages due to handrails, local buildings and fences in the floodplain and ineffective flow areas.

Table 5.2 compares structure affluxes predicted by MIKE 11 and HEC RAS models for two flow scenarios.

Table 5.2 Verification of structure afflux

Structure	Event	Flow (m3/s)	MIKE 11 (m)	HEC RAS (m)	Difference (m)
Boundary Road 9/3.55 x RCBCs	Jan 98	235.39	0.836	1.51	+0.67
	Mar 01	265.01	0.921	1.86	+0.94
Beenleigh Road (West) 5/3.55 x 2.25 RCBCs	Jan 98	130.05	0.419	1.02	+0.60
	Mar 01	142.93	0.452	1.27	+0.82
Beaudesert Road 8/ 2.43 x 2.48 RCBCs + 4/ 2.43 x 3.23 RCBCs	Jan 98	211.09	0.217	0.46	+0.24
	Mar 01	216.68	0.130	0.51	+0.38
Brisbane - Beenleigh Railway Bridge (North Branch) 5Spans (45.4m total)	Jan 98	74.67	0.010	0.01	0.00
	Mar 01	115.87	0.020	0.02	0.00

RCBCs - Reinforced Concrete Box Culverts

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5.4 Sensitivity to model parameters

The sensitivity of the Stable Swamp Creek 2010 MIKE 11 model to adjustments to model parameters was tested by varying Manning's n and structure losses.

Manning's n

Manning's n values were uniformly increased and decreased by 20% across the entire model by modifying the global value resistance number. By increasing Manning's values by 20%, peak water levels were increased by a maximum of 250mm. Decreasing Manning's values by 20% had a similar affect, decreasing water levels by an maximum of 280mm across the model. The sensitivity test demonstrates that this particular model is sensitive to the application of roughness.

Structure losses at Beryl Roberts Basin

The stage discharge (Q/H) relationship generated by MIKE 11 for the outlet pipe of Beryl Roberts Basin was compared to a Q/H relationship derived by hand calculations based on QUDM recommended equations for field inlets under both weir and orifice flow conditions (Section 5.05.4, QUDM 2008). Inflow and outflow losses for the outlet pipe were varied in MIKE 11 to improve correlation with the hand calculations.

Table 5.3 details the three structure loss scenarios for the Beryl Roberts outlet structure investigated in the MIKE 11 model.

Table 5.3 Sensitivity testing of loss parameters at Beryl Roberts Basin

Scenario number	MIKE 11 Culvert Parameters		% change from default parameter
	Inflow loss	Outflow loss	
#24	0.5	1.0	Default
#25	0.3	0.7	- 40 - - 30%
#27	0.8	1.3	+ 40 - + 30%

Figure 5.4 plots the hand calculated Q/H relationship vs. the MIKE 11 derived Q/H relationship with default, increased and decreased losses at the structure.

The results of the sensitivity testing indicate the Q/H relationship derived by MIKE 11 for the outlet structure at Beryl Roberts Basin gives lower flows when basin levels are below 19m AHD and higher flows once basin levels are above 19m AHD than the Q/H relationship derived using QUDM recommended methods. Increasing the loss parameters for the outlet structure in the MIKE 11 model increases the underestimation below 19m AHD but reduces the overestimation above 19m AHD.

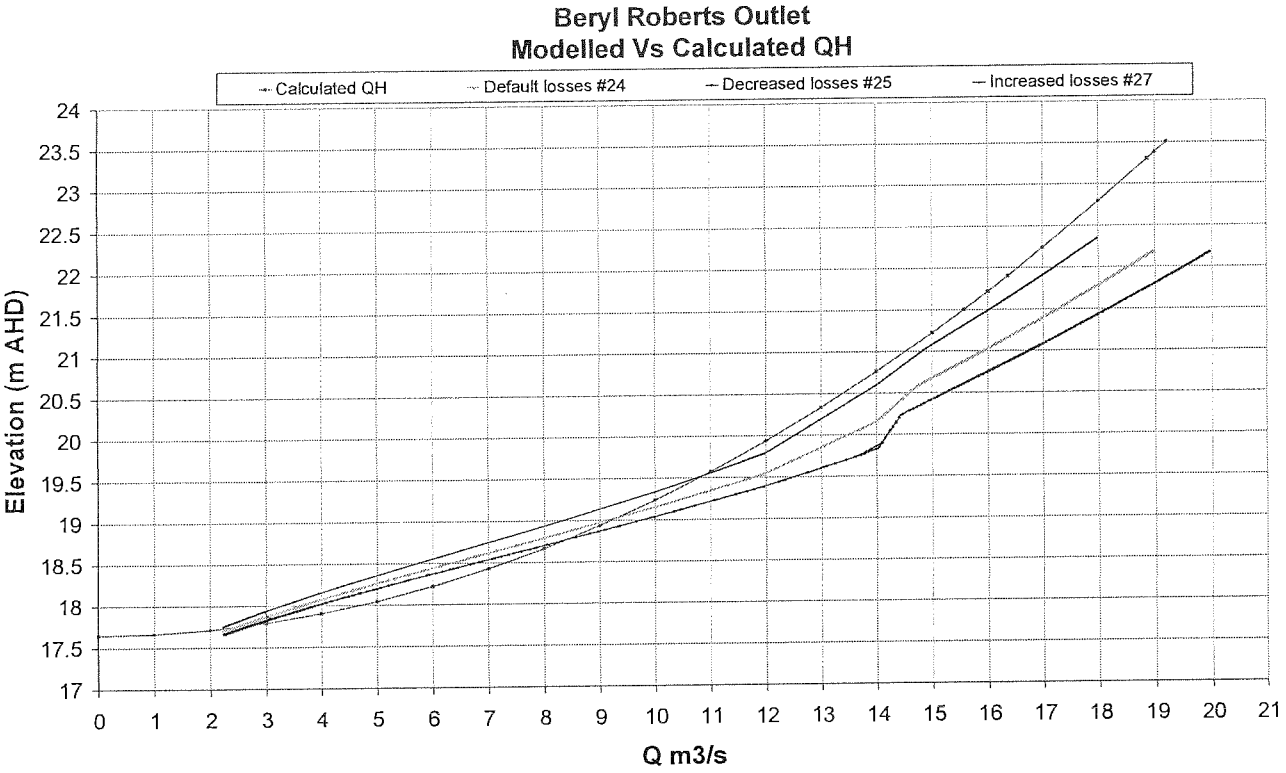

Figure 5.4 Beryl Roberts Basin QH relationship

Water levels downstream of the basin are not significantly sensitive to the losses applied to the pipe culvert. In the 2001 event, one of the largest on record, the impact of increased and decreased losses applied to the outlet pipe on peak downstream discharge is within +/- 0.1 m^3/s, see Figure 5.5.

As the maximum discharge capacity of the outlet pipe is approximately 19 m^3/s, in larger events the operation of the pipe culvert is overtaken by the spillway, which in the 2001 event was estimated to be passing up to 67 m^3/s. The impact of losses applied at the outlet pipe may be greater in smaller events where there is no or little discharge over the spillway and downstream water levels are largely a function of pipe discharge.

Table 5.4 documents discharge over the spillway during the calibration events.

Sensitively testing has demonstrated in large events, water levels downstream of the Beryl Roberts basin are not significantly sensitive to the inflow and outflow losses applied to the outlet pipe. Therefore default losses at the Beryl Roberts outlet structure were adopted for the study.

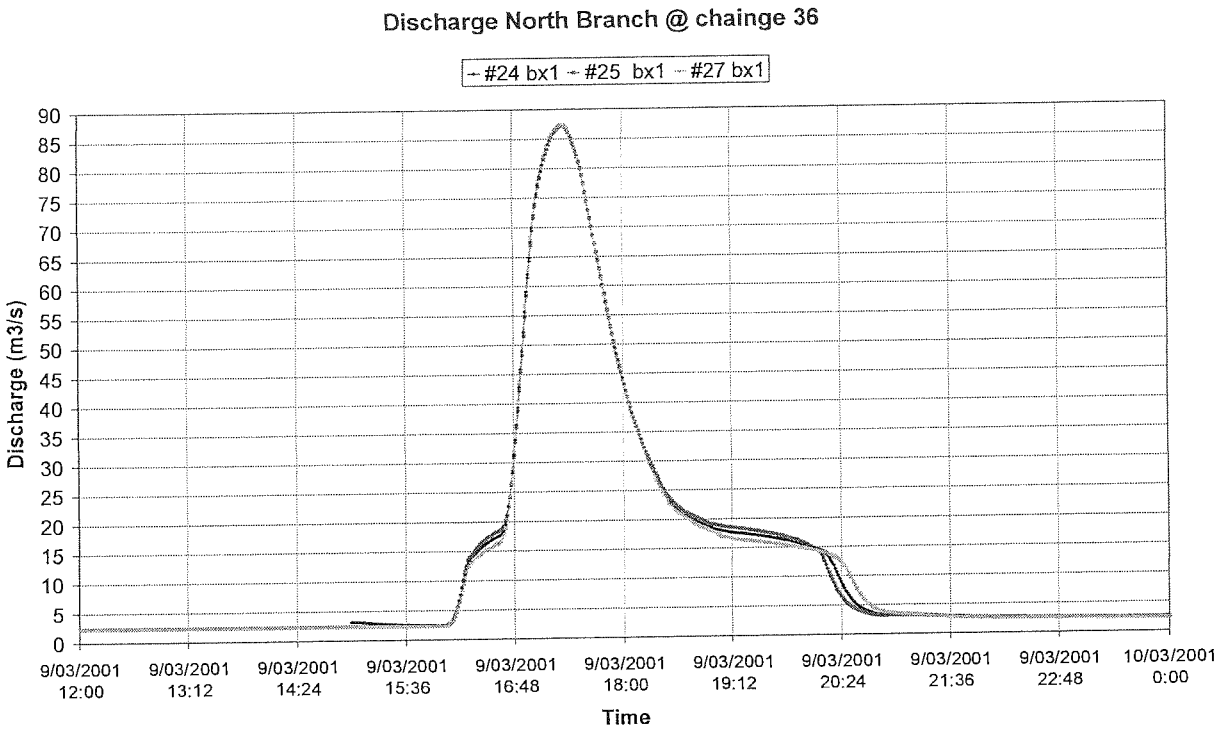

Figure 5.5 Beryl Roberts Basin Outlet – Modelled vs. Calculated Q/H

Table 5.4 Peak modelled basin level for calibration events

Event	Peak water level (m AHD)	Spillway at 21.63m AHD
1996	21.34	No spill
1998	22.23	Spill peak Q 44m3/s
2001	22.34	Spill peak Q 67m3/s
2004	22.18	Spill peak Q 36m3/s

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5.5 Calibration and verification summary

A reasonable calibration was achieved for the Stable Swamp Creek 2010 model. The following comments should be noted:

- Modelled results for the MHG between Boundary and Beenleigh Road are consistently above recorded levels.
- Results consistently match well through the centre of the model from downstream of confluence of North Branch at Coopers Plains to the Ipswich Motorway crossing at Rocklea.
- Results at the downstream boundary are often above recorded levels, however at the downstream reaches of the model, peak water levels will be largely determined by tide levels and levels in Oxley Creek and Brisbane River. Recorded data in Oxley Creek were unavailable for two of the calibration/verification events.
- The model calibration is considered to be poor at gauge location SS210 near Gay Street where modelled levels are below gauged levels across all simulations.
- Model results are often higher in the upper reaches of the model than recorded results. This may be considered acceptable on the basis that it is conservative.

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APPENDIX A: Model Data

Appendix A1: Hydrologic Model Data

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Table A.1 Hydrologic Model Sub-Catchment Properties – Ultimate Catchment Development

RAFTS Sub-Catchment Name	Total Area (ha)	Slope (%)	Open Space (ha)	Commercial/ Industrial (ha)	Urban Area (ha)	Pervious (ha)	Impervious (ha)
Shelleys Creek							
A-1	17.2	3.0	0.9	0.0	15.5	10.3	6.9
B-2	22.2	2.3	0.0	3.3	18.9	11.8	10.4
C-3	20.2	2.3	2.0	0.0	18.2	11.1	9.1
D-4	19.5	2.3	3.9	0.0	15.6	10.7	8.8
E-5	5.4	2.3	1.3	0.0	4.0	3.2	2.1
F-6	25.4	2.3	3.8	0.0	21.6	16.3	9.2
G-7	18.38	2.3	0.9	0.0	17.5	9.2	9.2
H-8	11.09	2.3	0.0	0.0	11.1	5.6	5.6
I-9-HellDS	13.61	2.3	1.4	0.0	12.2	11.2	2.4
K-12	8.18	2.3	0.0	0.0	8.2	6.5	1.6
J-10-Hell	6.92	2.3	1.7	0.0	5.2	4.2	2.6
L-13	13.95	3.3	2.8	0.0	11.2	9.2	4.7
M-14	22.64	3.3	2.3	0.0	20.4	11.3	11.3
N-15-Kent	37.63	3.3	3.8	0.0	33.9	21.5	16.2
O-16-Ash	25.77	4.2	1.3	0.0	24.5	12.9	12.9
P-17-Chilt	16.17	4.5	1.6	0.0	14.6	8.1	8.1
Q-18	20.76	5.0	1.0	0.0	19.7	10.4	10.4
R-19	4.64	5.0	0.7	0.0	3.9	1.9	2.8
S-20-Lang	7.26	5.0	0.7	0.0	6.5	2.9	4.4
T-21	22.89	4.4	0.0	0.0	22.9	9.2	13.7
Stable Swamp Creek (upstream of North Arm)							
Woff	32.3	6.3	8.1	0.0	24.2	23.3	9.0
Feltwell	43.6	1.7	13.1	0.0	30.5	28.8	14.8
Stones	21.6	6.7	8.6	0.0	13.0	16.4	5.2
Keats	26.6	6.2	2.7	10.6	13.3	17.6	9.0
Jackson	39.8	3.5	4.0	0.0	35.8	18.9	20.9
Dyson	29.1	5.5	7.3	0.0	21.8	18.6	10.5
Gaddes	38.7	3.3	9.7	0.0	29.0	27.9	10.8
Beenl W	47.0	3.0	11.8	11.8	23.5	33.8	13.2
Gay	15.4	2.0	0.0	15.4	0.0	1.5	13.9
Wanless	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rail 1	93.9	2.0	14.1	32.9	47.0	49.8	44.1
Rail 2	230.3	3.0	23.0	172.7	34.5	56.4	173.9
Railyard	138.4	1.5	6.9	90.0	41.5	30.5	108.0
Selhurst	47.8	2.2	2.4	38.2	7.2	16.7	31.1
Boundary	61.1	1.6	3.1	39.7	18.3	11.6	49.5
Edith	57.4	2.5	0.0	51.7	5.7	23.0	34.4

RAFTS Sub-Catchment Name	Total Area (ha)	Slope (%)	Open Space (ha)	Commercial/ Industrial (ha)	Urban Area (ha)	Pervious (ha)	Impervious (ha)
Conf U/S	11.4	1.0	0.0	11.4	0.0	6.3	5.1
North Arm							
Beryl A	63.1	8.0	63.1	0.0	0.0	48.0	15.1
Beryl B	75.6	3.3	7.6	0.0	68.0	38.6	37.0
Beryl C	45.9	5.0	9.2	0.0	36.7	28.5	17.5
Beryl E	83.8	4.0	12.6	0.0	71.2	50.3	33.5
Beryl F	44.1	3.0	11.0	0.0	33.1	28.3	15.9
Beryl Basin	0.0	0.0	0.0	0.0	0.0	0.00	0
Musgrave	15.3	4.5	3.8	0.0	11.5	9.2	6.1
Orange Grove	16.8	5.0	0.8	0.0	16.0	10.1	6.7
Debra	12.2	3.0	1.5	2.4	9.8	2.8	9.5
Elma	117.3	5.0	23.5	0.0	93.8	83.9	33.4
Perrin	48.4	3.0	0.0	31.5	16.9	23.7	24.7
Deal	8.6	1.0	0.0	8.6	0.0	4.7	3.9
Stable Swamp (downstream of North Arm)							
Gauge	28.0	0.8	0.0	28.0	0.0	5.3	22.7
Norbury	63.4	2.3	0.0	50.7	12.7	19.0	44.4
Riawena	21.6	1.7	0.0	20.5	1.1	2.2	19.4
Beaudest	20.6	5.0	2.1	16.5	2.1	6.2	14.4
Arch D/S	0.001	0.001	0.0	0.0	0.0	0.0	0.0
Ipswich	55.8	0.8	11.3	39.6	5.7	18.4	37.4
Marshall	102.6	2.5	43.4	27.2	38.0	65.2	37.4
Mouth	274.4	0.5	109.8	164.6	0.0	126.2	148.2
Archerfield Channel							
AA	15.4	3.4	0.0	0.0	15.4	6.2	9.2
BA	11.1	2.7	3.9	0.0	7.2	4.4	6.7
CA	16.5	3.2	0.0	0.0	16.5	7.4	9.1
DA	10.0	1.0	10.0	0.0	0.0	8.0	2.0
EA	18.8	1.7	9.4	0.0	9.4	13.2	5.6
FA	6.7	1.4	0.0	0.0	6.7	2.7	4.0
GA	18.6	2.6	9.3	9.3	0.0	7.4	11.2
HA	18.5	0.4	0.0	18.5	0.0	1.9	16.7
IA	17.4	2.4	0.0	17.4	0.0	8.7	8.7
ABAS1	1.5	2.3	-	-	-	0.0	1.5
JA	10.6	2.3	1.1	8.5	1.1	2.1	8.5
ABAS2	1.0	2.3	-	-	-	0.0	1.0
KA	5.9	2.5	0.9	1.8	3.2	2.4	3.5
LA	7.6	1.5	0.8	5.7	1.1	3.8	3.8
MA	14.8	1.0	14.8	0.0	0.0	7.4	7.4
NA	11.0	1.0	0.0	11.0	0.0	5.5	5.5

RAFTS Sub-Catchment Name	Total Area (ha)	Slope (%)	Open Space (ha)	Commercial/ Industrial (ha)	Urban Area (ha)	Pervious (ha)	Impervious (ha)
OA	8.1	0.4	0.0	8.1	0.0	0.8	7.3
PA	4.3	0.4	0.0	4.3	0.0	0.4	3.9
QA	5.6	0.3	0.0	5.6	0.0	0.6	5.0
RA	4.6	0.5	0.0	4.6	0.0	0.9	3.7
SA	14.8	0.4	0.0	14.8	0.0	2.2	12.6
TA	17.4	0.8	17.4	0.0	0.0	13.9	3.5
UA	9.9	0.9	8.4	1.5	0.0	7.9	2.0
VA	6.3	1.0	0.0	4.4	1.9	1.4	5.6
WA	2.3	1.2	0.0	3.6	1.6	2.1	3.1
XA	7.0	0.1	0.0	6.3	0.0	0.6	5.7
YA	5.2	0.1	0.0	2.3	0.0	0.7	1.6
ZA	6.2	0.8	0.0	6.2	0.0	0.6	5.6
AA1	7.6	1.6	0.8	1.1	5.3	3.0	4.6
BA1	10.0	1.6	1.3	0.0	7.5	4.0	6.0
CA1	3.3	0.1	0.4	0.0	2.5	1.3	2.0
DA1#239	7.7	2.4	1.0	0.0	5.8	3.1	4.6
EA1	1.8	0.1	0.5	1.4	0.0	0.2	1.6
TOTALS	**2679**	-	**525**	**1002**	**1152**	**1263**	**1416**

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Table A.2 RAFTS Model – Rainfall Assignment and Rainfall Totals – Calibration Events

Node	January 1998 Event		March 2001 Event		November 2004 Event		May 1996 Event	
	Rainfall Gauge	Total Rainfall (mm)	Rainfall Gauge	Total Rainfall (mm)	Rainfall Gauge	Total Rainfall (mm)	Rainfall Gauge	Total Rainfall (mm)
A1	OXR114	153	OXR114	178	OXR114	256	BMR138	219
B2	OXR114	153	OXR114	178	OXR114	256	BMR138	219
C3	OXR114	153	OXR114	178	OXR114	256	BMR138	219
D4	OXR114	153	OXR114	178	OXR114	256	BMR138	219
E5	OXR114	153	OXR114	178	OXR114	256	BMR138	219
F6	OXR114	153	OXR114	178	OXR114	256	BMR138	219
G7	OXR114	153	OXR114	178	OXR114	256	BMR138	219
H8	OXR114	153	OXR114	178	OXR114	256	BMR138	219
I9	OXR114	153	OXR114	178	OXR114	256	BMR138	219
J10	OXR114	153	OXR114	178	OXR114	256	BMR138	219
K12	OXR114	153	OXR114	178	OXR114	256	BMR138	219
L13	OXR114	153	OXR114	178	OXR114	256	BMR138	219
M14	OXR114	153	OXR114	178	OXR114	256	BMR138	219
N15	OXR114	153	OXR114	178	OXR114	256	BMR138	219
O16	OXR114	153	OXR114	178	OXR114	256	BMR138	219
P17	OXR114	153	OXR114	178	OXR114	256	BMR138	219
Q18	OXR114	153	OXR114	178	OXR114	256	BMR138	219
R19	OXR114	153	OXR114	178	OXR114	256	BMR138	219
S20	OXR114	153	OXR114	178	OXR114	256	BMR138	219
T21	OXR114	153	OXR114	178	OXR114	256	BMR138	219
Woff	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Feltwell	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Stones	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Keats	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Jackson	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Dyson	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Gaddes	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Beenl W	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Gay	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Wanless	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Rail 1	OXR126	107	SSR130	175	RVR747	211	OXR126	192
Rail 2	OXR126	107	SSR130	175	RVR747	211	OXR126	192
Railyard	SSR130	89	SSR130	175	RVR747	211	OXR126	192
Selhurst	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Boundary	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Edith	SSR130	89	SSR130	175	RVR747	211	SSR130	196
Conf U/S	SSR130	89	SSR130	175	RVR747	211	SSR130	196

Node	January 1998 Event		March 2001 Event		November 2004 Event		May 1996 Event	
	Rainfall Gauge	Total Rainfall (mm)	Rainfall Gauge	Total Rainfall (mm)	Rainfall Gauge	Total Rainfall (mm)	Rainfall Gauge	Total Rainfall (mm)
Basin	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Musgrave	SSR130	89	SSR130	175	RVR747	211	BMR138	219
OrangeGr	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Debra	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Elma	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Perrin	SSR130	89	SSR130	175	RVR747	211	SSR130	196
Deal	SSR130	89	SSR130	175	RVR747	211	SSR130	196
Gauge	SSR130	89	SSR130	175	RVR747	211	SSR130	196
Norbury	SSR130	89	SSR130	175	RVR747	211	SSR130	196
Riawena	SSR130	89	SSR130	175	RVR747	211	SSR130	196
Beaudest	SSR130	89	SSR130	175	RVR747	211	SSR130	196
Marshall	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Ipswich	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Mouth	OXR020	42	SSR130	175	RVR747	211	OXR020	157
Beryl A	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Beryl B	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Beryl C	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Beryl E	SSR130	89	SSR130	175	RVR747	211	BMR138	219
Beryl F	SSR130	89	SSR130	175	RVR747	211	BMR138	219
AA	OXR126	107	SSR130	175	RVR747	211	OXR126	192
BA	OXR126	107	SSR130	175	RVR747	211	OXR126	192
CA	OXR126	107	SSR130	175	RVR747	211	OXR126	192
DA	OXR126	107	SSR130	175	RVR747	211	OXR126	192
EA	OXR126	107	SSR130	175	RVR747	211	OXR126	192
FA	OXR126	107	SSR130	175	RVR747	211	OXR126	192
HA	OXR126	107	SSR130	175	RVR747	211	OXR126	192
IA	OXR126	107	SSR130	175	RVR747	211	OXR126	192
JA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
KA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
LA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
MA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
NA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
OA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
PA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
QA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
RA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
SA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
TA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
UA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
XA	SSR130	89	SSR130	175	RVR747	211	OXR126	192

Node	January 1998 Event		March 2001 Event		November 2004 Event		May 1996 Event	
	Rainfall Gauge	Total Rainfall (mm)	Rainfall Gauge	Total Rainfall (mm)	Rainfall Gauge	Total Rainfall (mm)	Rainfall Gauge	Total Rainfall (mm)
YA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
VA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
WA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
ZA	SSR130	89	SSR130	175	RVR747	211	OXR126	192
AA1	SSR130	89	SSR130	175	RVR747	211	OXR126	192
BA1	SSR130	89	SSR130	175	RVR747	211	OXR126	192
CA1	SSR130	89	SSR130	175	RVR747	211	OXR126	192
DA1	SSR130	89	SSR130	175	RVR747	211	OXR126	192
EA1	SSR130	89	SSR130	175	RVR747	211	OXR126	192

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Appendix A2: Hydraulic Model Data

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Table A.3 Stable Swamp Model 2010 – Branches

Branch Name	Upstream Chainage (m)	Downstream Chainage (m)	Upstream Junction		Downstream Junction		Branch Type
			Branch	Chainage (m)	Branch	Chainage (m)	
Archerfield Channel	1010	2500			Stable Swamp Creek	6540	Regular
Archerfield Overflow 01	0	100	Stable Swamp Creek	5849	Archerfield Channel	2004	Link Channel
Archerfield Overflow 02	0	160	Stable Swamp Creek	5995	Archerfield Channel	2128	Link Channel
Archerfield Overflow 03	0	42	Stable Swamp Creek	6095	Archerfield Channel	2238	Link Channel
Archerfield Overflow 04	0	45	Stable Swamp Creek	6191	Archerfield Channel	2302	Link Channel
Archerfield Overflow 05	0	28	Stable Swamp Creek	6324	Archerfield Channel	2384	Link Channel
Archerfield Overflow 06	0	31	Stable Swamp Creek	6470	Archerfield Channel	2463	Link Channel
Beryl Roberts Basin	0	389					Regular
Beryl Roberts Main	0	388			Beryl Roberts Basin	0	Regular
Beryl Roberts Spillway	0	24	Beryl Roberts Basin	314	Beryl Roberts Basin	375	Regular
Beryl Roberts Trib	0	260			Beryl Roberts Basin	0	Regular
Bridge - Ipswich Motorway	7981	8112	Stable Swamp Creek	7981	Stable Swamp Creek	8112	Regular
North Branch	0	1900	Beryl Roberts Basin	389	Stable Swamp Creek	5020	Regular
Railway Overflow	10000	10581			Stable Swamp Creek	5131	Regular
Railway Overflow_drain	9813	10211			Railway Overflow	10233	Regular
Railway Overflow_drain_wier_1	0	46	Stable Swamp Creek	3996	Railway Overflow_drain	9813	Link Channel
Railway Overflow_drain_wier_2	0	40	Stable Swamp Creek	4166	Railway Overflow_drain	10101	Link Channel
Railway Overflow_weir	0	40	Stable Swamp Creek	4278	Railway Overflow	10292	Link Channel
Riawena Road	10000	10176			North Branch	916	Regular
Shelleys Creek	10000	12165			Stable Swamp Creek	737	Regular
Stable Swamp Creek	737	10100					Regular

Table A.4 Stable Swamp Model 2010 – MIKE 11 Cross Sections

BCC Cross Section	AMTD (m)	MIKE 11 Branch	MIKE 11 Chainage (m)	Bridge Loops Branch	MIKE 11 Chainage (m)	Comments
Copy of SS30	0	Stable Swamp Creek	10100			Stable Swamp Creek at confluence with Oxley Creek flood plain.
SS30	403	Stable Swamp Creek	9740			Original Ground Survey Section
SS40	596	Stable Swamp Creek	9548			Original Ground Survey Section
SS50	785	Stable Swamp Creek	9359			Original Ground Survey Section
SS60	985	Stable Swamp Creek	9162			Original Ground Survey Section
SS61	1011	Stable Swamp Creek	9135			Maximum Height Gauge 1 – SS100
SS70	1257	Stable Swamp Creek	8890			Original Ground Survey Section
SS80	1435	Stable Swamp Creek	8712			Original Ground Survey Section
SS90	1553	Stable Swamp Creek	8593			Original Ground Survey Section
Copy of SS90	1617	Stable Swamp Creek	8530			Edited Ground Survey Section
Copy of SS100	1697	Stable Swamp Creek	8450			Edited Ground Survey Section
SS100	1824	Stable Swamp Creek	8323			Original Ground Survey Section
SS110	1933	Stable Swamp Creek	8215			Original Ground Survey Section
SS120	2015	Stable Swamp Creek	8135			Maximum Height Gauge 1A – SS110
SS130	2036	Stable Swamp Creek	8112	Bridge - Ipswich Motorway	8112	Ipswich Motorway (inbound road)
Copy of SS130	2037	Stable Swamp Creek	8111			Edited Ground Survey Section
Copy of SS130	2107			Bridge - Ipswich Motorway	8041	Edited Ground Survey Section
SS140	2168	Stable Swamp Creek	7981	Bridge - Ipswich Motorway	7981	Ipswich Motorway (outbound road)
SS150	2217	Stable Swamp Creek	7932			Original Ground Survey Section
SS160	2266	Stable Swamp Creek	7849			Original Ground Survey Section
SS170	2333	Stable Swamp Creek	7817			Bridge Marshall Road
SS190	2361	Stable Swamp Creek	7788			Maximum Height Gauge 2 – SS120

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BCC Cross Section	AMTD (m)	MIKE 11 Branch	MIKE 11 Chainage (m)	Bridge Loops Branch	MIKE 11 Chainage (m)	Comments
SS200	2417	Stable Swamp Creek	7734			Original Ground Survey Section
SS210	2559	Stable Swamp Creek	7591			Original Ground Survey Section
SS220	2680	Stable Swamp Creek	7472			Original Ground Survey Section
SS230	2949	Stable Swamp Creek	7203			Original Ground Survey Section
SS231	3113	Stable Swamp Creek	7041			Freney Street Bridge
SS233	3123	Stable Swamp Creek	7028			Original Ground Survey Section
Copy of SS235	3162	Stable Swamp Creek	6991			Original Ground Survey Section
SS235	3166	Stable Swamp Creek	6987			Original Ground Survey Section
SS240	3175	Stable Swamp Creek	6978			Maximum Height Gauge 3 – SS130
SS250	3316	Stable Swamp Creek	6838			Original Ground Survey Section
SS260	3548	Stable Swamp Creek	6607			Original Ground Survey Section
SS261	3566	Stable Swamp Creek	6587			Original Ground Survey Section
Copy of SS261	3575	Stable Swamp Creek	6579			Colvin Street Pedestrian Crossing
Copy of SS263	3579	Stable Swamp Creek	6575			Edited Ground Survey Section
SS263	3594	Stable Swamp Creek	6560			Maximum Height Gauge 4 – SS140
SS263	3612	Stable Swamp Creek	6540			Original Ground Survey Section
Copy of SS263	3648	Stable Swamp Creek	6504			Edited Ground Survey Section
Copy of SS270	3682	Stable Swamp Creek	6470			Edited Ground Survey Section
SS270	3702	Stable Swamp Creek	6450			Original Ground Survey Section
Copy of SS270	3708	Stable Swamp Creek	6444			Bridge Beaudesert Road
Copy of SS290	3736	Stable Swamp Creek	6416			Edited Ground Survey Section
SS290	3751	Stable Swamp Creek	6403			Original Ground Survey Section
SS291	3829	Stable Swamp Creek	6324			Maximum Height Gauge 5 – SS150
SS300	3891	Stable Swamp Creek	6264			Original Ground Survey Section
SS310	3964	Stable Swamp Creek	6191			Original Ground Survey Section
SS330	3983	Stable Swamp Creek	6174			Original Ground Survey Section
SS340	4061	Stable Swamp Creek	6095			Original Ground Survey Section

FINAL

BCC Cross Section	AMTD (m)	MIKE 11 Branch	MIKE 11 Chainage (m)	Bridge Loops Branch	MIKE 11 Chainage (m)	Comments
SS350	4161	Stable Swamp Creek	5995			Original Ground Survey Section
SS360	4251	Stable Swamp Creek	5905			Original Ground Survey Section
Copy of SS360	4257	Stable Swamp Creek	5898			Bridge Riawena Road
Copy of SS380	4293	Stable Swamp Creek	5862			Edited Ground Survey Section
SS380	4306	Stable Swamp Creek	5849			Original Ground Survey Section
SS400	4474	Stable Swamp Creek	5683			Original Ground Survey Section
SS419	4588	Stable Swamp Creek	5570			Maximum Height Gauge 5A – SS160
SS420	4619	Stable Swamp Creek	5538			Original Ground Survey Section
SS430	4673	Stable Swamp Creek	5486			Original Ground Survey Section
SS450	4738	Stable Swamp Creek	5420			Bridge Musgrave Road
Copy of SS450	4744	Stable Swamp Creek	5414			Edited Ground Survey Section
Copy of SS470	4756	Stable Swamp Creek	5402			Edited Ground Survey Section
SS470	4778	Stable Swamp Creek	5380			Maximum Height Gauge 6 – SS170
SS480	4867	Stable Swamp Creek	5292			Original Ground Survey Section
SS490	4984	Stable Swamp Creek	5159			Gauging Station SSE129
Copy of SS490	4985	Stable Swamp Creek	5158			Original Ground Survey Section
SS500	5054	Stable Swamp Creek	5105			Bridge Inbound Railway
SS510	5085	Stable Swamp Creek	5074			Original Ground Survey Section
SS520	5115	Stable Swamp Creek	5045			Bridge Outbound Railway
SS521	5158	Stable Swamp Creek	5002			Original Ground Survey Section
SS530	5278	Stable Swamp Creek	4882			Original Ground Survey Section
SS540	5388	Stable Swamp Creek	4774			Original Ground Survey Section
SS550	5497	Stable Swamp Creek	4662			Original Ground Survey Section
SS560	5502	Stable Swamp Creek	4656			Original Ground Survey Section
SS570	5513	Stable Swamp Creek	4645			Bridge Edith Street
SS589	5523	Stable Swamp Creek	4635			Original Ground Survey Section
SS590	5531	Stable Swamp Creek	4627			Original Ground Survey Section

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BCC Cross Section	AMTD (m)	MIKE 11 Branch	MIKE 11 Chainage (m)	Bridge Loops Branch	MIKE 11 Chainage (m)	Comments
SS600	5567	Stable Swamp Creek	4594			Maximum Height Gauge 6A – SS180
SS610	5641	Stable Swamp Creek	4521			Original Ground Survey Section
SS620	5749	Stable Swamp Creek	4414			Original Ground Survey Section
SS630	5849	Stable Swamp Creek	4278			Original Ground Survey Section
Copy of SS638	5987	Stable Swamp Creek	4176			Original Ground Survey Section
SS638	5991	Stable Swamp Creek	4171			Original Ground Survey Section
SS639	5997	Stable Swamp Creek	4166			Original Ground Survey Section
SS640	6001	Stable Swamp Creek	4163			Original Ground Survey Section
SS641	6034	Stable Swamp Creek	4131			Maximum Height Gauge 6B – SS190
SS650	6146	Stable Swamp Creek	4016			Original Ground Survey Section
SS660	6167	Stable Swamp Creek	3995			Bridge Boundary Road
SS670	6195	Stable Swamp Creek	3967			Original Ground Survey Section
SS671	6243	Stable Swamp Creek	3921			Maximum Height Gauge 10 – SS200
SS680	6325	Stable Swamp Creek	3838			Original Ground Survey Section
SS690	6504	Stable Swamp Creek	3659			Original Ground Survey Section
Copy of SS690	6519	Stable Swamp Creek	3644			Edited Ground Survey Section
Copy of SS690	6524	Stable Swamp Creek	3639			Edited Ground Survey Section
SS690	6527	Stable Swamp Creek	3637			Max Height Gauge – Trib branch near Gay Street – SS210
Copy of SS690	6535	Stable Swamp Creek	3629			Edited Ground Survey Section
Copy of SS690	6552	Stable Swamp Creek	3612			Edited Ground Survey Section
Copy of SS690	6578	Stable Swamp Creek	3586			Edited Ground Survey Section
Copy of SS690	6585	Stable Swamp Creek	3579			Edited Ground Survey Section
SS700	6650	Stable Swamp Creek	3516			Original Ground Survey Section
Copy of SS710	6755	Stable Swamp Creek	3411			Edited Ground Survey Section
Copy of SS710	6769	Stable Swamp Creek	3397			Edited Ground Survey Section
Copy of SS710	6774	Stable Swamp Creek	3392			Edited Ground Survey Section
Copy of SS710	6784	Stable Swamp Creek	3382			Edited Ground Survey Section

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BCC Cross Section	AMTD (m)	MIKE 11 Branch	MIKE 11 Chainage (m)	Bridge Loops Branch	MIKE 11 Chainage (m)	Comments
SS710	6817	Stable Swamp Creek	3350			Original Ground Survey Section
Copy of SS720	6830	Stable Swamp Creek	3337			Edited Ground Survey Section
SS720	6832	Stable Swamp Creek	3334			Original Ground Survey Section
SS730	6968	Stable Swamp Creek	3199			Original Ground Survey Section
Copy of SS740	7065	Stable Swamp Creek	3102			Edited Ground Survey Section
SS740	7104	Stable Swamp Creek	3063			Bridge Beenleigh Rd and Max Height Gauge 11 – SS220
SS760	7138	Stable Swamp Creek	3029			Original Ground Survey Section
SS770	7226	Stable Swamp Creek	2942			Original Ground Survey Section
SS780	7360	Stable Swamp Creek	2810			Original Ground Survey Section
SS790	7496	Stable Swamp Creek	2674			Original Ground Survey Section
SS800	7654	Stable Swamp Creek	2516			Original Ground Survey Section
SS810	7753	Stable Swamp Creek	2417			Original Ground Survey Section
SS820	7854	Stable Swamp Creek	2316			Original Ground Survey Section
SS830	7931	Stable Swamp Creek	2240			Original Ground Survey Section
SS840	8040	Stable Swamp Creek	2132			Original Ground Survey Section
SS850	8132	Stable Swamp Creek	2040			Original Ground Survey Section
SS860	8209	Stable Swamp Creek	1962			Dyson Avenue Pedestrian Bridge
Section 2	8221	Stable Swamp Creek	1950			Keats Street Park 2007 survey
Section 9	8312	Stable Swamp Creek	1859			Keats Street Park 2007 survey
Section 12	8348	Stable Swamp Creek	1823			Keats Street Park 2007 survey
Section 15	8381	Stable Swamp Creek	1790			Keats Street Park 2007 survey
Section 16	8391	Stable Swamp Creek	1780			Keats Street Park 2007 survey
Section 17	8400	Stable Swamp Creek	1771			Keats Street Park 2007 survey
Section 19	8416	Stable Swamp Creek	1755			Keats Street Park 2007 survey
Section 3	8450	Stable Swamp Creek	1721			Keats Street Park 2007 survey
Section 2	8506	Stable Swamp Creek	1665			Keats Street Park 2007 survey
SS900	8535	Stable Swamp Creek	1641			Bridge Keats Street

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BCC Cross Section	AMTD (m)	MIKE 11 Branch	MIKE 11 Chainage (m)	Bridge Loops Branch	MIKE 11 Chainage (m)	Comments
SS920	8550	Stable Swamp Creek	1625			Original Ground Survey Section
SS922	8554	Stable Swamp Creek	1618			Original Ground Survey Section
SS928	8580	Stable Swamp Creek	1593			Maximum Height Gauge 12 – SS230
SS930	8595	Stable Swamp Creek	1577			Original Ground Survey Section
Section 1	8658	Stable Swamp Creek	1514			Keats Street Park 2007 survey
SS938	8725	Stable Swamp Creek	1447			Original Ground Survey Section
Copy of SS965	8728	Stable Swamp Creek	1441			Original Ground Survey Section
SS965	8742	Stable Swamp Creek	1430			Bridge Stones Road - 2007
SS970	8975	Stable Swamp Creek	1272			Original Ground Survey Section
SS980	9115	Stable Swamp Creek	1199			Original Ground Survey Section
SS990	9216	Stable Swamp Creek	1059			Original Ground Survey Section
SS1000	9319	Stable Swamp Creek	960			Original Ground Survey Section
SS1010	9443	Stable Swamp Creek	859			Original Ground Survey Section
SS1020	8209	Stable Swamp Creek	737			Original Ground Survey Section
SS1030	9530	Shelleys Creek	12165			Original Ground Survey Section
SS1040	9626	Shelleys Creek	12069			Bridge - Beenleigh Road 2
SS1060	9655	Shelleys Creek	12041			Original Ground Survey Section
SS1070	9769	Shelleys Creek	11928			Original Ground Survey Section
SS1078	9833	Shelleys Creek	11869			Maximum Height Gauge 13
SS1080	9834	Shelleys Creek	11867			Original Ground Survey Section
Copy of SS1080	9837	Shelleys Creek	11866			Lang Street Drop Structure
Copy of SS1080	9838	Shelleys Creek	11865			Edited Ground Survey Section
Copy of SS1100	9839	Shelleys Creek	11862			Lang Street Pedestrian Bridge
SS1100	9841	Shelleys Creek	11848			Channel section at Lang Street Bridge (U/S face)
SS1105	9849	Shelleys Creek	11844			Maximum Height Gauge 13A
Copy of SS1110	9932	Shelleys Creek	11766			Edited Ground Survey Section
SS1110	10003	Shelleys Creek	11709			Original Ground Survey Section

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BCC Cross Section	AMTD (m)	MIKE 11 Branch	MIKE 11 Chainage (m)	Bridge Loops Branch	MIKE 11 Chainage (m)	Comments
SS1120	10121	Shelleys Creek	11638			Original Ground Survey Section
SS1130	10180	Shelleys Creek	11520			Chilton Road (Downstream)
Copy of SS1140	10215	Shelleys Creek	11485			Edited Ground Survey Section
Copy of SS1140	10230	Shelleys Creek	11470			Edited Ground Survey Section
SS1140	10238	Shelleys Creek	11462			Original Ground Survey Section
SS1160	10257	Shelleys Creek	11443			Original Ground Survey Section
Copy of SS160	10270	Shelleys Creek	11430			Edited Ground Survey Section
SS1170	10386	Shelleys Creek	11314			Original Ground Survey Section
SS1180	10477	Shelleys Creek	11223			Original Ground Survey Section
SS1190	10566	Shelleys Creek	11134			Original Ground Survey Section
SS1200	10664	Shelleys Creek	11036			Original Ground Survey Section
SS1203	10731	Shelleys Creek	10969			Original Ground Survey Section
SS1204	10735	Shelleys Creek	10965			Original Ground Survey Section
Copy of SS1204	10738	Shelleys Creek	10962			Original Ground Survey Section
SS1210	10752	Shelleys Creek	10948			Original Ground Survey Section
SS1220	10834	Shelleys Creek	10866			Original Ground Survey Section
SS1230	10879	Shelleys Creek	10821			Original Ground Survey Section
SS1240	10971	Shelleys Creek	10729			Original Ground Survey Section
SS1250	11070	Shelleys Creek	10630			Original Ground Survey Section
Copy of SS1260	11180	Shelleys Creek	10520			Edited Ground Survey Section
SS1260	11186	Shelleys Creek	10514			Original Ground Survey Section
SS1270	11288	Shelleys Creek	10412			Original Ground Survey Section
SS1290	11314	Shelleys Creek	10386			Original Ground Survey Section
SS1297	11324	Shelleys Creek	10376			Original Ground Survey Section
SS1298	11331	Shelleys Creek	10369			Original Ground Survey Section
SS1299	11384	Shelleys Creek	10316			Original Ground Survey Section
SS1300	11417	Shelleys Creek	10283			Original Ground Survey Section

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BCC Cross Section	AMTD (m)	MIKE 11 Branch	MIKE 11 Chainage (m)	Bridge Loops Branch	MIKE 11 Chainage (m)	Comments
SS1308	11471	Shelleys Creek	10229			Original Ground Survey Section
SS1309	11500	Shelleys Creek	10200			Original Ground Survey Section
SS1310	11513	Shelleys Creek	10187			Original Ground Survey Section
SS1320	11609	Shelleys Creek	10091			Original Ground Survey Section
SS1324	11653	Shelleys Creek	10047			Original Ground Survey Section
SS1328	11661	Shelleys Creek	10039			Original Ground Survey Section
Copy of S1330	11690	Shelleys Creek	10010			Edited Ground Survey Section
SS1330	11700	Shelleys Creek	10000			Original Ground Survey Section
Copy of SS521	12045	North Arm	1900			Confluence with Stable Swamp Creek
SS9001	12070	North Arm	1872			Bridge Musgrave Road (West)
SS9003	12095	North Arm	1852			Original Ground Survey Section
SS9004	12147	North Arm	1800			Original Ground Survey Section
SS9010	12229	North Arm	1720			Bridge Brisbane-Beenleigh Railway Line
SS9030	12254	North Arm	1700			Maximum Height Gauge 7 – SS300
SS9040	12354	North Arm	1604			Bridge Perrin Place
SS9044	12366	North Arm	1584			Original Ground Survey Section
SS9050	12529	North Arm	1430			Original Ground Survey Section
SS9060	12778	North Arm	1180			Original Ground Survey Section
SS9070	12888	North Arm	1070			Original Ground Survey Section
Copy of SS9074	13005	North Arm	967			Edited Ground Survey Section
SS9074	13108	North Arm	850			Confluence with Southside Christian College Creek and Maximum Height Gauge 8 – SS310
SS9075	13141	North Arm	818			Original Ground Survey Section
SS9080	13248	North Arm	710			Original Ground Survey Section
SS9090	13350	North Arm	600			Original Ground Survey Section
SS9100	13460	North Arm	494			Bridge Orange Grove Road
SS9120	13479	North Arm	472			Original Ground Survey Section
SS9130	13509	North Arm	444			Original Ground Survey Section

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BCC Cross Section	AMTD (m)	MIKE 11 Branch	MIKE 11 Chainage (m)	Bridge Loops Branch	MIKE 11 Chainage (m)	Comments
SS9140	13552	North Arm	402			Bridge Musgrave Road
SS9160	13571	North Arm	382			Original Ground Survey Section
SS9161	13643	North Arm	312			Bridge Baroda Pedestrian
SS9163	13649	North Arm	304			Maximum Height Gauge 9 – SS320
SS9170	13671	North Arm	284			Original Ground Survey Section
SS9180	13796	North Arm	158			Original Ground Survey Section
SS9190	13804	North Arm	150			Bridge Peringa Street Pedestrian
SS9210	13810	North Arm	144			Original Ground Survey Section
SS9220	13875	North Arm	80			Bridge Barham Street
SS9240	13881	North Arm	72			Original Ground Survey Section
SS9250	13934	North Arm	0			Original Ground Survey Section
SS6000	38	Archerfield Channel	2500			Original Ground Survey Section
Copy of SS6000	76	Archerfield Channel	2463			Copy of SS6000
Interpolated	90	Archerfield Channel	2449			Interpolated Section
Interpolated	103	Archerfield Channel	2436			Interpolated Section
Copy of SS6010	117	Archerfield Channel	2418			Copy of SS6010
SS6030	147	Archerfield Channel	2404			Original Ground Survey Section
Copy of SS6030	163	Archerfield Channel	2390			Copy of SS6030
Copy of SS6030	169	Archerfield Channel	2384			Copy of SS6030
Interpolated	209	Archerfield Channel	2344			Interpolated Section
Interpolated	244	Archerfield Channel	2302			Interpolated Section
Interpolated	264	Archerfield Channel	2280			Interpolated Section
Interpolated	283	Archerfield Channel	2251			Interpolated Section
SS6070	297	Archerfield Channel	2238			Original Ground Survey Section
SS6090	311	Archerfield Channel	2224			Original Ground Survey Section
Interpolated	345	Archerfield Channel	2190			Interpolated Section
Interpolated	385	Archerfield Channel	2150			Interpolated Section

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BCC Cross Section	AMTD (m)	MIKE 11 Branch	MIKE 11 Chainage (m)	Bridge Loops Branch	MIKE 11 Chainage (m)	Comments
SS6100	403	Archerfield Channel	2132			Original Ground Survey Section
Copy of SS6100	407	Archerfield Channel	2128			Original Ground Survey Section
Copy of SS6120	453	Archerfield Channel	2082			Edited Ground Survey Section
SS6120	504	Archerfield Channel	2032			Edited Ground Survey Section
SS6140	529	Archerfield Channel	2004			Edited Ground Survey Section
Interpolated	583	Archerfield Channel	1950			Interpolated Section
SS6150	695	Archerfield Channel	1840			Original Ground Survey Section
SS6160	784	Archerfield Channel	1750			Original Ground Survey Section
SS6170	802	Archerfield Channel	1732			Edited Ground Survey Section
Interpolated	845	Archerfield Channel	1690			Interpolated Section
SS6180	884	Archerfield Channel	1650			Original Ground Survey Section
SS6190	944	Archerfield Channel	1594			Original Ground Survey Section- Lengthened
SS6200	984	Archerfield Channel	1550			Original Ground Survey Section- Lengthened
SS6220	1030	Archerfield Channel	1504			Original Ground Survey Section- Lengthened
interpolated	1111	Archerfield Channel	1424			Interpolated section
SS6230	1190	Archerfield Channel	1344			Original Ground Survey Section
SS6240	1219	Archerfield Channel	1316			Original Ground Survey Section
SS6250	1281	Archerfield Channel	1252			Original Ground Survey Section- Lengthened
interpolated	1323	Archerfield Channel	1208			Interpolated Section
Interpolated	1425	Archerfield Channel	1108			Interpolated Section
SS6260	1469	Archerfield Channel	1068			Original Ground Survey Section- Lengthened
SS6280	1535	Archerfield Channel	1010			Original Ground Survey Section

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Table A.5 Stable Swamp Model 2010 – Hydraulic Structures

Location Description	Main Branch	Weir Branch	Chainage (m)	Structure Description	Modelled as
Ipswich Motorway	Stable Swamp Creek	Bridge - Ipswich Motorway	8047	Corrugated Iron Culverts: 3 - 9.20w x 5.83h Oval Pipes	Weir + Irregular Culvert
Marshall Road	Stable Swamp Creek	-	7803	Culverts: 5 - 2.65w x 1.99h RCBCs	Weir + Rectangular Culvert
Freney Street Pedestrian Bridge	Stable Swamp Creek	-	7034	Timber Footbridge: 4 spans – Total = 36.5m	Weir + Irregular Culvert
Freney Street Pipe Crossing	Stable Swamp Creek	-	6989	Steel Pipeline: 800mm diameter, 117.1m long	Weir + Irregular Culvert
Colvin Street Pedestrian Bridge	Stable Swamp Creek	-	6577	Timber Footbridge: 2 spans – Total = 18.2m	Weir + Irregular Culvert
Beaudesert Road	Stable Swamp Creek	-	6430	Culverts: 8 - 2.43w x 2.48h; 4 - 2.43w x 3.23h RCBCs	Weir + 2 Rectangular Culverts
Riawena Road	Stable Swamp Creek	-	5880	Culverts: 8 - 3.85w x 3.70h; 2 - 3.85w x 4.27h RCBCs	Weir + 2 Rectangular Culverts
Musgrave Road (Main Branch)	Stable Swamp Creek	-	5408	Culverts: 6 - 3.62w x 3.14h; 2 - 3.62w x 4.40h RCBCs	Weir + 1 Rectangular + 1 Irregular Culverts
Interstate Railway - Inbound	Stable Swamp Creek	-	5077	Bridge: 6 spans - Total = 59.4m	Weir + Irregular Culvert
Interstate Railway - Outbound	Stable Swamp Creek	-	5066	Bridge: 2 spans - Total = 29.6m	Weir + Irregular Culvert
Edith Street	Stable Swamp Creek	-	4640	Culverts: 6 - 3.70w x 2.75h RCBCs	Weir + Rectangular Culvert
Boundary Road	Stable Swamp Creek	-	3983	Culverts: 9 - 3.00w x 3.00h RCBCs	Weir + Rectangular Culvert
Beenleigh Road (West)	Stable Swamp Creek	-	3046	Culverts: 5 - 3.55w x 2.25h RCBCs	Weir + Rectangular Culvert
Dyson Avenue Pedestrian Bridge	Stable Swamp Creek	-	1955	Steel Footbridge: 1 span - Total = 16.5m	Weir + Irregular Culvert

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Location Description	Main Branch	Weir Branch	Chainage (m)	Structure Description	Modelled as
Keats Street	Stable Swamp Creek	-	1633	Culverts: 2 – 3.1w x 1.80h; 1 - 0.80w x 2.06h RCBCs	Weir + 1 Rectangular + 1 Irregular Culvert
Stones Road	Stable Swamp Creek	-	1437	Bridge: 1 span Total = 21m	Weir + Irregular Culvert
Musgrave Road (North Branch - West)	North Branch	-	1862	Culverts: 3 - 3.05w x 2.15h RCBCs	Weir + Rectangular Culvert
Brisbane-Beenleigh Railway	North Branch	-	1710	Bridge: 5 spans - Total = 45.4m	Weir + Irregular Culvert
Perrin Place	North Branch	-	1594	Culverts: 3 - 2.04w x 2.70h; 2 - 3.20w x 2.92h RCBCs	Weir + 2 Rectangular Culverts
Orange Grove Road	North Branch	-	484	Culverts: 6 - 1500mm diameter RCPs	Weir + Circular Culvert
Musgrave Road (North Branch - East)	North Branch	-	392	Culverts: 6 - 1500mm diameter RCPs	Weir + Circular Culvert
Baroda Street Pedestrian Bridge	North Branch	-	308	Steel Deck: 1 span - Total = 7.8m	Weir + Irregular Culvert
Peringa Street Pedestrian Bridge	North Branch	-	147	Steel Footbridge: 1 span - Total = 14.7m	Weir + Irregular Culvert
Barham Street	North Branch	-	76	Culverts: 3 - 1.15w x 0.90h RCBCs	Weir + Rectangular Culvert
Marshall Road	Archerfield Channel	-	2231	Culverts: 4 – 2.12w x 1.23h RCBCs	Weir + Rectangular Culvert
Granard Road	Archerfield Channel	-	2018	Culverts: 2- 2.13w x 1.12h RCBCs	Weir + Regular Culvert
Beenleigh Road (East)	Shelleys Creek	-	12045	Culverts: 5 - 2.75w x 1.86h RCBCs	Weir + Rectangular Culvert
Lang Street Drop Structure	Shelleys Creek	-	11868	Drop Structure: 6.85w x 1.49 drop	Weir
Lang Street Pedestrian Bridge	Shelleys Creek	-	11864	Timber Footbridge: 1 span – Total = 12.3m; Culverts: 6 - 2.70w x 0.90h RCBCs	Weir + 2 Rectangular Culverts
Lang Street	Shelleys creek	-	11864	Culverts: 1-12.3w x 1.21h ; 6-2.7w x 0.9h RCBCs	Weir + 2 Regular Culverts
Chilton Street	Shelleys creek	-	11448	Culverts: 3-3w x 1.8h RCBC	Weir + Regular Culvert
Kingman Street	Shelleys creek	-	10964	Pedestrian Bridge	Weir + Irregular Culvert
Hellawell Road	Shelleys creek	-	10592	Culverts: 3-3w x 1.8h RCBC	Weir + Regular Culvert
Forestlea Place	Shelleys creek	-	10043	Culverts: 1- 450mm diameter RCPs	Weir + 1 Circular Culvert

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Table A.6 Stable Swamp Model 2010 – Inflows

Name of Inflow	Description	Point of Inflow to MIKE 11	
		Branch	Chainage (m)
LDEAL	Flow from local sub-catchment	North Branch	1800
LPERRIN	Flow from local sub-catchment	North Branch	1430
LDEBRA	Flow from local sub-catchment	North Branch	850
LORANGEGR	Flow from local sub-catchment	North Branch	444
LMUSGRAVE	Flow from local sub-catchment	North Branch	284
LMOUTH	Flow from local sub-catchment	Stable Swamp Creek	9547
LIPSWICH	Flow from local sub-catchment	Stable Swamp Creek	7932
LMARSHALL	Flow from local sub-catchment	Stable Swamp Creek	7203
LBEAUDEST	Flow from local sub-catchment	Stable Swamp Creek	6324
LRIAWENA	Flow from local sub-catchment	Stable Swamp Creek	5755
LNORBURY	Flow from local sub-catchment	Stable Swamp Creek	5486
LGAUGE	Flow from local sub-catchment	Stable Swamp Creek	5208
LCONF U/S	Flow from local sub-catchment	Stable Swamp Creek	5002
LEDITH	Flow from local sub-catchment	Stable Swamp Creek	4521
LBOUNDARY	Flow from local sub-catchment	Stable Swamp Creek	3921
LSELHURST	Flow from local sub-catchment	Stable Swamp Creek	3838
TRAILYARD	Flow from local sub-catchment	Stable Swamp Creek	3637
LGAY	Flow from local sub-catchment	Stable Swamp Creek	3516
LBEENL W	Flow from local sub-catchment	Stable Swamp Creek	2674
LGADDES	Flow from local sub-catchment	Stable Swamp Creek	2132
LDYSON	Flow from local sub-catchment	Stable Swamp Creek	1831
LJACKSON	Flow from local sub-catchment	Stable Swamp Creek	1773
LKEATS	Flow from local sub-catchment	Stable Swamp Creek	1577
LSTONES	Flow from local sub-catchment	Stable Swamp Creek	1272
LFELTWELL	Flow from local sub-catchment	Stable Swamp Creek	1059
LWOFF	Flow from local sub-catchment	Stable Swamp Creek	960
MHWS	Boundary with Oxley Creek	Stable Swamp Creek	10100
BASEFLOW	Trickle Flow	Railway Overflow	10000
LELMA	Flow from local sub-catchment	Riawena Road	10000
TBERYLDUM	Flow into Beryl Roberts Basin	Beryl Roberts Trib	0
TBERYLDUM2	Flow into Beryl Roberts Basin	Beryl Roberts Main	0
TDA1	Flow from local sub-catchment	Archerfield Channel	1010
TPA	Flow from local sub-catchment	Archerfield Channel	1252
TSA	Flow from local sub-catchment	Archerfield Channel	1594
TDA17	Flow from local sub-catchment	Archerfield Channel	1650
TWA	Flow from local sub-catchment	Archerfield Channel	1732
TAA1	Flow from local sub-catchment	Archerfield Channel	2004
TZA	Flow from local sub-catchment	Archerfield Channel	2004
TBA1	Flow from local sub-catchment	Archerfield Channel	2224

Name of Inflow	Description	Point of Inflow to MIKE 11	
		Branch	Chainage (m)
TCA1	Flow from local sub-catchment	Archerfield Channel	2224
TDA1#239	Flow from local sub-catchment	Archerfield Channel	2280
TEA1	Flow from local sub-catchment	Archerfield Channel	2280
TDUM1	Flow from local sub-catchment	Shelleys creek	10000
TF-6	Flow from local sub-catchment	Shelleys creek	10091
TJ-10-HELL	Flow from local sub-catchment	Shelleys creek	10386
TI-9-HELLDS	Flow from total catchment	Shelleys creek	10412
LL-13	Flow from local sub-catchment	Shelleys creek	10630
LM-14	Flow from local sub-catchment	Shelleys creek	10821
LN-15-KENT	Flow from local sub-catchment	Shelleys creek	10948
LO-16-ASH	Flow from local sub-catchment	Shelleys creek	11223
LP-17-CHILT	Flow from local sub-catchment	Shelleys creek	11443
LQ-18	Flow from local sub-catchment	Shelleys creek	11520
LR-19	Flow from local sub-catchment	Shelleys creek	11638
LS-20-Lang	Flow from local sub-catchment	Shelleys creek	11844
LT-21	Flow from local sub-catchment	Shelleys creek	12041

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APPENDIX B: Calibration & Verification Events Results

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Table B 1 Calibration Events – Peak Flood Levels

AMTD (m)	BCC Cross Section	MIKE 11 Cross Section	Peak Flood Level (m AHD)			
			Jan 98	May 96	Mar 01	Nov 04
1535	SS6280	ARCHERFIELD 1010.00	10.26	9.40	10.18	9.95
1469	SS6260	ARCHERFIELD 1068.00	10.12	9.27	10.07	9.84
1425	Interpolated	ARCHERFIELD 1108.00	9.98	9.14	9.91	9.69
1323	Interpolated	ARCHERFIELD 1208.00	9.61	8.81	9.51	9.31
1281	SS6250	ARCHERFIELD 1252.00	9.34	8.59	9.25	9.07
1219	SS6240	ARCHERFIELD 1316.00	8.86	8.13	8.77	8.60
1190	SS6230	ARCHERFIELD 1344.00	8.72	7.99	8.63	8.45
1111	Interpolated	ARCHERFIELD 1424.00	8.23	7.58	8.14	7.97
1030	SS6220	ARCHERFIELD 1504.00	7.82	7.16	7.73	7.55
984	SS6200	ARCHERFIELD 1550.00	7.70	7.02	7.62	7.43
944	SS6190	ARCHERFIELD 1594.00	7.59	6.90	7.52	7.33
884	SS6180	ARCHERFIELD 1650.00	7.35	6.67	7.29	7.10
845	Interpolated	ARCHERFIELD 1690.00	7.19	6.53	7.13	6.95
802	SS6170	ARCHERFIELD 1732.00	7.02	6.38	6.98	6.81
784	SS6160	ARCHERFIELD 1750.00	6.93	6.30	6.89	6.73
695	SS6150	ARCHERFIELD 1840.00	6.66	6.12	6.62	6.47
583	Interpolated	ARCHERFIELD 1950.00	6.50	6.08	6.48	6.36
529	SS6140	ARCHERFIELD 2004.00	6.47	6.08	6.45	6.34
529	SS6140	ARCHERFIELD 2004.00	6.47	6.08	6.45	6.34
504	SS6120	ARCHERFIELD 2032.00	6.04	5.32	6.25	5.94
453	Copy of SS6120	ARCHERFIELD 2082.00	5.97	5.17	6.25	5.88
407	Copy of SS6100	ARCHERFIELD 2128.00	5.88	5.11	6.25	5.87
407	Copy of SS6100	ARCHERFIELD 2128.00	5.88	5.11	6.25	5.87
403	SS6100	ARCHERFIELD 2132.00	5.88	5.11	6.25	5.86
385	Interpolated	ARCHERFIELD 2150.00	5.88	5.11	6.25	5.86
345	Interpolated	ARCHERFIELD 2190.00	5.86	5.10	6.25	5.86
311	SS6090	ARCHERFIELD 2224.00	5.85	5.09	6.25	5.85
297	SS6070	ARCHERFIELD 2238.00	5.84	5.04	6.24	5.85
297	SS6070	ARCHERFIELD 2238.00	5.84	5.04	6.24	5.85
283	Interpolated	ARCHERFIELD 2251.00	5.83	5.01	6.24	5.84
264	Interpolated	ARCHERFIELD 2280.00	5.79	4.97	6.23	5.81
244	Interpolated	ARCHERFIELD 2302.00	5.76	4.99	6.21	5.79
244	Interpolated	ARCHERFIELD 2302.00	5.76	4.99	6.21	5.79
202	-	ARCHERFIELD 2344.00	5.68	5.01	6.18	5.76
169	Copy of SS6030	ARCHERFIELD 2384.00	5.63	5.01	6.16	5.74
169	Copy of SS6030	ARCHERFIELD 2384.00	5.63	5.01	6.16	5.74
163	Copy of SS6030	ARCHERFIELD 2390.00	5.63	5.01	6.16	5.73
147	SS6030	ARCHERFIELD 2404.00	5.62	5.01	6.15	5.73
117	Copy of SS6010	ARCHERFIELD 2418.00	5.60	5.01	6.13	5.71
99	Interpolated	ARCHERFIELD 2436.00	5.63	5.02	6.14	5.73
86	Interpolated	ARCHERFIELD 2449.00	5.63	5.02	6.14	5.73
76	Copy of SS6000	ARCHERFIELD 2463.00	5.62	5.02	6.13	5.73
76	Copy of SS6000	ARCHERFIELD 2463.00	5.62	5.02	6.13	5.73
38	SS6000	ARCHERFIELD 2500.00	5.61	5.02	6.12	5.72

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AMTD (m)	BCC Cross Section	MIKE 11 Cross Section	Peak Flood Level (m AHD)			
			Jan 98	May 96	Mar 01	Nov 04
-	2002 ALS	ARCHERFIELD OVERFLOW 01 0.00	6.59	5.70	6.99	6.56
-	2002 ALS	ARCHERFIELD OVERFLOW 01 100.00	6.47	6.08	6.45	6.34
-	2002 ALS	ARCHERFIELD OVERFLOW 02 0.00	6.42	5.62	6.73	6.40
-	2002 ALS	ARCHERFIELD OVERFLOW 02 160.31	5.88	5.11	6.25	5.87
-	2002 ALS	ARCHERFIELD OVERFLOW 03 0.00	6.25	5.50	6.54	6.24
-	2002 ALS	ARCHERFIELD OVERFLOW 03 42.43	5.84	5.04	6.24	5.85
-	2002 ALS	ARCHERFIELD OVERFLOW 04 0.00	6.12	5.38	6.43	6.14
-	2002 ALS	ARCHERFIELD OVERFLOW 04 44.72	5.76	4.99	6.21	5.79
-	2002 ALS	ARCHERFIELD OVERFLOW 05 0.00	5.97	5.23	6.32	6.02
-	2002 ALS	ARCHERFIELD OVERFLOW 05 28.28	5.63	5.01	6.16	5.74
-	Copy of SS9310	BERYL ROBERTS BASIN 0.16	22.31	21.55	22.48	22.29
-	SS9310	BERYL ROBERTS BASIN 78.74	22.28	21.52	22.43	22.26
-	SS9300	BERYL ROBERTS BASIN 161.19	22.26	21.51	22.41	22.25
-	Copy of SS9300	BERYL ROBERTS BASIN 313.55	22.26	21.50	22.40	22.24
-	Copy of SS9300	BERYL ROBERTS BASIN 313.55	22.26	21.50	22.40	22.24
-	Copy of SS9250	BERYL ROBERTS BASIN 375.00	18.94	17.99	19.22	18.91
-	Copy of SS9250	BERYL ROBERTS BASIN 375.00	18.94	17.99	19.22	18.91
-	Copy of SS9250	BERYL ROBERTS BASIN 389.43	18.92	17.98	19.20	18.89
-	Copy of SS9350	BERYL ROBERTS MAIN 0.00	27.40	26.66	27.38	27.18
-	SS9350	BERYL ROBERTS MAIN 126.00	26.95	26.24	26.94	26.73
-	SS9340	BERYL ROBERTS MAIN 200.66	25.82	25.28	25.81	25.66
-	SS9330	BERYL ROBERTS MAIN 265.62	24.73	24.23	24.71	24.57
-	SS9320	BERYL ROBERTS MAIN 349.77	22.91	22.57	22.96	22.82
-	Copy of SS9320	BERYL ROBERTS MAIN 388.24	22.31	22.17	22.48	22.29
-	2006 Survey	BERYL ROBERTS SPILLWAY 0.00	22.26	21.50	22.40	22.24
-	2006 Survey	BERYL ROBERTS SPILLWAY 24.00	19.20	19.20	19.22	19.20
-	Copy of SS10060	BERYL ROBERTS TRIB 0.00	24.77	24.00	24.78	24.53
-	SS10060	BERYL ROBERTS TRIB 39.90	24.56	23.81	24.57	24.32
-	SS10050	BERYL ROBERTS TRIB 86.27	24.11	23.36	24.13	23.86
-	SS10040	BERYL ROBERTS TRIB 165.21	22.95	22.12	23.03	22.77
-	SS10030	BERYL ROBERTS TRIB 234.53	22.33	21.56	22.50	22.30
-	Copy of SS10030	BERYL ROBERTS TRIB 259.87	22.31	21.55	22.48	22.29
2168.3	Copy of SS140	BRIDGE - IPSWICH MOTORWAY 7981.00	4.92	4.11	5.65	5.12
2107	Copy of SS130	BRIDGE - IPSWICH MOTORWAY 8041.00	1.20	1.20	1.20	1.20
2036	Copy of SS130	BRIDGE - IPSWICH MOTORWAY 8112.00	4.68	4.01	5.19	4.84
13934	SS9250	NORTH BRANCH 0.00	18.92	17.98	19.20	18.89
13881	SS9240	NORTH BRANCH 72.00	18.84	17.92	19.09	18.81
13875	SS9220	NORTH BRANCH 80.00	18.25	17.17	18.72	18.22
13810	SS9210	NORTH BRANCH 144.00	17.73	16.37	18.30	17.68
13804	SS9190	NORTH BRANCH 150.00	17.38	16.18	18.03	17.35
13796	SS9180	NORTH BRANCH 158.00	17.33	16.13	17.99	17.30
13671	SS9170	NORTH BRANCH 284.00	16.90	15.75	17.64	16.89
13649	SS9163	NORTH BRANCH 304.00	16.89	15.74	17.63	16.88
13643	SS9161	NORTH BRANCH 312.00	16.04	14.67	16.74	16.07
13571	SS9160	NORTH BRANCH 382.00	15.75	14.15	16.49	15.80
13552	SS9140	NORTH BRANCH 402.00	15.74	14.02	16.49	15.79
13509	SS9130	NORTH BRANCH 444.00	15.69	13.95	16.45	15.75

AMTD (m)	BCC Cross Section	MIKE 11 Cross Section	Peak Flood Level (m AHD)			
			Jan 98	May 96	Mar 01	Nov 04
13479	SS9120	NORTH BRANCH 472.00	15.67	13.88	16.44	15.74
13460	SS9100	NORTH BRANCH 494.00	14.57	13.64	15.41	14.61
13350	SS9090	NORTH BRANCH 600.00	13.61	12.78	14.42	13.64
13248	SS9080	NORTH BRANCH 710.00	13.11	12.26	13.98	13.16
13141	SS9075	NORTH BRANCH 818.00	12.66	11.82	13.58	12.73
13108	SS9074	NORTH BRANCH 850.00	12.54	11.71	13.47	12.61
13005	Copy of SS9074	NORTH BRANCH 967.19	11.92	11.03	12.73	11.85
12888	Copy of SS9074	NORTH BRANCH 967.19	11.92	11.03	12.73	11.85
12778	SS9070	NORTH BRANCH 1070.00	11.21	10.26	12.09	11.15
12529	SS9060	NORTH BRANCH 1180.00	10.58	9.49	11.54	10.53
12366	SS9050	NORTH BRANCH 1430.00	9.66	8.55	10.62	9.64
12354	SS9044	NORTH BRANCH 1584.00	9.33	7.80	10.32	9.24
12254	SS9040	NORTH BRANCH 1604.00	9.26	7.75	10.06	9.16
12229	SS9030	NORTH BRANCH 1700.00	9.22	7.41	9.94	9.04
12147	SS9010	NORTH BRANCH 1720.00	9.21	7.33	9.92	9.03
12095	SS9004	NORTH BRANCH 1800.00	9.21	7.34	9.91	9.04
12070	SS9003	NORTH BRANCH 1852.00	9.21	7.32	9.95	9.04
12045	SS9001	NORTH BRANCH 1872.00	9.20	7.25	9.94	9.03
13934	Copy of SS521	NORTH BRANCH 1900.00	9.21	7.27	9.91	9.03
-	2002 ALS	RAILWAY OVERFLOW 10000.00	10.95	10.95	10.95	10.95
-	2002 ALS	RAILWAY OVERFLOW 10122.64	10.43	10.43	10.43	10.43
-	2002 ALS	RAILWAY OVERFLOW 10232.98	9.89	9.81	9.94	9.81
-	2002 ALS	RAILWAY OVERFLOW 10232.98	9.89	9.81	9.94	9.81
-	2002 ALS	RAILWAY OVERFLOW 10291.62	9.45	9.29	9.54	9.33
-	2002 ALS	RAILWAY OVERFLOW 10291.62	9.45	9.29	9.54	9.33
-	2002 ALS	RAILWAY OVERFLOW 10319.58	9.24	9.04	9.35	9.10
-	2002 ALS	RAILWAY OVERFLOW 10480.69	8.63	8.47	8.70	8.54
-	2002 ALS	RAILWAY OVERFLOW 10536.48	8.14	7.88	8.34	8.00
-	2002 ALS	RAILWAY OVERFLOW 10581.46	7.91	7.85	8.25	7.85
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 9813.25	11.85	11.85	11.85	11.85
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 9870.52	11.59	11.59	11.59	11.59
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 9964.10	11.82	11.82	11.82	11.82
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10000.00	11.14	11.14	11.14	11.14
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10034.60	10.93	10.82	11.04	10.82
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10100.81	10.93	10.69	11.04	10.72
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10100.81	10.93	10.69	11.04	10.72
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10119.55	10.89	10.66	11.00	10.67
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10181.01	10.60	10.47	10.67	10.48
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10211.02	10.47	10.47	10.47	10.47
-	2002 ALS	RAILWAY OVERFLOW_DRAIN_WIER_1 0.00	11.98	10.95	12.10	11.76
-	2002 ALS	RAILWAY OVERFLOW_DRAIN_WIER_1 46.28	11.83	11.83	11.85	11.83
-	2002 ALS	RAILWAY OVERFLOW_DRAIN_WIER_2 0.00	11.39	10.45	11.49	11.20
-	2002 ALS	RAILWAY OVERFLOW_DRAIN_WIER_2 40.00	10.93	10.69	11.04	10.72
-	2002 ALS	RAILWAY OVERFLOW_WEIR 0.00	10.96	9.95	11.07	10.78
-	2002 ALS	RAILWAY OVERFLOW_WEIR 40.00	9.45	9.29	9.54	9.33
-	2002 ALS	RIAWENA ROAD 10000.00	14.43	13.90	14.42	14.25
-	2002 ALS	RIAWENA ROAD 10008.37	14.36	13.83	14.34	14.18

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AMTD (m)	BCC Cross Section	MIKE 11 Cross Section	Peak Flood Level (m AHD)			
			Jan 98	May 96	Mar 01	Nov 04
-	2002 ALS	RIAWENA ROAD 10058.31	13.80	13.31	13.79	13.64
-	2002 ALS	RIAWENA ROAD 10088.23	13.58	13.13	13.57	13.43
-	2002 ALS	RIAWENA ROAD 10118.20	13.04	12.63	13.04	12.89
-	2002 ALS	RIAWENA ROAD 10175.73	12.24	11.49	12.73	12.01
-	2002 ALS	RIAWENA ROAD 10245.72	11.92	11.03	12.73	11.85
9530	SS1330	SHELLEYS CREEK 10000.00	65.27	65.01	65.19	65.14
9626	Copy of S1330	SHELLEYS CREEK 10010.00	65.11	64.81	65.02	64.97
9655	SS1328	SHELLEYS CREEK 10039.00	65.01	64.78	64.94	64.90
9769	SS1324	SHELLEYS CREEK 10047.00	63.98	63.47	63.82	63.74
9833	SS1320	SHELLEYS CREEK 10091.00	63.50	62.81	63.33	63.24
9834	SS1310	SHELLEYS CREEK 10187.00	61.99	61.24	61.78	61.69
9837	SS1309	SHELLEYS CREEK 10200.00	61.83	61.10	61.62	61.52
9838	SS1308	SHELLEYS CREEK 10229.00	61.44	60.70	61.21	61.11
9839	SS1300	SHELLEYS CREEK 10283.00	60.78	59.92	60.49	60.38
9841	SS1299	SHELLEYS CREEK 10316.00	60.57	59.63	60.24	60.12
9849	SS1298	SHELLEYS CREEK 10369.00	60.33	58.96	59.93	59.74
9932	SS1297	SHELLEYS CREEK 10376.00	60.33	58.95	59.92	59.73
10003	SS1290	SHELLEYS CREEK 10386.00	60.31	58.93	59.91	59.71
10121	SS1270	SHELLEYS CREEK 10412.00	60.08	58.92	59.79	59.64
10180	SS1260	SHELLEYS CREEK 10514.00	59.28	58.68	59.15	59.08
10215	Copy of SS1260	SHELLEYS CREEK 10520.00	56.54	55.88	56.36	56.27
10230	SS1250	SHELLEYS CREEK 10630.00	55.57	54.72	55.36	55.25
10238	SS1240	SHELLEYS CREEK 10729.00	54.24	53.47	54.03	53.94
10257	SS1230	SHELLEYS CREEK 10821.00	52.98	51.99	52.75	52.64
10270	SS1220	SHELLEYS CREEK 10866.00	52.63	51.56	52.35	52.24
10386	SS1210	SHELLEYS CREEK 10948.00	52.07	50.97	51.78	51.68
10477	Copy of SS1204	SHELLEYS CREEK 10962.00	51.87	50.72	51.54	51.44
10566	SS1204	SHELLEYS CREEK 10965.00	51.83	50.60	51.49	51.37
10664	SS1203	SHELLEYS CREEK 10969.00	51.78	50.56	51.44	51.32
10731	SS1200	SHELLEYS CREEK 11036.00	51.00	49.80	50.67	50.55
10735	SS1190	SHELLEYS CREEK 11134.00	49.87	48.79	49.55	49.45
10738	SS1180	SHELLEYS CREEK 11223.00	49.35	48.15	49.00	48.89
10752	SS1170	SHELLEYS CREEK 11314.00	48.55	47.15	48.18	48.07
10834	Copy of SS1160	SHELLEYS CREEK 11430.00	47.90	46.34	47.54	47.44
10879	SS1160	SHELLEYS CREEK 11443.00	47.87	46.32	47.52	47.42
10971	SS1140	SHELLEYS CREEK 11462.00	47.63	46.28	47.31	47.22
11070	Copy of SS1140	SHELLEYS CREEK 11470.00	47.61	46.28	47.30	47.21
11180	Copy of SS1140	SHELLEYS CREEK 11485.00	47.50	46.22	47.20	47.12
11186	SS1130	SHELLEYS CREEK 11520.00	47.02	46.06	46.75	46.69
11288	SS1120	SHELLEYS CREEK 11638.00	45.84	44.71	45.52	45.44
11314	SS1110	SHELLEYS CREEK 11709.00	45.09	44.01	44.77	44.70
11324	Copy of SS1110	SHELLEYS CREEK 11766.00	44.65	43.56	44.33	44.26
11331	SS1105	SHELLEYS CREEK 11844.00	43.80	42.98	43.50	43.43
11384	Copy of SS1100	SHELLEYS CREEK 11848.00	43.80	42.98	43.49	43.43
11417	SS1100	SHELLEYS CREEK 11862.00	43.79	42.98	43.48	43.42
11471	Copy of SS1080	SHELLEYS CREEK 11865.00	43.64	42.97	43.40	43.36
11500	Copy of SS1080	SHELLEYS CREEK 11866.00	43.63	42.96	43.40	43.35

AMTD (m)	BCC Cross Section	MIKE 11 Cross Section	Peak Flood Level (m AHD)			
			Jan 98	May 96	Mar 01	Nov 04
11513	SS1078	SHELLEYS CREEK 11867.00	43.63	42.97	43.40	43.35
11609	SS1080	SHELLEYS CREEK 11869.00	42.57	40.88	41.94	41.81
11653	SS1070	SHELLEYS CREEK 11928.00	42.39	40.73	41.75	41.61
11661	SS1060	SHELLEYS CREEK 12041.00	42.06	40.29	41.34	41.19
11690	SS1040	SHELLEYS CREEK 12069.00	40.95	39.83	40.62	40.54
11700	SS1030	SHELLEYS CREEK 12165.00	40.15	39.11	39.89	39.81
9443	SS1020	STABLE SWAMP CREEK 737.00	40.15	39.11	39.89	39.81
9319	SS1010	STABLE SWAMP CREEK 859.00	39.46	38.61	39.27	39.20
9216	SS1000	STABLE SWAMP CREEK 960.00	38.85	38.04	38.73	38.62
9115	SS990	STABLE SWAMP CREEK 1059.00	37.98	37.12	37.89	37.72
8975	SS980	STABLE SWAMP CREEK 1199.00	36.23	35.75	36.17	36.07
8902	SS970	STABLE SWAMP CREEK 1272.00	34.92	34.51	34.87	34.75
8742	SS965	STABLE SWAMP CREEK 1430.00	33.82	32.64	33.73	33.51
8728	SS960	STABLE SWAMP CREEK 1441.00	32.94	31.55	32.82	32.39
8725	SS938	STABLE SWAMP CREEK 1447.00	32.88	31.48	32.76	32.33
8728	Section 1	STABLE SWAMP CREEK 1514.00	31.49	30.01	31.38	30.90
8595	SS930	STABLE SWAMP CREEK 1577.00	31.30	29.84	31.20	30.70
8580	SS928	STABLE SWAMP CREEK 1593.00	31.24	29.74	31.14	30.62
8554	SS922	STABLE SWAMP CREEK 1618.00	31.08	29.08	30.96	30.36
8550	SS920	STABLE SWAMP CREEK 1625.00	31.06	29.01	30.95	30.34
8535	SS900	STABLE SWAMP CREEK 1641.00	29.02	27.61	28.92	28.42
8550	Section 2	STABLE SWAMP CREEK 1665.00	28.88	27.47	28.78	28.29
8574	Section 3	STABLE SWAMP CREEK 1721.00	28.38	27.16	28.31	27.83
8630	Section 19	STABLE SWAMP CREEK 1755.00	27.59	26.28	27.56	26.98
8664	Section 17	STABLE SWAMP CREEK 1771.00	27.26	25.76	27.27	26.59
8680	Section 16	STABLE SWAMP CREEK 1780.00	27.09	25.49	27.11	26.41
8689	Section 15	STABLE SWAMP CREEK 1790.00	27.04	25.46	27.06	26.36
8699	Section 12	STABLE SWAMP CREEK 1823.00	26.91	25.31	26.94	26.21
8732	Section 9	STABLE SWAMP CREEK 1859.00	26.83	25.25	26.86	26.14
8221	Section 2	STABLE SWAMP CREEK 1950.00	26.57	24.97	26.60	25.82
8209	SS860	STABLE SWAMP CREEK 1962.00	25.41	24.25	25.44	24.91
8132	SS850	STABLE SWAMP CREEK 2040.00	24.29	22.98	24.34	23.73
8040	SS840	STABLE SWAMP CREEK 2132.00	23.50	22.19	23.57	22.95
7931	SS830	STABLE SWAMP CREEK 2240.00	23.18	21.98	23.24	22.67
7854	SS820	STABLE SWAMP CREEK 2316.00	22.61	21.46	22.68	22.14
7753	SS810	STABLE SWAMP CREEK 2417.00	22.17	20.80	22.23	21.67
7654	SS800	STABLE SWAMP CREEK 2516.00	21.99	20.64	22.05	21.52
7496	SS790	STABLE SWAMP CREEK 2674.00	20.95	19.68	21.03	20.49
7360	SS780	STABLE SWAMP CREEK 2810.00	20.18	18.97	20.27	19.75
7226	SS770	STABLE SWAMP CREEK 2942.00	18.98	17.71	19.09	18.42
7313	SS760	STABLE SWAMP CREEK 3029.00	18.61	17.12	18.74	17.85
7347	SS740	STABLE SWAMP CREEK 3063.00	18.19	17.03	18.29	17.73
7386	Copy of SS740	STABLE SWAMP CREEK 3102.00	18.09	16.96	18.19	17.64
6968	SS730	STABLE SWAMP CREEK 3199.00	17.68	16.55	17.79	17.21
6832	SS720	STABLE SWAMP CREEK 3334.00	17.39	16.15	17.52	16.87
6817	SS710	STABLE SWAMP CREEK 3350.00	15.46	14.81	15.54	15.18
6849	Copy of SS710	STABLE SWAMP CREEK 3382.00	15.24	14.17	15.34	14.83

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6859	Copy of SS710	STABLE SWAMP CREEK 3392.00	15.22	14.16	15.33	14.82
6864	Copy of SS710	STABLE SWAMP CREEK 3397.00	15.22	14.15	15.32	14.81
6878	Copy of SS710	STABLE SWAMP CREEK 3411.00	15.19	14.13	15.30	14.79
6650	SS700	STABLE SWAMP CREEK 3516.00	14.66	13.58	14.80	14.21
6657	Copy of SS690	STABLE SWAMP CREEK 3579.00	14.42	13.29	14.59	13.91
6683	Copy of SS690	STABLE SWAMP CREEK 3586.00	14.41	13.27	14.58	13.90
6700	Copy of SS690	STABLE SWAMP CREEK 3612.00	13.98	12.51	14.14	13.58
6710	Copy of SS690	STABLE SWAMP CREEK 3629.00	13.99	12.47	14.14	13.59
6527	Copy of SS690	STABLE SWAMP CREEK 3637.00	13.98	12.46	14.14	13.58
6532	Copy of SS690	STABLE SWAMP CREEK 3639.00	13.98	12.46	14.13	13.58
6547	Copy of SS690	STABLE SWAMP CREEK 3644.00	13.97	12.45	14.12	13.57
6728	SS690	STABLE SWAMP CREEK 3659.00	13.92	12.41	14.08	13.52
6325	SS680	STABLE SWAMP CREEK 3838.00	12.99	11.29	13.20	12.54
6243	SS671	STABLE SWAMP CREEK 3921.00	12.89	11.12	13.10	12.42
6273	SS670	STABLE SWAMP CREEK 3967.00	12.88	11.06	13.09	12.40
6167	SS650	STABLE SWAMP CREEK 3995.00	12.04	10.99	12.17	11.81
6146	SS641	STABLE SWAMP CREEK 4016.00	11.98	10.95	12.10	11.76
6146	SS640	STABLE SWAMP CREEK 4016.00	11.98	10.95	12.10	11.76
6034	SS639	STABLE SWAMP CREEK 4131.00	11.48	10.54	11.58	11.29
6001	SS690	STABLE SWAMP CREEK 4163.00	11.40	10.47	11.50	11.22
5997	SS680	STABLE SWAMP CREEK 4166.00	11.39	10.45	11.49	11.20
5997	SS680	STABLE SWAMP CREEK 4166.00	11.39	10.45	11.49	11.20
5991	SS638	STABLE SWAMP CREEK 4171.00	11.37	10.43	11.47	11.19
6093	Copy of SS638	STABLE SWAMP CREEK 4176.00	11.35	10.40	11.45	11.17
5849	SS630	STABLE SWAMP CREEK 4278.00	10.96	9.95	11.07	10.78
5849	SS620	STABLE SWAMP CREEK 4278.00	10.96	9.95	11.07	10.78
5749	SS610	STABLE SWAMP CREEK 4414.00	10.36	9.44	10.50	10.20
5641	SS600	STABLE SWAMP CREEK 4521.00	10.02	8.95	10.22	9.88
5567	SS590	STABLE SWAMP CREEK 4594.00	9.67	8.13	10.00	9.51
5577	SS589	STABLE SWAMP CREEK 4627.00	9.59	7.88	9.97	9.43
5591	SS570	STABLE SWAMP CREEK 4635.00	9.61	7.89	9.98	9.46
5595	SS560	STABLE SWAMP CREEK 4645.00	9.43	7.81	9.96	9.26
5502	SS550	STABLE SWAMP CREEK 4656.00	9.34	7.76	9.95	9.17
5497	SS540	STABLE SWAMP CREEK 4662.00	9.40	7.81	9.96	9.23
5388	SS638	STABLE SWAMP CREEK 4774.00	9.40	7.79	9.94	9.22
5278	SS501	STABLE SWAMP CREEK 4882.00	9.26	7.50	9.90	9.08
5158	SS521	STABLE SWAMP CREEK 5002.00	9.21	7.27	9.91	9.03
5158	SS521	STABLE SWAMP CREEK 5002.00	9.21	7.27	9.91	9.03
5115	SS520	STABLE SWAMP CREEK 5045.00	9.21	7.30	9.91	9.04
5085	SS510	STABLE SWAMP CREEK 5074.00	8.44	7.23	8.79	8.36
5054	SS500	STABLE SWAMP CREEK 5105.00	8.01	7.10	8.34	7.94
5054	Copy of SS490	STABLE SWAMP CREEK 5158.00	7.91	7.00	8.25	7.84
4985	Copy of SS490	STABLE SWAMP CREEK 5158.00	7.91	7.00	8.25	7.84
4984	SS490	STABLE SWAMP CREEK 5159.00	7.91	6.99	8.25	7.84
4867	SS480	STABLE SWAMP CREEK 5292.00	7.62	6.68	7.97	7.56
4778	SS470	STABLE SWAMP CREEK 5380.00	7.44	6.46	7.79	7.38
4790	Copy of SS470	STABLE SWAMP CREEK 5402.00	7.42	6.42	7.77	7.36

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			Jan 98	May 96	Mar 01	Nov 04
4797	Copy of SS450	STABLE SWAMP CREEK 5414.00	7.33	6.38	7.73	7.27
4738	SS450	STABLE SWAMP CREEK 5420.00	7.32	6.37	7.72	7.26
4673	SS430	STABLE SWAMP CREEK 5486.00	7.22	6.27	7.62	7.16
4619	SS420	STABLE SWAMP CREEK 5538.00	7.13	6.18	7.54	7.08
4588	SS419	STABLE SWAMP CREEK 5570.00	7.08	6.12	7.49	7.02
4474	SS400	STABLE SWAMP CREEK 5683.00	6.88	5.93	7.29	6.83
4306	SS380	STABLE SWAMP CREEK 5849.00	6.59	5.70	6.99	6.56
4306	Copy of SS380	STABLE SWAMP CREEK 5849.00	6.59	5.70	6.99	6.56
4293	Copy of SS360	STABLE SWAMP CREEK 5862.00	6.59	5.70	6.98	6.56
4257	SS360	STABLE SWAMP CREEK 5898.00	6.50	5.68	6.82	6.48
4251	SS350	STABLE SWAMP CREEK 5905.00	6.49	5.67	6.81	6.47
4161	SS490	STABLE SWAMP CREEK 5995.00	6.42	5.62	6.73	6.40
4161	SS490	STABLE SWAMP CREEK 5995.00	6.42	5.62	6.73	6.40
4061	SS340	STABLE SWAMP CREEK 6095.00	6.25	5.50	6.54	6.24
4061	SS340	STABLE SWAMP CREEK 6095.00	6.25	5.50	6.54	6.24
3983	SS340	STABLE SWAMP CREEK 6174.00	6.14	5.41	6.45	6.16
3964	SS310	STABLE SWAMP CREEK 6191.00	6.12	5.38	6.43	6.14
3964	SS310	STABLE SWAMP CREEK 6191.00	6.12	5.38	6.43	6.14
3891	SS300	STABLE SWAMP CREEK 6264.00	6.04	5.30	6.37	6.07
3829	SS291	STABLE SWAMP CREEK 6324.00	5.97	5.23	6.32	6.02
3829	SS291	STABLE SWAMP CREEK 6324.00	5.97	5.23	6.32	6.02
3751	SS290	STABLE SWAMP CREEK 6403.00	5.85	5.12	6.26	5.92
3779	Copy of SS290	STABLE SWAMP CREEK 6416.00	5.84	5.11	6.26	5.91
3787	Copy of SS270	STABLE SWAMP CREEK 6444.00	5.63	5.05	6.13	5.73
3702	SS270	STABLE SWAMP CREEK 6450.00	5.63	5.04	6.13	5.73
3682	Copy of SS270	STABLE SWAMP CREEK 6470.00	5.63	5.04	6.13	5.73
3682	Copy of SS270	STABLE SWAMP CREEK 6470.00	5.63	5.04	6.13	5.73
3648	Copy of SS263	STABLE SWAMP CREEK 6504.00	5.61	5.03	6.11	5.72
3612	SS263	STABLE SWAMP CREEK 6540.00	5.61	5.02	6.12	5.72
3612	SS263	STABLE SWAMP CREEK 6540.00	5.61	5.02	6.12	5.72
3594	SS263	STABLE SWAMP CREEK 6560.00	5.59	5.01	6.11	5.71
3579	Copy of SS263	STABLE SWAMP CREEK 6575.00	5.57	5.00	6.10	5.70
3575	Copy of SS261	STABLE SWAMP CREEK 6579.00	5.54	4.82	6.09	5.68
3566	SS261	STABLE SWAMP CREEK 6587.00	5.53	4.81	6.09	5.67
3548	SS260	STABLE SWAMP CREEK 6607.00	5.51	4.79	6.07	5.65
3316	SS250	STABLE SWAMP CREEK 6838.00	5.33	4.58	5.95	5.50
3175	SS240	STABLE SWAMP CREEK 6978.00	5.28	4.51	5.91	5.46
3166	SS235	STABLE SWAMP CREEK 6987.00	5.27	4.51	5.91	5.45
3162	Copy of SS235	STABLE SWAMP CREEK 6991.00	5.27	4.48	5.90	5.44
3123	SS233	STABLE SWAMP CREEK 7028.00	5.25	4.46	5.88	5.43
3113	SS232	STABLE SWAMP CREEK 7041.00	5.24	4.45	5.87	5.42
2949	SS231	STABLE SWAMP CREEK 7203.00	5.18	4.39	5.83	5.37
2680	SS230	STABLE SWAMP CREEK 7472.00	5.12	4.30	5.77	5.31
2559	SS220	STABLE SWAMP CREEK 7591.00	5.07	4.25	5.73	5.26
2417	SS210	STABLE SWAMP CREEK 7734.00	5.01	4.21	5.69	5.21
2361	SS200	STABLE SWAMP CREEK 7788.00	5.00	4.19	5.68	5.20
2333	SS190	STABLE SWAMP CREEK 7817.00	4.99	4.18	5.67	5.19

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			Jan 98	May 96	Mar 01	Nov 04
2266	SS170	STABLE SWAMP CREEK 7849.00	4.98	4.17	5.67	5.18
2217	SS160	STABLE SWAMP CREEK 7932.00	4.93	4.12	5.66	5.13
2168	SS150	STABLE SWAMP CREEK 7981.00	4.92	4.11	5.65	5.12
2168	SS150	STABLE SWAMP CREEK 7981.00	4.92	4.11	5.65	5.12
2037	Copy of SS130	STABLE SWAMP CREEK 8111.00	4.69	4.01	5.19	4.84
2036	SS130	STABLE SWAMP CREEK 8112.00	4.68	4.01	5.19	4.84
2036	SS130	STABLE SWAMP CREEK 8112.00	4.68	4.01	5.19	4.84
2015	SS120	STABLE SWAMP CREEK 8135.00	4.67	4.00	5.17	4.82
1933	SS110	STABLE SWAMP CREEK 8215.00	4.65	3.99	5.14	4.80
1824	SS100	STABLE SWAMP CREEK 8323.00	4.56	3.91	5.03	4.70
1697	Copy of SS100	STABLE SWAMP CREEK 8450.00	4.45	3.81	4.91	4.59
1617	Copy of SS90	STABLE SWAMP CREEK 8530.00	4.33	3.72	4.81	4.48
1553	SS90	STABLE SWAMP CREEK 8593.00	4.24	3.66	4.73	4.40
1435	SS80	STABLE SWAMP CREEK 8712.00	4.08	3.54	4.55	4.23
1257	SS70	STABLE SWAMP CREEK 8890.00	3.84	3.36	4.29	3.98
1011	SS61	STABLE SWAMP CREEK 9135.00	3.49	3.10	3.89	3.62
985	SS60	STABLE SWAMP CREEK 9162.00	3.47	3.09	3.86	3.60
785	SS50	STABLE SWAMP CREEK 9359.00	3.15	2.84	3.47	3.26
596	SS40	STABLE SWAMP CREEK 9548.00	2.93	2.66	3.24	3.04
403	SS30	STABLE SWAMP CREEK 9740.00	2.62	2.43	2.84	2.70
0	Copy of SS30	STABLE SWAMP CREEK 10100.00	2.00	2.00	2.00	2.00
-	2002 ALS	ARCHERFIELD OVERFLOW 06 0.00	5.63	5.04	6.13	5.73
-	2002 ALS	ARCHERFIELD OVERFLOW 06 22.36	5.62	5.02	6.13	5.73

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Table B 2 Calibration Events – Peak Flood Discharge m3/s

MIKE 11 Flow Locations	Peak Discharge (m^3/s)			
	Jan 98	May 96	Mar 01	Nov 04
ARCHERFIELD 1039.00	64	16	54	39
ARCHERFIELD 1088.00	64	16	54	39
ARCHERFIELD 1158.00	64	16	54	39
ARCHERFIELD 1230.00	64	16	54	39
ARCHERFIELD 1284.00	71	18	60	44
ARCHERFIELD 1330.00	70	18	60	44
ARCHERFIELD 1384.00	70	18	59	44
ARCHERFIELD 1464.00	70	18	59	44
ARCHERFIELD 1527.00	70	18	59	44
ARCHERFIELD 1572.00	70	18	59	43
ARCHERFIELD 1622.00	83	22	73	53
ARCHERFIELD 1670.00	88	23	79	57
ARCHERFIELD 1711.00	88	23	79	57
ARCHERFIELD 1741.00	94	25	85	62
ARCHERFIELD 1795.00	94	25	85	62
ARCHERFIELD 1895.00	93	24	85	61
ARCHERFIELD 1977.00	92	23	84	61
ARCHERFIELD 2018.00	96	25	88	63
ARCHERFIELD 2057.00	95	24	87	62
ARCHERFIELD 2105.00	92	25	85	61
ARCHERFIELD 2130.00	91	24	89	63
ARCHERFIELD 2141.00	90	23	89	62
ARCHERFIELD 2170.00	88	23	88	62
ARCHERFIELD 2207.00	86	22	86	61
ARCHERFIELD 2231.00	88	22	89	62
ARCHERFIELD 2244.50	114	24	141	93
ARCHERFIELD 2265.50	114	21	141	93
ARCHERFIELD 2291.00	114	22	142	94
ARCHERFIELD 2323.00	118	22	156	98
ARCHERFIELD 2364.00	116	22	155	97
ARCHERFIELD 2387.00	123	22	178	105
ARCHERFIELD 2397.00	123	22	178	105
ARCHERFIELD 2411.00	123	22	178	105
ARCHERFIELD 2427.00	122	21	178	104
ARCHERFIELD 2442.50	122	21	177	104
ARCHERFIELD 2456.00	122	21	177	104
ARCHERFIELD 2481.50	136	38	176	121
ARCHERFIELD OVERFLOW 01 50.00	0	0	0	0
ARCHERFIELD OVERFLOW 02 80.16	4	0	16	3
ARCHERFIELD OVERFLOW 03 21.21	36	0	74	38
ARCHERFIELD OVERFLOW 04 22.36	6	0	20	7
ARCHERFIELD OVERFLOW 05 14.14	10	0	28	12
BERYL ROBERTS BASIN 39.45	90	27	89	61
BERYL ROBERTS BASIN 119.96	83	26	89	57
BERYL ROBERTS BASIN 237.37	60	21	88	56

MIKE 11 Flow Locations	Peak Discharge (m^3/s)			
	Jan 98	May 96	Mar 01	Nov 04
BERYL ROBERTS BASIN 350.00	19	17	19	19
BERYL ROBERTS BASIN 382.22	58	17	88	55
BERYL ROBERTS MAIN 63.00	41	12	41	29
BERYL ROBERTS MAIN 163.33	41	12	40	29
BERYL ROBERTS MAIN 233.14	41	12	40	29
BERYL ROBERTS MAIN 307.70	41	12	40	29
BERYL ROBERTS MAIN 369.00	41	12	40	29
BERYL ROBERTS SPILLWAY 12.00	39	0	68	36
BERYL ROBERTS TRIB 19.95	55	15	55	38
BERYL ROBERTS TRIB 63.08	55	15	55	38
BERYL ROBERTS TRIB 125.74	55	15	55	38
BERYL ROBERTS TRIB 199.87	55	15	55	38
BERYL ROBERTS TRIB 247.20	54	15	54	38
BRIDGE - IPSWICH MOTORWAY 8016.00	0	0	0	0
BRIDGE - IPSWICH MOTORWAY 8066.00	0	0	0	0
NORTH BRANCH 36.00	57	17	88	54
NORTH BRANCH 76.00	57	17	88	54
NORTH BRANCH 112.00	57	17	88	54
NORTH BRANCH 147.00	56	17	88	54
NORTH BRANCH 154.00	56	17	87	54
NORTH BRANCH 221.00	56	17	87	54
NORTH BRANCH 294.00	56	18	90	55
NORTH BRANCH 308.00	56	18	90	55
NORTH BRANCH 347.00	55	18	90	54
NORTH BRANCH 392.00	53	18	89	53
NORTH BRANCH 423.00	51	18	89	51
NORTH BRANCH 458.00	51	20	92	52
NORTH BRANCH 484.00	51	20	92	52
NORTH BRANCH 547.00	50	20	91	52
NORTH BRANCH 655.00	50	20	91	52
NORTH BRANCH 764.00	50	20	91	52
NORTH BRANCH 834.00	50	20	91	52
NORTH BRANCH 908.59	50	21	93	52
NORTH BRANCH 1018.59	67	31	115	64
NORTH BRANCH 1125.00	67	30	115	63
NORTH BRANCH 1305.00	66	30	114	63
NORTH BRANCH 1507.00	77	34	120	68
NORTH BRANCH 1594.00	76	34	119	68
NORTH BRANCH 1652.00	75	34	118	68
NORTH BRANCH 1710.00	75	34	116	69
NORTH BRANCH 1760.00	74	34	115	71
NORTH BRANCH 1826.00	73	34	121	74
NORTH BRANCH 1862.00	72	34	126	76
NORTH BRANCH 1886.00	71	34	143	78
RAILWAY OVERFLOW 10061.32	0	0	0	0
RAILWAY OVERFLOW 10177.81	0	0	0	0
RAILWAY OVERFLOW 10262.30	2	1	5	1

MIKE 11 Flow Locations	Peak Discharge (m^3/s)			
	Jan 98	May 96	Mar 01	Nov 04
RAILWAY OVERFLOW 10305.60	8	1	18	2
RAILWAY OVERFLOW 10400.13	8	1	18	2
RAILWAY OVERFLOW 10508.58	8	1	18	2
RAILWAY OVERFLOW 10558.97	8	1	18	2
RAILWAY OVERFLOW_DRAIN 9841.88	0	0	0	0
RAILWAY OVERFLOW_DRAIN 9929.68	0	0	0	0
RAILWAY OVERFLOW_DRAIN 9982.05	0	0	0	0
RAILWAY OVERFLOW_DRAIN 10017.30	0	0	0	0
RAILWAY OVERFLOW_DRAIN 10067.70	0	0	0	0
RAILWAY OVERFLOW_DRAIN 10110.18	1	0	4	0
RAILWAY OVERFLOW_DRAIN 10150.28	1	0	4	0
RAILWAY OVERFLOW_DRAIN 10196.01	1	0	4	0
RAILWAY OVERFLOW_DRAIN_WIER_1 23.14	0	0	0	0
RAILWAY OVERFLOW_DRAIN_WIER_2 20.00	1	0	4	0
RAILWAY OVERFLOW_WEIR 20.00	6	0	13	1
RIAWENA ROAD 10004.18	38	10	37	26
RIAWENA ROAD 10033.34	38	10	37	26
RIAWENA ROAD 10073.27	38	10	37	26
RIAWENA ROAD 10103.22	38	10	37	26
RIAWENA ROAD 10146.97	38	10	37	26
RIAWENA ROAD 10210.73	38	10	36	26
SHELLEYS CREEK 10005.00	15	4	11	9
SHELLEYS CREEK 10024.50	15	4	11	9
SHELLEYS CREEK 10043.00	15	4	11	9
SHELLEYS CREEK 10069.00	14	4	11	9
SHELLEYS CREEK 10139.00	37	9	27	23
SHELLEYS CREEK 10193.50	37	9	27	23
SHELLEYS CREEK 10214.50	37	9	27	23
SHELLEYS CREEK 10256.00	37	9	27	23
SHELLEYS CREEK 10299.50	37	9	27	23
SHELLEYS CREEK 10342.50	37	9	27	23
SHELLEYS CREEK 10372.50	37	9	27	23
SHELLEYS CREEK 10381.00	37	9	27	23
SHELLEYS CREEK 10392.00	42	10	30	26
SHELLEYS CREEK 10463.00	57	14	42	35
SHELLEYS CREEK 10517.00	57	12	42	35
SHELLEYS CREEK 10575.00	57	12	42	35
SHELLEYS CREEK 10679.50	61	12	45	38
SHELLEYS CREEK 10775.00	61	12	45	38
SHELLEYS CREEK 10843.50	67	14	49	42
SHELLEYS CREEK 10907.00	67	14	49	42
SHELLEYS CREEK 10955.00	78	16	57	49
SHELLEYS CREEK 10964.00	78	16	57	49
SHELLEYS CREEK 10967.00	78	16	57	49
SHELLEYS CREEK 11002.50	78	16	57	49
SHELLEYS CREEK 11085.00	78	16	56	49
SHELLEYS CREEK 11178.50	78	16	56	49

MIKE 11 Flow Locations	Peak Discharge (m^3/s)			
	Jan 98	May 96	Mar 01	Nov 04
SHELLEYS CREEK 11268.50	85	18	61	54
SHELLEYS CREEK 11372.00	85	18	60	54
SHELLEYS CREEK 11436.50	85	18	60	54
SHELLEYS CREEK 11448.00	89	19	63	57
SHELLEYS CREEK 11466.00	89	19	63	57
SHELLEYS CREEK 11477.50	89	19	63	57
SHELLEYS CREEK 11502.50	88	19	63	57
SHELLEYS CREEK 11579.00	93	21	66	60
SHELLEYS CREEK 11673.50	94	22	66	61
SHELLEYS CREEK 11737.50	94	21	66	61
SHELLEYS CREEK 11805.00	94	21	66	60
SHELLEYS CREEK 11846.00	96	22	67	61
SHELLEYS CREEK 11855.00	96	22	67	61
SHELLEYS CREEK 11864.00	96	22	67	61
SHELLEYS CREEK 11865.50	96	22	67	61
SHELLEYS CREEK 11866.50	96	22	67	61
SHELLEYS CREEK 11868.00	96	22	67	61
SHELLEYS CREEK 11898.50	96	22	67	61
SHELLEYS CREEK 11984.50	95	22	67	61
SHELLEYS CREEK 12045.00	101	24	71	65
SHELLEYS CREEK 12117.00	101	24	71	65
STABLE SWAMP CREEK 798.00	101	24	71	64
STABLE SWAMP CREEK 909.50	101	24	71	64
STABLE SWAMP CREEK 1009.50	105	26	81	66
STABLE SWAMP CREEK 1129.00	113	29	94	69
STABLE SWAMP CREEK 1235.50	113	29	94	69
STABLE SWAMP CREEK 1351.00	115	31	100	71
STABLE SWAMP CREEK 1437.00	115	31	100	70
STABLE SWAMP CREEK 1444.00	115	31	100	70
STABLE SWAMP CREEK 1480.50	115	31	100	70
STABLE SWAMP CREEK 1545.50	115	31	100	70
STABLE SWAMP CREEK 1585.00	118	32	107	73
STABLE SWAMP CREEK 1605.50	118	32	107	73
STABLE SWAMP CREEK 1621.50	118	32	107	73
STABLE SWAMP CREEK 1633.00	118	32	107	73
STABLE SWAMP CREEK 1653.00	118	32	107	73
STABLE SWAMP CREEK 1693.00	118	32	107	73
STABLE SWAMP CREEK 1738.00	118	32	107	73
STABLE SWAMP CREEK 1763.00	118	32	107	73
STABLE SWAMP CREEK 1775.50	121	35	118	77
STABLE SWAMP CREEK 1785.00	121	35	118	77
STABLE SWAMP CREEK 1806.50	121	35	118	77
STABLE SWAMP CREEK 1841.00	124	37	127	80
STABLE SWAMP CREEK 1904.50	124	37	127	80
STABLE SWAMP CREEK 1955.00	124	37	127	80
STABLE SWAMP CREEK 2001.00	124	37	127	80
STABLE SWAMP CREEK 2086.00	124	37	127	80

MIKE 11 Flow Locations	Peak Discharge (m^3/s)			
	Jan 98	May 96	Mar 01	Nov 04
STABLE SWAMP CREEK 2186.00	130	40	138	83
STABLE SWAMP CREEK 2278.00	130	40	137	83
STABLE SWAMP CREEK 2366.50	130	40	137	83
STABLE SWAMP CREEK 2466.50	130	40	137	83
STABLE SWAMP CREEK 2595.00	130	40	136	83
STABLE SWAMP CREEK 2742.00	136	42	149	87
STABLE SWAMP CREEK 2876.00	136	42	148	87
STABLE SWAMP CREEK 2985.50	133	42	146	86
STABLE SWAMP CREEK 3046.00	130	42	143	86
STABLE SWAMP CREEK 3082.50	129	42	142	86
STABLE SWAMP CREEK 3150.50	127	42	139	86
STABLE SWAMP CREEK 3266.50	124	42	135	85
STABLE SWAMP CREEK 3341.00	122	42	134	84
STABLE SWAMP CREEK 3366.00	122	42	134	84
STABLE SWAMP CREEK 3387.00	122	42	134	84
STABLE SWAMP CREEK 3394.50	122	42	134	84
STABLE SWAMP CREEK 3404.00	122	42	134	84
STABLE SWAMP CREEK 3463.50	122	42	133	84
STABLE SWAMP CREEK 3547.50	121	42	134	86
STABLE SWAMP CREEK 3582.50	121	42	133	86
STABLE SWAMP CREEK 3601.00	121	42	133	86
STABLE SWAMP CREEK 3620.50	121	42	134	86
STABLE SWAMP CREEK 3633.00	121	42	134	86
STABLE SWAMP CREEK 3638.00	225	70	241	176
STABLE SWAMP CREEK 3641.50	224	70	241	176
STABLE SWAMP CREEK 3651.50	224	70	241	176
STABLE SWAMP CREEK 3748.50	223	70	240	175
STABLE SWAMP CREEK 3879.50	227	72	251	180
STABLE SWAMP CREEK 3944.00	236	77	265	194
STABLE SWAMP CREEK 3983.00	235	77	265	191
STABLE SWAMP CREEK 4005.50	235	77	265	191
STABLE SWAMP CREEK 4073.50	235	77	265	190
STABLE SWAMP CREEK 4147.00	235	77	265	189
STABLE SWAMP CREEK 4164.50	234	77	265	189
STABLE SWAMP CREEK 4168.50	233	77	260	188
STABLE SWAMP CREEK 4173.50	233	77	260	188
STABLE SWAMP CREEK 4227.00	233	77	260	187
STABLE SWAMP CREEK 4346.00	226	77	247	185
STABLE SWAMP CREEK 4467.50	225	77	246	185
STABLE SWAMP CREEK 4557.50	230	80	258	193
STABLE SWAMP CREEK 4610.50	229	80	256	193
STABLE SWAMP CREEK 4631.00	228	80	255	192
STABLE SWAMP CREEK 4640.00	227	80	255	192
STABLE SWAMP CREEK 4650.50	227	80	254	192
STABLE SWAMP CREEK 4659.00	227	80	253	192
STABLE SWAMP CREEK 4718.00	225	80	245	191
STABLE SWAMP CREEK 4828.00	217	79	234	187

MIKE 11 Flow Locations	Peak Discharge (m^3/s)			
	Jan 98	May 96	Mar 01	Nov 04
STABLE SWAMP CREEK 4942.00	212	79	225	185
STABLE SWAMP CREEK 5023.50	266	114	341	256
STABLE SWAMP CREEK 5066.00	263	115	337	249
STABLE SWAMP CREEK 5077.00	263	114	337	249
STABLE SWAMP CREEK 5131.50	263	114	337	248
STABLE SWAMP CREEK 5158.50	267	117	348	249
STABLE SWAMP CREEK 5225.50	268	118	350	251
STABLE SWAMP CREEK 5336.00	267	118	349	250
STABLE SWAMP CREEK 5391.00	266	118	349	250
STABLE SWAMP CREEK 5408.00	266	127	349	250
STABLE SWAMP CREEK 5417.00	266	121	349	250
STABLE SWAMP CREEK 5453.00	266	118	348	250
STABLE SWAMP CREEK 5512.00	268	120	354	253
STABLE SWAMP CREEK 5554.00	267	120	353	253
STABLE SWAMP CREEK 5626.50	267	120	353	253
STABLE SWAMP CREEK 5766.00	267	121	354	254
STABLE SWAMP CREEK 5855.50	267	120	354	254
STABLE SWAMP CREEK 5880.00	267	120	354	254
STABLE SWAMP CREEK 5901.50	267	120	354	254
STABLE SWAMP CREEK 5950.00	267	120	354	254
STABLE SWAMP CREEK 6045.00	263	120	337	250
STABLE SWAMP CREEK 6134.50	227	120	264	212
STABLE SWAMP CREEK 6182.50	227	120	263	212
STABLE SWAMP CREEK 6227.50	220	120	244	205
STABLE SWAMP CREEK 6294.00	221	120	243	206
STABLE SWAMP CREEK 6363.50	211	121	217	195
STABLE SWAMP CREEK 6409.50	211	121	217	195
STABLE SWAMP CREEK 6430.00	211	121	217	195
STABLE SWAMP CREEK 6447.00	211	121	216	195
STABLE SWAMP CREEK 6460.00	211	121	216	195
STABLE SWAMP CREEK 6487.00	181	100	216	177
STABLE SWAMP CREEK 6522.00	181	100	215	176
STABLE SWAMP CREEK 6550.00	314	137	389	295
STABLE SWAMP CREEK 6567.50	314	137	389	294
STABLE SWAMP CREEK 6577.00	314	137	389	294
STABLE SWAMP CREEK 6583.00	314	137	389	294
STABLE SWAMP CREEK 6597.00	313	137	389	294
STABLE SWAMP CREEK 6722.50	311	137	386	292
STABLE SWAMP CREEK 6908.00	302	136	376	287
STABLE SWAMP CREEK 6982.50	299	136	371	284
STABLE SWAMP CREEK 6989.00	299	136	370	286
STABLE SWAMP CREEK 7009.50	298	136	368	285
STABLE SWAMP CREEK 7034.00	296	137	371	283
STABLE SWAMP CREEK 7122.00	289	134	364	280
STABLE SWAMP CREEK 7337.50	265	136	359	277
STABLE SWAMP CREEK 7531.50	247	134	350	269
STABLE SWAMP CREEK 7662.50	240	133	346	265

MIKE 11 Flow Locations	Peak Discharge (m^3/s)			
	Jan 98	May 96	Mar 01	Nov 04
STABLE SWAMP CREEK 7761.00	238	133	344	262
STABLE SWAMP CREEK 7803.00	238	133	344	265
STABLE SWAMP CREEK 7833.00	237	133	343	261
STABLE SWAMP CREEK 7890.50	236	133	342	260
STABLE SWAMP CREEK 7956.50	234	135	342	262
STABLE SWAMP CREEK 8047.00	232	134	341	260
STABLE SWAMP CREEK 8111.50	231	134	340	260
STABLE SWAMP CREEK 8123.50	231	134	340	259
STABLE SWAMP CREEK 8175.00	230	134	340	259
STABLE SWAMP CREEK 8269.00	230	134	339	259
STABLE SWAMP CREEK 8386.50	230	134	339	259
STABLE SWAMP CREEK 8490.00	229	134	339	258
STABLE SWAMP CREEK 8561.50	229	134	339	258
STABLE SWAMP CREEK 8652.50	229	134	339	258
STABLE SWAMP CREEK 8801.00	228	133	338	257
STABLE SWAMP CREEK 9012.50	227	133	338	257
STABLE SWAMP CREEK 9148.50	226	133	337	257
STABLE SWAMP CREEK 9260.50	226	133	337	256
STABLE SWAMP CREEK 9453.50	223	132	338	255
STABLE SWAMP CREEK 9644.00	226	141	357	268
STABLE SWAMP CREEK 9920.00	223	140	354	266
ARCHERFIELD OVERFLOW 06 11.18	35	21	30	33

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Stable Swamp Creek Flood Study

Report B - Design Event Modelling

June 2010

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Prepared by
Water and Environment
City Design

Prepared for
Water Resources
City Planning and Sustainability

Stable Swamp Creek Flood Study

Report B - Design Event Modelling

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1 Introduction

Following on from Report A – Model Calibration, Report B provides the results of the design event model simulations obtained using the calibrated hydrologic and hydraulic models. The 100, 50, 20, 10, 5 and 2 year ARI (average recurrence interval) events were modelled. Peak flood levels and peak flood discharges for all design events are tabulated in Appendix A of this report, Report B.

As part of Report B, the impact of the revegetation and restoration of riparian (streamside) habitat on flood levels was considered.

Using the calibrated MIKE 11 model, the following scenarios were investigated as part of the design event modelling:

- Existing conditions (catchment conditions as at November 2007) and
- Ultimate catchment conditions (including minimum riparian vegetated corridor and waterway corridor).

The results include modelled peak flood levels and modelled peak discharges.

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2 Model Data

Design Rainfall

Design rainfall events were synthesised according to the Synthetic Design Event Storms method proposed by Morris (1996). Rather than modelling multiple storms with each storm representing a different duration, the method allows one storm representing the full range of durations be used for each ARI event.

A frequency analysis was undertaken on the annual maximum series of discharges obtained from the calibrated hydrologic model and 88 years of recorded rainfall data at each of six locations as listed in Section 3.1. Section 3.2 contains further details of the frequency analysis.

Tailwater Conditions

During events in Oxley Creek and the Brisbane River, the lower reaches of Stable Swamp Creek act as a backwater flood storage area. Consequently, the water level in the lower reaches of the creek will be essentially equal to the peak flood level in Oxley Creek at the mouth of Stable Swamp Creek or the peak flood level in the Brisbane River at the mouth of Oxley Creek.

A review of the flood levels calculated for Stable Swamp Creek indicated that the 100 year level in Oxley Creek affects flood levels in Stable Swamp Creek upstream to Riawena Road, while the peak design event in the Brisbane River affects flood levels upstream to Edith Street.

Due to the relatively small catchment area of Stable Swamp Creek compared to Oxley Creek and the Brisbane River, the potential for coincident flooding in Stable Swamp Creek and either Oxley Creek or the Brisbane River is slight.

In summary, the conditions affecting flood levels in the lower reaches of Stable Swamp Creek are as follows:

- Mean High Water Spring Level (Queensland Transport 1998) RL 1.20m AHD
- Oxley Creek 100 Year Flood Level (Brisbane City Council 2008) RL 7.08m AHD
- Brisbane River Peak Design Flood Level (City Design 2000) RL 9.88m AHD

A Mean High Water Spring (MHWS) Level at Corinda gauge (1.2 m AHD) was adopted for all the design events.

Topographic and Structure Data

As described in the Model Calibration Report, surveys of the creeks and hydraulic structures for this study were undertaken between November 1998 and March 1999. A number of additional cross-sections and structure details were acquired after field inspections identified recent (since the creek survey) changes to creek and floodplain topography and new structures. This additional information is described below:

- A replacement bridge at Stones Road, Sunnybank Hills;
- Replacement footbridges at Freney Street and Colvin Street Archerfield; and
- Channel modifications to Keats Street Park Sunnybank Hills.

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Land Use

The calibrated RAFTS model was altered to reflect the ultimate catchment development situation as detailed in the Brisbane City Plan (2000).

Areas of future parkland, industrial and urban land were determined for each sub-catchment based on the Brisbane City Plan. Land-use properties (impervious and pervious areas) for each sub-catchment were recalculated based on future development and are contained in Table 4.2.

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3 Design Event Modelling

Design event modelling was undertaken using the calibrated RAFTS and MIKE 11 models.

Flood levels and discharges for design events were estimated by undertaking a flood frequency analysis to determine flows in the Stable Swamp Creek for a range of reoccurrence events. The discharges determined from the flood frequency analysis were then compared to the discharges calculated using duration independent storms synthesised as proposed in Morris (1996). Factors were derived for the synthetic storms to provide the best possible agreement between the peak flows predicted by the synthetic storms and the peak flows predicted by the flood frequency analysis.

The factors were then applied to the duration independent storms (DIS) in the RAFTS model to determine inflow hydrographs for all design events at various locations throughout the catchment. The MIKE 11 hydraulic model was then used to determine flood levels throughout the catchment.

A flood frequency analysis of RAFTS model flows based on Brisbane CBD rainfall was undertaken in 2000. The analysis assumed historically recorded Brisbane CBD rainfall was representative of rainfall in the Stable Swamp Creek catchment as a whole. This frequency analysis was considered suitable for the purposes of this study on the basis that the inclusion of an additional seven years of recorded data was unlikely to change the outcomes of the flood frequency analysis significantly. The following sections detail the flood frequency analysis and derivation of design rainfall events using DIS storms undertaken in June 2000.

Historical Rainfall Data

The most severe recorded rainfall events from each year between 1911 and 1998 (inclusive), for a range of standard durations were selected. The rainfall recorded at gauges located within the Brisbane Central Business District (CBD) was used for analysis rather than data collected within the Stable Swamp Creek catchment due to the long and continuous record available via the CBD gauges. Further, given the relatively close proximity of the Stable Swamp Creek catchment to the Brisbane CBD, it was considered that the use of the CBD data was acceptable.

A range of standard duration storms, from 30 minutes to 24 hours, was applied to the catchment to ensure that the peak discharge was calculated at all points along the creek, regardless of the critical time of concentration of each point.

The standard duration storms used in the analysis were:

- 30 minutes
- 1 hour
- 1.5 hours
- 2 hours
- 3 hours
- 4 hours
- 6 hours
- 12 hours
- 24 hours

The longer standard duration rainfall events i.e. between 3 and 24 hours, were applied to the catchment to ensure that the rainfall events critical to the retention basin in the North Branch of the catchment (i.e. Beryl Roberts Park) were considered.

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Discharges in Stable Swamp Creek were calculated for the nine standard duration rainfall events for each of the 88 years of rainfall data. Four key representative locations in the catchment were then selected to perform the flood frequency analysis:

- Boundary Road
- Gauging Station near intersection of Musgrave Road and Interstate Railway.
- Ipswich Motorway
- Orange Grove Road (North Branch)

Flood Frequency Analysis

The 88 annual peak discharges at each of the six locations listed above were ranked from highest to lowest.

The annual exceedance probability (AEP) of each calculated discharged was determined using the Weibull formula (Institution of Engineers Australia 1987, p203):

$$AEP = \frac{r}{N+1}$$

Where r = rank of discharge
N = number of annual peak discharges

The ARI, or return period, of a discharge (in years) was therefore given by:

$$ARI = \frac{1}{AEP}$$

The peak annual discharge series at each location (on a logarithmic scale) was plotted against the average recurrence interval of the storms (on a normal distribution scale). A line of best fit was drawn through these annual peak discharge series to determine the anticipated design discharge at each location, for return periods ranging from 2 years to 100 years.

3.1.1 Duration of Flood Frequency Factors

The duration independent synthetic storm for a given average recurrence interval contains the highest intensity bursts of rainfall for all durations. Therefore, one rainfall event can be applied to the entire catchment to determine the peak discharge at all points along a waterway, rather than the large number of rainfall temporal patterns representing the range of standard storm durations presented in Australian Rainfall and Runoff.

However, hydrologic modelling of other catchments has shown that the magnitude of these synthetic storms needs to be factored down to achieve results consistent with the flood frequency analysis discharges.

Therefore, factored synthetic storms were applied to the Stable Swamp Creek catchment to achieve calculated discharges consistent with those determined from the flood frequency analysis.

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3.1.2 Derivation of Flood Frequency Factors

The peak flow rates determined from the flood frequency analysis and unfactored duration independent synthetic storms are presented in Tables 3.1 and 3.2.

Table 3.1 Peak Discharges Resulting from Statistical Analysis

ARI (Years)	Statistically Estimated Peak Discharge (m^3/s)			
	Boundary Road	Gauging Station	Ipswich Motorway	Orange Grove Road
2	77.0	104.0	100.0	14.0
5	110.0	152.0	150.0	18.0
10	134.0	185.0	190.0	27.0
20	156.0	220.0	225.0	36.0
50	186.0	265.0	282.0	51.0
100	215.0	315.0	325.0	65.0

Table 3.2 Peak Discharges Resulting from Unfactored Synthetic Storms

ARI (Years)	Unfactored Synthetic Storm Peak Discharge (m^3/s)			
	Boundary Road	Gauging Station	Ipswich Motorway	Orange Grove Road
2	99.4	138.4	136.6	16.4
5	133.5	176.4	186.5	38
10	159.6	216.8	225.8	51
20	190.1	272.7	276.3	61.7
50	239.4	341.3	350.9	88.8
100	277.8	408.1	418.9	107.1

Based on the peak flows predicted by the flood frequency analysis, factors were applied to the duration independent synthetic storms to provide flow rates which agreed as closely as possible with the results of the frequency analysis. The factors derived for the synthetic storms are shown in Table 3.3.

Table 3.3 Duration Independent Storm Maximum Discharge Reduction Factors

ARI	DIS Factor
100 Year	0.9
50 Year	0.88
20 Year	0.86
10 Year	0.86
5 Year	0.84
2 Year	0.81

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4 Hydrological Modelling

The factored synthetic storms were used for design event modelling. Design events for 2, 5, 10, 20, 50, and 100 year ARI were modelled in RAFTS to develop hydrographs for the ultimate catchment development scenario for input into the hydraulic model.

The RAFTS model was calibrated for the Stable Swamp Creek Flood Study Model Calibration Report (Report A) and represents the catchment in its existing state of development. To consider future development, the impervious areas associated with certain sub-catchments were modified to represent changes in land use under ultimate catchment development. These were the only modifications made to the calibrated hydrologic model.

Table 4.1 summarises future land uses for each sub-catchment based on the City Plan (2000) Table 4.2 details the calculated impervious and pervious areas.

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Table 4.1 Summary of Land Uses for RAFTS Sub-catchments

Catchment ID	Ultimate Land Use Breakdown		
	% Open space	% Urban	% Commercial-Industrial
A1	25	75	0
B2	11	89	0
C3	15	85	0
D4	15	85	0
E5	25	75	0
F6	32	68	0
G7	6	94	0
H8	6	94	0
I9	66	34	0
J10	25	75	0
K12	62	38	0
L13	36	64	0
M14	6	94	0
N15	19	81	0
O16	6	94	0
P17	6	94	0
Q18	6	94	0
R19	0	100	0
S20	0	100	0
T21	0	82	18
Woff	47	53	0
Feltwell	36	64	0
Stones	55	45	0
Keats	36	64	0
Jackson	10	75	15
Dyson	32	68	0
Gaddes	47	53	0
Beenl W	47	53	0
Gay	0	0	100
Wanless	-	-	-

Catchment ID	Ultimate Land Use Breakdown		
	% Open space	% Urban	% Commercial-Industrial
Rail 1	32	38	30
Rail 2	7	20	73
Railyard	7	15	78
Selhurst	15	30	55
Boundary	10	0	90
Edith	9	60	31
Conf U/S	50	0	50
Basin	-	-	-
Musgrave	0	100	0
Orange Grove	0	100	0
Debra	3	25	72
Elma	49	46	5
Perrin	25	45	30
Deal	50	0	50
Gauge	10	0	90
Norbury	6	40	54
Riawena	0	0	100
Beaudesert	5	40	55
Marshal	48	27	25
Ipswich	21	10	69
Mouth	40	0	60
Beryl A	55	45	0
Beryl B	9	91	0
Beryl C	28	72	0
Beryl E	25	75	0
Beryl F	32	68	0
AA	29	10	61
BA	31	50	64
CA	35	10	55
DA	77	0	23

Catchment ID	Ultimate Land Use Breakdown		
	% Open space	% Urban	% Commercial-Industrial
EA	43	57	0
FA	21	30	49
GA	25	75	0
HA	-13	30	83
IA	32	30	38
ABAS1	-	-	-
JA	7	10	83
ABAS2	-	-	-
KA	10	55	35
LA	38	15	47
MA	27	43	30
NA	36	20	44
OA	0	0	100
PA	0	0	100
QA	0	0	100
RA	11	0	89
SA	5	0	95
TA	78	0	22
UA	77	0	23
XA	0	0	100
YA	22	0	78
VA	0	40	65
WA	5	70	25
ZA	0	0	100
AA1	0	80	20
BA1	8	60	32
CA1	8	60	32
DA1	8	60	32
A1	0	0	100

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Table 4.2 Summary of Impervious areas for RAFTS Sub-catchments

Catchment Number	Ultimate Catchment Development	
	% Pervious	% Impervious
A1	60	40
B2	53	47
C3	55	45
D4	55	45
E5	60	40
F6	64	36
G7	50	50
H8	50	50
I9	82	18
J10	60	40
K12	80	20
L13	66	34
M14	50	50
N15	57	43
O16	50	50
P17	50	50
Q18	50	50
R19	40	60
S20	40	60
T21	40	60
Woff	72	28
Feltwell	66	34
Stones	76	24
Keats	66	34
Jackson	47	53
Dyson	64	36
Gaddes	72	28
Beenl W	72	28
Gay	10	90
Wanless	0	100

Catchment Number	Ultimate Catchment Development	
	% Pervious	% Impervious
Rail 1	53	47
Rail 2	24	76
Railyard	22	78
Selhurst	35	65
Boundary	19	81
Edith	40	60
Conf U/S	55	45
Basin	0	100
Musgrave	60	40
Orange Grove	60	40
Debra	22	78
Elma	71	29
Perrin	49	51
Deal	55	45
Gauge	19	81
Norbury	30	70
Riawena	10	90
Beaudesert	30	70
Marshal	63	37
Ipswich	33	67
Mouth	46	54
Beryl A	76	24
Beryl B	52	48
Beryl C	62	38
Beryl E	60	40
Beryl F	64	36
AA	40	60
BA	40	60
CA	45	55
DA	80	20

Catchment Number	Ultimate Catchment Development	
	% Pervious	% Impervious
EA	70	30
FA	40	60
GA	60	40
HA	10	90
IA	0	100
ABAS1	0	100
JA	20	80
ABAS2	0	100
KA	40	60
LA	50	50
MA	50	50
NA	50	50
OA	10	90
PA	10	90
QA	10	90
RA	20	80
SA	15	85
TA	80	20
UA	80	20
XA	10	90
YA	30	70
VA	20	80
WA	40	60
ZA	10	90
AA1	40	60
BA1	40	60
CA1	40	60
DA1	40	60
EA1	10	90

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5 Hydraulic Modelling

Model Setup

The calibrated Stable Swamp 2010 MIKE 11 model as described in Report A - Model Calibration was updated to represent conditions in the Stable Swamp Creek catchment as at January 2008. Waterway crossings and creek mitigation works constructed after the Stable Swamp Creek survey were included (as discussed in Section 2.4). Additionally, cross sections were altered to:

- limit the effective flow widths to the Waterway Corridors limits as defined in Section 5.2 below, and
- represent minimum (vegetated) riparian corridor widths.

RAFTS design event flows based on the factored synthetic events were applied to the MIKE 11 model. All inflow points are identical to those in the calibration model.

A tailwater boundary of MHWS at the Corinda gauge (1.2m AHD) was adopted for all design event modelling.

The ultimate development scenario was considered for the 2, 5, 10, 20, 50, and 100 year ARI design events.

Modelling Ultimate Waterway Conditions

5.1.1 Existing Waterway Corridors

Waterway corridors are an important planning tool used in Brisbane. They are intended to minimise adverse impacts of urban development on waterways. The Waterway Code in Brisbane City Plan 2000 aims to generally exclude development from the waterway corridor to protect and enhance water flows, water quality, ecology, open space, and the recreational and amenity values of the waterway (BCC 2000, vol. 1, ch. 5, p. 261).

A waterway corridor is defined by:

- a flood regulation line (FRL)
- a Local Plan, environmental corridor or waterway corridor
- a waterway corridor as defined in a Council Stormwater Management Plan (SMP) or Waterway Management Plan (WMP)
- if more than one of these measurements is available, the largest width applies
- if there is no FRL, Local Plan, SMP or WMP, then a 30 m distance measured on each side from the centreline of the waterway applies (BCC 2000, vol. 1, ch. 3, p. 75).

The existing waterway corridors are represented in the MIKE 11 model as vertical walls and were horizontally positioned within the applicable cross sections. This concept assumes that there is ultimate development up to the waterway corridor lines, only allowing for flow within the waterway corridors.

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5.1.2 Minimum Riparian Vegetated Corridor

Vegetation beside a waterway is called riparian vegetation. It is a key contributor to waterway health, acting as a buffer between the waterway and adjacent lands. A well vegetated riparian zone can improve water quality by filtering overland flow and reducing erosion along creek banks.

Shady trees protect vulnerable organisms from extremes of temperature; root systems and woody debris become habitat for fauna; and organic matter sustains aquatic food webs. Vegetation also provides habitat and forage for fauna and adds to a waterway's recreational value.

This study calculates anticipated flood levels assuming a minimum vegetated riparian corridor width along the entire creek system. It does not in any way imply that Council is planning to establish a minimum riparian vegetated corridor width in the creek catchment.

The minimum vegetated riparian corridor is modelled solely in recognition that at some unspecified time in the future, revegetation may occur, either through natural regeneration or as a result of human planting programs. The results of this modelling are intended to ensure that the habitable floor levels of new developments within the floodplain take account of future revegetation.

Minimum vegetated riparian corridors have been applied to the main channels of all the reaches modelled in the hydraulic models. The minimum vegetated riparian corridors were simulated as dense vegetation (i.e. Manning's n value of 0.15) extending from the top of the low flow channel for a minimum width of 15 m on both sides of the creek.

Where there is no obvious low flow channel, the vegetation was applied at the anticipated 2 year ARI flood level on the basis that this size event is generally contained within the bed and banks of the low flow channel.

The riparian corridor with a Manning's n value of 0.15 was added to all creek cross-sections in the MIKE 11 model. Where the existing Manning's n value of the cross-section in that region is higher than 0.15, the existing value has not been altered.

The Minimum Riparian Corridor (MRC) assumptions for each branch of Stable Swamp Creek are outlined below. Where adopted MRC corridors are approximately 15 wide on either side of the bank and a Manning's n value of 0.15 has been adopted in the model.

- Archerfield Channel:
  Constrained by buildings, Archerfield Channel is largely a trapezoidal concrete lined channel therefore it is understood there will be no future vegetation in the Archerfield Channel floodway and a MRC corridor was not applied.

- North Branch:
  As a part of flood mitigation works the lower reaches of North Branch, below Orange Grove Road is made up of trapezoidal channel and therefore it is understood that no future vegetation is planned for this reach and a MRC corridor was not applied. For the remainder of the North Branch above Orange Grove Road and below beryl Roberts Basin a MRC has been applied.

- Shelleys Creek Branch:
  Revegetation is considered to be possible for the entire length of the Shelleys Creek branch and therefore a 15m wide MRC corridor has been applied.

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- Stable Swamp Main Branch:
  The upstream reaches of Stable Swamp, immediately downstream from Beenleigh Road crossing in Sunnybank Hills to the Beenleigh Road crossing at Coopers Plains is considered to have potential for further revegetation and therefore the MRC corridor has been applied.

  Downstream from Beenleigh Road culverts in Coopers Plains to the Beaudesert Road crossing in Rocklea, mitigation works were completed in conjunction with those of North Branch and therefore modelling undertaken has assumed no revegetation (MRC corridor) in this reach.

  For the remainder of Stable Swamp Creek, extending from Beaudesert Road crossing to the confluence with Oxley Creek, Manning's values of n = 0.15 have been adopted in the MRC corridor to account for possible future vegetation.

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6 Final Model Results

Flood Levels and Discharges

Anticipated flood levels were calculated for the 2, 5, 10, 20, 50 and 100 year ARI events assuming the presence of:

- future development as outlined in City Plan (2000);
- waterway corridors (as described in Section 5.2.1);
- minimum vegetated riparian corridor (as described in Section 5.2.2); and
- tailwater level equivalent to MHWS.

Anticipated peak modelled flood levels and discharges calculated for ultimate catchment development and the existing catchment development scenarios by the MIKE 11 model are summarised in tables in Appendix B of this report, Report B.

Appendix B of this report contains structure dimensions and associated flow results for all MIKE 11 model design run scenarios in Hydraulic Structure Reference Sheets.

Flood Contouring

Flood contours or flood cells were developed at approximately 0.1m intervals based on the ultimate development 100 year ARI event. The contours extend to a height approximately 1m greater than the 100 year flood limit and are clipped to the catchment boundary in the lower areas of Stable Swamp Creek

Flood Cells developed by this study have been incorporated into the Council's I-BIMAP system.

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7 References

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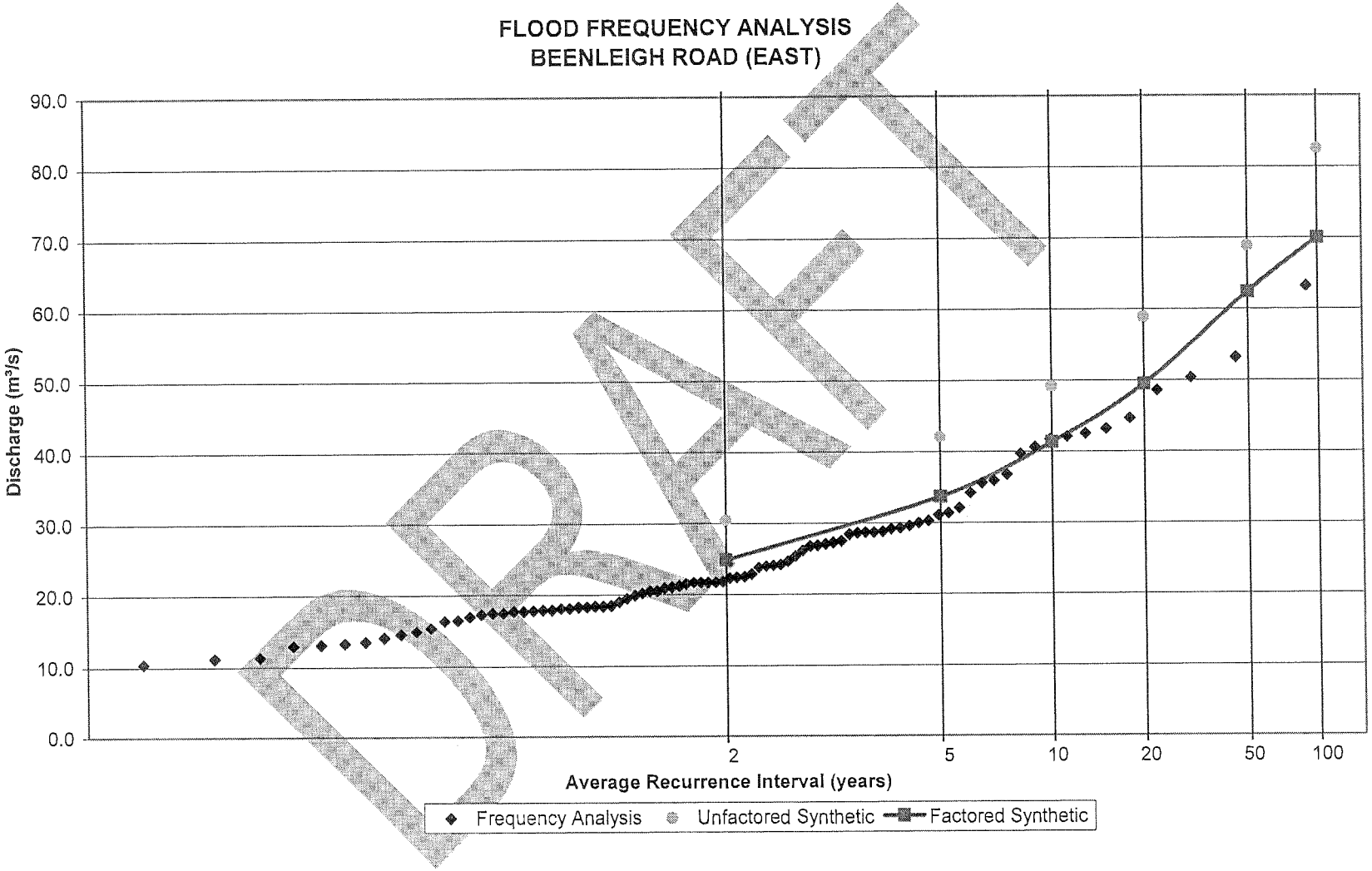
APPENDIX A: RESULTS OF FLOOD FREQUENCY ANALYSIS



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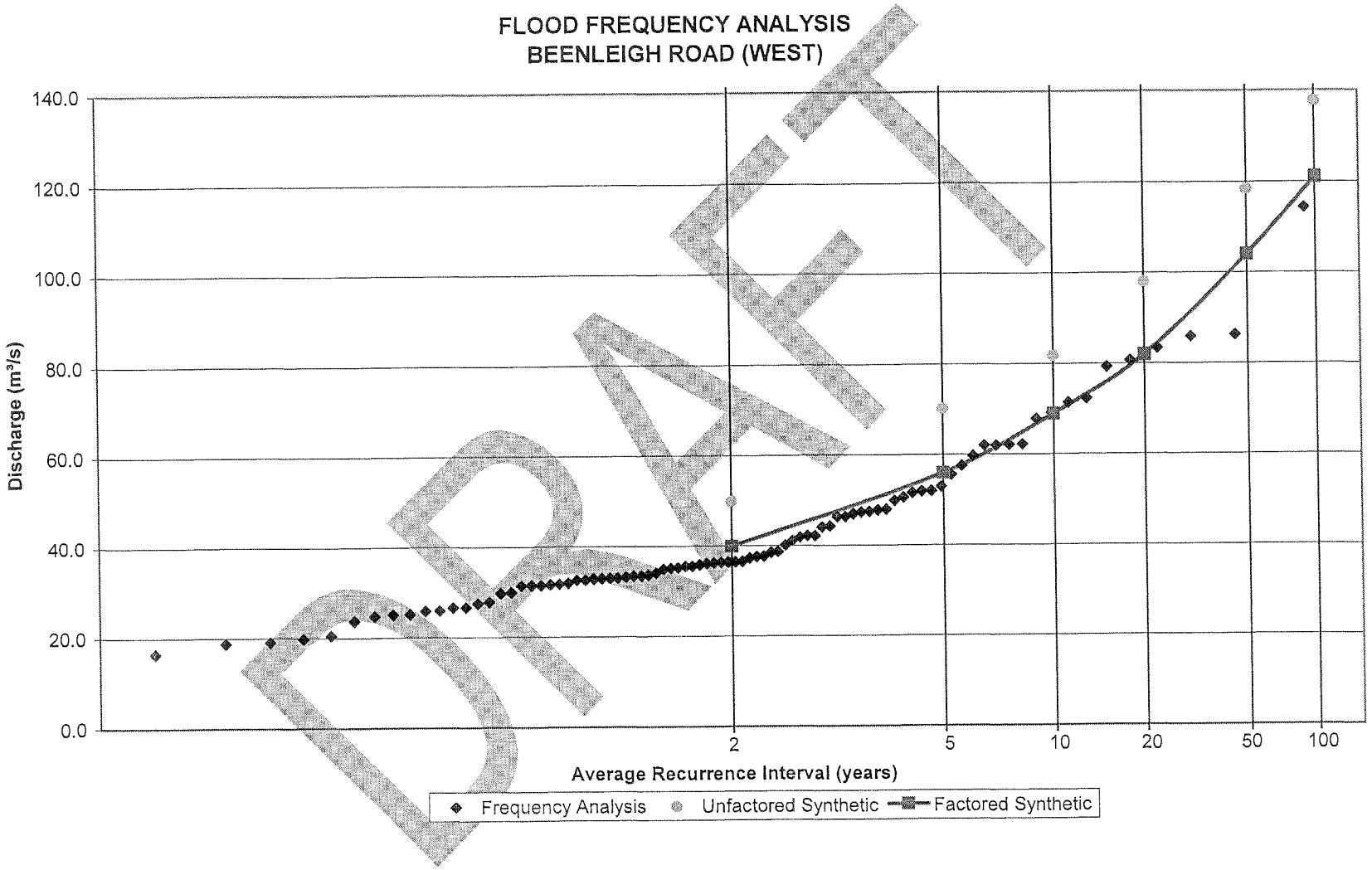
Source: Appendix D: BCC in draft, *Stable Swamp Creek Catchment Waterway Management Plan, Catchment Flooding Report*, prepared by Cardno MBK for BCC, Final Draft June 2000



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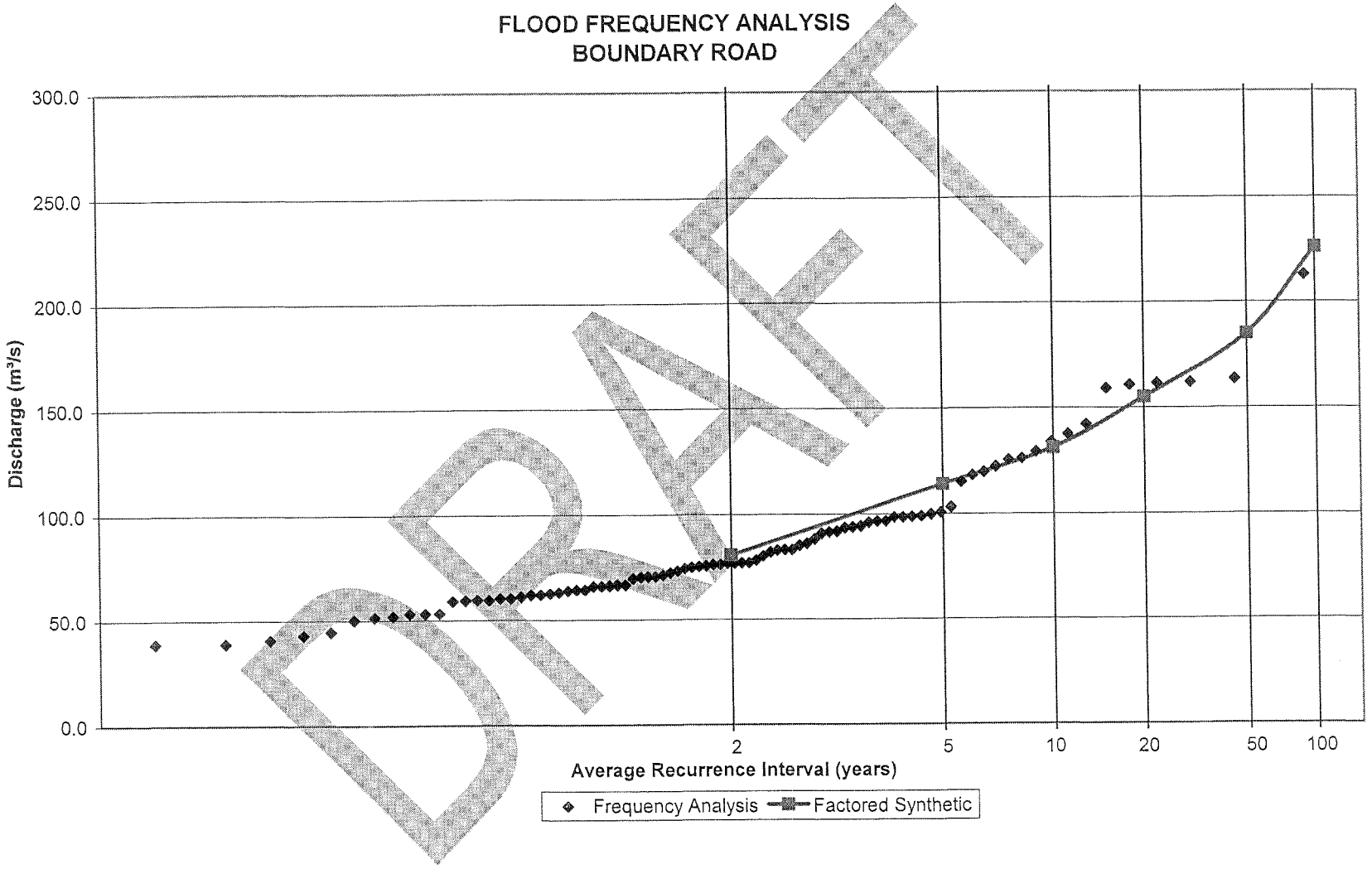

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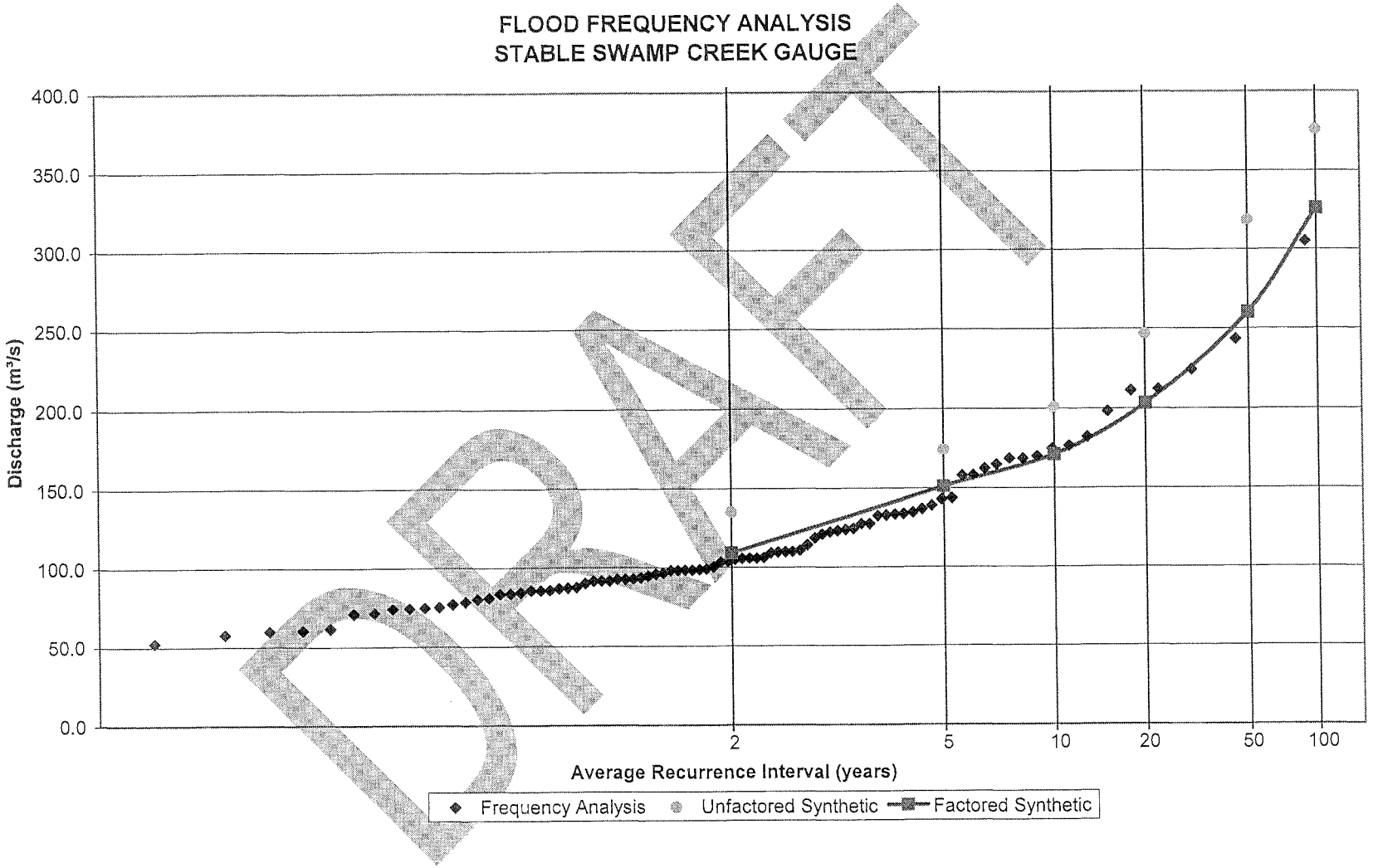

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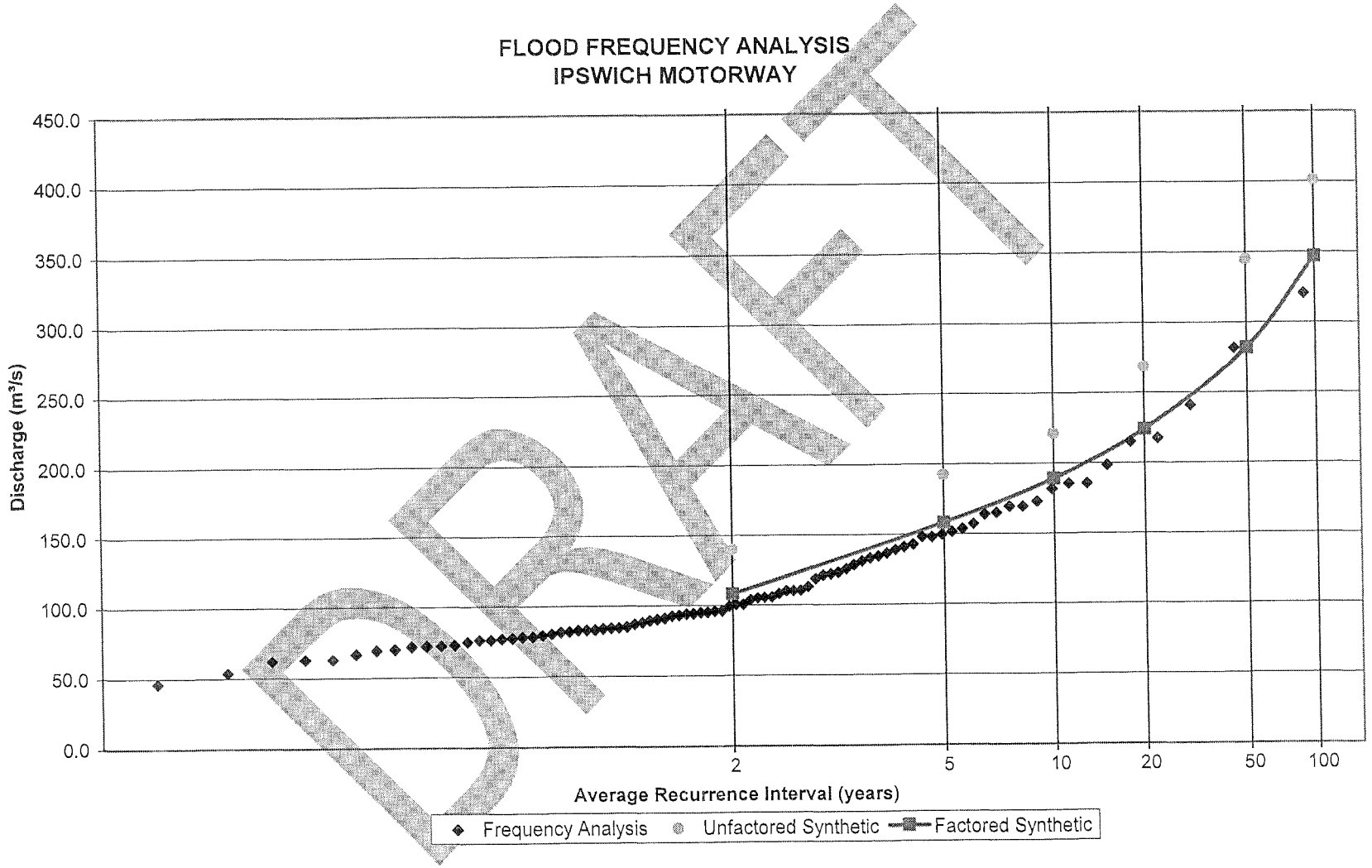

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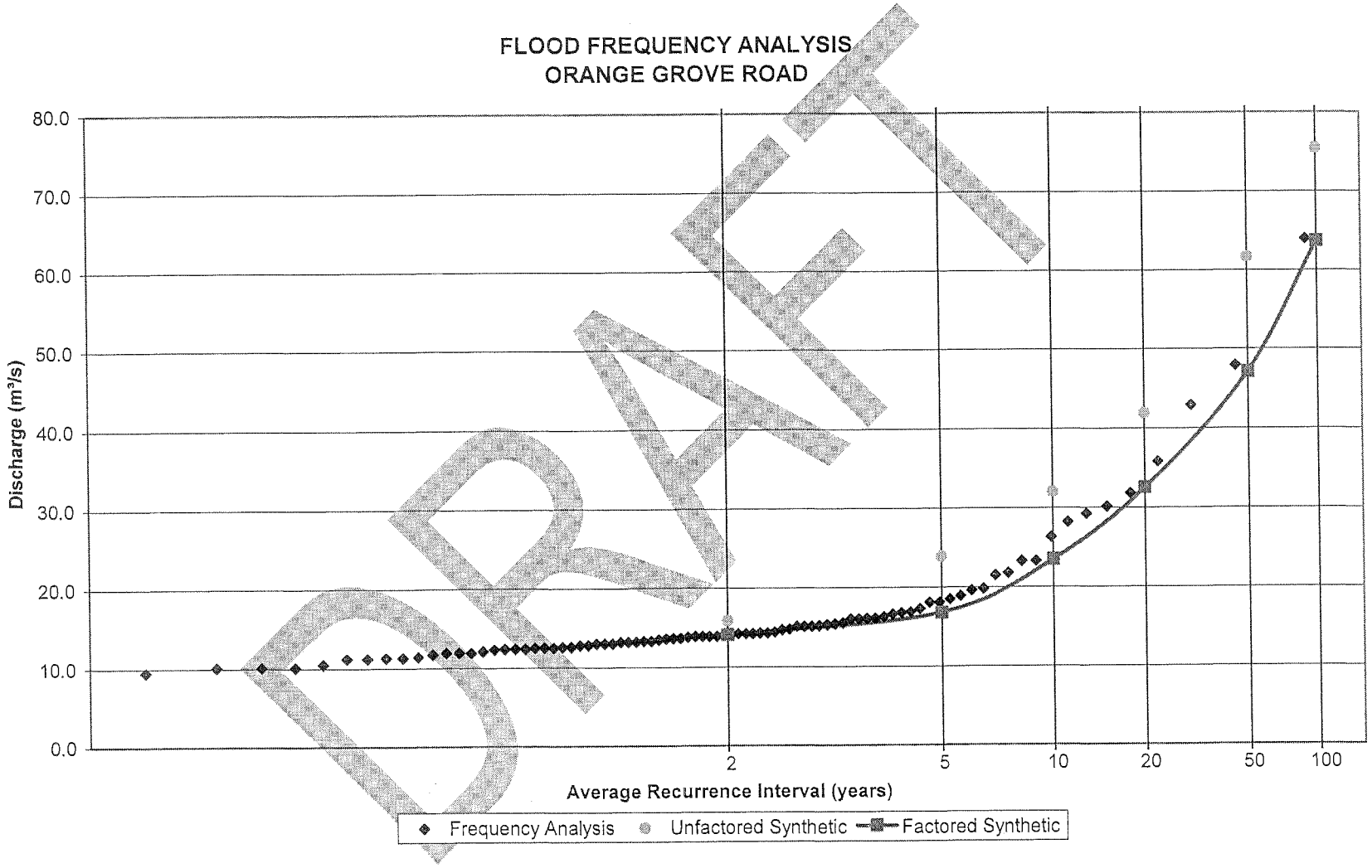

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Source: Appendix D: BCC in draft, *Stable Swamp Creek Catchment Waterway Management Plan, Catchment Flooding Report*, prepared by Cardno MBK for BCC, Final Draft June 2000.

APPENDIX B: PEAK WATER LEVEL AND DISCHARGE RESULTS

MIKE 11 Peak Water Levels and Flood Discharges – Ultimate and Existing Catchment Development Scenarios

Table B1 Stable Swamp Creek Peak Design Event Water Levels – Ultimate Development Scenario

AMTD (m)	BCC Cross Section	MIKE 11 Cross Section	Peak Flood Level (m AHD)					
			Q2	Q5	Q10	Q20	Q50	Q100
1535	SS6280	ARCHERFIELD 1010.00	9.83	10.06	10.18	10.25	10.32	10.38
1469	SS6260	ARCHERFIELD 1068.00	9.71	9.95	10.06	10.12	10.16	10.18
1425	Interpolated	ARCHERFIELD 1108.00	9.57	9.80	9.91	9.97	10.02	10.05
1323	Interpolated	ARCHERFIELD 1208.00	9.21	9.41	9.51	9.60	9.71	9.74
1281	SS6250	ARCHERFIELD 1252.00	8.98	9.16	9.25	9.34	9.45	9.48
1219	SS6240	ARCHERFIELD 1316.00	8.51	8.69	8.78	8.87	8.99	9.09
1190	SS6230	ARCHERFIELD 1344.00	8.35	8.53	8.63	8.71	8.83	8.92
1111	Interpolated	ARCHERFIELD 1424.00	7.89	8.05	8.13	8.22	8.35	8.46
1030	SS6220	ARCHERFIELD 1504.00	7.45	7.63	7.72	7.82	7.96	8.08
984	SS6200	ARCHERFIELD 1550.00	7.33	7.51	7.61	7.71	7.85	7.96
944	SS6190	ARCHERFIELD 1594.00	7.23	7.41	7.51	7.61	7.75	7.86
884	SS6180	ARCHERFIELD 1650.00	7.00	7.18	7.27	7.37	7.50	7.59
845	Interpolated	ARCHERFIELD 1690.00	6.85	7.03	7.11	7.21	7.33	7.43
802	SS6170	ARCHERFIELD 1732.00	6.70	6.88	6.96	7.05	7.17	7.25
784	SS6160	ARCHERFIELD 1750.00	6.62	6.80	6.88	6.96	7.07	7.14
695	SS6150	ARCHERFIELD 1840.00	6.38	6.52	6.60	6.68	6.78	6.94
583	Interpolated	ARCHERFIELD 1950.00	6.26	6.38	6.44	6.50	6.60	6.94
529	SS6140	ARCHERFIELD 2004.00	6.25	6.36	6.41	6.47	6.59	6.94
529	SS6140	ARCHERFIELD 2004.00	6.25	6.36	6.41	6.47	6.59	6.94
504	SS6120	ARCHERFIELD 2032.00	5.71	5.92	6.04	6.21	6.59	6.94
453	Copy of SS6120	ARCHERFIELD 2082.00	5.59	5.84	5.97	6.20	6.59	6.94
407	Copy of SS6100	ARCHERFIELD 2128.00	5.51	5.76	5.95	6.20	6.59	6.94
407	Copy of SS6100	ARCHERFIELD 2128.00	5.51	5.76	5.95	6.20	6.59	6.94
403	SS6100	ARCHERFIELD 2132.00	5.51	5.76	5.95	6.20	6.58	6.94
385	Interpolated	ARCHERFIELD 2150.00	5.50	5.75	5.95	6.20	6.58	6.94
345	Interpolated	ARCHERFIELD 2190.00	5.48	5.74	5.94	6.20	6.58	6.93
311	SS6090	ARCHERFIELD 2224.00	5.48	5.74	5.94	6.20	6.58	6.93
297	SS6070	ARCHERFIELD 2238.00	5.40	5.72	5.93	6.19	6.57	6.92
297	SS6070	ARCHERFIELD 2238.00	5.40	5.72	5.93	6.19	6.57	6.92
283	Interpolated	ARCHERFIELD 2251.00	5.40	5.71	5.93	6.18	6.57	6.92
264	Interpolated	ARCHERFIELD 2280.00	5.37	5.69	5.91	6.16	6.56	6.91
244	Interpolated	ARCHERFIELD 2302.00	5.34	5.67	5.89	6.14	6.54	6.89
244	Interpolated	ARCHERFIELD 2302.00	5.34	5.67	5.89	6.14	6.54	6.89
202	-	ARCHERFIELD 2344.00	5.35	5.66	5.87	6.12	6.52	6.86
169	Copy of SS6030	ARCHERFIELD 2384.00	5.34	5.64	5.85	6.10	6.50	6.85
169	Copy of SS6030	ARCHERFIELD 2384.00	5.34	5.64	5.85	6.10	6.50	6.85
163	Copy of SS6030	ARCHERFIELD 2390.00	5.34	5.64	5.85	6.10	6.50	6.85
147	SS6030	ARCHERFIELD 2404.00	5.34	5.64	5.85	6.10	6.50	6.84
117	Copy of SS6010	ARCHERFIELD 2418.00	5.33	5.62	5.82	6.07	6.47	6.82
99	Interpolated	ARCHERFIELD 2436.00	5.35	5.64	5.84	6.08	6.48	6.82
86	Interpolated	ARCHERFIELD 2449.00	5.35	5.64	5.84	6.07	6.46	6.80
76	Copy of SS6000	ARCHERFIELD 2463.00	5.35	5.64	5.84	6.07	6.46	6.80
76	Copy of SS6000	ARCHERFIELD 2463.00	5.35	5.64	5.84	6.07	6.46	6.80
38	SS6000	ARCHERFIELD 2500.00	5.35	5.64	5.84	6.07	6.46	6.80
-	2002 ALS	ARCHERFIELD OVERFLOW 01 0.00	6.12	6.43	6.60	6.80	7.08	7.39
-	2002 ALS	ARCHERFIELD OVERFLOW 01 100.00	6.25	6.36	6.41	6.47	6.59	6.94
-	2002 ALS	ARCHERFIELD OVERFLOW 02 0.00	6.02	6.30	6.45	6.61	6.87	7.15
-	2002 ALS	ARCHERFIELD OVERFLOW 02 160.31	5.51	5.76	5.95	6.20	6.59	6.94
-	2002 ALS	ARCHERFIELD OVERFLOW 03 0.00	5.88	6.14	6.28	6.43	6.70	6.99
-	2002 ALS	ARCHERFIELD OVERFLOW 03 42.43	5.40	5.72	5.93	6.19	6.57	6.92
-	2002 ALS	ARCHERFIELD OVERFLOW 04 0.00	5.76	6.03	6.17	6.33	6.61	6.92
-	2002 ALS	ARCHERFIELD OVERFLOW 04 44.72	5.34	5.67	5.89	6.14	6.54	6.89
-	2002 ALS	ARCHERFIELD OVERFLOW 05 0.00	5.61	5.90	6.05	6.22	6.52	6.85
-	2002 ALS	ARCHERFIELD OVERFLOW 05 28.28	5.34	5.64	5.85	6.10	6.50	6.85
-	Copy of SS9310	BERYL ROBERTS BASIN 0.16	21.67	22.02	22.17	22.31	22.45	22.54
-	SS9310	BERYL ROBERTS BASIN 78.74	21.65	22.00	22.15	22.28	22.41	22.49
-	SS9300	BERYL ROBERTS BASIN 161.19	21.64	22.00	22.14	22.26	22.38	22.46
-	Copy of SS9300	BERYL ROBERTS BASIN 313.55	21.64	21.99	22.14	22.26	22.37	22.45
-	Copy of SS9300	BERYL ROBERTS BASIN 313.55	21.64	21.99	22.14	22.26	22.37	22.45
-	Copy of SS9250	BERYL ROBERTS BASIN 375.00	17.99	18.40	18.67	18.94	19.18	19.33
-	Copy of SS9250	BERYL ROBERTS BASIN 375.00	17.99	18.40	18.67	18.94	19.18	19.33
-	Copy of SS9250	BERYL ROBERTS BASIN 389.43	17.99	18.39	18.66	18.93	19.16	19.31
-	Copy of SS9350	BERYL ROBERTS MAIN 0.00	27.03	27.22	27.32	27.41	27.54	27.64
-	SS9350	BERYL ROBERTS MAIN 126.00	26.57	26.77	26.87	26.96	27.09	27.17
-	SS9340	BERYL ROBERTS MAIN 200.66	25.54	25.68	25.76	25.84	25.95	26.03
-	SS9330	BERYL ROBERTS MAIN 265.62	24.47	24.60	24.67	24.74	24.83	24.89
-	SS9320	BERYL ROBERTS MAIN 349.77	22.69	22.78	22.84	22.90	22.98	23.06
-	Copy of SS9320	BERYL ROBERTS MAIN 388.24	22.17	22.17	22.17	22.31	22.45	22.54
-	2006 Survey	BERYL ROBERTS SPILLWAY 0.00	21.64	21.99	22.14	22.26	22.37	22.45
-	2006 Survey	BERYL ROBERTS SPILLWAY 24.00	19.20	19.20	19.20	19.20	19.20	19.33
-	Copy of SS10060	BERYL ROBERTS TRIB 0.00	24.29	24.49	24.59	24.70	24.85	24.96
-	SS10060	BERYL ROBERTS TRIB 39.90	24.08	24.27	24.38	24.48	24.64	24.74
-	SS10050	BERYL ROBERTS TRIB 86.27	23.61	23.79	23.90	24.02	24.20	24.31
-	SS10040	BERYL ROBERTS TRIB 165.21	22.38	22.59	22.73	22.87	23.06	23.19
-	SS10030	BERYL ROBERTS TRIB 234.53	21.68	22.03	22.19	22.33	22.47	22.57
-	Copy ofSS10030	BERYL ROBERTS TRIB 259.87	21.67	22.02	22.17	22.31	22.45	22.54
2168	Copy of SS140	BRIDGE - IPSWICH MOTORWAY 7981.00	4.32	4.78	5.05	5.34	5.79	6.15
2107	Copy of SS130	BRIDGE - IPSWICH MOTORWAY 8041.00	1.20	1.20	1.20	1.20	1.21	5.99
2036	Copy of SS130	BRIDGE - IPSWICH MOTORWAY 8112.00	4.19	4.58	4.79	5.00	5.28	5.47
13934	SS9250	NORTH BRANCH 0.00	17.99	18.39	18.66	18.93	19.16	19.31
13881	SS9240	NORTH BRANCH 72.00	17.92	18.31	18.57	18.84	19.04	19.18
13875	SS9220	NORTH BRANCH 80.00	17.19	17.62	17.95	18.31	18.73	19.00

FOR INFORMATION ONLY - NOT COUNCIL POLICY

AMTD (m)	BCC Cross Section	MIKE 11 Cross Section	Peak Flood Level (m AHD)					
			Q2	Q5	Q10	Q20	Q50	Q100
13810	SS9210	NORTH BRANCH 144.00	16.38	16.82	17.29	17.76	18.28	18.59
13804	SS9190	NORTH BRANCH 150.00	16.19	16.65	17.03	17.44	17.98	18.36
13796	SS9180	NORTH BRANCH 158.00	16.14	16.61	16.98	17.40	17.94	18.32
13671	SS9170	NORTH BRANCH 284.00	15.74	16.19	16.56	16.96	17.50	17.89
13649	SS9163	NORTH BRANCH 304.00	15.73	16.18	16.55	16.95	17.48	17.87
13643	SS9161	NORTH BRANCH 312.00	14.67	15.22	15.85	16.35	16.83	17.12
13571	SS9160	NORTH BRANCH 382.00	14.17	14.77	15.59	16.12	16.56	16.83
13552	SS9140	NORTH BRANCH 402.00	14.06	14.45	15.08	15.92	16.49	16.77
13509	SS9130	NORTH BRANCH 444.00	14.01	14.38	15.03	15.88	16.45	16.72
13479	SS9120	NORTH BRANCH 472.00	13.93	14.32	14.99	15.86	16.42	16.69
13460	SS9100	NORTH BRANCH 494.00	13.69	13.98	14.30	14.71	15.29	15.62
13350	SS9090	NORTH BRANCH 600.00	12.84	13.09	13.38	13.74	14.29	14.64
13248	SS9080	NORTH BRANCH 710.00	12.35	12.59	12.89	13.27	13.84	14.22
13141	SS9075	NORTH BRANCH 818.00	11.96	12.14	12.44	12.82	13.41	13.80
13108	SS9074	NORTH BRANCH 850.00	11.87	12.06	12.31	12.69	13.28	13.67
13005	Copy of SS9074	NORTH BRANCH 967.19	11.30	11.55	11.70	11.90	12.49	12.89
13005	Copy of SS9074	NORTH BRANCH 967.19	11.30	11.55	11.70	11.90	12.49	12.89
12888	SS9070	NORTH BRANCH 1070.00	10.53	10.79	10.95	11.18	11.80	12.21
12778	SS9060	NORTH BRANCH 1180.00	9.79	10.10	10.28	10.54	11.20	11.64
12529	SS9050	NORTH BRANCH 1430.00	8.86	9.20	9.41	9.64	10.30	10.71
12366	SS9044	NORTH BRANCH 1584.00	8.27	8.74	8.98	9.28	9.94	10.36
12354	SS9040	NORTH BRANCH 1604.00	8.22	8.68	8.92	9.20	9.71	10.09
12254	SS9030	NORTH BRANCH 1700.00	8.02	8.57	8.83	9.12	9.53	9.91
12229	SS9010	NORTH BRANCH 1720.00	8.01	8.56	8.82	9.11	9.52	9.88
12147	SS9004	NORTH BRANCH 1800.00	8.01	8.57	8.83	9.11	9.52	9.88
12095	SS9003	NORTH BRANCH 1852.00	8.00	8.57	8.83	9.11	9.51	9.87
12070	SS9001	NORTH BRANCH 1872.00	7.89	8.55	8.82	9.10	9.50	9.86
12045	Copy of SS521	NORTH BRANCH 1900.00	7.90	8.55	8.82	9.10	9.50	9.86
-	2002 ALS	RAILWAY OVERFLOW 10000.00	10.95	10.95	10.95	10.95	10.95	10.95
-	2002 ALS	RAILWAY OVERFLOW 10122.64	10.43	10.43	10.43	10.43	10.43	10.43
-	2002 ALS	RAILWAY OVERFLOW 10232.98	9.81	9.81	9.84	9.94	10.01	10.07
-	2002 ALS	RAILWAY OVERFLOW 10232.98	9.81	9.81	9.84	9.94	10.01	10.07
-	2002 ALS	RAILWAY OVERFLOW 10291.62	9.29	9.32	9.40	9.53	9.65	9.75
-	2002 ALS	RAILWAY OVERFLOW 10291.62	9.29	9.32	9.40	9.53	9.65	9.75
-	2002 ALS	RAILWAY OVERFLOW 10319.58	9.04	9.09	9.19	9.34	9.48	9.60
-	2002 ALS	RAILWAY OVERFLOW 10480.69	8.48	8.53	8.60	8.69	8.83	9.08
-	2002 ALS	RAILWAY OVERFLOW 10536.48	7.89	7.98	8.12	8.33	8.63	9.00
-	2002 ALS	RAILWAY OVERFLOW 10581.46	7.85	7.85	7.97	8.22	8.56	8.96
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 9813.25	11.85	11.85	11.85	11.85	11.89	12.14
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 9870.52	11.59	11.59	11.59	11.59	11.65	12.14
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 9964.10	11.82	11.82	11.82	11.82	11.82	11.83
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10000.00	11.14	11.14	11.14	11.14	11.22	11.34
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10034.60	10.82	10.82	10.88	11.05	11.22	11.34
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10100.81	10.69	10.71	10.87	11.05	11.22	11.34
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10100.81	10.69	10.71	10.87	11.05	11.22	11.34
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10119.55	10.66	10.67	10.83	11.00	11.17	11.28
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10181.01	10.47	10.48	10.52	10.67	10.79	10.88
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10211.02	10.47	10.47	10.47	10.47	10.47	10.47
-	2002 ALS	RAILWAY OVERFLOW_DRAIN_WIER_1 0.00	11.40	11.69	11.83	12.01	12.21	12.36
-	2002 ALS	RAILWAY OVERFLOW_DRAIN_WIER_1 46.28	11.83	11.83	11.83	11.83	11.89	12.14
-	2002 ALS	RAILWAY OVERFLOW_DRAIN_WIER_2 0.00	10.91	11.20	11.34	11.49	11.65	11.77
-	2002 ALS	RAILWAY OVERFLOW_DRAIN_WIER_2 40.00	10.69	10.71	10.87	11.05	11.22	11.34
-	2002 ALS	RAILWAY OVERFLOW_WEIR 0.00	10.46	10.76	10.90	11.05	11.19	11.29
-	2002 ALS	RAILWAY OVERFLOW_WEIR 40.00	9.29	9.32	9.40	9.53	9.65	9.75
-	2002 ALS	RIAWENA ROAD 10000.00	14.12	14.26	14.35	14.43	14.55	14.63
-	2002 ALS	RIAWENA ROAD 10008.37	14.05	14.19	14.27	14.35	14.47	14.55
-	2002 ALS	RIAWENA ROAD 10058.31	13.52	13.65	13.72	13.80	13.90	13.98
-	2002 ALS	RIAWENA ROAD 10088.23	13.31	13.43	13.50	13.57	13.67	13.75
-	2002 ALS	RIAWENA ROAD 10118.20	12.78	12.89	12.95	13.02	13.12	13.20
-	2002 ALS	RIAWENA ROAD 10175.73	11.74	11.93	12.05	12.18	12.49	12.89
-	2002 ALS	RIAWENA ROAD 10245.72	11.30	11.55	11.70	11.90	12.49	12.89
9530	SS1330	SHELLEYS CREEK 10000.00	65.12	65.18	65.22	65.26	65.32	65.36
9626	Copy of S1330	SHELLEYS CREEK 10010.00	64.93	65.01	65.05	65.09	65.16	65.20
9655	SS1328	SHELLEYS CREEK 10039.00	64.88	64.93	64.97	65.00	65.05	65.10
9769	SS1324	SHELLEYS CREEK 10047.00	63.67	63.79	63.86	63.94	64.04	64.13
9833	SS1320	SHELLEYS CREEK 10091.00	63.10	63.27	63.35	63.44	63.57	63.68
9834	SS1310	SHELLEYS CREEK 10187.00	61.55	61.73	61.83	61.94	62.10	62.23
9837	SS1309	SHELLEYS CREEK 10200.00	61.39	61.57	61.67	61.79	61.95	62.08
9838	SS1308	SHELLEYS CREEK 10229.00	61.00	61.19	61.30	61.42	61.61	61.75
9839	SS1300	SHELLEYS CREEK 10283.00	60.34	60.56	60.69	60.84	61.05	61.22
9841	SS1299	SHELLEYS CREEK 10316.00	60.01	60.24	60.37	60.52	60.75	60.93
9849	SS1298	SHELLEYS CREEK 10369.00	59.44	59.74	59.93	60.13	60.42	60.62
9932	SS1297	SHELLEYS CREEK 10376.00	59.43	59.73	59.92	60.13	60.41	60.62
10003	SS1290	SHELLEYS CREEK 10386.00	59.41	59.71	59.90	60.11	60.40	60.60
10121	SS1270	SHELLEYS CREEK 10412.00	59.37	59.64	59.78	59.93	60.14	60.30
10180	SS1260	SHELLEYS CREEK 10514.00	58.96	59.08	59.14	59.21	59.31	59.39
10215	Copy of SS1260	SHELLEYS CREEK 10520.00	56.12	56.28	56.36	56.46	56.60	56.71
10230	SS1250	SHELLEYS CREEK 10630.00	55.09	55.31	55.42	55.53	55.70	55.83
10238	SS1240	SHELLEYS CREEK 10729.00	53.74	53.93	54.03	54.13	54.29	54.42
10257	SS1230	SHELLEYS CREEK 10821.00	52.37	52.64	52.78	52.92	53.12	53.28
10270	SS1220	SHELLEYS CREEK 10866.00	52.01	52.30	52.45	52.62	52.86	53.05
10386	SS1210	SHELLEYS CREEK 10948.00	51.52	51.83	52.00	52.18	52.43	52.63
10477	Copy of SS1204	SHELLEYS CREEK 10962.00	51.24	51.58	51.77	51.96	52.23	52.44
10566	SS1204	SHELLEYS CREEK 10965.00	51.22	51.57	51.75	51.94	52.21	52.43
10664	SS1203	SHELLEYS CREEK 10969.00	51.19	51.54	51.72	51.91	52.18	52.39
10731	SS1200	SHELLEYS CREEK 11036.00	50.28	50.58	50.74	50.92	51.17	51.36
10735	SS1190	SHELLEYS CREEK 11134.00	49.30	49.61	49.77	49.95	50.21	50.41
10738	SS1180	SHELLEYS CREEK 11223.00	48.55	48.88	49.06	49.25	49.51	49.72
10752	SS1170	SHELLEYS CREEK 11314.00	47.60	47.99	48.19	48.39	48.66	48.87
10834	Copy of SS1160	SHELLEYS CREEK 11430.00	46.91	47.33	47.53	47.73	47.98	48.16

AMTD (m)	BCC Cross Section	MIKE 11 Cross Section	Peak Flood Level (m AHD)					
			Q2	Q5	Q10	Q20	Q50	Q100
10879	SS1160	SHELLEYS CREEK 11443.00	46.89	47.30	47.50	47.69	47.94	48.12
10971	SS1140	SHELLEYS CREEK 11462.00	46.75	47.14	47.32	47.52	47.77	47.97
11070	Copy of SS1140	SHELLEYS CREEK 11470.00	46.75	47.13	47.31	47.51	47.76	47.96
11180	Copy of SS1140	SHELLEYS CREEK 11485.00	46.68	47.04	47.21	47.39	47.63	47.82
11186	SS1130	SHELLEYS CREEK 11520.00	46.40	46.66	46.80	46.96	47.17	47.34
11288	SS1120	SHELLEYS CREEK 11638.00	45.05	45.40	45.59	45.80	46.07	46.29
11314	SS1110	SHELLEYS CREEK 11709.00	44.39	44.73	44.91	45.11	45.37	45.57
11324	Copy of SS1110	SHELLEYS CREEK 11766.00	43.91	44.22	44.39	44.58	44.81	45.00
11331	SS1105	SHELLEYS CREEK 11844.00	43.26	43.51	43.66	43.85	44.08	44.27
11384	Copy of SS1100	SHELLEYS CREEK 11848.00	43.25	43.50	43.65	43.84	44.07	44.26
11417	SS1100	SHELLEYS CREEK 11862.00	43.24	43.49	43.64	43.83	44.06	44.25
11471	Copy of SS1080	SHELLEYS CREEK 11865.00	43.23	43.48	43.62	43.79	44.01	44.20
11500	Copy of SS1080	SHELLEYS CREEK 11866.00	43.21	43.45	43.59	43.75	43.98	44.16
11513	SS1078	SHELLEYS CREEK 11867.00	43.21	43.45	43.60	43.76	43.98	44.16
11609	SS1080	SHELLEYS CREEK 11869.00	41.22	41.62	41.85	42.13	42.50	42.74
11653	SS1070	SHELLEYS CREEK 11928.00	41.04	41.42	41.65	41.92	42.31	42.54
11661	SS1060	SHELLEYS CREEK 12041.00	40.59	40.99	41.23	41.53	41.97	42.21
11690	SS1040	SHELLEYS CREEK 12069.00	40.13	40.44	40.60	40.77	40.99	41.16
11700	SS1030	SHELLEYS CREEK 12165.00	39.52	39.81	39.95	40.09	40.26	40.38
9443	SS1020	STABLE SWAMP CREEK 737.00	39.52	39.81	39.95	40.09	40.26	40.38
9319	SS1010	STABLE SWAMP CREEK 859.00	39.01	39.20	39.29	39.39	39.51	39.60
9216	SS1000	STABLE SWAMP CREEK 960.00	38.32	38.57	38.67	38.76	38.89	38.97
9115	SS990	STABLE SWAMP CREEK 1059.00	37.38	37.67	37.78	37.89	38.03	38.11
8975	SS980	STABLE SWAMP CREEK 1199.00	35.93	36.07	36.13	36.19	36.28	36.35
8902	SS970	STABLE SWAMP CREEK 1272.00	34.61	34.73	34.80	34.87	34.96	35.03
8742	SS965	STABLE SWAMP CREEK 1430.00	33.16	33.45	33.58	33.69	33.83	33.94
8728	SS960	STABLE SWAMP CREEK 1441.00	31.83	32.27	32.52	32.75	33.02	33.15
8725	SS938	STABLE SWAMP CREEK 1447.00	31.76	32.21	32.45	32.69	32.96	33.09
8658	Section 1	STABLE SWAMP CREEK 1514.00	30.27	30.76	31.04	31.29	31.58	31.74
8595	SS930	STABLE SWAMP CREEK 1577.00	30.07	30.56	30.84	31.10	31.39	31.55
8580	SS928	STABLE SWAMP CREEK 1593.00	29.97	30.46	30.76	31.03	31.32	31.48
8554	SS922	STABLE SWAMP CREEK 1618.00	29.44	30.15	30.54	30.83	31.16	31.32
8550	SS920	STABLE SWAMP CREEK 1625.00	29.39	30.13	30.52	30.82	31.14	31.30
8535	SS900	STABLE SWAMP CREEK 1641.00	27.87	28.30	28.54	28.79	29.14	29.39
8511	Section 2	STABLE SWAMP CREEK 1665.00	27.74	28.17	28.41	28.65	28.99	29.25
8455	Section 3	STABLE SWAMP CREEK 1721.00	27.37	27.72	27.95	28.18	28.50	28.75
8421	Section 19	STABLE SWAMP CREEK 1755.00	26.48	26.86	27.12	27.38	27.74	28.00
8405	Section 17	STABLE SWAMP CREEK 1771.00	26.01	26.45	26.72	27.02	27.43	27.72
8396	Section 16	STABLE SWAMP CREEK 1780.00	25.78	26.25	26.53	26.84	27.27	27.57
8386	Section 15	STABLE SWAMP CREEK 1790.00	25.75	26.21	26.49	26.80	27.23	27.52
8353	Section 12	STABLE SWAMP CREEK 1823.00	25.59	26.05	26.33	26.66	27.10	27.40
8317	Section 9	STABLE SWAMP CREEK 1859.00	25.52	25.98	26.26	26.59	27.02	27.32
8221	Section 2	STABLE SWAMP CREEK 1950.00	25.24	25.67	25.94	26.31	26.76	27.08
8209	SS860	STABLE SWAMP CREEK 1962.00	24.45	24.79	25.01	25.23	25.56	25.77
8132	SS850	STABLE SWAMP CREEK 2040.00	23.21	23.61	23.85	24.10	24.46	24.70
8040	SS840	STABLE SWAMP CREEK 2132.00	22.44	22.84	23.08	23.32	23.66	23.89
7931	SS830	STABLE SWAMP CREEK 2240.00	22.21	22.58	22.80	23.01	23.32	23.53
7854	SS820	STABLE SWAMP CREEK 2316.00	21.69	22.05	22.26	22.47	22.75	22.94
7753	SS810	STABLE SWAMP CREEK 2417.00	21.14	21.59	21.82	22.03	22.30	22.48
7654	SS800	STABLE SWAMP CREEK 2516.00	21.00	21.44	21.67	21.86	22.12	22.28
7496	SS790	STABLE SWAMP CREEK 2674.00	20.11	20.49	20.68	20.86	21.10	21.27
7360	SS780	STABLE SWAMP CREEK 2810.00	19.51	19.84	20.01	20.17	20.40	20.56
7226	SS770	STABLE SWAMP CREEK 2942.00	18.83	19.03	19.15	19.27	19.44	19.57
7139	SS760	STABLE SWAMP CREEK 3029.00	18.76	18.92	19.00	19.09	19.23	19.33
7105	SS740	STABLE SWAMP CREEK 3063.00	17.16	17.49	17.69	17.90	18.23	18.47
7066	Copy of SS740	STABLE SWAMP CREEK 3102.00	17.05	17.37	17.56	17.77	18.07	18.30
6958	SS730	STABLE SWAMP CREEK 3199.00	16.44	16.72	16.89	17.07	17.35	17.59
6832	SS720	STABLE SWAMP CREEK 3334.00	15.24	15.44	15.57	15.72	15.95	16.11
6829	Copy of SS720	STABLE SWAMP CREEK 3337.00	15.09	15.30	15.43	15.58	15.82	15.99
6817	SS710	STABLE SWAMP CREEK 3350.00	14.95	15.15	15.29	15.45	15.69	15.86
6785	Copy of SS710	STABLE SWAMP CREEK 3382.00	14.42	14.78	14.99	15.21	15.52	15.72
6775	Copy of SS710	STABLE SWAMP CREEK 3392.00	14.41	14.77	14.97	15.19	15.50	15.71
6770	Copy of SS710	STABLE SWAMP CREEK 3397.00	14.40	14.76	14.97	15.19	15.50	15.70
6756	Copy of SS710	STABLE SWAMP CREEK 3411.00	14.38	14.74	14.94	15.16	15.47	15.67
6650	SS700	STABLE SWAMP CREEK 3516.00	13.80	14.14	14.35	14.61	14.99	15.22
6587	Copy of SS690	STABLE SWAMP CREEK 3579.00	13.44	13.76	13.96	14.25	14.74	15.02
6580	Copy of SS690	STABLE SWAMP CREEK 3586.00	13.41	13.73	13.93	14.22	14.73	15.01
6554	Copy of SS690	STABLE SWAMP CREEK 3612.00	13.00	13.41	13.68	13.96	14.26	14.47
6537	Copy of SS690	STABLE SWAMP CREEK 3629.00	13.01	13.41	13.68	13.95	14.26	14.46
6527	Copy of SS690	STABLE SWAMP CREEK 3637.00	13.01	13.41	13.68	13.95	14.25	14.46
6525	Copy of SS690	STABLE SWAMP CREEK 3639.00	13.00	13.40	13.67	13.94	14.25	14.45
6520	Copy of SS690	STABLE SWAMP CREEK 3644.00	12.99	13.39	13.66	13.93	14.23	14.44
6505	SS690	STABLE SWAMP CREEK 3659.00	12.95	13.34	13.61	13.88	14.19	14.39
6325	SS680	STABLE SWAMP CREEK 3838.00	11.79	12.15	12.56	12.88	13.21	13.46
6243	SS671	STABLE SWAMP CREEK 3921.00	11.62	12.00	12.45	12.78	13.11	13.37
6197	SS670	STABLE SWAMP CREEK 3967.00	11.56	11.93	12.42	12.76	13.10	13.35
6167	SS650	STABLE SWAMP CREEK 3995.00	11.44	11.74	11.88	12.07	12.27	12.43
6146	SS640	STABLE SWAMP CREEK 4016.00	11.40	11.69	11.83	12.01	12.21	12.36
6146	SS640	STABLE SWAMP CREEK 4016.00	11.40	11.69	11.83	12.01	12.21	12.36
6034	SS639	STABLE SWAMP CREEK 4131.00	10.99	11.28	11.41	11.57	11.74	11.87
6001	SS690	STABLE SWAMP CREEK 4163.00	10.93	11.21	11.35	11.51	11.67	11.79
5997	SS680	STABLE SWAMP CREEK 4166.00	10.91	11.20	11.34	11.49	11.65	11.77
5997	SS680	STABLE SWAMP CREEK 4166.00	10.91	11.20	11.34	11.49	11.65	11.77
5991	SS638	STABLE SWAMP CREEK 4171.00	10.89	11.18	11.32	11.47	11.63	11.75
5986	Copy of SS638	STABLE SWAMP CREEK 4176.00	10.87	11.16	11.30	11.45	11.61	11.73
5849	SS630	STABLE SWAMP CREEK 4278.00	10.46	10.76	10.90	11.05	11.19	11.29
5849	SS620	STABLE SWAMP CREEK 4278.00	10.46	10.76	10.90	11.05	11.19	11.29
5749	SS610	STABLE SWAMP CREEK 4414.00	9.88	10.19	10.33	10.49	10.65	10.77
5641	SS600	STABLE SWAMP CREEK 4521.00	9.40	9.74	9.91	10.09	10.28	10.44
5567	SS590	STABLE SWAMP CREEK 4594.00	8.68	9.20	9.44	9.67	9.93	10.17

FOR INFORMATION ONLY - NOT COUNCIL POLICY

AMTD (m)	BCC Cross Section	MIKE 11 Cross Section	Peak Flood Level (m AHD)					
			Q2	Q5	Q10	Q20	Q50	Q100
5534	SS589	STABLE SWAMP CREEK 4627.00	8.50	9.08	9.34	9.59	9.86	10.12
5526	SS570	STABLE SWAMP CREEK 4635.00	8.54	9.13	9.39	9.64	9.91	10.16
5516	SS560	STABLE SWAMP CREEK 4645.00	8.41	8.95	9.18	9.43	9.74	10.05
5502	SS550	STABLE SWAMP CREEK 4656.00	8.35	8.88	9.11	9.36	9.69	10.01
5497	SS540	STABLE SWAMP CREEK 4662.00	8.41	8.93	9.17	9.41	9.73	10.04
5388	SS638	STABLE SWAMP CREEK 4774.00	8.38	8.91	9.14	9.39	9.71	10.01
5278	SS501	STABLE SWAMP CREEK 4882.00	8.10	8.69	8.94	9.21	9.58	9.92
5158	SS521	STABLE SWAMP CREEK 5002.00	7.90	8.55	8.82	9.10	9.50	9.86
5158	SS521	STABLE SWAMP CREEK 5002.00	7.90	8.55	8.82	9.10	9.50	9.86
5115	SS520	STABLE SWAMP CREEK 5045.00	7.94	8.60	8.86	9.15	9.56	9.92
5085	SS510	STABLE SWAMP CREEK 5074.00	7.86	8.18	8.35	8.52	8.74	9.13
5054	SS500	STABLE SWAMP CREEK 5105.00	7.53	7.88	8.07	8.30	8.64	9.02
5001	Copy of SS490	STABLE SWAMP CREEK 5158.00	7.43	7.78	7.97	8.22	8.56	8.96
4985	Copy of SS490	STABLE SWAMP CREEK 5158.00	7.43	7.78	7.97	8.22	8.56	8.96
4984	SS490	STABLE SWAMP CREEK 5159.00	7.42	7.78	7.97	8.22	8.56	8.96
4867	SS480	STABLE SWAMP CREEK 5292.00	7.13	7.49	7.69	7.94	8.28	8.70
4778	SS470	STABLE SWAMP CREEK 5380.00	6.92	7.30	7.50	7.74	8.09	8.52
4756	Copy of SS470	STABLE SWAMP CREEK 5402.00	6.88	7.26	7.46	7.70	8.04	8.48
4744	Copy of SS450	STABLE SWAMP CREEK 5414.00	6.83	7.18	7.37	7.60	7.92	8.24
4738	SS450	STABLE SWAMP CREEK 5420.00	6.82	7.17	7.36	7.59	7.92	8.24
4673	SS430	STABLE SWAMP CREEK 5486.00	6.73	7.07	7.25	7.48	7.80	8.11
4619	SS420	STABLE SWAMP CREEK 5538.00	6.64	6.98	7.16	7.39	7.70	8.02
4588	SS419	STABLE SWAMP CREEK 5570.00	6.57	6.91	7.10	7.32	7.63	7.95
4474	SS400	STABLE SWAMP CREEK 5683.00	6.38	6.72	6.90	7.12	7.43	7.75
4306	SS380	STABLE SWAMP CREEK 5849.00	6.12	6.43	6.60	6.80	7.08	7.39
4306	Copy of SS380	STABLE SWAMP CREEK 5849.00	6.12	6.43	6.60	6.80	7.08	7.39
4293	Copy of SS360	STABLE SWAMP CREEK 5862.00	6.12	6.43	6.59	6.78	7.07	7.37
4257	SS360	STABLE SWAMP CREEK 5898.00	6.08	6.37	6.52	6.69	6.96	7.24
4251	SS350	STABLE SWAMP CREEK 5905.00	6.07	6.36	6.51	6.68	6.95	7.23
4161	SS490	STABLE SWAMP CREEK 5995.00	6.02	6.30	6.45	6.61	6.87	7.15
4161	SS490	STABLE SWAMP CREEK 5995.00	6.02	6.30	6.45	6.61	6.87	7.15
4061	SS340	STABLE SWAMP CREEK 6095.00	5.88	6.14	6.28	6.43	6.70	6.99
4061	SS340	STABLE SWAMP CREEK 6095.00	5.88	6.14	6.28	6.43	6.70	6.99
3983	SS340	STABLE SWAMP CREEK 6174.00	5.79	6.05	6.20	6.35	6.64	6.95
3964	SS310	STABLE SWAMP CREEK 6191.00	5.76	6.03	6.17	6.33	6.61	6.92
3964	SS310	STABLE SWAMP CREEK 6191.00	5.76	6.03	6.17	6.33	6.61	6.92
3891	SS300	STABLE SWAMP CREEK 6264.00	5.68	5.96	6.11	6.27	6.57	6.90
3829	SS291	STABLE SWAMP CREEK 6324.00	5.61	5.90	6.05	6.22	6.52	6.85
3829	SS291	STABLE SWAMP CREEK 6324.00	5.61	5.90	6.05	6.22	6.52	6.85
3751	SS290	STABLE SWAMP CREEK 6403.00	5.49	5.78	5.96	6.16	6.50	6.84
3738	Copy of SS290	STABLE SWAMP CREEK 6416.00	5.48	5.78	5.96	6.16	6.49	6.83
3710	Copy of SS270	STABLE SWAMP CREEK 6444.00	5.38	5.66	5.85	6.08	6.47	6.81
3702	SS270	STABLE SWAMP CREEK 6450.00	5.37	5.65	5.85	6.08	6.47	6.80
3682	Copy of SS270	STABLE SWAMP CREEK 6470.00	5.37	5.65	5.85	6.08	6.47	6.81
3682	Copy of SS270	STABLE SWAMP CREEK 6470.00	5.37	5.65	5.85	6.08	6.47	6.81
3648	Copy of SS263	STABLE SWAMP CREEK 6504.00	5.35	5.64	5.84	6.07	6.46	6.80
3612	SS263	STABLE SWAMP CREEK 6540.00	5.35	5.64	5.84	6.07	6.46	6.80
3612	SS263	STABLE SWAMP CREEK 6540.00	5.35	5.64	5.84	6.07	6.46	6.80
3594	SS263	STABLE SWAMP CREEK 6560.00	5.33	5.62	5.82	6.06	6.45	6.80
3579	Copy of SS263	STABLE SWAMP CREEK 6575.00	5.32	5.61	5.81	6.05	6.45	6.79
3575	Copy of SS261	STABLE SWAMP CREEK 6579.00	5.22	5.57	5.79	6.03	6.44	6.78
3566	SS261	STABLE SWAMP CREEK 6587.00	5.22	5.57	5.78	6.03	6.43	6.77
3548	SS260	STABLE SWAMP CREEK 6607.00	5.20	5.55	5.76	6.01	6.42	6.76
3316	SS250	STABLE SWAMP CREEK 6838.00	4.97	5.35	5.60	5.87	6.29	6.64
3175	SS240	STABLE SWAMP CREEK 6978.00	4.82	5.24	5.49	5.77	6.20	6.56
3166	SS235	STABLE SWAMP CREEK 6987.00	4.81	5.23	5.48	5.77	6.20	6.56
3162	Copy of SS235	STABLE SWAMP CREEK 6991.00	4.79	5.22	5.47	5.76	6.19	6.54
3123	SS233	STABLE SWAMP CREEK 7028.00	4.76	5.19	5.45	5.73	6.16	6.52
3113	SS232	STABLE SWAMP CREEK 7041.00	4.75	5.18	5.44	5.72	6.15	6.51
2949	SS231	STABLE SWAMP CREEK 7203.00	4.63	5.07	5.33	5.62	6.06	6.41
2680	SS230	STABLE SWAMP CREEK 7472.00	4.51	4.97	5.23	5.52	5.96	6.31
2559	SS220	STABLE SWAMP CREEK 7591.00	4.47	4.93	5.19	5.48	5.93	6.28
2417	SS210	STABLE SWAMP CREEK 7734.00	4.44	4.89	5.15	5.45	5.89	6.24
2361	SS200	STABLE SWAMP CREEK 7788.00	4.41	4.86	5.13	5.42	5.87	6.22
2333	SS190	STABLE SWAMP CREEK 7817.00	4.40	4.85	5.12	5.42	5.86	6.21
2266	SS170	STABLE SWAMP CREEK 7849.00	4.38	4.84	5.10	5.40	5.85	6.20
2217	SS160	STABLE SWAMP CREEK 7932.00	4.32	4.78	5.05	5.35	5.80	6.15
2168	SS150	STABLE SWAMP CREEK 7981.00	4.32	4.78	5.05	5.34	5.79	6.15
2168	SS150	STABLE SWAMP CREEK 7981.00	4.32	4.78	5.05	5.34	5.79	6.15
2037	Copy of SS130	STABLE SWAMP CREEK 8111.00	4.20	4.59	4.80	5.01	5.29	5.47
2036	SS130	STABLE SWAMP CREEK 8112.00	4.19	4.58	4.79	5.00	5.28	5.47
2036	SS130	STABLE SWAMP CREEK 8112.00	4.19	4.58	4.79	5.00	5.28	5.47
2015	SS120	STABLE SWAMP CREEK 8135.00	4.18	4.57	4.77	4.98	5.26	5.45
1933	SS110	STABLE SWAMP CREEK 8215.00	4.17	4.56	4.76	4.97	5.24	5.42
1824	SS100	STABLE SWAMP CREEK 8323.00	4.07	4.45	4.64	4.84	5.09	5.26
1697	Copy of SS100	STABLE SWAMP CREEK 8450.00	3.95	4.33	4.52	4.71	4.96	5.13
1617	Copy of SS90	STABLE SWAMP CREEK 8530.00	3.84	4.19	4.39	4.60	4.86	5.03
1553	SS90	STABLE SWAMP CREEK 8593.00	3.78	4.11	4.31	4.52	4.79	4.96
1435	SS80	STABLE SWAMP CREEK 8712.00	3.65	3.97	4.15	4.35	4.61	4.78
1257	SS70	STABLE SWAMP CREEK 8890.00	3.46	3.74	3.92	4.10	4.35	4.52
1011	SS61	STABLE SWAMP CREEK 9135.00	3.19	3.42	3.57	3.73	3.94	4.09
985	SS60	STABLE SWAMP CREEK 9162.00	3.17	3.40	3.55	3.71	3.92	4.05
785	SS50	STABLE SWAMP CREEK 9359.00	2.86	3.06	3.19	3.32	3.49	3.60
596	SS40	STABLE SWAMP CREEK 9548.00	2.58	2.77	2.89	3.01	3.16	3.26
403	SS30	STABLE SWAMP CREEK 9740.00	2.21	2.36	2.45	2.54	2.67	2.74
0	Copy of SS30	STABLE SWAMP CREEK 10100.00	1.20	1.20	1.20	1.20	1.20	1.20
-	2002 ALS	ARCHERFIELD OVERFLOW 06 0.00	5.37	5.65	5.85	6.08	6.47	6.81
-	2002 ALS	ARCHERFIELD OVERFLOW 06 22.36	5.35	5.64	5.84	6.07	6.46	6.80

FINAL

Table B2 Stable Swamp Creek Peak Design Event Discharge – Ultimate Development Scenario

MIKE 11 Low Locations	Peak Discharge (m^3/s)					
	Q2	Q5	Q10	Q20	Q50	Q100
ARCHERFIELD 1039.00	33	46	53	62	76	87
ARCHERFIELD 1088.00	33	45	53	62	75	87
ARCHERFIELD 1158.00	33	45	53	62	75	87
ARCHERFIELD 1230.00	33	45	53	62	75	87
ARCHERFIELD 1284.00	37	51	59	69	84	97
ARCHERFIELD 1330.00	37	51	59	69	83	97
ARCHERFIELD 1384.00	37	51	59	68	83	97
ARCHERFIELD 1464.00	37	50	58	68	83	96
ARCHERFIELD 1527.00	37	50	58	68	83	97
ARCHERFIELD 1572.00	37	50	59	68	83	97
ARCHERFIELD 1622.00	44	60	70	82	100	117
ARCHERFIELD 1670.00	48	65	75	88	108	126
ARCHERFIELD 1711.00	47	65	75	88	108	126
ARCHERFIELD 1741.00	51	69	81	95	116	136
ARCHERFIELD 1795.00	50	69	80	94	116	135
ARCHERFIELD 1895.00	49	67	79	93	115	134
ARCHERFIELD 1977.00	48	67	78	92	114	134
ARCHERFIELD 2018.00	50	69	81	95	119	139
ARCHERFIELD 2057.00	49	67	79	93	115	135
ARCHERFIELD 2105.00	48	65	77	90	111	129
ARCHERFIELD 2130.00	46	63	76	92	117	142
ARCHERFIELD 2141.00	45	63	76	91	116	141
ARCHERFIELD 2170.00	43	62	74	89	114	138
ARCHERFIELD 2207.00	42	60	73	87	111	134
ARCHERFIELD 2231.00	42	62	75	88	113	137
ARCHERFIELD 2244.50	46	79	100	124	167	198
ARCHERFIELD 2265.50	45	78	99	123	165	196
ARCHERFIELD 2291.00	45	78	99	124	166	196
ARCHERFIELD 2323.00	45	78	101	130	178	211
ARCHERFIELD 2364.00	43	76	99	128	175	209
ARCHERFIELD 2387.00	42	79	106	144	199	237
ARCHERFIELD 2397.00	42	79	106	144	198	237
ARCHERFIELD 2411.00	42	78	105	144	198	236
ARCHERFIELD 2427.00	41	78	105	143	197	236
ARCHERFIELD 2442.50	41	78	105	143	197	235
ARCHERFIELD 2456.00	41	77	105	143	197	235
ARCHERFIELD 2481.50	75	118	147	181	231	268
ARCHERFIELD OVERFLOW 01 50.00	0	0	0	0	1	7
ARCHERFIELD OVERFLOW 02 80.16	0	2	5	11	26	46
ARCHERFIELD OVERFLOW 03 21.21	10	28	42	59	81	95
ARCHERFIELD OVERFLOW 04 22.36	0	4	7	14	24	34
ARCHERFIELD OVERFLOW 05 14.14	0	7	12	20	28	31
BERYL ROBERTS BASIN 39.45	43	58	68	80	97	113
BERYL ROBERTS BASIN 119.96	41	55	64	74	87	106
BERYL ROBERTS BASIN 237.37	31	37	44	59	83	102
BERYL ROBERTS BASIN 350.00	18	18	19	19	19	20
BERYL ROBERTS BASIN 382.22	18	29	40	57	82	101
BERYL ROBERTS MAIN 63.00	22	31	36	43	53	62
BERYL ROBERTS MAIN 163.33	22	31	36	43	53	61
BERYL ROBERTS MAIN 233.14	22	31	36	42	53	61
BERYL ROBERTS MAIN 307.70	22	31	36	42	53	61
BERYL ROBERTS MAIN 369.00	22	30	36	42	52	61
BERYL ROBERTS SPILLWAY 12.00	0	10	21	38	63	82

DRAFT

MIKE 11 Low Locations	Peak Discharge (m^3/s)					
	Q2	Q5	Q10	Q20	Q50	Q100
BERYL ROBERTS TRIB 19.95	26	36	42	49	61	70
BERYL ROBERTS TRIB 63.08	26	36	42	49	61	70
BERYL ROBERTS TRIB 125.74	26	36	42	49	61	70
BERYL ROBERTS TRIB 199.87	26	36	42	49	60	70
BERYL ROBERTS TRIB 247.20	26	35	41	49	60	70
BRIDGE - IPSWICH MOTORWAY 8016.00	0	0	0	0	0	17
BRIDGE - IPSWICH MOTORWAY 8066.00	0	0	0	0	0	0
NORTH BRANCH 36.00	18	29	40	57	82	101
NORTH BRANCH 76.00	18	29	40	57	82	101
NORTH BRANCH 112.00	18	29	40	57	82	101
NORTH BRANCH 147.00	18	29	43	56	82	101
NORTH BRANCH 154.00	18	29	41	56	82	101
NORTH BRANCH 221.00	18	29	40	56	82	101
NORTH BRANCH 294.00	18	29	40	57	83	103
NORTH BRANCH 308.00	18	29	40	57	83	103
NORTH BRANCH 347.00	18	29	40	57	83	103
NORTH BRANCH 392.00	18	29	40	56	83	103
NORTH BRANCH 423.00	18	29	40	55	83	103
NORTH BRANCH 458.00	21	30	40	56	84	105
NORTH BRANCH 484.00	21	30	40	56	84	105
NORTH BRANCH 547.00	21	30	40	56	84	105
NORTH BRANCH 655.00	21	30	40	56	84	105
NORTH BRANCH 764.00	21	30	40	55	83	104
NORTH BRANCH 834.00	21	30	40	55	83	104
NORTH BRANCH 908.59	23	30	41	56	84	105
NORTH BRANCH 1018.59	40	50	57	66	99	126
NORTH BRANCH 1125.00	40	50	57	66	98	125
NORTH BRANCH 1305.00	39	49	56	66	97	124
NORTH BRANCH 1507.00	45	56	63	72	102	130
NORTH BRANCH 1594.00	43	55	62	71	102	130
NORTH BRANCH 1652.00	43	54	61	70	102	129
NORTH BRANCH 1710.00	41	53	59	70	102	219
NORTH BRANCH 1760.00	41	52	59	71	103	129
NORTH BRANCH 1826.00	42	52	59	72	104	130
NORTH BRANCH 1862.00	43	52	58	73	104	130
NORTH BRANCH 1886.00	43	52	58	73	104	130
RAILWAY OVERFLOW 10061.32	0	0	0	0	0	0
RAILWAY OVERFLOW 10177.81	0	0	0	0	0	0
RAILWAY OVERFLOW 10262.30	1	1	1	5	14	24
RAILWAY OVERFLOW 10305.60	1	1	5	17	40	67
RAILWAY OVERFLOW 10400.13	1	1	5	17	40	67
RAILWAY OVERFLOW 10508.58	1	1	5	17	40	66
RAILWAY OVERFLOW 10558.97	1	1	5	17	40	65
RAILWAY OVERFLOW_DRAIN 9841.88	0	0	0	0	0	2
RAILWAY OVERFLOW_DRAIN 9929.68	0	0	0	0	0	0
RAILWAY OVERFLOW_DRAIN 9982.05	0	0	0	0	0	0
RAILWAY OVERFLOW_DRAIN 10017.30	0	0	0	0	0	0
RAILWAY OVERFLOW_DRAIN 10067.70	0	0	0	0	0	0
RAILWAY OVERFLOW_DRAIN 10110.18	0	0	1	4	14	24
RAILWAY OVERFLOW_DRAIN 10150.28	0	0	1	4	14	24
RAILWAY OVERFLOW_DRAIN 10196.01	0	0	1	4	14	24
RAILWAY OVERFLOW_DRAIN_WIER_1 23.14	0	0	0	0	0	2
RAILWAY OVERFLOW_DRAIN_WIER_2 20.00	0	0	1	5	14	24
RAILWAY OVERFLOW_WEIR 20.00	0	1	4	12	27	42
RIAWENA ROAD 10004.18	19	27	32	38	47	54
RIAWENA ROAD 10033.34	19	27	32	38	47	54
RIAWENA ROAD 10073.27	19	27	32	38	47	54

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MIKE 11 Low Locations	Peak Discharge (m^3/s)					
	Q2	Q5	Q10	Q20	Q50	Q100
RIAWENA ROAD 10103.22	19	27	32	38	47	54
RIAWENA ROAD 10146.97	19	27	32	37	46	54
RIAWENA ROAD 10210.73	19	26	31	37	46	53
SHELLEYS CREEK 10005.00	7	10	12	14	17	20
SHELLEYS CREEK 10024.50	7	10	12	14	17	20
SHELLEYS CREEK 10043.00	7	10	12	14	17	20
SHELLEYS CREEK 10069.00	7	10	12	14	17	20
SHELLEYS CREEK 10139.00	18	24	29	33	41	48
SHELLEYS CREEK 10193.50	18	24	28	33	41	48
SHELLEYS CREEK 10214.50	18	24	28	33	41	48
SHELLEYS CREEK 10256.00	18	24	28	33	41	47
SHELLEYS CREEK 10299.50	17	24	28	33	40	47
SHELLEYS CREEK 10342.50	17	24	28	33	40	47
SHELLEYS CREEK 10372.50	17	24	28	32	40	47
SHELLEYS CREEK 10381.00	17	24	28	32	40	47
SHELLEYS CREEK 10392.00	19	27	31	37	45	53
SHELLEYS CREEK 10463.00	25	35	41	48	60	70
SHELLEYS CREEK 10517.00	25	35	41	48	60	69
SHELLEYS CREEK 10575.00	24	35	41	48	59	69
SHELLEYS CREEK 10679.50	26	37	44	52	64	74
SHELLEYS CREEK 10775.00	26	37	44	51	64	74
SHELLEYS CREEK 10843.50	28	40	48	56	70	81
SHELLEYS CREEK 10907.00	27	40	47	56	70	81
SHELLEYS CREEK 10955.00	31	45	54	64	79	93
SHELLEYS CREEK 10964.00	31	45	54	64	79	93
SHELLEYS CREEK 10967.00	31	45	54	64	79	93
SHELLEYS CREEK 11002.50	31	45	54	64	79	93
SHELLEYS CREEK 11085.00	31	45	54	64	79	92
SHELLEYS CREEK 11178.50	31	45	53	63	79	92
SHELLEYS CREEK 11268.50	33	48	58	69	85	100
SHELLEYS CREEK 11372.00	33	48	57	68	85	99
SHELLEYS CREEK 11436.50	32	48	57	68	85	99
SHELLEYS CREEK 11448.00	33	50	60	71	89	104
SHELLEYS CREEK 11466.00	33	50	60	71	89	104
SHELLEYS CREEK 11477.50	33	50	60	71	89	104
SHELLEYS CREEK 11502.50	33	50	60	71	89	104
SHELLEYS CREEK 11579.00	35	52	63	75	94	110
SHELLEYS CREEK 11673.50	35	52	63	76	95	111
SHELLEYS CREEK 11737.50	35	52	63	76	95	111
SHELLEYS CREEK 11805.00	35	52	63	76	95	111
SHELLEYS CREEK 11846.00	35	52	64	77	96	112
SHELLEYS CREEK 11855.00	35	52	64	77	96	112
SHELLEYS CREEK 11864.00	35	52	64	77	96	112
SHELLEYS CREEK 11865.50	35	52	64	77	96	112
SHELLEYS CREEK 11866.50	35	52	64	77	96	112
SHELLEYS CREEK 11868.00	35	52	64	77	96	112
SHELLEYS CREEK 11898.50	35	52	64	77	96	112
SHELLEYS CREEK 11984.50	35	52	64	77	96	112
SHELLEYS CREEK 12045.00	36	55	66	80	101	118
SHELLEYS CREEK 12117.00	36	55	66	80	101	118
STABLE SWAMP CREEK 798.00	36	54	66	80	101	118
STABLE SWAMP CREEK 909.50	36	54	66	80	100	118
STABLE SWAMP CREEK 1009.50	38	57	70	85	107	126
STABLE SWAMP CREEK 1129.00	41	63	77	92	118	139
STABLE SWAMP CREEK 1235.50	41	62	76	92	117	139
STABLE SWAMP CREEK 1351.00	42	64	79	95	122	144
STABLE SWAMP CREEK 1437.00	42	64	78	95	128	143

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MIKE 11 Low Locations	Peak Discharge (m^3/s)					
	Q2	Q5	Q10	Q20	Q50	Q100
STABLE SWAMP CREEK 1444.00	42	64	78	95	126	143
STABLE SWAMP CREEK 1480.50	42	64	78	95	124	143
STABLE SWAMP CREEK 1545.50	42	64	78	95	122	143
STABLE SWAMP CREEK 1585.00	43	66	81	98	126	149
STABLE SWAMP CREEK 1605.50	43	66	81	98	126	149
STABLE SWAMP CREEK 1621.50	43	66	81	98	126	149
STABLE SWAMP CREEK 1633.00	43	66	81	98	126	149
STABLE SWAMP CREEK 1653.00	43	66	81	98	126	149
STABLE SWAMP CREEK 1693.00	43	66	81	98	126	149
STABLE SWAMP CREEK 1738.00	43	66	81	98	126	149
STABLE SWAMP CREEK 1763.00	43	66	81	98	126	149
STABLE SWAMP CREEK 1775.50	46	69	85	103	134	157
STABLE SWAMP CREEK 1785.00	46	69	85	103	134	157
STABLE SWAMP CREEK 1806.50	46	69	85	103	134	157
STABLE SWAMP CREEK 1841.00	48	71	88	107	139	163
STABLE SWAMP CREEK 1904.50	48	71	88	107	139	163
STABLE SWAMP CREEK 1955.00	48	71	88	107	139	163
STABLE SWAMP CREEK 2001.00	48	71	88	107	139	163
STABLE SWAMP CREEK 2086.00	48	71	88	107	139	163
STABLE SWAMP CREEK 2186.00	52	75	93	113	147	173
STABLE SWAMP CREEK 2278.00	52	75	93	113	147	173
STABLE SWAMP CREEK 2366.50	52	75	93	113	147	173
STABLE SWAMP CREEK 2466.50	52	75	93	113	146	172
STABLE SWAMP CREEK 2595.00	52	75	92	112	146	172
STABLE SWAMP CREEK 2742.00	56	81	98	119	154	183
STABLE SWAMP CREEK 2876.00	56	81	98	118	154	182
STABLE SWAMP CREEK 2985.50	56	81	98	118	153	182
STABLE SWAMP CREEK 3046.00	56	81	98	118	153	182
STABLE SWAMP CREEK 3082.50	56	81	98	118	153	182
STABLE SWAMP CREEK 3150.50	56	80	98	118	153	182
STABLE SWAMP CREEK 3266.50	56	80	98	118	153	181
STABLE SWAMP CREEK 3335.50	56	80	98	118	153	181
STABLE SWAMP CREEK 3343.00	56	80	98	118	153	181
STABLE SWAMP CREEK 3366.00	56	80	98	118	153	181
STABLE SWAMP CREEK 3387.00	56	80	98	118	153	181
STABLE SWAMP CREEK 3394.50	56	80	98	118	153	181
STABLE SWAMP CREEK 3404.00	56	80	98	118	153	180
STABLE SWAMP CREEK 3463.50	56	80	98	118	152	180
STABLE SWAMP CREEK 3547.50	57	81	98	118	151	179
STABLE SWAMP CREEK 3582.50	57	81	98	118	150	178
STABLE SWAMP CREEK 3601.00	57	81	98	118	150	178
STABLE SWAMP CREEK 3620.50	57	81	98	118	151	179
STABLE SWAMP CREEK 3633.00	57	81	98	118	151	180
STABLE SWAMP CREEK 3638.00	115	157	183	213	254	299
STABLE SWAMP CREEK 3641.50	115	157	183	213	254	299
STABLE SWAMP CREEK 3651.50	115	157	183	213	253	298
STABLE SWAMP CREEK 3748.50	115	157	182	211	251	293
STABLE SWAMP CREEK 3879.50	120	162	183	215	258	298
STABLE SWAMP CREEK 3944.00	128	168	191	224	268	310
STABLE SWAMP CREEK 3983.00	128	168	190	224	268	310
STABLE SWAMP CREEK 4005.50	128	168	190	224	268	310
STABLE SWAMP CREEK 4073.50	128	167	190	224	268	308
STABLE SWAMP CREEK 4147.00	127	167	190	224	268	308
STABLE SWAMP CREEK 4164.50	127	167	190	224	268	308
STABLE SWAMP CREEK 4168.50	127	167	189	219	254	284
STABLE SWAMP CREEK 4173.50	127	167	189	219	254	284
STABLE SWAMP CREEK 4227.00	127	167	189	219	254	284

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MIKE 11 Low Locations	Peak Discharge (m^3/s)					
	Q2	Q5	Q10	Q20	Q50	Q100
STABLE SWAMP CREEK 4346.00	126	166	185	207	227	242
STABLE SWAMP CREEK 4467.50	126	166	185	207	227	241
STABLE SWAMP CREEK 4557.50	131	173	193	215	238	254
STABLE SWAMP CREEK 4610.50	131	172	192	215	237	254
STABLE SWAMP CREEK 4631.00	130	172	192	215	237	253
STABLE SWAMP CREEK 4640.00	130	172	192	215	237	253
STABLE SWAMP CREEK 4650.50	130	172	192	215	237	253
STABLE SWAMP CREEK 4659.00	130	172	192	215	237	253
STABLE SWAMP CREEK 4718.00	130	171	192	214	237	253
STABLE SWAMP CREEK 4828.00	130	171	192	214	236	253
STABLE SWAMP CREEK 4942.00	129	170	191	214	236	252
STABLE SWAMP CREEK 5023.50	172	221	248	279	326	370
STABLE SWAMP CREEK 5066.00	172	221	248	279	326	370
STABLE SWAMP CREEK 5077.00	172	221	248	279	326	370
STABLE SWAMP CREEK 5131.50	171	220	248	279	327	371
STABLE SWAMP CREEK 5158.50	172	221	252	295	361	431
STABLE SWAMP CREEK 5225.50	173	224	255	298	364	433
STABLE SWAMP CREEK 5336.00	173	223	255	298	364	433
STABLE SWAMP CREEK 5391.00	172	223	255	298	364	433
STABLE SWAMP CREEK 5408.00	172	223	255	298	364	433
STABLE SWAMP CREEK 5417.00	172	223	255	298	364	433
STABLE SWAMP CREEK 5453.00	172	223	255	298	364	433
STABLE SWAMP CREEK 5512.00	177	229	261	305	372	440
STABLE SWAMP CREEK 5554.00	177	229	261	305	372	440
STABLE SWAMP CREEK 5626.50	176	229	261	305	371	439
STABLE SWAMP CREEK 5766.00	177	230	262	307	373	441
STABLE SWAMP CREEK 5855.50	177	230	262	306	373	434
STABLE SWAMP CREEK 5880.00	176	230	262	306	373	433
STABLE SWAMP CREEK 5901.50	176	230	262	306	373	433
STABLE SWAMP CREEK 5950.00	176	230	262	306	372	433
STABLE SWAMP CREEK 6045.00	175	227	257	295	348	389
STABLE SWAMP CREEK 6134.50	165	199	215	236	268	295
STABLE SWAMP CREEK 6182.50	165	199	215	236	268	294
STABLE SWAMP CREEK 6227.50	165	195	208	222	246	265
STABLE SWAMP CREEK 6294.00	165	195	207	222	245	264
STABLE SWAMP CREEK 6363.50	165	189	197	205	222	238
STABLE SWAMP CREEK 6409.50	165	189	196	204	222	237
STABLE SWAMP CREEK 6430.00	165	189	196	203	226	242
STABLE SWAMP CREEK 6447.00	165	189	196	203	224	236
STABLE SWAMP CREEK 6460.00	164	189	196	203	225	236
STABLE SWAMP CREEK 6487.00	128	145	152	164	188	205
STABLE SWAMP CREEK 6522.00	128	145	152	163	187	204
STABLE SWAMP CREEK 6550.00	202	262	298	343	416	466
STABLE SWAMP CREEK 6567.50	202	262	298	342	415	465
STABLE SWAMP CREEK 6577.00	202	262	299	342	415	465
STABLE SWAMP CREEK 6583.00	202	262	297	342	415	465
STABLE SWAMP CREEK 6597.00	202	261	296	341	415	464
STABLE SWAMP CREEK 6722.50	199	258	291	337	405	458
STABLE SWAMP CREEK 6908.00	193	252	284	329	394	448
STABLE SWAMP CREEK 6982.50	191	249	281	326	390	445
STABLE SWAMP CREEK 6989.00	190	248	281	326	390	444
STABLE SWAMP CREEK 7009.50	190	247	280	325	388	443
STABLE SWAMP CREEK 7034.00	189	246	279	328	387	442
STABLE SWAMP CREEK 7122.00	186	242	275	320	382	437
STABLE SWAMP CREEK 7337.50	186	242	277	322	386	442
STABLE SWAMP CREEK 7531.50	179	231	267	311	374	433
STABLE SWAMP CREEK 7662.50	175	226	261	303	368	429

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MIKE 11 Low Locations	Peak Discharge (m^3/s)					
	Q2	Q5	Q10	Q20	Q50	Q100
STABLE SWAMP CREEK 7761.00	172	222	256	298	363	426
STABLE SWAMP CREEK 7803.00	182	220	255	296	362	425
STABLE SWAMP CREEK 7833.00	169	219	254	295	361	424
STABLE SWAMP CREEK 7890.50	165	215	251	292	359	422
STABLE SWAMP CREEK 7956.50	164	215	252	294	361	426
STABLE SWAMP CREEK 8047.00	158	210	246	289	356	405
STABLE SWAMP CREEK 8111.50	157	209	245	288	355	404
STABLE SWAMP CREEK 8123.50	157	207	244	287	354	403
STABLE SWAMP CREEK 8175.00	156	207	244	286	353	402
STABLE SWAMP CREEK 8269.00	155	206	243	286	352	402
STABLE SWAMP CREEK 8386.50	154	205	242	285	352	401
STABLE SWAMP CREEK 8490.00	153	204	241	284	351	400
STABLE SWAMP CREEK 8561.50	152	203	241	284	350	399
STABLE SWAMP CREEK 8652.50	152	203	240	283	350	399
STABLE SWAMP CREEK 8801.00	150	202	239	283	349	398
STABLE SWAMP CREEK 9012.50	149	200	238	282	348	397
STABLE SWAMP CREEK 9148.50	148	200	237	281	347	396
STABLE SWAMP CREEK 9260.50	147	199	236	280	347	396
STABLE SWAMP CREEK 9453.50	144	196	234	278	345	394
STABLE SWAMP CREEK 9644.00	150	207	247	293	365	417
STABLE SWAMP CREEK 9920.00	147	203	244	290	362	414
ARCHERFIELD OVERFLOW 06 11.18	36	43	44	40	40	51

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Table B3 Stable Swamp Creek Peak Design Event Water Levels – Existing Development Scenario

AMTD (m)	BCC Cross Section	MIKE 11 Cross Section	Peak Flood Level (m AHD)					
			Q2	Q5	Q10	Q20	Q50	Q100
1535	SS6280	ARCHERFIELD 1010.00	9.82	10.06	10.18	10.25	10.32	10.37
1469	SS6260	ARCHERFIELD 1068.00	9.71	9.94	10.06	10.12	10.16	10.18
1425	Interpolated	ARCHERFIELD 1108.00	9.57	9.79	9.90	9.97	10.02	10.05
1323	Interpolated	ARCHERFIELD 1208.00	9.21	9.40	9.50	9.59	9.70	9.74
1281	SS6250	ARCHERFIELD 1252.00	8.97	9.15	9.24	9.33	9.43	9.47
1219	SS6240	ARCHERFIELD 1316.00	8.50	8.67	8.76	8.85	8.96	9.05
1190	SS6230	ARCHERFIELD 1344.00	8.35	8.53	8.62	8.71	8.82	8.91
1111	Interpolated	ARCHERFIELD 1424.00	7.89	8.04	8.12	8.21	8.34	8.43
1030	SS6220	ARCHERFIELD 1504.00	7.45	7.62	7.71	7.81	7.94	8.03
984	SS6200	ARCHERFIELD 1550.00	7.33	7.50	7.59	7.69	7.82	7.90
944	SS6190	ARCHERFIELD 1594.00	7.22	7.40	7.49	7.58	7.71	7.78
884	SS6180	ARCHERFIELD 1650.00	6.98	7.16	7.25	7.34	7.45	7.49
845	Interpolated	ARCHERFIELD 1690.00	6.83	7.00	7.09	7.18	7.30	7.38
802	SS6170	ARCHERFIELD 1732.00	6.67	6.85	6.93	7.01	7.12	7.21
784	SS6160	ARCHERFIELD 1750.00	6.59	6.77	6.84	6.92	7.02	7.10
695	SS6150	ARCHERFIELD 1840.00	6.36	6.50	6.57	6.64	6.75	6.84
583	Interpolated	ARCHERFIELD 1950.00	6.26	6.37	6.43	6.49	6.57	6.64
529	SS6140	ARCHERFIELD 2004.00	6.25	6.35	6.40	6.45	6.53	6.59
529	SS6140	ARCHERFIELD 2004.00	6.25	6.35	6.40	6.45	6.53	6.59
504	SS6120	ARCHERFIELD 2032.00	5.66	5.82	5.90	5.99	6.14	6.26
453	Copy of SS6120	ARCHERFIELD 2082.00	5.52	5.70	5.80	5.91	6.08	6.22
407	Copy of SS6100	ARCHERFIELD 2128.00	5.40	5.57	5.69	5.82	6.03	6.22
407	Copy of SS6100	ARCHERFIELD 2128.00	5.40	5.57	5.69	5.82	6.03	6.22
403	SS6100	ARCHERFIELD 2132.00	5.39	5.57	5.69	5.82	6.03	6.22
385	Interpolated	ARCHERFIELD 2150.00	5.38	5.57	5.68	5.81	6.03	6.22
345	Interpolated	ARCHERFIELD 2190.00	5.36	5.56	5.67	5.80	6.03	6.22
311	SS6090	ARCHERFIELD 2224.00	5.35	5.56	5.67	5.79	6.03	6.22
297	SS6070	ARCHERFIELD 2238.00	5.32	5.55	5.66	5.78	6.02	6.21
297	SS6070	ARCHERFIELD 2238.00	5.32	5.55	5.66	5.78	6.02	6.21
283	Interpolated	ARCHERFIELD 2251.00	5.31	5.54	5.65	5.78	6.02	6.21
264	Interpolated	ARCHERFIELD 2280.00	5.28	5.51	5.61	5.75	6.00	6.20
244	Interpolated	ARCHERFIELD 2302.00	5.25	5.48	5.58	5.73	5.98	6.18
244	Interpolated	ARCHERFIELD 2302.00	5.25	5.48	5.58	5.73	5.98	6.18
202	-	ARCHERFIELD 2344.00	5.26	5.47	5.55	5.72	5.96	6.16
169	Copy of SS6030	ARCHERFIELD 2384.00	5.25	5.45	5.53	5.70	5.95	6.14
169	Copy of SS6030	ARCHERFIELD 2384.00	5.25	5.45	5.53	5.70	5.95	6.14
163	Copy of SS6030	ARCHERFIELD 2390.00	5.25	5.44	5.53	5.70	5.95	6.14
147	SS6030	ARCHERFIELD 2404.00	5.25	5.44	5.53	5.70	5.94	6.13
117	Copy of SS6010	ARCHERFIELD 2418.00	5.25	5.43	5.52	5.69	5.93	6.11
99	Interpolated	ARCHERFIELD 2436.00	5.26	5.45	5.54	5.70	5.94	6.12
86	Interpolated	ARCHERFIELD 2449.00	5.27	5.46	5.54	5.70	5.94	6.12
76	Copy of SS6000	ARCHERFIELD 2463.00	5.27	5.45	5.54	5.70	5.93	6.11
76	Copy of SS6000	ARCHERFIELD 2463.00	5.27	5.45	5.54	5.70	5.93	6.11
38	SS6000	ARCHERFIELD 2500.00	5.26	5.45	5.53	5.69	5.92	6.10
-	2002 ALS	ARCHERFIELD OVERFLOW 01 0.00	6.09	6.38	6.51	6.60	6.81	6.99
-	2002 ALS	ARCHERFIELD OVERFLOW 01 100.00	6.25	6.35	6.40	6.45	6.53	6.59
-	2002 ALS	ARCHERFIELD OVERFLOW 02 0.00	5.99	6.25	6.32	6.43	6.59	6.73
-	2002 ALS	ARCHERFIELD OVERFLOW 02 160.31	5.40	5.57	5.69	5.82	6.03	6.22
-	2002 ALS	ARCHERFIELD OVERFLOW 03 0.00	5.85	6.08	6.16	6.26	6.41	6.53
-	2002 ALS	ARCHERFIELD OVERFLOW 03 42.43	5.32	5.55	5.66	5.78	6.02	6.21
-	2002 ALS	ARCHERFIELD OVERFLOW 04 0.00	5.73	5.97	6.04	6.15	6.30	6.42
-	2002 ALS	ARCHERFIELD OVERFLOW 04 44.72	5.25	5.48	5.58	5.73	5.98	6.18
-	2002 ALS	ARCHERFIELD OVERFLOW 05 0.00	5.58	5.82	5.89	6.01	6.18	6.31
-	2002 ALS	ARCHERFIELD OVERFLOW 05 28.28	5.25	5.45	5.53	5.70	5.95	6.14
-	Copy of SS9310	BERYL ROBERTS BASIN 0.16	21.67	22.02	22.17	22.31	22.45	22.54
-	SS9310	BERYL ROBERTS BASIN 78.74	21.65	22.00	22.15	22.28	22.41	22.49
-	SS9300	BERYL ROBERTS BASIN 161.19	21.64	22.00	22.14	22.26	22.38	22.46
-	Copy of SS9300	BERYL ROBERTS BASIN 313.55	21.64	21.99	22.14	22.26	22.37	22.45
-	Copy of SS9300	BERYL ROBERTS BASIN 313.55	21.64	21.99	22.14	22.26	22.37	22.45
-	Copy of SS9250	BERYL ROBERTS BASIN 375.00	18.01	18.40	18.67	18.93	19.18	19.31
-	Copy of SS9250	BERYL ROBERTS BASIN 375.00	18.01	18.40	18.67	18.93	19.18	19.31
-	Copy of SS9350	BERYL ROBERTS BASIN 389.43	18.00	18.39	18.66	18.92	19.16	19.29
-	SS6350	BERYL ROBERTS MAIN 0.00	27.03	27.22	27.32	27.41	27.54	27.64
-	SS9340	BERYL ROBERTS MAIN 126.00	26.57	26.77	26.87	26.96	27.09	27.17
-	SS9330	BERYL ROBERTS MAIN 200.66	25.54	25.68	25.76	25.84	25.95	26.03
-	SS9320	BERYL ROBERTS MAIN 265.62	24.47	24.60	24.67	24.74	24.83	24.89
-	Copy of SS9320	BERYL ROBERTS MAIN 349.77	22.69	22.78	22.84	22.90	22.98	23.06
-	2006 Survey	BERYL ROBERTS MAIN 388.24	22.17	22.17	22.17	22.31	22.45	22.54
-	2006 Survey	BERYL ROBERTS SPILLWAY 0.00	21.64	21.99	22.14	22.26	22.37	22.45
-	Copy of SS10060	BERYL ROBERTS SPILLWAY 24.00	19.20	19.20	19.20	19.20	19.20	19.31
-	SS10060	BERYL ROBERTS TRIB 0.00	24.29	24.49	24.59	24.70	24.85	24.96
-	SS10050	BERYL ROBERTS TRIB 39.90	24.08	24.27	24.38	24.48	24.64	24.74
-	SS10040	BERYL ROBERTS TRIB 86.27	23.61	23.79	23.90	24.02	24.20	24.31
-	SS10040	BERYL ROBERTS TRIB 165.21	22.38	22.59	22.73	22.87	23.06	23.19
-	SS10030	BERYL ROBERTS TRIB 234.53	21.68	22.03	22.19	22.33	22.47	22.57
-	Copy of SS10030	BERYL ROBERTS TRIB 259.87	21.67	22.02	22.17	22.31	22.45	22.54
2168	Copy of SS140	BRIDGE - IPSWICH MOTORWAY 7981.00	4.23	4.64	4.86	5.07	5.39	5.63
2107	Copy of SS130	BRIDGE - IPSWICH MOTORWAY 8041.00	1.20	1.20	1.20	1.20	1.20	1.20
2036	Copy of SS130	BRIDGE - IPSWICH MOTORWAY 8112.00	4.11	4.46	4.63	4.80	5.02	5.17
13934	SS9250	NORTH BRANCH 0.00	18.00	18.39	18.66	18.92	19.16	19.29
13881	SS9240	NORTH BRANCH 72.00	17.94	18.32	18.58	18.84	19.06	19.17
13875	SS9220	NORTH BRANCH 80.00	17.19	17.60	17.92	18.26	18.64	18.84
13810	SS9210	NORTH BRANCH 144.00	16.38	16.81	17.28	17.73	18.21	18.43
13804	SS9190	NORTH BRANCH 150.00	16.19	16.64	16.99	17.39	17.87	18.20
13796	SS9180	NORTH BRANCH 158.00	16.14	16.59	16.95	17.34	17.83	18.17
13671	SS9170	NORTH BRANCH 284.00	15.74	16.19	16.54	16.92	17.45	17.83

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AMTD (m)	BCC Cross Section	MIKE 11 Cross Section	Peak Flood Level (m AHD)					
			Q2	Q5	Q10	Q20	Q50	Q100
13649	SS9163	NORTH BRANCH 304.00	15.73	16.18	16.53	16.91	17.43	17.82
13643	SS9161	NORTH BRANCH 312.00	14.67	15.22	15.76	16.08	16.57	16.81
13571	SS9160	NORTH BRANCH 382.00	14.17	14.77	15.46	15.81	16.32	16.55
13552	SS9140	NORTH BRANCH 402.00	14.06	14.45	15.07	15.80	16.32	16.55
13509	SS9130	NORTH BRANCH 444.00	14.01	14.38	15.02	15.76	16.28	16.50
13479	SS9120	NORTH BRANCH 472.00	13.93	14.32	14.98	15.74	16.27	16.50
13460	SS9100	NORTH BRANCH 494.00	13.68	13.98	14.29	14.61	15.14	15.49
13350	SS9090	NORTH BRANCH 600.00	12.83	13.09	13.37	13.64	14.13	14.48
13248	SS9080	NORTH BRANCH 710.00	12.34	12.58	12.88	13.16	13.67	14.03
13141	SS9075	NORTH BRANCH 818.00	11.95	12.13	12.43	12.73	13.24	13.61
13108	SS9074	NORTH BRANCH 850.00	11.86	12.06	12.31	12.61	13.13	13.49
13005	Copy of SS9074	NORTH BRANCH 967.19	11.29	11.54	11.69	11.86	12.32	12.70
13005	Copy of SS9074	NORTH BRANCH 967.19	11.29	11.54	11.69	11.86	12.32	12.70
12888	SS9070	NORTH BRANCH 1070.00	10.54	10.80	10.96	11.13	11.66	12.06
12778	SS9060	NORTH BRANCH 1180.00	9.80	10.12	10.30	10.53	11.08	11.51
12529	SS9050	NORTH BRANCH 1430.00	8.86	9.17	9.35	9.69	10.22	10.60
12366	SS9044	NORTH BRANCH 1584.00	8.31	8.67	8.99	9.37	9.93	10.31
12354	SS9040	NORTH BRANCH 1604.00	8.26	8.61	8.95	9.28	9.73	10.06
12254	SS9030	NORTH BRANCH 1700.00	8.09	8.48	8.89	9.20	9.63	9.95
12229	SS9010	NORTH BRANCH 1720.00	8.08	8.47	8.88	9.19	9.61	9.93
12147	SS9004	NORTH BRANCH 1800.00	8.09	8.48	8.89	9.21	9.63	9.94
12095	SS9003	NORTH BRANCH 1852.00	8.09	8.49	8.90	9.21	9.63	9.94
12070	SS9001	NORTH BRANCH 1872.00	7.98	8.45	8.88	9.19	9.60	9.91
12045	Copy of SS521	NORTH BRANCH 1900.00	7.99	8.45	8.87	9.18	9.59	9.91
-	2002 ALS	RAILWAY OVERFLOW 10000.00	10.95	10.95	10.95	10.95	10.95	10.95
-	2002 ALS	RAILWAY OVERFLOW 10122.64	10.43	10.43	10.43	10.43	10.43	10.43
-	2002 ALS	RAILWAY OVERFLOW 10232.98	9.81	9.81	9.82	9.86	9.94	9.98
-	2002 ALS	RAILWAY OVERFLOW 10232.98	9.81	9.81	9.82	9.86	9.94	9.98
-	2002 ALS	RAILWAY OVERFLOW 10291.62	9.29	9.29	9.35	9.42	9.53	9.60
-	2002 ALS	RAILWAY OVERFLOW 10291.62	9.29	9.29	9.35	9.42	9.53	9.60
-	2002 ALS	RAILWAY OVERFLOW 10319.58	9.04	9.06	9.12	9.22	9.34	9.42
-	2002 ALS	RAILWAY OVERFLOW 10480.69	8.48	8.51	8.55	8.61	8.69	8.74
-	2002 ALS	RAILWAY OVERFLOW 10536.48	7.89	7.93	8.01	8.12	8.28	8.39
-	2002 ALS	RAILWAY OVERFLOW 10581.46	7.85	7.85	7.85	7.93	8.12	8.27
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 9813.25	11.85	11.85	11.85	11.85	11.85	11.95
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 9870.52	11.59	11.59	11.59	11.59	11.59	11.68
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 9964.10	11.82	11.82	11.82	11.82	11.82	11.82
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10000.00	11.14	11.14	11.14	11.14	11.14	11.14
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10034.60	10.82	10.82	10.82	10.89	11.04	11.13
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10100.81	10.69	10.69	10.74	10.89	11.04	11.13
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10100.81	10.69	10.69	10.74	10.89	11.04	11.13
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10119.55	10.66	10.66	10.68	10.85	11.00	11.09
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10181.01	10.47	10.47	10.49	10.58	10.67	10.73
-	2002 ALS	RAILWAY OVERFLOW_DRAIN 10211.02	10.47	10.47	10.47	10.47	10.47	10.47
-	2002 ALS	RAILWAY OVERFLOW_DRAIN_WIER_1 0.00	11.43	11.67	11.80	11.93	12.11	12.22
-	2002 ALS	RAILWAY OVERFLOW_DRAIN_WIER_1 46.28	11.83	11.83	11.83	11.83	11.85	11.95
-	2002 ALS	RAILWAY OVERFLOW_DRAIN_WIER_2 0.00	10.92	11.13	11.25	11.35	11.49	11.57
-	2002 ALS	RAILWAY OVERFLOW_DRAIN_WIER_2 40.00	10.69	10.69	10.74	10.89	11.04	11.13
-	2002 ALS	RAILWAY OVERFLOW_WEIR 0.00	10.45	10.68	10.82	10.93	11.06	11.13
-	2002 ALS	RAILWAY OVERFLOW_WEIR 40.00	9.29	9.29	9.35	9.42	9.53	9.60
-	2002 ALS	RIAWENA ROAD 10000.00	14.12	14.26	14.35	14.43	14.55	14.63
-	2002 ALS	RIAWENA ROAD 10008.37	14.05	14.19	14.27	14.35	14.47	14.55
-	2002 ALS	RIAWENA ROAD 10058.31	13.52	13.65	13.72	13.80	13.90	13.98
-	2002 ALS	RIAWENA ROAD 10088.23	13.31	13.43	13.50	13.57	13.67	13.75
-	2002 ALS	RIAWENA ROAD 10118.20	12.78	12.89	12.95	13.02	13.12	13.20
-	2002 ALS	RIAWENA ROAD 10175.73	11.74	11.93	12.05	12.18	12.37	12.70
-	2002 ALS	RIAWENA ROAD 10245.72	11.29	11.54	11.69	11.86	12.32	12.70
9530	SS1330	SHELLEYS CREEK 10000.00	65.12	65.18	65.22	65.26	65.32	65.36
9626	Copy of S1330	SHELLEYS CREEK 10010.00	64.93	65.01	65.05	65.10	65.16	65.20
9655	SS1328	SHELLEYS CREEK 10039.00	64.88	64.93	64.97	65.00	65.05	65.10
9769	SS1324	SHELLEYS CREEK 10047.00	63.67	63.79	63.86	63.94	64.04	64.13
9833	SS1320	SHELLEYS CREEK 10091.00	63.10	63.26	63.35	63.44	63.56	63.67
9834	SS1310	SHELLEYS CREEK 10187.00	61.54	61.71	61.81	61.91	62.06	62.18
9837	SS1309	SHELLEYS CREEK 10200.00	61.37	61.54	61.64	61.75	61.90	62.02
9838	SS1308	SHELLEYS CREEK 10229.00	60.96	61.13	61.23	61.34	61.51	61.64
9839	SS1300	SHELLEYS CREEK 10283.00	60.20	60.40	60.51	60.65	60.85	61.02
9841	SS1299	SHELLEYS CREEK 10316.00	59.91	60.12	60.25	60.41	60.64	60.82
9849	SS1298	SHELLEYS CREEK 10369.00	59.44	59.74	59.92	60.13	60.41	60.62
9932	SS1297	SHELLEYS CREEK 10376.00	59.43	59.73	59.92	60.13	60.41	60.62
10003	SS1290	SHELLEYS CREEK 10386.00	59.41	59.72	59.90	60.11	60.39	60.60
10121	SS1270	SHELLEYS CREEK 10412.00	59.38	59.64	59.78	59.93	60.14	60.30
10180	SS1260	SHELLEYS CREEK 10514.00	58.96	59.08	59.14	59.21	59.30	59.38
10215	Copy of SS1260	SHELLEYS CREEK 10520.00	56.11	56.26	56.35	56.44	56.57	56.68
10230	SS1250	SHELLEYS CREEK 10630.00	55.04	55.24	55.35	55.46	55.61	55.73
10238	SS1240	SHELLEYS CREEK 10729.00	53.74	53.93	54.02	54.13	54.27	54.39
10257	SS1230	SHELLEYS CREEK 10821.00	52.35	52.61	52.73	52.85	53.01	53.14
10270	SS1220	SHELLEYS CREEK 10866.00	51.94	52.20	52.33	52.47	52.66	52.81
10386	SS1210	SHELLEYS CREEK 10948.00	51.35	51.62	51.75	51.89	52.09	52.24
10477	Copy of SS1204	SHELLEYS CREEK 10962.00	51.11	51.37	51.51	51.67	51.90	52.08
10566	SS1204	SHELLEYS CREEK 10965.00	51.00	51.30	51.46	51.62	51.86	52.03
10664	SS1203	SHELLEYS CREEK 10969.00	50.96	51.25	51.41	51.57	51.81	51.98
10731	SS1200	SHELLEYS CREEK 11036.00	50.19	50.48	50.64	50.80	51.03	51.22
10735	SS1190	SHELLEYS CREEK 11134.00	49.12	49.38	49.52	49.68	49.90	50.08
10738	SS1180	SHELLEYS CREEK 11223.00	48.50	48.80	48.96	49.14	49.38	49.57
10752	SS1170	SHELLEYS CREEK 11314.00	47.60	47.97	48.15	48.34	48.59	48.77
10834	Copy of SS1160	SHELLEYS CREEK 11430.00	46.91	47.33	47.52	47.70	47.93	48.09
10879	SS1160	SHELLEYS CREEK 11443.00	46.89	47.30	47.49	47.67	47.89	48.06
10971	SS1140	SHELLEYS CREEK 11462.00	46.75	47.12	47.29	47.45	47.65	47.80
11070	Copy of SS1140	SHELLEYS CREEK 11470.00	46.74	47.11	47.28	47.44	47.64	47.78

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AMTD (m)	BCC Cross Section	MIKE 11 Cross Section	Peak Flood Level (m AHD)					
			Q2	Q5	Q10	Q20	Q50	Q100
11180	Copy of SS1140	SHELLEYS CREEK 11485.00	46.65	47.01	47.18	47.34	47.53	47.66
11186	SS1130	SHELLEYS CREEK 11520.00	46.35	46.60	46.73	46.87	47.04	47.18
11288	SS1120	SHELLEYS CREEK 11638.00	45.03	45.33	45.49	45.65	45.87	46.03
11314	SS1110	SHELLEYS CREEK 11709.00	44.31	44.60	44.75	44.90	45.11	45.26
11324	Copy of SS1110	SHELLEYS CREEK 11766.00	43.88	44.16	44.31	44.47	44.68	44.84
11331	SS1105	SHELLEYS CREEK 11844.00	43.15	43.35	43.47	43.61	43.82	43.98
11384	Copy of SS1100	SHELLEYS CREEK 11848.00	43.15	43.35	43.47	43.61	43.82	43.98
11417	SS1100	SHELLEYS CREEK 11862.00	43.14	43.34	43.46	43.60	43.81	43.97
11471	Copy of SS1080	SHELLEYS CREEK 11865.00	43.13	43.29	43.39	43.50	43.65	43.78
11500	Copy of SS1080	SHELLEYS CREEK 11866.00	43.12	43.28	43.38	43.49	43.65	43.78
11513	SS1078	SHELLEYS CREEK 11867.00	43.12	43.28	43.38	43.49	43.65	43.78
11609	SS1080	SHELLEYS CREEK 11869.00	41.24	41.64	41.88	42.19	42.56	42.77
11653	SS1070	SHELLEYS CREEK 11928.00	41.06	41.45	41.68	41.99	42.37	42.58
11661	SS1060	SHELLEYS CREEK 12041.00	40.62	41.02	41.25	41.64	42.07	42.26
11690	SS1040	SHELLEYS CREEK 12069.00	40.11	40.42	40.58	40.74	40.96	41.13
11700	SS1030	SHELLEYS CREEK 12165.00	39.42	39.72	39.85	39.98	40.15	40.28
9443	SS1020	STABLE SWAMP CREEK 737.00	39.42	39.72	39.85	39.98	40.15	40.28
9319	SS1010	STABLE SWAMP CREEK 859.00	38.91	39.13	39.24	39.34	39.47	39.57
9216	SS1000	STABLE SWAMP CREEK 960.00	38.32	38.57	38.67	38.75	38.87	38.96
9115	SS990	STABLE SWAMP CREEK 1059.00	37.40	37.68	37.79	37.89	38.01	38.10
8975	SS980	STABLE SWAMP CREEK 1199.00	35.90	36.04	36.11	36.17	36.25	36.31
8902	SS970	STABLE SWAMP CREEK 1272.00	34.61	34.73	34.79	34.86	34.94	35.01
8742	SS965	STABLE SWAMP CREEK 1430.00	33.19	33.47	33.59	33.70	33.85	33.93
8728	SS960	STABLE SWAMP CREEK 1441.00	31.86	32.30	32.54	32.77	33.01	33.11
8725	SS938	STABLE SWAMP CREEK 1447.00	31.79	32.24	32.48	32.70	32.95	33.05
8658	Section 1	STABLE SWAMP CREEK 1514.00	30.31	30.80	31.07	31.30	31.57	31.72
8595	SS930	STABLE SWAMP CREEK 1577.00	30.11	30.59	30.87	31.11	31.39	31.54
8580	SS928	STABLE SWAMP CREEK 1593.00	30.00	30.50	30.79	31.04	31.33	31.48
8554	SS922	STABLE SWAMP CREEK 1618.00	29.49	30.20	30.57	30.85	31.17	31.32
8550	SS920	STABLE SWAMP CREEK 1625.00	29.45	30.18	30.55	30.84	31.16	31.31
8535	SS900	STABLE SWAMP CREEK 1641.00	27.91	28.32	28.57	28.80	29.15	29.38
8511	Section 2	STABLE SWAMP CREEK 1665.00	27.78	28.20	28.43	28.67	29.00	29.23
8455	Section 3	STABLE SWAMP CREEK 1721.00	27.40	27.75	27.97	28.19	28.50	28.73
8421	Section 19	STABLE SWAMP CREEK 1755.00	26.52	26.89	27.15	27.39	27.74	27.97
8405	Section 17	STABLE SWAMP CREEK 1771.00	26.06	26.48	26.75	27.04	27.44	27.70
8396	Section 16	STABLE SWAMP CREEK 1780.00	25.84	26.29	26.56	26.86	27.28	27.55
8386	Section 15	STABLE SWAMP CREEK 1790.00	25.80	26.25	26.52	26.82	27.23	27.50
8353	Section 12	STABLE SWAMP CREEK 1823.00	25.64	26.09	26.37	26.68	27.10	27.37
8317	Section 9	STABLE SWAMP CREEK 1859.00	25.58	26.02	26.29	26.61	27.03	27.30
8221	Section 2	STABLE SWAMP CREEK 1950.00	25.29	25.71	25.98	26.33	26.77	27.06
8209	SS860	STABLE SWAMP CREEK 1962.00	24.49	24.82	25.03	25.25	25.56	25.75
8132	SS850	STABLE SWAMP CREEK 2040.00	23.26	23.63	23.87	24.11	24.46	24.68
8040	SS840	STABLE SWAMP CREEK 2132.00	22.49	22.87	23.10	23.33	23.66	23.87
7931	SS830	STABLE SWAMP CREEK 2240.00	22.25	22.60	22.81	23.03	23.32	23.51
7854	SS820	STABLE SWAMP CREEK 2316.00	21.72	22.07	22.28	22.47	22.75	22.91
7753	SS810	STABLE SWAMP CREEK 2417.00	21.17	21.60	21.83	22.03	22.29	22.45
7654	SS800	STABLE SWAMP CREEK 2516.00	21.02	21.45	21.67	21.86	22.10	22.25
7496	SS790	STABLE SWAMP CREEK 2674.00	20.04	20.44	20.64	20.82	21.06	21.21
7360	SS780	STABLE SWAMP CREEK 2810.00	19.30	19.68	19.88	20.05	20.28	20.44
7226	SS770	STABLE SWAMP CREEK 2942.00	17.95	18.30	18.53	18.71	19.05	19.26
7139	SS760	STABLE SWAMP CREEK 3029.00	17.27	17.61	17.92	18.09	18.63	18.89
7105	SS740	STABLE SWAMP CREEK 3063.00	17.20	17.52	17.74	17.89	18.13	18.31
7066	Copy of SS740	STABLE SWAMP CREEK 3102.00	17.09	17.40	17.60	17.75	17.98	18.15
6968	SS730	STABLE SWAMP CREEK 3199.00	16.47	16.74	16.92	17.06	17.26	17.41
6832	SS720	STABLE SWAMP CREEK 3334.00	15.26	15.46	15.59	15.70	15.86	15.99
6829	Copy of SS720	STABLE SWAMP CREEK 3337.00	15.11	15.31	15.45	15.57	15.75	15.89
6817	SS710	STABLE SWAMP CREEK 3350.00	14.97	15.17	15.31	15.43	15.61	15.76
6785	Copy of SS710	STABLE SWAMP CREEK 3382.00	14.47	14.82	15.02	15.20	15.43	15.61
6775	Copy of SS710	STABLE SWAMP CREEK 3392.00	14.45	14.80	15.01	15.19	15.41	15.59
6770	Copy of SS710	STABLE SWAMP CREEK 3397.00	14.45	14.80	15.00	15.18	15.41	15.58
6756	Copy of SS710	STABLE SWAMP CREEK 3411.00	14.42	14.77	14.98	15.15	15.38	15.56
6650	SS700	STABLE SWAMP CREEK 3516.00	13.85	14.19	14.41	14.62	14.90	15.12
6587	Copy of SS690	STABLE SWAMP CREEK 3579.00	13.55	13.89	14.12	14.37	14.70	14.97
6580	Copy of SS690	STABLE SWAMP CREEK 3586.00	13.54	13.87	14.11	14.36	14.70	14.97
6554	Copy of SS690	STABLE SWAMP CREEK 3612.00	13.08	13.48	13.70	13.91	14.18	14.35
6537	Copy of SS690	STABLE SWAMP CREEK 3629.00	13.09	13.48	13.70	13.91	14.18	14.35
6527	Copy of SS690	STABLE SWAMP CREEK 3637.00	13.08	13.47	13.70	13.91	14.18	14.34
6525	Copy of SS690	STABLE SWAMP CREEK 3639.00	13.08	13.47	13.70	13.90	14.17	14.34
6520	Copy of SS690	STABLE SWAMP CREEK 3644.00	13.07	13.46	13.68	13.89	14.16	14.33
6505	SS690	STABLE SWAMP CREEK 3659.00	13.02	13.41	13.64	13.84	14.11	14.28
6325	SS680	STABLE SWAMP CREEK 3838.00	11.85	12.37	12.66	12.91	13.22	13.40
6243	SS671	STABLE SWAMP CREEK 3921.00	11.68	12.24	12.55	12.80	13.12	13.31
6197	SS670	STABLE SWAMP CREEK 3967.00	11.61	12.21	12.53	12.79	13.11	13.31
6167	SS650	STABLE SWAMP CREEK 3995.00	11.48	11.72	11.86	12.00	12.18	12.30
6146	SS640	STABLE SWAMP CREEK 4016.00	11.43	11.67	11.80	11.93	12.11	12.22
6146	SS640	STABLE SWAMP CREEK 4016.00	11.43	11.67	11.80	11.93	12.11	12.22
6034	SS639	STABLE SWAMP CREEK 4131.00	11.01	11.21	11.33	11.44	11.58	11.67
6001	SS690	STABLE SWAMP CREEK 4163.00	10.94	11.14	11.26	11.37	11.50	11.59
5997	SS680	STABLE SWAMP CREEK 4166.00	10.92	11.13	11.25	11.35	11.49	11.57
5997	SS680	STABLE SWAMP CREEK 4166.00	10.92	11.13	11.25	11.35	11.49	11.57
5991	SS638	STABLE SWAMP CREEK 4171.00	10.90	11.11	11.23	11.34	11.47	11.55
5986	Copy of SS638	STABLE SWAMP CREEK 4176.00	10.88	11.09	11.21	11.32	11.45	11.54
5849	SS630	STABLE SWAMP CREEK 4278.00	10.45	10.68	10.82	10.93	11.06	11.13
5849	SS620	STABLE SWAMP CREEK 4278.00	10.45	10.68	10.82	10.93	11.06	11.13
5749	SS610	STABLE SWAMP CREEK 4414.00	9.85	10.08	10.21	10.33	10.46	10.55
5641	SS600	STABLE SWAMP CREEK 4521.00	9.44	9.70	9.87	9.99	10.13	10.23
5567	SS590	STABLE SWAMP CREEK 4594.00	8.75	9.18	9.47	9.64	9.81	10.01
5534	SS589	STABLE SWAMP CREEK 4627.00	8.57	9.06	9.38	9.55	9.74	9.97
5526	SS570	STABLE SWAMP CREEK 4635.00	8.61	9.12	9.41	9.58	9.75	9.98

AMTD (m)	BCC Cross Section	MIKE 11 Cross Section	Peak Flood Level (m AHD)					
			Q2	Q5	Q10	Q20	Q50	Q100
5516	SS560	STABLE SWAMP CREEK 4645.00	8.48	8.91	9.19	9.39	9.68	9.97
5502	SS550	STABLE SWAMP CREEK 4656.00	8.42	8.83	9.09	9.30	9.64	9.96
5497	SS540	STABLE SWAMP CREEK 4662.00	8.47	8.88	9.15	9.36	9.66	9.96
5388	SS638	STABLE SWAMP CREEK 4774.00	8.45	8.86	9.13	9.36	9.66	9.95
5278	SS501	STABLE SWAMP CREEK 4882.00	8.17	8.61	8.95	9.23	9.59	9.90
5158	SS521	STABLE SWAMP CREEK 5002.00	7.99	8.45	8.87	9.18	9.59	9.91
5158	SS521	STABLE SWAMP CREEK 5002.00	7.99	8.45	8.87	9.18	9.59	9.91
5115	SS520	STABLE SWAMP CREEK 5045.00	8.03	8.47	8.89	9.19	9.60	9.91
5085	SS510	STABLE SWAMP CREEK 5074.00	7.90	8.19	8.28	8.43	8.63	8.79
5054	SS500	STABLE SWAMP CREEK 5105.00	7.51	7.80	7.88	8.03	8.21	8.36
5001	Copy of SS490	STABLE SWAMP CREEK 5158.00	7.40	7.70	7.78	7.93	8.12	8.27
4985	Copy of SS490	STABLE SWAMP CREEK 5158.00	7.40	7.70	7.78	7.93	8.12	8.27
4984	SS490	STABLE SWAMP CREEK 5159.00	7.40	7.69	7.78	7.93	8.12	8.27
4867	SS480	STABLE SWAMP CREEK 5292.00	7.10	7.41	7.50	7.65	7.84	8.00
4778	SS470	STABLE SWAMP CREEK 5380.00	6.91	7.23	7.32	7.48	7.67	7.83
4756	Copy of SS470	STABLE SWAMP CREEK 5402.00	6.89	7.21	7.30	7.46	7.65	7.81
4744	Copy of SS450	STABLE SWAMP CREEK 5414.00	6.80	7.10	7.20	7.33	7.54	7.73
4738	SS450	STABLE SWAMP CREEK 5420.00	6.79	7.09	7.19	7.32	7.54	7.72
4673	SS430	STABLE SWAMP CREEK 5486.00	6.70	6.99	7.10	7.22	7.44	7.62
4619	SS420	STABLE SWAMP CREEK 5538.00	6.60	6.90	7.02	7.14	7.36	7.54
4588	SS419	STABLE SWAMP CREEK 5570.00	6.55	6.85	6.96	7.08	7.30	7.49
4474	SS400	STABLE SWAMP CREEK 5683.00	6.34	6.65	6.77	6.89	7.11	7.29
4306	SS380	STABLE SWAMP CREEK 5849.00	6.09	6.38	6.51	6.60	6.81	6.99
4306	Copy of SS380	STABLE SWAMP CREEK 5849.00	6.09	6.38	6.51	6.60	6.81	6.99
4293	Copy of SS360	STABLE SWAMP CREEK 5862.00	6.10	6.38	6.51	6.60	6.80	6.98
4257	SS360	STABLE SWAMP CREEK 5898.00	6.06	6.31	6.39	6.51	6.68	6.82
4251	SS350	STABLE SWAMP CREEK 5905.00	6.05	6.31	6.38	6.50	6.67	6.81
4161	SS490	STABLE SWAMP CREEK 5995.00	5.99	6.25	6.32	6.43	6.59	6.73
4161	SS490	STABLE SWAMP CREEK 5995.00	5.99	6.25	6.32	6.43	6.59	6.73
4061	SS340	STABLE SWAMP CREEK 6095.00	5.85	6.08	6.16	6.26	6.41	6.53
4061	SS340	STABLE SWAMP CREEK 6095.00	5.85	6.08	6.16	6.26	6.41	6.53
3983	SS340	STABLE SWAMP CREEK 6174.00	5.75	5.99	6.06	6.17	6.32	6.44
3964	SS310	STABLE SWAMP CREEK 6191.00	5.73	5.97	6.04	6.15	6.30	6.42
3964	SS310	STABLE SWAMP CREEK 6191.00	5.73	5.97	6.04	6.15	6.30	6.42
3891	SS300	STABLE SWAMP CREEK 6264.00	5.65	5.88	5.96	6.07	6.24	6.36
3829	SS291	STABLE SWAMP CREEK 6324.00	5.58	5.82	5.89	6.01	6.18	6.31
3829	SS291	STABLE SWAMP CREEK 6324.00	5.58	5.82	5.89	6.01	6.18	6.31
3751	SS290	STABLE SWAMP CREEK 6403.00	5.45	5.69	5.77	5.90	6.10	6.25
3738	Copy of SS290	STABLE SWAMP CREEK 6416.00	5.44	5.68	5.76	5.90	6.10	6.25
3710	Copy of SS270	STABLE SWAMP CREEK 6444.00	5.29	5.47	5.55	5.70	5.93	6.11
3702	SS270	STABLE SWAMP CREEK 6450.00	5.29	5.47	5.55	5.70	5.93	6.11
3682	Copy of SS270	STABLE SWAMP CREEK 6470.00	5.28	5.47	5.55	5.70	5.93	6.11
3682	Copy of SS270	STABLE SWAMP CREEK 6470.00	5.28	5.47	5.55	5.70	5.93	6.11
3648	Copy of SS263	STABLE SWAMP CREEK 6504.00	5.27	5.45	5.53	5.69	5.92	6.10
3612	SS263	STABLE SWAMP CREEK 6540.00	5.26	5.45	5.53	5.69	5.92	6.10
3612	SS263	STABLE SWAMP CREEK 6540.00	5.26	5.45	5.53	5.69	5.92	6.10
3594	SS263	STABLE SWAMP CREEK 6560.00	5.25	5.43	5.52	5.68	5.91	6.09
3579	Copy of SS263	STABLE SWAMP CREEK 6575.00	5.23	5.42	5.51	5.67	5.90	6.08
3575	Copy of SS261	STABLE SWAMP CREEK 6579.00	5.07	5.34	5.48	5.65	5.89	6.07
3566	SS261	STABLE SWAMP CREEK 6587.00	5.07	5.33	5.47	5.64	5.88	6.07
3548	SS260	STABLE SWAMP CREEK 6607.00	5.04	5.31	5.45	5.62	5.86	6.05
3316	SS250	STABLE SWAMP CREEK 6838.00	4.75	5.09	5.27	5.47	5.73	5.93
3175	SS240	STABLE SWAMP CREEK 6978.00	4.66	5.02	5.22	5.42	5.69	5.89
3166	SS235	STABLE SWAMP CREEK 6987.00	4.66	5.02	5.21	5.41	5.68	5.89
3162	Copy of SS235	STABLE SWAMP CREEK 6991.00	4.64	5.01	5.21	5.40	5.68	5.88
3123	SS233	STABLE SWAMP CREEK 7028.00	4.61	4.99	5.19	5.39	5.66	5.86
3113	SS232	STABLE SWAMP CREEK 7041.00	4.60	4.98	5.18	5.38	5.65	5.85
2949	SS231	STABLE SWAMP CREEK 7203.00	4.53	4.92	5.12	5.33	5.60	5.81
2680	SS230	STABLE SWAMP CREEK 7472.00	4.44	4.85	5.06	5.27	5.54	5.75
2559	SS220	STABLE SWAMP CREEK 7591.00	4.38	4.79	5.01	5.22	5.50	5.71
2417	SS210	STABLE SWAMP CREEK 7734.00	4.33	4.74	4.95	5.17	5.45	5.67
2361	SS200	STABLE SWAMP CREEK 7788.00	4.32	4.72	4.93	5.15	5.44	5.65
2333	SS190	STABLE SWAMP CREEK 7817.00	4.31	4.71	4.93	5.14	5.43	5.64
2266	SS170	STABLE SWAMP CREEK 7849.00	4.30	4.70	4.91	5.13	5.42	5.65
2217	SS160	STABLE SWAMP CREEK 7932.00	4.24	4.65	4.86	5.08	5.40	5.64
2168	SS150	STABLE SWAMP CREEK 7981.00	4.23	4.64	4.86	5.07	5.39	5.63
2168	SS150	STABLE SWAMP CREEK 7981.00	4.23	4.64	4.86	5.07	5.39	5.63
2037	Copy of SS130	STABLE SWAMP CREEK 8111.00	4.11	4.47	4.64	4.81	5.02	5.18
2036	SS130	STABLE SWAMP CREEK 8112.00	4.11	4.46	4.63	4.80	5.02	5.17
2036	SS130	STABLE SWAMP CREEK 8112.00	4.11	4.46	4.63	4.80	5.02	5.17
2015	SS120	STABLE SWAMP CREEK 8135.00	4.09	4.45	4.62	4.78	5.00	5.15
1933	SS110	STABLE SWAMP CREEK 8215.00	4.08	4.44	4.60	4.77	4.98	5.13
1824	SS100	STABLE SWAMP CREEK 8323.00	4.00	4.35	4.51	4.67	4.87	5.01
1697	Copy of SS100	STABLE SWAMP CREEK 8450.00	3.90	4.23	4.40	4.56	4.76	4.90
1617	Copy of SS90	STABLE SWAMP CREEK 8530.00	3.79	4.10	4.28	4.44	4.65	4.80
1553	SS90	STABLE SWAMP CREEK 8593.00	3.73	4.03	4.19	4.36	4.57	4.71
1435	SS80	STABLE SWAMP CREEK 8712.00	3.61	3.88	4.04	4.19	4.39	4.53
1257	SS70	STABLE SWAMP CREEK 8890.00	3.40	3.65	3.79	3.93	4.13	4.26
1011	SS61	STABLE SWAMP CREEK 9135.00	3.12	3.33	3.44	3.56	3.73	3.85
985	SS60	STABLE SWAMP CREEK 9162.00	3.10	3.31	3.42	3.54	3.70	3.82
785	SS50	STABLE SWAMP CREEK 9359.00	2.81	2.98	3.08	3.18	3.31	3.40
596	SS40	STABLE SWAMP CREEK 9548.00	2.57	2.75	2.84	2.94	3.06	3.15
403	SS30	STABLE SWAMP CREEK 9740.00	2.20	2.34	2.41	2.48	2.58	2.65
0	Copy of SS30	STABLE SWAMP CREEK 10100.00	1.20	1.20	1.20	1.20	1.20	1.20
-	2002 ALS	ARCHERFIELD OVERFLOW 06 0.00	5.28	5.47	5.55	5.70	5.93	6.11
-	2002 ALS	ARCHERFIELD OVERFLOW 06 22.36	5.27	5.45	5.54	5.70	5.93	6.11

FOR INFORMATION ONLY - NOT COUNCIL POLICY

Table B4 Stable Swamp Creek Peak Design Event Discharge – Ultimate Development Scenario

MIKE 11 Low Locations	Peak Discharge (m^3/s)					
	Q2	Q5	Q10	Q20	Q50	Q100
ARCHERFIELD 1039.00	33	46	53	62	76	87
ARCHERFIELD 1088.00	33	45	53	62	75	87
ARCHERFIELD 1158.00	33	45	53	62	75	87
ARCHERFIELD 1230.00	33	45	53	62	75	87
ARCHERFIELD 1284.00	37	51	59	69	84	97
ARCHERFIELD 1330.00	37	51	59	69	83	97
ARCHERFIELD 1384.00	37	50	59	68	83	97
ARCHERFIELD 1464.00	37	50	58	68	83	96
ARCHERFIELD 1527.00	37	50	58	68	83	97
ARCHERFIELD 1572.00	37	50	58	68	83	97
ARCHERFIELD 1622.00	44	60	70	81	100	117
ARCHERFIELD 1670.00	48	64	75	87	108	126
ARCHERFIELD 1711.00	47	64	75	87	107	126
ARCHERFIELD 1741.00	51	68	80	93	115	136
ARCHERFIELD 1795.00	51	68	79	93	114	133
ARCHERFIELD 1895.00	49	66	78	91	111	130
ARCHERFIELD 1977.00	48	65	76	89	110	128
ARCHERFIELD 2018.00	49	67	79	92	113	132
ARCHERFIELD 2057.00	48	66	77	90	111	129
ARCHERFIELD 2105.00	47	65	76	88	107	125
ARCHERFIELD 2130.00	46	64	74	86	107	126
ARCHERFIELD 2141.00	45	64	74	85	107	125
ARCHERFIELD 2170.00	44	63	72	83	105	122
ARCHERFIELD 2207.00	43	62	70	81	102	120
ARCHERFIELD 2231.00	44	63	71	82	104	122
ARCHERFIELD 2244.50	46	72	86	105	135	159
ARCHERFIELD 2265.50	46	71	85	104	134	158
ARCHERFIELD 2291.00	46	72	85	105	135	159
ARCHERFIELD 2323.00	46	71	85	107	139	166
ARCHERFIELD 2364.00	45	69	84	105	138	164
ARCHERFIELD 2387.00	44	69	86	111	147	177
ARCHERFIELD 2397.00	44	69	86	110	147	176
ARCHERFIELD 2411.00	44	68	85	110	146	176
ARCHERFIELD 2427.00	43	68	85	110	146	176
ARCHERFIELD 2442.50	43	68	85	110	146	175
ARCHERFIELD 2456.00	43	67	85	109	146	175
ARCHERFIELD 2481.50	68	96	113	127	151	173
ARCHERFIELD OVERFLOW 01 50.00	0	0	0	0	0	0
ARCHERFIELD OVERFLOW 02 80.16	0	1	2	5	11	16
ARCHERFIELD OVERFLOW 03 21.21	10	24	29	39	58	74
ARCHERFIELD OVERFLOW 04 22.36	0	3	4	7	14	20
ARCHERFIELD OVERFLOW 05 14.14	0	5	7	12	20	28
BERYL ROBERTS BASIN 39.45	43	58	68	80	97	113
BERYL ROBERTS BASIN 119.96	41	55	64	74	87	106
BERYL ROBERTS BASIN 237.37	31	37	44	59	83	102
BERYL ROBERTS BASIN 350.00	18	18	19	19	19	20
BERYL ROBERTS BASIN 382.22	18	29	40	57	82	101
BERYL ROBERTS MAIN 63.00	22	31	36	43	53	62
BERYL ROBERTS MAIN 163.33	22	31	36	43	53	61
BERYL ROBERTS MAIN 233.14	22	31	36	42	53	61
BERYL ROBERTS MAIN 307.70	22	31	36	42	53	61
BERYL ROBERTS MAIN 369.00	22	30	36	42	52	61
BERYL ROBERTS SPILLWAY 12.00	0	10	21	38	63	82

FINAL

MIKE 11 Low Locations	Peak Discharge (m^3/s)					
	Q2	Q5	Q10	Q20	Q50	Q100
BERYL ROBERTS TRIB 19.95	26	36	42	49	61	70
BERYL ROBERTS TRIB 63.08	26	36	42	49	61	70
BERYL ROBERTS TRIB 125.74	26	36	42	49	61	70
BERYL ROBERTS TRIB 199.87	26	36	42	49	60	70
BERYL ROBERTS TRIB 247.20	26	35	41	49	60	70
BRIDGE - IPSWICH MOTORWAY 8016.00	0	0	0	0	0	0
BRIDGE - IPSWICH MOTORWAY 8066.00	0	0	0	0	0	0
NORTH BRANCH 36.00	18	29	40	57	82	101
NORTH BRANCH 76.00	18	29	40	57	82	101
NORTH BRANCH 112.00	18	29	40	56	82	101
NORTH BRANCH 147.00	18	29	39	56	81	101
NORTH BRANCH 154.00	18	29	39	56	81	100
NORTH BRANCH 221.00	18	29	39	56	80	99
NORTH BRANCH 294.00	18	29	40	56	81	100
NORTH BRANCH 308.00	18	29	40	56	81	100
NORTH BRANCH 347.00	18	29	40	56	80	100
NORTH BRANCH 392.00	18	29	40	54	76	97
NORTH BRANCH 423.00	18	29	40	51	75	96
NORTH BRANCH 458.00	21	30	40	52	76	98
NORTH BRANCH 484.00	21	30	40	52	76	98
NORTH BRANCH 547.00	21	30	40	52	76	97
NORTH BRANCH 655.00	21	30	40	52	76	97
NORTH BRANCH 764.00	21	30	40	52	76	97
NORTH BRANCH 834.00	21	30	40	52	75	96
NORTH BRANCH 908.59	23	30	41	52	76	97
NORTH BRANCH 1018.59	40	50	57	65	88	112
NORTH BRANCH 1125.00	40	50	57	64	88	112
NORTH BRANCH 1305.00	39	49	56	63	87	111
NORTH BRANCH 1507.00	44	56	64	74	90	115
NORTH BRANCH 1594.00	43	55	63	73	90	114
NORTH BRANCH 1652.00	42	54	63	72	90	114
NORTH BRANCH 1710.00	41	53	68	71	90	112
NORTH BRANCH 1760.00	40	52	85	71	90	110
NORTH BRANCH 1826.00	42	52	142	81	93	110
NORTH BRANCH 1862.00	42	50	78	72	90	108
NORTH BRANCH 1886.00	43	48	96	88	90	108
RAILWAY OVERFLOW 10061.32	0	0	0	0	0	0
RAILWAY OVERFLOW 10177.81	0	0	0	0	0	0
RAILWAY OVERFLOW 10262.30	1	1	1	1	5	8
RAILWAY OVERFLOW 10305.60	1	1	2	6	18	28
RAILWAY OVERFLOW 10400.13	1	1	2	6	18	28
RAILWAY OVERFLOW 10508.58	1	1	2	6	17	28
RAILWAY OVERFLOW 10558.97	1	1	2	6	17	28
RAILWAY OVERFLOW_DRAIN 9841.88	0	0	0	0	0	0
RAILWAY OVERFLOW_DRAIN 9929.68	0	0	0	0	0	0
RAILWAY OVERFLOW_DRAIN 9982.05	0	0	0	0	0	0
RAILWAY OVERFLOW_DRAIN 10017.30	0	0	0	0	0	0
RAILWAY OVERFLOW_DRAIN 10067.70	0	0	0	0	0	0
RAILWAY OVERFLOW_DRAIN 10110.18	0	0	0	1	4	8
RAILWAY OVERFLOW_DRAIN 10150.28	0	0	0	1	4	8
RAILWAY OVERFLOW_DRAIN 10196.01	0	0	0	1	4	8
RAILWAY OVERFLOW_DRAIN_WIER_1 23.14	0	0	0	0	0	0
RAILWAY OVERFLOW_DRAIN_WIER_2 20.00	0	0	0	1	4	8
RAILWAY OVERFLOW_WEIR 20.00	0	0	1	5	13	20
RIAWENA ROAD 10004.18	19	27	32	38	47	54
RIAWENA ROAD 10033.34	19	27	32	38	47	54
RIAWENA ROAD 10073.27	19	27	32	38	47	54

DRAFT

MIKE 11 Low Locations	Peak Discharge (m^3/s)					
	Q2	Q5	Q10	Q20	Q50	Q100
RIAWENA ROAD 10103.22	19	27	32	38	47	54
RIAWENA ROAD 10146.97	19	27	32	37	46	54
RIAWENA ROAD 10210.73	19	26	31	37	46	53
SHELLEYS CREEK 10005.00	7	10	12	14	17	20
SHELLEYS CREEK 10024.50	7	10	12	14	17	20
SHELLEYS CREEK 10043.00	7	10	12	14	17	20
SHELLEYS CREEK 10069.00	7	10	12	14	17	20
SHELLEYS CREEK 10139.00	18	24	29	33	41	48
SHELLEYS CREEK 10193.50	18	24	28	33	41	48
SHELLEYS CREEK 10214.50	18	24	28	33	41	48
SHELLEYS CREEK 10256.00	18	24	28	33	41	48
SHELLEYS CREEK 10299.50	17	24	28	33	41	47
SHELLEYS CREEK 10342.50	17	24	28	33	40	47
SHELLEYS CREEK 10372.50	17	24	28	33	40	47
SHELLEYS CREEK 10381.00	17	24	28	32	40	47
SHELLEYS CREEK 10392.00	19	27	31	37	46	53
SHELLEYS CREEK 10463.00	25	35	41	49	60	70
SHELLEYS CREEK 10517.00	25	35	41	48	60	70
SHELLEYS CREEK 10575.00	24	35	41	48	60	70
SHELLEYS CREEK 10679.50	26	37	44	52	64	75
SHELLEYS CREEK 10775.00	26	37	44	52	64	75
SHELLEYS CREEK 10843.50	28	40	48	57	70	82
SHELLEYS CREEK 10907.00	28	40	48	57	70	82
SHELLEYS CREEK 10955.00	31	46	55	65	81	95
SHELLEYS CREEK 10964.00	31	46	55	65	81	95
SHELLEYS CREEK 10967.00	31	46	55	65	81	95
SHELLEYS CREEK 11002.50	31	46	54	65	81	94
SHELLEYS CREEK 11085.00	31	46	54	64	80	94
SHELLEYS CREEK 11178.50	31	45	54	64	80	94
SHELLEYS CREEK 11268.50	33	49	59	70	87	102
SHELLEYS CREEK 11372.00	33	49	58	70	87	102
SHELLEYS CREEK 11436.50	33	49	58	69	87	102
SHELLEYS CREEK 11448.00	34	51	61	73	91	107
SHELLEYS CREEK 11466.00	34	51	61	73	91	107
SHELLEYS CREEK 11477.50	34	51	61	73	91	107
SHELLEYS CREEK 11502.50	34	51	61	73	91	107
SHELLEYS CREEK 11579.00	35	53	64	77	96	113
SHELLEYS CREEK 11673.50	36	53	65	77	97	114
SHELLEYS CREEK 11737.50	35	53	64	77	97	113
SHELLEYS CREEK 11805.00	35	53	64	77	97	113
SHELLEYS CREEK 11846.00	36	54	65	78	98	115
SHELLEYS CREEK 11855.00	36	54	65	78	98	115
SHELLEYS CREEK 11864.00	36	54	65	78	98	115
SHELLEYS CREEK 11865.50	36	54	65	78	98	115
SHELLEYS CREEK 11866.50	36	54	65	78	98	115
SHELLEYS CREEK 11868.00	36	54	65	78	98	115
SHELLEYS CREEK 11898.50	36	54	65	78	98	115
SHELLEYS CREEK 11984.50	36	54	65	78	98	115
SHELLEYS CREEK 12045.00	37	56	68	81	102	120
SHELLEYS CREEK 12117.00	37	56	68	81	102	120
STABLE SWAMP CREEK 798.00	37	56	68	81	102	120
STABLE SWAMP CREEK 909.50	37	55	67	81	102	120
STABLE SWAMP CREEK 1009.50	39	59	72	86	108	128
STABLE SWAMP CREEK 1129.00	42	64	78	94	118	140
STABLE SWAMP CREEK 1235.50	42	64	78	94	118	140
STABLE SWAMP CREEK 1351.00	43	66	80	97	122	144
STABLE SWAMP CREEK 1437.00	43	65	80	96	133	143

FINAL

MIKE 11 Low Locations	Peak Discharge (m^3/s)					
	Q2	Q5	Q10	Q20	Q50	Q100
STABLE SWAMP CREEK 1444.00	43	65	80	96	129	143
STABLE SWAMP CREEK 1480.50	43	65	80	96	127	143
STABLE SWAMP CREEK 1545.50	43	65	80	96	125	143
STABLE SWAMP CREEK 1585.00	45	67	83	100	128	148
STABLE SWAMP CREEK 1605.50	45	67	82	100	128	148
STABLE SWAMP CREEK 1621.50	45	67	82	100	128	148
STABLE SWAMP CREEK 1633.00	45	67	82	100	128	148
STABLE SWAMP CREEK 1653.00	45	67	82	100	128	148
STABLE SWAMP CREEK 1693.00	45	67	82	100	128	148
STABLE SWAMP CREEK 1738.00	45	67	82	100	128	148
STABLE SWAMP CREEK 1763.00	45	67	82	100	128	148
STABLE SWAMP CREEK 1775.50	48	71	87	105	135	156
STABLE SWAMP CREEK 1785.00	48	71	87	105	135	156
STABLE SWAMP CREEK 1806.50	48	71	87	105	135	156
STABLE SWAMP CREEK 1841.00	51	73	90	108	140	162
STABLE SWAMP CREEK 1904.50	51	73	90	108	139	162
STABLE SWAMP CREEK 1955.00	51	73	90	108	139	162
STABLE SWAMP CREEK 2001.00	51	73	90	108	139	162
STABLE SWAMP CREEK 2086.00	51	73	90	108	139	162
STABLE SWAMP CREEK 2186.00	54	78	95	114	147	171
STABLE SWAMP CREEK 2278.00	54	78	95	114	147	171
STABLE SWAMP CREEK 2366.50	54	78	95	114	147	170
STABLE SWAMP CREEK 2466.50	54	77	95	114	146	170
STABLE SWAMP CREEK 2595.00	54	77	94	114	146	170
STABLE SWAMP CREEK 2742.00	59	83	100	120	154	180
STABLE SWAMP CREEK 2876.00	59	83	100	120	153	179
STABLE SWAMP CREEK 2985.50	59	83	101	119	150	177
STABLE SWAMP CREEK 3046.00	59	83	117	118	147	175
STABLE SWAMP CREEK 3082.50	59	83	106	118	147	175
STABLE SWAMP CREEK 3150.50	59	83	103	118	146	174
STABLE SWAMP CREEK 3266.50	59	83	102	118	146	173
STABLE SWAMP CREEK 3335.50	59	83	102	118	146	173
STABLE SWAMP CREEK 3343.00	59	83	102	118	146	173
STABLE SWAMP CREEK 3366.00	59	83	102	118	146	173
STABLE SWAMP CREEK 3387.00	59	83	101	118	146	173
STABLE SWAMP CREEK 3394.50	59	83	101	118	146	172
STABLE SWAMP CREEK 3404.00	59	83	101	118	146	172
STABLE SWAMP CREEK 3463.50	59	83	101	117	145	172
STABLE SWAMP CREEK 3547.50	59	84	101	118	144	170
STABLE SWAMP CREEK 3582.50	59	84	101	117	143	169
STABLE SWAMP CREEK 3601.00	59	84	101	117	143	168
STABLE SWAMP CREEK 3620.50	59	84	101	117	144	169
STABLE SWAMP CREEK 3633.00	60	84	101	118	144	169
STABLE SWAMP CREEK 3638.00	125	162	187	212	253	281
STABLE SWAMP CREEK 3641.50	125	162	187	212	253	281
STABLE SWAMP CREEK 3651.50	125	162	187	212	252	281
STABLE SWAMP CREEK 3748.50	125	162	187	212	250	277
STABLE SWAMP CREEK 3879.50	130	166	191	216	257	286
STABLE SWAMP CREEK 3944.00	137	173	199	226	268	299
STABLE SWAMP CREEK 3983.00	137	173	198	225	268	299
STABLE SWAMP CREEK 4005.50	137	173	198	225	268	299
STABLE SWAMP CREEK 4073.50	136	173	198	225	268	299
STABLE SWAMP CREEK 4147.00	136	172	198	225	268	299
STABLE SWAMP CREEK 4164.50	135	172	198	225	268	298
STABLE SWAMP CREEK 4168.50	135	172	198	224	263	290
STABLE SWAMP CREEK 4173.50	135	172	198	224	263	290
STABLE SWAMP CREEK 4227.00	135	172	197	224	263	290

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MIKE 11 Low Locations	Peak Discharge (m^3/s)					
	Q2	Q5	Q10	Q20	Q50	Q100
STABLE SWAMP CREEK 4346.00	134	172	195	218	250	270
STABLE SWAMP CREEK 4467.50	133	171	194	218	249	269
STABLE SWAMP CREEK 4557.50	138	177	200	225	259	280
STABLE SWAMP CREEK 4610.50	138	176	199	224	257	279
STABLE SWAMP CREEK 4631.00	138	176	198	223	256	278
STABLE SWAMP CREEK 4640.00	138	176	197	223	256	277
STABLE SWAMP CREEK 4650.50	138	176	197	222	256	277
STABLE SWAMP CREEK 4659.00	138	176	197	222	255	276
STABLE SWAMP CREEK 4718.00	137	175	196	221	252	269
STABLE SWAMP CREEK 4828.00	137	174	192	214	245	256
STABLE SWAMP CREEK 4942.00	136	174	192	211	237	245
STABLE SWAMP CREEK 5023.50	177	222	286	273	310	339
STABLE SWAMP CREEK 5066.00	177	222	236	261	303	337
STABLE SWAMP CREEK 5077.00	177	222	236	261	303	337
STABLE SWAMP CREEK 5131.50	176	221	235	261	303	337
STABLE SWAMP CREEK 5158.50	176	222	236	263	308	351
STABLE SWAMP CREEK 5225.50	177	224	238	265	310	353
STABLE SWAMP CREEK 5336.00	174	222	236	264	310	352
STABLE SWAMP CREEK 5391.00	173	222	236	264	309	352
STABLE SWAMP CREEK 5408.00	173	222	236	264	309	351
STABLE SWAMP CREEK 5417.00	173	221	236	264	309	351
STABLE SWAMP CREEK 5453.00	172	221	236	264	309	351
STABLE SWAMP CREEK 5512.00	176	225	240	267	313	355
STABLE SWAMP CREEK 5554.00	176	224	239	267	312	355
STABLE SWAMP CREEK 5626.50	175	224	239	267	312	354
STABLE SWAMP CREEK 5766.00	176	225	240	268	313	355
STABLE SWAMP CREEK 5855.50	175	225	240	268	313	355
STABLE SWAMP CREEK 5880.00	175	225	240	268	313	355
STABLE SWAMP CREEK 5901.50	175	225	240	268	313	355
STABLE SWAMP CREEK 5950.00	175	224	240	268	313	355
STABLE SWAMP CREEK 6045.00	174	223	238	263	302	339
STABLE SWAMP CREEK 6134.50	164	198	209	224	245	265
STABLE SWAMP CREEK 6182.50	163	198	209	224	245	265
STABLE SWAMP CREEK 6227.50	163	196	204	217	231	245
STABLE SWAMP CREEK 6294.00	163	195	204	217	231	245
STABLE SWAMP CREEK 6363.50	164	192	199	207	213	219
STABLE SWAMP CREEK 6409.50	164	192	199	207	213	219
STABLE SWAMP CREEK 6430.00	163	192	199	206	213	219
STABLE SWAMP CREEK 6447.00	163	192	199	206	212	219
STABLE SWAMP CREEK 6460.00	163	192	198	206	212	219
STABLE SWAMP CREEK 6487.00	133	156	164	179	200	215
STABLE SWAMP CREEK 6522.00	133	156	164	179	200	215
STABLE SWAMP CREEK 6550.00	199	252	273	300	341	376
STABLE SWAMP CREEK 6567.50	199	251	273	299	340	376
STABLE SWAMP CREEK 6577.00	199	251	272	299	341	376
STABLE SWAMP CREEK 6583.00	199	251	272	299	340	376
STABLE SWAMP CREEK 6597.00	198	251	272	299	340	376
STABLE SWAMP CREEK 6722.50	198	250	271	297	337	373
STABLE SWAMP CREEK 6908.00	196	244	264	289	328	364
STABLE SWAMP CREEK 6982.50	195	242	262	290	340	362
STABLE SWAMP CREEK 6989.00	194	240	259	300	334	361
STABLE SWAMP CREEK 7009.50	194	239	258	285	333	361
STABLE SWAMP CREEK 7034.00	193	238	257	287	330	367
STABLE SWAMP CREEK 7122.00	190	235	254	278	319	358
STABLE SWAMP CREEK 7337.50	178	222	242	268	311	352
STABLE SWAMP CREEK 7531.50	169	211	234	262	307	345
STABLE SWAMP CREEK 7662.50	165	207	229	259	306	342

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MIKE 11 Low Locations	Peak Discharge (m^3/s)					
	Q2	Q5	Q10	Q20	Q50	Q100
STABLE SWAMP CREEK 7761.00	162	203	227	257	304	340
STABLE SWAMP CREEK 7803.00	183	216	227	258	304	339
STABLE SWAMP CREEK 7833.00	160	201	226	256	303	339
STABLE SWAMP CREEK 7890.50	158	199	225	255	302	338
STABLE SWAMP CREEK 7956.50	157	199	225	256	304	339
STABLE SWAMP CREEK 8047.00	153	196	223	254	302	338
STABLE SWAMP CREEK 8111.50	152	195	223	254	301	338
STABLE SWAMP CREEK 8123.50	152	195	222	253	301	337
STABLE SWAMP CREEK 8175.00	151	195	222	253	301	337
STABLE SWAMP CREEK 8269.00	151	194	222	253	300	337
STABLE SWAMP CREEK 8386.50	150	193	221	253	300	337
STABLE SWAMP CREEK 8490.00	149	193	221	252	300	336
STABLE SWAMP CREEK 8561.50	149	193	220	252	299	336
STABLE SWAMP CREEK 8652.50	149	192	220	252	299	336
STABLE SWAMP CREEK 8801.00	148	191	220	251	299	336
STABLE SWAMP CREEK 9012.50	146	190	219	251	298	335
STABLE SWAMP CREEK 9148.50	145	190	218	250	298	335
STABLE SWAMP CREEK 9260.50	144	189	218	250	297	335
STABLE SWAMP CREEK 9453.50	141	187	216	248	296	334
STABLE SWAMP CREEK 9644.00	147	196	227	261	311	351
STABLE SWAMP CREEK 9920.00	145	194	225	259	310	350
ARCHERFIELD OVERFLOW 06 11.18	30	36	35	27	26	28

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APPENDIX C: HYDRAULIC STRUCTURE REFERENCE SHEETS

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**STONES RD, SUNNYBANK**

DATE OF SURVEY:	UBD REF: 220 H1
AERIAL PHOTO No:	STRUCTURE ID: Stones Road Culvert
BCC XS No: SS960	AMTD (m): 1437
STRUCTURE DESCRIPTION: PIPE CULVERTS	
STRUCTURE SIZE 6 / 1500 diameter For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 29.682 DOWNSTREAM INVERT LEVEL: 29.682 For culverts give floor level.	UPSTREAM OBVERT LEVEL: DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 10.9 LENGTH OF CULVERT BARREL AT OBVERT (m): 10.9 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 10.9 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 34.57 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: W12317

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CREEK	STABLE SWAMP CREEK
LOCATION	STONES RD, SUNNYBANK

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	84.7	62.2	143.3	33.93	820	11.7	39.0	4.7	2.3
50	69.9	62.7	132.5	33.85	830	11.7	33.7	4.6	2.3
20	49.0	47.4	96.4	33.70	940	10.5	25.8	4.5	1.9
10	34.6	45.4	80.0	32.54	70	10.2	20.0	4.5	1.7
5	22.2	43.2	65.4	33.47	1160	9.8	14.4	4.4	1.5
2	4.6	38.5	43.1	33.19	1330	9.1	4.4	4.2	1.0

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BCC.079.0645

HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**KEATS ST, SUNNYBANK**

DATE OF SURVEY:	UBD REF: 200 H20
AERIAL PHOTO No:	STRUCTURE ID: Keats Street Bridge
BCC XS No: SS910	AMTD (m): 1633
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 2 / 3100 x 1800 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 27.16	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 27.14 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 13.25 LENGTH OF CULVERT BARREL AT OBVERT (m): 13.25 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 13.25 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 29.98 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE:	PLAN NUMBER: W4393
HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable.	
ADDITIONAL COMMENTS:	

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BCC.079.0646

CREEK	STABLE SWAMP CREEK
LOCATION	KEATS ST, SUNNYBANK

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	56.1	61.2	148.3	31.31	1930	11.2	24.7	5.5	2.3
50	38.7	59.4	128.0	31.16	2010	11.2	17.8	5.3	2.2
20	16.7	55.4	99.6	30.84	2040	11.1	8.8	5.0	1.9
10	6.5	51.7	82.5	30.55	1990	11.0	4.1	4.7	1.6
5	0.7	46.2	67.3	30.18	1860	10.7	0.7	4.3	1.0
2	0.0	31.8	44.9	29.45	1540	8.6	0.0	3.7	0.0

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**KEATS ST, SUNNYBANK**

DATE OF SURVEY:	UBD REF: 200 G20
AERIAL PHOTO No:	STRUCTURE ID: Keats Street Bridge
BCC XS No: SS910	AMTD (m): 1633
STRUCTURE DESCRIPTION: BOX (CENTRE) CULVERT	
STRUCTURE SIZE 1 / 800 x 2060 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 27.16 DOWNSTREAM INVERT LEVEL: 27.14 For culverts give floor level.	UPSTREAM OBVERT LEVEL: DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 13.25 LENGTH OF CULVERT BARREL AT OBVERT (m): 13.25 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 13.25 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 27.01 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: W4393

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BCC.079.0648

CREEK	STABLE SWAMP CREEK
LOCATION	KEATS ST, SUNNYBANK

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	56.1	31.0	148.3	31.31	1930	6.2	24.7	5.0	2.3
50	38.7	29.8	128.0	31.16	2010	6.1	17.8	4.9	2.2
20	16.7	27.4	99.6	30.84	2040	6.0	8.8	4.6	1.9
10	6.5	24.3	82.5	30.55	1990	5.6	4.1	4.3	1.6
5	0.7	20.4	67.3	30.18	1860	5.0	0.7	4.1	1.0
2	0.0	13.1	44.9	29.45	1540	3.7	0.0	3.5	0.0

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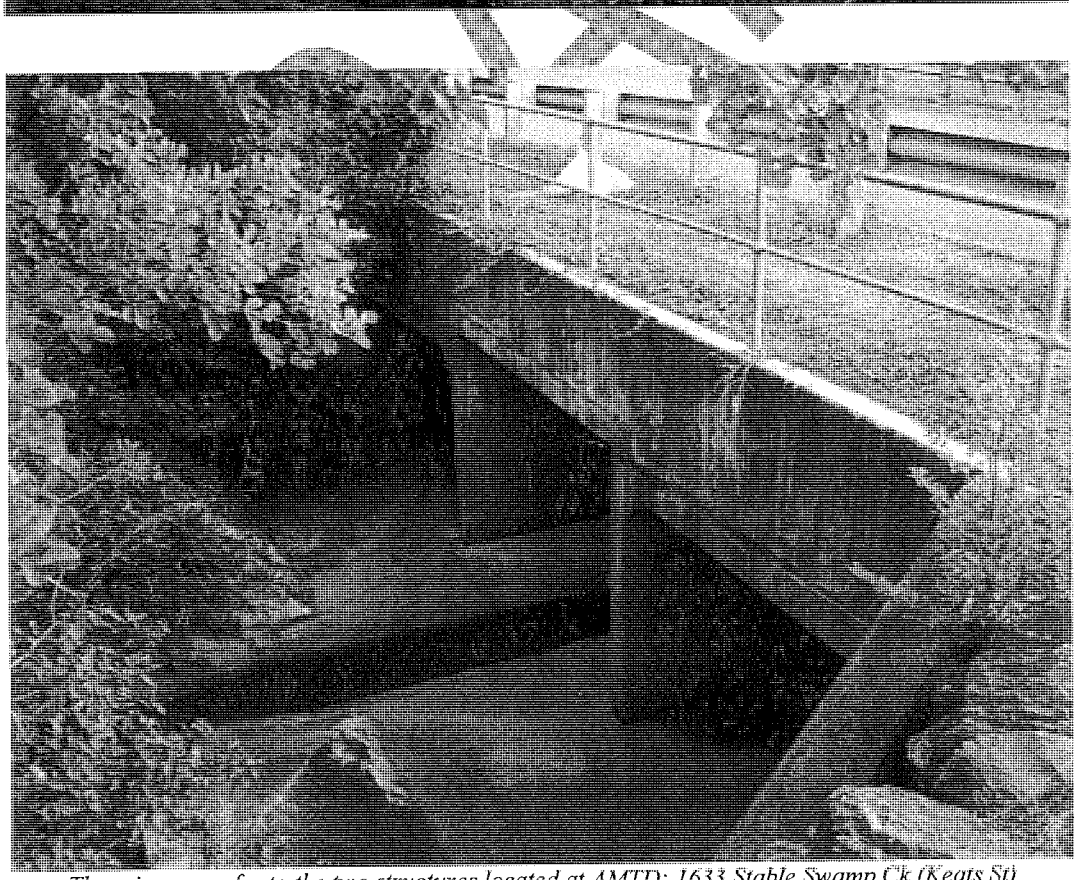

These images refer to the two structures located at AMTD: 1633 Stable Swamp Ck (Keats St)

BCC.079.0650

HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**DYSON AVENUE PEDESTRIAN BRIDGE, SUNNYBANK**

DATE OF SURVEY:	UBD REF: 200 G19
AERIAL PHOTO No:	STRUCTURE ID: Dyson Avenue
BCC XS No: SS870	AMTD (m): 1955
STRUCTURE DESCRIPTION: BRIDGE	
STRUCTURE SIZE SINGLE SPAN / 8.5m For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 22.68	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 22.68 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 1.32 LENGTH OF CULVERT BARREL AT OBVERT (m): 1.32 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 1.32 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 26.09 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: 01-JUL-1984 HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: B0670

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CREEK	STABLE SWAMP CREEK
LOCATION	DYSON AVENUE PEDESTRIAN BRIDGE, SUNNYBANK

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	18.8	142.8	161.6	27.06	1350	32.2	8.8	4.4	2.1
50	9.6	129.8	139.4	26.77	1210	30.2	5.3	4.3	1.8
20	1.2	107.1	108.3	26.33	1080	26.5	1.2	4.0	1.0
10	0.0	89.7	89.7	25.98	950	23.5	0.0	3.8	0.0
5	0.0	73.0	73.0	25.71	890	19.9	0.0	3.7	0.0
2	0.0	50.5	50.5	25.29	800	14.9	0.0	3.4	0.0

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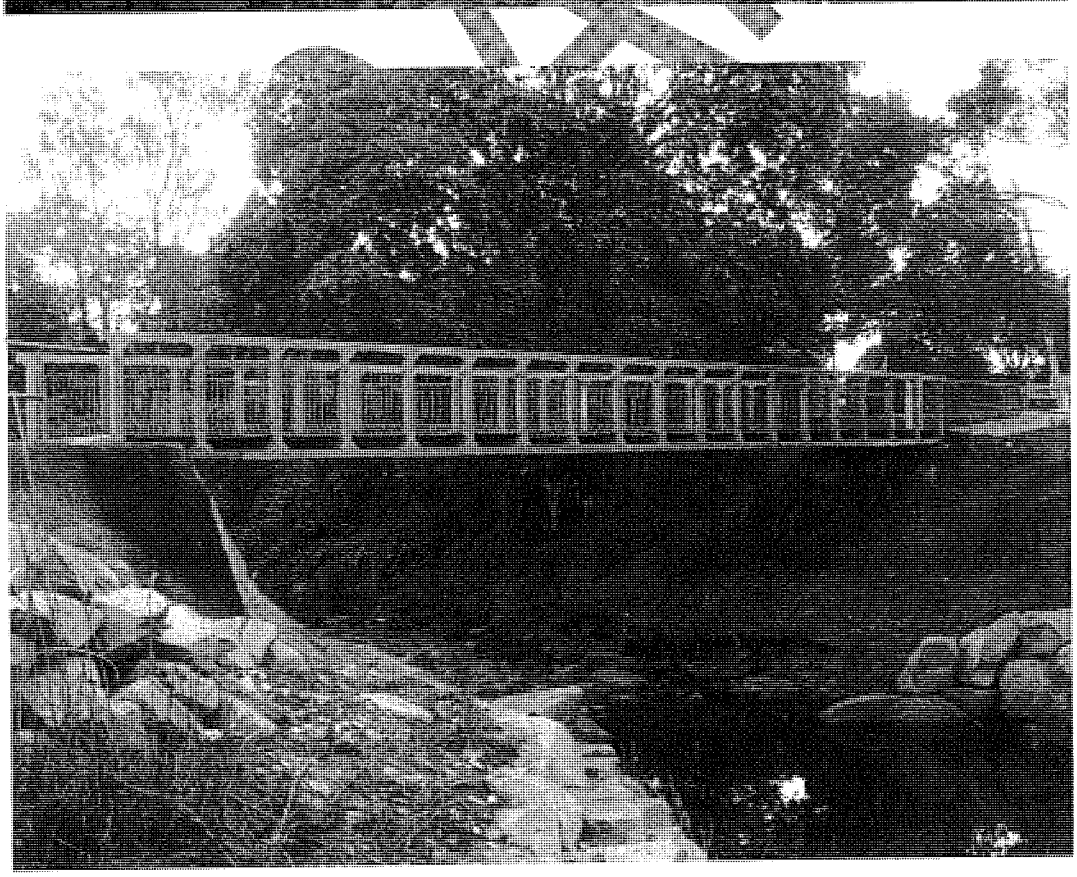
BCC.079.0652





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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**BEENLEIGH RD, SUNNYBANK**

DATE OF SURVEY:	UBD REF: 200 C17
AERIAL PHOTO No:	STRUCTURE ID: Beenleigh Road
BCC XS No: SS750	AMTD (m): 3046
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 5 / 3550 x 2250 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 15.55	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 15.66 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 32.56 LENGTH OF CULVERT BARREL AT OBVERT (m): 32.56 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 32.56 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 17.57 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE:	PLAN NUMBER: W8029
HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable.	
ADDITIONAL COMMENTS:	

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BCC.079.0654

CREEK	STABLE SWAMP CREEK
LOCATION	BEENLEIGH RD, SUNNYBANK

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	45.0	140.0	175.5	18.89	580	39.9	11.3	4.3	1.8
50	17.3	92.2	132.3	18.63	500	39.9	6.2	3.8	1.6
20	0.1	117.8	117.9	18.09	200	38.8	0.2	4.1	0.9
10	0.0	100.0*	100.0*	17.92	180	36.0	0.0	4.1	0.0
5	0.0	83.0	83.0	17.61	90	32.5	0.0	2.6	0.0
2	0.0	58.8	58.8	17.27	70	27.0	0.0	2.2	0.0

* These values are based upon the theoretical peak of the resultant curve and not the peak recorded value for this result.

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BCC.079.0655





BCC.079.0656

HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**BOUNDARY RD, ACACIA RIDGE**

DATE OF SURVEY:	UBD REF: 199 R15
AERIAL PHOTO No:	STRUCTURE ID: Boundary Road
BCC XS No: SS660	AMTD (m): 3983
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 9 / 3000 x 3000 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 9.59	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 9.35 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 27.5 LENGTH OF CULVERT BARREL AT OBVERT (m): 27.5 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 27.5 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 12.43 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: JAN-1978 HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: W5555

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BCC.079.0657

CREEK	STABLE SWAMP CREEK
LOCATION	BOUNDARY RD, ACACIA RIDGE

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	25.2	273.9	299.1	13.31	1010	59.8	13.9	4.6	1.8
50	13.6	254.4	268.0	13.11	930	59.9	8.7	4.5	1.6
20	2.8	222.5	225.3	12.79	790	60.0	2.4	4.4	1.1
10	0.1	198.1	198.3	12.53	670	55.1	0.2	4.2	0.6
5	0.0	172.7	172.7	12.21	490	54.7	0.0	4.0	0.0
2	0.0	136.8	136.8	11.61	130	52.6	0.0	2.6	0.0

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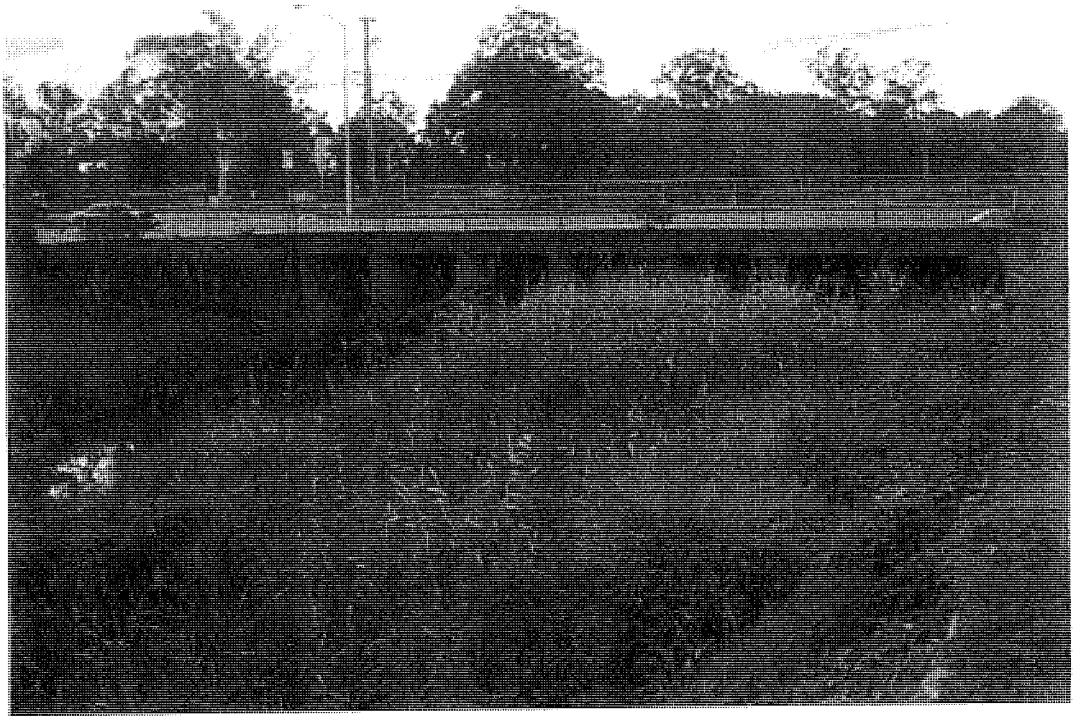

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**EDITH ST, COOPERS PLAINS**

DATE OF SURVEY:	UBD REF: 200 A13
AERIAL PHOTO No:	STRUCTURE ID: Edith Street
BCC XS No: SS580	AMTD (m): 4640
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 6 / 3700 x 2750 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 6.02	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 5.99 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 8.6 LENGTH OF CULVERT BARREL AT OBVERT (m): 8.6 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 8.6 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 8.93 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: W6242

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CREEK	STABLE SWAMP CREEK
LOCATION	EDITH ST, COOPERS PLAINS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	189.1	184.7	277.5	9.98	20	61.1	167.8	3.1	2.1
50	121.8	185.3	256.1	9.75	70	61.1	63.4	3.1	1.9
20	70.6	181.6	222.7	9.58	190	61.1	42.0	3.1	1.7
10	35.2	179.2	197.2	9.41	220	61.1	24.8	3.0	1.5
5	3.8	172.9	175.7	9.12	220	60.8	4.3	2.9	0.9
2	0.0	137.7	137.7	8.61	140	51.4	0.0	2.7	0.0

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BCC.079.0662

HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**OUTBOUND RAILWAY BRIDGE, COOPERS PLAINS**

DATE OF SURVEY:	UBD REF: 199 Q12
AERIAL PHOTO No:	STRUCTURE ID: Outbound Railway
BCC XS No: SS511	AMTD (m): 5066
STRUCTURE DESCRIPTION: BRIDGE	
STRUCTURE SIZE 2 SPANS / 15m For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 4.19	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 4.16 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 3.82 LENGTH OF CULVERT BARREL AT OBVERT (m): 3.82 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 3.82 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 10.69 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER:

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BCC.079.0663

CREEK	STABLE SWAMP CREEK
LOCATION	OUTBOUND RAILWAY BRIDGE, COOPERS PLAINS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	0.0	336.9	336.9	9.91	1120	67.8	0.0	5.0	0.0
50	0.0	302.7	302.7	9.60	970	67.8	0.0	4.8	0.0
20	0.0	261.4	261.4	9.19	760	67.7	0.0	4.6	0.0
10	0.0	236.1	236.1	8.89	610	67.8	0.0	4.5	0.0
5	0.0	221.9	221.9	8.47	280	66.0	0.0	2.4	0.0
2	0.0	177.0	177.0	8.03	130	62.6	0.0	2.9	0.0

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BCC.079.0664

HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**INBOUND RAILWAY BRIDGE, COOPERS PLAINS**

DATE OF SURVEY:	UBD REF: 199 Q12
AERIAL PHOTO No:	STRUCTURE ID: Inbound Railway
BCC XS No: SS509	AMTD (m): 5077
STRUCTURE DESCRIPTION: BRIDGE	
STRUCTURE SIZE 6 SPANS / 10m For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 4.15 DOWNSTREAM INVERT LEVEL: 4.11 For culverts give floor level.	UPSTREAM OBVERT LEVEL: DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 3.6 LENGTH OF CULVERT BARREL AT OBVERT (m): 3.6 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 3.6 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 10.66 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER:

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CREEK	STABLE SWAMP CREEK
LOCATION	INBOUND RAILWAY BRIDGE, COOPERS PLAINS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	0.0	336.9	336.9	8.79	430	81.3	0.0	4.1	0.0
50	0.0	302.7	302.7	8.63	420	74.9	0.0	4.1	0.0
20	0.0	261.4	261.4	8.43	400	65.6	0.0	4.1	0.0
10	0.0	236.1	236.1	8.28	400	60.6	0.0	4.1	0.0
5	0.0	221.9	221.9	8.19	390	57.5	0.0	4.1	0.0
2	0.0	177.0	177.0	7.90	390	46.6	0.0	4.1	0.0

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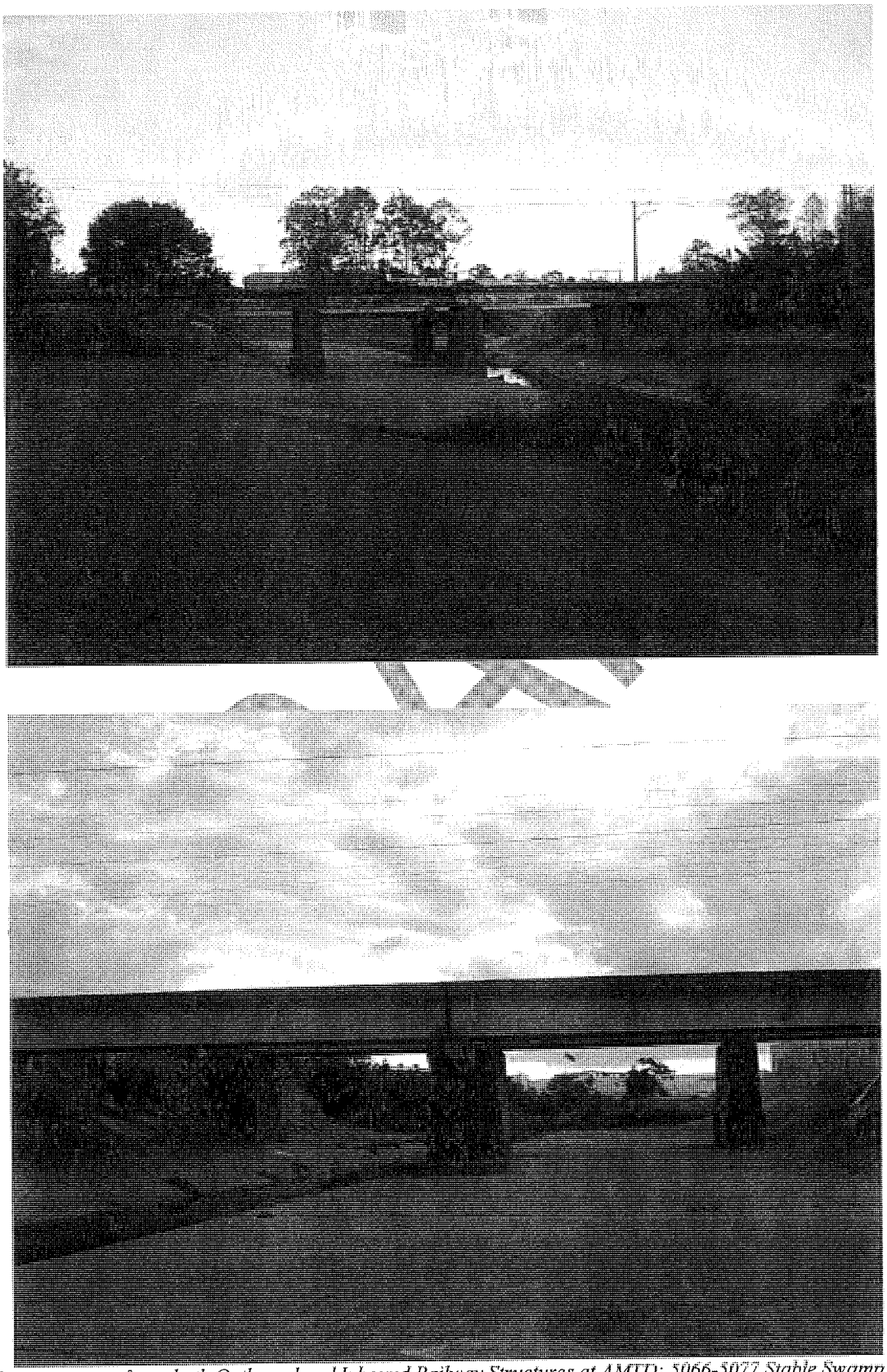

These images refer to both Outbound and Inbound Railway Structures at AMTD: 5066-5077 Stable Swamp Ck

BCC.079.0667

HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**MUSGRAVE RD BRIDGE, COOPERS PLAINS**

DATE OF SURVEY:	UBD REF: 199 P11
AERIAL PHOTO No:	STRUCTURE ID: Musgrave Road
BCC XS No: SS460	AMTD (m): 5408
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 6 / 3620 x 3140 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 4.22	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 4.2 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 11.05 LENGTH OF CULVERT BARREL AT OBVERT (m): 11.05 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 11.05 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 2.83 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: W5501

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CREEK	STABLE SWAMP CREEK
LOCATION	MUSGRAVE RD BRIDGE, COOPERS PLAINS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	258.2	90.3	351.4	7.81	80	47.4	100.3	1.9	2.6
50	199.0	89.5	309.2	7.65	110	47.4	80.9	1.9*	2.5*
20	138.4	93.7	263.7	7.46	130	47.4	61.0	1.9	2.4
10	95.5	106.8	236.1	7.30	100	47.4	54.4	2.2	2.2
5	74.7*	107.2*	221.5	7.21	110	47.4	37.2	2.2*	2.1*
2	27.1*	102.8*	172.8	6.89	80	47.4	16.2	2.1*	1.9*

* These values are based upon the theoretical peak of the resultant curve and not the peak recorded value for this result.

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BCC.079.0669

HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**MUSGRAVE RD BRIDGE, COOPERS PLAINS**

DATE OF SURVEY:	UBD REF: 199 P11
AERIAL PHOTO No:	STRUCTURE ID: Musgrave Road
BCC XS No: SS460	AMTD (m): 5408
STRUCTURE DESCRIPTION: BRIDGE	
STRUCTURE SIZE 2 SPANS / 17.5m For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 3.45	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 3.44 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 11.05 LENGTH OF CULVERT BARREL AT OBVERT (m): 11.05 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 11.05 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 2.83 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER:

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CREEK	STABLE SWAMP CREEK
LOCATION	MUSGRAVE RD BRIDGE, COOPERS PLAINS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	258.2	48.8	351.4	7.81	80	20.2	100.3	2.3	2.6
50	199.0	48.6	309.2	7.65	110	20.2	80.9	2.3*	2.5
20	138.4	50.2	263.7	7.46	130	20.2	61.0	2.4	2.4
10	95.5	46.9	236.1	7.30	100	20.2	54.4	2.2	2.2
5	74.7*	47.5*	221.5	7.21	110	20.2	37.2	2.2*	2.1*
2	27.1*	46.5*	172.8	6.89	80	20.2	16.2	2.2*	1.9*

* These values are based upon the theoretical peak of the resultant curve and not the peak recorded value for this result.

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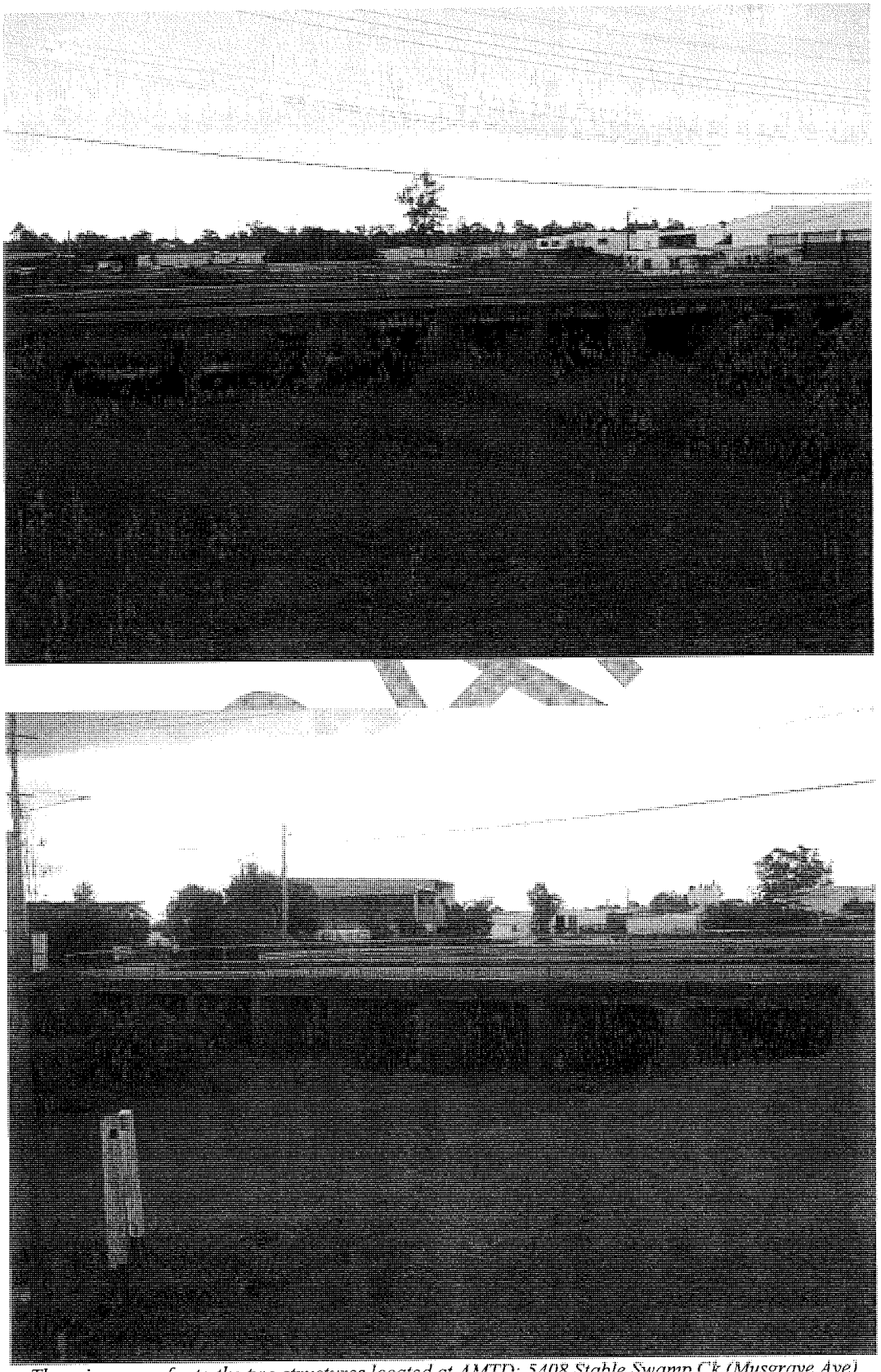

These images refer to the two structures located at AMTD: 5408 Stable Swamp Ck (Musgrave Ave)

BCC.079.0672

HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**RIAWENA RD BRIDGE, SALISBURY**

DATE OF SURVEY:	UBD REF: 199 N10
AERIAL PHOTO No:	STRUCTURE ID: Riawena Road
BCC XS No: SS370	AMTD (m): 5880
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 8 / 3850 x 3700 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 3.14	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 3.14 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 34.37 LENGTH OF CULVERT BARREL AT OBVERT (m): 34.37 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 34.37 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 6.61 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE:	PLAN NUMBER: W6214
HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable.	
ADDITIONAL COMMENTS:	

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CREEK	STABLE SWAMP CREEK
LOCATION	RIAWENA RD BRIDGE, SALISBURY

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	13.1	267.8	355.0	6.98	160	108.6	10.9	2.5	1.1
50	6.3	240.9	312.9	6.80	130	104.7	5.5	2.3	1.0
20	0.0	210.7	267.6	6.60	90	100.2	0.0	2.1	0.0
10	0.0	181.3	240.2	6.51	120	98.9	0.0	1.8	0.0
5	0.0	176.4	224.6	6.38	60	95.1	0.0	1.8	0.0
2	0.0	136.2	175.3	6.10	40	88.3	0.0	1.5	0.0

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**RIAWENA RD BRIDGE, SALISBURY**

DATE OF SURVEY:	UBD REF: 199 N10
AERIAL PHOTO No:	STRUCTURE ID: Riawena Road
BCC XS No: SS370	AMTD (m): 5880
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 2 / 3850 x 4270 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 2.58	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 2.58 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 34.37 LENGTH OF CULVERT BARREL AT OBVERT (m): 34.37 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 34.37 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 6.61 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE:	PLAN NUMBER: W6214
HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable.	
ADDITIONAL COMMENTS:	

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CREEK	STABLE SWAMP CREEK
LOCATION	RIAWENA RD BRIDGE, SALISBURY

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	13.1	74.3	355.0	6.98	160	31.4	10.9	2.5	1.1
50	6.3	65.8	312.9	6.80	130	30.5	5.5	2.3	1.0
20	0.0	56.9	267.6	6.60	90	29.3	0.0	2.1	0.0
10	0.0	59.0	240.2	6.51	120	28.4	0.0	2.1	0.0
5	0.0	48.2	224.6	6.38	60	28.1	0.0	1.9	0.0
2	0.0	39.1	175.3	6.10	40	26.4	0.0	1.9	0.0

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NO PICTURE

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**BEAUDESERT RD BRIDGE, ROCKLEA**

DATE OF SURVEY:	UBD REF: 199 M9
AERIAL PHOTO No:	STRUCTURE ID: Beaudesert Road
BCC XS No: SS280	AMTD (m): 6430
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 8 / 2430 x 2480 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 2.57	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 2.41 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 26.35 LENGTH OF CULVERT BARREL AT OBVERT (m): 26.35 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 26.35 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 5.25 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE:	PLAN NUMBER: MRD153850
HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable.	
ADDITIONAL COMMENTS:	

DRAFT

CREEK	STABLE SWAMP CREEK
LOCATION	BEAUDESERT RD BRIDGE, ROCKLEA

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	72.6	104.6	218.6	6.25	140	48.2	32.4	2.2	2.2
50	54.2	102.1	212.7	6.10	170	48.2	26.1	2.1	2.0
20	33.9	106.5	206.5	5.90	200	48.2	18.6	2.2	1.8
10	21.9	107.0	198.5	5.76	210	48.2	13.5	2.2	1.5
5	16.3	106.3	191.7	5.68	200	48.2	11.0	2.2	1.4
2	4.3	96.7	163.5	5.44	150	48.2	4.2	2.0	1.0

DRAFT

HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**BEAUDESERT RD BRIDGE, ROCKLEA**

DATE OF SURVEY:	UBD REF: 199 M9
AERIAL PHOTO No:	STRUCTURE ID: Beaudesert Road
BCC XS No: SS280	AMTD (m): 6430
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 4 / 2430 x 3230 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 1.8	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 1.66 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 26.35 LENGTH OF CULVERT BARREL AT OBVERT (m): 26.35 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 26.35 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 5.25 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE:	PLAN NUMBER: MRD153850
HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable.	
ADDITIONAL COMMENTS:	

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CREEK	STABLE SWAMP CREEK
LOCATION	BEAUDESERT RD BRIDGE, ROCKLEA

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	72.6	68.0	218.6	6.25	140	31.4	32.4	2.2	2.2
50	54.2	66.3	212.7	6.10	170	31.4	26.1	2.1	2.0
20	33.9	69.5	206.5	5.90	200	31.4	18.6	2.2	1.8
10	21.9	69.7	198.5	5.76	210	31.4	13.5	2.2	1.5
5	16.3	69.1	191.7	5.68	200	31.4	11.0	2.2	1.4
2	4.3	62.4	163.5	5.44	150	31.4	4.2	2.0	1.0

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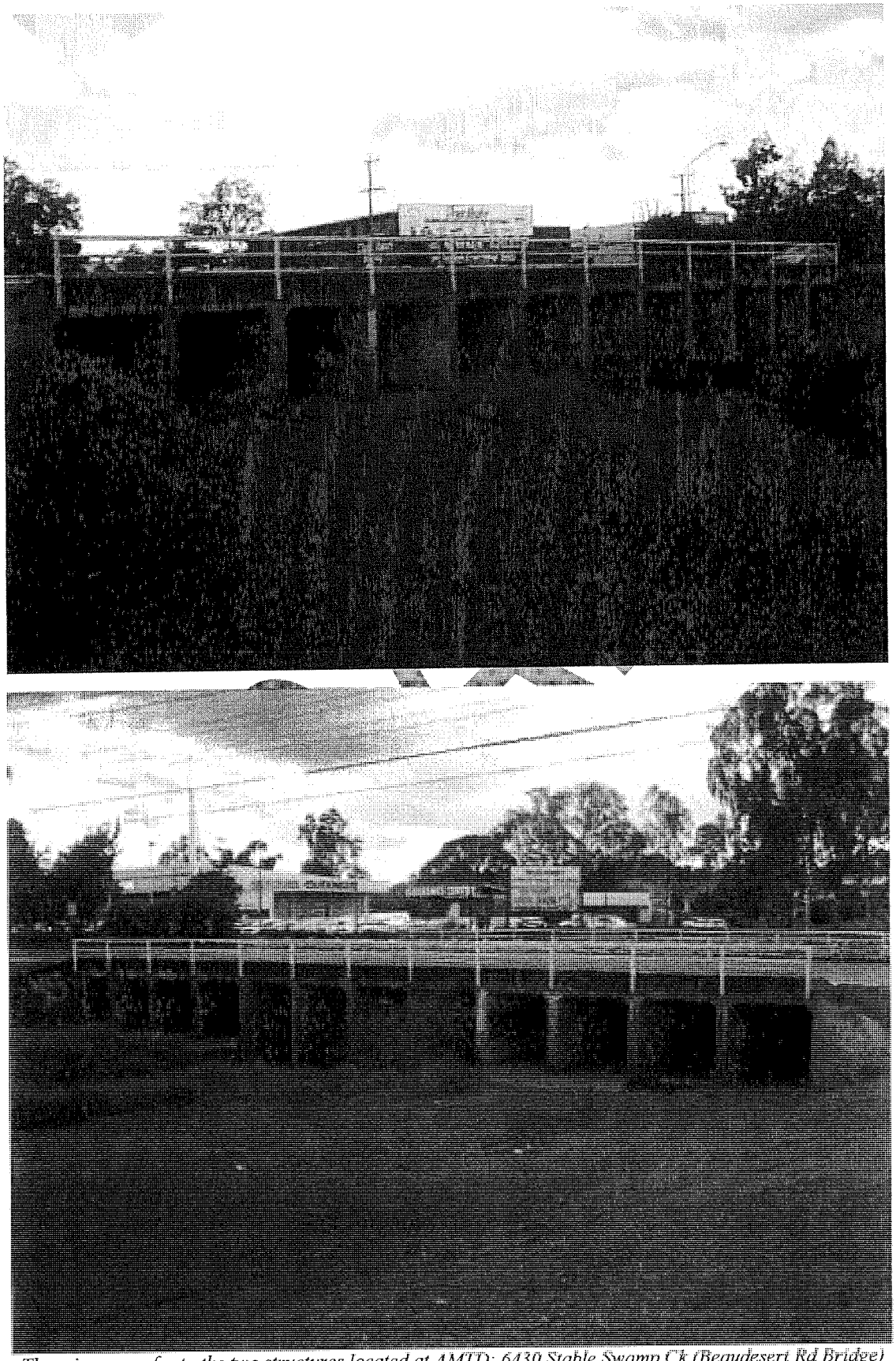

These images refer to the two structures located at AMTD: 6430 Stable Swamp Ck (Beaudesert Rd Bridge)

HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**COLVIN ST PEDESTRIAN BRIDGE, ROCKLEA**

DATE OF SURVEY:	UBD REF: 199 M8
AERIAL PHOTO No:	STRUCTURE ID: Colvin Street
BCC XS No: SS262	AMTD (m): 6577
STRUCTURE DESCRIPTION: BRIDGE	
STRUCTURE SIZE SINGLE SPAN / 20m For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 0.71	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 0.71 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 3.5 LENGTH OF CULVERT BARREL AT OBVERT (m): 3.5 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road. eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 3.5 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 4.765 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: B9857

DRAFT

CREEK	STABLE SWAMP CREEK
LOCATION	COLVIN ST PEDESTRIAN BRIDGE, ROCKLEA

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	338.9	76.3	375.7	6.09	10	32.0	259.0	2.4	2.7
50	301.3	76.8	341.4	5.90	20	32.0	225.6	2.4	2.7
20	260.4	77.9	299.4	5.67	20	32.0	181.0	2.4	2.6
10	224.7	79.7	272.5	5.51	30	32.0	149.3	2.5	2.5
5	192.2	81.2	251.4	5.42	80	32.0	78.9	2.5	2.4
2	128.5	81.9	198.6	5.23	160	32.0	57.9	2.5	2.2

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**FRENEY ST PIPE BRIDGE, ROCKLEA**

DATE OF SURVEY:	UBD REF: 199 K7
AERIAL PHOTO No:	STRUCTURE ID: Freney Street
BCC XS No: SS235	AMTD (m): 6989
STRUCTURE DESCRIPTION: PIPE BRIDGE	
STRUCTURE SIZE 2 SPANS / 19.5m For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 0.86	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 0.86 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 1 LENGTH OF CULVERT BARREL AT OBVERT (m): 1 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 1 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 3.46 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE:	PLAN NUMBER:
HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	

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CREEK	STABLE SWAMP CREEK
LOCATION	FRENEY ST PIPE BRIDGE, ROCKLEA

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	345.1	61.1	361.4	5.89	10	25.6	572.5	2.4	2.1
50	314.7	57.1	333.8	5.68	20	25.6	494.9	2.2	2.2
20	279.4	55.6	300.2	5.41	10	25.6	398.1	2.2	2.3
10	239.1	55.2	259.4	5.21	10	25.6	331.8	2.1	2.3
5	217.2	55.3	240.4	5.02	10	25.6	307.4	2.2	2.2
2	172.9	56.5	194.5	4.66	20	25.6	159.5	2.2	2.2

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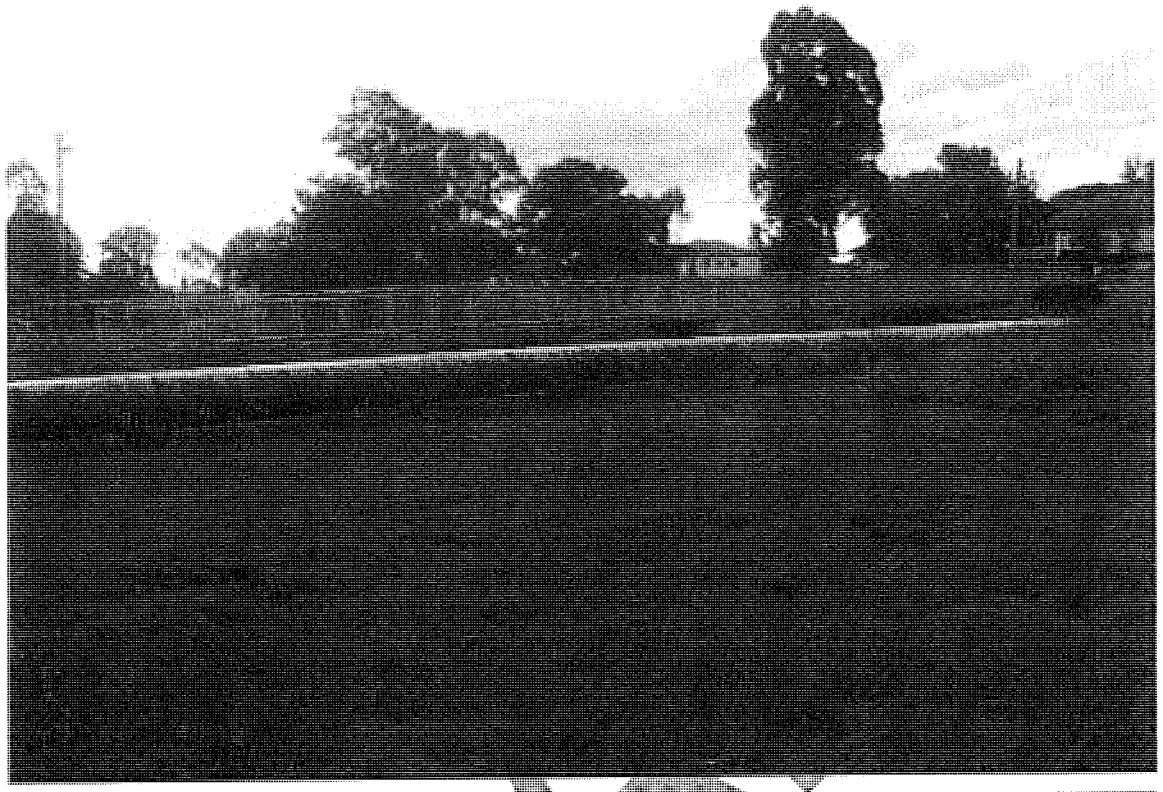

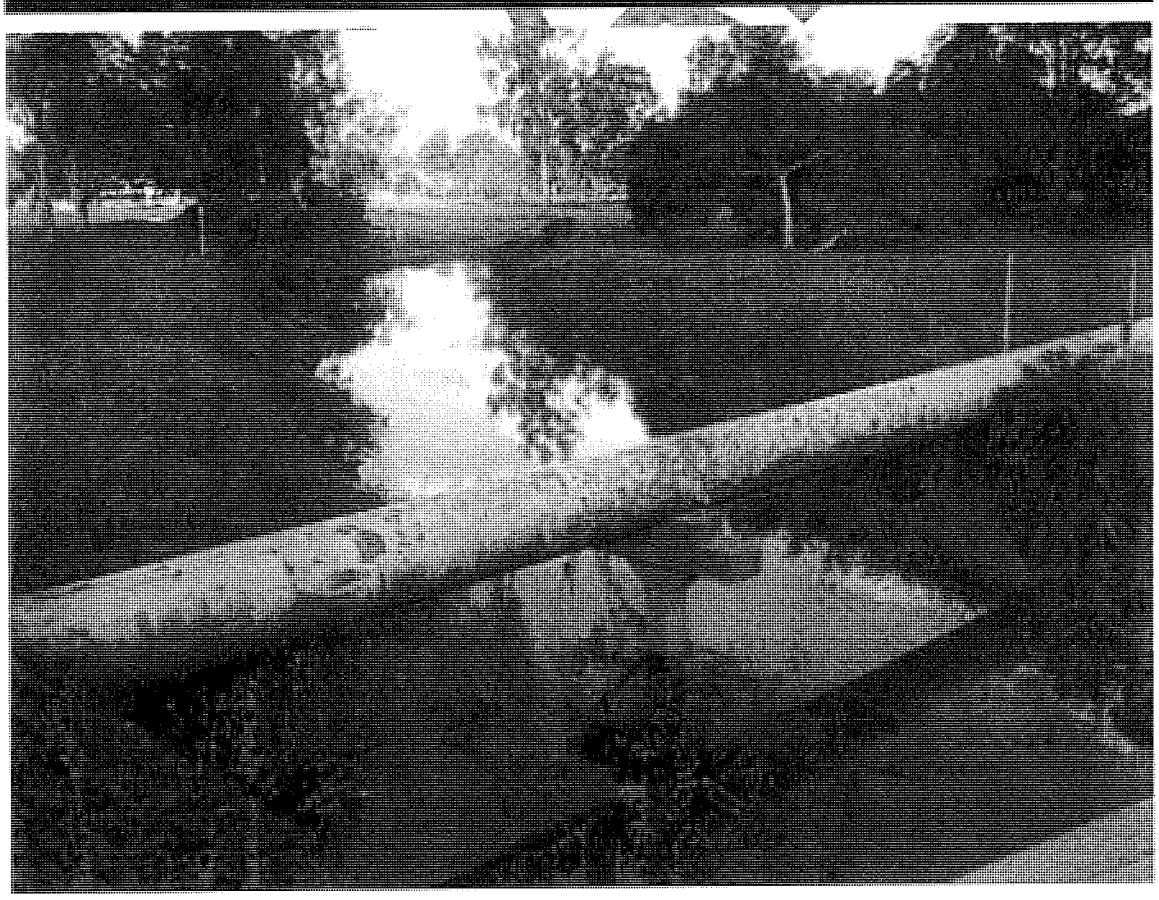

HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**FRENEY ST PEDESTRIAN BRIDGE, ROCKLEA**

DATE OF SURVEY:	UBD REF: 199 K7
AERIAL PHOTO No:	STRUCTURE ID: Freney Street
BCC XS No: SS235	AMTD (m): 7034
STRUCTURE DESCRIPTION: PEDESTRIAN BRIDGE	
STRUCTURE SIZE 2 SPANS / 19.5m For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 1.1	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 1.1 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 3.6 LENGTH OF CULVERT BARREL AT OBVERT (m): 3.6 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 3.6 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 5.5 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: B9858

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CREEK	STABLE SWAMP CREEK
LOCATION	FRENEY ST PEDESTRIAN BRIDGE, ROCKLEA

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	328.3	67.0	367.1	5.86	10	44.4	379.0	2.0	1.9
50	286.1	60.3	329.6	5.66	10	44.4	330.6	1.8	1.9
20	257.8	58.1	287.1	5.39	10	44.4	268.4	1.7	1.9
10	214.1	58.0	257.4	5.21	20	44.4	230.9	1.7	2.0
5	193.2	59.8	238.4	4.99	10	44.4	197.1	1.7	2.0
2	146.9	64.6	193.0	4.61	10	44.4	140.9	1.7	2.1

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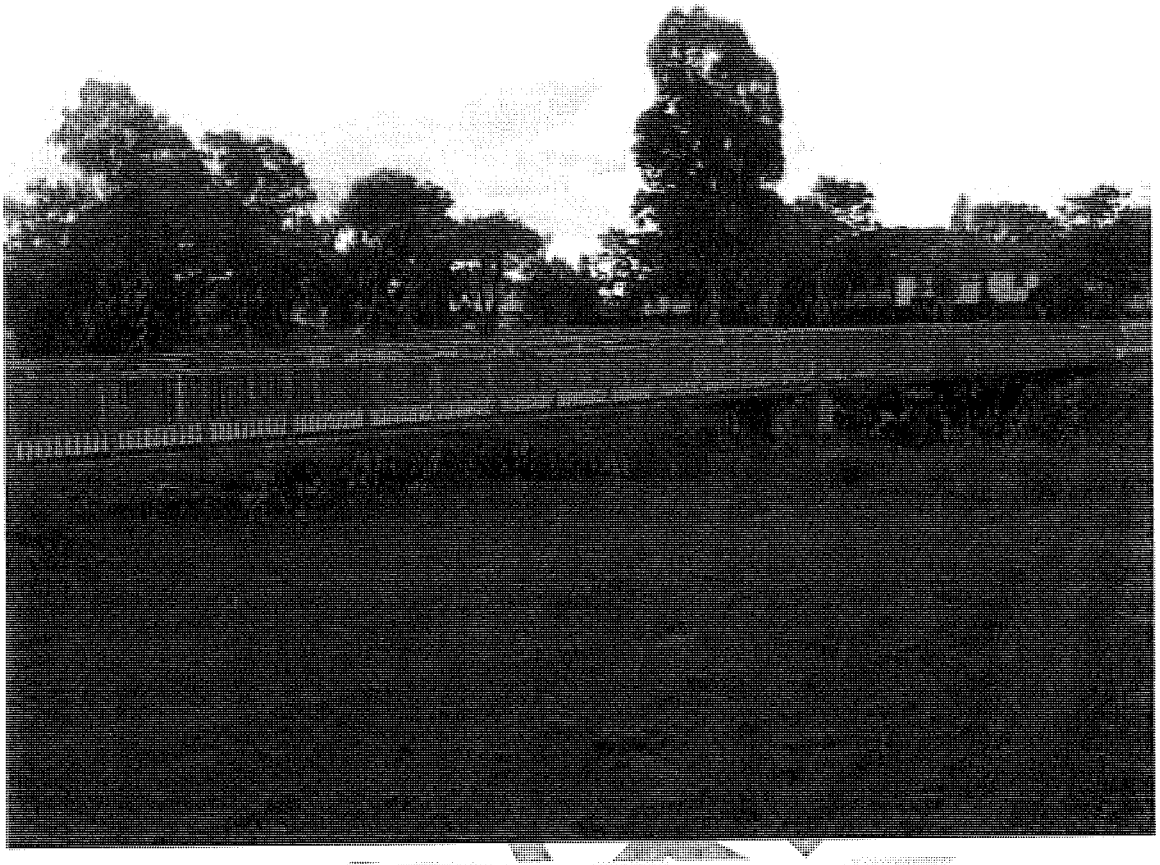



HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**MARSHALL RD BRIDGE, ROCKLEA**

DATE OF SURVEY:	UBD REF: 199 I9
AERIAL PHOTO No:	STRUCTURE ID: Marshall Road
BCC XS No: SS180	AMTD (m): 7803
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 5 / 2650 x 1990 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 0.24	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 0.23 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 14.7 LENGTH OF CULVERT BARREL AT OBVERT (m): 14.7 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m):14.7 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 2.92 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: W8217

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CREEK	STABLE SWAMP CREEK
LOCATION	MARSHALL RD BRIDGE, ROCKLEA

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	311.6	59.7	339.3	5.65	10	26.4	405.7	2.3	2.0
50	278.6	57.9	303.8	5.44	10	26.4	358.5	2.2	2.1
20	235.9	56.2	258.4	5.15	10	26.4	338.8	2.1	2.1
10	203.9	55.6	227.2	4.93	10	26.4	253.5	2.1	2.2
5	188.0	53.9	215.7	4.72	10	26.4	211.8	2.0	2.2
2	152.6	57.8	183.1	4.32	10	26.4	144.8	2.2	2.2

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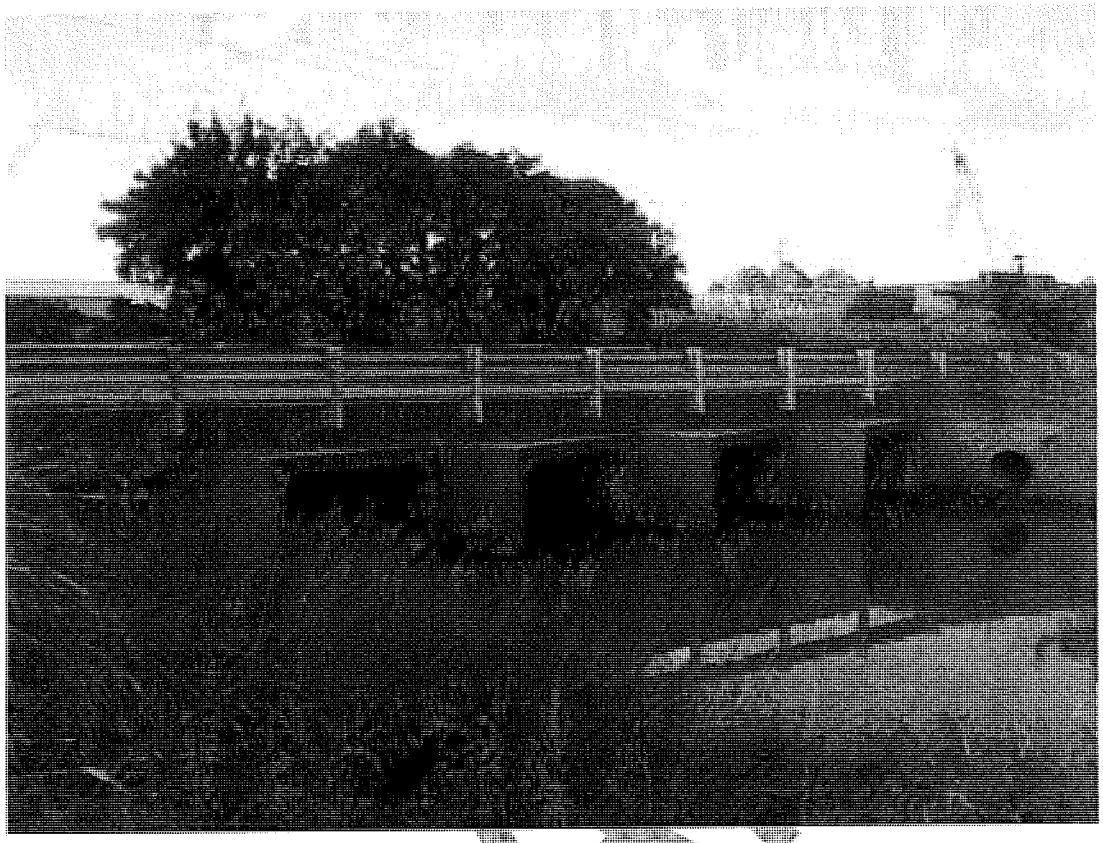



HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**STABLE SWAMP CREEK**
LOCATION	**IPSWICH MWY BRIDGE, ROCKLEA**

DATE OF SURVEY:	UBD REF: 199 H8
AERIAL PHOTO No:	STRUCTURE ID: Ipswich Motorway
BCC XS No: SS130	AMTD (m): 8047
STRUCTURE DESCRIPTION: PIPE CULVERTS	
STRUCTURE SIZE 3 / 7250 diameter For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: -0.53	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: -0.56 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 107 LENGTH OF CULVERT BARREL AT OBVERT (m): 107 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 107 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 5.79 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: MRD219229

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CREEK	STABLE SWAMP CREEK
LOCATION	IPSWICH MWY BRIDGE, ROCKLEA

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	0.0	338.0	338.0	5.63	460	123.2	0.0	2.7	0.0
50	0.0	301.7	301.7	5.39	370	121.7	0.0	2.5	0.0
20	0.0	254.3	254.3	5.07	270	119.0	0.0	2.1	0.0
10	0.0	223.4	223.4	4.86	220	116.5	0.0	1.9	0.0
5	0.0	196.1	196.1	4.64	170	113.6	0.0	1.7	0.0
2	0.0	152.9	152.9	4.23	120	106.6	0.0	1.5	0.0

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**SHELLEYS CREEK**
LOCATION	**FORESTLEA PLACE, SUNNYBANK HILLS**

DATE OF SURVEY:	UBD REF: 220 G10
AERIAL PHOTO No:	STRUCTURE ID: Forestlea Place
BCC XS No: SS1330	AMTD (m): 10043
STRUCTURE DESCRIPTION: PIPE CULVERT	
STRUCTURE SIZE 1 / 450 diameter For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 63.02 DOWNSTREAM INVERT LEVEL: 62.92 For culverts give floor level.	UPSTREAM OBVERT LEVEL: DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 2.7 LENGTH OF CULVERT BARREL AT OBVERT (m): 2.7 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 2.7 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 64.56 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER:

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CREEK	SHELLEYS CREEK
LOCATION	FORESTLEA PL, SUNNYBANK HILLS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	19.4	0.7	20.1	65.10	970	0.2	11.3	4.1	1.7
50	16.6	0.6	17.2	65.05	1010	0.2	10.1	4.0	1.6
20	13.4	0.6	14.0	65.00	1070	0.2	8.7	4.0	1.5
10	11.4	0.6	12.0	64.97	1100	0.2	7.7	3.9	1.5
5	9.6	0.6	10.2	64.93	1140	0.2	6.8	3.9	1.4
2	6.8	0.6	7.4	64.88	1210	0.2	5.3	3.8	1.3

DRAFT

NO PICTURES

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**SHELLEYS CREEK**
LOCATION	**HELLAWELL RD, SUNNYBANK HILLS**

DATE OF SURVEY:	UBD REF: 220 H9
AERIAL PHOTO No:	STRUCTURE ID: Hellawell Rd Culv
BCC XS No: SS1290	AMTD (m): 10392
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 3 / 3050 x 1850 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 57.73	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 57.63 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 19.7 LENGTH OF CULVERT BARREL AT OBVERT (m): 19.7 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher	
WEIR WIDTH (m): 19.7 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 60.01 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: W6626

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CREEK	SHELLEYS CREEK
LOCATION	HELLAWELL RD, SUNNYBANK HILLS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	6.4	46.9	53.2	60.60	310	16.9	4.2	2.7	1.6
50	2.4	13.3	45.6	60.39	260	16.9	1.9	2.5	1.3
20	0.3	36.7	37.0	60.11	180	16.9	0.3	2.2	1.0
10	0.0	31.4	31.4	59.90	120	16.9	0.0	1.9	0.0
5	0.0	26.8	26.8	59.72	70	16.9	0.0	1.7	0.0
2	0.0	18.9	18.9	59.41	30	15.3	0.0	1.8	0.0

DRAFT





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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**SHELLEYS CREEK**
LOCATION	**BASIN CULVERT, SUNNYBANK HILLS**

DATE OF SURVEY:	UBD REF: 220 H7
AERIAL PHOTO No:	STRUCTURE ID: basin_culv
BCC XS No: SS1250	AMTD (m): 10517
STRUCTURE DESCRIPTION: BOX CULVERT	
STRUCTURE SIZE 1 / 2400 x 1200 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 55.76	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 55.71 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 6 LENGTH OF CULVERT BARREL AT OBVERT (m): 6 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 6 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 58.7 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER:

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CREEK	SHELLEYS CREEK
LOCATION	BASIN CULVERT, SUNNYBANK HILLS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	56.1	13.7	69.8	59.38	2700	2.9	28.6	4.8	2.0
50	46.3	13.5	59.8	59.30	2730	2.9	25.2	4.7	1.8
20	35.2	13.2	48.5	59.21	2770	2.9	20.9	4.6	1.7
10	28.2	13.0	41.2	59.14	2790	2.9	18.0	4.5	1.6
5	22.2	12.9	35.1	59.08	2810	2.9	15.3	4.5	1.5
2	12.2	12.5	24.7	58.96	2850	2.9	10.1	4.3	1.2

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NO PICTURES

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**SHELLEYS CREEK**
LOCATION	**KINGMAN ST FOOTBRIDGE, SUNNYBANK HILLS**

DATE OF SURVEY:	UBD REF: 220 I6
AERIAL PHOTO No:	STRUCTURE ID: Kingman St Footbridge
BCC XS No: SS1204	AMTD (m): 10964
STRUCTURE DESCRIPTION: BRIDGE	
STRUCTURE SIZE 2 SPANS / 15.5m For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 49.3	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 49.25 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 2.62 LENGTH OF CULVERT BARREL AT OBVERT (m): 2.62 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 2.62 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 51.7 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: 01-JUL-1985 HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: B1200

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CREEK	SHELLEYS CREEK
LOCATION	KINGMAN ST FOOTBRIDGE, SUNNYBANK HILLS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	1.8	92.8	94.6	52.08	40	34.6	1.4	3.1	1.3
50	0.4	80.2	80.7	51.90	40	30.7	0.5	3.1	0.9
20	0.0	64.6	64.6	51.67	50	24.8	0.0	3.1	0.0
10	0.0	54.6	54.6	51.51	60	20.9	0.0	3.0	0.0
5	0.0	45.8	45.8	51.37	70	17.1	0.0	2.9	0.0
2	0.0	31.5	31.5	51.11	110	11.9	0.0	2.6	0.0

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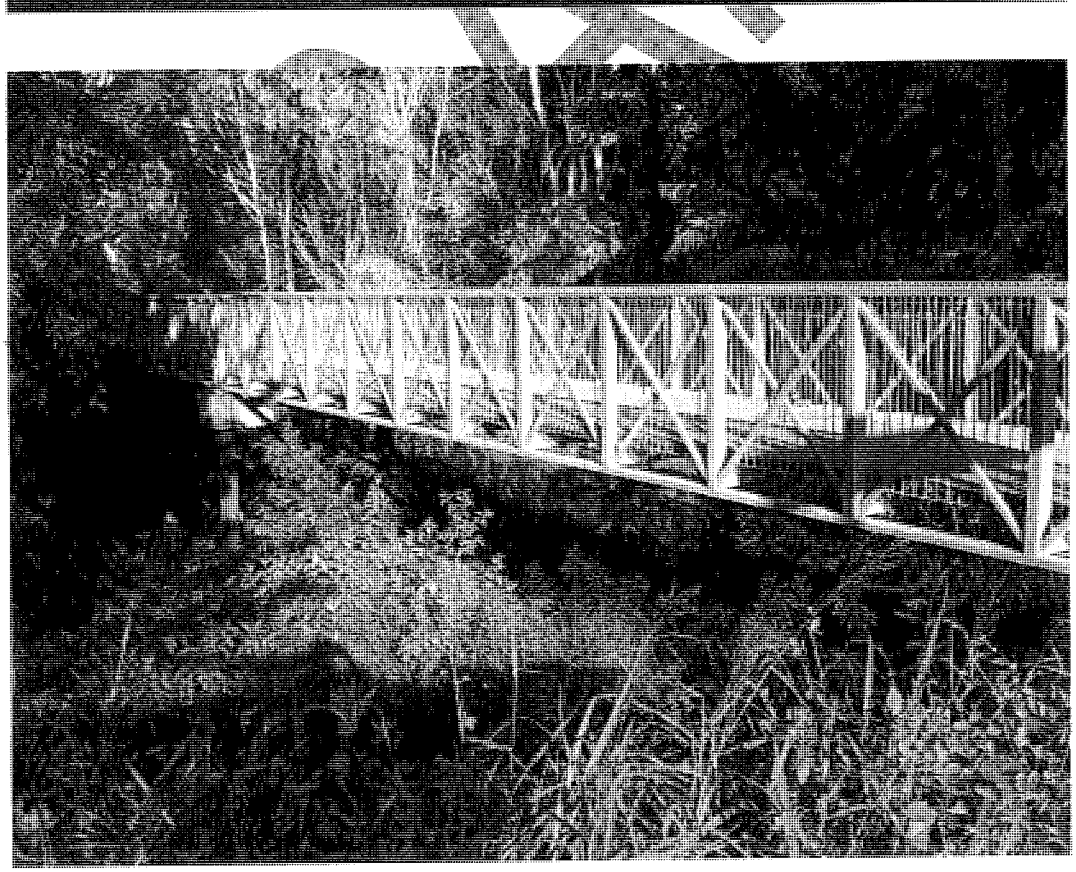

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**SHELLEYS CREEK**
LOCATION	**CHILTON ST, SUNNYBANK HILLS**

DATE OF SURVEY:	UBD REF: 220 J4
AERIAL PHOTO No:	STRUCTURE ID: Chilton Street Culvert
BCC XS No: SS1150	AMTD (m): 11448
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 3 / 3050 x 1850 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 43.91	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 43.94 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 17.2 LENGTH OF CULVERT BARREL AT OBVERT (m): 17.2 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 17.2 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 46.45 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE:	PLAN NUMBER: W5579
HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable.	
ADDITIONAL COMMENTS:	

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CREEK	SHELLEYS CREEK
LOCATION	CHILTON ST, SUNNYBANK HILLS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	64.9	42.1	106.9	48.06	260	16.9	23.9	2.5	2.7
50	51.0	40.2	91.0	47.89	240	16.9	19.8	2.4	2.6
20	35.4	37.6	72.8	47.67	220	16.9	15.0	2.2	2.3
10	25.4	35.7	60.9	47.49	200	16.9	11.6	2.1	2.2
5	17.0	33.8	50.6	47.30	180	16.9	8.6	2.0	2.0
2	4.6	29.5	34.0	46.89	140	16.9	3.3	1.7	1.4

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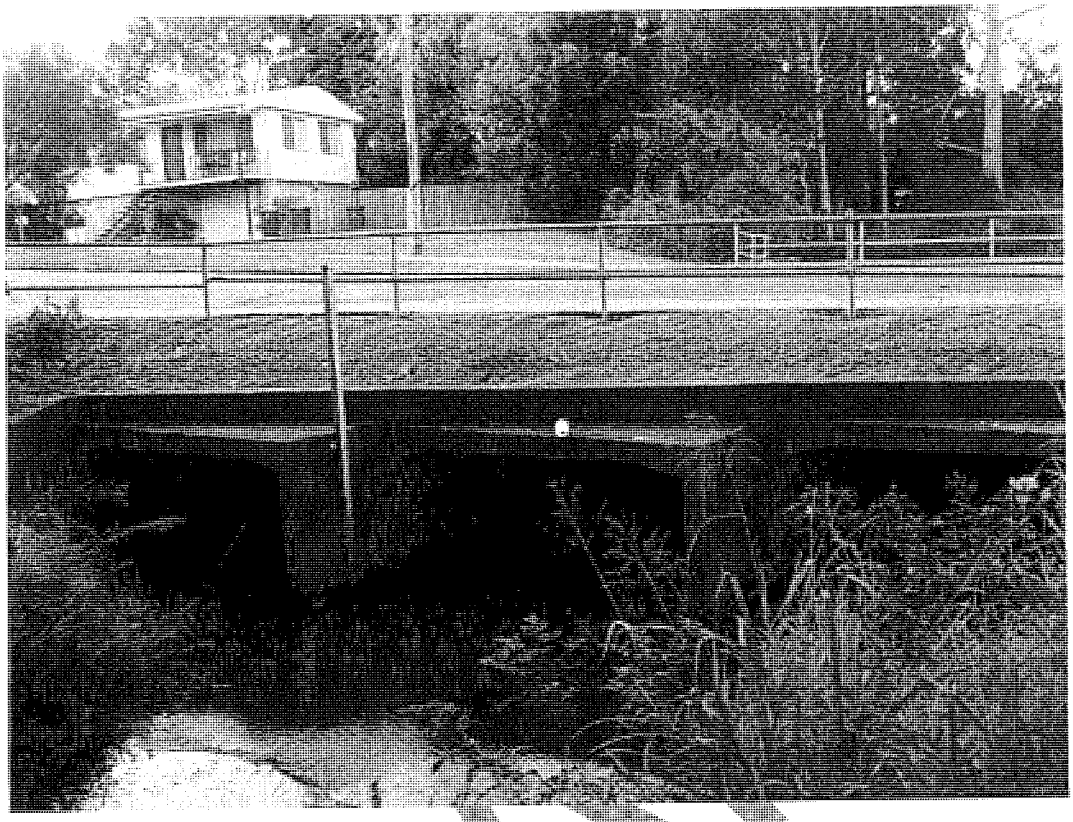

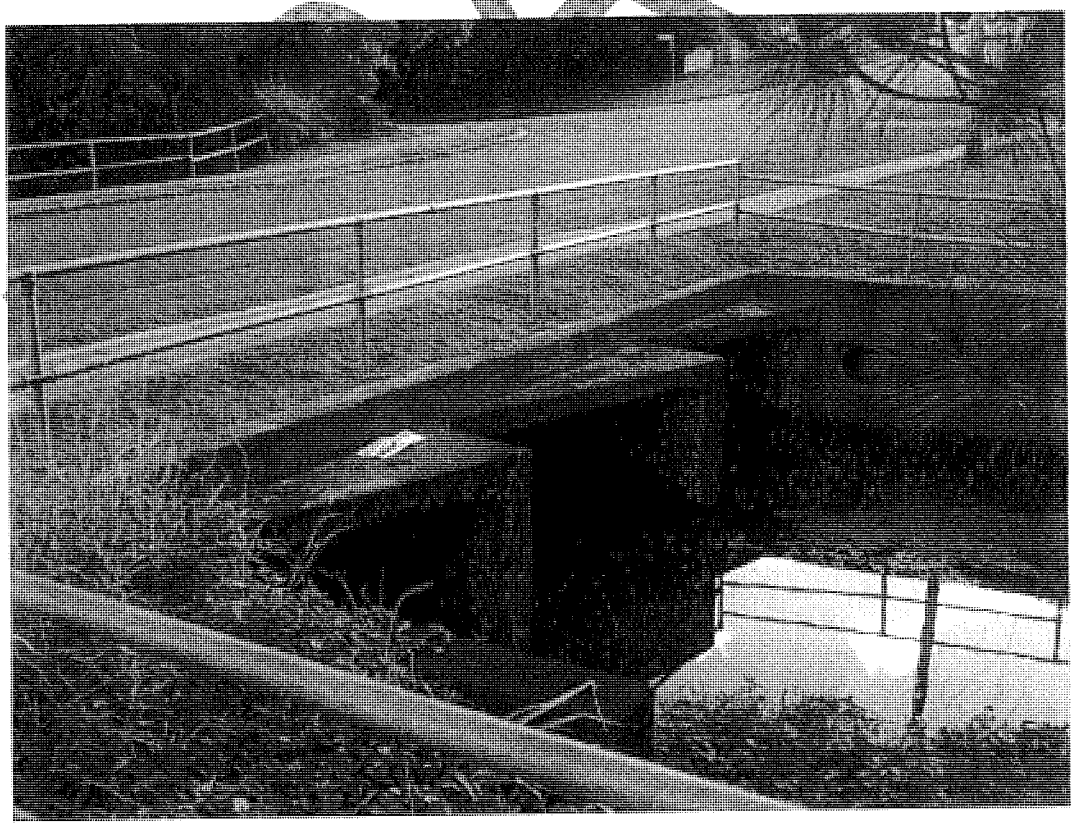

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**SHELLEYS CREEK**
LOCATION	**LANG ST PEDESTRIAN BRIDGE, SUNNYBANK HILLS**

DATE OF SURVEY:	UBD REF: 220 K3
AERIAL PHOTO No:	STRUCTURE ID: Lang Street
BCC XS No: SS1090	AMTD (m): 11864
STRUCTURE DESCRIPTION: PEDESTRIAN BRIDGE	
STRUCTURE SIZE 1 / 12m For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 42.28 DOWNSTREAM INVERT LEVEL: 42.28 For culverts give floor level.	UPSTREAM OBVERT LEVEL: DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 2.44 LENGTH OF CULVERT BARREL AT OBVERT (m): 2.44 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 2.44 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 42.89 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: -1-JUL-1966 HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: B1220

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CREEK	SHELLEYS CREEK
LOCATION	LANG ST PEDESTRIAN BRIDGE, SUNNYBANK HILLS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	40.9	37.6	115.0	43.97	190	14.9	18.5	2.5	2.3
50	28.1	35.4	97.9	43.81	160	14.9	13.6	2.3	2.1
20	16.3	31.4	78.1	43.60	110	14.9	8.8	2.1	1.9
10	10.2	27.7	64.9	43.46	70	14.9	6.2	1.9	1.7
5	6.5	24.9	53.5	43.34	50	14.9	4.4	1.7	1.5
2	2.2	17.8	35.7	43.14	20	14.9	1.9	1.2	1.1

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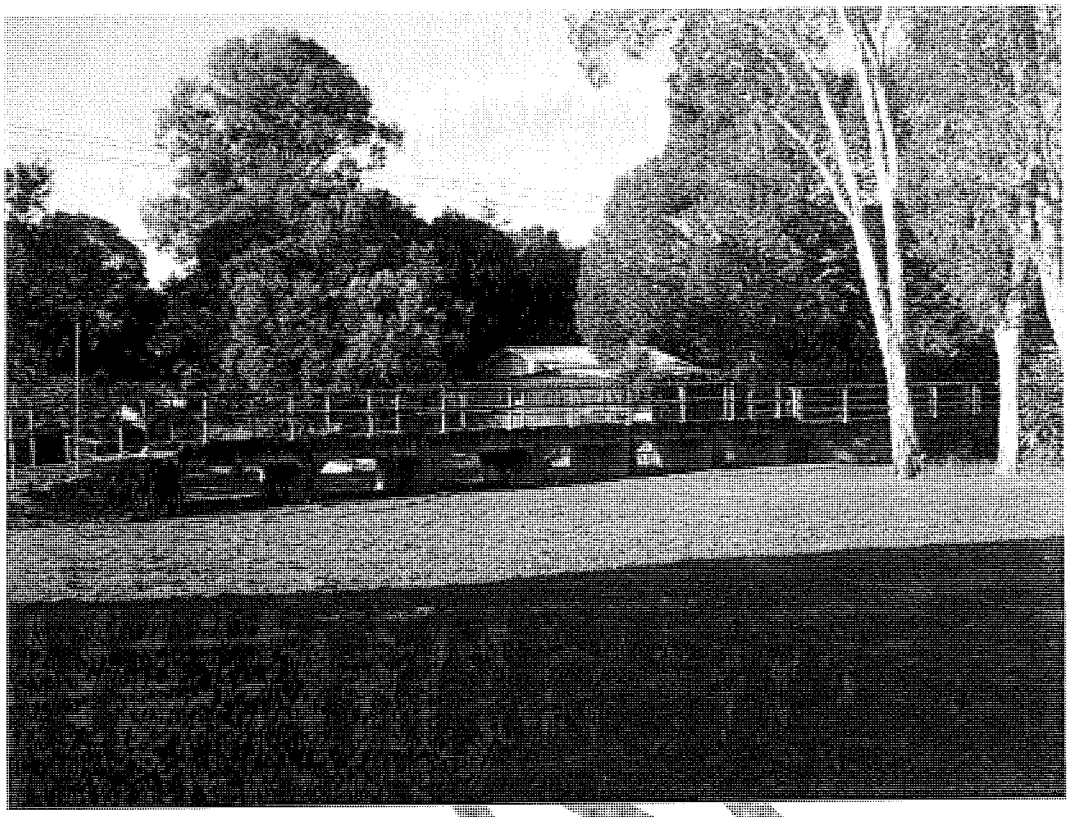



HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**SHELLEYS CREEK**
LOCATION	**LANG ST DROP STRUCTURE, SUNNYBANK HILLS**

DATE OF SURVEY:	UBD REF: 220 K3
AERIAL PHOTO No:	STRUCTURE ID: Lang Street
BCC XS No: SS1080	AMTD (m): 11864
STRUCTURE DESCRIPTION: DROP STRUCTURE	
STRUCTURE SIZE 1 / 12300 x 1210 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 41.67 DOWNSTREAM INVERT LEVEL: 41.67 For culverts give floor level.	UPSTREAM OBVERT LEVEL: DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 2.44 LENGTH OF CULVERT BARREL AT OBVERT (m): 2.44 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 2.44 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 41.33 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER:

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CREEK	SHELLEYS CREEK
LOCATION	LANG ST DROP STRUCTURE, SUNNYBANK HILLS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	40.9#	36.5	115.0#	43.97#	190#	14.6	18.5#	2.5	2.3#
50	28.1#	34.4	97.9#	43.81#	160#	14.6	13.6#	2.3	2.1#
20	16.3#	30.4	78.1#	43.60#	110#	14.6	8.8#	2.1	1.9#
10	10.2#	26.9	64.9#	43.46#	70#	14.6	6.2#	1.8	1.7#
5	6.5#	22.2	53.5#	43.34#	50#	14.6	4.4#	1.5	1.5#
2	2.2#	15.8	35.7#	43.14#	20#	14.6	1.9#	1.2	1.1#

 # These values are used from the previous structure dataset (LANG ST DROP STRUCTURE, SUNNYBANK HILLS, AMTD = 11864) as they have a common weir. Also, the afflux is calculated using both structures for the same location.

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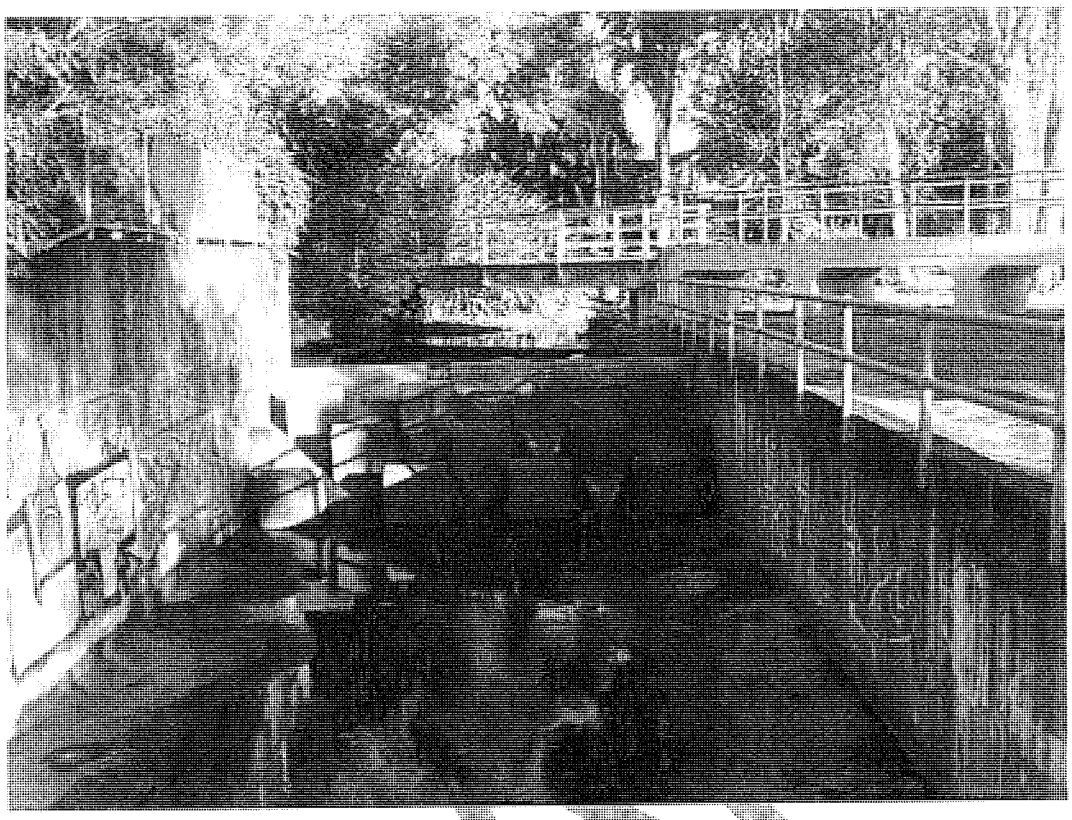

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**SHELLEYS CREEK**
LOCATION	**BEENLEIGH RD, SUNNYBANK**

DATE OF SURVEY:	UBD REF: 220 K3
AERIAL PHOTO No:	STRUCTURE ID: Beenleigh Road
BCC XS No: SS1050	AMTD (m): 12045
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 5 / 2750 x 1860 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 39.38	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 39 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 26.6 LENGTH OF CULVERT BARREL AT OBVERT (m): 26.6 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 26.6 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 41.45 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE:	PLAN NUMBER: W6381
HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable.	
ADDITIONAL COMMENTS:	

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CREEK	SHELLEYS CREEK
LOCATION	BEENLEIGH RD, SUNNYBANK

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	21.2	99.1	120.3	42.26	1130	24.1	12.2	4.1	1.7
50	9.9	92.2	102.1	42.07	1110	22.8	6.2	4.0	1.6
20	0.7	80.5	81.1	41.64	900	20.9	0.7	3.9	0.9
10	0.0	67.8	67.8	41.25	680	18.6	0.0	3.6	0.0
5	0.0	55.8	55.8	41.02	600	16.3	0.0	3.4	0.0
2	0.0	37.0	37.0	40.62	510	12.4	0.0	3.0	0.0

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**NORTH BRANCH**
LOCATION	**BARHAM ST, COOPERS PLAINS**

DATE OF SURVEY:	UBD REF: 200 E13
AERIAL PHOTO No:	STRUCTURE ID: Barham St
BCC XS No: SS9230	AMTD (m): 76
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 3 / 1150 x 900 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 15.68	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 15.66 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 4.82 LENGTH OF CULVERT BARREL AT OBVERT (m): 4.82 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 4.82 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 16.99 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: W5501/111A

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CREEK	NORTH BRANCH
LOCATION	BARHAM ST, COOPERS PLAINS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	95.5	8.8	101.2	19.17	320	3.1	34.6	2.8	2.8
50	75.8	8.8	82.1	19.06	420	3.1	27.9	2.8	2.7
20	49.4	8.8	56.8	18.84	580	3.1	18.5	2.8	2.7
10	31.8	8.8	39.7	18.58	660	3.1	12.3	2.8	2.6
5	20.3	8.8	28.7	18.32	710	3.1	8.4	2.8	2.5
2	9.0	8.7	17.8	17.94	750	3.1	4.5	2.8	2.3

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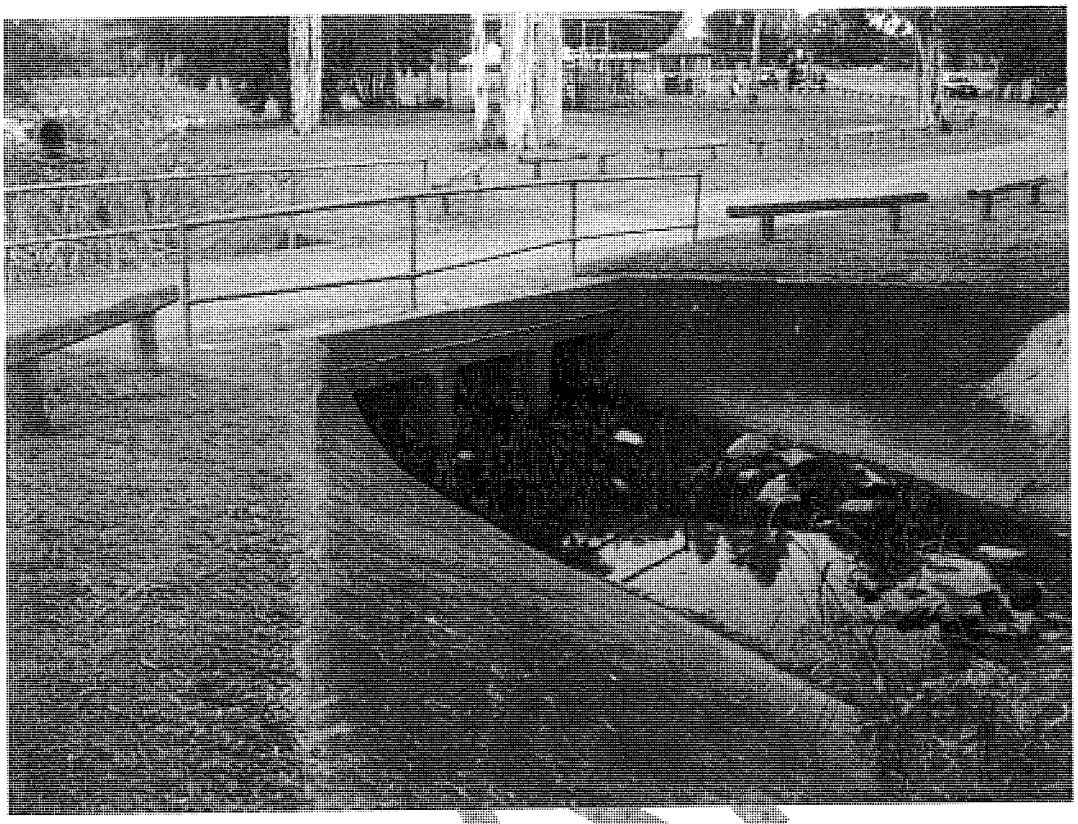

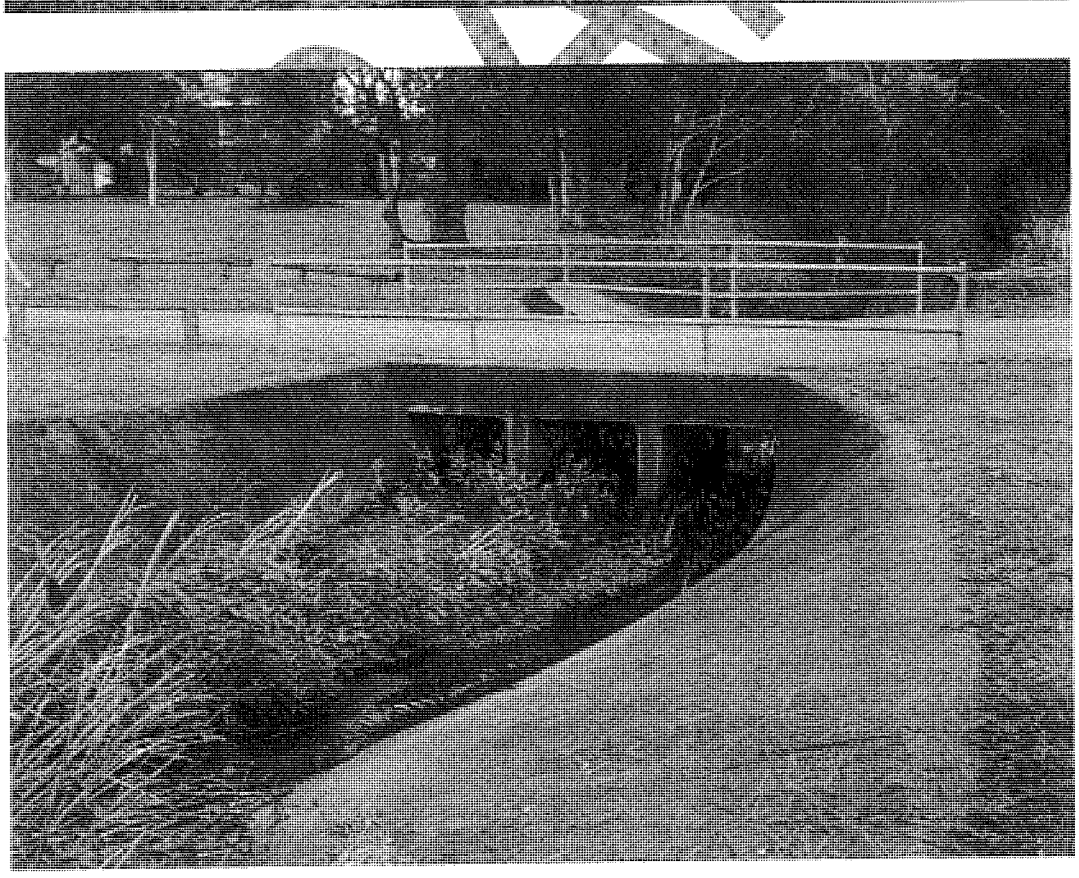

HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**NORTH BRANCH**
LOCATION	**PERINGA ST FOOTBRIDGE, COOPERS PLAINS**

DATE OF SURVEY:	UBD REF: 200 E13
AERIAL PHOTO No:	STRUCTURE ID: Peringa St Footbridge
BCC XS No: SS9200	AMTD (m): 147
STRUCTURE DESCRIPTION: BRIDGE	
STRUCTURE SIZE SINGLE SPAN / 14m For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 14.79	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 14.55 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 2.62 LENGTH OF CULVERT BARREL AT OBVERT (m): 2.62 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 2.62 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 16.88 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: 01-JUL-1983 PLAN NUMBER: B1600 HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	

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CREEK	NORTH BRANCH
LOCATION	PERINGA ST FOOTBRIDGE, COOPERS PLAINS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	66.5	46.8	100.5	18.43	220	19.7	26.7	2.5	2.5
50	41.4	45.9	81.4	18.21	330	19.7	17.6	2.5	2.4
20	13.3	44.1	56.1	17.73	350	19.7	6.9	2.5	2.0
10	2.4	37.2	39.5	17.28	290	19.7	1.8	2.5	1.4
5	0.0	28.6	28.6	16.81	170	15.2	0.0	2.4	0.0
2	0.0	17.8	17.8	16.38	190	10.0	0.0	2.5	0.0

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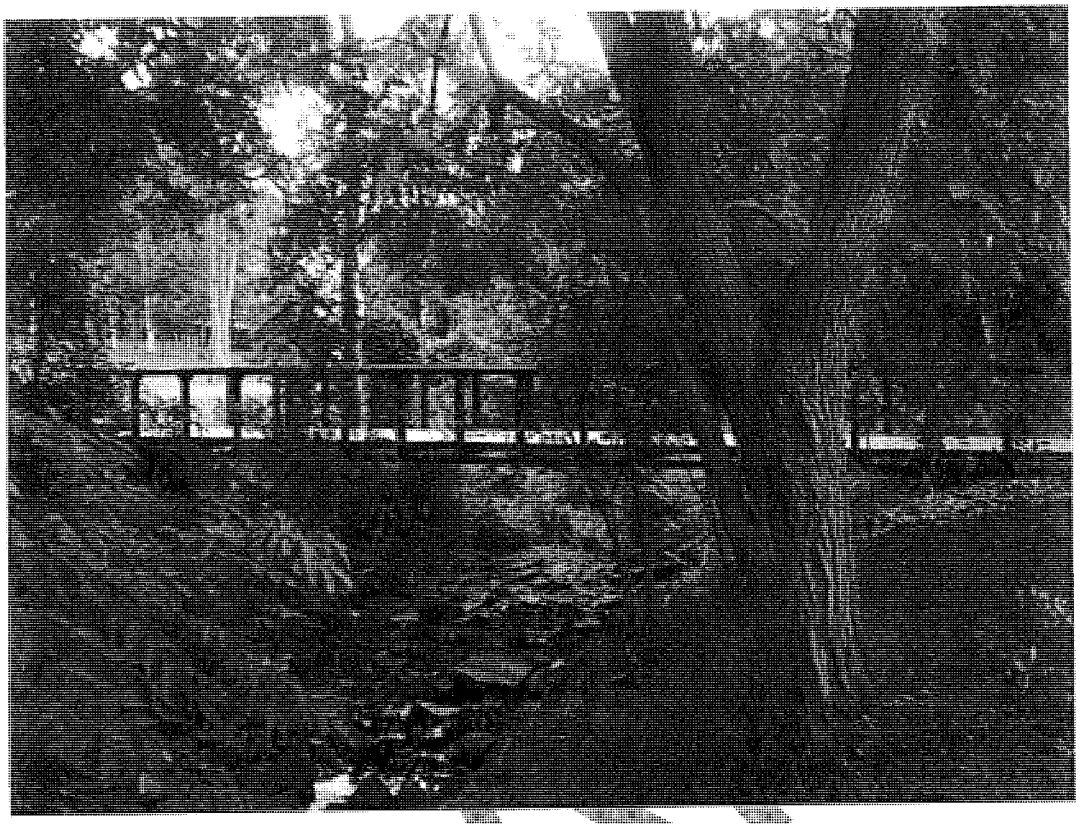

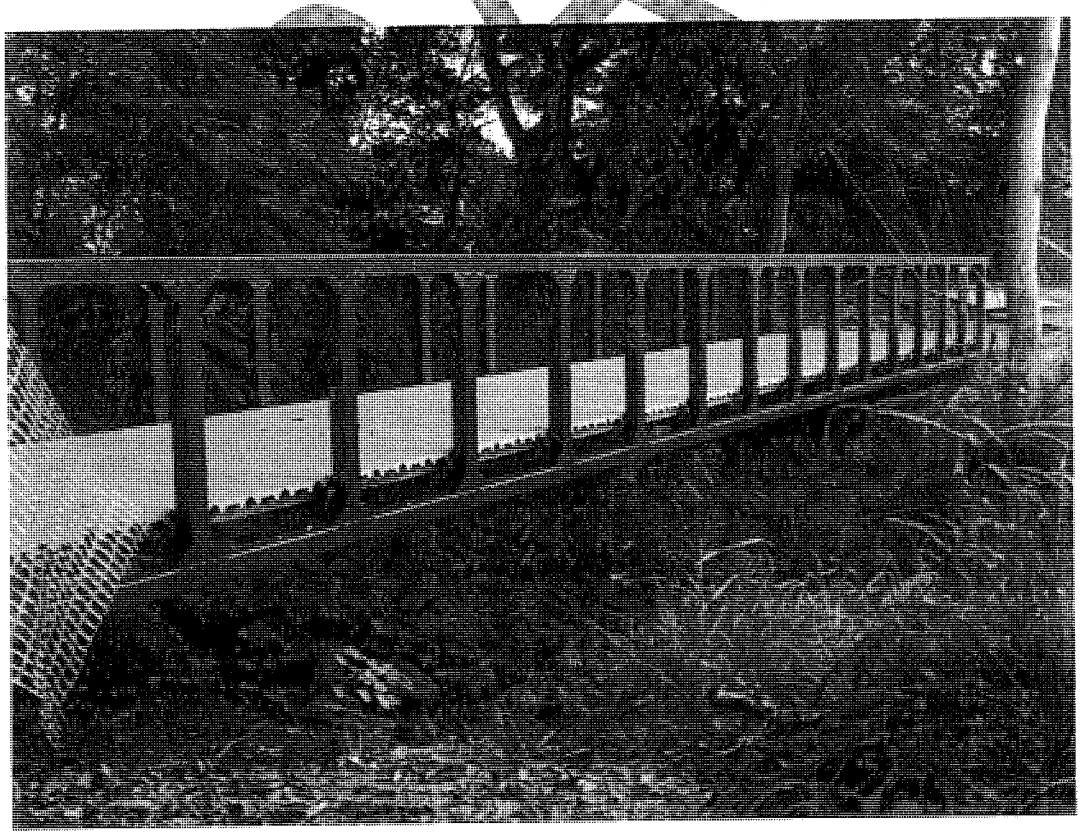

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**NORTH BRANCH**
LOCATION	**BARODA ST FOOTBRIDGE, COOPERS PLAINS**

DATE OF SURVEY:	UBD REF: 200 E13
AERIAL PHOTO No:	STRUCTURE ID: Baroda St Footbridge
BCC XS No: SS9170	AMTD (m): 308
STRUCTURE DESCRIPTION: BRIDGE	
STRUCTURE SIZE For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 13.08 DOWNSTREAM INVERT LEVEL: 13.08 For culverts give floor level.	UPSTREAM OBVERT LEVEL: DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 3.54 LENGTH OF CULVERT BARREL AT OBVERT (m): 3.54 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 3.54 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 15.15 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER:

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CREEK	NORTH BRANCH
LOCATION	BARODA ST FOOTBRIDGE, COOPERS PLAINS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	86.4	14.3	100.1	17.82	1010	5.7	16.7	2.9	5.2
50	68.0	14.0	81.1	17.43	860	5.7	16.7	2.9	4.1
20	43.7	14.0	56.3	16.91	830	5.7	14.9	2.9	3.0
10	28.0	14.0	40.0	16.53	770	5.7	10.9	2.9	2.6
5	15.7	13.9	29.1	16.18	960	5.7	7.3	2.9	2.2
2	4.5	13.9	18.4	15.73	1070	5.7	3.1	2.9	1.5

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NO PICTURES

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**NORTH BRANCH**
LOCATION	**MUSGRAVE RD, COOPERS PLAINS**

DATE OF SURVEY:	UBD REF: 200 D13
AERIAL PHOTO No:	STRUCTURE ID: Musgrave Rd 2
BCC XS No:	AMTD (m): 392
STRUCTURE DESCRIPTION: PIPE CULVERTS	
STRUCTURE SIZE 6 / 1500 diameter For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 12.765	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 12.57 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 16.8 LENGTH OF CULVERT BARREL AT OBVERT (m): 16.8 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 16.8 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 15.19 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: W1998

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CREEK	NORTH BRANCH
LOCATION	MUSGRAVE RD, COOPERS PLAINS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	93.4	32.5	96.8	16.55	10	10.6	246.9	3.1	1.7
50	72.6	32.9	76.2	16.32	10	10.6	184.6	3.1	1.6
20	45.5	34.4	54.0	15.81	10	10.6	65.5	3.2	1.6
10	8.2	34.6	39.6	15.46	400	10.6	7.2	3.3	1.2
5	0.0	29.1	29.1	14.77	320	10.6	0.0	2.7	0.0
2	0.0	18.4	18.4	14.17	110	9.8	0.0	2.7	0.0

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**NORTH BRANCH**
LOCATION	**ORANGE GROVE RD, COOPERS PLAINS**

DATE OF SURVEY:	UBD REF: 200 D13
AERIAL PHOTO No:	STRUCTURE ID: Orange Grove Rd
BCC XS No:	AMTD (m): 484
STRUCTURE DESCRIPTION: PIPE CULVERTS	
STRUCTURE SIZE 6 / 1500 diameter For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 12.51	UPSTREAM OBVERT LEVEL:
DOWNSTREAM INVERT LEVEL: 12.35 For culverts give floor level.	DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 22 LENGTH OF CULVERT BARREL AT OBVERT (m): 22 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 22 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 15.56 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: W1998

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CREEK	NORTH BRANCH
LOCATION	ORANGE GROVE RD, COOPERS PLAINS

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	49.9	53.1	97.6	16.50	1010	10.6	24.0	5.0	2.2
50	26.9	53.0	76.3	16.27	130	10.6	14.9	5.0	1.9
20	1.3	50.4	51.7	15.74	1140	10.6	1.5	4.8	0.9
10	0.0	40.3	40.3	14.98	690	10.6	0.0	3.8	0.0
5	0.0	29.7	29.7	14.32	340	8.8	0.0	3.4	0.0
2	0.0	21.0	21.0	13.93	250	7.3	0.0	2.9	0.0

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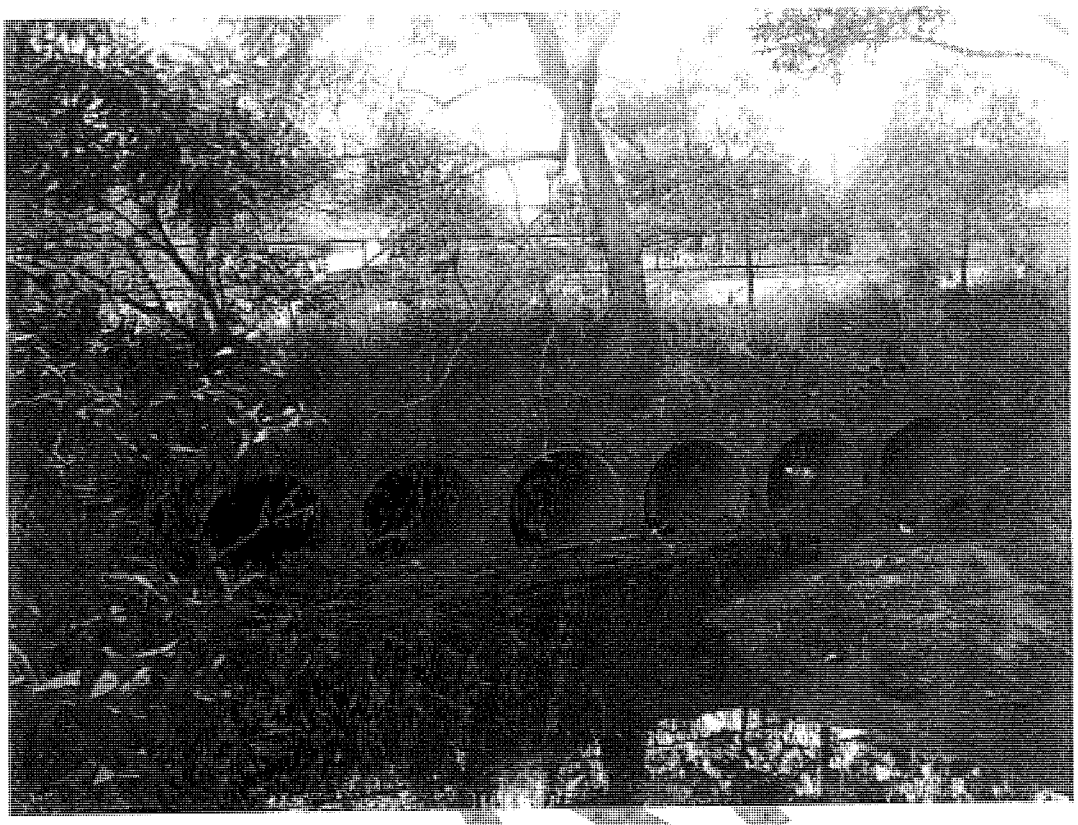



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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**NORTH BRANCH**
LOCATION	**PERRIN PLACE, SALISBURY**

DATE OF SURVEY:	UBD REF: 199 R11
AERIAL PHOTO No:	STRUCTURE ID: Perrin Place
BCC XS No: SS9042	AMTD (m): 1594
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 3 / 2040 x 2700 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 6.15 DOWNSTREAM INVERT LEVEL: 6.16 For culverts give floor level.	UPSTREAM OBVERT LEVEL: DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 14.6 LENGTH OF CULVERT BARREL AT OBVERT (m): 14.6 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 14.6 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 9.56 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: 04-1998 HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: WP1020

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CREEK	NORTH BRANCH
LOCATION	PERRIN PLACE, SALISBURY

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	22.9	45.8	114.3	10.31	250	16.5	12.3	2.8	1.9
50	5.2	42.1	90.1	9.93	190	16.5	4.2	2.6	1.3
20	0.0	35.4	72.9	9.37	90	16.5	0.0	2.3	0.0
10	0.0	30.7	63.2	8.99	50	16.5	0.0	2.2	0.0
5	0.0	26.8	55.2	8.67	60	14.6	0.0	2.1	0.0
2	0.0	21.1	43.5	8.31	50	12.5	0.0	2.0	0.0

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**NORTH BRANCH**
LOCATION	**PERRIN PLACE, SALISBURY**

DATE OF SURVEY:	UBD REF: 200 R11
AERIAL PHOTO No:	STRUCTURE ID: Perrin Place
BCC XS No: SS9042	AMTD (m): 1594
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 2 / 3200 x 2920 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 6.15 DOWNSTREAM INVERT LEVEL: 6.16 For culverts give floor level.	UPSTREAM OBVERT LEVEL: DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 14.6 LENGTH OF CULVERT BARREL AT OBVERT (m): 14.6 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 14.6 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 9.56 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: APR-1998 HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: WP1020

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CREEK	NORTH BRANCH
LOCATION	PERRIN PLACE, SALISBURY

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	22.9	52.4	114.3	10.31	250	18.7	12.3	4.2	1.9
50	5.2	45.4	90.1	9.93	190	18.7	4.2	2.6	1.3
20	0.0	37.5	72.9	9.37	90	18.7	0.0	2.3	0.0
10	0.0	32.5	63.2	8.99	50	17.5	0.0	2.2	0.0
5	0.0	28.4	55.2	8.67	60	15.2	0.0	2.1	0.0
2	0.0	22.5	43.5	8.31	50	13.1	0.0	2.1	0.0

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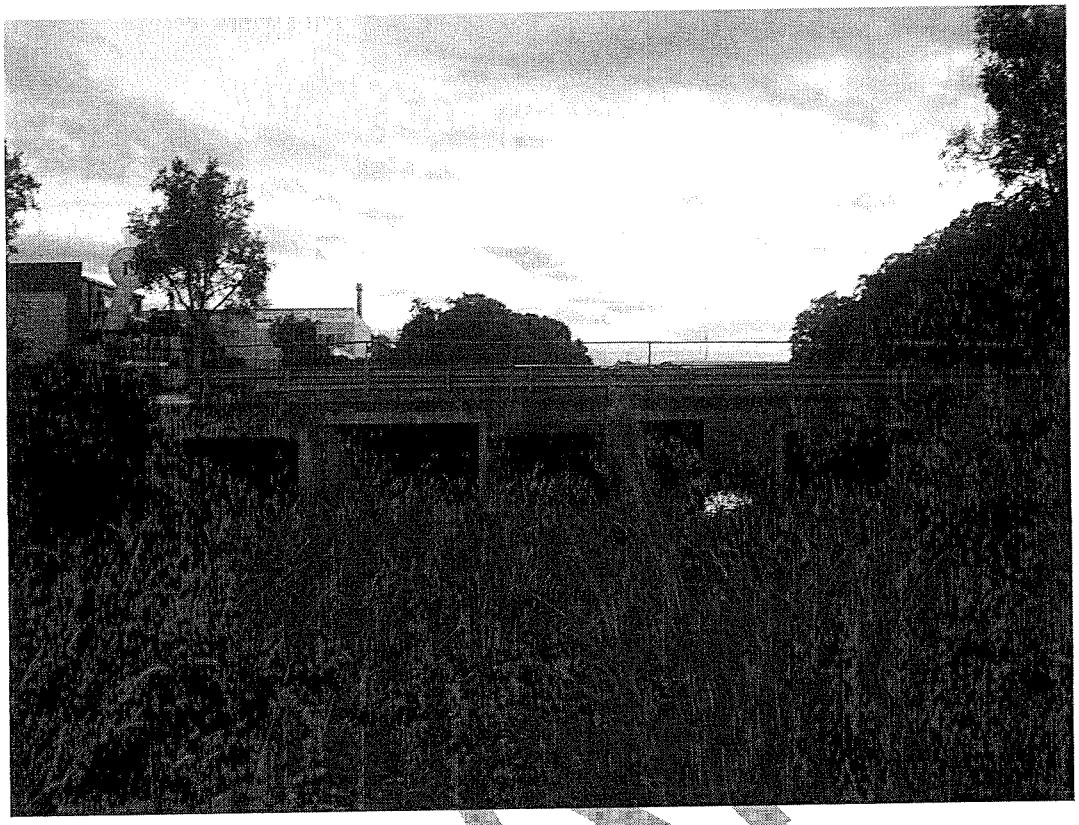

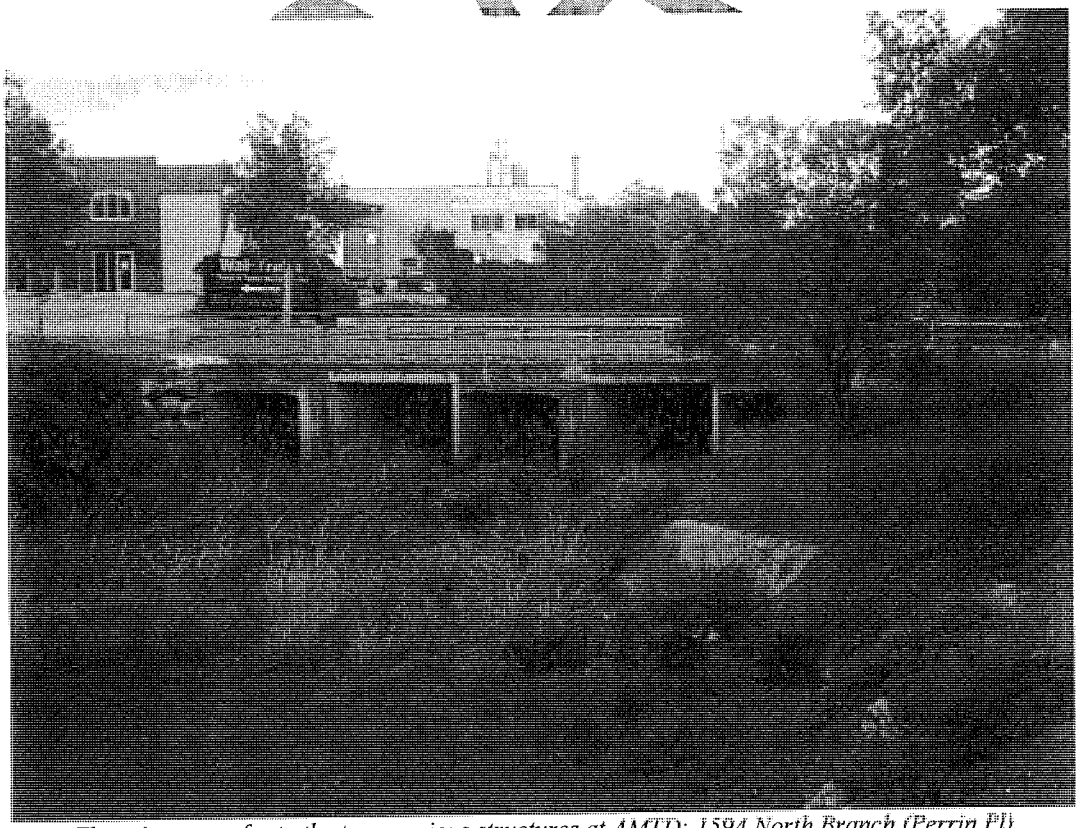

These images refer to the two previous structures at AMTD: 1594 North Branch (Perrin Pl)

BCC.079.0741

HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**NORTH BRANCH**
LOCATION	**RAILWAY BRIDGE, SALISBURY**

DATE OF SURVEY:	UBD REF: 199 R11
AERIAL PHOTO No:	STRUCTURE ID: Railway Bridge
BCC XS No: SS9020	AMTD (m): 1710
STRUCTURE DESCRIPTION: BRIDGE	
STRUCTURE SIZE 5 SPANS / 9m For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 6.19 DOWNSTREAM INVERT LEVEL: 5.96 For culverts give floor level.	UPSTREAM OBVERT LEVEL: DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 6.7 LENGTH OF CULVERT BARREL AT OBVERT (m): 6.7 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 6.7 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 9.36 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: W5501/90

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CREEK	NORTH BRANCH
LOCATION	RAILWAY BRIDGE, SALISBURY

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	22.8	96.1	111.8	9.95	20	95.2	19.8	2.7	1.2
50	0.0	89.8	89.8	9.63	20	94.4	0.0	2.7	0.0
20	0.0	71.5	71.5	9.20	10	79.2	0.0	2.7	0.0
10	0.0	67.5	67.5	8.89	10	67.0	0.0	2.7	0.0
5	0.0	53.2	53.2	8.48	10	52.4	0.0	2.8	0.0
2	0.0	41.0	41.0	8.09	10	40.0	0.0	2.8.	0.0

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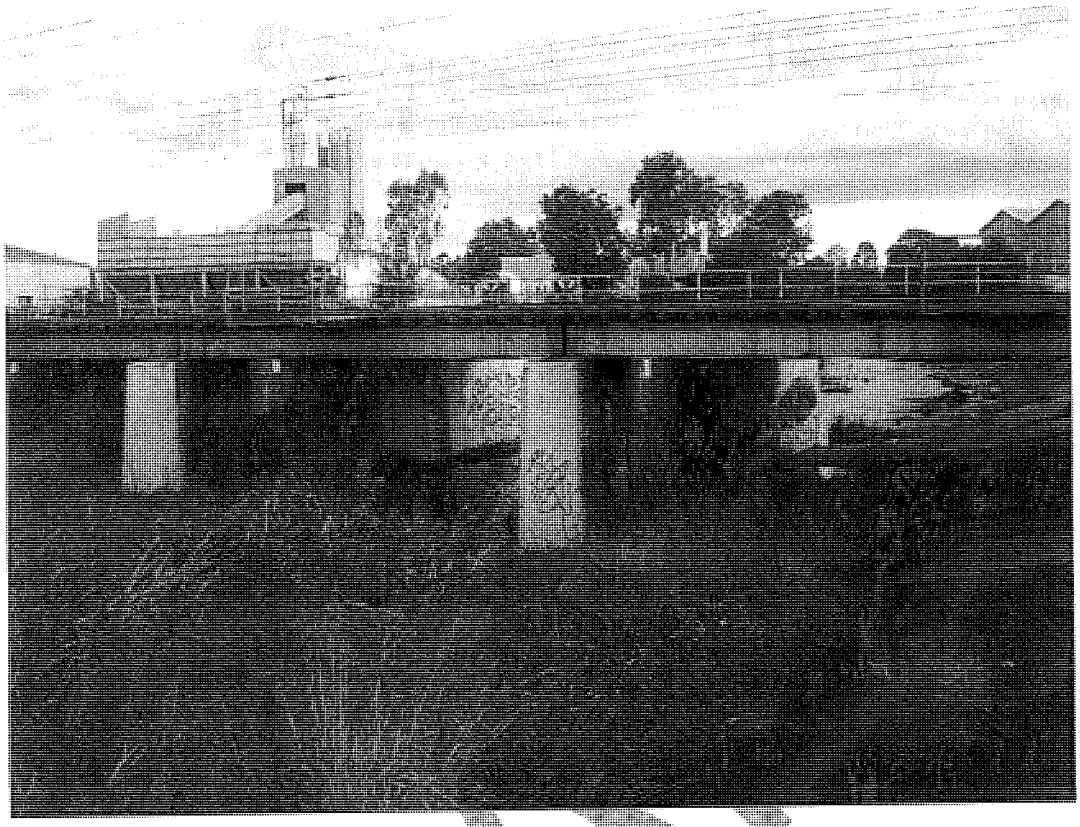

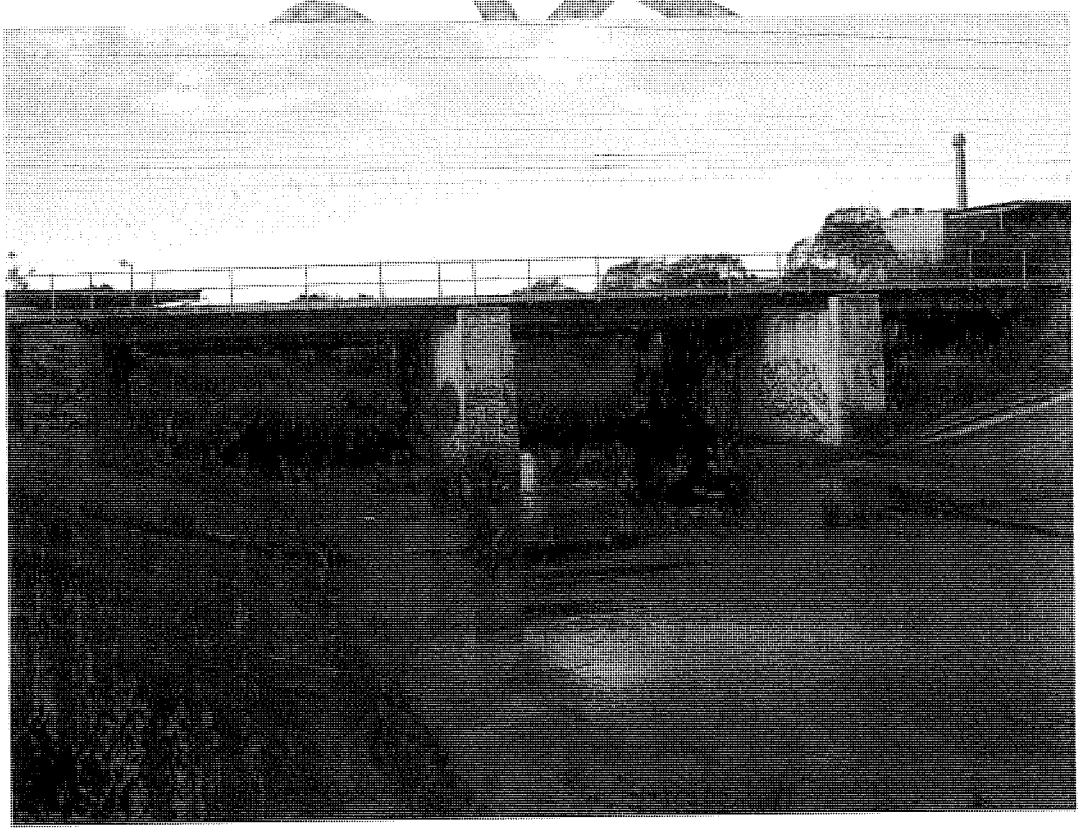

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**NORTH BRANCH**
LOCATION	**MUSGRAVE RD, SALISBURY**

DATE OF SURVEY:	UBD REF: 199 R11
AERIAL PHOTO No:	STRUCTURE ID: Musgrave Rd
BCC XS No: SS9002	AMTD (m): 1862
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 3 / 3050 x 2150 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 4.83 DOWNSTREAM INVERT LEVEL: 4.78 For culverts give floor level.	UPSTREAM OBVERT LEVEL: DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 13.5 LENGTH OF CULVERT BARREL AT OBVERT (m): 13.5 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 13.5 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 7.37 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: W5501

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CREEK	NORTH BRANCH
LOCATION	MUSGRAVE RD, SALISBURY

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	91.9	51.0	108.3	9.94	30	19.7	107.6	2.6	2.3
50	74.7	50.9	90.3	9.63	30	19.7	91.0	2.6	2.3
20	53.9	53.5	72.1	9.21	20	19.7	69.1	2.7	2.2
10	54.8	50.5	57.5	8.90	20	19.7	52.7	2.8	2.3
5	29.0	39.7	49.7	8.49	40	19.7	29.8	2.0	2.1
2	8.5	35.5	42.2	8.09	100	19.7	4.8	1.8	1.8

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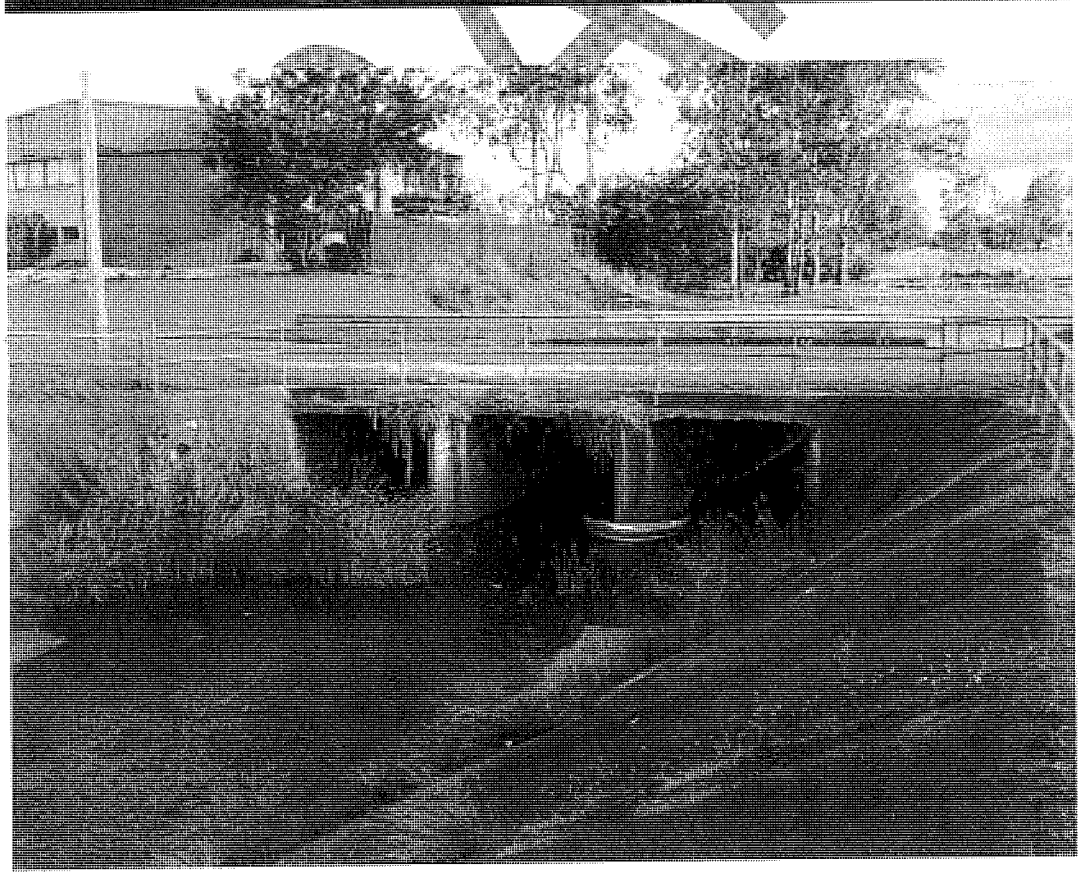

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**ARCHERFIELD DRAIN**
LOCATION	**GRANARD RD, ARCHERFIELD**

DATE OF SURVEY:	UBD REF: 199 I10
AERIAL PHOTO No:	STRUCTURE ID: Granard_Rd
BCC XS No:	AMTD (m): 2018
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 2 / 2130 x 1120 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 4.21 DOWNSTREAM INVERT LEVEL: 4 For culverts give floor level.	UPSTREAM OBVERT LEVEL: DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 28 LENGTH OF CULVERT BARREL AT OBVERT (m): 28 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 28 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 5.85 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: MRD219231

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CREEK	ARCHERFIELD DRAIN
LOCATION	GRANARD RD, ARCHERFIELD

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	120.4	18.1	132.0	6.59	330	4.8	62.9	3.5	2.1
50	100.9	18.4	113.1	6.53	390	4.8	55.2	3.2	2.1
20	79.1	18.7	92.1	6.45	460	4.8	46.1	3.6	1.9
10	65.3	18.5	78.7	6.40	500	4.8	40.0	3.2	2.1
5	53.3	19.8	67.1	6.35	530	4.8	34.5	3.2	2.1
2	33.6	18.3	48.9	4.10	100	4.8	24.6	3.3	2.1

SUMMARY OF STRUCTURE CHARACTERISTICS FOR THE EXISTING STRUCTURE WITH FLOWS FROM THE EXISTING CATCHMENT

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HYDRAULIC STRUCTURE REFERENCE SHEET

CREEK	**ARCHERFIELD DRAIN**
LOCATION	**MARSHALL RD, ARCHERFIELD**

DATE OF SURVEY:	UBD REF: 199 I9
AERIAL PHOTO No:	STRUCTURE ID: Marshall_Rd
BCC XS No: SS180	AMTD (m): 2231
STRUCTURE DESCRIPTION: BOX CULVERTS	
STRUCTURE SIZE 4 / 2120 x 1230 For Culverts: Number of cells/pipes & sizes For Bridges: Number of Spans and their lengths	
UPSTREAM INVERT LEVEL: 3.14 DOWNSTREAM INVERT LEVEL: 3.11 For culverts give floor level.	UPSTREAM OBVERT LEVEL: DOWNSTREAM OBVERT LEVEL: For bridges give bed level
For Culverts LENGTH OF CULVERT BARREL AT INVERT (m): 14 LENGTH OF CULVERT BARREL AT OBVERT (m): 14 TYPE OF LINING: Grouted stone pitching (e.g. concrete, stones, brick, corrugated iron)	
IS THERE A SURVEYED WEIR PROFILE? If yes give details ie. Plan number and/or survey book number. Note: This section should be at the highest part of the road eg crown, kerb, hand rails guard rails whichever is higher.	
WEIR WIDTH (m): 14 (In direction of flow, ie. distance from u/s face to d/s face)	LOWEST POINT OF WEIR (m AHD): 4.87 PIER WIDTH:
HEIGHT OF GUARDRAILS: DESCRIPTION OF ALL HAND AND GUARD RAILS AND HEIGHTS TO TOP AND UNDERSIDE OF GUARD RAILS:	
The following should also be provided. Wingwall/Headwall details, entrance details eg. pipe flush with embankment or projecting, socket or square end, entrance rounding, levels. For bridges, details of piers and section under bridge including abutment details. Specify Survey Book No.	
CONSTRUCTION DATE OF CURRENT STRUCTURE: HAS THE STRUCTURE BEEN UPGRADED? If yes, explain type and date of upgrade. Include plan number and location if applicable. ADDITIONAL COMMENTS:	PLAN NUMBER: W8217

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CREEK	SHELLEYS CREEK
LOCATION	MARSHALL RD, ARCHERFIELD

ARI (years)	DISCHARGE (m^3/s)			U/S WATER LEVEL (m AHD)	AFFLUX AT MAX FLOW (mm)	AREA (m^2)		VELOCITY (m/s)	
	Weir	Structure	Total			Structure	Weir	Structure	Weir
100	113.2	18.4	122.2	6.22	10	10.4	116.3	1.8	1.7
50	96.8	19.0	104.3	6.03	10	10.4	116.3	1.8	1.7
20	74.6	19.5	82.3	5.79	10	10.4	96.4	1.9	1.8
10	62.5	19.5	71.3	5.67	10	10.4	77.6	1.9	1.8
5	53.5	20.0	63.3	5.56	10	10.4	61.5	1.9	1.7
2	27.9	21.2	44.3	3.13	20	10.4	33.1	2.0	1.5

SUMMARY OF STRUCTURE CHARACTERISTICS FOR THE EXISTING STRUCTURE WITH FLOWS FROM THE EXISTING CATCHMENT

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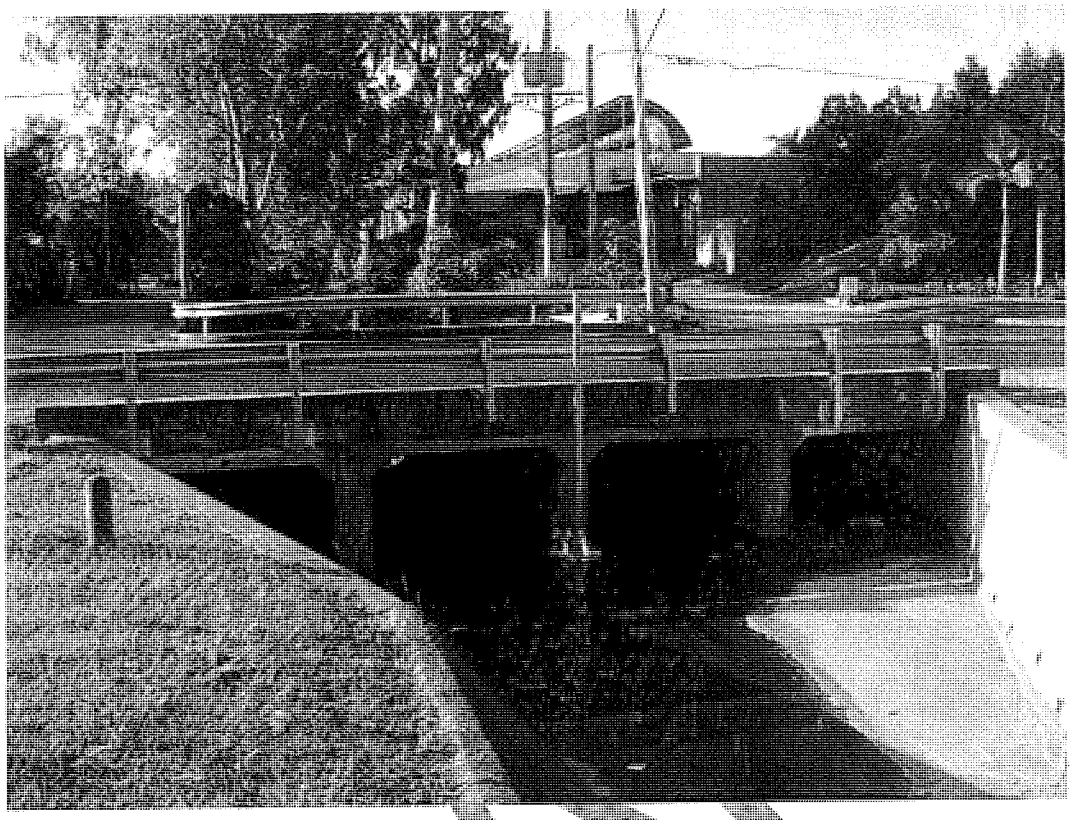

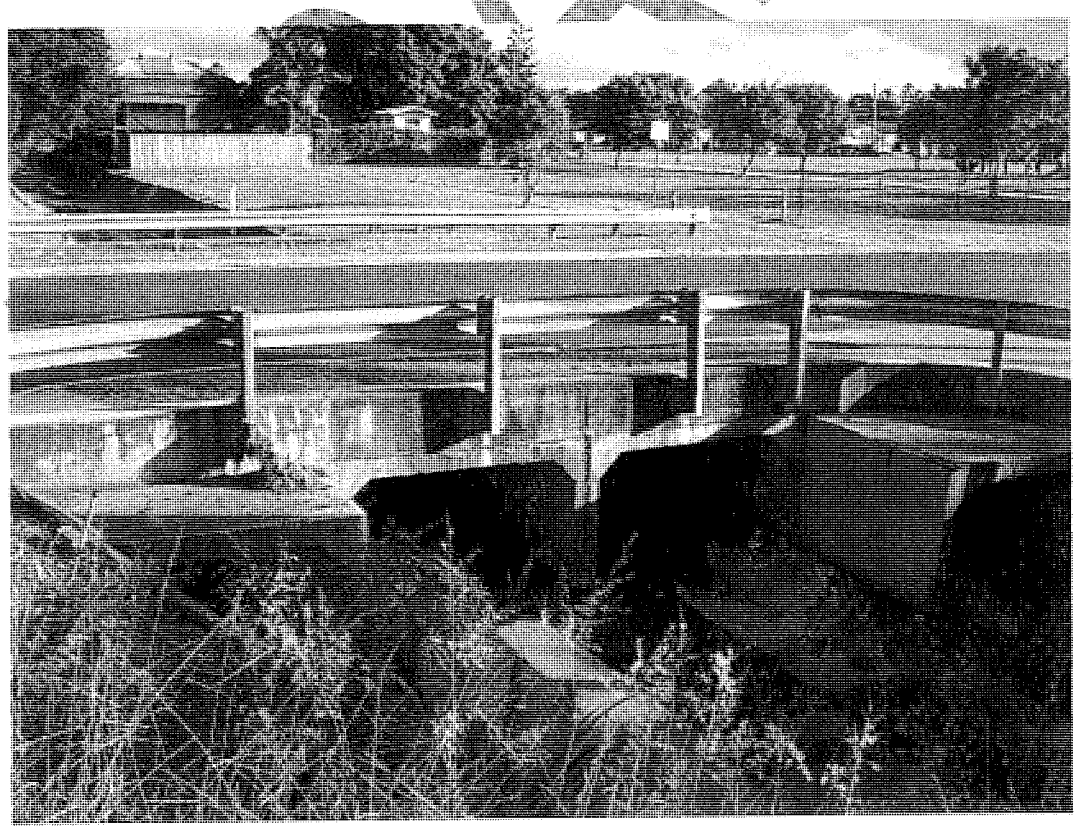

Stable Swamp Creek Flood Study

Report C - Flood Mitigation Options Report

May 2006

Prepared by
Water and Environment
City Design
Brisbane City Council

Prepared for
Water Resources
City Policy and Strategy
Brisbane City Council

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1	May 06		[redacted]							

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1 Introduction

Over recent years flooding has affected a number of residential properties situated adjacent to Stable Swamp Creek within the area around Ipswich Road, Rocklea. Stable Swamp Creek is affected by 'flash flooding'. Flash flooding is unexpected flooding caused by local heavy rainfall and typically occurs within six hours of the rainfall. Recent flash flooding events include March 2001 and November 2004, resulting in the flooding of homes within this area.

This investigation report comments on opportunities to reduce the flooding from Stable Swamp Creek, with a particular focus on the area between Ipswich and Beaudesert roads. It summarises the reviewed mitigation options and includes the relative benefit each mitigation option provides to reduce flooding.

Figure 1 shows the historical rain data (peak three hour rainfall) for the Calamvale area (at the headwaters of Stable Swamp and Bulimba Creeks). It demonstrates that large storm events like March 2001 and November 2004 are very infrequent compared to historical storms over that area.

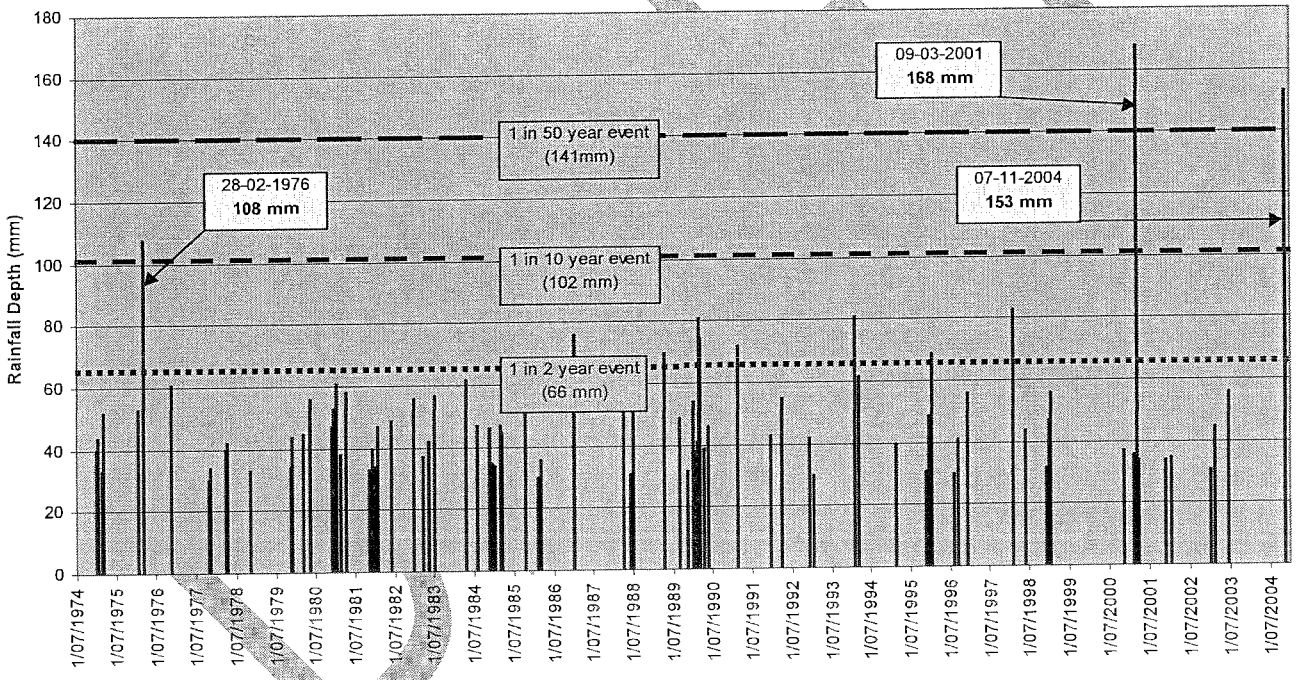

Figure 1: Peak 3 Hour Rainfall Totals - Calamvale Area (Headwaters of Stable Swamp and Bulimba Creeks)
(Please note that there was no recorded rainfall at this rainfall gauge/ pluviograph in January 1974)

2 Assessment of Existing Flooding

The study area is subject to flooding from Brisbane River, Oxley Creek and Stable Swamp Creek. **Table 2.1** shows the design flood levels from these sources at Leeds Street[1]. These are shown for a range of return periods. In the following sections there is a range of mitigation options presented (**Section 3**) and assessed (**Section 4**). The flood reduction benefits mentioned in **Section 4** are based on the levels shown in **Table 2.1**; however, the mitigation options for Stable Swamp Creek **do not** reduce the flooding from Oxley Creek or Brisbane River.

A computer flood simulation representing Stable Swamp Creek was developed to provide a point of reference against which various flood mitigation options could be assessed. The simulation predicted existing flood levels within the Stable Swamp Creek study area for a range of different design return period storm events (i.e. 2, 5, 10, 20, 50 and 100 year Average Recurrence Interval[2] (ARI)) as shown in **Table 2.1**.

Table 2.1: Design Flood Levels for Various Return Periods at Leeds St

Design Event	Flood Source				
	Brisbane River	Oxley Ck (new)	Oxley Ck (old)	Stable Swamp Ck u/s Leeds St (Includes Backwater from Oxley Ck)	Stable Swamp Ck u/s Leeds St (without backwater from Oxley Ck)
Defined Flood Event[3]	8.00	-	-	-	-
100 yr ARI	8.00	7.05	7.05	7.10	5.81
50 yr ARI	6.70	6.06	5.85	n/a	5.60
20 yr ARI	4.50	5.19	4.88	n/a	5.27
10 yr ARI	n/a	4.56	4.10	n/a	5.05
5 yr ARI	n/a	4.16	3.85	n/a	4.87
2 yr ARI	n/a	3.60	3.50	n/a	4.63
Data Sources:	*Flood cells*	*Oxley 2D Model*	*Existing Flood profile*	*Flood counter (Cell Enquiry)*	*Flood Counter (Stable Swamp Creek Flood Cells)*
	BN88	*AMTD 6000 (FRL_Revised)*	*AMTD 6000*	*Flood Cell SS39*	*Flood Cell SS39*

[1] Leeds Street was used as a reference point due to the large number of residents from this location concerned about/ affected by flooding in Stable Swamp Creek.
[2] ARI is a statistical estimate of the average period between the occurrence of a flood of a given size or larger (eg. the 100 year ARI flood event will occur on average once every 100 years). The ARI gives no indication of when a flood of that size will occur next.
[3] The Defined Flood Event is the design event for the Defined Flood Level (DFL). The DFL is used for planning purposes (eg. habitable floor level of a building is the DFL + 500 mm). For creeks it is generally based on the anticipated 100 year ARI flood event. DFLs are usually produced using historic information and computer modelling; where no models are available, DFL is estimated on the basis of the highest recorded flood level.

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3 Flood Mitigation Options

Eight potential mitigation options were identified. **Table 3.1** lists the concepts investigated for six of these options. The six options detailed in **Table 3.1** were represented in computer flood simulations to investigate their effectiveness. Please note that two additional options (concrete lined channel downstream of Ipswich Rd and the construction of levee banks along Stable Swamp Creek) were not investigated in detail. Reason for their exclusion is provided in the following sections.

Figure 2 shows the location of each of the mitigation options.

Table 3.1: Potential Flood Mitigation Options

OPTION	DESCRIPTION
Mitigation Option 1 – Upgrade of Ipswich Road Culvert	
1.1	The community perceives Ipswich Rd to be a constriction to flow within the Stable Swamp Creek system, resulting in a localised increase in upstream flooding. Upgrade existing arch culverts under Ipswich Rd to reduce flood levels by adding two additional 9.2 m wide by 5.8 m high arch culverts. This will increase the capacity by 67%.
1.2	Upgrade Ipswich Rd culverts with three additional 9.2 m wide by 5.8 m high arch culverts. This will increase the capacity by 100%.
Mitigation Option 2 – Reprofiling Upstream of Ipswich Road to Improve Waterway Area	
2	Reprofile Stable Swamp Creek between Beaudesert Rd and Ipswich Rd to increase the flow area. This will increase flow capacity and lower flood levels.
Mitigation Option 3 – Removal of 'Pinch Point' Downstream of Ipswich Road	
3	A potential constriction downstream of Ipswich Rd may limit the creek's flow area. This option considers the hydraulic benefit of removing this pinch point to lower flood levels.
Mitigation Option 4 – Management of Vegetation within Core Riparian Corridor Upstream of Ipswich Road	
4.1	The existing stand of dense vegetation on the southern bank of Stable Swamp Creek, which has important intrinsic habitat value, reduces the overland (floodplain) flow path. Introduce a dedicated 20 m wide grass lined flow path through this existing vegetated area.
4.2	As per Option 4.1, but with a more densely vegetated 20 m wide flow path.
Mitigation Option 5 – Management of Vegetated Riparian Corridor Downstream of Ipswich Road	
5.1	The existing Stable Swamp Creek corridor downstream of Ipswich Rd is characterised by swathes of relatively dense riparian vegetation. To reduce flood levels, reduce the width (by half) of this vegetated riparian corridor.
5.2	As per Option 5.1, but reduce the vegetated riparian corridor density (i.e. thinning out the vegetation so that it is not as dense and allows more flow through the vegetation).
Mitigation Option 6 – Combination of Option 1.1 + Option 3 + Option 5.2	
6	This option incorporates the combined benefits of – an additional two culvert arches beneath Ipswich Rd (Option 1.1) – removal of the pinch point downstream of Ipswich Rd (Option 3) and – reduction of vegetation density within the riparian corridor downstream of Ipswich Rd (Option 5.2).

3.1 Concrete Lined Channel Downstream of Ipswich Road

Installing a concrete lined channel downstream of Ipswich Road was not considered practical or appropriate in this area.

Concrete lined channels have, in the past, been designed to cater for conveyance values lost due to piping or modification of the watercourse. These channels destroy the ecosystem, are contributing factors to the transport of significant sediment loads, and increase peak flood heights downstream. Brisbane City Council has developed the *Natural Channel Design Guidelines*[4] to maximise environmental outcomes while maintaining conveyance values.

In nature the small main channel of a waterway only carried small regular flows. Large flows would break the banks of the creek and flow down the flood plain area. Management of the flood plain is a better, more sustainable solution to flooding issues in the longer term. The low flow channel should be managed in order that floodwaters can recede after an event. Concrete lining will only provide a path for water to travel once the floodwaters recede. A vegetated channel can achieve this equally well.

3.2 Construct Levees along Stable Swamp Creek

Construction of levees along Stable Swamp Creek was not considered practical or appropriate in this area.

The construction of levees is only appropriate in extremely large catchments (eg. some large river catchments) where there is a significant timing difference between the local rainfall/ flood and a flood in the main channel. This time difference gives the local floodwaters time to escape before the flood in the main channel arrives. This is not the case at a small local catchment like Stable Swamp Creek. A levee in this area would act as a dam to local flooding by preventing overland flow from entering the creek, thereby increasing instead of reducing flood levels.

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[4] BCC 2003, *Natural Channel Design Guidelines*, prepared in cooperation with G Witheridge, Catchment & Creeks, for Brisbane City Council, Brisbane, available online at:
<http://www.brisbane.qld.gov.au/BCC:STANDARD:1177898071:pc=PC_1859#natural>

4 Assessment of the Mitigation Options

Computer simulations were developed for each of the six mitigation options listed in **Table 3.1** and the results compared to the flood simulation results for the current creek condition. **Table 4.1** summarises the changes in peak design flood level achieved by each of the six mitigation options. The results are reported at the Leeds Street footbridge. Flood level reductions are shown as negative changes. A summary of the results and flood level reduction for the options, based on the results of a 100 year ARI storm are outlined below.

4.1 Upgrade of Ipswich Road Culvert (Mitigation Options 1.1 and 1.2)

The addition of extra cells at the major Ipswich Road culvert crossing provides a localised reduction in flood levels of up to 170 mm (Option 1.1) and 200 mm (Option 1.2) immediately upstream of Ipswich Road for the 100 year ARI event. However the changes in flood levels become minimal upstream of Beaudesert Road, with only a respective 80 mm and 90 mm reduction in flood levels at the area of interest. Although this option lowers flood levels upstream by improving the flow area through the culverts at Ipswich Road, there is a small increase in peak design flood levels downstream. This is due to the removal of constrictions within the creek, thereby increasing the flow downstream of the culverts. Consequently, there will be a rise in floodwaters downstream.

4.2 Reprofiling Upstream of Ipswich Road to Improve Waterway Area (Option 2)

Reprofiling the channel upstream of Ipswich Road provides a local reduction in peak design flood levels of up to 90 mm in a 100 year ARI event. Little reduction in flood levels occurs elsewhere in the study area. Due to such a minor impact on flood level reduction at the mitigation site, no significant increase in flood levels downstream was observed.

4.3 Removal of 'Pinch Point' Downstream of Ipswich Road (Option 3)

The removal of the localised constriction approximately 500 m downstream of Ipswich Road (Option 3) results in a reduction of up to 190 mm within the immediate vicinity of this constriction for the 100 year ARI event. The reduction at the area of interest though is only approximately 40 mm. This benefit reduces considerably to no reduction upstream of Beaudesert Road.

4.4 Management of Vegetation within Core Riparian Corridor Upstream of Ipswich Road (Option 4)

The management of vegetation within the core riparian corridor upstream of Ipswich Road near the Leeds Street footbridge (Options 4.1 and 4.2) showed little benefit in reducing flood levels, apart from a minor localised reduction of approximately 10 mm in a 100 year ARI event.

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4.5 Management of Vegetated Riparian Corridor Downstream of Ipswich Road (Option 5)

The proposed vegetation management options downstream of Ipswich Road provide a reduction at that location of up to 100 mm (Option 5.1) and 300 mm (Option 5.2). The benefit in flood levels reduces progressively upstream of Beaudesert Road with a maximum achievable reduction in peak design flood levels of approximately 40 mm and 90 mm for each respective option, at the site of interest.

4.6 Combination of Option 1.1 + Option 3 + Option 5.2 (Option 6)

Option 6 proposes the combination of the addition of two arch culverts at Ipswich Road (Option 1.1), the removal of localised constriction (Option 3) and vegetation management downstream of Ipswich Road (Option 5.2). Little improvement in flood levels was shown for this option when compared to the results of mitigation Option 5.2 alone.

The results indicate that many of the options considered may provide a small localised benefit for the larger storm events such as the 100 year ARI however they do not provide any significant reduction in flood levels for the frequent smaller events such as the two year ARI (refer **Table 4.1**).

Table 4.1: Reduction in Peak Design Flood for Each Mitigation Option

Mitigation Option	Reduction (m)					
	100 yr ARI	50 yr ARI	20 yr ARI	10 yr ARI	5 yr ARI	2 yr ARI
Option 1 – Upgrade of Ipswich Road Culvert (established cost of order of $9M – Option 1.2)						
1.1 Two additional culverts	-0.08	-0.06	-0.05	-0.01	-0.01	-0.01
1.2 Three additional culverts	-0.09	-0.07	-0.04	-0.01	-0.02	-0.01
Option 2 – Reprofiling Upstream of Ipswich Road to Improve Waterway Area (established cost of order of $3M)						
2	-0.09	-0.10	-0.11	-0.08	-0.09	-0.07
Option 3 – Removal of 'Pinch Point' Downstream of Ipswich Road (established cost of order of $7M)						
3	-0.04	-0.06	-0.03	-0.01	-0.02	0.00
Option 4 – Management of Vegetation within Core Riparian Corridor Upstream of Ipswich Road (established cost of order of $30K – Option 4.1)						
4.1 Vegetated flow path	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
4.2 Denser vegetated flow path[1]	0.00	0.00	0.00	0.00	0.00	0.00
Option 5 – Management of Vegetated Riparian Corridor Downstream of Ipswich Road (established cost of order of $300K – Option 5.1)						
5.1	-0.04	-0.05	-0.04	-0.02	-0.02	0.00

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Mitigation Option	Reduction (m)					
	100 yr ARI	50 yr ARI	20 yr ARI	10 yr ARI	5 yr ARI	2 yr ARI
Reduce width of riparian corridor						
5.2 Reduce density of riparian corridor	-0.09	-0.09	-0.07	-0.04	-0.04	0.00
Option 6 – Combination of Option 1.1 + Option 3 + Option 5.2 (established cost of order of $13M)						
6	-0.09	-0.09	-0.07	-0.04	-0.04	0.00

Notes: [1] Reducing the vegetation density slightly for the 20 m flow path has no measurable impact on flood levels.

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5 Discussion of Results

Based on the results outlined in **Table 4.1**, there is minimal benefit to be gained from any of the proposed mitigation options. Some of the options provide a minor localised benefit during large storm events but little or no benefit during smaller events. The most effective of the options (Option 2) provides only a 0.07 m reduction in flood levels during a 2 year ARI event. Current peak flood levels for the 2 year ARI event are in excess of 4.6 m AHD (refer **Table 2.1**).

To provide a basis for comparison, an investigation was undertaken to determine the potential benefits of lowering flood levels downstream of Ipswich Road, through the use of the most extreme concrete channel. This option assumed a wide concrete channel with a high flow capacity to produce the lowest flood levels just downstream of Ipswich Road. It is not envisaged that this is a practical option, it was only studied to provide a context to the difficult flooding environment of the residential area adjacent the creek upstream of Ipswich Road.

Figure 3 shows that the installation of a concrete lined channel results in large reductions downstream of Ipswich Road; however, the benefits of this are greatly reduced in the target area. While the benefits of this work exceed results of the other mitigation options, it is still foreseeable that the cost of such work would outweigh the benefits of the minor flood reductions. It is also important to note that while there may be benefits available from a Stable Swamp Creek flood, the target area is still very susceptible to flooding from Oxley Creek and the Brisbane River. In addition, the installation of a concrete lined channel is contrary to Council's other responsibilities, such as environmental protection.

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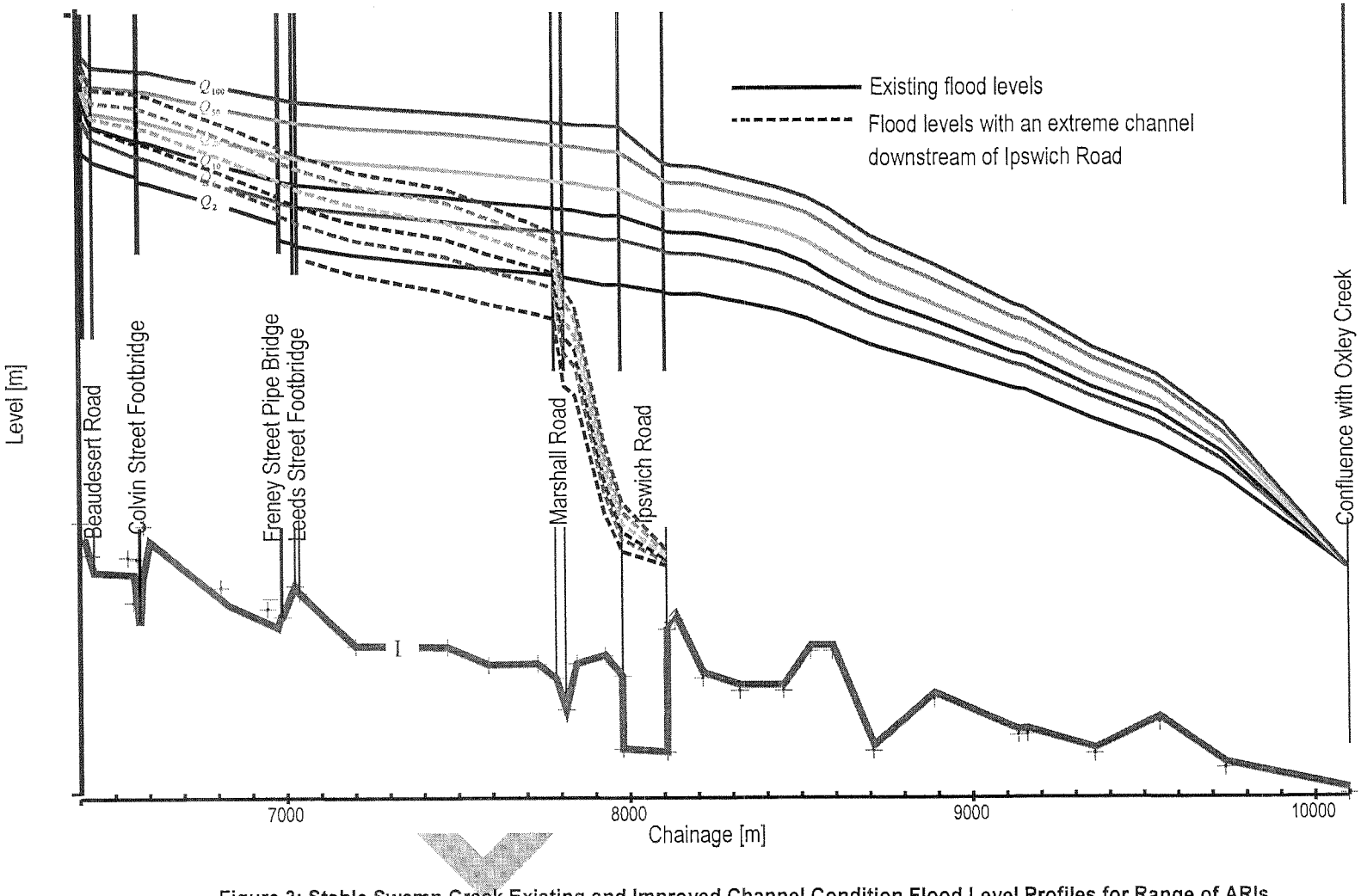

Figure 3: Stable Swamp Creek Existing and Improved Channel Condition Flood Level Profiles for Range of ARIs

(Note large change in flood levels at Ipswich Rd, but minor changes at Leeds St Footbridge, suggesting that this mitigation option is not so effective in reducing flood levels at area of interest)

6 Conclusion

Potential flood mitigation options for the section of Stable Swamp Creek between Beaudesert Road and Ipswich Road, Rocklea have been assessed using a computer model of the creek, as outlined below:

- Mitigation Option 1 – Upgrade of Ipswich Road culvert
- Mitigation Option 2 – Reprofiling upstream of Ipswich Road to improve waterway area
- Mitigation Option 3 – Removal of pinch-point downstream of Ipswich Road
- Mitigation Option 4 – Management of vegetation within core riparian corridor upstream of Ipswich Rd
- Mitigation Option 5 – Management of vegetated riparian corridor downstream of Ipswich Road
- Mitigation Option 6 – Combination of Option 1.1 + Option 3 + Option 5.2.

The benefits to the residential area of interest are generally less than 100 mm in a 100 year ARI event. This is a minor reduction.

Two other alternatives were also investigated but not considered as viable options:

- engineering a concrete-lined channel
- construction of levees.

Based on the results of this study, there are no practical means to significantly reduce flooding from Stable Swamp Creek in this vicinity. There is also a significant flood risk in the area from Oxley Creek and Brisbane River. To mitigate the impact of flooding in this area, the following options are suggested:

- Planning tools to ensure that, with redevelopment and rebuilding, potential flood damage is minimised.
- Voluntary purchase by Brisbane City Council of homes with low flood immunity.

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Joint Flood Taskforce Report
March 2011

Prepared for Brisbane City Council by the Joint Flood Taskforce

This document has been approved on behalf of the Joint Flood Taskforce by

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Executive Summary

In January 2011, Brisbane experienced the second-highest flood of the last 100 years, after January 1974. There was major flooding through most of the Brisbane River catchment, most severely in the Lockyer and Bremer catchments where numerous flood height records were set. The flooding caused substantial loss of life in the Lockyer Valley and thousands of properties were inundated in metropolitan Brisbane, Ipswich and elsewhere.

Joint Flood Taskforce Brief

As with any such event, questions about flood control levels are raised. Given that the flood control levels are theoretical, it is prudent to review them in light of an actual event to assess the reliability of the present theoretical model. To this end a Joint Flood Taskforce (JFTF) was established to report within 30 days, which it has done, on the following three questions.

- How does the January 2011 flood event compare to the Q100 as presently defined and Brisbane City Council's Defined Flood Event?
- Does Q100, as it is currently described, remain the best estimate of a 1 in 100 year event?
- Accordingly, what standard should be used to enable new development and redevelopment to proceed with confidence and certainty?

Findings of Joint Flood Taskforce

In answering these questions the JFTF has focussed on river flooding only. Creek flooding and the impact of Storm Surge are considered to be outside the scope for this review. The JFTF was limited by the data and modelling available and that could be made available. Further the answers provided stress their interim nature given a number of other reviews that are currently underway. These reviews include "Queensland Floods Commission of Inquiry" and Council's Flood Response Review Board.

How does the January 2011 flood event compare to the Q100 as currently defined and Brisbane City Council's Defined Flood Event (DFE)?

In the flood event experienced, the heaviest rains were inland on the western fringe of the Brisbane River catchment and on the Great Dividing Range. Over the Brisbane River catchment as a whole, based on rainfall captured by the BoM's Enviromon rain gauges, the estimated average 5-day rainfall is 322mm, with the major sub-catchments of Wivenhoe Dam, Bremer River and Lockyer Creek receiving 370mm, 223mm and 268mm respectively.

Given the pattern of rainfall, the Brisbane River received significant flows from the upstream catchments of the Lockyer and Bremer. The flow down the upper Brisbane River (above the Lockyer Creek) and Stanley River were mitigated by Wivenhoe Dam. However Brisbane felt the full force of the flows down the Lockyer and Bremer Rivers. As a result of the rainfall, Brisbane experienced a significant river flood. During this

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flood event, the rainfall over much of Brisbane was not sufficient to cause any significant creek flooding from local runoff. However, creeks that are tributaries of the Brisbane River were flooded deeply in their lower reaches by water backing up from the River.

Based on examination of the rainfall patterns of a number of previous Brisbane River floods, it is concluded that the Brisbane catchment experienced a significant rainfall event with a rain pattern that was different from that experienced in 1974. Full details of the rainfall magnitudes were not available at the date of this Report. However back calculation from recorded releases from Wivenhoe and the record of water level in the dam suggest significantly more flood producing rainfall occurred than indicated by the presently available rainfall data. The calculated dam inflow hydrographs show two inflow peaks, the first of the magnitude of 1974 and the second 36 hours later of greater magnitude than 1974. The level recorded at Savages Crossing was higher than in 1974. Flood inflow volumes to Wivenhoe as calculated from the known releases from Wivenhoe dam and the recorded water levels in the dam total 2,650 GL, as compared to a total of 1,410 GL for that location in 1974 and 2,744 GL in February 1893.

On balance the JFTF considers that the flood runoff resulting from the major rainfall event of January 2011 was greater than the 1974 event but not as great as the 1893 event.

All of the peak flood levels recorded in January 2011 by the gauges along the Brisbane River were higher than the existing Defined Flood Level, ie. the level previously calculated for the 1974 flood event mitigated by Wivenhoe Dam. Therefore, taking into account this fact together with its assessment of the rainfall event, the JFTF considers that the January 2011 flood event was larger than the Brisbane City Council's Defined Flood Event.

The Q100 as presently defined is, in general, a slightly lesser flood than the Defined Flood Event. Therefore the JFTF considers that the January 2011 flood event was larger than the Q100 as presently defined.

Much more detailed work is required to accurately identify the probability of this event for Brisbane. The information needed and the work required to complete this analysis are summarised in the Recommendations below.

Does Q100, as it is currently described, remain the best estimate of a 1 in 100 year event?

The term, Q100, can be misunderstood. Some people mistakenly believe a 1 in 100 year flood will only occur once every 100 years on average. However, Q100 is a probability-based design flood event, aimed to reflect *typical combinations of flood producing and flood modifying factors* which act together to produce a flood event that has a 1 in 100 chance in any one year (or an average recurrence interval of 100 years) of being equalled or exceeded at a specific location of interest. It is a theoretical flood model used to inform planning and policy.

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The January 2011 flood has brought a significant amount of new data and information on the nature of flooding in the Brisbane River and about the factors contributing to very large flood events in this catchment. Significant work is required to review Brisbane's Q100 in the light of this new information. This work could not be completed given the data available to the JFTF report, some of which is still being collected.

In light of the available information about the 2011 flood event, the JFTF considers that it is essential that the current Q100 is reviewed. It is not possible to predict the outcome of such review but it is considered more likely than not that this review will lead to an increase in the magnitude of the Q100 and increases in associated flood levels.

Accordingly, what standard should be used to enable new development and redevelopment to proceed with confidence and certainty?

To answer this question five (5) scenarios have been evaluated. These scenarios are:

- Current Q100 (3.3m at City Gauge)
- Current Defined Flood Level, DFL (3.7m AHD[1] at City Gauge)
- January 2011 Flood Event (4.46m AHD at City Gauge)
- 1974 without Wivenhoe Dam (5.45 m AHD at City Gauge)
- 1893 without Somerset and Wivenhoe Dams (8.35m AHD at City Gauge)

On balance, the JFTF believes that, in the absence of results of a detailed flood study review, a precautionary approach should be adopted. Therefore, it considers that the actual January 2011 flood event, as observed during the event, should be used as the **interim** standard on which Brisbane City Council bases its decisions concerning habitable floor levels for new development and should be a consideration for habitable floor levels for redevelopment of existing properties. Wherever the existing DFL is higher than the January 2011 flood event, the existing higher flood level should prevail.

The JFTF notes that, in regions where the interim standard will be applied, the degree of immunity from flood risk will vary with location. This is because the January 2011 flood event is an actual event and will have variable tidal influences along the tidal reach. Consequently variable probabilities will apply along this reach.

The recommendation of an **interim** development standard refers to land use types that are currently assessed against a DFE in the City Plan. This currently excludes industrial development however this should be considered through the current City Plan review.

Further the DFE and resulting flood regulation lines are considered only part of a flood risk management framework for a community. The approach to flood risk management for Brisbane needs to consider a broader range of initiatives if it is to effectively manage flood risk for the City. Flood risk management requires that the consequences of floods be investigated for a range of flood events up to and including the PMF. For land use planning, flood levels as well as flood flows corresponding to specific

[1] AHD - Australian Height Datum - is the national surface level datum corresponding approximately to mean sea level. Levels measured relative to this datum are given as "m" AHD.

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probabilities must be considered. This approach must include identification of the benefits of the management of risk, rather than seeing it as all cost.

Recommendations of Joint Flood Taskforce

It is recommended,

That the actual January 2011 flood event, as observed during the event, be used as the **interim** standard, on which Brisbane City Council bases its decisions concerning new development and redevelopment, with the essential condition that, wherever a higher level has been set as the current DFL, the higher level must apply; and that this interim standard apply until conclusion of the Commission of Inquiry and the comprehensive flood study recommended below is completed.

That all data relating to the January 2011 flood event be gathered from all sources and archived so that further analysis can make use of all data available.

That the bathymetry (river bed and banks) of the Brisbane River and its tributaries and the characteristics of the bed material from Wivenhoe dam to the mouth be measured as soon as possible.

That a comprehensive flood study be commissioned to review flood flows and levels within the Brisbane River catchment making full use of the data relating to the January 2011 flood event.

That the effects of morphological (river bed level and cross section) changes due to sediment erosion and deposition during flood events be studied for a range of flood magnitudes to determine their effects on flood levels.

That consideration be given to whether a Monte Carlo approach to the flood risk for the Brisbane Catchment is feasible and, if yes, whether it should be carried out and which influencing factors should be included in the Monte Carlo approach. This may include consideration whether two or more types of rainfall events should be built into the statistical analysis for theoretical floods. In a Monte Carlo analysis the influencing input factors such as rainfall patterns, storm tracks, catchment conditions, tide and storm surge are sampled, either randomly or in accordance with their joint probabilities, to select a large number of different combinations of inputs for simulation with a catchment modelling system to develop many alternative predictions of flood events. These predictions are then analysed statistically to estimate their exceedance probabilities.

That a complete Flood Risk Management analysis for the area of Brisbane affected by flooding by Brisbane River and its tributaries be carried out. It is essential to move from the Q100 mentality and to adopt a risk management approach inline with National Flood Risk Advisory Group (NFRAG) and other relevant guidelines. The risk management approach would require a detailed assessment of the benefits and costs of a full range of flood mitigation options.

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1.0 Purpose and Scope of the Report

1.1 Purpose

On the 11 February 2011 the JFTF was established by the Brisbane City Council. Ipswich City Council were then invited to participate in accordance with the Terms of Reference as given in Appendix A. Ipswich City Council chose to adopt an observer status, providing technical input and were not an approval entity. An outcome of the JFTF required by the TOR was the response to the following questions.

1. How does the January 20011 flood event compare to the Q100 as presently defined and Brisbane City Council's Defined Flood Event (DFE)?
2. Does Q100, as it is currently described, remain the best estimate of a 1 in 100 year event?
3. Accordingly, what standard should be used to enable new development and redevelopment to proceed with confidence and certainty?

A Technical Reference Group and an Industry Reference Group were established at the same time, as detailed in the TOR, to provide input to the work of the core JFTF. The role of the Technical Reference Group was focussed essentially on the first two questions while the role of the Industry Reference Group was critical in the response to the third question.

This report provides the response of the JFTF to the TOR including its answers to the three questions.

1.2 Approach

To provide the context for this work, the flood history of the Brisbane River is summarised including the event of January 2011. An overview the catchment in which Brisbane is situated is provided including major dams with their impacts.

Brisbane's Q100 and DFE control levels are discussed as are their role as development standards. The January 2011 event is then compared to the current Q100 event and the current DFE and the appropriateness of the current Q100 is examined.

Five potential DFEs are examined. These scenarios are:

- Current Q100 (3.3m AHD at City Gauge)
- Current Defined Flood Level, DFL (3.7m AHD at City Gauge)
- January 2011 Flood Event (4.46m AHD at City Gauge)
- 1974 without Wivenhoe Dam (5.45 m AHD at City Gauge)
- 1893 without Somerset and Wivenhoe Dams (8.35m AHD at City Gauge)

The effectiveness and impacts of each option are discussed and a conclusion reached as to their suitability from both a hydrological and planning perspective.

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1.3 Limitations

This report only considers river flooding within Brisbane. Flooding in the Bremer River is not examined, neither is creek flooding and nor is the impact of storm surge or climate change.

The State government's "Queensland Floods Commission of Inquiry" will consider and make recommendations relating to any long term planning changes. However, this will not be available for some time. This report aims to provide certainty to Brisbane's community by providing interim guidance on flood levels and controls. The focus of this report is the next 1 to 2 years. As a result, longer term impacts such as changing sea levels and variations in rainfall patterns and other consequences of climate change are not considered.

Given the interim nature of the report, there are limitations on the data that could be collected, flood modelling that could be completed and the economic analysis that could be completed for the analysis of benefit and cost. Therefore recommendations are made for future work to increase the robustness of the recommendations or revise them if necessary.

Finally, the appropriateness of the Wivenhoe Dam operation procedures and potential improvements in these procedures are a consideration for the State's Judicial Commission. This report assumes Dams were operated inline with current legislated operating procedures. Consequently, Wivenhoe Dam operation is not considered.

2.0 Background

2.1 Flood Risk Management

2.1.1 Introduction

Flood risk is the potential for people or property to suffer damage from flooding. Flood risk at a location depends upon the frequency of flooding at different levels and the associated consequences to the community.

The objective of flood risk management is to reduce a community's flood risk to acceptable levels, either by reducing exposure to flooding or by reducing the vulnerability of people and property to flooding. This involves trading off the economic, social and environmental costs of flooding against the benefits of allowing a broad range of activities to take place on the floodplain. Such trade-off decisions need to be made in a proper risk management framework, based on firstly assessing the probabilities and consequences of flooding at different levels of severity and then considering the benefits and costs of a range of flood risk management options. The benefits of flood risk management options can be expressed in terms of the reduction in expected flood damages; environmental, social and economic, while the costs include the cost of implementing the flood risk management measures as well as associated opportunity costs.

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In a broader sense, flood risk management also includes flood response and flood recovery actions but in the context of this report the focus is on the *prevention aspects* of flood risk management.

2.1.2 Flood risk management principles and guidelines

In Australia, flood risk management is guided by principles, policies and guidelines established at the national, state and local government levels. At the national level, the National Flood Risk Advisory Group (NFRAG) has been established to follow up on COAG reform commitments, including the development of National Flood Risk Management Guidelines (see AJEM, 2008). The national guidelines developed by NFRAG describe the vision for flood risk management as:

> *"Floodplains are managed for the long term benefit of the local and wider community such that hazards to people and damages to property and infrastructure are minimised and environmental values are protected." (AJEM, 2008)*

The Queensland State Planning Policy 1/03 : Mitigating the Adverse Impacts of Flood, Bushfire and Landslide 1.0 (SPP, 2003) and the associated State Planning Policy 1/03 Guideline: Mitigating the Impacts of Flood, Bushfire and Landslide 1.0, which form the basis for development decisions in relation to floods and other natural hazards, are consistent with the flood risk management framework outlined in 'Floodplain Management in Australia – Best Practice Principles and Guidelines' (SCARM, 2000).

2.1.3 Flood risk management options

The range of flood mitigation options available to reduce the exposure of a community to flooding or its vulnerability to flood risk includes the following main groups:

(i) *Land use planning and development controls* (including building regulations) to exclude development from the most hazardous parts of the floodplain and ensure that exposure to flooding and flood damage are minimised for development in fringe areas of the floodplain.

(ii) *Other non-structural measures* such as developing flood warning systems, improving community awareness and readiness by community education on the nature and impacts of flooding.

(iii) *Major structural flood mitigation works* to reduce the frequency of flooding above a given level (e.g. flood control storages) or the extent of flooding (e.g. levees) – these options can be employed to reduce the flood risk to *existing development* in the flood plain

(iv) *Flood proofing measures* to reduce the exposure of property to flood damage (e.g. raising of house floors, flood barriers, use of flood resistant building materials).

This report only concentrates on benefits derived directly or indirectly from the first group, with other potential flood risk management options to be considered as part of a more comprehensive future study. The specific focus of the report is on land use planning and development controls through setting of *defined flood levels for planning and building purposes* in the areas affected by Brisbane River flooding.

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2.1.4 Residual flood risk

Flood risk management options are designed to reduce the flood risk for flood events up to a design flood (and the associated defined flood level). There is still a chance of the defined flood level being exceeded by larger floods; this is referred to as '*residual flood risk*'. The larger the average recurrence interval selected for the defined flood event (and thus the higher the defined flood level), the lower the residual flood risk. As an example, if the Q100 is adopted as the defined flood level, then the residual flood risk will consist of the consequences associated with all the floods larger than the Q100 event, weighted by the probability of their occurrence. While floods much larger than the January 2011 event may occur, their low probability of occurrence means that, in the determination of residual flood damages, they will be given a much lower weight than flood events which occur relatively frequently.

2.1.5 Conclusion

Flood Risk Management is a best practice approach and if adopted will provide a framework to mitigate damage from flooding for all properties at risk from flood. No matter what flood DFE is in place it should be considered as only one integral part of the Flood Risk Management framework which needs to be complemented with other flood risk controls as outlined in section 2.1.3

2.2 Details of the river flood event of January 2011

In January 2011, Brisbane experienced the second-highest flood of the last 100 years, after January 1974. There was major flooding through most of the Brisbane River catchment, most severely in the Lockyer and Bremer catchments where numerous flood height records were set. The flooding caused substantial loss of life in the Lockyer Valley and thousands of properties were inundated in metropolitan Brisbane, Ipswich and elsewhere.

2.2.1 Rainfall

For the 2011 event, the heaviest rains were inland on the western fringe of the Brisbane River catchment and on the Great Dividing Range. Recorded gauge levels for this event, show Brisbane's peak three-day rainfall was 166 mm, while the peak one-day total was 110 mm.

Over the Brisbane River catchment as a whole, based on rainfall captured by the BoM's Enviromon rain gauges, the estimated average 5-day rainfall was 322mm, with the major sub-catchments of Wivenhoe Dam, Bremer River and Lockyer Creek receiving 370mm, 223mm and 268mm respectively.

However back-calculation from recorded releases from Wivenhoe and the record of water level in the dam suggest significantly more flood producing rainfall occurred. The calculated dam inflow hydrographs show two peaks, the first of the magnitude of 1974 and the second of greater magnitude than 1974, 36 hours later. The peak level recorded at Savages Crossing was higher than in 1974 but not as great as estimated for the 1893 event. Estimated flood volume inflows to Wivenhoe as calculated from the known Wivenhoe dam releases and the recorded water levels in the dam total 2,650 GL as compared to a total of 1,410 GL for that location in 1974 and 2,744 GL in February 1893

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It is thought that the coverage of the existing rain gauge network[2] was insufficient to accurately capture the variation in rainfall intensities for this event. This is supported by evidence from radar imaging which suggested significant falls not recorded in rain gauges. For example, there were large falls observed over Wivenhoe Dam itself that would not be captured by any rain gauge. To obtain a greater understanding of the total rainfall received, further work is required to analyse the recorded radar imaging of the event.

Insufficient rainfall data exist for a comprehensive assessment of the 1893 event. However, the available station data indicate that peak rainfalls in the region during the 1893 event were much heavier than those during either the 1974 or 2011 events. Crohamhurst, in the Glasshouse Mountains inland from the Sunshine Coast, received 907.0 mm on 3 February 1893, which remains an Australian daily record, whilst three-day totals included 1715.0 mm at Mooloolah and 1680 mm at Crohamhurst.

On balance the JFTF considers that the flood runoff caused by the rainfall event of January 2011 was greater than the 1974 event but not as great as the 1893 event.

2.2.2 Flood resulting from Rainfall

In 2011 Brisbane experienced a significant river flood. Given the pattern of rainfall, the Brisbane River received significant flows from the upstream catchments of the Lockyer and Bremer. The flow down the upper Brisbane River above Wivenhoe Dam and Stanley River was mitigated by Wivenhoe Dam. However, Brisbane felt the full force of the flows down Locker Creek and Bremer River

The flooding caused thousands of properties to be inundated in metropolitan Brisbane. It should be noted that the pattern of rainfall experienced caused little to no creek flooding within Brisbane, though creeks were flooded by backwater from the river.

It is reported that the flood levels recorded at Savages Crossing were higher than in 1974. DERM reported the peak level recorded at Savages Crossing was 24.167m AHD at 03.40 am on 12 January 2011, somewhat higher than the peak level of 23.767m AHD in the 1974 flood. The corresponding discharge based on the extrapolated rating curve was 6,900 cubic metres per second (cumecs). It has been suggested that the extrapolated rating curve may have underestimated the actual flow rate. Nevertheless the discharge of 6,900 cumecs is larger than that for the current DFE.

The peak height at the Brisbane Port Office gauge of 4.46 m was less than that in 1974[3]. The flood level in Brisbane in January 2011 was reduced by the mitigating effect of Wivenhoe Dam.

Measurements of flood levels for January 2011 have been based on marks on buildings where available, rather than on debris marks. Levels vary across the river by substantial amounts – up to 0.4m at bends; the water surface is curved generally because of the effects of super-elevation at the outsides and of local reduction at the insides of bends,

[2] The existing rain gauge network is made up mostly of gauges owned by BOM and Seqwater.
[3] There are two gauges at/near the Port Office. The "Port Office gauge" is at the end of Edward Street on the true left side of the river. There is also an 'Alert' gauge on the true right side a little downstream from the Thornton Street ferry pier.

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as well as the tendency for the water to be higher towards the centre of a fast flowing river than near the banks. All the measured flood levels are higher than the Defined Flood Levels and these correspond to the levels calculated for a flood with the characteristics of the 1974 flood after the reducing effects of Wivenhoe Dam.

2.2.3 Outstanding Information Required for Description of 2011 Event

A number of important items required for a complete description of the January 2011 event were not available at the time of writing this report. These include the following:

- BoM is still assembling and checking the rainfall data.
- Department of Environment and Resources Management (DERM) gauged the flow at Jindalee Bridge with Acoustic Doppler instrumentation – this data is still awaited.
- There is a strong suspicion that the extrapolated part of the DERM rating curve for the gauging station at Savages Crossing is inaccurate causing some underestimates of flows in the order of 20% or more.
- The bathymetry of the river, from Wivenhoe Dam to the mouth of the river, may have changed substantially and it needs to be measured as soon as possible. There was very extensive erosion of the Lockyer and there is a strong suspicion that much of this was deposited in the Brisbane River. There are suggestions that this may be part of the reason for the apparent "discrepancy" in the differences between the DFLs and 2011 levels upstream from the Tennyson Tennis Centre – further upstream the differences are similar in magnitude but, in some reaches, they decrease before increasing again. However, there are substantial differences in the shapes of the hydrographs for the different flood events and this could be a major contributor.
- The accuracy of the stage/volume relationship for Wivenhoe dam storage needs to be checked.

2.2.4 Comparison of January 2011 with Present DFE

As stated above in 2.2.1, the JFTF considers that the flood runoff caused by the rainfall event of January 2011 was greater than the 1974 event. Further, as noted above in 2.2.2, all the measured flood levels for the January 2011 flood event are higher than the levels calculated for a flood with the characteristics of the 1974 flood after mitigation by the effects of Wivenhoe Dam and these latter levels are the presently Defined Flood Levels (DFLs) for areas where river flooding causes the highest level of flooding.

Consequently, despite the lack of complete data at this time, the JFTF has concluded that the January 2011 flood event, as actually experienced, was larger than a flood similar to that of 1974 after mitigation by Wivenhoe and therefore larger than the Council's presently defined DFE.

2.3 River Flood history

Flood records held by the Bureau of Meteorology and the Queensland Government extend back as far as the 1840's for Brisbane. These records show Brisbane is a city built on the flood plain of a river with a history of flooding. While flood peaks are referenced to the Brisbane Port Office gauge in Brisbane City, the flood levels reached upstream are significantly higher. The figure below shows the history of the highest

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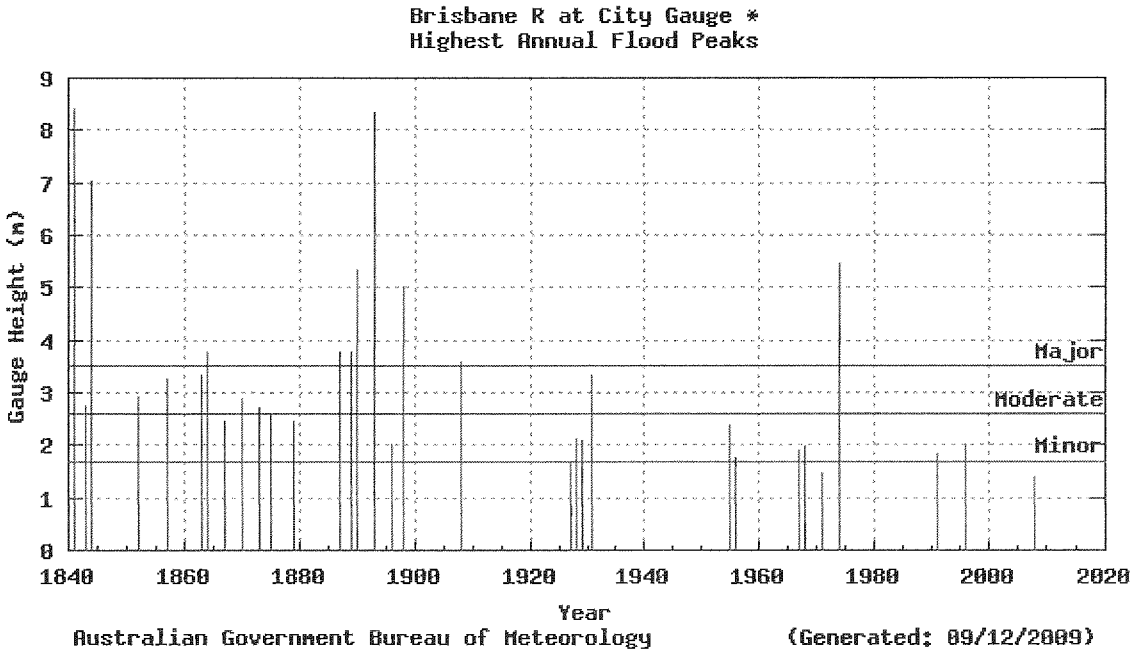
annual flood peaks recorded at the City Gauge between 1840 and December 2009 (so it does not include the January 2011 flood). In that period, Brisbane experienced 10 Major, 8 Moderate and 12 Minor flood events. The descriptions of Major, Moderate and Minor as used by the Bureau of Meteorology are given in the Glossary. The table below shows flood levels on the Brisbane River for a selected number of river flood events.

Table 1: Selected Flood events

River Height Station (m AHD)	Feb 1893	Feb 1931	Jan 1974	Jan 2011
Gatton	16.33	n/a	14.63	n/a
Mt Crosby	32.00	21.78	26.74	n/a
Ipswich	24.50	15.50	20.70	19.25
Moggill	24.50	15.40	19.93	17.48
Jindalee	17.90	9.60	14.10	12.91
Brisbane City	8.35	3.32	5.45	4.46

The floods of 1841 and 1893 reached over 8 m AHD in Brisbane City. This represents a depth of approximately 6.5 m above the highest tide level. Since 1893 the largest flood in the Brisbane - Bremer systems was in 1974. In Brisbane the 1974 flood rose to a height of 5.45 m at Brisbane Port Office gauge while Ipswich reached a height of 20.7 m. As the Brisbane River flooded it backed up the Bremer River resulting in 4 to 5 days of record heights in Ipswich. Seqwater has been quoted in the media as saying the 1974 flood saw a river flow rate of 9,500 cubic metres of water per second. Note that the Jan 2011 flood (4.46m at City Gauge) is not included in the graph below, which was prepared in 2009 by the Bureau of Meteorology.



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2.4 The Brisbane River Catchment

2.4.1 Geographical Characteristics

The Brisbane River is a large catchment of 14,000 km^2. Numerous creek systems feed the Bremer and Brisbane rivers. Rainfall across the catchment varies for any single event with differences of 1,000mm been observed values in the catchment for historic events.

2.4.2 Catchment Characteristics

Runoff is largely controlled by topography (draining system structure, catchment area, grades, etc.), land classification (land use, soil type, vegetation etc.), waterway capacity (conveyance and storage) and antecedent soil moisture content. These characteristics dictate the catchment's response to rainfall. This includes the depth, rate and duration of runoff.

In the Brisbane catchment, these characteristics have changed significantly since the 1893 events due to progressive settlement and development. This development included two large dams that provide temporary flood storage within the catchment. As a result the catchment's response to rainfall has changed significantly since 1893 and continues to change.

Furthermore, the generation of runoff and hence the development of a flood hydrograph is influenced by the characteristics of an individual storm event. The characteristics include the storm intensity, the spatial and temporal patterns of rainfall and the movement of the storm over the catchment

2.4.3 Flood Mitigation Dams

Two large dams provide temporary flood storage in the Brisbane River catchment, Wivenhoe and Somerset dams. Both dams are upstream of where the Lockyer Creek and the Bremer River joins the Brisbane River. As such where the rain event is centred within this large catchment and how it moves over it, determines their effectiveness as a flood mitigation measure for any event.

Table 2: Major Dams

Dam	Wivenhoe	Somerset
Completed	1985	*1959*
Water supply Storage (GL)	1,150	370
Temporary Flood Storage	1,450	524
Location	Brisbane River Upstream of Lockyer & Bremer	Stanley River upstream of Brisbane River
Catchment (km^2)	7,000 including Somerset Dam	1,330
Reservoir surface area (km^2)	107.5	42.1

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While Wivenhoe and Somerset dams are capable of significantly reducing Brisbane River events, they have a limited mitigating effect on the Bremer River acting only to reduce the downstream level of the Bremer River as it enters the Brisbane River.

2.4.4 Creeks

As mentioned above, this report does not consider creek flooding. It is the opinion of the review group that given the power of the flow in the Brisbane River during flood, any creek flooding will have limited impact on the flood levels seen along the river. The more likely scenario is that the Brisbane River will back up any creek causing greater localised flooding or creek flooding. Given this, the increased creek flooding is outside the scope of this report but should be considered as part of a more comprehensive flooding review.

2.4.5 Tide and Storm Surge

The Brisbane River is tidal for approximately 86km from its mouth to around Colleges Crossing. Mean High Water Spring Tide in the bay is approximately 0.927 m AHD. Highest Astronomical Tide is 1.487 m AHD.

Storm tide risk in the Bay is significant. The storm tide level on January 1974 was approximately 1.6m AHD while in May 1996 the storm tide level was around 2.8m AHD. It appears that tide and storm surge can account for approximately +/- 2 m range in the Bay. However, the probability of the largest observed storm tide level coinciding with a flood of the magnitude of the January 2011 event is significantly less than 1 in 100.

2.5 Flood control levels in Brisbane

2.5.1 Differences between Design Events and Actual Events

Before any comparative information is presented it is important to understand the difference between actual observed flood events and probability-based design flood events such as Q100.

The flood event experienced in January 2011 is an *actual observed flood event*. It is *one of many possible events* from a large population of flood events that have occurred or could occur in the Brisbane River catchment from a combination of meteorological, hydrological and hydraulic factors. Observations on these factors during actual flood events are the main source of data and information for the derivation of probabilistic design flood events such as the Q100.

The term, Q100, can be misunderstood. Some people believe a 1 in 100 year flood will only occur once every 100 years on average. Rather, Q100 is a probability-based design flood event, aimed to reflect *typical combinations of flood producing and flood modifying factors* which act together to produce a flood event at a specific location of interest that has a 1 in 100 chance of being equalled or exceeded in any one year (1% annual exceedance probability – AEP); it is described as having an Average Recurrence Interval (ARI) of 100 years. It is a theoretical flood model used to inform planning and policy.

Flood event characteristics of interest for flood management considerations are the peak flow, flood event volume and flood duration, and the resulting flood levels at specific locations. Best estimates of Q100, or similar probability-based design floods, together with information on the bounds of uncertainty attached to these estimates, form the basis for the selection of the DFE for a specific location.

As such, any actual flood event will vary in some degree from the theoretical flood model. This is particularly an issue for a large catchment such as the Brisbane-Bremer catchment. In such large catchments there is a greater chance that actual events will have variables that exceed the range used in developing the theoretical flood model.

2.5.2 Q100 for Brisbane

For Brisbane the Q100 for river flood has a history of calculation and review based on specific events. The current Q100 for Brisbane was last estimated in 2003 as a peak flow of 6,000 cumecs (with uncertainty bounds of ± 1000 cumecs) and a corresponding flood level of 3.3 m AHD at Brisbane's Port Office gauge (with uncertainty bounds of ± 0.5 m).

2.5.3 Defined Flood Event (DFE) and Defined Flood Level (DFL) for Brisbane

DFL is the level above Australian Height Datum (AHD)[4] that Council requires habitable floors to be built above to provide protection against floods up to the magnitude of the DFE. DFL is based on the flood levels that are estimated in the DFE. It is a planning control to avoid people building habitable floor levels in locations or at heights that carry greater risk of flooding than that protected against by the DFL. The Brisbane City Plan also requires an additional 500mm of "freeboard" to be added to allow for a factor of safety, uncertainties and localised effects. It should be noted that in unusual circumstances Queensland's performance based planning system under the Sustainable Planning Act 2009 can allow alternate solutions other than set floor levels, to be considered.

It is desired that the floor levels of commercial and industrial uses meet or exceed the DFL, however an applicant may use a risk management approach if adopting the DFL leads to undesirable outcome.. Although this may be worthy of some reconsideration, it is beyond the scope of the TOR for the Joint Flood Taskforce.

State Planning Policy 1/03 states the Queensland Government's default position is that the 1% Annual Exceedance Probability (AEP) flood or Q100 is generally suitable as the DFE for a Local Government. However, there is a provision to allow a Local Government to define the DFE as higher than the Q100.

Brisbane City Council has defined the DFE to be higher than the Q100 due to previous experience with river flooding (1974 floods). Brisbane City Council uses a flow of 6,800 cumecs as its DFE with a resulting level of 3.7 m AHD at Brisbane's City gaugeas its DFL. This was first set in 1978 and was reconfirmed in 2003.

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2.5.4 The role DFE and DFL in development

DFE and the resulting DFL are fundamental in setting levels for development. Levels for a development are set from the DFL though they vary with building classification and use (eg. habitable or non-habitable). The DFL reflects the slope of the flood profile and thus increases in level progressively as one moves upstream from the City gauge.

Levels set for development include a 'freeboard' margin which allows for uncertainties in the hydrologic and hydraulic models to determine design flood flows and corresponding flood levels, as well as a range of factors which may raise the flood levels locally. The freeboard margin may vary for different locations and types of development.

3.0 How January 2011 Flood compares to Q 100

As discussed above in 2.4.1, before any comparative information is presented it is important to understand the difference between actual observed flood events and a probability-based design flood event such as Q100. The flood event experienced in January 2011 is an *actual observed flood event*. It is *one sample from many possible events* that have occurred or could occur in the Brisbane River catchment from the combination of meteorological, hydrological and hydraulic factors. Observations on these factors during actual flood events are the main source of data and information for the derivation of probabilistic design flood events such as the Q100. Q100 is a theoretical statistical estimate of flood characteristics used to inform planning and policy.

3.1 Runoff

On balance the JFTF considers that the flood runoff resulting from the major rainfall event of January 2011 was greater than the 1974 event but not as great as the 1893 event. One likely contributing factor is the nearly complete saturation of the ground resulting from the long period of rainfall preceding the flood event.

Two large rainfall events, separated by 36 hours were recorded. Further analysis of the rainfall is required to confirm that the January 2011 event was rarer than the Q100 design event. However, this analysis can be undertaken only after the BoM have collated and checked the rainfall data.

3.2 Antecedent catchment conditions

The Q100 calculation assumes 10 mm initial loss and 1 mm/h continuing loss, uniformly distributed over whole catchment. This reflects the relatively saturated state of the catchment at the start of a 72-hour design storm and the resulting flood event. In the months leading up to January 2011, sustained rainfall was experienced across the catchment resulting in a saturated catchment. It is possible that the initial loss and continuing loss were less than those assumed in the Q100 calculation.

In the Q100 calculation the initial reservoir volume was assumed to be 100 percent of its water supply storage with the corresponding level of 67.0m AHD (the "F.S.L.") The conditions at the beginning of the Jan 2011 flood were similar. The dam level was at 67.0m AHD on 2nd February 2011 and had risen slightly to 67.3m AHD on 6th February.

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3.3 Inflows to Wivenhoe Dam

Flood volumes for Q100 for various rainfall durations are given in Table 4-7 of SKM (2003). The 72-hour volume is 2,180 GL.

The total flood inflow volume to Wivenhoe dam during the Jan 2011 flood event was estimated to be 2,650 GL. This estimated inflow volume exceeds the available flood storage in the Dam of 1,450 GL.

3.4 Flood Routing Effect of Storages

The 2003 review of Q100 estimated that there was a reduction of about 50% in peak flows between pre-dam and post-dam estimates of Q100 in Brisbane. This reduction arose from the attenuation effect of the estimated available flood storage in the dams. A comparison of the magnitude and effectiveness (attenuation capacity) of the available flood storage between the Q100 and the January 2011 event needs to be assessed in future work.

Currently the mitigating effect of the dams on the 2011 flood is not available. The operation of Wivenhoe dam is outside the Terms of Reference of the JFTF and it is expected that it will be one of the matters examined by the State Commission of Inquiry. It is necessary that this mitigating effect is assessed in future work.

3.5 Relative timing of Flood Contributions from different parts of the Catchment

The twin rainfall events separated by 36 hrs created nearly coincident peaks at the confluence of Lockyer Creek. The timing of peak discharge from the dam was separated by only a relatively small time interval from the arrival of the peak flow from the Lockyer at its junction with the Brisbane River. The design parameters used in design Q100 modelling do not consider coincident peaks.

3.6 Interaction with Tides and Storm Surge

The flood peak of January 2011 was influenced by a high tide of 0.46 m AHD at 3.13am on 13 January. In the Q100 design model the downstream control used was a level at the mouth of the Brisbane River corresponding to Mean High Water Spring Tide (MWHS), 0.9m AHD ("the tailwater level").

3.7 Resulting Flood Levels Q100 versus January 2011 Flood Levels

Table 3: Level Difference - Q100 Vs January 2011 Flood

Selected Locations	Jan 2011 Flood Approx. Level (m AHD) #	Q100 Design Level (m AHD)	Difference between 2011 and Q100 (m)	DFE Design Level- DFL (m AHD)	Difference between 2011 and DFL (m)
Brett's Wharf	2.48	1.63	0.85	2.05	0.43
Mouth Breakfast Creek	2.80	1.80	1.00	2.05	0.75
Powerhouse	3.20	2.35	0.85	2.80	0.4
New Farm Park	3.41	2.40	1.1	3.10	0.31
Story Bridge	4.35	3.00	1.35	3.66	0.69
City Gauge	4.46	3.30	1.36	3.70	0.76
SouthBank	5.35	3.70	1.65	4.30	1.05
Park Road	6.63	4.31	2.32	5.11	1.52
West End Ferry	7.42	4.92	2.50	5.79	1.64
Fairfield	8.72	5.97	2.75	6.78	1.94
Tennyson Tennis Centre	9.84	7.00	2.84	7.79	2.05
Mouth Oxley Creek	10.0	7.12	2.88	7.99	2.01
Graceville (Low Side)	10.10	7.18	2.92	8.05	2.05
Sherwood Arboretum	11.61	8.44	3.17	9.51	2.10
Seventeen Mile Rocks	12.57	9.24	3.33	10.30	2.27
Centenary Bridge	12.91	9.51	3.40	10.80	2.11
Westlake	13.80	10.30	3.50	11.88	1.92
Goodna Creek	16.79	13.30	3.49	15.20	1.59
Moggill Ferry	17.48	14.00	3.48	15.90	1.58
Karana Downs	22.98	19.31	3.67	21.10	1.88

Jan 2011 level subject to final verification

3.8 Comparison of January 2011 with Present Q100

Despite the lack of complete data at this time, the JFTF has concluded that the January 2011 flood event was larger than the Q100 as presently defined.

4.0 Q100 Reviewed

4.1 Basis of current Q100 estimate

4.1.1 Overview

Q100 refers to the peak flow rate at a specific location that has a 1 in 100 chance of being equalled or exceeded in any one year (1% Annual Exceedance Probability – AEP) or an Average Recurrence Interval (ARI) of 100 years. There are many alternative characteristics of flood hydrographs that are important in risk management of flood events and for the selection of the DFE at a specific location. These characteristics

include the peak flood flow, the peak flood level, the rate of rise in the flood hydrograph and the flood volume among many others.

From the perspective of land use planning, it is usually the peak flood level that is of interest and hence it is the peak flood level quantiles (the levels that correspond to given annual exceedance probabilities) that are desired from the design flood process. In many flood situations, estimation of the peak flood level quantile is achievable by estimation of the peak flood flow quantile. This occurs as a result of the peak flood level being dominated only by the peak flood flow. However, in many estuarine situations, the peak flood level is the result of interaction between coastal and ocean processes and the flood flow. In these situations, there is a need to consider the joint probability between flood flows and ocean conditions in determining the peak flood level quantile.

For the Brisbane River, peak flood levels in the upstream sections of the catchment would be flow dominated while the peak flood levels in downstream sections of the catchment require consideration of the joint probability between flood flows and ocean conditions.

The estimation of Q100 (and flood characteristics for other probabilistic design floods) is based on the application of a range of hydrological methods and tools, using all the available storm rainfall and flood data that are directly relevant to the area of interest. In the particular case of the Brisbane River design flood estimates, the approach adopted in 2003 used the best elements of two methods: statistical flood frequency analysis and simulation modelling of design flood events, with subsequent reconciliation of the results obtained by the individual methods (SKM; Independent Review Panel Report, 2003). The steps involved in the estimation process can be briefly described as follows.

Flood Frequency Analysis (FFA)
This is generally the most direct method for estimating peak flows (or flood volumes), using recorded flood data from many previous flood events of different magnitudes. FFA can be reliably applied where long-term flood records are available and where catchment conditions have remained essentially unchanged over the period of record. In the Brisbane River catchment this applies to flood data from most of the tributaries but for the lower Brisbane River the construction of dams means that pre-dam and post-dam conditions need to be analysed separately. The period of record since the completion of Wivenhoe Dam is quite short and insufficient to allow reliable estimation of Q100 for post-dam conditions. Furthermore, the increased urbanisation downstream of the dam has the potential to modify the flow-probability relationship for the more frequent floods (i.e. the Q2 to Q10 flows).

Rainfall-runoff modelling of design flood events
In this method the processes that convert probability-based design rainfall events to design flood events (hydrographs) of corresponding probability are simulated by means of a rainfall-runoff model of the catchment. This process requires assumptions about typical combinations of flood producing/modifying factors to define design storms and their conversion to flood events of given AEP or ARI (e.g. Q100). Modelling has the advantage that it is quite flexible in allowing different catchment conditions to be

simulated. Specifically, the flood mitigation impacts of dams (i.e. the modification of the inflow hydrograph to an attenuated outflow hydrograph) can be modelled quite accurately. However, in the case of a dam spillway that is controlled by flood gates, this also requires assumptions on how the dam is operated during flood conditions.

It is worth noting that the probability based design rainfalls refer to the most intense portion of a storm event. Hence the parameters used in the design modelling process usually are selected with knowledge of this constraint. Where flood volume is an important aspect of the design flood hydrograph, techniques for inclusion of pre and post peak burst rainfall are available; these techniques have been developed since the publication of the last edition of Australian Rainfall and Runoff and therefore are not included in the current document.

Reconciliation of flood estimates from different methods
The approach adopted in the Brisbane River flood studies (SKM, 2003) then combines the strengths of the two estimation methods by using FFA results to verify the model outputs for the pre-dam situation and then applying a modified version of the model (which simulates the effects of the dams) with probability based design storm inputs to derive peak flows and flood hydrographs for the post-dam condition.

4.1.2 Brief summary of flood studies to produce 2003 estimate of Q100

Only a brief summary is given here of the flood studies that were carried out in 2003 to produce the current estimate of Q100; more details are presented in Appendix B. The complete description of the studies and the recommendations drawn from them are given in the SKM (2003) report and the Independent Review Panel Report (2003).

The SKM (2003) study included a broad range of *flood frequency analyses* for a number of sites within the Brisbane River catchment but focussed specifically on the estimation of Q100 at Savages Crossing for the pre-dam conditions. This was based on recorded flood peak data at this site for the period from 1909 to 1958 (prior to completion of Somerset Dam), extension of flood peak data (by DNRM) to cover the period from 1890 to 1909, simulated pre-dam flood peaks for the period from 1959 to 2000 (from modelling studies by DNRM), as well as a regional flood frequency analysis using flood data from Brisbane River tributaries with adequate flood record lengths.
The *rainfall-runoff model* adopted in the SKM (2003) study is the RAFTS runoff routing model, which had earlier been developed by BCC and calibrated in a previous study. The key inputs to the model and assumptions for the estimation of Q100 are listed in Appendix B. Here it is noted that a 72-hour design storm was used, with rainfall distributed over the catchment according to the typical variation of design rainfall intensities and that the design losses assumed were 10 mm initial loss and 1 mm/h continuing loss, uniformly distributed over whole catchment; these losses reflect a relatively saturated state of the catchment at the start of a flood event

For the post-dam situation it was assumed that Wivenhoe dam was at Full Supply Level (RL 67.0 m AHD) at the start of the flood event and that the dam was operated according to operational rules incorporated into the WIVOPS simulation program, provided at that time by DNRM.

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The Independent Review Panel noted the relatively wide band of uncertainty about the Q100 estimates from both methods. Taking into account all aspects of the study it recommended that the Q100 (peak flood) values shown in Table 4. be adopted.

Table 4: Recommended Pre - and Post-Dam Q100 flow estimates (m3/s) with indication of plausible range of variability (from Independent Review Panel Report, 2003 and SKM, 2003)

Location	Pre-Dams			Post-Dams		
	Q100	Plausible Bound		Q100	Plausible Bound	
		Lower	Upper		Lower	Upper
Savages Crossing	12,000	10,000	14,000	6,000	4,000	8,000
Moggill	12,000	11,000	13,000	6,000	5,000	7,000
Port Office	12,000	11,000	13,000	6,000	5,000	7,000

4.1.3 Summary

The final outcome from the Independent Review Panel Report (2003), drawing on the SKM 2003 flood study, was the conclusion that, for a flood with 1% Annual Exceedance Probability, the best current (i.e. 2003) estimate are a Q100 flow of 6,000 m3/s at the Brisbane Port Office and a corresponding flood level of 3.3 m AHD. It is very important to stress the inevitable degree of uncertainty in estimates of this kind. The Panel considered the possible range for Q100 at this location to be 5,000 to 7,000 m3/s and the associated range of levels to be 2.8 to 3.8 m AHD.

4.2 Critical factors in estimating Q100

4.2.1 Flood frequency analysis

The Q100 estimate for the pre-dam situation from FFA, as discussed in 4.1.2, is affected by a number of sources of uncertainty. The most basic factor relates to the rating curve that is used to convert the observed flood levels at the gauging site to flood flow estimates. As the flow magnitudes of floods for which gaugings have been undertaken are significantly smaller than the largest observed floods, the estimation of peak flows for these larger floods relies on the uncertain extrapolation of rating curves.

The largest floods in the Brisbane River catchment are likely to have resulted from different combinations of flood producing factors than the more frequent events. The statistical methods for fitting flood frequency distributions use data from the whole range of flood magnitudes and the relatively few observations of large floods may be insufficient to define the shape of the flood frequency curve in the range of large to rare events, resulting in wide uncertainty bounds for the Q100. While some of the analyses have tried to overcome these limitations by extending the record to the floods of the 1890s and by adjusting recorded post-dam floods for the flood mitigating impacts of the dams, these steps introduce additional uncertainty in the basic data used for flood frequency analysis and may thus provide only limited additional information.

Additional flood gauging information collected during the January 2011 flood event may help to redefine rating curves in the extrapolated range and thus reduce the influence

of this source of uncertainty on flood estimates. An additional very large observed event also hasthe potential to reduce uncertainty in the extrapolation of the flood frequency curve, but uncertainty in the conversion of post-dam peak flows to pre-dam peak flows still remains.

4.2.2 Rainfall-runoff modelling

The key uncertainty factors in the derivation of Q100 from rainfall-runoff modelling are:

- The spatial pattern of rainfall and the storm movement over the catchment which can be considered typical for producing the flood characteristics of the Q100 in Brisbane under post-dam conditions.
- The typical temporal pattern of rainfall associated with a design storm of 100 years ARI.
- The typical depth of rainfall that occurs in the period prior to the peak burst of rainfall.
- The antecedent conditions (rainfall losses) that would be typical for a Q100 event.
- The expected initial level of the storages at the beginning of the design flood event and the spillway operation during the event.

The flood data and information collected during the January 2011 event can be expected to provide additional insight into the appropriateness of the assumptions made in the 2003 studies, which could lead to a revision of some of these assumptions. However, only part of this data is available at present.

When it becomes available, the additional information on the above five flood producing/modifying factors available from observations of the January 2011 event should be used to assess the sensitivity of the rainfall-runoff model results to key assumptions, and to consider if some of the assumptions made in the 2003 studies should be revised.

In principle, it would also be possible to use the rainfall and flood observations from the January 2011 flood event to check the rainfall-runoff model calibration/validation. This is outside the scope of this interim assessment but should form part of future more detailed studies.

4.2.3 Revision of best estimate of Q100

The analysis of the currently available data from the January 2011 flood event has led to the following observations relevant to a possible revision of assumptions made in the determination of Q100:

- There are additional factors to be considered when defining a 'design storm' and a 'design flood event' that produces design flood levels of corresponding probability in Brisbane.
- The key additional factors include the special characteristics of the temporal rainfall pattern (longer duration, double peak) and spatial distribution of rainfall that tend to be critical for the post-dam flooding situation in Brisbane.
- Both of these factors are highly variable and the Jan 2011 flood indicated a different range of variation than previously assumed.

- The assumed losses in the derivation of the current Q100 event may be higher than what can typically be expected during rare storm events.
- A detailed study of the joint probability of the various flood producing factors (using Monte Carlo simulation) will be necessary to determine the typical combinations of factors that are likely to produce a Q100 event for Brisbane.
- For the determination of flood levels in Brisbane associated with the Q100 event, the joint probability of river flooding, tidal influences and creek flooding will also need to be considered.
- A revised Q100 estimate from a detailed study and the resulting flood levels in Brisbane will still have a significant band of uncertainty associated with them.
- Even without such a detailed study it is clear that any review/revision of Q100 should allow for the special factors experienced during the Jan 2011 flood event which point to an increase in estimated design flood peaks and design flood levels downstream of Wivenhoe Dam compared to the current Q100 event and the DFE.
- In the absence of results of detailed studies, a precautionary approach should be adopted in the revision of previous Q100 estimates as an interim measure.

These observations support the following conclusions on the likely direction and magnitude of a revision of the current Q100 for the Brisbane River:

- The flood hydrograph reaching Brisbane during the Jan 2011 event can be interpreted as providing a likely upper bound estimate of the revised Q100 flood estimate for Brisbane and is thus consistent with a precautionary approach.

4.2.4 Flood level considerations

Estimation of a design flood level can be considered to comprise two components; namely estimation of the design flow and secondly, the conversion of the design flow to a design level at a specific site. Typical approaches for conversion of flows to levels include

- Rating curve;
- Hydrodynamic model.

The use of a rating curve assumes a unique relationship between flow and level. While this approach is applicable for many situations, it is unlikely to be appropriate for the Brisbane River in the tidal region. The 2003 studies recognised this limitation and therefore used the second approach.

The basis of the use of a hydrodynamic model to convert flood flows to flood levels is the numerical solution of the unsteady flow equations for flow over surfaces. There are many factors influencing the local transformation of flow to level with the more important of these being:

- Energy gradient – in general, the steeper the energy gradient, the larger the flow rate. Hence, the same flood flow can result in different flood levels due to different energy gradients which may occur during the rising and falling stages of a flood hydrograph or for different types of flood events.
- Floodplain representation – there is a need to represent the floodplain in a digital form either as a cross section or as a Digital Terrain Model. This digital representation is assumed to be representative of the catchment characteristics.

If the calibrated model is capable of reproducing historical events, then it is assumed that the representation is adequate for the purpose. The 2003 studies used a calibrated Mike-11 model.

- Hydrograph volume – the third parameter is the hydrograph volume. There are two components to the hydrograph volume which are the volume arising from the runoff generated by the rainfall prior to the peak burst and the runoff volume generated from the peak burst of rainfall. It is the former volume which can be important in the transformation of flood flows into flood levels as this prior volume can pre-fill the floodplain thereby reducing the energy gradient and hence increasing the flood level for a given flood flow.
- The bathymetry of the river channels – it is likely this has changed in the Brisbane River and in its major tributaries, possibly substantially, since it was last measured.

Of the four components noted above, it is considered that the flood volume is the most important consideration. The flood hydrograph volume for the January 2011 flood event was far greater than that for the Q100 design hydrograph. The design event was based on a flow dominant problem and not one where volume is a major issue. This greater volume will result in filling of the floodplain prior to arrival of the peak flow thereby limiting the available floodplain storage for attenuation of the flood hydrograph. Hence design flood levels calculated for the same peak flow as for the January 2011 flood event are likely to be biased low in the design event in the regions where floodplain storage was assumed to be available.

The peak ocean level during the Jan 2011 event was 0.46 m AHD compared with the level of 0.9 m AHD used for the design event. This means that, in the downstream reaches, the Jan 2011 levels will be lower than in a design event for the same flow rate but with an ocean level of 0.9 m AHD. In downstream reaches influenced by the ocean levels, there is no direct relationship between flow rates and flood levels.

4.2.5 Unknown information required for new estimate of Q100

Before a new estimate for Q100 can be developed, it will be necessary for the following information to be obtained:

- BoM is still assembling the rainfall data for Jan 2011.
- There is strong suspicion that the extrapolated rating curve for the gauging station at Savages Crossing (owned by DERM) is seriously inaccurate causing underestimates of flows of order 20% or more.
- BoM is finding that large floods often have intense localised rainfall events. These are not adequately recorded by the existing rain gauge network and they may be missed completely.
- BoM suspects that it may be necessary to increase substantially the estimates of peak flows for the 1893 floods, for 1974 and for 2011 because of the previous matter and also because some of the rainfall data is for relatively long periods – up to daily rainfall – and this misses out on high intensity shorter periods within the event.
- There is some belief that the 2011 rainfall event was greater than that in 1974 but this requires clarification when the complete data is available. However there is clear evidence that the runoff volumes were greater than those in 1974 and if

Wivenhoe dam had not been present it is possible that the peak flow and peak levels would have been greater than that in 1974.

4.3 Conclusion

On the basis of the data currently available, the flood levels experienced during the Jan 2011 flood event provide an indication of the levels that may be expected from a revised Q100 event. However, varying tidal influences and creek contributions mean that the probability associated with these levels may be different at different locations.

The January 2011 flood has brought a significant amount of new data and information on the nature of flooding in the Brisbane River and about the factors contributing to very large flood events in this catchment. Significant work is required to review Q100 for the Brisbane River in the light of this new information. This work could not be completed given the data available to the JFTF, some of which is still being collected as detailed in 4.2.5.

In light of the available information it is clear that the current Q100 needs to be reviewed. It is more likely than not that this review will raise the Q100 upwards.

On balance, the JFTF believes that, in the absence of results of a detailed flood study review, a precautionary approach should be adopted. Therefore, it considers that the actual January 2011 flood event, as observed during the event, should be used as the **interim** standard on which Brisbane City Council bases its decisions concerning habitable floor levels for new development and should be a consideration for habitable floor levels for redevelopment of existing properties. Wherever the existing DFL is higher than the January 2011 flood event, the existing higher flood level should prevail.

5.0 Benefits and Cost of New Defined Flood Event

To assist with understanding the consequences of a new DFE, five (5) alternate DFL scenarios have been qualitatively compared. These scenarios are:

- Current Q100 (3.3m at City Gauge),
- Current Defined Flood Level (3.7m AHD at City Gauge),
- January 2011 Flood Event (4.46m AHD at City Gauge),
- 1974 without Wivenhoe Dam (5.45 m AHD at City Gauge), and
- 1893 without Somerset and Wivenhoe Dams (8.35m AHD at City Gauge).

Section 6 of this report then draws conclusions on the overall benefits and consequences of changing the Brisbane River flood standard, for each of the scenarios.

5.1 Flood Risk Management Benefits

5.1.1 Nature of Flood Risk Management Benefits

The benefits of different flood risk management strategies are measured by their potential to reduce expected future flood damages and other flood impacts (including risk of injury and loss of life) compared to a base case. In the Brisbane River flooding context considered here, the benefits of various *defined flood event scenarios* are

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expressed as marginal benefit in comparison with the flood damage costs and flood impacts associated with the *current DFE* (the 'do nothing' option).

The estimation of the expected future flood damages/impacts has to take into account the full range of possible flood events, weighted by their annual exceedance probability. The benefits of a higher DFE (and associated higher defined flood levels) are then measured by the reduction in residual flood damages (the flood damages that are not avoided by the adoption of a specific DFE).

The types of benefits may include:

(i) Reduction in trauma to the community associated with the occurrence of a flood event that exceeds the adopted habitable flood standard and consequential loss of valued possessions. This is a result of development being more resilient to flood damage. This benefit will accrue over the long term as development and redevelopment occurs. It is generally accepted that as the DFE increases in height, the reduction in trauma to the community would reduce, over a period of time.

(ii) Existing development – gradual reduction of flood damage potential as habitable floor levels are raised through redevelopment of existing buildings. It must be noted this is a long term benefit and depends on the rate of redevelopment and refurbishment of existing building stock. Similar to trauma reduction, higher DFE's will lead to a reduction in flood damage potential.

(iii) Future development – reduction in residual flood damage cost in areas subject to the new flood level regulations. This effect provides benefits from the commencement of a new flood standard and continues to accrue as new development comes on line ie. it is a long term benefit.

(iv) Reduced cost of flood response and flood recovery measures when an event that exceeds the current DFE occurs. This benefit occurs over the long term through the overall accrual of higher flood protection afforded to people, buildings and infrastructure through development and redevelopment.

These benefits associated with setting defined flood levels for planning and building purposes can be enhanced by other flood risk management measures that raise public awareness of the flood risk, helping the affected community to reduce its exposure to flood risk by preventative measures, flood warning systems, flood mitigation and improved flood resilience. Through the Lord Mayor's Task Force on Suburban Flooding, Council has initiated many such measures since 2005.

5.2 Flood Risk Management Costs

In determining costs of alternate DFE scenarios a descriptive methodology has been used as described below.

5.2.1 Impact Assessment Descriptors

To help determine how these costs can be assessed, three key descriptors have been developed. The criteria are listed below and shown in more detail in Appendix B.

1. Urban Fabric – the impact upon infrastructure and development costs to deliver the desired urban growth patterns for Brisbane ie. the SEQ Regional Plan and CityShape 2026.

2. Social Fabric – the number of people affected, impacts upon their built environment, community facilities, amenity and the amount of change they will be required to manage in their day to day lives. For example, where a property owner's home was not previously included with the DFE, once included there may be consequences for insurance, the value of the dwelling and even community facilities may no longer be able to be located close by.
3. Economic Fabric – relates primarily to the impacts upon businesses such as development costs to achieve flood resilience. Changes in flood standards can also impact upon the decisions about locations of commercial operations that may have higher levels of flood risk e.g. private schools or a manufacturing industry with low ability to relocate expensive machinery quickly at a time of flood.

5.2.2 Limitations of Methodology

Given the data available for this investigation, there are known impacts which were not possible to consider. Some of these are listed below, but there may be others:

- Precise knowledge of cost to each property,
- Property market response,
- Housing affordability,
- Development costs, and
- Social wellbeing and health.

Additionally, habitable floor level information was not available for the various scenarios, so inundation of part or all of a property was used as a proxy in Section 5.3.3.

5.3 Assessment of Individual Criteria

Where data was available it has been used in the following assessment of impacts. Where data was not available, impact has been classified from "low" to "extreme" with reference to the descriptors in Section 5.2.1.

5.3.1 Impact on growth centres & corridors

Significant planning has been undertaken in Brisbane City through Neighbourhood Planning to deliver the CityShape 2026 and support the SEQ Regional Plan 2009-2031 growth framework and housing targets. This section aims to give an indication of the potential magnitude of impact of the various DFE scenarios on these planning initiatives.

The growth corridors and centres listed in the table below are those which could be physically affected by some form of inundation from one or more of the various DFE scenarios.

Table 5: Possible consequence of DFL scenarios on growth centres and corridors

DFE Scenario	Current Q100	Current DFE	Jan 2011	5.45m (1974)	8.35m (1893)
Albion	Low	Minor	Medium	High	Extreme
Eastern Corridor	Low	Low	Low	Minor	Medium
City Centre	Low	Low	Minor	Medium	Extreme
South Brisbane Riverside	Low	Low	Medium	High	Extreme
Woolloongabba	Low	Low	Low	Low	Minor
Milton	Low	Low	Medium	High	Extreme
Towong-Taringa	Low	Low	Minor	High	High
South West Rail Corridor	Low	Low	Medium	Medium	High
Overall Impact	Low	Low	Minor	Medium	High

5.3.2 Transport Network

Brisbane and Ipswich are to a large degree established areas with much of the transport network already in place. The consequences of new DFEs are the ability of the transport network to improve its flood immunity without significant impacts on the surrounding area in terms of amenity or functionality with other parts of the network. On this basis the consequence has been assessed subjectively on a number of elements of the transport network.

Table 6: Transport Network Consequences

DFE Scenario	Current Q100	Current DFE	Jan 2011	5.45m (1974)	8.35m (1893)
Local Roads	Minor	Medium	High	High	Extreme
Arterial Roads	Low	Low	Minor	Medium	Medium
Rail Network	Low	Low	Low	Minor	Medium
Overall Impact	Low	Minor	Medium	High	Extreme

5.3.3 Additional number of properties within DFE area

For the purpose of this exercise, properties within the DFE area are defined as those properties situated on land that shows any level of inundation during the peak of these selected flood event scenarios. Where land parcels are held together these are counted as one property. For multi-unit residential development the total number of units on that property has been counted, as they all are affected in some way, if not from direct inundation. For example, a community title development with 150 individual dwelling units may have received flood waters in its basement, though no flooding of habitable areas within any of the individual units may have occurred. In some instances, the flooding impact would have been immaterial, affecting vacant land only.

For residential properties it would have been preferable to compare the number of dwellings that would receive inundation of the habitable floor level, but this information was not available.

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Table 7: Numbers of properties within DFE area

DFE Scenario	Current Q100	Current DFE	Jan 2011	5.45m (1974)	8.35m# (1893)	Jan 2011-Current DFE
Commercial	1,171	1,178	2,759	2,907	n/a	1,581
Industrial	783	1,589	2,000	2,482	n/a	411
Community	24	34	46	48	n/a	12
Multi-Unit Residential	6,814	10,756	15,834	18,025	n/a	5,078
Single Dwelling Residential	4,666	7,543	10,228	12,306	n/a	2,685
Total	13,445	21,100	30,867	35,768	n/a	9,767

This measure is not available at this time.

5.3.4 Impact on streetscapes

In determining the impact on residential streetscapes, the additional depth of inundation for each DFE scenario, compared to the current DFE is shown in Table 8. In many areas, such as Fairfield and Rocklea, the existing level of inundation currently causes difficulties with achieving house design under 8.5m. The additional consequence is dealing with the amenity issues of bulk and scale in the local setting of isolated houses over 8.5m. Therefore the assessment of this measure also factors in this consequence.

To assess this impact it is considered a typical two (2) storey house of timber and tin construction may be between 7.5 and 8.3 m in height (including 0.5m flood freeboard).

Since a large proportion of these types of houses affected during the January 2011 event are located between West End/Milton and Graceville, the average relative difference in level between Park Road and Graceville has been used. The reason for this is the effect of a rise at the City Gauge is magnified upstream. This effect is shown in the comparison of river heights in Table 8.

Table 8: Height difference of DFE scenarios from current DFE and impact on residential design.

DFE Scenario	Q100	Current DFE	Jan 2011	5.45m (1974)	8.35m (1893)
Height Difference to DFL at Park Road	-0.8	0.00	1.52	2.01	5.59
Height Difference to DFL m at Graceville	-0.87	0.00	2.05	2.75	6.73
Average Difference	-0.84	0.00	1.79	2.38	6.16
Relative Impact	Low	Nil	Medium	High	Extreme

The effective interface of a use and the street is a key factor in achieving street activation and amenity. As the height difference between the street and active building uses increases, safety, activation and amenity become harder to successfully achieve. While small differences can be accommodated, greater increases may only be accommodated by graduated design and potentially flood resistant uses.

Many inner city commercial streetscapes are situated between Teneriffe and West End, including the lower city centre and Southbank. As the majority of new development is currently occurring from the City to West End, the difference between the current DFE and the scenario DFEs at the City Gauge and West End Ferry are used as a guide to average consequence as seen in Table 9.

Table 9: Height difference (m) of DFE scenarios from current DFE and impact on streetscape

DFE Scenario	Q100	Current DFE	Jan 2011	5.45m (1974)	8.35m (1893)
Height Difference to DFE Scenario Level (m) at City Gauge	-0.4	0.00	0.76	1.75	4.76
Height Difference to DFE Scenario Level (m) at West End Ferry	-0.87	0.00	1.64	2.16	5.90
Average Difference	-0.64	0.00	1.20	1.96	5.33
Relative Impact	Low	Nil	Medium	High	Extreme

5.3.5 Impact on community infrastructure

Community infrastructure such as medical facilities, schools and the like are particularly susceptible to flood risk and many received some level of inundation during the January 2011 event. For comparative purposes, Table 10 shows the number of community facilities that would receive some level of inundation at the various scenarios.

Table 10: Potential impact on community infrastructure – medical & schools

DFE Scenario Event	Q100	Current DFE	Jan2011	5.45m (1974)	8.35m (1893)#
Facilities Affected	24	34	46	49	n/a
Relative impact	Low	Low	Minor	Medium	High

Information not available at this point of time however it is considered the impact is likely to be at least high.

5.3.7 Industry and commercial development

The principal industrial area affected by the January 2011 event is at Rocklea. This is an established area which reuses or rebuilds sites. Much of the area is under the current DFE and consequently risk management solutions are often required to manage the impacts of flooding on individual sites. As a risk management approach may be applied to development applications for industrial uses, in-depth investigation of the impacts on industry is considered outside the scope of the Terms of Reference. It is hoped however that property and business owners in these areas will choose to manage their own flood risk, using a new DFE as a guide. Table 11 shows the height difference between the current DFE and the various scenarios at Rocklea.

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Table 11: DFE comparisons at Rocklea

DFE Scenario	Q100	Current DFE	Jan2011	1974	1893
Relative Difference in DFL scenarios compared to current DFL at Rocklea (m)	-087	0.0	2.05	2.99	7.05
Relative impact	Low	Nil	High	High	Extreme

Commercial development along the River is concentrated generally between the CBD and Toowong/West End. The impact on these activities will be measured by its ability to adapt to a new DFE over time. This may be through built form/design changes and/or risk and disaster management approaches, such as locating essential building services out of basements and in upper parts of buildings. As the change in DFE increases the process of adaptation becomes more challenging. Therefore, as flood restrictions on built form increase, flexibility in design decreases with potential adverse impact on building utility and costs. There is however a positive benefit over the long term as commercial precincts would become more flood resilient. The difference in level from City Gauge to West End Ferry has been used for comparison. The impact is then applied as per the discussion above, as shown below in Table 12.

Table 12: DFE comparisons in several commercial areas

Flood Scenario	Current Q100	DFE	Jan 2011	5.45m (1974)	8.35m (1893)
Height Difference to DFE Scenario Level (m) at City Gauge	-0.4	0.00	0.76	1.75	4.76
Height Difference to DFE Scenario Level (m) at West End Ferry	-0.87	0.00	1.63	2.16	5.9
Average Difference (m)	-0.64	0.00	1.20	1.96	5.33
Relative Impact	Low	Nil	Medium	High	Extreme

6.0 Discussion of DFE Scenarios

In the limited time available, the assessment of the benefits and costs of the different options could only be undertaken in a qualitative way but it is important that a full flood risk management study should be undertaken as soon as possible.

6.1 Current Q100 of 3.3m AHD at City Gauge

As can be seen from the tables throughout Section 5, the current Q100 is a theoretical flood level that is below the current DFE. Given the research undertaken into the January 2011 flood event and the advice of the expert hydrologists, it is not advisable to reduce the current DFE for the Brisbane River. Due to a lack of available information, the JFTF was unable to redefine the Q100 for the River in the time frame available although this work clearly needs to be done. Adopting the current Q100 as a new DFE would have a negative benefit in terms of improving Brisbane's flood risk management.

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6.2 Current DFE of 3.7m AHD at City Gauge

The current DFE is a theoretical event that has been in place for the Brisbane River since 1978. The January 2011 flood was significantly higher than the current DFE by 0.76m at the City Gauge, encompassing an estimated 9,767 additional properties. This height difference is amplified as the distance from the river mouth increases (with some local variations), demonstrated by a height difference of approximately 2.05m at Rocklea and Graceville. Given the recommendations of the expert hydrologists, maintaining the current DFE as an interim development standard would not change the current flood risk and damage profile of the city and is not recommended.

6.3 January 2011 Flood Event Level of 4.46m AHD at City Gauge

As can be seen by looking at the history of Brisbane River annual flood peaks dating back to 1840 (refer to Section 2.3), this event of 4.46m at the City Gauge is very significant. Prior to the January 2011 flood event, only 6 other events have exceeded 4m at the City Gauge since the 1840s. All of these events occurred prior to the construction of Wivenhoe Dam.

The effect of adopting an interim DFE equal to the 2011 flood level has been assessed against the impact on the urban, social and economic fabric as defined in Section 5.2.1. Where possible the effect has been quantified. The overall impact has been assessed as Minor to Medium, with significant benefits for flood risk management accruing over time, as redevelopment and new development occurs.

Due to the limited time available, accurate financial cost implications of this option were not able to be quantified. One notable feature is that if the DFE was to move to such a level, there would be a significant impact on those communities affected by the change. Predominant matters are building heights in the suburbs upstream of West End and difficulty in maintaining streetscape in some local areas with a risk management approach. It does however set the City on a path for achieving a long term outcome of proportions approaching a medium value of flood risk management benefit. It also provides greater protection against a possible trend of more frequent large flood events.

6.4 1974 Flood level of 5.45 m AHD at City Gauge

As a comparison, the pre-Wivenhoe Dam 1974 flood event was assessed. It was used because the level was already modelled making it possible to draw the comparisons to other events.

A DFE of this level would have a High consequence on the city's urban, social and economic fabric. It would be difficult for many areas to develop properly with land sterilisation for certain uses locally, a real prospect. It would also have an impact on house raising options with this becoming an unrealistic option in many locations such as Rocklea where the habitable floor level could increase by an estimated 2.99m. In addition to the practicalities of achieving habitable floor levels above this height, detrimental impacts on both residential and commercial streetscapes should be considered.

At this level, some reconsideration of land uses may be necessary. Notably however the overall impact on growth centres and community facilities is limited, though transport networks implications will be high. Long term flood risk and damage profile of the city is likely to be significantly reduced but the costs would outweigh the benefits.

6.5 1893 Flood Level of 8.35m AHD at City Gauge

This level was assessed to provide a feeling for what an extreme event may do. In summary, a DFE of such a magnitude would require a complete reappraisal of how the city is planned, its transport network security and location of community facilities, however long term flood risk and damage profile of the city would likely be significantly reduced.

7.0 Conclusion

How does the January 2011 flood event compare to the Q100 as currently defined and Brisbane City Council's Defined Flood Event (DFE)?

In the January 2011 flood event experienced, the heaviest rains were inland on the western fringe of the Brisbane River catchment and on the Great Dividing Range. Over the Brisbane River catchment as a whole, based on rainfall captured by BoM's Enviromon rain gauges, the estimated average 5-day rainfall is 322mm, with the major sub-catchments of Wivenhoe Dam, Bremer River and Lockyer Creek receiving 370mm, 223mm and 268mm respectively.

Given the pattern of rainfall, the Brisbane River received significant flows from the upstream catchments of the Lockyer and Bremer. The flow down the upper Brisbane River (above the Lockyer Creek) and Stanley River were mitigated by Wivenhoe Dam. However Brisbane felt the full force of the flows down the Lockyer and Bremer Rivers. As a result of the rainfall, Brisbane experienced a significant river flood.

Based on examination of the rainfall patterns of a number of previous Brisbane River floods, it is concluded that the Brisbane catchment experienced a significant rainfall event with a rain pattern that was different from that experienced in 1974. Full details of the rainfall magnitudes were not available at the date of this Report. However back calculations from recorded releases from Wivenhoe and the record of water level in the dam suggest significantly more flood producing rainfall occurred than indicated by the presently available rainfall data. The calculated dam inflow hydrographs show two peaks, the first of the magnitude of 1974 and the second of greater magnitude than 1974, 36 hours later. The level recorded at Savages Crossing was higher than in 1974. Flood inflow volumes to Wivenhoe as calculated from the known releases from Wivenhoe dam and the recorded water levels in the dam total 2,650 GL as compared to a total of 1,410 GL for that location in 1974 and 2,744 GL in February 1893.

On balance the JFTF considers that the flood runoff resulting from the major rainfall event of January 2011 was greater than the 1974 event but not as great as the 1893 event.

All of the peak flood levels recorded in January 2011 by the gauges along the Brisbane River were higher than the existing Defined Flood Levels, ie. levels previously calculated

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for the 1974 flood event mitigated by Wivenhoe Dam. Therefore, taking into account this fact together with its assessment of the rainfall event, the JFTF considers that the January 2011 flood event was larger than the Brisbane City Council's Defined Flood Event.

The Q100 as presently defined is, in general, a slightly lesser flood than the Defined Flood Event. Therefore the JFTF considers that the January 2011 flood event was larger than the Q100 as presently defined.

Much more detailed work is required to accurately identify the probability of this event for Brisbane.

Does Q100, as it is currently described, remain the best estimate of a 1 in 100 year event?

Q100 is a theoretical flood model used to inform planning and policy. This probability-based design flood event aims to reflect typical combinations of flood producing and flood modifying factors which act together to produce a flood event that has a 1 in 100 chance in any one year of occurring at a specific location of interest.

The January 2011 flood has brought a significant amount of new data and information on the nature of flooding in the Brisbane River and about the factors contributing to very large flood events in this catchment. Significant work is required to review Brisbane's Q100 in the light of this new information. This work could not be completed given the data available to the JFTF report, some of which is still being collected.

In light of the available information about the 2011 flood event, the JFTF considers that it is essential that the current Q100 is reviewed. It is not possible to predict the outcome of such review but it is considered more likely than not that this review will lead to an increase in the magnitude of the Q100 and increases in associated flood levels.

Accordingly, what standard should be used to enable new development and redevelopment to proceed with confidence and certainty?

To answer this question five (5) scenarios have been evaluated. These scenarios are:

- Current Q100 (3.3m at City Gauge),
- Current Defined Flood Level,DFL (3.7m AHD at City Gauge),
- January 2011 Flood Event (4.46m AHD at City Gauge),
- 1974 without Wivenhoe Dam (5.45 m AHD at City Gauge),and
- 1893 without Somerset and Wivenhoe Dams (8.35m AHD at City Gauge).

On balance, the JFTF believes that, in the absence of results of a detailed flood study review, a precautionary approach should be adopted. Therefore, it considers that the actual January 2011 flood event, as observed during the event, should be used as the **interim** standard on which Brisbane City Council bases its decisions concerning habitable floor levels for new development and should be a consideration for habitable floor levels for redevelopment of existing properties. Wherever the existing DFL is higher than the January 2011 flood event, the existing higher flood level should prevail.

The JFTF notes that, in regions where the interim standard will be applied, the degree of immunity from flood risk will vary with location. This is because the January 2011 flood event is an actual event and will have variable tidal influences along the tidal reach. Consequently variable probabilities will apply along this reach.

The recommendation of a new development standard refers to land use types that are currently assessed against a DFE in the City Plan. This currently excludes industrial development however this should be considered through the current City Plan review.

Further the DFE and resulting flood regulation lines are considered only part of a flood risk management framework for a community. The approach to flood risk management for Brisbane needs to consider a broader range of initiatives if it is to effectively manage flood risk for the City. Flood risk management requires that the consequences of floods be investigated for a range of flood events up to and including the PMF. For land use planning, flood levels as well as flood flows corresponding to specific probabilities must be considered. This approach must include identification of the benefits of the management of risk, rather than seeing it as all cost.

8.0 Recommendations

It is recommended,

That the actual January 2011 flood event, as observed during the event, be used as the **interim** standard, on which Brisbane City Council bases its decisions concerning new development and redevelopment, with the essential condition that, wherever a higher level has been set as the current DFL, the higher level must apply; and that this interim standard apply until conclusion of the Commission of Inquiry and the comprehensive flood study recommended below is completed.

That all data relating to the January 2011 flood event be gathered from all sources and archived so that further analysis can make use of all data available.

That the bathymetry (river bed and banks) of the Brisbane River and its tributaries and the characteristics of the bed material from Wivenhoe dam to the mouth be measured as soon as possible.

That a comprehensive flood study be commissioned to review flood flows and levels within the Brisbane River catchment making full use of the data relating to the January 2011 flood event.

That the effects of morphological (river bed level and cross section) changes due to sediment erosion and deposition during flood events be studied for a range of flood magnitudes to determine their effects on flood levels.

That consideration be given to whether a Monte Carlo approach to the flood risk for the Brisbane Catchment is feasible and if yes, whether it should be carried out and which influencing factors should be included in the Monte Carlo approach. This may include consideration whether two or more types of rainfall events should be built into the statistical analysis for theoretical floods (In a Monte Carlo analysis the influencing input

factors such as rainfall patterns, storm tracks, catchment conditions, tide and storm surge are sampled, either randomly or in accordance with their joint probabilities, to select a large number of different combinations of inputs for simulation with a catchment modelling system to develop many alternative predictions of flood events. These predictions are then analysed statistically to estimate their exceedance probabilities).

That a complete Flood Risk Management analysis for the area of Brisbane affected by flooding from the Brisbane River and its tributaries be carried out. It is essential to move from the Q100 mentality and to adopt a risk management approach in line with National Flood Risk Advisory Group (NFRAG) and other relevant guidelines. The risk management approach would require a detailed assessment of the benefits and costs of a full range of flood mitigation options.

Appendix A: Terms of Reference

Joint Flood Taskforce

TERMS OF REFERENCE (TOR)

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Document Purpose

The purpose of this document is to clearly define the Terms of Reference (TOR) for a Brisbane City Council/Ipswich City Council Joint Flood Taskforce.

Role of the Joint Flood taskforce

Brisbane City Council, in partnership with Ipswich City Council will form a Joint Flood Taskforce to investigate the January 2011 flooding events. The Taskforce will recommend interim flood immunity standards and development guidelines to manage redevelopment of flood affected properties and new development activity within the Brisbane River floodplain.

Operation of Joint Flood taskforce

The Taskforce will utilise available information to make its recommendations on the questions posed in 3.3 *Outcomes of the Joint Flood Taskforce*

The Taskforce shall provide recommendations to the Lord Mayor's Recovery Task Group by **Thursday 10 March**.

Relationship to State Commission of Inquiry

The Joint Flood Taskforce does not form part of the State's Commission of Inquiry.

The recommendations of the Joint Flood Taskforce are interim and their application may be validated or varied dependant on the outcome of the State's Commission of Inquiry. The recommendations of the Joint Flood Taskforce will be provided to the Commission of Inquiry and Flood Response Review Board.

Relationship to Lord Mayor's Flood Response Review Board and Lord mayor's Recovery Task Group (LMRTG)

The Lord Mayor has established an independent Flood Response Review Board. This Board will review the effectiveness of Council's response and disaster management arrangements, the impact of planning regulations in flood affected areas and the effectiveness of public warnings and advice, as well as the effectiveness of storm water and flood prevention infrastructure, and failure of river-based infrastructure. This Board will report in May 2011 to the Lord Mayor and the LMRTG. The progressive minutes and final recommendations of the Joint Flood Taskforce will be provided to the Lord Mayor's Flood Response Review Board.

The LMRTG, and the Town Planning Recovery Sub-Committee, will oversee the Joint Flood Taskforce and implement its recommendations on an interim basis.

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Outcomes of the joint flood taskforce

The primary goal of the Taskforce is to provide expert advice and develop interim recommendations guiding development and redevelopment in Brisbane and Ipswich.

Key questions the Taskforce will need to answer are:

1. How does the January 2011 flood event compare to the Q100 as presently defined and BCC's Defined Flood Event?
2. Does Q100, as it is currently described, remain the best estimate of a 1 in 100 year event?
3. Accordingly, what standard should be used to enable new development and redevelopment to proceed with confidence and certainty?

Membership – Joint Flood Taskforce

The proposed Joint Flood Taskforce shall be comprised of:

- Chair - Emeritus Professor Colin Apelt
- [redacted] – Acting Manager Water Resources Branch, Brisbane City Council
- [redacted] – Senior Engineer, Hydraulics, Ipswich City Council
- Erwin Weinmann - Experience: Senior Lecturer in water subjects at Monash University, Former Deputy Director CRC for Catchment Hydrology (Monash Node), and Co-author of Book VI (Estimation of Large and Extreme Floods)
- Professor [redacted] - University of Technology Sydney

Membership – Technical Reference Group

In addition to the Joint Flood Taskforce, a Technical Reference Group will be established for the Taskforce to interface with as required.

It is expected the Joint Flood Taskforce would establish smaller expert technical working groups for input into the recommendations (formed from amongst the members of the Technical Reference Group).

Internal

- [redacted] Manager City Planning
- [redacted] – Manager Development Assessment
- [redacted] – Manager Major Development
- [redacted] Group Manager Water – City Design
- [redacted] Principal Engineer Flood Management – City Design
- [redacted] Chair Urban Futures Brisbane

External (subject to confirmation)

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- Water CRC, Canberra
- BMT
- Bureau of Meteorology
- Department of Infrastructure and Planning
- Department of Environment and Resource Management
- SEQ Water Grid Manager
- SEQ Water

Membership- Industry reference Group

The Taskforce will establish, consult and advise an Industry Reference Group on the proceedings of the taskforce. The Industry Reference Group will have the opportunity to provide comment and advice to the Taskforce on the release of their interim recommendations.

The Industry Reference Group will provide external advice on the needs of industry to respond to the flood in terms of redevelopment and new development standards. The group will also provide industry perspective on the potential impact of the implementation of new standards on practicality, affordability and implantation needs.

The proposed Industry Reference Group will comprise;

- Chair - [redacted] – Urban Futures Brisbane
- BDO Kendalls - [redacted]
- Commonwealth Bank - [redacted]
- MIRVAC - [redacted]
- Pradella [redacted]
- UDIA – [redacted]
- HIA - [redacted]
- Property Council of Australia – [redacted]
- Lend Lease - [redacted]
- Insurance Council of Australia – [redacted]
- UDIA - [redacted]
- PIA – [redacted]
- Master Plumbers - [redacted]
- AIA President - [redacted]

- BDA - [redacted]
- UDAL [redacted]
- Others tbc

Role of the Joint Taskforce members

The Joint Flood taskforce Chairman will be responsible for day to day decision making within the scope of the Terms of Reference and be responsible for decision making where;

- Any significant variation to scope.
- Any change in schedule that will have an impact on delivery
- Any significant issues or risks which they are not able to deal with.

If the designated Chair is not available, then the BCC Manager Water Resources will act as proxy. The acting Chair will be responsible for convening and conducting that meeting. The Acting Chair is responsible for informing the Chair as to the salient points/decisions raised or agreed to at that meeting.

Administration

Agenda

All agenda items for each Taskforce meeting must be forwarded to the Joint Flood Taskforce secretariat by C.O.B. 2 working days prior to the next scheduled meeting.

The agenda, with attached meeting papers will be distributed at least 1 working day prior to the next scheduled meeting. The Chair has the right to refuse to list an item on the formal agenda, but members may raise an item under 'Other Business' if necessary and as time permits.

Minutes & Meeting Papers

The minutes of each Taskforce will be prepared by the Joint Flood Taskforce secretariat. The secretariat will be supported by Brisbane City Council's Water Resources Branch.

Meeting Agendas will include:
- Minutes and actions from previous meeting
- Update from the last Meeting
- Update on progress of the activities
- Key upcoming events, activities, changes
- Any Other Business
- Action summary and next meeting date

Action items arising from the meeting minutes will be forwarded to the relevant Divisional Manager and Taskforce member within two working days following each meeting.

Frequency of Meetings

Meetings are held weekly or at the determination of the Chair.

Proxies to Meetings

Members of the Taskforce will only have a proxy in exceptional circumstances. Where an extended period of absence is anticipated or known, a proxy shall be nominated with the approval of the Chairman.

The nominated proxy shall have voting rights at the attended meeting. The nominated proxy shall provide relevant comments/feedback to the Taskforce member they are representing of the salient points from the meetings they have attended

Quorum Requirements

The Taskforce members are key advisors to the Chair in their decision making capacity, however all decisions lie with the Chair.

A minimum of 4 Taskforce members is required for the meeting to be recognised as an authorised meeting and for the recommendations or resolutions to be valid.

Review Timetable

TBC

Appendix B: Details of Flood Studies that produced the 2003 Estimate of Q100

B.1 Results of flood frequency analyses

The SKM (2003) study included a broad range of flood frequency analyses for a number of sites within the Brisbane River catchment but focussed specifically on the estimation of Q100 at Savages Crossing for the pre-dam conditions. This was based on recorded flood peak data at this site for the period from 1909 to 1958 (prior to completion of Somerset Dam), extension of flood peak data (by DNRM) to cover the period from 1890 to 1909, simulated pre-dam flood peaks for the period from 1959 to 2000 (from modelling studies by DNRM), as well as a regional flood frequency analysis using flood data from Brisbane River tributaries with adequate flood record lengths.

The Q100 estimate from flood frequency analysis for the pre-dam situation is given in Table B1, together with nominal upper and lower bounds.

Table B1: Summary of Q100 estimates from FFA at Savages Crossing – pre-dam conditions (from Review Panel Report, 2003 and SKM, 2003)

Method	Q100 estimates [m^3/s]		
	Best Estimate	Plausible Range	
		Lower Bound	Upper Bound
Flood Frequency Analysis	12,000	10,000	14,000

B.2 Results of rainfall-runoff modelling

A number of different rainfall-runoff models of the Brisbane River catchment have been developed for a range of purposes. The model adopted by SKM is the RAFTS runoff routing model, which had earlier been developed by BCC and calibrated in a previous study.

The key inputs to the model and assumptions for the estimation of Q100 for the pre-dam situation are:

- Design rainfall depths for an ARI of 100 years and for a range of durations (adopted average rainfall depth over catchment = 308 mm, based on CRC-FORGE design rainfalls for a critical duration of 72-hours, with allowance for an areal reduction factor)
- Rainfall temporal pattern – standard ARR87 temporal pattern for this location, duration and ARI applied over whole catchment (with a sensitivity analysis of temporal patterns based on 4 other patterns)
- Rainfall spatial pattern – based on the spatial variation of CRC-FORGE point design rainfall estimates (with a sensitivity analysis of spatial patterns based on rainfall distributions experience during 7 historical storms); storm assumed to be stationary over the catchment
- Design losses – 10 mm initial loss and 1 mm/h continuing loss, uniformly distributed over whole catchment – these losses reflect a relatively saturated state of the catchment at the start of a flood event

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For the post-dam situation two further inputs/assumptions were necessary:

- Initial state of storages – assumed to be at FSL (RL 67.0 m AHD) at the start of the flood event
- Flood operation of dams – Wivenhoe assumed to be operated according to operational rules incorporated into WIVOPS simulation program

The best estimates of Q100 for the pre-dam and post-dam situation at three key locations are given in Table B2, together with nominal upper and lower bounds.

Table B2: RAFTS based Pre- and Post-Dam Q100 flow estimates (m3/s) with indication of plausible range of variability (from Review Panel report, 2003, and SKM, 2003)

Location	Pre-Dams			Post-Dams			Reduction (%)
	RAFTS Q100	Plausible Bound		RAFTS Q100	Plausible Bound		
		Lower	Upper		Lower	Upper	
Savages Crossing	9,600	8,100	10,800	5,400	3,900	6,600	60
Moggill	10,100	9,500	10,800	5,000	4,200	6,000	50
Port Office	10,100	9,500	10,800	5,000	4,200	6,000	50

B.3 Adopted Q100 estimate and uncertainty bounds

The Review Panel noted the relatively wide band of uncertainty about the Q100 estimates from both methods but considered that the pre-dam flood peak estimates at Savages Crossing derived by flood frequency analysis were more reliable than the RAFTS model-based estimates, which involved a range of additional assumptions. The post-dam estimates from RAFTS modelling were thus adjusted accordingly to give the recommended Q100 (peak flood) values shown in Table B3.

Table B3: Recommended Pre- and Post-Dam Q100 flow estimates (m3/s) with indication of plausible range of variability (from Review Panel Report, 2003 and SKM, 2003)

Location	Pre-Dams			Post-Dams		
	Q100	Plausible Bound		Q100	Plausible Bound	
		Lower	Upper		Lower	Upper
Savages Crossing	12,000	10,000	14,000	6,000	4,000	8,000
Moggill	12,000	11,000	13,000	6,000	5,000	7,000
Port Office	12,000	11,000	13,000	6,000	5,000	7,000

Glossary

ARI- Average Recurrence Interval - the expectation (or average over many occurrences) of the interval (years) between flood events with a similar magnitude

AEP – Average Exceedance Probability, the likelihood of occurrence of a flood of given size or larger in any one year, usually expressed as a percentage

AHD - Australian Height Datum - is the national surface level datum corresponding approximately to mean sea level. Levels measured relative to this datum are given as "m AHD".

Bathymetry – Bed levels and cross sectional dimensions of a river channel

COAG – The Council of Australian Governments

CRC-FORGE- Cooperative Research Centre Focussed Rainfall Growth Estimation. The CRC-FORGE method is a regional analytical method for point rainfall estimates of low Average Exceedance Probability (AEP) from data records on average less than 100 years duration. The method is a development of the FORGE method (UK) by the Cooperative Research Centre for Catchment Hydrology

DFE - Defined Flood Event - The flood event from which defined flood levels are developed and ultimately the flood control lines for development

DFL- Defined Flood Level- The flood level resulting from the Defined Flood Event

DTM- Digital Terrain Model

Environmon – a network of rain gauges owned by BoM

Flood hydrograph- Expresses peak flow, flood event volume and flood duration in a graph.

Flood quantiles – the values of a flood characteristic (peak flow, flood volume, flood level at a site) that correspond to specified ARIs

Freeboard – a margin above a defined flood level set to provide a factor of safety for uncertainties in flood level estimates and localised flood effects

Mike-11- A computer program for simulation of channel flows using one dimensional equations

Monte Carlo methods (or Monte Carlo experiments) - a class of computational algorithms that rely on repeated random sampling to compute their results. With respect to catchment simulation, the influencing factors are sampled (either randomly or in accordance with their joint probabilities) for simulation with a catchment modelling system to develop alternative

predictions. These predictions are then analysed statistically to estimate their exceedance probabilities

Minor, Moderate and Major flooding- as defined by BoM:

- minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.
- moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.
- major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

NFRAG- National Flood Risk Advisory Group

PMF- Probable Maximum Flood- PMF cannot be assigned a probability of occurrence but may be considered as the largest flood that could possibly occur and never be exceeded

Q100- the peak flow rate at a specific location that has a 1 in 100 chance of being equalled or exceeded in any one year (1% annual exceedance probability – AEP; or an average recurrence interval (ARI) of 100 years).

SCARM - the Standing Committee on Agriculture and Resource Management, a committee of the Agriculture and Resource Council of Australia and New Zealand (ARMCANZ)

RAFTS - an acronym for a catchment simulation model - River And Flow Training System

Rating Curve - a rating curve is used to convert a recorded flood level at a gauging station to the equivalent discharge at the gauging station.

WIVOPS- Wivenhoe Dam Operations Systems

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BRISBANE FLOOD JANUARY 2011

Independent Review of Brisbane City Council's Response

9–22 January 2011

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The graph on the cover is based on the Bureau of Meteorology's record of Highest Annual Flood Peaks as estimated or recorded at the Brisbane River City Gauge for the period covering 1840 to 2011. In some years, particularly in 1893, there were several large floods; however the graph shows only the largest flood for each year.

The Bureau classifies floods as Major, Moderate or Minor. Major floods are represented in red, Moderate in blue and Minor in green.

In the graph, for the period 1840 to 1900 there were 15 floods which were classified as Moderate or Major.

By contrast, in each of the periods 1901 to 1960 and 1961 to 2011 there were only two floods which were classified as Moderate or Major.

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BRISBANE FLOOD JANUARY 2011

INDEPENDENT REVIEW OF BRISBANE CITY COUNCIL'S RESPONSE

9 - 22 JANUARY 2011

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FOREWORD

The Board was established in late January 2011 and requested to present its report by the middle of May 2011. With the benefit of support from many people, the Board has been able to conduct the review and produce its report within this timeframe.

The Board consists of Major General Peter Arnison AC, CVO (Retd), [redacted] and Emeritus Professor Colin Apelt.

The Board wishes to acknowledge the particular assistance given by the following:

From within Council

Lord Mayor Graham Quirk and former Lord Mayor Campbell Newman;

Councillor Shayne Sutton, Leader of the Opposition;

Councillors Abrahams, Griffith, Johnston, Matic and Owen-Taylor with all of whom the Board held discussions;

Other Councillors who made submissions to the Board; and

Council officers who briefed the Board on a wide range of Council activities and provided information relevant to the review, and who assisted the Board administratively.

External to Council

Mr Jim Davidson and Mr Peter Baddiley of the Bureau of Meteorology;

[redacted] of ENERGEX Ltd;

[redacted] of Australian Red Cross (Qld);

[redacted] of GHD;

[redacted] of Fieldworx; and

Members of the public who made written submissions to the Board or who were interviewed by GHD and Fieldworx.

The Board also acknowledges [redacted] Y & R for the analysis of the use of social media channels.

The Board is grateful for the assistance of [redacted] in producing this Report.

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Major General Peter Arnison, AC, CVO (Retd) served in the Australian Army for 37 years, retiring as Land Commander Australia. He was Governor of Queensland from 1997 to 2003 and is currently Chancellor Queensland University of Technology.

[redacted] has practised at the Queensland Bar since 1976, having taken silk in 1988. He is a former President of the Law Council of Australia; the Australian Bar Association and the Bar Association of Queensland.

Emeritus Professor Colin Apelt is a Civil Engineer with extensive professional experience in design, research and specialist consulting in water and coastal engineering. He was a member of the Civil Engineering Department at the University of Queensland for 37 years and was Head of Department for twelve of these. He was a member of the Independent Panel that reviewed the 2003 Brisbane River Flood Study for Brisbane City Council and was Chair of the Lord Mayor's Taskforce on Suburban Flooding for Council in 2005.

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GLOSSARY OF TERMS

ABS	Australian Bureau of Statistics
ADF	Australian Defence Force
AEP	Annual Exceedance Probabilities
AHD	Australian Height Datum
AR&R	Australian Rainfall & Runoff
ARI	Average Recurrence Interval
BCC	Brisbane City Council
BCLDMG	Brisbane City Council Local Disaster Management Group
BCP	Business Continuity Plan
BoM	Bureau of Meteorology
CARS	Compliance and Regulatory Services
CBD	Central Business District
CD	Collection Districts
CEO	Chief Executive Officer
CIPMA	Critical Infrastructure Protection Modelling and Analysis
CSA	Community Service Announcements
CWS	City Waste Services
DDCC	District Disaster Coordination Centre
DDMG	District Disaster Management Group
DDMP	District Disaster Management Plan
DERM	Department of the Environment and Resource Management
DFE	Defined Flood Event
DFL	Defined Flood Level
DIG	Disaster Intelligence Group
DMP	Disaster Management Plan
DOM	Disaster Operations Manager
EMA	Emergency Management Australia

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EMQ	Emergency Management Queensland (of Department of Community Safety)
EWAS	Early Warning Alert Service
EWN	Early Warning Network
EWS	Early Warning Systems
FIC	Flood Information Centre
Flood COP	Dynamic web-based mapping tool developed by Esri Info
FOG	Field Operations Group
FPG	Forward Planning Group
FSL	Full Supply Level
GHD	GHD Pty Ltd
GIS	Geographic Information System
GL	1GL = one million cubic metres
IPND	Integrated Public Number Database
ISG	Incident Support Group
LAS	Local Asset Services (Brisbane City Council)
LDCC	Local Disaster Coordination Centre
LDMG	Local Disaster Management Group
LM	Lord Mayor
LO	Liaison Officer
MSQ	Maritime Safety Queensland
NEWS	National Emergency Warning System
NFRAG	National Flood Risk Advisory Group
Q100	Q100 is a theoretical flood that has a 1 in 100 (1%) chance of being equalled or exceeded in each and every year at a particular location.
QFRS	Queensland Fire and Rescue Service
QPS	Queensland Police Service
RIMT	Regional Incident Management Team
SDCC	State Disaster Coordination Centre

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SDMG	State Disaster Management Group
SES	State Emergency Service
SITREP	Situation Report
SKM	Sinclair Knight Merz Pty Ltd
SLA	Statistical Local Area
SMS	Short Message System
SOP	Standard Operating Procedures
SPA	Sustainable Planning Act
TLPI	Temporary Local Planning Instrument

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EXECUTIVE SUMMARY

In January 2011, Brisbane experienced the second-highest flood in the past 100 years, after the January 1974 flood. There was major flooding through most of the Brisbane River catchment, most severely in the Lockyer and Bremer catchments where many flood height records were set. The flooding caused substantial loss of life in the Lockyer Valley and thousands of properties were inundated in metropolitan Brisbane.

Seqwater, in its review of the magnitude of the January 2011 flood, concluded that the river flood volumes indicated that the volume of the January 2011 flood was almost double that of the January 1974 flood and similar to the February 1893 flood and that peak water levels at gauging stations in the Brisbane River above Wivenhoe Dam were the highest on record.

The Lord Mayor of Brisbane, the Right Honourable Campbell Newman, on 21 January 2011, appointed a Board of Enquiry to review the response to the flood event in Brisbane during the period Sunday 9 January to Saturday 22 January 2011. The Board consists of Major General Peter Arnison AC, CVO (Retd), [redacted] and Emeritus Professor Colin Apelt. The Board's Terms of Reference are contained in the List of Attachments.

The Report addresses the Terms of Reference in five Sections. Section One examines the characteristics of the flood and the resultant levels including a comparison against the Q100 flood level and an explanation of terms relating to the probability of flooding occurrence and defined flood events and levels. Section Two deals with the effectiveness of Brisbane City Council's disaster management arrangements including preparation, response and recovery. Section Three considers the effectiveness of Brisbane City Council's response to the flood event including the actions in inundated areas, the establishment of evacuation centres, the organising and tasking of volunteers for the clean up, and waste and debris collection and disposal. Section Four looks at the impact of the existing planning regulations in flood affected areas. Section Five deals with the effectiveness of flood prevention and stormwater infrastructure and the reasons for Brisbane City Council's riverine infrastructure failures.

Section One – The Characteristics of The Flood

Following a record period of drought, the annual rainfall in 2010 caused the wettest year on record for Queensland and the wettest year since 1974 for Brisbane City. The catchment of the Brisbane River system was saturated and most of the rain that fell on it in January 2011 ran off rapidly to produce the flood event. The distribution of the flood-producing rainfalls and the behaviour of the flood that they caused are described in this Section. The mitigating effect of Wivenhoe Dam is noted but the Brisbane River flood was joined by floods from Lockyer Creek and the Bremer River downstream from the dam and their impacts are described. The pattern of rainfall caused little, if any, significant creek flooding in Brisbane, though creeks were flooded by backwater from the river.

The peak flood levels along the Brisbane River are given for Moggill, Bellbowrie, Jindalee, Oxley Creek mouth and Brisbane City. For each location, the times are given for when the water rose above moderate then major flood levels to reach heights greater than the Defined Flood Level, together with the lengths of time that the flooding lasted above these levels.

The technical terms, "Defined Flood Event", "Defined Flood Level" and "Q100" used to describe the nature and level of a flood event and its probability and to inform planning and policy for dealing with floods, are explained. Since all measured flood levels throughout greater Brisbane for the January 2011 flood event, except towards the river mouth, are higher than the Defined Flood Levels and these have been calculated for a flood with the same characteristics as the January 1974 flood but after its effects have been reduced by Wivenhoe Dam, it is considered that the January 2011 flood event, as actually experienced, was larger than a flood similar to that of 1974 after mitigation by Wivenhoe Dam. The flood was therefore larger than the theoretical Q100 flood which, for Brisbane, is a little smaller than the flood corresponding to the Defined Flood Levels.

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The history of flooding in Brisbane since the 1840s shows clearly that periods of frequent flooding can occur as well as long intervals with few floods and that the timing of flood events is variable. Comparison with records of historical floods shows that the January 2011 flood was a rare and large flood event.

Section Two – Brisbane City Council's Disaster Management Arrangements including Preparation, Response and Recovery

The Board's analysis of Council's response to the January 2011 flood event indicates that it performed at a highly creditable level. Fatalities were minimised with only one death recorded in the greater Brisbane area that was linked to the flood event, compared to around 14 people who died in the Brisbane and Ipswich areas during the January 1974 flood.

While early public warnings during November and December were issued and alerts in January worked reasonably well, many citizens, and particularly those who had not experienced the 1974 flood, developed little understanding of the size and scale of the impending threat.

Council has developed a very effective set of arrangements to enable it to deal with a major flood event. These arrangements reflect and follow the various Commonwealth and Queensland Government Acts, policies and best practice guidelines pertaining to disaster management. Council has ensured that appropriate disaster management organisational structures are in place and that facilities, equipment and systems are available and most importantly, individuals are nominated for duties and prepared to undertake them through training and exercises. The Report indicates that Council performed very well in this regard, with some areas requiring minor additional effort.

Council demonstrated a very good appreciation of the major risks associated with flooding and has a good capability to detect, monitor and respond to flood events. The importance of an education strategy aimed at improving community knowledge and resilience was well understood by Council and implemented, although there are opportunities for further improvement.

Council's conduct of the flood disaster operations through the Brisbane City Local Disaster Management Group (BCLDMG) chaired by the Lord Mayor provided clear, high level strategic direction to the Local District Coordinating Centre (LDCC). Council's Chief Executive Officer coordinated disaster operations as determined by the BCLDMG through the LDCC and its subordinate entities. Effective strategic level forward planning was undertaken by the Forward Planning Group, including developing the response and recovery concepts. The Field Operations Group was responsible for the conduct of response and recovery operations either directly or through the Regional Incident Management Teams active in each of Council's regions (Central, North, South, East and West). The Disaster Intelligence Group supported the LDCC with the provision of information and intelligence analysis across a range of areas and worked closely with the Flood Information Centre as it provided forecasts, based on analysis of the Bureau of Meteorology (BoM) forecasts and Seqwater data. The Incident Support Group provided communications, administrative and logistics planning and support to the LDCC. The Board assessed that these arrangements worked very well with some scope for minor improvement.

Before and during the flood event Council sought to provide the public with both general and detailed, specific to property, information. All available communication channels were used including print media: newspapers, Council bulletins and notes and large poster displays; electronic media: radio, television and the internet and most significantly social media including Facebook and Twitter which proved remarkably successful in rapidly disseminating information. Council's Call Centre played a very significant role in responding to caller's questions and requests for information. Council's website collapsed under an avalanche of contacts, particularly for flood flag maps for individual properties, and because of band-width limitations. The site was re-established in a more limited fashion within 24 hours, hosted off shore using cloud computing.

In an attempt to provide flood information to a wide range of individuals in a very short time period Council, along with Townsville City Council, had contracted the Early Warning Network System to deliver pre-prepared Short Message System (SMS) messages to the mobile phones of those who had subscribed. Despites Council's efforts to widely publicise the availability and utility of this free system, the take up prior to the flood was disappointing.

All Council staff made an enormous contribution prior to, during and after the flood to ensure that the disaster was properly managed, that safety considerations were a priority, and that the care of people, their property and communities was of paramount importance. Similarly, the contribution by the Lord Mayor and Councillors was highly commendable.

Section Three – Brisbane City Council's Operational Response in the Field

Council's operational response in the suburbs and the Central Business District (CBD) was coordinated and well managed. Decision making authority was delegated so the regionally-based staff could deploy local assets effectively in dealing with local problems. Dedicated operations rooms at the regional level are suggested.

The volunteer response by the citizens of Brisbane was a truly amazing example of the City's spirit. Council's management of the Mud Army, as these volunteers became known, was impressive. The Board's review has identified some matters which should be addressed in future planning. They relate to briefing of volunteers, liaison with residents concerning their wishes and health care arrangements.

Council established two large scale evacuation centres at very short notice. About 2400 evacuees registered at these centres. They were well managed by Red Cross with participation of other Agencies. In a future flood event, evacuation centres should be more decentralized, with arrangements made for areas isolated by flood waters. Issues relating to security, diversity and suitability for handling donated goods need to be addressed in future planning.

The large volume of debris produced by the flood and the major disruption to waste disposal systems posed significant health risks. The use of temporary waste disposal sites, the placement of skips for food waste, and the support of waste disposal contractors, industry volunteers and the broader waste industry were instrumental in the successful response,

Section Four – The Impact of Existing Planning Regulations in Flood Affected Areas

Council is progressively implementing the "Key Actions" recommended by the Lord Mayor's Taskforce on Suburban Flooding (2005). Council does not have a free hand in setting planning regulations for the city. It has to work within the legal framework created by State legislation.

Council's planning regulations and guidelines have been influenced to a significant degree, by the Defined Flood Level (DFL) adopted in 1978. It has been, in part, responsible for guiding development away from flood-prone areas. Almost 90% of residential properties in Brisbane that were flood affected are in areas that had been predominantly developed prior to 1978.

However, the adopted DFL is not without limitations. The time has come to undertake a complete Flood Risk Management analysis of flood affected areas in the city. Though very expensive, the analysis should be seen as vital for an important metropolis. It needs to be constantly borne in mind that large floods do occur in Brisbane; that they occur with unpredictable frequency; and that when they have occurred, great loss and hardship has been caused to the city and its citizens.

Section Five – Flood Prevention, Stormwater and Riverine Infrastructure

The most important infrastructure items for mitigation of flooding from the Brisbane River are the Wivenhoe and Somerset Dams but Council has no statutory role in dam releases or flood mitigation operations. In this Section the engineering options that Council could consider for

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flood prevention in Brisbane are reviewed but only two measures, backflow prevention devices and use of levees to protect specific high value infrastructure, are found to be appropriate for further consideration. Detailed review of their feasibility including a full risk analysis would be required to determine whether the use of either would be suitable for specific application.

The flood event in January 2011 was essentially a river flood, with little run-off in Brisbane from local rainfall. The stormwater network system did not add to flood levels. Some flooding was caused by backwater flooding from the river that entered low lying areas through stormwater pipes and open drains. The main impact of the flood on the stormwater system was from the large amounts of silt and debris deposited within the network. Council's rapid response in cleaning all gully pits within the flood affected areas and initiating the major program of works required to remove silt from all of the stormwater system affected by the flood is commended.

The flood caused substantial damage to much of Council's riverine infrastructure. Nearly half of the Floating Riverwalk was washed away. Thirty of Council's 97 river walls failed. At least 34 bank slips occurred on Council sites and six of these are assessed as Very High Risk, four as High Risk and five as Medium Risk. Six stormwater outlets were damaged by scouring or slumping during the flood and require repair. Council owns 23 ferry terminals, four moorings/refuelling stations and 25 pontoons and jetties. Eight of the ferry terminals, two of the moorings and 15 pontoons were significantly damaged. In some cases the damage arose because of the need to locate these facilities to meet their functional requirements in places where they were subject to the full force of the river flood. Reports from independent engineering consultants commissioned to provide advice to Council on reasons for the failure of riverine infrastructure assets is expected to be presented in May 2011. Fortunately, the entire fleet of City Cats and cross river ferries was saved by Council's prompt actions in removing it to safe locations.

Commendations, Affirmations and Recommendations

The Board has arrived at a number of Commendations, Affirmations and Recommendations arising from its consideration of the circumstances relating to the January 2011 Brisbane Flood. The Commendations indicate those actions and activities which the Board considers Council performed at a very high standard. The Affirmations refer to those actions and activities which the Board considers Council performed at a high standard and include Recommendations for further improvement. The Recommendations refer to actions and activities which the Board considers Council should adopt to further improve Council's capability to respond to another such flooding emergency. The Commendations, Affirmations and Recommendations follow.

Commendations

The Board highly commends the actions of Council staff in their preparation for, and response to, the flooding disaster which may appropriately be characterised as well above and beyond that usually expected.

The Board commends Brisbane City Council's disaster management approach and in particular for:

Its compliance with, and implementation of, the various Commonwealth and Queensland Government legislative and policy parameters which direct and inform disaster management arrangements.

,Its integrated response through the BCLDMG with other Queensland and Federal Government agencies and Non-Government Organisations.

Its alignment with the State Disaster Management Plan, and the District Disaster Management Plan.

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The Board commends Council's approach to preparing for a possible disaster event over the summer months and, in particular, for the general public warnings and advice in the November - December 2010 period, and for the conduct of readiness training and exercises.

The Board commends Council's approach, during the flood event, in providing public information, advice and alerts using a multi-channel broadcast approach, for print and electronic media, the internet including website, email and social media, telecommunications including Council's Call Centre, mobile SMS and the Early Warning Alert Service (EWAS) and off-line, including the "Living in Brisbane" newsletter, fact sheets, other community newsletters, posters, and outdoor advertising.

The Board commends the efforts of Council's Call Centre and Social Media staff for their untiring efforts to respond, in a calm and helpful manner, to the thousands of requests for information and advice during the flood event.

The Board commends Council's coordination and management of the field operations response through the Field Operations Group (FOG), the Regional Incident Management Teams (RIMTs) and other appropriate Council business units.

The Board commends Council for developing and implementing at short notice a citizens' volunteer management strategy, including establishing the capacity to register, brief, equip and deploy the volunteers to priority recovery locations, and for coordinating and deploying business and professional volunteers (including trades people, contractors and plant operators) and community groups to enhance the pace and efficiency of the cleanup.

The Board commends Council for undertaking a major waste collection and disposal effort for vast quantities of flood debris and household waste, in conjunction with waste disposal contractors, industry volunteers and the broader waste industry.

The Board commends Council's transition to recovery policies and procedures including the establishment of the various Council sub-committees as recommended in the Concept for Recovery document prepared by the Forward Planning Group (FPG), the formation of the Joint Flood Taskforce and the engagement of engineering consultants.

The Board commends Council for its Growth Planning Strategy which envisages growth centres and transport corridors outside potentially flood affected areas and notes that 89.5% of all flood affected residential properties were in areas developed predominantly prior to 1978.

The Board commends Council for its progressive implementation of the recommendations of the Lord Mayor's Taskforce on Suburban Flooding (2005) which has resulted in a reduction in the risk of flooding in recently developed areas.

The Board commends the initiative of Council through its Town Planning Sub-Committee in developing strategies and effective planning instruments to encourage development of flood resilient building design and construction.

The Board commends Council for the rapid response in cleaning gully pits within the flood affected areas and for initiating the major program of works required to remove silt from all of the stormwater system affected by the flood.

The Board commends Council's prompt actions in relocating the entire fleet of City Cats and cross river ferries to safe locations.

The Board commends Council for commissioning independent engineering consultants to provide advice on reasons for the failure of certain riverine infrastructure assets.

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Affirmations

The Board affirms Council's approach to its business as usual and risk management policies. The Board **recommends** that:

In relation to Council activities, Information Services Branch reviews its Business Continuity Plans (BCPs) to ensure the capacity exists to maintain the data centre, including an alternative site capable of taking over without delay and to maintain Council's website at all times, particularly during significant disasters.

Line of business managers review BCPs to ensure their ongoing robustness and to capture any lessons learnt from the flood event.

Contracts and arrangements be reviewed to ensure that the business continuity plans for key external outsourced service and infrastructure providers are understood, robust and able to support Council during times of emergency and disaster.

In relation to the Brisbane Central Business District and high-rise residential building inundation, that Council consider hosting a symposium for all affected parties with a view to identifying best practice approaches to ensure improved flooding resilience.

The Board affirms Council's approach to training, exercising and workforce planning in relation to disaster management preparation. The Board **recommends** that further emphasis be placed on:

Individual and team training, including opportunities to attend Emergency Management Australia Disaster and Emergency Response courses;

Workforce planning to reflect a needs analysis including disaster management related job descriptions, and a specific Council term be developed to describe "internal volunteers" to avoid confusion and to reflect the professional nature of the training and tasks; and

Annual exercises continue to be conducted with a theme of "Brisbane Ready for Summer".

The Board affirms the operations and workings of the Local Disaster Coordination Centre (LDCC) and, in particular, the integration of operations (tasking), intelligence, public information, logistics and the coordination with external supporting agencies. The Board **recommends** that:

Further training and development occur for senior appointments including LDCC Incident Controllers and group leaders as well as for more junior appointments.

The Disaster Intelligence Group's structure, manning and core competencies be reviewed and further staff training be conducted.

The Forward Planning Group's responsibilities to the Brisbane City Local Disaster Management Group (BCLDMG) and to the LDCC be examined to remove ambiguity.

Enhancements to process be implemented including:

Ensuring that Situation Reports are well drafted and widely distributed on a regular basis using multiple communications channels;

Developing a readily accessible database of frequently asked questions to address "who does what" to support the LDCC staff and agencies (this could also include information available on Council's Call Centre database);

Synchronising the shifts of Council and agencies staff working in the LDCC to better facilitate handover briefings;

Improvements to logging incoming and outgoing information and tasking; and

Formalising the written briefing processes for handovers between shifts.

The Board affirms Council's flood intelligence management and information dissemination arrangements. The Board **recommends** that Council undertake upgrades to the Flood Information Centre (FIC) along the following lines:

Review and update Standing Operating Procedures (SOPs), including a major update of selected Brisbane River and Creek Flooding SOPs, river flood maps and storm tide maps, property counts and critical infrastructure lists;

Upgrade the Brisbane River Flood Forecast Reporting System to the most extreme flood event (Probable Maximum Flood) and to include a flood forecast system for Brisbane creeks;

Conduct additional training and exercises including with the LDCC and Queensland Government agencies, and develop better communications protocols;

Provide computers capable of GIS modelling tasks and 3D visualisation analysis; and

Provide a dedicated flat screen television for situation awareness and news monitoring.

The Board affirms Council's approach to implementing a range of early warning systems and alert measures across a number of delivery channels. The Board **recommends** that Council examine and develop the range and variety of early warning systems and alert measures; including the proposed National Emergency Warning System, social media platforms and further improve the effectiveness of door knocking.

The Board affirms the contribution of region-based RIMTs noting that they provide a critical layer in the command and control structure for dealing with the on ground situation, managing local resources and coordinating external resources allocated to them. The Board **recommends** that:

A senior officer be assigned to mentor each Regional Incident Management Team Manager and conduct high level discussions with the LDCC;

Dedicated Regional Incident Management Team operations rooms be established; and

Planning for alternative Regional Incident Management Team sites, in the event that the primary sites become unusable, be conducted.

The Board affirms Council's planning for and implementation of evacuation centres as detailed in the Disaster Management Plan. The Board **recommends** that further consideration be given to refining Council's evacuation centre planning to address:

Greater decentralisation of evacuation centres, particularly for communities that are known to be prone to isolation by flooding;

Early and close liaison with Red Cross, particularly in regard to registration of evacuees and vetting of volunteers;

Early and close liaison with Queensland Police Service (QPS) in regard to exclusion of persons not suitable to be in a general public evacuation centre;

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The special needs of frail, aged, incapacitated, nursing home and oxygen-dependant evacuees for whom separate and special arrangements need to be made;

Social, cultural and religious diversity of evacuees, including those with a non-English speaking background; and

Purchase and supply of special items such as personal hygiene kits and baby requisites.

The Board affirms Council's action in rapidly increasing sandbag production to a total of more than 390,000. The Board **recommends** that estimates be developed of likely sandbag demand for regions during future flood events and that the best situated potential sites for filling and distribution points in each region be identified.

The Board affirms Council's collaborative efforts with QPS and the Australian Defence Force (ADF) in providing a workable framework for overall traffic management. The Board **recommends** that the Council consider developing advanced plans, in consultation with QPS, to improve traffic flow in flood recovery congested areas including converting some streets into one way, route designation for heavy vehicles and identification for residents' vehicles.

Recommendations

The Board recommends that the term, DFL, be used exclusively in public documents concerning flood planning levels for Brisbane, regardless of the cause of the flooding.

The Board recommends that Council use a more readily understandable description of flood levels (to reflect BoM descriptions).

The Board recommends that effort continue to be put into providing more localised (property, street, suburb and Ward) information regarding inundation and flood level forecasts through a range of channels including the Early Warning Alert Service EWAS, Floodwise Property Report and Flood Flag Maps (including rate notices to draw attention to the existence of the Floodwise Property Report) and flood markers.

The Board recommends that the Flood Flag Map be further developed to enable NearMap data obtained on the morning of 13 January 2011 to be included and accessed.

The Board recommends that Council investigate the Flood COP system and examine its utility, in conjunction with hand held devices, to improve the efficiency and effectiveness of data collection, the provision of information, the prioritisation of tasks and the deployment of resources.

The Board recommends that Council further develop its capabilities to produce flood maps for a larger set of scenarios based on a range of 2000 to 20,000 m^3/s in electronic and hard copy format.

The Board recommends that Council review the disaster management arrangements for a major flooding situation as they apply to Pullenvale Ward.

The Board recommends that Council review the disaster management arrangements for a major flooding situation as they apply to Tennyson Ward to ensure the ongoing provision of a flood-free Ward Office.

The Board recommends that Council examine appropriate ways for Councillors to assist during disaster events, particularly given their community leadership responsibilities and their detailed local knowledge of circumstances and capabilities that exist in their Wards, in a way which does not cut across the existing and appropriate arrangements detailed in Council's disaster management arrangements.

The Board recommends that permanent flood markers be installed on key roads that are known to become flood affected to complement other public awareness and safety campaigns.

The Board recommends Council develop a process for handling donated goods separately from evacuation centres.

The Board recommends Council implement strategies in relation to volunteer clean up activities for:

Development of a proforma briefing sheet for volunteers based on experience gained in this flood event;

Identification of house team leaders to liaise with residents so that clean up activity is in accordance with the residents' wishes;

Ensuring the provision of appropriate health care arrangements to accompany deployed volunteer groups;

In conjunction with QPS, developing processes to ensure the security of flooded residents' dwellings during volunteer cleanup activity; and

Making provision for a co-ordination cell within the LDCC particularly for individual volunteers.

The Board recommends that Council develop a comprehensive single list of potential sites suitable for temporary waste collection, incorporate a liaison officer from the CWS team into the LDCC; and strengthen the link between procurement and waste management during a disaster by establishing a dedicated liaison officer position in the City Waste Services (CWS) team.

The Board recommends that, in relation to planning, Council undertake a complete Flood Risk Management analysis for the area of Brisbane affected by flooding from the Brisbane River and associated tributaries in line with National Flood Risk Advisory Group (NFRAG) and other relevant guidelines. This would require a detailed assessment of the benefits and costs of a full range of flood mitigation options.

The Board recommends that:

Council investigate the feasibility of the installation of devices to prevent backflow from river flooding in locations such as in parts of the Central Business District (CBD) and in high rise buildings which would not have been flooded otherwise, where all those potentially affected by backflow flooding have responsibility for oversight of the maintenance of the device in working order; and

No backflow prevention device should be incorporated into the stormwater network system unless a complete risk based flood management analysis has confirmed that this is the best option.

The Board recommends that Council investigate the feasibility and appropriateness of establishing local levees to protect areas of strategic significance such as the Rocklea Markets. This will require a complete risk based flood management analysis.

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INTRODUCTION

In January 2011, Brisbane experienced the second-highest flood in the past 100 years, after the January 1974 flood. There was major flooding through most of the Brisbane River catchment, most severely in the Lockyer and Bremer catchments where many flood height records were set. The flooding caused substantial loss of life in the Lockyer Valley and thousands of properties were inundated in metropolitan Brisbane.

Seqwater, in its review of the magnitude of the January 2011 flood, concluded that the flood volumes indicated that the volume of the January 2011 flood was almost double that of the January 1974 flood and similar to the February 1893 flood and that peak water levels at gauging stations in the Brisbane River above Wivenhoe Dam were the highest on record.

The Lord Mayor of Brisbane, the Right Honourable Campbell Newman, on 21 January 2011, appointed a Board of Enquiry to review the response to the flood event in Brisbane during the period Sunday 9 January to Saturday 22 January 2011. The Board consisted of Major General Peter Arnison AC, CVO (Retd), [redacted] and Emeritus Professor Colin Apelt. The Board's Terms of Reference are given in the List of Attachments.

The primary purpose of the review is to provide Council with an external independent assessment of its flood preparedness and disaster responses to assist it in achieving best practice standards in the future. Council has also indicated that the review will form an integral part of its submissions to the Queensland Government's Commission of Inquiry.

Brisbane City Council is Australia's largest local government authority and serves a population of more than one million people. Council's revenues for financial year 2010 were $2.152 billion and its assets were $21.606 billion (Brisbane City Council Annual Report 2009-10). While the Council's size and financial strength enables it to devote the resources to planning and preparation for a range of emergency contingencies, there is always an overriding need for leadership to ensure that planning and preparation occurs. Such leadership was demonstrated at both the political and organisational levels in Brisbane City Council by the Lord Mayor and his Councillors and by the Chief Executive Officer and his staff.

The Report will address the Terms of Reference in five Sections. Section One examines the characteristics of the flood and the resultant levels including a comparison against the Defined Flood Level and an explanation of terms relating to the probability of flooding occurrence and Defined Flood Levels and events. Section Two deals with the effectiveness of Brisbane City Council's disaster management arrangements including preparation, response and recovery. Section Three considers the effectiveness of Brisbane City Council's response to the flood event, including the actions in inundated areas, the establishment of evacuation centres, the organising and tasking volunteers for the clean up, and waste and debris collection and disposal. Section Four looks at the impact of the existing planning regulations in flood affected areas. Section Five deals with the effectiveness of flood prevention and stormwater infrastructure and the reasons for Brisbane City Council's riverine infrastructure failures. The Terms of Reference require the Board to consider events in the period from Sunday 9 to Saturday 22 January 2011.

The Board has arrived at a number of Commendations, Affirmations and Recommendations arising from its consideration of the circumstances relating to the January 2011 Brisbane Flood. The Commendations indicate those actions and activities which the Board considers Council performed at a very high standard. The Affirmations refer to those actions and activities which the Board considers Council performed at a high standard and include Recommendations for further improvement. The Recommendations refer to actions and activities which the Board considers Council should adopt to further improve Council's capability to respond to another such flooding emergency. The Commendations, Affirmations and Recommendations follow each Section of this Report.

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SECTION ONE - THE CHARACTERISTICS OF THE FLOOD

Description of the January 2011 flood event

In January 2011, Brisbane experienced the second-highest flood of the past 100 years, after January 1974. There was major flooding through most of the Brisbane River catchment, most severely in the Lockyer and Bremer catchments where many flood height records were set. The flooding caused substantial loss of life in the Lockyer Valley and thousands of properties were inundated in metropolitan Brisbane, Ipswich and elsewhere. The catchment for the Brisbane River and its tributaries is shown in Map 1.

The Board's approach has been to describe the characteristics of this flood without entering the debate concerning whether these characteristics were affected by human intervention. This description is based on information from the following sources:

Joint Flood Taskforce Report March 2011 (refer List of References)

January 2011 Flood Event - Report on the operation of Somerset Dam and Wivenhoe Dam (refer List of References)

Bureau of Meteorology (BoM) records of flood heights measured at the Alert Water Level gauges along the Brisbane River at the Brisbane City Gauge, Oxley Creek mouth, Jindalee and Moggill and interpolated flood heights at Bellbowrie.

The numerical values of the characteristics of the flood, including rainfall statistics, peak flow rates, peak levels and extents of inundation were still subject to review at the time when this Report was completed, because much of the detailed checking and analysis of data was still in progress. The description provided here is based on the best data available at the time. Nevertheless, it is not intended to be a definitive statement and it is recognised that some details provided here may be revised in the light of further analysis by other authorities.

Antecedent Conditions

Following a record drought period, the annual rainfall for Queensland in 2010 was exceptional, with the year being the wettest on record for the State. Brisbane City recorded the highest annual total since 1974 (BoM) (refer List of References). After such a wet year the catchments of the Brisbane River system and of many other Queensland river systems were saturated and their conditions were such that heavy rainfall would cause rapid run-off of most of the rain that fell. In the 25 days prior to Thursday 6 January, above average levels of rainfall occurred in the catchments of Wivenhoe Dam and Somerset Dam. Further rain fell on those catchments on the morning of 6 January and a flood event was declared. The flood event continued until Wednesday 19 January, the critical period being from 11 to 14 January 2011 when the major flooding occurred in the urban areas of Ipswich and Brisbane.

Rainfall

For the January 2011 flood event, the heaviest rains were inland on the western fringe of the Brisbane River catchment and on the Great Dividing Range.

The estimated average five-day rainfall (from 9am on Friday 7 to 9am on Wednesday 12 January) over the Brisbane River catchment as a whole, based on rainfall captured by the BoM Enviromon rain gauges, was 322mm, with the major sub-catchments of Wivenhoe Dam, Bremer River and Lockyer Creek receiving 370mm, 223mm and 268mm respectively in the same period. However, calculations based on the recorded releases from Wivenhoe Dam and water levels in the dam suggest that significantly more flood-producing rainfall occurred over part of the Wivenhoe catchment, and particularly over the dam storage area, than was recorded in existing rain gauges. Much of this appears to have occurred during an extremely

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intense rainfall event beginning early on Tuesday 11 January and lasting for about six hours or more.

The preliminary assessment by Seqwater (refer List of References) indicates that the average rainfalls for the Wivenhoe Dam catchment for durations between 72 hours and 120 hours had Annual Exceedance Probabilities (AEPs) between 1% and 0.5%, i.e. the risk of their being equalled or exceeded in any year is between 1 in 100 and 1 in 200. This highlights the significance of the flood-producing rainfall event. The rainfall intensities varied significantly in the catchment areas above the Dams and at some locations, especially around Wivenhoe Dam, the short duration rainfalls appear to have been extreme with AEPs significantly rarer than 1%.

The rainfall measurements by the rain gauges do not explain all of the recorded inflows and, at the date of this report, analysis by BoM of rainfall was still ongoing, as advised by the Regional Director (Qld) of BoM on 7 April 2011.

For the same period the 5-day rainfall in Brisbane was 193mm. For the three days ending at 9am on Wednesday 12 January, the peak three-day rainfall in Brisbane was 166mm while the peak one-day total was 110mm for the 24 hours ending at 9am on Monday 10 January. The rainfall over Brisbane caused little, if any, flash flooding in Brisbane's suburban creeks. The flooding that did occur in Brisbane's creeks was essentially due to backing up from the flood waters in the Brisbane River.

Flood Resulting from Rainfall

The January 2011 flood event caused a significant river flood in Brisbane. The flow down the upper Brisbane River above Wivenhoe Dam and Stanley River was mitigated substantially by Wivenhoe Dam. However, the pattern of rainfall caused significant flows from the upstream catchments of the Lockyer Creek and Bremer River into the Brisbane River, and Brisbane felt the full force of the flows down these streams. The resulting Brisbane River flood caused thousands of properties to be inundated in metropolitan Brisbane. As noted above, the pattern of rainfall experienced caused little, if any, significant creek flooding within Brisbane, although creeks were flooded by backwater from the river.

The flood levels recorded at Savages Crossing were higher than in 1974. The peak level recorded there was 24.17 metres above Australian Height Datum (m AHD) at 3.40am on Wednesday 12 January 2011, somewhat higher than the peak level of 23.77 m AHD in the January 1974 flood, but not as high as estimated for the 1893 flood event.

The peak level recorded at the Brisbane City Gauge of 4.46m AHD at 4am on Thursday 13 January was higher than the Defined Flood Level (DFL) there of 3.7m AHD but less than the level of 5.45m AHD recorded in 1974. As explained below, the DFLs for the areas of Brisbane where the worst flooding is caused by the river are the peak levels that have been calculated for a flood with the same characteristics as the January 1974 flood but after its effects have been reduced by Wivenhoe Dam.

All the measured flood levels throughout the greater Brisbane area for the January 2011 flood event are higher than the DFLs at the corresponding locations, except towards the river mouth. These flood levels in Brisbane in January 2011 were reduced by the mitigating effect of Wivenhoe Dam. Although some of the relevant data are still to be checked, the Joint Flood Taskforce (refer List of References) concluded that the evidence available shows that the flood runoff caused by the rainfall event of January 2011 was greater than that for the January 1974 flood event and that the January 2011 flood event, as actually experienced, was larger than a flood similar to that of January 1974 after mitigation by Wivenhoe Dam.

Impact of the Bremer River and Lockyer Creek

Floods in Lockyer Creek and the Bremer River added to the flood in the Brisbane River downstream from Wivenhoe Dam. The effects on the Brisbane River flood of these tributary inflows depend on their magnitudes and their timing relative to the peak flow releases from

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Wivenhoe Dam. The recorded flood levels in both tributaries indicate that major flood flows occurred in each tributary. Peak water levels in the Lockyer Creek area were the highest on record at Gatton, Glenore Grove and Lyons Bridge, easily exceeding the levels reached in the January 1974 and perhaps even the 1893 flood (Seqwater, refer List of References). The Bremer River also experienced major flooding though the peak water level at Ipswich was lower than that in 1974.

The releases from Wivenhoe Dam were increased rapidly on Tuesday 11 January from 2990 m^3/s at 9am to a peak of 7460 m^3/s at 7pm; they were held at this peak for two hours and then were reduced rapidly to 2550 m^3/s over the next 11 hours. The peak flood level in Lockyer Creek at Lyons Bridge, about 28km upstream from the junction with the Brisbane River, occurred at 5.27pm on 11 January and the peak of the flood in Lockyer Creek would have entered the Brisbane River some time later. This confluence is a short distance downstream from Wivenhoe Dam and the peak of the Lockyer flood would have reached it about the same time that the peak releases from Wivenhoe were passing. These flood peaks may not have been coincident but they were very close in time.

The peak of the flood in the Bremer River would have entered the Brisbane River some time after its peak level at Ipswich at 12.58pm on Wednesday 12 January. The peak level in the Brisbane River at Moggill occurred at 3pm on Wednesday 12 January. The confluence of the Bremer with the Brisbane River is about 20km downstream from Ipswich near Moggill and the peak of the Bremer River flood would have entered the Brisbane River at a time close to that of the occurrence of the Brisbane River peak flow at the confluence.

Although further analysis is required to establish the times of arrival in the Brisbane River of the peak floods from Lockyer Creek and the Bremer River relative to the flood peak as it passed down the Brisbane River, it is clear that the floods from these tributaries contributed substantially to the magnitude of the flood that impacted on Brisbane.

Impact of Wivenhoe Dam

The calculated dam inflow hydrographs show two peaks. The first peak of 10,100 m^3/s at 8.00am on Monday 10 January was similar in magnitude to that of 1974 and the second of 11,600 m^3/s at 1pm on Tuesday 11 January was even greater. The estimated flood volume inflows to Wivenhoe Dam based on these calculations total 2650 GL, as compared to a total of 1410 GL for that location in 1974 and 2744 GL in February 1893. (Note: 1GL = one million cubic metres).

At Full Supply Level (FSL), 67.0m AHD, the storage capacity of Wivenhoe Dam is 1165 GL. The temporary flood storage capacity above FSL is 1450 GL. Thus, the maximum total storage of the Dam is 2615 GL, slightly less than the total flood volume inflows during the January 2011 flood event. As required by the current policy settings, Wivenhoe Dam was at FSL at the beginning of the flood event and only the temporary flood storage capacity above FSL was available for flood mitigation. The operation of the dam mitigated the flood inflows and limited the peak releases to 7460 m^3/s for two hours from 7pm on Tuesday 11 January 2011, a reduction to 64% of the inflow peak.

Specific Situations along the River

The times when the flood peak reached particular locations along Brisbane River and the peak level at each location are given in Table A. These locations are shown in Map 2. The time lapse from the start of the peak releases from Wivenhoe Dam to the time of the peak flood level at the Brisbane City Gauge was about 32 hours. The LDCC received details of actual and predicted releases from Wivenhoe Dam at 3.48am on Wednesday 12 January 2011.

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Gauge Location along river	Peak Flood Level m AHD	Time of occurrence of peak level
Moggill	17.86	3pm, 12 January
Bellbowrie	14.86	6pm, 12 January
Jindalee	12.89	7.59pm, 12 January
Oxley Ck mouth	9.27	11.41pm, 12 January
Brisbane City	4.46	4am, 13 January

Table A. Times of occurrence of peak flood levels

The flood level hydrographs, the time histories of flood levels as metres above AHD, at the locations in Table A are shown in Figure 1 below. The hydrograph at each location shows how the flood level rose continually as the flood wave travelled down the river, reached its peak and then receded. The tidal variations appear superimposed on the flood wave and this is particularly noticeable in the hydrograph for Brisbane City. The set of hydrographs show the relative timing of the arrival of the flood peak and the reductions in the absolute and in the relative flood levels as the flood travelled down the river. As the flood wave moved downstream these changes occurred largely because the river bed becomes lower, the main river channel widens and increasing proportions of flood waters spread out over the widening flood plains.

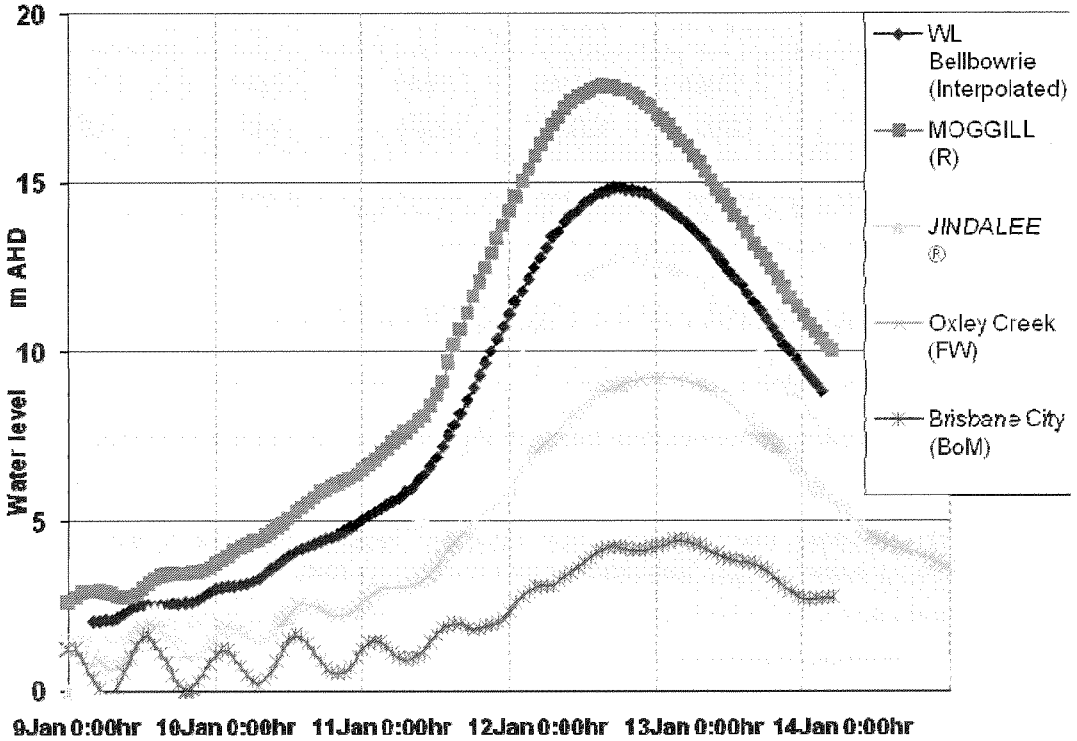

Figure 1. Flood level hydrographs for January 2011 flood event at locations along the Brisbane River

For residents affected by flooding, the more important information is the time when flooding becomes a matter of concern to them and the duration of that flooding. This information is given in Table B for the same locations as those in Table A. The flood levels corresponding to 'Moderate' and 'Major' flooding as defined by BoM are shown together with the time when

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each level was exceeded and the length of time during which the flood was above that level. In addition, the local DFL is given with the times and durations when it was exceeded. The DFL is higher than the level for a 'Major' flood at each location. The flood level in the January 2011 Flood Event was above the DFL for about one day in each of the locations in Table B. The durations of flooding at lower levels were considerably longer. A detailed explanation of the DFL and related concepts is given below.

Gauge Location	Moggill	Bellbowrie	Jindalee	Oxley Ck mouth	Brisbane City
Moderate flood; m AHD	13.00 m	11.00 m	8.00 m	3.50 m	2.60 m
Time start Date	9.06pm 11/01	11.39pm 11/01	7.33pm 11/01	11.07am 11/01	0.57am 12/01
Duration; hrs:min	43.30	42.00	54.00	95.00	52.30
Major flood; m AHD	15.50 m	12.00 m	10.00 m	5.50 m	3.50 m
Time Start Date	3.12am 12/01	2.32am 12/01	2.13am 12/01	9.32pm 11/01	10.00am 12/01
Duration; hrs:min	28.00	35.00	39.00	56.00	32.00
DFL; m AHD	16.20 m	13.80 m	11.40 m	8.00 m	3.70 m
Time start Date	5.13am 12/01	8.51am 12/01	7.16am 12/01	9.36am 12/01	11.15am 12/01
Duration; hrs:min	23.30	20.30	27.00	29.00	29.30

Table B. Times and durations of exceedances of flood level thresholds

The definitions of Minor, Moderate and Major flooding, as used by BoM are:

Minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.

Moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.

Major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

The extent of flooding during the January 2011 Flood Event and the line of DFLs for the whole of Brisbane are shown in Map 3. This information is given in greater detail for South Brisbane, Tennyson, Rosalie Area, Rocklea and Bellbowrie in Maps 4 to 8 respectively.

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Defined Flood Event, Defined Flood Level and Q100

Planning requirements for land use and development in Brisbane for areas that can be affected by flooding make use of the Defined Flood Level and related concepts, explained below.

The Defined Flood Event (DFE) is the flood event from which the Defined Flood Levels are calculated to establish the flood control lines for land planning and development.

The Defined Flood Level (DFL) is the peak flood level calculated for the Defined Flood Event at a particular location. It is used to inform land planning and development at that location.

Q100 is a theoretical flood that is commonly used to inform planning and policy. It is not a 'real flood' but, rather, it is a theoretical, probability-based design flood event that is chosen to reflect typical combinations of flood producing and flood modifying factors that act together to produce a flood event that has a 1 in 100 (1%) chance of being equalled or exceeded in each and every year at a particular location of interest. It is also described as the flood with 1% Annual Exceedance Probability (1% AEP), or with an Average Recurrence Interval of 100 years (ARI 100).

In many jurisdictions in Australia, the DFE for a particular location is chosen to be the Q100 for that location and the DFL is the peak flood level calculated for that theoretical flood.

It must be stressed, however, that Brisbane City Council has adopted a DFE that is larger than Q100 in the areas where the worst flooding is due to Brisbane River floods, rather than creek flooding, and the corresponding DFL is higher than that associated with Q100. The DFE for Brisbane, initially adopted in 1978, corresponds to the flood event of January 1974 after it has been mitigated (i.e. reduced) by the effects of Wivenhoe Dam and the corresponding DFLs are the peak levels that were calculated for this mitigated flood. The DFL at the Brisbane City Gauge was set then at 3.7m AHD.

In 2003, Council commissioned an Independent Review Panel to provide independent expert advice on estimates of the Q100 flow and level at the City Gauge, sometimes referred to as the Brisbane Port Office. The final outcome from the Independent Review Panel Report (2003) (refer List of References), drawing on the SKM 2003 flood study (refer List of References) was that, for a flood with 1% AEP, the best current (i.e. 2003) estimates give a Q100 flow of 6000 m^3/s at the Brisbane City Gauge and a corresponding flood level of 3.3 m AHD.

This estimate of the Q100 is, in general, a slightly lesser flood than the DFE that was adopted in 1978. The Independent Review Panel stressed the inevitable degree of uncertainty in estimates of this kind and it considered the possible range for Q100 at this location to be 5000 to 7000 m^3/s and the associated range of levels to be 2.8 to 3.8m AHD. It advised that the DFL adopted in 1978 should not be lowered. Council subsequently resolved to continue to use the DFE and DFL that were adopted in 1978 and these have been maintained unchanged since then.

The DFL increases progressively in level with increasing distance upstream from the City Gauge. The DFL is shown as a red line in for the whole of Brisbane and in greater detail for South Brisbane, Tennyson, Rosalie Area, Rocklea and Bellbowrie in Maps 3 to 8. The orange hatchings show the areas that would be inundated by creek flooding if there was no simultaneous river flooding. This is for local 100 year ARI floods in the creeks. At varying distances from the Brisbane River, the levels of flooding caused by the 100 year ARI creek floods are higher than the DFL that is associated with the river flood.

Defined Flood Level for Creek Flooding

In many areas of Brisbane, the worst flooding is caused by local creeks, not by flooding from the Brisbane River. In these areas, the 100 year ARI flood has been adopted as the DFE and DFLs have been calculated from Q100. Consequently, for each particular location, the DFL is the higher of the level that has been adopted for Brisbane River flooding and that calculated

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for creek flooding. This can be a continuing cause of confusion that would be reduced if all reference to 'Q100' were eliminated from public documents and the description 'Defined Flood Level' were used exclusively, regardless of the cause of flooding and of the degree of immunity associated with it.

Summary Comments on the Magnitude of the January 2011 Flood Event

Historical comparisons

Flood records for Brisbane, held by the BoM and Queensland, extend back as far as the 1840s. These records show that Brisbane is a city built on the flood plain of a river with a history of flooding. The flood peaks are referenced to the Brisbane City Gauge and the flood levels reached upstream are significantly higher. Table C below shows flood levels on the Brisbane and Bremer Rivers and Lockyer Creek for a selected number of river flood events.

River Height Station (m AHD)	Feb 1893	Feb 1931	Jan 1974	Jan 2011
Gatton (Lockyer)	16.33	9.14	14.63	> 16
Ipswich (Bremer)	24.50	15.50	20.70	19.25
Mt Crosby	32.00	21.78	26.74	n/a
Moggill	24.50	15.40	19.93	17.86
Jindalee	17.90	9.60	14.10	12.89
Brisbane City Gauge	8.35	3.32	5.45	4.46

Table C. Peak levels for selected flood events

The floods of 1841 and 1893 reached over 8m AHD in Brisbane City. This represents a depth of approximately 6.5m above the highest tide level. Since 1893, the largest flood in the Brisbane - Bremer systems was in 1974. In Brisbane, the January 1974 flood rose to a height of 5.45m at Brisbane City Gauge while Ipswich reached a height of 20.7m. As the Brisbane River flooded, it backed up the Bremer River resulting in four to five days of record heights in Ipswich.

The history of flooding in Brisbane is illustrated in Figure 2 below. The graph is based on BoM's record of Highest Annual Flood Peaks as estimated or recorded at the Brisbane City Gauge for the period since 1840. The January 2011 flood (4.46m at Brisbane City Gauge) has been added to the original BoM graph that was prepared in 2009. In some years, particularly in 1893, there were several large floods but the graph shows only the largest flood for each year.

As shown in the graph, for the period 1840 to 1900, there were 15 floods which were classified as Moderate or Major. By contrast, in each of the periods 1901 to 1960 and 1961 to 2011, there were only two floods which were classified as Moderate or Major.

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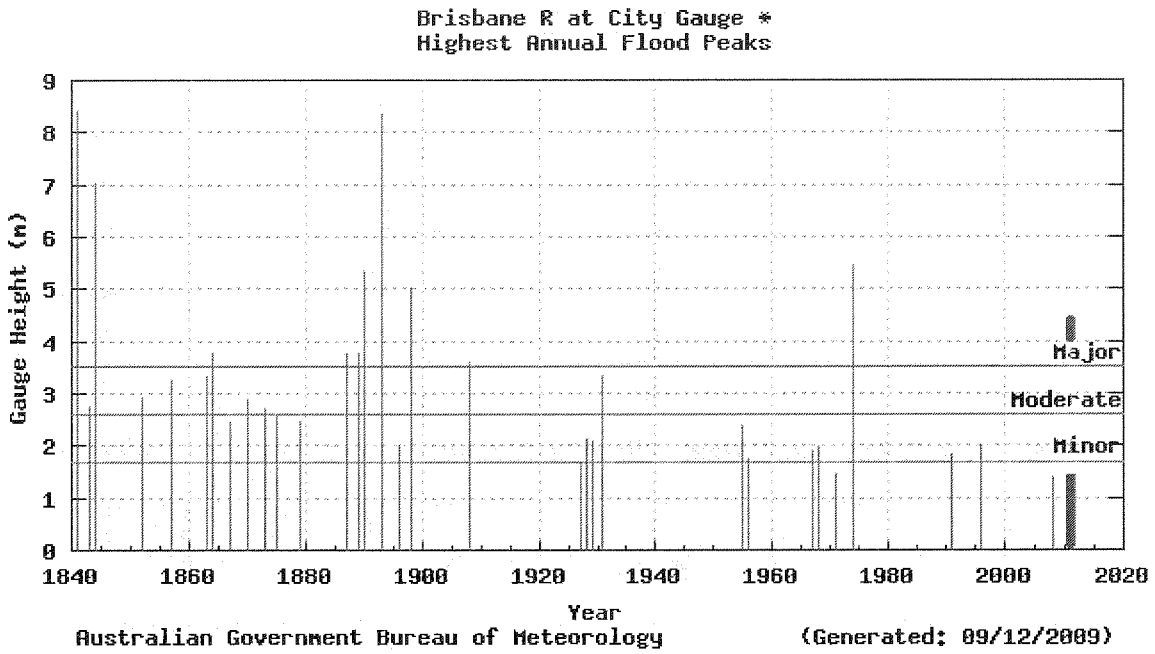

Figure 2. History of flooding in Brisbane – original by BoM with 2011 data added

Seqwater Summary

In its review of the magnitude of the January 2011 flood event the Seqwater Report (refer List of References) concludes that

> The flood volumes indicate the volume of the January 2011 flood event was almost double that of the January 1974 flood and similar to that of the February 1893 flood;
>
> Peak water levels at gauging stations in the Brisbane River above Wivenhoe Dam were the highest on record. In the Lockyer Valley, peak water levels exceeded the 1974 levels and may well have been larger than those of 1893;
>
> The recorded peak flows, volumes and peak levels at Somerset and Wivenhoe Dams indicate the January 2011 flood event was much more extreme than one with 1% AEP; and
>
> Overall, the January 2011 flood event is considered to represent a 'rare event' as defined by Australian Rainfall & Runoff (AR&R) in terms of rainfall, flood peaks, inflow volume and peak heights.

Both the historical comparisons and the Seqwater Report clearly show that the January 2011 flood was a rare and large flood event.

Recommendation

The Board recommends that the term, Defined Flood Level, be used exclusively in public documents concerning flood planning levels for Brisbane, regardless of the cause of the flooding.

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SECTION TWO - BRISBANE CITY COUNCIL'S DISASTER MANAGEMENT ARRANGEMENTS INCLUDING PREPARATION, RESPONSE AND RECOVERY

This section of the Report examines Brisbane City Council's preparation for, and response to, the major flood event in Brisbane during the period 9 to 22 January 2011. It discusses the legislative and policy settings which inform local authorities' duties and responsibilities, examines Council's preparation in relation to its policies, procedures and organisational structures and facilities, and explores the efficacy of Council's response to the flooding disaster.

Legislative and Policy Settings

Australian Emergency Manual Series (Commonwealth) This series of manuals, produced by the Federal Government Attorney General's Department through Emergency Management Australia, provide planning advice and operational guidance for a range of natural disasters including floods. The relevant manuals for this disaster include: Managing the Floodplain (Manual 19), Flood Preparedness (Manual 20), Flood Response (Manual 22), and Evacuation Planning.

From an analysis of these manuals against Council's response to the flood, it is apparent that Council has a very good appreciation of the risks associated with flooding, has in place a good capability to detect, monitor and respond to flood events and has a high order understanding of the importance of an education strategy aimed at improving community knowledge and resilience. Council performed well against the criteria for effective management of flood response operations identified in the manuals.

Disaster Management Act 2003 (Qld) The *Disaster Management Act 2003*, amended on 1 November 2010, forms the legislative basis for disaster management activities within all levels of Government in Queensland. The 2010 amendments focused on the delegation of District Disaster Coordination responsibilities to the Queensland Police Service (QPS), adjusting the authorities and criteria for declaration of a disaster and refining Local Disaster Management structures.

The key legislative requirements for Council involve establishing and providing the Chairperson for the Brisbane City Local Disaster Management Group (BCLDMG) which is required to meet at least six-monthly, and is responsible for maintaining a current and endorsed local Disaster Management Plan, a disaster response capability, for ensuring the District Disaster Coordinator is informed of events, and for appointing an appropriate senior and experienced Council officer as the Local Disaster Coordinator.

Council has a current, detailed Disaster Management Plan with appropriate supporting structures comprising the BCLDMG and the Local Disaster Coordination Centre (LDCC).

It is assessed that the legislative requirements in the *Disaster Management Act 2003* are supported by the disaster management arrangements maintained by Council and that the State-level disaster management legislation and guidelines were all supportive of the response arrangements in place for Brisbane.

Stakeholders indicated the powers invested in Council's disaster management organisation and those available to civil authorities and emergency services are more than adequate for an incident of this scale and nature. As a result, there were no issues regarding the impact of legislation, policies or guidelines on Council's ability to manage the disaster effectively.

Public Preservation Safety Act 1986 (Qld) The *Public Preservation Safety Act 1986* is an Act to provide protection for members of the public in terrorist, chemical, biological, radiological or other emergencies that create, or may create danger of death, injury or

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distress to any person, loss of or damage to any property or pollution of the environment and for other related purposes.

The operational activities undertaken by Council in response to the January 2011 flood are assessed as being consistent with the *Public Preservation Safety Act (1986)*.

State Planning Policy (SPP) 1/03 – Mitigating the Adverse Impacts of Flood, Bushfire and Landslide This policy is aimed at ensuring that the natural hazards of flood, bushfires and landslides are adequately considered when making decisions about development. The application of this policy at local government level is achieved through specific building codes and regulations as well as wider town planning mechanisms. For Council, City Plan provides one of the strategic mechanisms for guiding development. The current City Plan was adopted in 2000 and has been updated every six months since.

State Disaster Management Group (SDMG) Guidelines Analysis of SDMG documents indicates that Council disaster management documentation, plans and response structures aligned with the various guidelines and that Council officers had a very good to good understanding of these guidelines, especially those who had undertaken formal training conducted by Emergency Management Australia (EMA).

Council Policy Settings

Business as Usual Activities An analysis of Council policies in relation to Council's preparation for, and response to, the flood event indicated that they were relevant, appropriate and well understood. Policies considered included the Environmental Policy, Sustainability Policy, and the Media Relations Policy.

During the response and recovery phases sensible flexibility was shown, particularly in relation to the Environmental Policy, where the sheer volume of flood debris and waste and the possible adverse impact on public health, required expedient measures to be adopted. As the crisis eased, these measures were no longer required or used.

Risk Management Framework and Business Continuity Plans An examination of Council's Risk Management and Business Continuity Plans (BCPs) indicated that Council rated flooding as an extreme risk. Following the Lord Mayor's Task Force on Suburban Flooding (2005) and analysis of various local storm water flood events, and The Gap Storm in 2008, Council implemented a continual improvement process in relation to Risk Management and Business Continuity Plans.

In December 2010, risk managers were tasked to review their BCPs and adjust policy and practice as appropriate. This proved to be both sensible and prudent.

During the January 2011 flood, Council maintained corporate level BCPs for critical community services including; the customer Call Centre, flood warnings, regulatory services, the road network, transport bus services and waste management. At the divisional level, BCPs are maintained for critical support functions including; cash flow, commercial services, corporate accommodation, human resources, information communications technology, and media and communications.

An area of concern which emerged related to entities delivering outsourced functions to Council. In some cases the existences or otherwise of BCPs for entities providing outsourced services was not well understood. This is worthy of further investigation by Council, particularly as it relates to outsourced backup wireless communications.

Other unanticipated issues that arose during the flood event related to the Brisbane Square site power supply and Council's data centres. While a backup power supply system with diesel powered generators was in place at Brisbane Square, there were some uncertainties relating to fuel availability and supply. In relation to the data centres, Council servers are located in two sites at Brisbane Square and Holland Park. Concern was expressed that if the

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Brisbane Square was evacuated or if its data centre failed, it could take several days to have the alternate server site at Holland Park fully operational.

While the Business Continuity program may be regarded as close to best practice as it is well aligned with industry standards in terms of governance, development and maintenance, testing and training, there are some areas, as discussed above, worthy of further examination.

Council Disaster Management - Policies and Plans

Council's Disaster Management Arrangements Council's disaster management arrangements are expressed through the Disaster Management Plan and the Concept of Operations for Disaster Management. The Disaster Management Plan details the arrangements undertaken by Council to meet its obligations under the *Disaster Management Act 2003 (Qld)*. The plan outlines the disaster management system and specifies roles and responsibilities. It describes how the system works during an emergency, provides a framework of sub-plans for the most likely threats and for the recovery phase. The Concept of Operations for Disaster Operations adds detail to the Disaster Management Plan by outlining the manner in which Council will undertake the various tasks to respond to the emergency. Essentially it details the structures, functions, and responsibilities necessary to deal with the emergency and transition to recovery and business as usual.

Disaster Management Plan (DMP) Council's DMP was reviewed in October 2010 and provides the methodology by which Council responds to natural disasters, detailing structures, responsibilities and procedures across the organisation. Part 2 of the plan includes specific operational plans covering evacuation and emergency human services, bushfires, inundation from river floods and storm surge, pandemics, environmental health and the evacuation of Moreton Bay Islands. The Inundation Plan was updated in June 2010.

The DMP is a dynamic document with the current version updated recently and approved by Council while this report was being drafted. The DMP is assessed as well structured and the content has a very high degree of correlation with the extant risk assessment for natural hazards. The inclusion of specific operational plans enhances the utility of the DMP. The four 'Levels of Activation' that govern the degree of response are assessed as appropriate, allowing sufficient flexibility to scale internal and external response mechanisms.

The DMP proved to be very effective in guiding the Council response to the flood. Specifically, the Inundation Operational Plan indicates that the Council mission "was to coordinate the deployment of internal and external resources to reduce or eliminate potential loss of life or property and restore pre-inundation services as quickly as possible".

Analysis of the response indicates this mission was achieved for the January 2011 floods with a high degree of success. Fatalities were minimised (only one death recorded in the greater Brisbane area that was linked to the flood event, compared to around 14 people who died in the Brisbane and Ipswich areas during the January 1974 flood), (Bureau of Meteorology Report 1974) (refer List of References). The overall coordination of internal and external resources was extremely effective and Council undertook all actions that were feasible to protect property given the level of the flood and timeframes experienced.

The principles and priorities identified in the DMP are deemed appropriate and were consistently reflected in operational activities by Council during the flood.

Concept of Operations for Disaster Management The Concept of Operations was revised in November 2009 and details the structures, functions and responsibilities required to respond to an emergency. It conforms with, and reflects, the Queensland disaster management arrangements with a focus on Brisbane City disaster management arrangements. It details the roles and responsibilities of the BCLDMG and the LDCC, outlines the flexible and scalable approach for activations, provides for the appointment of the

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Disaster Operations Manager (DOM) and the Disaster Management Group (DMG) and provides guidance on concepts for recovery and transition to business as usual.

Disaster Management – Structures and Arrangements

Brisbane City Council Local Disaster Management Group (BCLDMG) The BCLDMG is chaired by the Lord Mayor. The role of the BCLDMG is to manage the disaster response to an event to the recovery phase in order to minimise adverse effects on the community, the natural environment, the built environment and the economy. The BCLDMG maintains a strategic approach by setting priorities and assigning resources to ensure the efficient and effective recovery of the disaster-affected community.

The BCLDMG is responsible for ensuring that disaster management and disaster operations in the Brisbane area are conducted consistently with the legislative and strategic policy framework for disaster management as enunciated by the State.

Local Disaster Coordination Centre (LDCC) The LDCC coordinates and prioritises the use of resources and assets to support Council's response and recovery operations. The LDCC is responsible for the implementation of BCLDMG priorities and reports directly to the BCLDMG. At higher levels of activation, the LDCC contains a number of specialist groups that undertake the detailed work in relation to the incident or event. These groups include the Forward Planning Group, the Field Operations Group (FOG), the Disaster Intelligence Group and the Incident Support Group. LDCC activities are coordinated by the LDCC Incident Controller, a senior Council Officer experienced in disaster management.

Forward Planning Group (FPG) The FPG is the strategic planning and advisory unit for the BCLDMG. The FPG supports the BCLDMG's decision making process, formulates strategic guidance on behalf of the BCLDMG, develops and delivers forward planning options (response and recovery considerations) to the BCLDMG, develops and manages the BCLDMG response and recovery agenda including consideration of agenda issues, provides a forum for consultation between the BCLDMG and other appropriate government departments, including State and Federal, undertakes consequence analysis and management, provides a strong communication network between the business community, responding agencies and non-government organisations at the strategic level, and provides a 'think tank' capacity beyond current operations.

Field Operations Group (FOG) The FOG coordinates and manages Council's operational response and internal logistical support to a disaster event, operating under the control of the LDCC Incident Controller. It assigns tasks to the Regional Incident Management Teams or other appropriate Council business units for implementation or action and provides information to the LDCC Incident Controller on the progress of Council's on-ground response as well as highlighting emerging issues. Further, the FOG establishes a close operational relationship with the Disaster Intelligence Group to ensure shared situational awareness and relevant information collection as well as identifying resource shortfalls and the requirement for additional Council or external support using Council procurement guidelines. Finally it conducts current operational planning for the 0-72 hours planning horizon.

Disaster Intelligence Group (DIG) The DIG has prime carriage of the intelligence function within the LDCC. It is responsible for collecting, collating, assessing, analysing and disseminating information in a timely manner to support the LDCC's planning, operations and logistics activities. The DIG develops an Intelligence Support Plan to inform LDCC current and future operations. It identifies critical information requirements and information gaps and ensures that key reporting requirements are met. It manages the collection of information through Rapid Assessment Teams (RAT) and other Council sources and verifies open source information from all sources. The RAT are provided by the five Compliance and Regulatory Services (CARS) regional offices and are coordinated and tasked by, and report back to, the DIG. The DIG undertakes analysis and assessment on information provided to identify key issues and priorities, disseminates intelligence to the LDCC, maintains a high level of

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situation awareness and ensures that the LDCC Incident Controller is advised of emerging issues.

Incident Support Group (ISG) The ISG provides administrative, logistics and crisis communications support functions to the LDCC. Its administrative support function involves monitoring staff rosters and fatigue management, coordinating Liaison Officers assigned for logistics purposes, managing shift handover and briefings and ensuring appropriate catering arrangement are in place. Its logistics support function includes managing contract support, coordinating resources augmentation and actioning requests for assistance from external sources. In relation to crisis communications, it develops messages for dissemination to Council's key stakeholders, manages messages and perceptions regarding the event and maintains liaison with the Council's Call Centre regarding key flood event messages.

Regional Incident Management Teams (RIMT) The RIMT conduct activities at the regional level in accordance with tasks allocated by the FOG (LDCC). RIMTs exercise command, control and coordination of Council assets within their respective region and provide feedback information to the LDCC.

Activation Four levels of activation are detailed in the Concept of Operations to provide a flexible and scalable response. At Level One, the response is managed through Council business functions and normal incident response reporting. At Level Two, the response relates to a localised situation and is managed by the appropriate Council business unit manager as determined by circumstances and who is appointed the Disaster Operations Manager (DOM). The DOM notifies and informs key internal and external stakeholders of the incident and provides advice regarding the likelihood of incident escalation and the requirement for subsequent activation to Levels Three and Four. At Level Three, the response relates to a more serious situation requiring Council-wide actions and triggers the activation of the LDCC, including expanded functions being placed on standby for possible activation to Level Four. At Level Four, the response requires high level coordination of a complex range of issues and requires the full activation of the LDCC functions.

Flood Information Centre (FIC) The FIC, unlike the BCLDMG and the LDCC and its components, operates on a permanent basis providing river state and flooding information to Council and especially to Council's Call Centre, for advice to the general public, during the more regular storm and flash flooding events that occur across the Brisbane River and its tributaries. During a major event, and when the LDCC is stood up, it provides all flood information to the LDCC in the form of situation reports, flood inundation maps and flooding interpretation to provide local flood levels. To inform its deliberations, the FIC is advised by BoM on weather predictions and modelling, and by Seqwater in relation to dam operations including their operating strategies and their view of downstream impacts. Based on this analysis, flood maps are provided both in hard copy and soft copy (PDF formats).

Council's disaster management structures and arrangements are shown diagrammatically at Figure 3 opposite.

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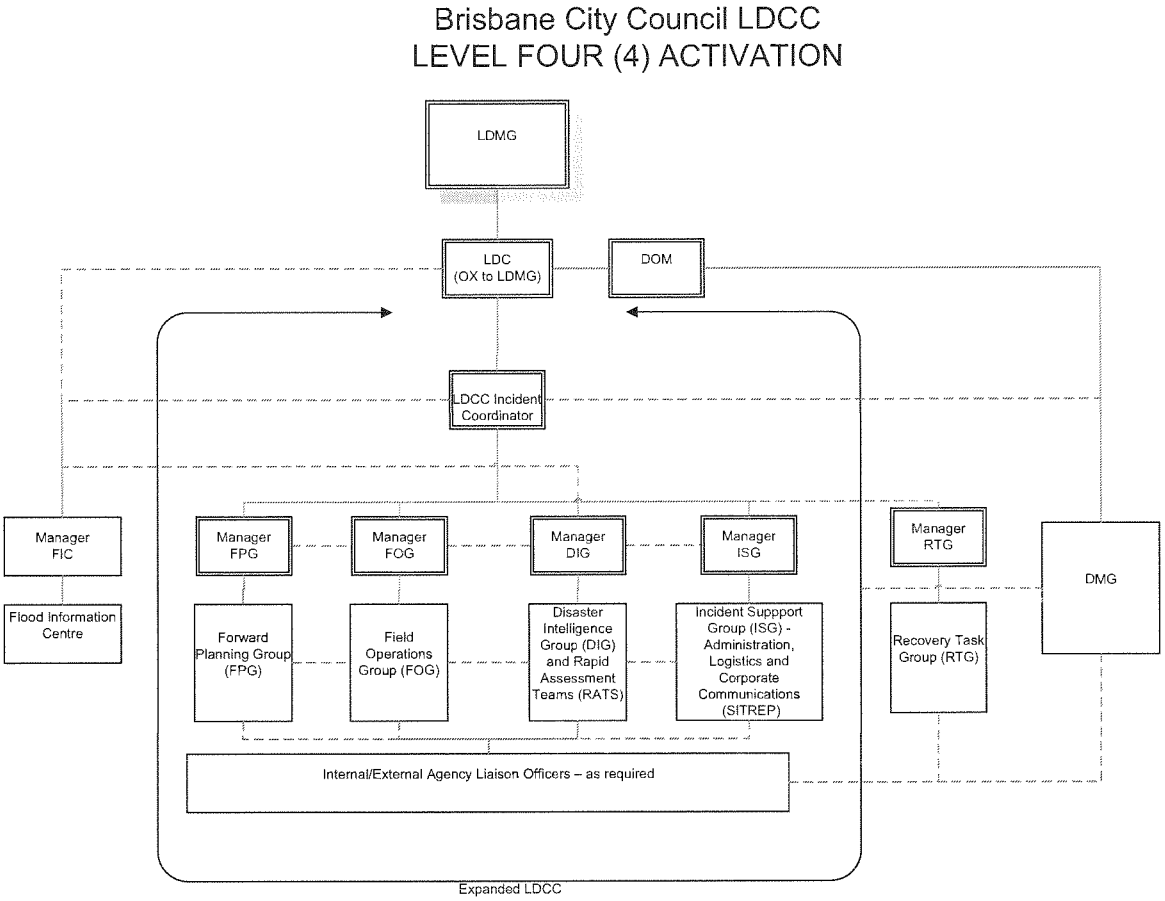

Figure 3. Council's disaster management structures and arrangements

Disaster Management Preparation

Emergency Management Australia Disaster management training conducted by Emergency Management Australia has been invaluable, particularly in building understanding and confidence regarding the division of responsibilities between command (management) aspects and operations, plans, intelligence, logistics, and administrative functions as well as gaining an overview of the capabilities of various external agencies. This training was particularly beneficial to Council staff operating the RIMTs.

Council Training Prior to the flood, Council had a number of staff experienced in disaster management who provided the basis for disaster management preparation and training and who were supported by other staff from various Council Divisions and Business units, trained in additional duties to provide support in emergency situations on an as-required basis. Such additional staff members are informally referred to by Council, as "internal volunteers". Selected internal volunteer staff are recruited from Council Divisions and Business units and trained across all roles in the LDCC including the senior leadership roles of Incident Controller and Group Managers for the FPG, FOG, DIG and ISG.

Council's DMG designs a training strategy and framework using both internal and external trainers to develop the individual skills for LDCC and RIMT staff across all required roles and tasks. An important element of the framework is the Incident Controllers' development program which is conducted by Council disaster management staff supported by Emergency Management Australia and Emergency Management Queensland. Incident Controllers may be assessed by the Australian Institute of Emergency Management to advise on their level of proficiency. Training completed prior to the January 2011 flood event included an Incident Controller development program and workshops for Incident Controllers, Situation Report Writers, and Motorola radio training.

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The term "internal volunteer" caused confusion, particularly when community volunteers were being sought for the cleanup operations and as it is also applied to State Emergency Service (SES) volunteers and those volunteering plant and equipment to support Council's response operations.

Readiness Exercises In the lead up to the summer storm period, Council implements an annual storm awareness program to highlight the importance of being prepared for major storms and potential flooding, based on recommendations from the Lord Mayor's Taskforce on Suburban Flooding (2005).

Training, testing and scenario planning programs and procedures have continued to evolve over a long period of time using the learnings from events such as The Gap storm. Each time the LDCC is activated, there has been a process implemented to review and identify opportunities for improvements.

In October 2010, and cognisant of long-range weather forecasts, the exercise program was modified to emphasise potential major river flood events. The emphasis and direction provided by the Lord Mayor, the CEO and senior management facilitated an increased focus on training, testing and scenario planning. Details were widely communicated internally to Council staff to ensure Council more generally was also ready for any potential major natural disaster.

Overall, the training and exercises conducted within Council, coordinated by the Disaster Response and Recovery Group, is assessed as very effective and timely in preparing Council for the flood disaster. A particular characteristic of the January 2011 flood response was the provision of significant external to Council resources, such as the ADF, SES, NGO's and heavy plant and equipment resources voluntarily provided by industrial contractors. Based on this experience, scope would seem to exist for a wider training program and progression to more complex exercises in which external agencies play an active role.

Along with larger exercises, desktop exercises are a very good mechanism for team skill development. It was particularly prescient that the desktop exercise conducted in December 2010 for the Executive Management Team and elements of the LDCC had major river flooding in Brisbane as one of its scenarios.

Workforce Planning Council uses an expression of interest process to attract internal volunteers to staff the LDCC and other disaster management organisations. While this worked well during the January 2011 flood event, a combination of the duration and the highest level of activation created stresses and indicated that a more formal approach to disaster workforce planning is required, particularly as in some instances staff worked both in the LDCC and also in their business as usual Council role resulting in very long hours on duty.

It is understood that Council is developing a new workforce plan to address the complex issues of training, fatigue and staff turnover and the requirement to step into other roles as well as to ensure best practice Industrial Relations policies and procedures are facilitated. This decision is commended and recommended to be implemented as a high priority.

Finally, the Board wishes to express the view in the strongest possible terms that Council staff made a very significant commitment in time and effort to ensure the flooding disaster was properly managed, that safety considerations were a priority, that the care of people, their communities and their property was the paramount consideration, and that Council services were delivered appropriately. This was a most commendable effort and particularly so against a backdrop where a number of Council staff were personally affected by flooding.

Conduct of the Flood Disaster Operations

Background Chronology Heavy rainfall during the week prior to the flood crisis between Sunday 2 and Sunday 9 January 2011, together with advice from the FIC led to the decision to activate the LDCC at 9pm on Sunday 9 January 2011. Subsequently, on Tuesday 11 January 2011, the LDCC was raised to its highest level of activation (Level Four) where it remained until 25 January 2011 and then continued at lower levels of staffing until Friday 1 April 2011. The LDMG was convened for its first meeting at 10am on Tuesday 11 January 2011 and met daily until Saturday 22 January 2011. On Tuesday 11 January 2011, the Premier of Queensland, the Honourable Anna Bligh MP, under the *Public Preservation Safety Act 1986 (Qld)* declared flood affected areas of Queensland, including Brisbane, a "disaster zone". This declaration remained in force until 10am on Tuesday 25 January 2011.

A more detailed chronology is provided after the Conclusion of this Report.

High Level Relationships The BCLDMG provided strong leadership and strategic direction setting for the response to the floods, establishing clear priorities and effectively utilising resources available from internal sources and external agencies. The BCLDMG undertook broad strategic analysis and provided clear direction to the LDCC.

Following the daily BCLDMG meetings, key communication messages for the public were developed and disseminated to all media sources. The Lord Mayor's sound leadership and clear and direct communication style were very effective and drew positive comments in response to interviews and in the feedback received from the residents and businesses community engagement survey.

The CEO, as the Local District Coordinator, under Section 36 of the *Disaster Management Act 2003 (Qld)* is charged with coordinating disaster operations for the BCLDMG. He does this by ensuring that the LDCC is properly established and functioning effectively and by making himself available to the LDCC Incident Controllers and other LDCC staff as appropriate. He also represents the BCLDMG at the Brisbane District Disaster Management Group and the State Disaster Management Group (SDMG) as appropriate and when required.

To further ensure sound working relationships, senior staff from the LDCC attend the BCLDMG meetings and this enables them to gain a clear understanding of the considerations behind the various decisions, thus avoiding problems of ambiguity and misinterpretation.

The Board assessed that the BCLDMG set a very high standard for responding to natural disasters at the strategic level.

The Board assessed that the relationship between the BCLDMG and the LDCC was both appropriate and effective, and ensured that strategic directives and plans emanating from the LDCC were well understood and effectively implemented.

Close and constructive relationships were established between the BCLDMG and the District Disaster Management Group (DDMG) and the SDMG. At the State level, the Deputy Premier, the Honourable Paul Lucas MP attended the BCLDMG meetings which ensured that the Queensland Government was abreast of, and able to support, the Council's response. At the District Level, Assistant Commissioner Peter Martin Queensland Police Service (QPS), the District Disaster Coordinator, also attended the BCLDMG meetings. While support from the Commonwealth Government, particularly from the Australian Defence Force (ADF), was both invaluable and highly effective, especially during the recovery phase of the operation, Council was generally able to meet most of its needs, due to its size and resource availability, thus allowing scarce, high-value resources to be directed to other disaster areas outside of Brisbane.

The Board assessed that relationships between the BCLDMG and the DDMG and SDMG were appropriate and effective, displaying high levels of cooperation. Unfortunately, the

Board was unable to confirm this opinion directly with Queensland Government representatives or agencies as they declined the Board's invitation to discuss these matters.

Command, Control, Coordination, Communications and Leadership As discussed earlier, the *Disaster Management Act 2003 (Qld)* provides for the establishment of the BCLDMG and other disaster management groups for the purpose of managing the effects of a disaster event. The Act further appoints the Lord Mayor as Chair of the BCLDMG and Council's Chief Executive Officer (CEO) as the Local Disaster Coordinator. The Lord Mayor, as Chair of the BCLDMG, ensured that a clear and unambiguous chain of command was established. He provided strategic leadership and oversight of the disaster event. The CEO coordinated Council's disaster operations for the BCLDMG by ensuring that that the LDCC was functioning effectively and efficiently, by ensuring that the BCLDMG's strategic decisions were implemented and by reporting regularly to the BCLDMG.

The Board is of the view that both the Lord Mayor and the CEO displayed very high levels of leadership the Lord Mayor in relation to the overarching strategic direction and public information and the CEO in both the high level outcomes achieved across a wide range of flood disaster activities as well as by his style which demonstrated commitment and support to staff including encouraging them to make decisions and to take actions "to get things done". This empowerment and delegation of authority and decision making was a key factor in the successful response to the January 2011 flood event.

Control Measures A wide range of appropriate control mechanisms were established and included the use of operational sectors as the focus for warning and recovery activities. The Brisbane City Council area is divided into five regions: North, South, East, West and Central, with each having an RIMT established within.

During the response phase, affected wards and suburbs were grouped into response sectors. Response sectors were created based on the Australian Bureau of Statistics (ABS) Census Collection Districts (CD) and Statistical Local Area (SLA) boundaries.

The use of response sectors for tasking and information gathering provided a clear understanding of the affected areas by Council and external agencies. This facilitated the coordinated and effective utilisation of Council and external agency resources and improved the ability to rapidly assess and provide accurate and timely reporting.

The use of ABS Census collection boundaries was appropriate as they already exist and can be easily accessed by all agencies. A Census CD provides a sound basis for high level impact assessment as each contains an average number of dwellings and data remains consistent and available across all agencies. Further, SLAs can be separated or combined to reflect the scale or severity of event, while tasking and communication is supported by a unique naming protocol for each SLA and Census CD. Finally, boundaries can be easily adopted by operational units.

Coordination Mechanisms A range of coordination measures were included in the LDCC structure where desks were provided for internal Council officers and external liaison staff representing the QPS, Queensland Fire and Rescue Service (QFRS), the SES, the ADF, and utility providers. This enabled all to attend regular briefings and be informed by the dissemination of periodic situation reports. Feedback from external agencies consistently highlighted that coordination with Council throughout the disaster was very successful. In a number of cases, agencies commended Council on how they managed inputs from, and links to, their respective agencies.

Liaison Officers (LOs) LOs provided by the relevant Council Business units were very effective to ensure sound information flows and inputs to planning, and the conduct of activities which added significantly to the overall coordination effort. In those instances where liaison gaps were identified they were quickly remedied. In the cases where the RIMTs deployed LOs to the LDCC they proved extremely effective. Further, it is assessed that there is an opportunity to enhance overall performance by both the establishment of dedicated LOs

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to manage queries and requests and to take local information detail from Councillors, and the inclusion of a waste management liaison officer for direct access to technical waste advice.

Communications Council fixed telephone lines including voice and facsimile, email and internet facilities supported by the mobile telephone system including voice and SMS provide the primary communications network. In the event of the failure of some or all of the primary network, hand-held radios provide a more limited capability, as did the small number of recently introduced hand held tasking devices. Communications between the LDCC, FOG and the RIMTs use mobile phones as the primary means, backed up by the hand held radio network.

Email communication issues arose with the LDCC email account whereby users used their individual (business as usual) GroupWise email addresses for operational communications between elements in the disaster management structure. This provided difficulties following shift changes if the new incumbent was not aware of a previous email address or, in the "heat of battle", forgot or failed to recognise the email address as pertaining to them. This had the effect that some emails were delayed in being answered or were ignored. A possible solution could be to establish email addresses for key roles or teams in the LDCC and its associated elements such as 'LDCC OPS', 'LDCC Incident Controller', 'DIG Watchkeeper', "FPG Planner" and so on.

In relation to telephones and to ease congestion, consideration should be given to implementing a phone system which allows incoming calls to be queued during busy times to achieve an orderly management of calls. The mobile phone system degraaded in part due to local congestion and the failure of mains power supplies to some towers.

Local District Coordination Centre (LDCC) Command and control was exercised by the LDCC in accordance with the broad directives from the BCLDMG. RIMTs were established based on Council's five Local Asset Services (LAS) existing areas and were given control of in-location LAS and Compliance and Regulatory Services (CARS) assets with additional resources allocated as required and available from both within Council resources and from external sources as available. High value (ADF, SES and specialist equipment) and scarce resources (such as street sweepers) were generally managed centrally.

The LDCC was operational from early on Monday 10 January 2011 at Level Three. Initial tasks centred on supporting the public information effort, coordination of limited local resources (such as sandbags) and activities in preparation for an escalation to Level Four. This included contacting and rostering Incident Controllers, supporting the activation of BCPs within Council, engaging external agencies in initial planning discussions and enhancing situation awareness.

On Tuesday 11 January 2011, when it appeared the Brisbane River was going to flood to levels approximating the January 1974 floods, the Activation Level was raised to Level Four and the full complement of disaster management structures was established.

The structure of the LDCC was validated during the conduct of disaster operations. The scale of the disaster necessitated a Level Four activation that resulted in an enhanced LDCC and component groups to manage the volume of information and the range and scale of emerging tasks. The enhanced structure ensured key functional areas with associated responsibilities were appropriately tasked and utilised throughout the disaster.

The upgrade and refurbishment of the LDCC facility on Level 1 at 266 George Street Brisbane was both timely and effective in enhancing the capacity of the LDCC. It is noted that further upgrades scheduled for this year include a dedicated small briefing room within the LDCC to allow update briefs and meetings to occur in an area close to, but separate from the centre of operations.

Comments from Council staff and other external agencies involved indicated that the new facilities, improved layout and the additional equipment greatly enhanced the efficiency of LDCC's operations during the January 2011 flood.

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It is assessed that the LDCC performed exceptionally well in managing and coordinating Council's response to the flood crisis. Some enhancements to process have been identified including the creation of a dedicated citizen volunteer management team, formalising the written briefing processes for handovers between shifts, improvements to logging incoming and outgoing information and jobs/tasks, particularly noting when jobs have been completed to avoid duplication of effort (there may be some smart technologies available to assist), developing a readily accessible database of frequently asked questions to address "who does what type issues" to support the LDCC staff and agencies (this could also include information available on Council's Call Centre database), synchronising the shifts of agencies and Council staff working in the LDCC to better facilitate handover briefings, and ensuring that Situation Reports are used on a regular basis and are widely distributed using multiple communications channels.

LDCC Activation The process for activation of the LDCC worked well with a graduated response by selected elements within the disaster management structure. The early decision to move to Level Three at 9pm on Sunday 9 January 2011 and then escalate to Level Four at 8am on Tuesday 11 January, as a clearer understanding of the emerging situation emerged, is evidence of a considered and deliberate response to the rapidly emerging situation.

Forward Planning Group (FPG) The FPG functioned well, particularly given the fast moving nature of the flood event. Consideration could be given to standing it up earlier in the proceedings as planning will always be required. While contrasting views were expressed regarding the extent and nature of the FPG's responsibilities to the BCLDMG and to the LDCC, its major effort was directed by the BCLDMG as outlined in Council's DMP.

Forward Planning Throughout the response the high quality of forward planning played a significant role in ensuring effective outcomes. The FPG focused on strategic planning to allow for efficient management and resource allocation to commence recovery considerations. The FPG identified the need for additional multi-agency assistance and involvement, as well as indicating where such additional resources may be sourced or procured. Specifically, the FPG supported the BCLDMG decision making process, formulated strategic guidance on behalf of the BCLDMG, developed forward planning options (response and recovery considerations) for the BCLDMG and provided a forum for consultation between the BCLDMG and other appropriate State and Federal departments and agencies and Non-Government Organisations (NGOs).

The Concept of Operations (for response) was produced by the FPG on 13 January and provided the basis for response operations over the coming days. It established priorities and provided for an intelligence and preliminary damage assessment phase, followed by the re-establishment of essential services, facilitation of the return of evacuees, an assessment of Council infrastructure and the transition to recovery and business as usual.

During the response, a "next day priorities" briefing was conducted (reflecting LDCC requirements and other considerations) each afternoon which allowed the coming 24 hours plans to be formulated and related instructions issued.

The FPG prepared and delivered the Response Concept, the Recovery Concept and the Recovery Plan. The FPG also undertook volunteer management planning.

On Friday 14 January 2011 the FPG initiated planning "The Brisbane River Flood Disaster January 2011 Concept for Recovery" to commence once the Response Phase to the flood event was completed. This document provided for a high level, strategic approach to recovery within the Council area and signalled the transition from the disaster response phase to a business as usual approach. The approach centred around the establishment of the Lord Mayor's Recovery Task Group and six recovery sub-committees, each chaired by a councillor, with a focus on the community, finance and economic activity, infrastructure matters, environmental matters, ward recovery matters and town planning considerations.

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Field Operations Group (FOG) The FOG was successfully led by experienced senior managers who directed and managed operations in the field. Noting that leadership roles were demanding and fatigue was a potential issue due to the duration of the flooding event and the nature and range of operations, it is recommended that consideration be given to increasing the number of managers, splitting the group into two elements with one focussing on current operations and the other focussing on future operations (72 hours and beyond); and to introducing IT tools to allow improved scheduling and prioritisation of tasking.

Further discussion of the FOG is contained in Section Three.

Disaster Intelligence Group (DIG) The DIG played a vital role supporting the LDCC and other component groups through the facilitation of situational awareness and the provision of specific intelligence products such as maps, infrastructure data and contact lists. The DIG managed large volumes of information associated with the disaster which demanded a very clear process for receiving, collating, analysing and disseminating information as well as tasking assets to collect information. These tasks require training in, and an understanding of, intelligence processes. While leveraging the skills of the Council's business analysts was effective, sensible and worked well, further training in these specialist skills is recommended.

Given the critical nature of intelligence, particularly in a rapidly developing and fast moving incident, the seniority and experience level of the DIG Manager should be commensurate with that of the other component managers. Comment was made about the reduced staffing levels during the night shifts which were not sufficient to enable appropriate analysis of information gained earlier in the day to be processed in readiness for the next day.

Incident Support Group (ISG) The ISG provided administrative, logistical, procurement, internal communications and the preparation of Situation Report (SITREP) support to the LDCC. The ISG performed well and some minor enhancements have been identified to further improve efficiency including the development of panel arrangements for the procurement of emergency goods and services that fall outside of Council's standard procurement needs.

Administrative and logistic support was coordinated by the ISG, which liaised with Council Business units, strategic procurement officers and contractors. The system worked well given the circumstances with general items being provided from within Council resources, primarily from the Stafford Depot and externally from commercial suppliers such as Coles for food supplies, although there were some issues regarding delays in payment by Council.

Council's procurement staff provided very high levels of support particularly as the requirement for items was usually determined during the early to mid-evening for supply the following day. Panel contracts were found to provide flexibility for unusual items such as clothing and equipment for civilian volunteers and outdoor signage. The provision and control of scarce resources, such as traffic controller teams and helicopters for emergency food stuff drops provided challenges. Suggested improvements include the development of up-to-date contact lists for panel suppliers and other likely specialist providers.

Regional Incident Management Team (RIMT) The RMITs were responsible for undertaking a variety of tasks within their sectors in accordance with directions from the LDCC and in response to emerging local requirements. The knowledge and insights of the LAS and CARS staff at each of the RIMTs ensured available resources were used to best effect with local initiatives and solutions to problems being addressed in a timely and effective manner.

In RIMT regions where there were minimal flood impacts, support was offered to other RIMTs where increased coordination and field support were required due to the level of inundation. This reflected the professional and flexible approach of Council staff in the field during the disaster. Mutual support between the regions was a local initiative resulting in an efficient Council-wide use of resources.

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The RIMTs provide a critical component in Council's response, providing a local, on-the-ground perspective and enabling local managers and staff to effectively manage local resources as well as coordinating the use of those external resources allocated to them. There appears to be scope for further delegation of responsibility from the LDCC to RIMTs.

RIMT leaders identified the need for a dedicated RIMT operations room within the regional offices to be activated for disaster management and to include around four telephone ports, computer connectivity for three to four computers and a printer, a projector and screen for update briefings and planning, and a television set for situational awareness.

Further discussion of RIMT is contained in Section Three.

Intelligence Management and Dissemination

The components of Council's intelligence system comprised the DIG including the Rapid Assessment Teams, the FIC (flood modelling), and Council's GIS mapmaking elements, business intelligence tools, damage assessment procedures and intelligence methodology, procedures and practices.

Rapid Assessment Team The Rapid Assessment Team is the primary means of information collection for the LDCC. The teams collect information to meet critical information requirements and reported on hazards, debris and public safety issues.

Flood Information Centre (FIC) The lead elements of the enhanced FIC were activated on the evening of Sunday 9 January 2011 and then transitioned to 24 hour operations on Monday 10 January 2011 as the BoM and Seqwater provided updated weather forecasts, and information on anticipated water levels and the release strategy from Wivenhoe Dam. The FIC continued 24 hour operations until Monday 17 January 2011.

The focus of the FIC was to interpolate the flood profile at the six gauges through analysis of BoM data and Seqwater reports. The primary tasks undertaken by the FIC included forecasting the extent of affected properties and damage (including CBD infrastructure), the development of inundation mapping throughout the flood event, development of recovery map products, monitoring and disseminating Seqwater reports, BoM updates, tidal data and flood water level data and the provision of on-call advice across the organisation.

The Federal Government's Attorney General's Department, through the Critical Infrastructure Protection Modelling and Analysis Program (CIPMA), maintains a national level database of critical infrastructure, and has an advanced capability to model the impacts of certain events within a defined area. The models consider both critical infrastructure impacts and the impacts on dependencies and may be useful to enhance the FIC's capabilities.

The FIC performed very effectively during the January 2011 flood event including the maintenance of good communications with, and access to, BoM and Seqwater and the provision of sound advice and user friendly geospatial products that assisted in planning and operations both within Council and for other agencies. While the FIC modelling system has recently been updated, the Board was advised that it will need to be replaced in the near future to include the capacity to forecast flooding in Brisbane creeks and for 3D visualisations.

The staff performed very well despite some minor deficiencies in the number and skill levels of staff trained to use FIC systems.

Intelligence Plan The Intelligence Plan was developed to enable the efficient provision of detail to the LDCC to support planning for current and future operations. It identified critical intelligence requirements and information gaps, coordinated the collection of information and assigned collection tasks to the Rapid Assessment Teams which assessed damage and reported debris, hazards and public safety issues to the DIG. The plan also ensured key reporting requirements to the LDCC and the BCLDMG were met, and monitored the accuracy and timeliness of information.

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Intelligence Requirements comprised those items of intelligence required by the LDCC Incident Controller or the FPG to enable planning for current and future operations. Examples included the locations and status of utilities including severity of inundation and damage, communications systems, transportation modes, roads and bridges, community facilities, population issues, including safety hazards, threats and risks.

The DIG provided information for Situation Reports, BCLDMG briefs, media briefs and LDCC shift handovers and displayed information priorities and requests for information, the current situation and operations, impacted areas shown on maps and GIS screens, contact lists (telephone, facsimile and email addresses), resources allocated and resources available but not committed, weather situation and forecasts including hazards and warnings, topographical and road maps of the affected area, lists and copies of publicly released information, staff rosters and timings, and details of briefings and reporting requirements.

Systems and Data

One of the most challenging tasks in dealing with a multi-jurisdictional response to a major disaster incident is the effective communication and sharing of information and data between agencies. To help address this issue during the flood, and following the collapse of Council's website, a dynamic web-based mapping solution was fielded using web mapping technology shared with all emergency response agencies to provide an up-to-date common operating picture. This application, known as Flood COP, was developed and funded by Esri Info (www.esri.com), a private enterprise provider for Council, at very short notice.

The web service was published using cloud computing technologies and made available within a matter of hours after the initial request. The system is scalable and allowed for LDCC operations and for significant growing use by the public. Flood COP proved to be a vital tool in disseminating information, and coordinating and publishing flood response efforts and progress. It is understood a similar approach to web mapping is being used by the Queensland Government to support the work of the Queensland Reconstruction Authority.

Based on the benefits that Flood COP provided during the floods, the provision of a readily available, scalable capability for Council should be considered. The adoption of this technology within Council will also complement the fast and effective publication of field data capture information that can now be undertaken using mobile mapping and data capture technology and hand-held devices recently acquired by Council.

Public Information.

Commencing in October 2010, the Lord Mayor undertook a series of initiatives to raise awareness in the community regarding the increased risk of flooding during the coming summer, using media opportunities and Council meetings to highlight the potential for a flooding event similar to the January 1974 flood. The challenge was to convince people of the need to prepare for flood after what had been an extended period of drought, and this was an obstacle to delivering key flood warning and information messages.

While the Lord Mayor and Council sought to engender a "sense of urgency", many in the public seemed not to be convinced and this was demonstrated by the relatively low level of registrations for the Early Warning Alert Service promoted extensively by Council.

Significant resources have been expended by Council on developing public education, awareness and information access relating to flooding over the last five years. Council has implemented many of the recommendations from the Lord Mayor's Task Force on Suburban Flooding (2005) and the Review of Council Response to Brisbane Storm Events 16-22 Nov ember 2008.

During the January 2011 flood event, public information was provided and accessed through a variety of channels including television, radio, print media, newsletters, the Council's Call Centre, website, and social media.

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Print and Electronic Media, Newsletters, Posters and Outdoor Advertising Council's use of print, radio and electronic media was considered very effective in providing general flood information to residents and businesses in the days preceding, and then during, the flood event. The role of the electronic media was particularly significant with television and radio stations broadcasting Community Service Announcements (CSAs) and other vital information in an extremely timely and efficient manner.

Significant use was made of newsletters and posters and included 30 fact sheets, eight community newsletters, evacuation centre newsletters, posters in prominent locations and outdoor advertising. Special flood editions of "Living in Brisbane" covering the period 31 December 2010 – 4 February 2011 were produced for all residents.

Council Call Centre Council's Call Centre worked very well over the period and provided a consistently high level of service. More than 81,000 calls were dealt with between Sunday 9 January and Saturday 22 January 2011, of which 32% were flood related. This was a 70% increase on the same period in 2010. On Tuesday 11 January, the Call Centre took 12,209 calls, which was the highest volume ever received and was handled by more than 100 staff. The Call Centre was able to maintain an Average Speed of Answer of 30 seconds over these two weeks and demonstrated a most commendable commitment to the general public.

During this period Call Centre staff worked very long hours, established additional Call Centre phones in other areas of council to allow for extra phone consultants, regularly updated the Queue Message to keep customers informed and extending the opening hours of regional sites at Carindale and Chermside. Fatigue levels were well managed using scheduled breaks. Staff from other areas of Council provided assistance, and were trained to take SES calls. Additional consultants were used to handle calls remotely from their homes.

Call Centre staff are to be highly commended on their committed and flexible approach to ensuring that this essential communications channel remained open and effective during the peak crisis period.

Council Website Unprecedented demand and bandwidth restrictions overwhelmed Council's website which was designed for a business as usual approach with capacity to cope for around a doubling in demand. The flood event, however, created an exponential increase in demand and resulted in the collapse of Council's website for around 24 hours. In the void that was created by the collapse, Council's Information Services Branch, in conjunction with the Marketing and Communications team, showed great commitment and initiative in ensuring there were other website options for residents and businesses to seek and receive key information. They played a key role in arranging access to an externally hosted website to reinstate web access. This matter is worthy of a more detailed examination than the Board can conduct and should be undertaken separately.

While the collapse of the website, caused by an unexpected torrent of hits and bandwidth limitations, was a major failing, Council staff and vendors are to be commended for their initiative in addressing the failure. The impact of the failure was significant as it removed a key communication channel for the community to access flood maps and critical information on the impact of the floods. This failure also impacted on Council's internal and external email system and remote access to Council's data systems by Council staff.

To address the failure, Council's website was converted to a static website to reduce the demand on processing power and bandwidth. The solution to reduce the high demand on Council's iInternet connection was to move the website operation to third parties to host the flood maps and the static website. IReckon.com, based in the USA, hosted the PDF flood maps and Amazon web services based out of Singapore, hosted the static website.

There were two other constraints noted by the community. Once mains power was lost they were unable to use the Internet, reducing the effectiveness of this communication channel and the use of mobile phones and other devices became an issue as batteries ran down and needed recharging.

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Social Media An unintended consequence of the collapse of the website was an increased and extensive use of social media channels such as Facebook and twitter. It is interesting to note that the increased demand for, and use of, the social media tools has continued after the flood event. George Patterson Y&R completed an analysis of social media during the period Monday 10 to Sunday 16 January 2011 and noted that "Overall, the Council and Queensland Police Service (QPS) Facebook pages demonstrated best in class response and continuity over other Local and State Government sites."

Facebook was used to convey official information such as CSAs and responses to residents' questions. It is estimated by that more than 4.5 million people were reached by this medium during the flood event.

Twitter was used to broadcast information, for re-tweeting information from trusted sources such as QPS, Energex and BoM and for responding to questions from residents. There were around 3000 twitter followers prior to the flood event with significantly more followers during and after the flood event. With re-tweets, during the flood it is estimated that more than 8 million people were twitter followers. (Radian 6 Social Media Tracking Tool).

The increased role of social media also highlights the need for Council Marketing and Communications staffing structures to better reflect these skill sets and the need to better integrate traditional communications functions and on-line communications functions within Council's structure.

Council's Marketing and Communications Branch staff are to be commended on their preparation for the flood event. A targeted and integrated communications strategy was developed and implemented using a variety of media presenting clear and consistent messages. The strategy focused on external communications as well as the development of a detailed Crisis Communications Manual with the objective of assisting staff to manage and operate in a natural disaster environment.

Warnings, Alerts and Advice

Early Warning Systems Multiple systems and media are available for the dissemination of warnings and alerts to the public for imminent or current disasters. Council uses the Early Warning Network (EWN), a system where individuals register online for email and SMS alerts relevant to locations entered in the database (generally residential addresses).

The EWN requires individuals to voluntarily register their details in order to receive the alerts. The system is hosted by an external service provider and requires a Council administrator to login, draft the alert message and release it to a pre-set distribution list based on registered users' data.

General observations from the community and internal stakeholders were that the EWN alerts for this disaster were too generic, inconsistently received across different locations and telecommunications carriers and were late in delivery, reducing their overall relevance and effectiveness. The Board was advised that delays in delivery were caused by a combination of network congestion and a degradation of mobile phone tower capacity due to mains power loss.

It was also commented that the take up rate for residents registering with the EWN system was relatively low (estimated at one in 10 households), despite active encouragement to do so over the last six to 12 months. It is understood that following this disaster, a spike in registrations was experienced but that overall proportion of residents registered is still insufficient to gain critical mass for cascading alerts to the community.

A further observation regarding warning and alert messages was the expectation by the public that warnings would be specific to streets or individual properties, impacting on their ability to determine relevance and appropriate actions. A wide range of stakeholders indicated a need for the ability to localise and personalise alert messages.

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Again the use of mobile phones and other devices became an issue as batteries ran down and needed recharging in circumstances where mains power was disconnected.

The Board understands that in response to the findings of the Victorian Bushfire Royal Commission following the events of Black Saturday in February 2009, the Federal Government commenced the development of a National Emergency Warning System (NEWS). It is understood that this system does not require registrations by individuals. Rather it extracts land line and mobile phone numbers from the Integrated Public Number Database (IPND), a national database maintained by Telstra on behalf of the Australian Communications and Media Authority.

The IPND contains all land line and mobile phone service details for Australia (phone numbers, billing address and type of service). The NEWS would allow SMS to be sent to mobile phones and pre-recorded messages to be disseminated to landline phones within a selected geographic area. In the event that this system becomes operational, a more detailed examination of its potential by Council is recommended.

Door Knocking While doorknocking occurred in a number of flooded suburbs by Council Officers, QPS Officers, SES volunteers and others, it was limited in some suburbs by restrictions to access due to the rapidly rising waters and by limitations to the number of people available to undertake door knocking. This matter is worthy of further consideration by Council.

Flood Maps. Flood maps and other associated information are invaluable tools in assisting residents and businesses to understand the potential impacts of flood events. In analysing the available information and in conducting community engagement, feedback indicated that enhancements in the manner in which information is presented would enable residents and businesses to better understand the impact of various flood event scenarios on individual properties and surrounding areas.

The implementation and recent enhancements to the FloodWise and FloodMap initiatives by Council allow an increased awareness by the public of risks associated with individual properties. A solid base of fact sheets, flood maps and CSAs are available on line for individuals and businesses, providing valid and simple advice on preparing for, and responding to, a flood event. When combined with data available on BoM's website, increasing amounts of information are becoming available for the public to better determine their risk exposure.

With the available technology and the growing desire for tailored information presented in simple, easy-to-understand language, the opportunity exists to further invest in such technology to develop a web-based tool that allows individuals and businesses in the community to better understand the risk of flooding to particular properties. With enhanced flood modelling, geospatial mapping systems (eg. Google Maps, NearMap), combined with property, essential services and infrastructure data, it is feasible that members of the public could access a website and click on a map or enter their address and be presented with an image of their property with an overlay of recent flood inundations and other flood information.

Supporting data could also be presented as and if available, indicating the height above ground level for the ground floor or inhabited floors. This would allow residents to quickly determine the level of inundation expected for their property, facilitating preparation and the decision to evacuate if necessary. It is feasible that such a web tool could also be made available as an application for mobile devices, in the widest range of mobile device formats. An approach like this would enable individuals to access current information specific to them and to their property in a timely fashion.

Flood Alerts General flood alerts provide background information to the community and need to be crafted in a way that avoids the use of technical terms such as Q100, DFL, City gauge level above AHD and so on. BoM uses terms such as "major", "moderate" and "minor" to describe river flooding together with a colour coding. It would be beneficial to conduct a

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public information program to educate the public about this system and then use it to alert the community.

During and prior to the flood event, alerts broadcast by the electronic media, with references to the city gauge, were generally confusing and not well understood. As flood levels vary along the river, the common practice to talk about the flood level at the Brisbane City Gauge has little relevance for those who only have lay knowledge and live up river. This issue is important in informing the public of what to expect during a major flood. In future, if reference is made to a flood level at the Brisbane City Gauge, it must be advised that flood levels will be higher than this level further up the river. Similarly general references to the January 1974 flood provided little information to those who had no experience of that flood event.

There was a desire expressed by members of the community for suburb specific flood information which could be broadcast regularly, say each hour, providing a suburb by suburb summary of flooding issues, and perhaps also including major road closures.

Internal Council Communications

Communications with Council staff not directly involved in the management of the disaster were affected by the collapse of the website and email. To enhance the effectiveness of internal communications, consideration should be given to greater usage of social media and SMS messaging in these circumstances.

Management and Integration of Response with other Supporting Agencies

Feedback sessions with external agencies consistently highlighted the relative ease of coordination with Council throughout the disaster. In a number of cases, agencies commended Council on how well it managed communications and information relationships. It may be assumed that this was due to training, confidence, strong relationships and experience of Council staff leading the response in the BCLDMG and LDCC.

The conduct of a very successful briefing session with the ADF commanders prior to their deployment was flagged as an example where Council proactively informed external agencies, ensuring that operational coordination was established very early. In general, Council was viewed as having an extremely good appreciation of the situation, a clear intent and well established priorities within a sound disaster management framework.

The SES is represented at the BCLDMG by a Council employee as acting Local Controller, supported by an administration officer, part-time training coordinator and a trainee. The demands on the acting Local Controller were high due to the number of SES volunteers in the field. There were reports of issues associated with the tasking and prioritisation of SES volunteers in the field but a complete analysis was not possible in this review as Emergency Management Queensland advised that it was not permitted to participate in discussions with Council's Review Board.

Pullenvale and Tennyson Wards

Pullenvale Ward Severe river flooding along Pullenvale Ward's south-eastern boundary resulted in Moggill, Bellbowrie and neighbouring suburbs being isolated for around two days causing a severe diminution of services. During this period, mains power was disrupted, as was fixed line, mobile and internet telecommunications. Mobile phones cell towers switched to battery backup and the system became congested, thus reducing capacity. As mobile phone batteries failed, there was limited scope to recharge them. This degradation of communications resulted in the LDCC not having a good understanding of the local situation in Pullenvale Ward during the early stages which appears to have led to a delay in its response.

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A number of issues emerged including a declining availability of foodstuffs and general personal requisites (as the only supermarket had flooded) and the inaccessibility of the two Council-designated Evacuation Centres. When supplies were airlifted in, the further distribution across the Ward was an ongoing challenge. While two small evacuation centres were established in Moggill and Karana Downs, they were not "officially recognised" by the LDCC and relied on the efforts of church groups, service clubs and volunteers.

Given the location of the local RIMT in Indooroopilly and the flooding impact of the Brisbane River which isolates many suburbs in Pullenvale Ward, the current arrangements should be reconsidered to ensure improvements.

Tennyson Ward The Tennyson Ward Office was flooded and not able to be used by the Councillor and her staff. While temporary accommodation was provided in the adjacent Moorooka Ward Office, this appeared to be a less than satisfactory arrangement, particularly as it impacted significantly on the availability and quality of communications and information available to the Councillor, restricting her ability to support and assist her Ward constituents. A functioning alternative temporary Ward Office should be available in the eventuality that the primary Ward Office is rendered unusable due to flooding.

The Role of Councillors in a Disaster Situation

Councillors in flood affected Wards worked very hard, over long hours, to provide support and comfort to their constituents. They were subject to a consistently high number of queries from residents regarding a range of issues including specific flood information relating to their properties and neighbourhoods, guidance on evacuation locations and processes, availability and access to local resources such as sandbags, advice on recovery processes including the availability and prospect of support and assistance for clean up and including how to deal with food waste and dangerous goods including asbestos. In those areas where mains power had been disconnected the lack of information during the flood event and the recovery phase was a particular issue.

The flow of formal information and advice from Council LDCCs to Councillors was via a dedicated Council email system which terminated at desktop computers in their respective Ward Offices. Given that Councillors in flood affected Wards were "out and about" responding to the needs of their constituents, their ability to remain abreast of the situation, and particularly the "big picture", was severely constrained. A mobile communication system, using social media (Facebook and twitter) and SMS, complementing the dedicated email system, may help to obviate these difficulties.

Issues such as the particular needs and situation of the frail aged, people with disabilities, and those from non-English speaking backgrounds could have more readily been made known to the LDCC with a better communication, briefing and reporting system. Councillors had a very good understanding of the particular needs and issues obtaining in their Wards and were potentially a significant source of local and timely information and intelligence.

While there were some instances of Councillors seeking to redirect the response effort as organised by Council through the LDCC, by and large, the principle that Councillors should not inject themselves into the formal tasking (command) structure was acknowledged and supported.

The Board formed the view that some Councillors did not have a good understanding of Council's disaster management arrangements. A program for Councillors including briefings and the opportunity to observe LDCC exercises may be useful in remedying this situation.

A further issue related to Councillors seeking information and assistance, especially in flood affected Wards. Invariably they would seek to contact Council officers they knew who worked in their local area, or the CEO if this proved problematical. Many Council officers had additional tasks assigned as part of the disaster management arrangements and were not available for their business as usual responsibilities. Understandably, and although the CEO was fully occupied with "whole of Council" issues, he sought to provide advice and support as

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he could, as did the LDCC Incident Controller. Given this, it would seem appropriate for a dedicated "Councillor Liaison Officer" to be appointed in the LDCC to operate as a clearing house for requests, issues and concerns as raised by Councillors. Tasks could include the dissemination of relevant situation reports and other information (newsletters, CSAs, and media releases) directly to Councillors as well as ensuring that requests are actioned by the LDCC or FOG, commensurate with their priority.

Naturally, none of this is designed to impede the normal relationship between Councillors and the Lord Mayor.

Commendations

The Board highly commends the actions of Council staff in their preparation for, and response to, the flooding disaster which may appropriately be characterised as well above and beyond that usually expected.

The Board commends Council's disaster management approach and in particular for:

Its compliance with, and implementation of, the various Commonwealth and Queensland Government legislative and policy parameters which direct and inform disaster management arrangements.

Its integrated response through the BCLDMG with other Queensland and Federal Government agencies and Non-Government Organisations.

Its alignment with the State Disaster Management Plan, and the District Disaster Management Plan.

The Board commends Council's approach to preparing for a possible disaster event over the summer months and, in particular, for the general public warnings and advice in the November, December 2010 period and for the conduct of readiness training and exercises.

The Board commends Council's approach, during the flood event, in providing public information, advice and alerts using a multi-channel broadcast approach, for print and electronic media, the internet including website, email and social media, telecommunications including Call Centre, mobile SMS and the Early Warning Alert Service and off-line including the "Living in Brisbane" newsletter, fact sheets, other community newsletters, posters, and outdoor advertising.

The Board commends the efforts of Council's Call Centre and Social Media staff for their untiring efforts to respond, in a calm and helpful manner, to the thousands of requests for information and advice during the flood event.

Affirmations

The Board affirms Council's approach to its business as usual and risk management policies. The Board **recommends** that:

In relation to Council activities, Information Services Branch reviews its Business Continuity Plans (BCPs) to ensure the capacity exists to maintain the data centre, including an alternative site capable of taking over without delay, and to maintain Council's website at all times, particularly during significant disasters.

Line of business managers review BCPs to ensure their ongoing robustness and to capture any lessons learnt from the flooding event.

Contracts and arrangements be reviewed to ensure that BCPs for key external outsourced service and infrastructure providers are understood, robust and able to support Council during times of emergency and disaster.

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In relation to the Brisbane Central Business District and high-rise residential building inundation, that Council consider hosting a symposium for all affected parties with a view to identifying best practice approaches to ensure improved flooding resilience.

The Board affirms Council's approach to training, exercising and workforce planning in relation to Disaster Management Preparation. The Board **recommends** that further emphasis be placed on:

Individual and team training, including opportunities to attend Emergency Management Australia Disaster and Emergency Response courses,

Workforce planning to reflect a needs analysis-including disaster management related job descriptions, and a specific Council term be developed to describe "internal volunteers" to avoid confusion and to reflect the professional nature of the training and tasks, and

Annual exercises continue to be conducted with a theme of "Brisbane Ready for Summer".

The Board affirms the operations and workings of the Local Disaster Coordination Centre (LDCC) and, in particular, the integration of operations (tasking), intelligence, public information, logistics and the coordination with external supporting agencies. The Board **recommends** that:

Further training and development occur for senior appointments including LDCC Incident Controllers and group leaders as well as for more junior appointments.

The Disaster Intelligence Group's structure, manning and core competencies be reviewed and further staff training be conducted.

The Forward Planning Group's responsibilities to the Brisbane City Local Disaster Management Group and to the LDCC be examined to remove ambiguity.

Enhancements to process be implemented including;

Ensuring that Situation Reports are well drafted and widely distributed on a regular basis using multiple communications channels.

Developing a readily accessible database of frequently asked questions to address "who does what" to support the LDCC staff and agencies (this could also include information available on Council's Call Centre database).

Synchronising the shifts of Council and agencies staff working in the LDCC to better facilitate handover briefings.

Improvements to logging incoming and outgoing information and tasking.

Formalising the written briefing processes for handovers between shifts.

The Board affirms Council's flood intelligence management and information dissemination arrangements. The Board **recommends** that Council undertake upgrades to the Flood Information Centre (FIC) along the following lines:

Review and update Standing Operating Procedures (SOPs), including a major update of selected Brisbane River and Creek Flooding SOPs, river flood maps and storm tide maps, property counts and critical infrastructure lists.

Upgrade the Brisbane River Flood Forecast Reporting System to the most extreme flood event (Probable Maximum Flood) and to include a flood forecast system for Brisbane creeks.

Conduct additional training and exercises including with the LDCC and Queensland Government agencies, and develop better communications protocols.

Provide computers capable of GIS modelling tasks and 3D visualisation analysis.

Provide a dedicated flat screen television for situation awareness and news monitoring.

The Board affirms Council's approach to implementing a range of early warning systems and alert measures across a number of delivery channels. The Board **recommends** that Council examine and develop the range and variety of early warning systems and alert measures; including the proposed National Emergency Warning System, social media platforms and further improve the effectiveness of door knocking.

Recommendations

The Board recommends that Council use a more readily understandable description of flood levels (to reflect BoM descriptions).

The Board recommends that effort continue to be put into providing more localised (property, street, suburb and Ward) information regarding inundation and flood level forecasts through a range of channels including the EWAS, Floodwise Property Report and Flood Flag Maps (including rate notices to draw attention to the existence of the Floodwise Property Report), and flood markers.

The Board recommends that the Flood Flag Map be further developed to enable NearMap data obtained on the morning of 13 January 2011 to be included and accessed.

The Board recommends that Council investigate the Flood COP system and examine its utility, in conjunction with hand held devices, to improve the efficiency and effectiveness of data collection, the provision of information, the prioritisation of tasks and the deployment of resources.

The Board recommends that Council further develop its capabilities to produce flood maps for a larger set of scenarios based on a range of 2000 to 20,000 m^3/s in electronic and hard copy format.

The Board recommends that Council review the disaster management arrangements for a major flooding situation as they apply to Pullenvale Ward.

The Board recommends that Council review the disaster management arrangements for a major flooding situation as they apply to Tennyson Ward to ensure the ongoing provision of a flood-free Ward Office.

The Board recommends that Council examine appropriate ways for Councillors to assist during disaster events, particularly given their community leadership responsibilities and their detailed local knowledge of circumstances and capabilities that exist in their Wards, in a way which does not cut across the existing and appropriate arrangements detailed in Council's disaster management arrangements.

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SECTION THREE - BRISBANE CITY COUNCIL'S OPERATIONAL RESPONSE IN THE FIELD

This section of the Report contains the Board's assessment of Council's operational response in the field to the flood event. There is specific consideration of the responsibilities of the Field Operations Group (FOG) and the Regional Incident Management Teams (RIMT), and of evacuation centres, disposal of debris and waste and management of volunteers. The assessment concludes with a brief review of arrangements for the Transition to Recovery.

Field Operations Group (FOG)

The role of the FOG is to co-ordinate and manage Council's operational response to a disaster event. It provides information to the Local Disaster Coordination Centre Incident Controller on the progress of Council's on-ground response and communicates emerging issues. The detailed Standard Operating Procedures for the FOG provide for preparatory work to be done within the Local Disaster Coordination Centre to establish the FOG at Level 3. Upon a Level 4 activation, the FOG transitions from an operational team within the Local Disaster Coordination Centre (LDCC) to a dedicated group which assumes responsibility from the LDCC for the co-ordination of event response operations and task management. The FOG is located within the Level 4 LDCC.

The FOG is intended to conduct operational planning for a 0-72 hour planning horizon. It assigns all tasks that have been prioritised by the LDCC Incident Controller to the Regional Incident Management Teams (RIMTs) or other Council business units for implementation or action.

The Board is of the view that the FOG was successfully led by experienced senior managers and that it provided the necessary direction and management, and made appropriate task allocations, for a truly effective operational response overall to the flood event. Leadership roles in the FOG were demanding. Fatigue was a potential issue. The workload for the FOG was compounded by a need, at times, to extend the operational planning horizon beyond 72 hours.

These aspects of the functioning of the FOG suggest to the Board that the following steps be taken to address them. With an eye to a lessening of the risk of fatigue, a greater number of managers should be identified from Council ranks and trained for leadership roles in the FOG. Secondly, as the likelihood is that the FOG will have a longer operational planning horizon than 72 hours, consideration should be given to forming two groups within the FOG, one with a focus upon the 0-72 hour period; and the other upon the period beyond 72 hours.

Regional Incident Management Teams (RIMTs)

Decentralisation and localisation in response operations is achieved principally through the RIMTs. A team is formed at Level 4 activation for each Council region (North, South, East, West and Central). The membership for each RIMT is drawn from the Local Assets Services (LAS) and Compliance and Regulatory Services (CARS) branches for that region. Each Regional Incident Management Team is based in Council offices or at a Council depot within the region.

The RIMT receives its tasks from the FOG only. It is responsible for the performance of operational tasks as allocated by the FOG. Council assets within the region fall under the command and control of the RIMT thereby enabling it to manage operations directly related to the event response within the region. However, in this instance, some "high value" resources, for example, street sweepers, were managed and deployed centrally by the LDCC.

The effort and combined knowledge of the LAS and CARS staff at each RIMT base, and in the field, ensured that available resources were used optimally and that initiatives and solutions to problems were devised locally in a timely and effective manner. The local

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knowledge held by RIMTs and field staff proved indispensible in prioritizing and co-ordinating local tasks.

SOPs for the FOG contain guidance on specific aspects of RIMT response to a disaster event. The Board has identified one area in which these guidelines should be developed. Allocation of Australian Defence Force (ADF) personnel and volunteers to Regions is made at the LDCC level. RIMT have detailed knowledge of local problems and their relative urgencies. There needs to be a clear description of the respective roles that the LDCC and RIMT are to have with respect to the co-ordination and, in the case of volunteers, the management, of these resources once they are deployed. Also, arrangements for liaison, as may be required, between RIMTs and Agencies should be outlined. This could be conveniently done within these guidelines.

The Board perceives a need for higher level Council officer representation at RIMTs. To that end, the Board recommends that a senior officer be assigned to each Regional Incident Management Team and tasked with a multi-faceted role of mentoring the Regional Incident Management Team manager and conducting higher level discussions with LDCC.

The siting and equipping of RIMT bases are factors which the Board has identified for comment. It is vital that these facilities remain functional during the currency of a disaster event. Future planning should identify alternative RIMT sites for a region if there is a risk that the primary site may become unusable, including risk through flooding.

Currently, the offices or depots that are used as RIMT bases do not have dedicated operations rooms. This is a significant shortcoming which, in the Board's view, should be rectified. The Board therefore recommends that a suitable room be equipped and fitted out at each RIMT base so that it can be activated as needed for disaster management.

There are two particular aspects to field operations which the Board proposes to discuss separately. They relate to sandbags and traffic management respectively.

Sandbags: Brisbane City Works was requested by Brisbane City Local Disaster Management Group on 10 January 2011 to commence the production of sandbags for use by residents and businesses. As reported to the BCLDMG meeting on the following day, production was at the rate of 4,000 sandbags per day. Direction was given by the meeting to increase the rate of production to 70,000 per day with four Council depots being used as distribution points.

Due to demand, the number of Council depots used was increased to six. They were located at Balmoral, Darra, Eagle Farm, Newmarket, Stafford and Zillmere. As well, a further seven locations were used for filling and distribution of sandbags. The locations are shown in Map 9. The Board observes that only one of these 13 distribution points was located in the south-western suburbs. The Council workforce at these distribution points, assisted by volunteers, addressed an escalating demand for filled bags. While the participation of volunteers reduced the potential for fatigue for Council staff, it did introduce other potential workplace health and safety risks.

In total, 395,878 sandbags were filled, with some 313,478 distributed. Distribution peaked on Wednesday 12 January when 174,510 sandbags were distributed. To have arranged for the production and distribution of such a large quantity of sandbags in so short a time was a commendable achievement.

The demand for, and availability of, sandbags did, however, have significant implications for traffic management with long queues at distribution points at times. With that in mind, the Board suggests that, drawing on recent experience, Council prepare estimates of likely sandbag demand for regions during future flooding events and identify the best situated potential sites for filling and distribution points in each region. In doing so Council should give consideration to how the number of distribution points in the western suburbs might be increased.

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Traffic Management: The sheer number of volunteers and agencies involved in the cleanup did impact upon traffic management, particularly in areas where access was limited due to geographical location and road closures. Collaborative efforts between Council, Queensland Police Service and the Australian Defence Force achieved as good a result at ground level as was reasonably achievable in the circumstances. Pro-active decisions by Council, particularly in using buses for ferrying volunteers from registration points to affected suburbs and blocking off badly impacted streets significantly reduced the number of vehicles on the road.

The volume of unregistered volunteers arriving in vehicles, uncertainty as to which streets would open when waters receded, the desire of residents of affected areas to return home, and the co-ordination of heavy vehicle and plant and equipment in suburban streets all added to the complexity of the issue. There is now a body of recent experience within Council and Queensland Police Service from which advanced plans to improve traffic flow in flood recovery congested areas can be developed. Such plans could include converting some streets to one-way, route designation for heavy vehicles, and identification for residents' vehicles.

A disturbing phenomenon noted by the Board is that despite extensive public awareness campaigns and media warnings, instances do occur of vehicles being caught as they attempt to cross streets which are inundated by rising flood water. The consequences for the occupants can be tragic. The problem is magnified by a "follow the leader" reaction on the part of some other drivers. Emergency rescue teams have to become involved, sometimes at significant risk to their own lives.

The Board considers that further public awareness measures must be taken. The installation of flood markers on key roads that are known to become flood affected needs to be considered by Council.

Council Evacuation Centres

Council is responsible for providing disaster evacuation centres and emergency shelters within its boundaries. An evacuation centre provides basic human needs including overnight accommodation, food and water, and assistance with recovery for those who are disaster affected. Emergency shelters are on a lower scale and do not provide overnight accommodation.

To discharge this responsibility, Council had in place a framework for handling evacuation prior to the 2011 flood event. Council's Disaster Management Plan 2005 covers the topic of Evacuation and Emergency Human Services and incorporates a set of Standard Operating Procedures for responding to it. The second edition of the Standard Operating Procedures (2010) was the version current at the time. Preparation of this version had been informed by Council experiences during The Gap storm.

As envisaged by the Disaster Management Plan, Council had entered into a Memorandum of Understanding with Australian Red Cross (Qld) for the management by Red Cross, as lead agency, of evacuation centres established by Council. Further, as provided for in the Standard Operating Procedures, by March 2009, Council had identified and registered a range of some 47 locations suitable for use as emergency shelter/evacuation centres in the event of river and creek flooding, and storm surge. The locations, their capacities and contact details, are listed in the Council document Emergency Shelters Riverflood dated 6 March 2009. These locations are sited across all Brisbane Regions and are categorized as large (to accommodate more than 100 people), medium (50 to 100 people) and small (less than 50 people). The Disaster Management Plan, Standard Operating Procedures, Memorandum of Understanding and the location register are key elements of the response framework.

The registered sites included RNA Showgrounds, QEII Queensland Sport and Athletic Centre and Suncorp Stadium. However, by the evening of Monday 10 January 2011 it was clear that due to the potential severity of the flood, Suncorp Stadium would not be suitable.

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At 8am on Tuesday 11 January 2011 RNA Showgrounds were confirmed by the Local Disaster Coordination Centre as the potential first port of call for evacuees. Later that morning, the Lord Mayor directed the commencement of operational evacuation planning and evacuation centre establishment, initially for 2500 evacuees to go up to 3500. At 6.30pm that day the requirement was increased by 10,000 evacuees. Ultimately, planning for evacuations involved a worst-case scenario of up to 16,000 people needing accommodation.

Establishment of two large evacuation centres was undertaken rapidly and at short notice with management at potentially suitable locations being contacted that day to assess immediate availability and accessibility. Considerations for location selection included, but were not limited to:

Location of centres and of potential evacuees;

Accessibility for evacuees and emergency services/agencies and volunteers;

Capacity to function, immediately and in the long-term; and

A need for containment of site numbers given human resourcing limitations in the initial stages, arising from agency responsibilities in Toowoomba, the Lockyer Valley and elsewhere in Queensland.

The two evacuation centres which were established by Council were:-

at the RNA Showgrounds, on Wednesday 12 January 2011; and

at QEII on Wednesday 12 January 2011,

in each case with the cooperation and support of the respective owners. The locations of these two centres and Council assets activated during the flood are shown in Map 10.

RNA Showgrounds evacuation centre was in operation from Wednesday 12 January 2011 until Wednesday 19 January 2011. More than 1650 evacuees registered over the period at the centre with a peak of 1450 in the early evening of Thursday 13 January 2011. QEII was operational from Wednesday 12 January 2011 until Friday 21 January 2011. There were more than 700 registrants over the period for this centre with a peak of about 480 also in the early evening of Thursday 13 January 2011. At each centre, not all registrants slept overnight. Peak usage in the early evenings was for meals and showers.

For each centre, the numbers of registrations were within capacity. There was no unmet demand for evacuation centre accommodation from evacuees who sought it. All registrants who required some form of short term accommodation thereafter were successfully rehoused: over 250 households from the RNA Showgrounds; and over 70 households from QEII.

Council remains the responsible entity for an evacuation centre. Conformably with the Memorandum of Understanding, the responsibility is exercised by a Red Cross Centre Management Team as soon as possible. An integrated discharge by Council of its continuing overall responsibility for evacuation centres and by Red Cross of its management responsibilities requires a high degree of co-operative interaction between staff of each organization throughout the operation of an evacuation centre. That occurred for each evacuation centre on this occasion.

In addition to Red Cross and Council, a large number of government and community agencies, building contractors and service providers and other volunteer workers assisted with the operational aspects of an evacuation centre. By way of illustration, the operation of an evacuation centre involves:

Council providing beds;

Salvation Army providing the food;

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Lifeline providing counselling services;

Save the Children providing entertainment/activities for children;

Red Cross managing the centre and maintaining the National Registration of Inquiry System of all evacuees;

St John's Ambulance providing First Aid,

and active participation by other community-based and government agencies.

As provided for in the Disaster Management Plan, Council acted in a co-ordination role for the agencies involved. The Queensland Police Service and Australian Defence Force also fulfilled significant and much-appreciated co-ordination roles.

The Board notes that Council formed a small team from its staff to oversee its responsibility for the evacuation centres. The team worked within a short timeframe and with commendable dedication and commitment during both the peak demand period and as demand declined. Fatigue management was an issue but was eased by the involvement of a greater number of Council staff than that envisaged in the Standard Operating Procedures.

The participation at the BCLDMG by the senior Council manager accountable for the supervision of the evacuation centres was an advantage as this provided firsthand knowledge of the response across all work streams and provided the opportunity to give daily reports on the demands and challenges at the centres. The delegation of authority by the BCLDMG to the teams responsible for the centres greatly assisted in meeting tight deadlines for getting the centres open and functioning.

As with other units in the field, there were some minor communications issues with the timelines and flow of information in and out of the Local Disaster Coordination Centre but this did not impact adversely upon the overall management of these centres.

The Board has identified a number of aspects to site selection, operations and donated goods, for incorporation into Council evacuation centre planning for the future.

Site Selection: While the considerations that played a part in site selection here were appropriate, they did lead to a centralisation of evacuation centres. Flooding and closure of roads did restrict some access to those centres for evacuees. Notable in this context are the Bellbowrie/Karana Downs areas for which both of the established evacuation centres were inaccessible. A site at Bellbowrie and another at Karana Downs had been identified and registered by Council but neither was selected for activation. A local community-organised response centre was set up at a school.

Consideration should be given to selecting sites on a more decentralised basis. In particular, is this so for communities that is known to be prone to isolation by flooding. Planning should include a strategy for logistical arrangements to supply these sites with personnel and emergency supplies during a flood.

An additional advantage of greater decentralisation is less reliance upon a few very large-scale centres which can present security and logistical challenges for the management of an evacuation centre on account of sheer size and a dispersed location of facilities.

Operations: There are several aspects to operations which warrant consideration in future planning. The Board was informed of instances where what might be termed "non bona fide use" was made of evacuation centres by registrants or by volunteers. These included registrations by "unhoused" persons who were not flood victims, and an instance of alleged predatory sexual behaviour by a non-vetted volunteer. The latter incident is of particular concern.

The Standard Operating Procedures recognise that registration of evacuees in a disaster is the responsibility of Red Cross. A reliable system for vetting volunteers also needs to be in place. Given Council's overall responsibility, there should be early and close liaison with Red Cross to confirm arrangements for the registration of evacuees and the vetting of other personnel, and with Queensland Police Service with respect to the exclusion of persons who are not suitable to be in a general public evacuation centre.

Separate consideration needs to be given to the capacity of evacuation centres to accommodate persons with special needs arising from frailty, significant incapacity, or oxygen dependency on their part. Time and resourcing constraints will usually mean that it is not possible to cater satisfactorily for such persons at evacuation centres. It is desirable that there be an arrangement in place for a system or systems for transferring persons with such needs to a facility more suited to their needs, when they report at, or are brought to, an evacuation centre.

Registrants at evacuation centres were representative of a wide cross-section social, cultural, language and religious groups. A sizable number were from non-English speaking backgrounds. Planning decisions on locations, sleeping arrangements within an evacuation centre, and provision of food and arrangements for services, need to take account of this wide diversity. Particularly, sleeping facilities for single men should not be placed near those for families.

To equip an evacuation centre with consumables will require purchase at very short notice of significant quantities of types of goods which Council does not purchase on a "business as usual" basis, for example, personal hygiene products and baby care products. The Council team managed to make arrangements for this. Planning should involve compilation of a list of such consumables and sources of ready supply of them in an emergency.

Donated Goods: Many people responded to the plight of flood affected persons by donating goods to be distributed to them. The Board recognises the generosity and sincerity of the donors. Without wishing in any way to discourage this commendable practice, the Board has concluded that the use of evacuation centres as a place for receipt and distribution of donated goods is not appropriate and should be discouraged.

In the first place, evacuation centres do not have the set-up for that function. Secondly, often goods that are donated do not match up with the immediate needs of registrants while they are in an evacuation centre. Their immediate needs are for items such as torches, personal hygiene products, clean new underwear, and towels. Thirdly, the receipt and distribution of donated goods imposes an additional burden upon the centre staff whose primary concern is for the immediate needs of registrants.

The Board considers that Council should develop a process for handling donated goods which is separated from evacuation centres and that the process should incorporate a public awareness strategy to inform the public on what types of goods are most useful to those who need assistance.

The Board understands that the Disaster Management Plan and Standard Operating Procedures will be revised in light of the experience with this recent disaster and suggests inclusion of detail for dealing with those aspects which the Board has identified for comment.

Management of Volunteers

The Board has reviewed the effectiveness of Council's management of volunteers, ranging from individual citizens through to large commercial support. The Board notes, by way of preface, that the Disaster Management Plan did not contain either a documented strategy for managing volunteering across the range or Standard Operating Procedures for the management of volunteers. Notwithstanding, in the Board's opinion, volunteering at all levels was successfully managed by Council.

The range of volunteers extended across:

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Individuals who offered their labour, in many instances as part of a community group;

Trades people who offered their skilled labour;

Plant and machinery owner/operators; and

Owners of businesses not involved in the construction industry.

The need for co-ordination and management of volunteering was foreseen early and discussed by BCLDMG on the morning of Tuesday 11 January 2011. An initial strategy involving the engagement of Volunteering Queensland for that role, particularly in relation to non-plant and equipment and business volunteering, was overtaken. The swiftness and scale of citizen volunteers seeking to assist flood victims overwhelmed the capacity of Volunteering Queensland to register and co-ordinate them. It quickly became evident that Council required its own mechanisms for managing the volunteer workforce based on a core role for it of coordinating resources across the city in response to the disaster.

At the BCLDMG level, decisions were made during the following days to develop Community Service Announcements calling for individual volunteers, and for plant and specialist trades volunteers. These announcements were publicised widely and complemented by the Lord Mayor's press releases.

Individual volunteers comprised the corps of what became known as the "Mud Army". It was raised and managed separately from the other categories of volunteered resources. The Mud Army was a very significant initiative of Council and is remarkable not only for the assistance given by it to flood victims but also for the civic spirit it inspired.

A small team of Council staff was engaged to develop a volunteer management strategy and establish a capability for registering, equipping and deploying volunteers to where support was most needed. To this team's credit, within 24 hours of engagement, a strategy was in place, registration points established, details advertised through the media and transport organized.

The Mud Army was mobilized on the weekends Saturday 15 to Sunday 16 January 2011 and Saturday 22 to Sunday 23 January 2011 and operationally managed from the Field Operations Group. Four volunteer co-ordination centres were established at each of:

Mount Coot-tha Botanic Gardens;

Boondall Entertainment Centre;

Doomben Racecourse; and

MacGregor State High School.

Volunteers were urged to register at these centres for morning shifts (7.30am–11.30am) and afternoon shifts (1pm–4pm). To even out registrations, volunteers were asked by the Lord Mayor to report on an "odds and evens" address basis for Saturdays and Sundays respectively. Volunteers were supplied with gloves, sunscreen and water.

Approximately 23,000 volunteers registered for the first weekend. Upon registration, they were allocated to sectors and then transported from the registration point to their allocated sector by Council bus. Council volunteer registration centres and drop off points are shown in Map 11.

These volunteers were co-ordinated on the ground by officers from Council's Libraries and Brisbane Transport. Notwithstanding some reported instances of buses being directed to streets that had already been cleaned, overall, the matching of resources to need was highly effective.

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The volunteers assisted householders and business owners with debris removal and cleanups. On the second weekend, a large number of parks were cleaned. Council's call for assistance was also answered by many volunteers who did not register. It is thought that, in all, there were between 50,000 and 60,000 volunteers who assisted over the first weekend.

For Council staff, managing spontaneous volunteerism on such a large scale presented challenges not encountered in the usual course of Council business. The Board's review of the experience of dealing with these challenges has identified a number of aspects to organization for, and management of, individual volunteers for which strategies should be developed and documented. Those aspects are listed immediately below. It may well be appropriate to incorporate the strategies within a separate section on volunteer management in the Disaster Management Plan itself, supplemented by appropriate Standard Operating Procedures.

Volunteer Co-ordination: There is good reason to expect that a future disaster in Brisbane would generate a powerful volunteer response on a similar scale. The Board considers that readiness for such a response is likely to be enhanced by the provision within the Local Disaster Coordination Centre of a cell of suitably experienced personnel with responsibility for co-ordinating volunteers. Positioning a representative from an agency such as Volunteering Queensland within the cell should be considered.

Briefing Sheet: A proforma briefing sheet for volunteers should be developed now, based upon experience in the recent flood event. A briefing sheet would be useful in preparation of Community Service Announcements and delivery of onsite briefings to volunteers at registration points.

The briefing sheet should be prepared with a consciousness that participation by volunteers adds a new dimension to legal risk management for Council. Perceived risks could arise, for example, from injury to, or conduct by, volunteers. Protocols for risk management in this regard need to be in place at the time of registration and briefing. Such protocols should be established in consultation with Council's legal advisers and, where appropriate, Council's insurers.

Health Care: Debris cleanup does expose volunteers to the risk of injury. Some 330 injuries were treated by St John's Ambulance. The Board notes that vaccination was offered to volunteers at registration points and that they were encouraged to wear protective clothing. Health care arrangements are needed first and foremost in the field where injuries occur. Planning should be directed towards arrangements which are to accompany deployed volunteer groups on site.

Residents' Wishes: The Board has been informed of instances of distress on the part of residents arising from the disposal of items of property of value to them. In an environment of enthusiastic volunteerism, care needs to be taken to ensure that where property is disposed of, it is disposed of with the consent and approval of the owner, and to recognise that residents who are in a state of some shock, may not be ready for decision making. To minimise the risk of distress on this account, the Board considers that "house team" leaders be identified within volunteer groups and that they be given the responsibility of liaising with residents so as to ensure that debris removal and clean up activity are carried out in accordance with the wishes of residents.

Security of Dwellings: Protection of the security of dwellings of flooded residents during volunteer cleanup activity is a priority consideration. The Board encourages Council to develop processes in conjunction with Queensland Police Service directed towards maintaining security of dwellings over that period.

Plant and equipment and skilled trades' assistance were volunteered in answer to the Community Service Announcements and the Lord Mayor's press releases to which the Board has referred. The response was very substantial. For example, some 700 offers of plant and equipment from owner/operators were recorded and logged. These offers were subsequently verified and refined.

Receipt of offers of assistance from plant and equipment owner/operators, tradespeople and non-construction businesses was managed principally by the Forward Planning Group. As well, Council officers liaised directly with large contractors and industry representative bodies who provided assistance. Heavy plant and equipment made available to Council, was co-ordinated by the Major Infrastructure Project Office and was used for removal of debris from temporary debris sites to landfill. Working groups of smaller plant and equipment were allocated to RIMTs and the Australian Defence Force to assist with the removal of debris from streets in flood-affected areas.

The Board is of the view that the co-ordination and management of volunteering at all levels was successfully undertaken. The Board endorses, as a model, the separate management of different categories of volunteers, particularly individuals. Operational management arrangements for volunteers ought not depend overly upon Forward Planning Group personnel whose focus is upon planning.

Waste and Debris Management and Disposal

The volume of debris produced by the flood was prodigious and its diversity extensive. Routine waste disposal systems were significantly disrupted, particularly in flood-affected areas. Both waste and debris posed significant public health risks.

Council has outsourced its waste management function, retaining a relatively small City Waste Services (CWS) team on staff. CWS co-ordinated the logistic requirements of the response to the waste and debris issue. Functionally, Council received strong support from the waste industry and contractors alike and was thereby enabled to provide a responsive, flexible and efficient approach to clearing flood debris and household waste.

Council adopted a strategy of using localised temporary waste disposal sites for holding waste and debris on a short-term basis pending transfer to a number of Council and commercially operated transfer stations and landfill sites. In excess of 60 temporary sites were used in the aftermath of the flood. They included parks, playing fields and vacant pieces of land. These sites were identified through a range of methods, namely:

Existing sites: Council utilised pre-existing sites, especially its four transfer stations and Rochedale landfill;

Pre-identified sites: CWS with Local Asset Services, had previously developed a list of potential temporary disposal sites which had been identified after the 2008 Gap storm;

Post-flood identified sites: CSW and Local Assets Services also identified other sites immediately after the flood that would provide suitable space for disposal and access for collection;

Naturally occurring sites: There were also a number of sites across Brisbane that by virtue of their natural features were suitable. These sites were used primarily by community volunteers and the Australian Defence Force.

These temporary waste disposal sites were established generally in the vicinity of flood-affected areas for immediate accessibility. They were cleared using heavy plant and equipment and larger capacity trucks on a priority basis. Some sites became waterlogged and required gravel drops. Those occurrences need to be taken into account in future site selection and in consideration of potential surface upgrades.

These sites enabled the rapid removal of debris and waste from streets and contributed significantly to the speed of the clean up. By Saturday 22 January 2011, some 126,700 tonnes of debris and waste had been removed from temporary waste disposal sites to landfill. The sites were cleaned up within a few weeks of the flood.

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Unquestionably, the temporary waste disposal sites served their purpose. Significant efficiencies in waste and debris disposal were achieved through their use, notably by making unnecessary the immediate transfer of all such material from the streets to the transfer stations in the outer suburbs. The Board considers that the temporary dump site strategy was very effective and is most suitable for incorporation into future flood disaster planning.

Council now has a substantial body of recent experience in selecting and operating temporary waste disposal sites. The Board believes that drawing upon that experience, Council should now prepare a comprehensive single list of sites suitable for use as temporary dumps in the event of a disaster. Core criteria should guide site selection. Those criteria ought to include:

Accessibility (road surface);

Size (capable of holding the required volume of waste);

Physical integrity (surface hardness, drainage);

Location (from a health, safety and convenience perspective); and

Impact (minimal direct and indirect impact on the environment and the community).

The locations of the temporary and permanent waste disposal sites (except for two located to the west of Brisbane) is shown in Map 12.

As has happened in the past, aerial reconnaissance is likely to play a key role in identifying temporary waste disposal sites. As well, planning arrangements should clearly designate where decision making on site selection is to reside.

Public health and safety was an issue with significant potential to impact upon the population of Brisbane. It was decided to use skip bins for food waste and to communicate that message to the community. This resulted in a separation of waste and a more effective method for clearing food waste from the streets. A shortage of skip bins across Brisbane placed limitations upon this resource. Notwithstanding it was managed and co-ordinated carefully through Local Disaster Coordination Centre, Field Operations Group and RIMTs. Approximately 220 skip bins were sourced for the disaster clean up and were allocated equitably across the five regions. The locations of skip sites were notified to the public; however, there were some instances where skips were not delivered to notified sites because roads were blocked by debris.

The need to inform the community of hazards associated with some of the waste was quickly identified and addressed through Community Service Announcements and information published on Council's website. CWS co-ordinated the collection of hazardous waste material during the period under review. Many requests for removal of hazardous waste were received. CWS also experienced a heavy inquiry load about safe disposal of asbestos. Requests for its removal were also received. Having regard to the level of public concern for it, Council should give further consideration to the asbestos issue from both planning and communications perspectives.

Given the jurisdiction and responsibility that Queensland Government Department of Environment and Resource Management (DERM) also has with respect to hazardous waste, effective outcomes required close cooperation between Council and DERM officers. That did occur on this occasion on the many practical aspects involved in hazardous waste removal and disposal.

There are several aspects to staffing which the Board considers ought to be incorporated in future planning arrangements. First, within the first one to two days of Local Disaster Coordination Centre activation, there was no waste representative at that centralized level. Once the nature and scale of the waste management issue became apparent, that omission was rapidly rectified. The Board's view is that a liaison officer from CWS should be incorporated into the Local Disaster Coordination Centre structure to facilitate integration of

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planning and decision making on this critical function early within the Local Disaster Coordination Centre processes.

Secondly, the engagement of contractor services was managed on an "as need arose" basis by a procurement specialist who was assigned to the CWS team. The procurement system that was adopted proved to be flexible and allowed local solutions to be sourced quickly. This experience suggests that Council should strengthen the link between procurement and waste management during a disaster by establishing a dedicated position within the CWS team tasked with the role of liaising with respect to procurement.

Transition to Recovery

The Forward Planning Group prepared a Concept for Recovery document which envisioned that the Lord Mayor's Recovery Task Group would lead Council's recovery effort and assist State agencies with broader recovery responsibilities. The Concept document proposed the formation of a number of sub-committees within Council to oversee, subject to Lord Mayor's Recovery Task Group governance, important aspects of Council's response to the flood event beyond the immediate aftermath. They are as follows:

Community Recovery Co-ordination Sub-committee;

Finance and Economic Recovery Sub-committee;

Infrastructure Sub-committee;

Environmental Recovery Sub-committee;

Ward Recovery Sub-committee; and

Town Planning Recovery Sub-committee.

The Board notes that these sub-committees were established promptly. Each of these sub-committees is chaired by a Councillor. Their work has been substantially undertaken after the Board's reference period. Notwithstanding, the Board records its endorsement of these sub-committees and governance arrangements as most appropriate for the circumstances.

Additionally, Council formed the Joint Flood Taskforce on Tuesday 11 February 2011 which was tasked to investigate the January 2011 flood event and make recommendations on interim flood immunity standards and certain development guidelines. The valuable work of the Joint Flood Taskforce is referred to in the Board's discussion of planning issues. Council has also commissioned the provision of external expert engineering advice by engaging engineering consultants in March 2011 to perform a Failure Analysis on the 12 worst affected asset categories (by estimate of cost damage) to determine the mode(s) of failure.

Other aspects of Council's response in the period immediately following the subsidence of the flood waters have already been mentioned in preceding observations in this report, notably, those with respect to evacuation, management of volunteers and debris and waste management and disposal. It is within those contexts that the Board has made the comments which it considers appropriate to make concerning the successful management by Council of relationships with its contractors and supporting agencies. There was a marked degree of reciprocal goodwill which plainly created a co-operative environment for producing good outcomes over a wide spectrum of Council functions and services.

Commendations

The Board commends Council's coordination and management of the field operations response through the Field Operations Group, the RIMTs and other appropriate Council business units.

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The Board commends Council for developing and implementing at short notice a citizens' volunteer management strategy, including establishing the capacity to register, brief, equip and deploy the volunteers to priority recovery locations; and for coordinating and deploying business and professional volunteers, (including trades people, contractors and plant operators) and community groups, to enhance the pace and efficiency of the cleanup.

The Board commends Council for undertaking a major waste collection and disposal effort for vast quantities of flood debris and household waste, in conjunction with waste disposal contractors, industry volunteers and the broader waste industry.

The Board commends Council's transition to recovery policies and procedures including the establishment of the various Council sub-committees as recommended in the Concept for Recovery document prepared by the Forward Planning Group, the formation of the Joint Flood Taskforce, and the engagement of engineering consultants.

Affirmations

The Board affirms the contribution of region-based RIMTs noting that they provide a critical layer in the command and control structure for dealing with the on ground situation, managing local resources and coordinating external resources allocated to them. The Board **recommends** that:

A senior officer be assigned to mentor each Regional Incident Management Team Manager and conduct high level discussions with the Local Disaster Coordination Centre;

Dedicated Regional Incident Management Team operations rooms be established; and

Planning for alternative Regional Incident Management Team sites, in the event that the primary sites become unusable, be conducted.

The Board affirms Council's planning for and implementation of evacuation centres as detailed in the Disaster Management Plan. The Board **recommends** that further consideration be given to refining Council's evacuation centre planning to address:

Greater decentralisation of evacuation centres particularly for communities that are known to be prone to isolation by flooding;

Early and close liaison with Red Cross particularly in regard to registration of evacuees and vetting of volunteers;

Early and close liaison with Queensland Police Service in regard to exclusion of persons not suitable to be in a general public evacuation centre;

The special needs of frail, aged, incapacitated, nursing home and oxygen dependant evacuees for whom separate and special arrangements need to be made;

Social, cultural and religious diversity of evacuees, including those with a non-English speaking background; and

Purchase and supply of special items such as personal hygiene kits and baby requisites.

The Board affirms Council's action in rapidly increasing sandbag production to a total of more than 390,000. The Board **recommends** that estimates be developed of likely sandbag demand for regions during future flooding events and that the best situated potential sites for filling and distribution points in each Region be identified.

The Board affirms Council's collaborative efforts with the Queensland Police Service and the Australian Defence Force in providing a workable framework for overall traffic management. The Board **recommends** that the Council consider developing advanced plans, in

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consultation with Queensland Police Service, to improve traffic flow in flood recovery congested areas including converting some streets into one way, route designation for heavy vehicles and identification for residents' vehicles.

Recommendations

The Board recommends that permanent flood markers be installed on key roads that are known to become flood affected to complement other public awareness and safety campaigns.

The Board recommends that Council develop a process for handling donated goods separately from evacuation centres.

The Board recommends Council implement strategies in relation to volunteer clean up activities for:

Development of a proforma briefing sheet for volunteers based on experience gained in this flood event;

Identification of house team leaders to liaise with residents so that clean up activity is in accordance with the residents' wishes;

Ensuring the provision of appropriate health care arrangements to accompany deployed volunteer groups;

In conjunction with Queensland Police Service, developing processes to ensure the security of flooded residents' dwellings during volunteer cleanup activity; and

Making provision for a co-ordination cell within the Local Disaster Coordination Centre, particularly for individual volunteers.

The Board recommends that Council develop a comprehensive single list of potential sites suitable for temporary waste collection, incorporate a liaison officer from the CWS team into the Local Disaster Coordination Centre; and strengthen the link between procurement and waste management during a disaster by establishing a dedicated liaison officer position in the CWS team.

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SECTION FOUR - THE IMPACT OF EXISTING PLANNING REGULATIONS IN FLOOD AFFECTED AREAS

This section of the Report outlines the statutory framework that regulates Council's planning powers. The use by Council of the Defined Flood Level adopted in 1978 as an important planning tool and its impact upon development in Brisbane are examined. Flood risk management in the future is considered and issues relating to basements, building services and the Voluntary House Purchase Scheme are discussed.

Council's Planning Jurisdiction

Council derives its jurisdiction in the field of town planning from State legislation. The jurisdiction is a limited one being regulated in many significant respects by statute. The *Sustainable Planning Act 2009 (Qld) (SPA)* (refer List of References) enables State planning instruments, such as State planning policies and standard planning scheme provisions, which have application to the City of Brisbane, to be made at State level. The SPA also empowers Council to make local planning instruments. These may be a planning scheme, a temporary local planning instrument or a planning scheme policy. Core matters for the preparation of a planning scheme are land use and development, infrastructure and valuable features.

A broadly similar planning law regime had also prevailed during the currency of the predecessor to the SPA, the *Integrated Planning Act 1997 (Qld)* (refer List of References) and the predecessor *City of Brisbane Act 1924 (Qld)* (refer List of References). State Planning Policy 1/03 (refer List of References), to which the Board has referred, is a product of that regime. The way in which the intent of that Policy is achieved at local government level, as outlined, is an illustration of how the regime operates in practice.

In making planning instruments, and in local law-making generally, Council is regulated, at numerous levels, by provisions in State legislation. At a very general level, local planning instruments must be consistent with State planning instruments. More specifically, and by way of example, the *City of Brisbane Act 2010 (Qld)* (refer List of References) prohibits Council from making a local law setting up an alternative process for development applications to that in the SPA; and the SPA itself forbids a council planning scheme from including provisions about building work to the extent that it is regulated under statutory building assessment laws and documents unless excepted by the *Building Act 1975 (Qld)* (refer List of References).

The CityPlan has limitations regarding the regulation of new development and/or rebuilds. Local government planning instruments are unable to cover a number of building and design issues as other pieces of legislation such as the Building Code of Australia and the Queensland Development Code are responsible for addressing these elements. This applies principally to single detached housing as Council has more control over the design of multi-unit dwellings. A rebuild or repair of a dwelling house to "as was" standard and design prior to flood damage requires neither development approval or building approval, provided that the "as was" was itself lawful.

Similarly, regulating the retro-fitting of commercial buildings with flood-proof design measures will be difficult from a Council perspective as the planning scheme primarily deals with triggers for new development (or changes to the intensity and scale of uses). These restrictions make it extremely difficult to channel modification of existing development through the Council approvals process. Accordingly, changes to Queensland Government legislation and statutory codes are likely to be the primary mechanism to achieve these aims.

The appropriateness of town planning and building codes in assisting residents and businesses in potentially flood affected areas to mitigate the effects of flooding was an issue raised in the community engagement process for this report and in media commentary. The reality is that whilst Council can take the lead on town planning reforms, many of the major planning issues can only be addressed comprehensively through changes to legislation, policies and codes at state government level. Bearing that in mind, the Board has not

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undertaken a detailed analysis of all aspects to town planning and building codes which impact upon flood risk.

Lord Mayor's Taskforce on Suburban Flooding

In December 2004, the Lord Mayor established the Taskforce on Suburban Flooding. This Taskforce reported in August 2005 (refer List of References). It identified a number of areas in which Council could enhance mitigation strategies for the impact of flood events and recommended 24 "Key Actions" of which seven are of a planning nature. Many of these action items directly contribute to minimizing the risk to people and property as specified in SPP1/03. There has been a progressive implementation by Council of the recommendations including amendments to CityPlan and significant upgrade of Council's subdivision and development guidelines to address particular risks for flood affected land and stormwater flow issues.

A high level review of the Taskforce's report and the status (as at December 2010) of each of the "Key Actions" indicated that while a number of the town planning mitigation measures have been fully delivered, several remain "in progress", partial delivery only having been achieved. The legal and legislative complexity of some action items and the planning review cycle are assessed as having impacted upon progress. These issues are being addressed through a variety of Council's deliberative bodies including the Joint Flood Taskforce and the Town Planning Sub-committee.

Defined Flood Level Planning Tool

The planning tool that has had the most impact upon Council's planning decisions for a number of decades now is the Defined Flood Level (DFL). In summary, the DFL at a particular location is the peak flood level calculated for the Defined Flood Event (DFE) for that location. The DFL establishes the flood control lines for the location and plays a fundamental role in planning and development decision making. A more full description of the DFL and an explanation of its derivation from the concept of a DFE are given in Section One of this report.

The habitable floor levels that Council requires for particular developments are prescribed by Codes in the City Plan. These levels are set by reference to the DFL, the relationship to the DFL being dependent upon the building classification and use proposed for that development. For example, for houses and multi units along the Brisbane River, the required level for habitable floors is DFL + 500mm; and for non-habitable commercial buildings similarly situated, it is DFL.

Council's Subdivision and Development Guidelines set flood immunity levels for new subdivisions also by reference to DFL. For Brisbane River flooding risk, the minimum lot level for residential land is DFL + 300mm and for land other than residential, it is DFL.

In 1978, and in response to the January 1974 flood, Council adopted a DFE and a DFL which correspond with the flood event of January 1974 as mitigated by the Wivenhoe Dam. The DFL was set at 3.7mAHD at the Brisbane City Gauge, progressively increasing with distance upstream of that measurement point. Council has continued to use the same DFE and DFL since 1978.

As the Board has already noted, for areas which are subject to the worst flooding in Brisbane, the adopted DFL is somewhat higher than a DFL that would apply for a DFE constructed upon a Q100 theoretical flood probability. Markings on the aerial photograph of the suburb of Tennyson (Map 5) depict the adopted DFL relative to a Q100-based flood line. The depiction shows the former as being more conservative.

The adopted DFL has had a beneficial influence upon land development within the city from a flood risk perspective. In line with Council's growth planning strategy which envisages growth centres and transport connections outside potentially flood affected areas, development has generally been away from such areas. Statistical estimates provided to the Board by Council

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illustrate this development pattern. In older suburbs and the Central Business District that were developed predominantly prior to 1978, some 24,696 properties, with an aggregate area of 13,175 hectares, were completely or partially inundated in the January 2011 flood. Of these, 19,786 were residential properties with an aggregate area of 2559 hectares. They represent about 89.5% of all flood affected residential properties in the city. By contrast, for suburbs developed predominantly after 1978, 1243 properties, with an aggregate area of 1422 hectares, were flood affected. Of these, 1017 were residential properties with an aggregate area of 251 hectares.

It is a chilling statistical fact that across the whole of Brisbane, 22,097 residential properties were wholly or partially inundated in the recent flood. Council does not have accurate or consistent records of floor heights for dwellings located on these properties and is not able to develop statistics which measure the extent of impact on these dwellings. However, it is evident that the impact, in many instances, was profound and the adverse consequences for the health, living arrangements, property and financial wellbeing for those concerned, were severe.

Throughout the whole of the city, some 7671 properties classified as non-residential were flood affected. This classification includes properties used for economic activity such as commercial office work, retail, industry, warehouses/bulk stores, and rural. Together, they represent 11.7% of all non-residential properties in the city. It is estimated that the land surface of 2940 of these properties was completely inundated while the land surface of the other 4731 properties was partially inundated. Here, also, the properties are concentrated in older areas. The impacts for the owners of these premises and of businesses carried on at them and for workers, differed from those for residents but, for some, were no less disruptive, injurious to health and/or financially devastating.

A total of 7926 properties were recorded in the CBD as at February 2011. Of these, 6680 properties, including their on-site facilities, (84.3%) were directly affected, by complete or partial inundation. The disruption to commercial and professional activity resulting from building closures and temporary relocations was extensive, particularly in the immediate aftermath of the flood.

Whilst the adopted DFL has had a demonstrably positive effect, it has in no way guaranteed a flood-proof Brisbane. It could not do so; nor was it designed to do so. In the January 2011 flood, an approximate area of 67.48km^2, 5.1% of the total city land area, was flood affected. Of this area, approximately 16km^2 (approximately 23.7%) has been identified as being above the adopted DFL. Map 5 also depicts areas within established suburban development, railway lands and infrastructure, and the newer tennis centre development where the January 2011 flood exceeded the adopted DFL for Tennyson.

It is in these circumstances that Council formed the Joint Flood Taskforce on 11 February 2011. In accordance with its mandate, the Taskforce delivered its report within 30 days. The Taskforce's report is a technical study which investigates and provides answers to several questions put to it by Council. The Taskforce was asked in light of the January 2011 flood event, what interim standard should be used to enable new development and redevelopment to proceed with confidence and certainty, until the Commission of Inquiry Reports.

The Taskforce recommended a number of strategies for the development of a long term plan for dealing with all aspects of flooding up to the most extreme event. A key recommendation was:

> "That a complete Flood Risk Management analysis for the area of Brisbane affected by flooding by Brisbane River and its tributaries be carried out. It is essential to move from the Q100 mentality and to adopt a risk management approach in line with National Flood Risk Advisory Group (NFRAG) and other relevant guidelines. The risk management approach would require a detailed assessment of the benefits and costs of a full range of flood mitigation options."

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The Board fully supports this strategy. While this analysis would be very costly, it would provide significant long term benefits. The cost should be seen as one that ought to be incurred for an important metropolis that has a significant flood risk. It needs to be borne constantly in mind that large floods do occur here; that, as the cover to this report depicts, they occur with an unpredictable frequency; and that when they have occurred, great loss and damage has been caused to the city and its citizens.

The Taskforce also recommended that the actual January 2011 flood, as observed during the event, be used as an interim standard for new development and redevelopment, with the essential condition that wherever a higher level has been set as the current DFL, the higher level must apply. The Board notes that Council has accepted this recommendation and acted promptly with a view to the formal adoption of the interim standard.

The interim standard sets the DFL at the City Gauge at 4.46m AHD compared with 3.7m AHD. According to the Joint Flood Taskforce Report, the re-set DFLs at other locations along the river are:

West End ferry, 7.42m AHD (from 5.79mAHD);

Tennyson Tennis Centre, 9.84m AHD (from 7.79mAHD);

Centenary Bridge, 12.91m AHD (from 10.8mAHD); and

Karana Downs, 22.98m AHD (from 21.1mAHD).

These levels may be revised as more accurate data becomes available.

The interim habitable floor level at each of these locations under the interim standard is therefore set at 500mm above the DFL based upon the 2011 flood experience, and significantly above the corresponding level that had previously applied at that location.

Basements and Building Services

The Board has received submissions which describe particular difficulties arising from flooding of basements. The disabling of machinery located in basements, including emergency electricity generators, for provision of necessary services to buildings, such as lifts, lighting and ventilation, was a recurrent serious problem. Many buildings became inaccessible and uninhabitable for protracted periods as a result. The Board notes that presently there are limited regulatory mechanisms that require developers to provide a flood-proof location for ENERGEX assets located on customer premises. During the recent flood, the incidence of adverse consequences arising from the siting of such assets in flood vulnerable locations was pronounced in the CBD.

Another serious problem was caused by the presence of thick layers of mud that remained on basement floors after flood waters had receded. Conventional basement design which does not provide for drainage at the lowest basement level, meant that mud, in a slurried form, had to be pumped upwards for extraction and could not be simply hosed away. The extraction was time consuming and costly for building owners and residents.

Council has taken measures to address basement flooding difficulties, principally through the Town Planning Sub-committee. These measures are detailed in Section Five of this report.

Voluntary House Purchase Scheme

The Board has been briefed on the Voluntary House Purchase Scheme. This scheme was a major strategy proposed by the Lord Mayor's Taskforce on Suburban Flooding Taskforce (2005). It provides for the removal of residences from the flood hazards identified in the Taskforce's report, on a voluntary basis.

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There are approximately 525 properties in the city that could be adversely affected during a two year Average Recurrence Interval (ARI) creek flood event. Council has approached in excess of 200 owners of these properties to participate in the scheme. The average annual budget allocation to the scheme has been $5 million. The limited budget and a modest acceptance rate have resulted in only 46 houses having been purchased under the scheme.

The Board regards the strategy as a good one for assisting residents who are affected by frequent flooding and suggests that Council consider an extension of the scheme to cover less frequent flooding. A very substantial increase in the budget allocation to the scheme would be needed to adequately fund a significant extension of it. This would most probably require additional financial assistance from the State and Commonwealth Governments.

Commendations

The Board commends Council for its Growth Planning Strategy which envisages growth centres and transport corridors outside potentially flood affected areas and notes that 89.5% of all flood affected residential properties were in areas developed predominantly prior to 1978.

The Board commends Council for its progressive implementation of the recommendations of the Lord Mayor's Taskforce on Suburban Flooding (2005) which has resulted in a reduction in the risk of flooding in recently developed areas.

Recommendations

The Board recommends that, in relation to planning, Council undertake a complete flood risk management analysis for the area of Brisbane affected by flooding from the Brisbane River and associated tributaries in line with National Flood Risk Advisory Group (NFRAG) and other relevant guidelines. This would require a detailed assessment of the benefits and costs of a full range of flood mitigation options.

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SECTION FIVE - FLOOD PREVENTION, STORMWATER AND RIVERINE INFRASTRUCTURE

This section discusses the types of flood mitigation infrastructure and identifies two types that may have limited application in Brisbane. It reviews the impact of the flood on the stormwater infrastructure and describes the damages sustained by Council's riverine infrastructure.

Flood Prevention Infrastructure

The most important infrastructure items for mitigation of flooding from the Brisbane River are the Wivenhoe and Somerset Dams. Council has a vital interest in the operations of the dams during river flood events but it has no statutory role in dam releases or flood mitigation operations for Wivenhoe and Somerset Dams. Seqwater has that role and responsibility and issues relating to these dams are outside the scope of this review.

In any consideration of the effectiveness of the Council's flood prevention and stormwater infrastructure in a particular flood event, it is essential to recognise that there are many different causes of flooding in Brisbane. This review has been commissioned because of the January 2011 flood event, a Brisbane River flood caused by heavy, sustained rainfalls over the catchments of the Brisbane River. The following discussion must be read in that context. A large river flood such as that of January 2011 causes extensive flooding in many low-lying areas close to the river. Such a flood is a relatively infrequent event and much more frequent flooding is caused by creek and by overland flow throughout much of Brisbane. This flooding can be as severe as that caused by a river flood, although the extent on each occasion is much smaller. Any infrastructure for prevention/mitigation of the effects of a Brisbane River flood must not cause unacceptable increases in flooding due to other causes.

Even when the effects of Brisbane River flooding are considered in isolation, it is necessary to recall that all river floods differ from each other to varying degrees. During the January 2011 flood event, the flooding was caused virtually everywhere by the river. The rainfall over Brisbane itself caused little, if any, flash flooding in Brisbane's suburban creeks. The flooding that did occur in Brisbane's creeks was essentially due to backing up from the flood waters in the river. In contrast, in the January 1974 flood event, extensive and severe flash flooding occurred in the suburban creeks before the flood peak in the Brisbane River arrived and caused a second flooding in many low-lying areas.

Some of the flooding during the January 2011 flood event caused by backwater flooding from the river may have been prevented by some form of engineering device such as flood gates, one-way valves and levees. While such infrastructure could have been beneficial during the January 2011 flood event, it would have caused increased flooding in many areas during the January 1974 flood event.

So that balanced consideration is given to strategies for flood prevention or mitigation by engineering works, Council commissioned GHD to investigate and evaluate all engineering options for Brisbane. The outcome is given in the report, "Engineering Solutions for Flood Mitigation in Brisbane", Discussion Paper prepared for Brisbane City Council by GHD, February 2011 (refer List of References).

Six types of engineering structural measures have been used for flood prevention or mitigation in Australia and overseas:

River barriers;

Flood gates;

Backflow prevention valves;

Levees and flood walls;

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Dredging; and

Flood mitigation storages.

The first three of these could be used in Brisbane only to prevent backwater flooding. The second group of three have general application.

After detailed consideration of the applicability of these options to Brisbane and of their advantages and disadvantages, the GHD report concludes that:

> There are no "silver bullets" to mitigate flood levels in Brisbane. The 2011 flood was characterised by high flows and water levels in the Brisbane River at a time of minimal flows in urban tributaries and most of the flooding was caused by "backflow" from the river. This was more pronounced than in 1974, for example, where flooding of tributaries such as Oxley Creek by local rainfall was also significant.
>
> The major difficulty in planning for infrastructure to mitigate flooding in Brisbane is that flood events are rarely the same. A variety of structural measures exist that could potentially be used to reduce the impacts of "backwater" flooding in Brisbane, but none of these measures comes without other impacts and risks.

"Engineered" or structural measures with the highest potential for application in Brisbane are:

> The use of backflow prevention devices such as flap valves and "duck-bill" valves, provided suitable maintenance regimes are implemented;
>
> The use of levees around specific, high-value infrastructure (such as the Brisbane Markets), but not along waterways; and
>
> Construction of flood mitigation dams on Lockyer Creek the Bremer River upstream of Ipswich.

The last two of these in particular would require further, more detailed, investigation to establish if they are viable and would provide a net benefit to the community. Construction of levees in flood prone areas of Brisbane would be under the control of Council. However, possible sites for flood mitigation dams would in areas where Council has no authority and this matter is outside the scope of this review.

Backflow Prevention Devices

A backflow prevention device is intended to ensure one-way flow downstream and prevent water from backing up from downstream into stormwater systems. Backwater valves must be designed and constructed to minimise clogging.

A wide range of backwater valve designs is in use, from simple flap valves through to more complex devices. The most common backflow prevention valves are the simple flap valve - used extensively in Australia and the rubber "duck-bill" valve. In both of these, the intention is that the valve will remain closed until there is flow from upstream and that it will then open to release the flow from upstream, closing again when flow stops and the downstream water level is higher than the upstream level. Issues of concern with these types of valve include the relatively high potential for them to be stuck open (e.g. by debris or accumulated sediment) and rendered ineffectual, and the potential for increased pressure losses in the system causing less effective drainage. Regular maintenance of these devices is essential to ensure their effective operation.

In Brisbane, Council has a range of backflow devices along tidal reaches of the Brisbane River, creeks (primarily Breakfast/Enogerra Creek) and along Moreton Bay. The only backflow device in the South Region is a flood valve located at Brisbane Corso in Yeronga.

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The purpose of these devices is to stop the inflow of tidal water at high tides into low lying streets and adjacent properties. They cannot reduce creek or river flooding if they are overtopped by flood waters that break over the banks of the river or creek. During the January 2011 flood event, backflow devices were engaged when water reached the height of a high tide and they stopped the inflow of water through the stormwater network. However, when the Brisbane River and creeks over-topped bank heights near these devices, flood waters flowed overland behind them. The backflow devices performed effectively to their stated purpose, which is to stop tidal ingress and not for stopping flooding of a higher magnitude.

While these backflow devices are stopping tidal water ingress they can cause a problem from local flooding behind them by preventing stormwater produced by local rainfall from flowing downstream through the stormwater pipes to the receiving waters, once the backflow device is engaged. The Board was informed that very minor flooding of local roads and properties did occur during the January 2011 flood event in the tidal reaches of Breakfast/Enoggera Creek, near Breakfast Creek, where Sandgate Road is higher and the area slopes back to Albion Park. This happened because, when it rained, the gates were shut by the tide and the runoff was dammed until the tide started to recede and the height of the runoff could open the gate. This happens only from time to time. Council has an SMS service and signage on-site to alert motorists of this risk.

The Board was informed that, during the January 2011 flood event some areas, such as parts of New Farm, were flooded by backflow from the river without the river banks being breached. In such cases the installation of backflow prevention devices might have prevented flooding on this occasion. However, this does not provide sufficient grounds for installation of such devices and extensive investigation would be required to assess whether they would have unacceptable impacts during other possible types of flood events. This is discussed further in the section below on the effectiveness of the stormwater infrastructure.

As noted above, regular maintenance of backflow prevention devices is essential to ensure their effective operation. In some situations, the impact of backwater flooding is restricted to a particular body or to a limited, identifiable group. If such interested parties accepted responsibility for oversight of this maintenance, this would reduce substantially the risk of failure in the time of need.

Levees

Levees have been proposed by some for flood protection in a number of locations in Brisbane and it is appropriate that this matter be given due consideration. Important issues that must be weighed before the decision is made to construct levees include:

Levees will need to extend over long distances since the river has a small longitudinal gradient in its lower reaches;

They will increase flood levels in the river because flood plain storage is reduced;

Levees will cause a major safety hazard if they are breached during a flood;

Dangerous failures will certainly result in a flood event that is larger than the "design" flood when the levee will be over-topped; and

Levees may form a barrier to overland flow paths and may need underground drainage structures across them to allow for normal drainage.

Nevertheless, levees may be found to be a suitable option to protect specific areas, such as areas with a high population density, some critical infrastructure installations or important industrial areas. One example might be the cold stores at the Brisbane Markets at Rocklea. Each case would require careful consideration of a range of design issues to assess its applicability and whether the benefits outweigh the costs.

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Flood Resilient Buildings

When buildings have been flooded, the time required for recovery and the costs of repairs depend on the degree of damage suffered. Appropriate design and the use of flood resilient construction can ensure that the damage caused to buildings by flooding and the recovery time after flooding is reduced very much. The Board has been advised that Council's Town Planning Sub-Committee has been actively considering the issues of flood resilient design for buildings. A Temporary Local Planning Instrument (TLPI) encompassing preliminary recommendations has been drafted. After approval by Council, it will require endorsement by the State.

Key elements of the TLPI relating to basements and services include recommendations that:

> New building work uses waterproof materials and corrosion free components;
>
> Essential services are located above the Interim Residential Flood Level (January 2011 flood event) and any electrical services, including photovoltaic panels, are easily isolated;
>
> Basement car parks must be suitably waterproofed and all air vents, air conditioning ducts, pedestrian access and entry/exit ramps at the car park entrance must have appropriate flood immunity; and
>
> Where essential services are proposed in a basement below the specified flood immunity level, a fully watertight basement design is required to prevent floodwaters entering the basement to ensure flood immunity for the essential services.

A Draft Code for Basements and Building Services is expected to be completed in May 2011. This will include design requirements that reduce the susceptibility of building basements to flooding and it will recommend mandatory design requirements for building services locations that reduce susceptibility to flooding.

A draft design code for resilient building design is being developed. The Board understands that designs will be available eventually through Council's website and other planning documents, such as Neighbourhood Plans for flood affected areas, as well as being promoted through peak industry bodies.

Effectiveness of Stormwater Infrastructure

For the period from 9am Friday 7 January to 9am Wednesday 12 January 2011, the five day rainfall in Brisbane was 193mm. Apart from a one day total of 110mm for the 24 hours ending at 9am on Monday 10 January 2011, Brisbane itself did not receive heavy rainfall during the January 2011 flood event and there was little, if any, flash flooding in Brisbane's suburban creeks and overland flow paths. The flooding that did occur in Brisbane's creeks was essentially due to backing up from the flood waters in the Brisbane River.

The essential purpose and function of the stormwater network is primarily to prevent or reduce flooding due to creek and overland flow flooding. Brisbane's stormwater system, shown in Map 13, is very extensive and complex. Only a relatively small proportion is in the flooded area. It is estimated that 17% (451km) of the Council's 2640km of enclosed pipe was significantly silted from the flood.

Noting these two factors, the effectiveness of the stormwater network system in the context of the January 2011 Brisbane River flood event is largely unrelated to the flood event. However, where the system was affected by flood water from the Brisbane River, its performance can be assessed from how well it functioned in the face of the large amounts of debris and silt deposited into the system by the Brisbane River.

The stormwater network system requires continual maintenance and repair to ensure that it performs to desired standards of service. Council undertakes planned maintenance and

BCC.100.5805

repair work on a yearly basis and that part of the work relating to the pipe network and to bank maintenance appears to have been proceeding more or less on schedule prior to the January 2011 flood event.

Some of the flooding during the January 2011 flood event was caused by backwater flooding from the river that entered low-lying areas through stormwater pipes and open drains, and some of this could have been prevented by some form of engineering device such as flood gates on drains or one-way valves in pipes. This issue is discussed above in the context of backflow prevention devices. Noting that the primary, essential function of the stormwater network is to prevent or reduce flooding due to creek and overland flow flooding, any proposal to incorporate backflow prevention devices in it to prevent some river flooding must be assessed with care to ensure that the effectiveness of the system is not thereby compromised during more frequent flood events due to local rainfall.

Impact of Flood on Stormwater Infrastructure

The major impact of the flood on the stormwater system was from the large amounts of silt and debris deposited within the network including, but not limited to, enclosed pipes, gully inlets and grates, open drains and waterways. The flood caused some damage to elements of the system but this is not likely to have impacted on its effectiveness during the flood. The damage is described under riverine infrastructure failures.

It is not known whether blocked storm water drains or inlets caused higher local flooding levels than those due to river flooding but this is considered unlikely. There was no significant rainfall in Brisbane while the Brisbane River peaked and blockages of stormwater infrastructure at or near the flood peak line would not have received additional stormwater of a significant enough volume to heighten the flood line.

It is not known whether blockages delayed the recession of flood waters locally but Council has not received any particular comment that warrants further investigation of this matter. It is thought that recession of flood waters may have been partially delayed in some instances but that the time period associated with a delay would be less than a few hours and that the effect of this was not a significant factor in the damage caused by the flood waters.

Maintenance of Stormwater Infrastructure Following the January 2011 Flood Event

As noted above, about 451km of the enclosed stormwater pipe system was significantly silted from the flood. The clean-up efforts after the flood added to the siltation deposited by the flood when large amounts of mud and debris were washed into stormwater drains.

Immediately after the flood receded, Local Asset Services (LAS) managed the process of cleaning all gully pits within the flood affected area. This was to ensure the stormwater network would be able to receive stormwater in the event of a storm or local rainfall event following the January 2011 flood.

Following this, LAS have been undertaking a planned maintenance program to clean the entire affected stormwater infrastructure.

To the end of March, 39.4km of enclosed pipe lines including associated manholes, inlets and outlets had been inspected. Of the 9.3km found to require cleaning, 3.5km have been cleaned and re-inspected. A total of 780 kilolitres of silt and debris has been removed from the stormwater network through line cleaning.

Eleven major open drainage lines in Toowong, Milton, St Lucia, New Farm, Yeronga and Rocklea have been identified as requiring cleansing and will be treated as individual projects.

This has been, and continues to be, a significant effort and the program of works started in February is not due for completion until at least the end of June 2011.

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Brisbane City Council's Riverine Infrastructure

Council has commissioned engineering consultants to provide independent advice on reasons for the failure of certain riverine infrastructure assets. The brief for this commission was prepared on 2 March 2011 and the Board notes that the consultant's final report is due to be delivered towards the end of May, which will be too late for the Board to consider its findings.

Although the Board is not able at this time to provide an analysis of the reasons for failures of Council's riverine infrastructure, it can provide comment on some aspects.

Council's Ferries

On the evening of Monday 10 January 2011, the ferry operators noted the difficulty in operating the ferries because of the increased velocity of the river and the increasing quantity of debris floating down the river. Ferry operations were terminated early on Monday night.

On Tuesday morning, the operators reported on the dangers associated with trying to continue to run the ferry service. It was decided then to move all ferries as far downstream and as close to the mouth of the river as possible.

The ferries are only licensed to operate in the Brisbane River. Approval from Maritime Safety Queensland (MSQ) and Council's insurer was required prior to removing the ferries beyond the river. Because of the unusual circumstances, MSQ supported Council's request.

At approximately 11am on Tuesday 11 January 2011 and after MSQ and insurance approval, seven vessels were moved to the Wynnum Manly boat harbour for safe mooring. Two other ferries were protected on hardstand at Council's maintenance facility at Bulimba. The remaining eight were moored at River Gate moorings in the vicinity of the Gateway Bridge. On Wednesday morning, nine mono-hull vessels were relocated from River Gate to the Wynnum Manly boat harbour.

The River Gate moorings are a protected mooring at a location where the river widens and there is lower river velocity. One of the City Cats moored at River Gate was struck by a loose pontoon. The hull of the vessel was punctured and it broke free from its mooring. The City Cat was recaptured by one of the tugs in the area and it was secured.

Floating Riverwalk

As flood levels rose and debris began to be carried down the river, the gate of the Floating Riverwalk was opened by Council in accordance with design requirements before any significant amounts of debris built up. With the gate open, debris was able to flow through to the downstream gangway/section. However, debris gathered on the lookout and on the leading edge of the downstream section of the Floating Riverwalk. Debris also gathered on the upstream approach structures. The Riverwalk floated upwards on its piles as the water level rose.

At about 4am on Thursday 13 January 2011, the downstream portion of the Floating Riverwalk broke free and floated down the river. A length of about 380m was washed away at this time and about 400m remained. A little before this time the peak flood level was recorded at the Brisbane City Gauge, about 2km upstream from the Floating Riverwalk.

The study being undertaken by consulting engineers is expected to report on the mechanism and causes of the failure of the Floating Riverwalk.

The location of the Floating Riverwalk is shown in Map 14.

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Ferry Terminals

Council owns 23 ferry terminals and four moorings/refuelling stations. Eight of the ferry terminals and two of the moorings were significantly damaged in the flood. The locations of the ferry terminals and moorings are shown in Map 14. The terminals and moorings which suffered significant damage are identified.

It is thought that the location of each of the ferry terminals, which is determined by their functional requirement, was the main reason that some of them were severely damaged while others suffered little damage and were able to be re-opened quickly after minor maintenance works.

Some terminals were exposed to the full force of the river flood flow, e.g., at the Terminal at QUT Gardens Point where the pontoon was never recovered and two spans of its gangway were damaged. In contrast, others in more sheltered locations, such as the South Bank Terminal, suffered little damage and were reopened after minor works.

Since the engineering assessment of the causes of failure is still awaited, it is not within the competence of the Board to make any recommendation at this time. However, it is suggested that any review of the design standards for the terminals should consider whether different design standards need to be developed for exposed and for sheltered locations.

Pontoons and Jetties

Council owns 25 pontoons and jetties and fifteen of these were found to be significantly damaged in the floods. In most cases sections of the damaged pontoons have been washed away.

It has not been possible to identify clearly the difference in the circumstances associated with degrees of damage to pontoons without the input of the pending engineering assessment. The locations of pontoons are shown in Map 14. The pontoons which suffered significant damage are identified.

Stormwater Outlets Damaged During the Flood

The most recent information provided to the Board on 13 April 2011 is that, at that time six stormwater outlets had been identified as damaged during the flood and requiring remedial treatment. Generally, failure was due to scouring or slumping of the surrounding supporting material. Much of the cost of remediation is expected to be associated with scour and erosion repair rather than with the cost of repair of the pipe and headwall.

Stormwater Drainage and Enclosed Pipes

Approximately 17% (451km) of the Council's 2640km enclosed stormwater drainage pipe was significantly silted from the flood.

Where failures occurred, most were due to the unavoidable location which resulted in erosion or slumping of support. A minor proportion of failures were caused by the physical capacity being exceeded. For example, some joints were popped by internal pressure.

River Walls

Thirty of Council's 97 river walls failed from damage by the flood. Approximately half of the failures were considered to be due to the physical capacity being exceeded or to the unavoidable location of the wall.

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River Banks

As at 1 March 2011, a visual survey of the Brisbane River from Story Bridge to Colleges Crossing by the Ground Engineering Team in City Design recorded 399 instances of bank slip. Of these, 34 have been identified as Council sites, 238 as sites owned by the State, Ipswich Council or privately. Ownership of the remaining 127 sites was being investigated.

The bank slips on Council sites have been assessed by Council officers according to the risk associated with them. Six bank slips are assessed as Very High Risk, (Orleigh Park, Rocks Riverside Park, Sir John Chandler Park, Priors Pocket Road Park no. 300A, Spinkbrae Street Park and Ormsby Street Park), four bank slips are assessed as High Risk (Wolston Creek Bushland Reserve, Barcoorah Street Park, Kookaburra Park West and Moggill Ferry Reserve), and five bank slips are assessed as Medium Risk (Illawong Reserve, Howard Smith Wharf Precinct, Botticelli Street Park, Booker Place Park and Kurilpa Point Park).

Expectations for Riverine Infrastructure

It is not realistic to demand that riverine infrastructure of the kind that Council owns should be able to withstand the worst possible flood that could occur, nor would it be justifiable economically, particularly since the infrastructure normally has a replacement cycle. Each item should be designed to a standard that is appropriate to their importance and normal 'life expectancy'.

Commendations

The Board commends the initiative of Council through its Town Planning Sub-Committee in developing strategies and effective planning instruments to encourage development of flood resilient building design and construction.

The Board commends Council for the rapid response in cleaning gully pits within flood affected areas and for initiating the major program of works required to remove silt from all of the stormwater system affected by the flood.

The Board commends Council's prompt actions in relocating the entire fleet of City Cats and cross river ferries to safe locations.

The Board commends Council for commissioning independent engineering consultants to provide advice on reasons for the failure of certain riverine infrastructure assets.

Recommendations

The Board recommends that:

> Council investigate the feasibility of the installation of devices to prevent backflow from river flooding in locations such as in parts of the Central Business District (CBD) and in high rise buildings which would not have been flooded otherwise, where all those potentially affected by backflow flooding have responsibility for oversight of the maintenance of the device in working order, and
>
> No backflow prevention device should be incorporated into the stormwater network system unless a complete risk based flood management analysis has confirmed that this is the best option.

The Board recommends that Council investigate the feasibility and appropriateness of establishing local levees to protect areas of strategic significance such as the Rocklea Markets. This will require a complete risk based flood management analysis.

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CONCLUSION

The Queensland Government (Department of Emergency Services) has enunciated concepts and principles for disaster management that is in accordance with the Federal Government and accepted international guidelines. These concepts and principles detail the requirement for a "Comprehensive and Integrated" approach to disaster management.

The Comprehensive approach recognises that dealing with the risks to community safety and sustainability requires a range of strategies that provide a balanced approach to prevention, preparedness, response and recovery.

The Integrated approach recognises that no single agency has the capacity to deal with the disruption to community life and infrastructure that can result from a disaster event. As such, an integrated approach requires the effective coordination of activities of a large number of organisations and agencies within and across all levels of government and of Non Government Organisations. The Integrated approach also recognises the importance of a prepared community which can take measures to increase resilience during the prevention and preparedness phases, as well as provide self help and help to others during the response and recovery phases.

The Board is of the view that Council has a well developed set of disaster management arrangements, which are congruent with Commonwealth and Queensland Government legislative and policy requirements and accord with the principles of best practice disaster management. The Council's disaster management arrangements are well resourced and reflect the application of very sound personnel and training policies.

Council's response to the second worst Brisbane flood in more than 100 years can be described as of a very high order including a consistent pre-flood public information program which had commenced in 2006 following the acceptance of the Recommendations by the Lord Mayor's Taskforce on Suburban Flooding, and was reiterated with urgency in November 2010; the development of clear and effective set of strategic directions as the flood loomed; the implementation of a broad based public information program during the flood; the provision of vast quantities of sandbags to assist with prevention; and the establishment of two large evacuation centres to shelter and care for those forced from their homes.

The arrangements fostered flexibility and the use of initiative at the local level. Council staff and assets were deployed efficiently in the Central Business District and in the suburbs, except initially in Pullenvale Ward while it was isolated. The mutual cooperation with other agencies at numerous localities throughout the city deserves commendation.

As the waters subsided Council organised a volunteer cleanup program for private dwellings, small business premises and Council Parks. The people of Brisbane came forward in their thousands to assist in cleaning up homes and streets, while Council arranged a massive waste collection and disposal effort to remove hundreds of tonnes of waste and debris. During this time Council developed and implemented a strategy for recovery which is ongoing.

Parts of Brisbane have been settled on the river's flood plain where a large number of residential commercial and industrial buildings have been built. The majority of these buildings were constructed prior to the January 1974 flood and the adoption of the Defined Flood Level in 1978. It is sobering to realise that no matter how comprehensive Brisbane's flood disaster management arrangements are, or how effective the response to a flood event is, flooding will occur in the Brisbane River. Floods similar in magnitude to and even greater than, the January 2011 flood will probably occur in the future and will inundate these areas again.

In this context, Council's pre-flood public warnings regarding the possibility of serious flooding, its robust disaster management arrangements, together with their regular updating and refinement, are essential elements of Council's continuing service to the citizens of Brisbane.

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Chronology

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Terms of Reference (including Glossary)

REVIEW OF THE BCC RESPONSE TO BRISBANE FLOOD EVENT

Brisbane City Council (BCC) will review its response to the flood event in Brisbane during the period Sunday 9 January – Saturday 22 January 2011. BCC is establishing a Flood Response Review Board to undertake this review.

The Board will consist of:

- Major General (Retd) Peter Arnison AC, CVO
- [redacted]
- Emeritus Professor Colin Apelt

Context
The review is to establish the characteristics of the flood and the resultant levels (including a comparison against the Q100 flood level). These characteristics will provide the context against which the review is to be undertaken.

The review will focus on:

- Effectiveness of BCC's disaster management arrangements (including the Local Disaster Management Group and Local Disaster Coordination Centre)
- The impact of the existing planning regulations in flood affected areas
- Command, control, coordination & communications
- Effectiveness and timeliness of public warnings and advice
- Information management (including GIS, flood modelling and monitoring systems) and ICT arrangements
- Effectiveness of flood prevention and stormwater infrastructure
- Analysis of the reasons for BCC's riverine infrastructure failures
- Integration of Council's response with other agencies
- Effectiveness of the response, including:
    - Field operations
    - Evacuation
    - Intelligence management and dissemination
    - Forward planning
    - Management of supporting agencies
    - Logistics planning and procurement arrangements
    - Contractor support and management
    - Management of volunteers (individuals through to large commercial support)
    - Waste and debris management and disposal
    - Transition to recovery
- Other issues (ie activation & escalation) are to be noted in the report.

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Internal aspects are to include consideration of:

- Clarification of roles & responsibilities
- Systems & data (for collecting, modelling, collating and sharing data)
- Emergency shelters / one-stop-shops and recovery centres and
- Communications between the LDCC and operationally deployed elements (multiple RIMT's)
- Interaction between LDCC (FOG, DIG and ISG), FPG, RIMT's and Recovery Committees

External aspects are to include consideration of:

- Systems & data - (for collecting, collating and sharing data with other agencies)
- The division of responsibilities for emergency shelters / one-stop-shops and recovery centres
- Council's relationship with LDMG and the wider disaster management system (including the DDCC and SDCC)

The review activities are to include:

- Facilitated debrief sessions
- Review of LDCC information (logs and other documentation)
- Briefing reports from business units if available
- Interviews of BCC persons (including LM, CEO, Incident Controllers & LDCC personnel, RIMT commanders and peer executives)
- Interviews of key external stakeholders
- Attendance at CEO debrief session
- Limited interviews with a representative sample of residents across the inundation area

The Final Report will be produced by early May 2011.

The report is to summarise the key findings regarding Council's response to the flood events that occurred from Sunday 9 – Saturday 22 January 2011, to document observations and to make recommendations on amendments to plans, procedures, roles and responsibilities, and on improvements that will enhance BCC's disaster management arrangements and the response to future events.

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Glossary

BCC	Brisbane City Council
CEO	Chief Executive Officer
DDCC	District Disaster Coordination Centre
DIG	Disaster Intelligence Group
FOG	Field Operations Group
FPG	Forward Planning Group
GIS	Geospatial Information Services
ICT	Information and Communication Technology
ISG	Incident Support Group
LDCC	Local Disaster Coordination Centre
LDMG	Local Disaster Management Group
LM	Lord Mayor
RIMT	Regional Incident Management Team
SDCC	State Disaster Coordination Centre

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Chronology of Key Events

A chronology of events and key dates is listed below

Sunday 9 January 2011

Heavy rainfall being experienced across the catchment

Local Disaster Coordination Centre (LDCC) activated at 9pm to Level 3

Monday 10 January 2011

Council Warning Order issued outlining situation, likely tasks and organisational structures

5000 letters sent to potentially flood-affected households

High demand for sandbags

River ferry operations ceased at 8.15pm

Call Centre recorded 10,000 calls

Council website experiencing difficulties due to significantly increased demand

Tuesday 11 January 2011

Premier's Announcement of Disaster Declaration

Brisbane City Council Local Disaster Management Group (BCLDMG) convened for first meeting

LDCC activation raised to Level 4

Approximately 53,000 sandbags distributed

Lord Mayor directs commencement of evacuation planning and RNA confirmed as first evacuation centre

Temporary Council website available

Council media release, sandbag availability and flood map detail

Community Service Announcements (CSAs) relating to street flooding, closure of Council libraries and residents encouraged to assist neighbours and friends

Letterbox drops commenced

Floating Riverwalk closed

LDCC discussions with Volunteering Queensland to coordinate volunteer effort

Lord Mayor directs flood modelling for very severe flood event

Wednesday 12 January 2011

Brisbane River prediction is 9,500m^3/s at Brisbane City Gauge

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Approximately 23,300 properties estimated to be inundated

Approximately 67,100 sandbags distributed

Evacuation centres situation: RNA: 305 evacuees, QE2: 105 evacuees

BCLDMG briefed on possibility of Floating Riverwalk breaking free

Lord Mayor's media release, residents likely to be affected by flooding urged to evacuate

Final prediction of flood peak advised by Bureau of Meteorology (BoM) at 5.5m AHD at the Brisbane City Gauge for Thursday 13 January 2011 at around 4am

Thursday 13 January 2011

The peak flood level of 4.46m AHD at the Brisbane City Gauge was reached at approximately 4:00am.

Floating Riverwalk breaks free

Arrangements confirmed for aerial photography of Brisbane River and inundated areas

Regional Incident Management Team (RIMT) West unable to access the far western regions

Approximately 4am a downstream section of the Floating Riverwalk broke free

Council media release about waste services update

Community Service Announcements relating to advice for residents in isolated areas of the western suburbs

River peak level revised down by BoM to under 5m

CEO indicated the start of the recovery effort

Forward Planning Group (FPG) identifies priorities for recovery: Phase 1 re-establish essential services, information gathering and debris clearance of main thoroughfares, Phase 2 evacuees commence to return home, assess and repair Council assets and move to recovery.

Friday 14 January 2011

Australian Defence Force (ADF) deployed across Brisbane

Lord Mayor's media releases regarding hazardous material, waste and debris disposal, and volunteer support

Trans Link announces free public transport for one week

Rapid Assessment Teams deployed to assess damage and inform priorities

Evacuation Centres: RNA Showgrounds: 994 evacuees, QEII Stadium: 419 evacuees

Flood waters receding to below 2.2m at the Brisbane City Gauge with a few hundred properties continuing to be flooded

Saturday 15 January 2011

Around 12,000 volunteers registered for cleanup tasks

Council transfer stations free for waste disposal

Food drops to Mt Crosby area in the western suburbs

Approximately 28,500 customers without electricity

Sunday 16 January 2011

10,389 registered volunteers for cleanup tasks

Rocklea Markets scene of major cleanup effort

Evacuation centres: RNA Showgrounds: 277 evacuees, QEII Stadium: 200 evacuees

Monday 17 January 2011

800 soldiers deployed across Brisbane for cleanup and associated tasks

Brisbane ferry operations suspended until further notice due to infrastructure damage

Bus and train services recommenced

Evacuation centres: RNA Showground: 180 evacuees, QEII Stadium: 120 evacuees

Tuesday 18 January 2011

Vaccination clinics set up at recovery centres

Rapid damage assessments continue by Queensland Fire and Rescue Service (QFRS) and Council Rapid Assessment Teams

Approximately 12,535 customers without electricity

Wednesday 19 January 2011

Bridge inspections commence

Evacuation centres: RNA Showground: closing 5pm, QEII Stadium: 87 evacuees

Thursday 20 January 2011

2500 volunteers vaccinated since 15/1

Approximately 3700 customers without electricity

Friday 21 January 2011

Approximately 885 customers without electricity

107,000 tonnes of flood-related waste deposited in landfills

31,300 insurance claims submitted to date across Queensland, approximately 50% from Brisbane

Navy sweeping for obstacles in Moreton Bay

Saturday 22 January 2011

Final BCLDMG meeting held

Coronation Drive being scanned by radar following formation of sink-hole

17 land slips identified across Brisbane

Evacuation centres closed

Navy completes survey of Moreton Bay

LDCC to Level 3 on Monday 25 January 2011

References

The following documentation was referenced during this review:

Title	Document Owner/Author	Date/Version	Source
Disaster Management Act 2003 (Qld)			Office of Queensland Parliamentary Counsel Website
Public Preservation Safety Act 1986 (Qld)			Office of Queensland Parliamentary Counsel Website
Sustainable Planning Act 2009 (Qld)			Office of Queensland Parliamentary Counsel Website
Integrated Planning Act 1997 (Qld)			Office of Queensland Parliamentary Counsel Website
City of Brisbane Act 1924 (Qld)			Office of Queensland Parliamentary Counsel Website
Building Act 1975 (Qld)			Office of Queensland Parliamentary Counsel Website
City of Brisbane Act 2010 (Qld)			Office of Queensland Parliamentary Counsel Website
The Australian Emergency Manual Series (Cwth)			Commonwealth Attorney General's Department
The State Planning Policy 1/03 – Mitigating the Adverse Impacts of Flood, Bushfire and Landslide	Queensland Government Department of Emergency Services	June 2003	Queensland Department of Community Safety Website (10 Feb 2011)

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Title	Document Owner/Author	Date/Version	Source
The State Disaster Management Group Guidelines			Queensland Government
Brisbane Floods January 1974 –	Australian Government Publishing Service Canberra	January 1974	Bureau of Meteorology
Annual Climate Summary for Queensland 2010		4 Jan 2011	Bureau of Meteorology
Annual Climate Summary for Brisbane Metro 2010		4 Jan 2011	Bureau of Meteorology
January 2011 Flood Event – Report on the operation of Somerset Dam and Wivenhoe Dam		2 March 2011	Seqwater
Review of Brisbane River Flood Study – Report to Brisbane City Council		3 Sept 2003	Independent Review Panel
Joint Flood Taskforce Report March 2011		8 March 2011	Brisbane City Council
Brisbane River Flood Study: Further investigation of flood frequency analysis, incorporating dam operations and CRC-FORGE rainfall analysis – Brisbane River (Final issue)		December 2003	SKM
Lord Mayor's Taskforce on Suburban Flooding Report	Brisbane City Council	Aug 2005	Brisbane City Council
January 2011 Flood Disaster Draft Performance Review		17 March 2011	GHD
Engineering Solutions for Flood Mitigation in Brisbane		February 2011	GHD
Summary Report Brisbane City Council Flood Response: Resident and Business Perceptions		28 February 2011	Fieldworx
[redacted] Y & R – Report on Social Media		9 February 2011	[redacted] Y & R

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14	Brisbane City Council Riverine Infrastructure

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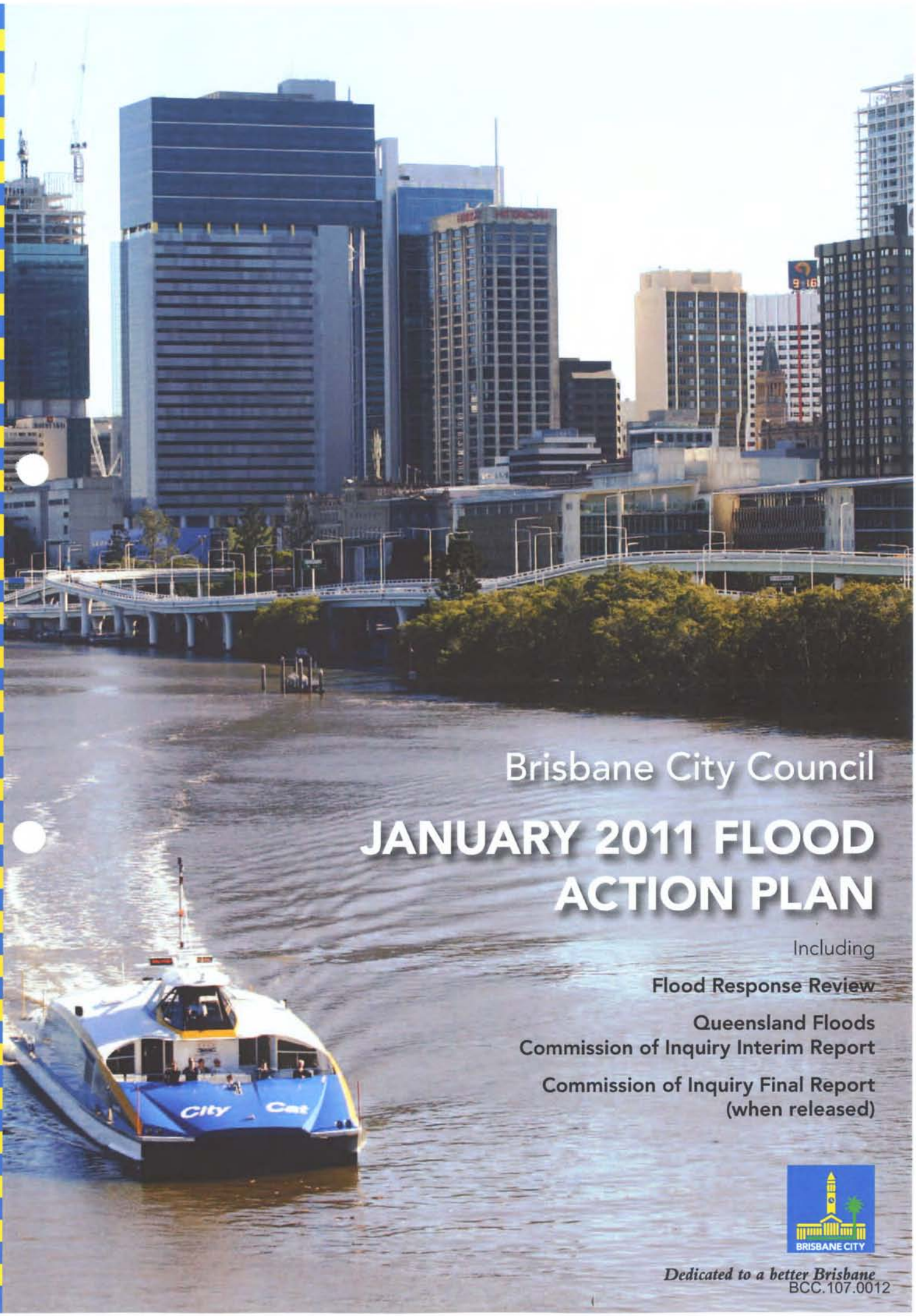

Brisbane City Council

JANUARY 2011 FLOOD ACTION PLAN

Including

Flood Response Review

Queensland Floods Commission of Inquiry Interim Report

Commission of Inquiry Final Report (when released)

BRISBANE CITY

Dedicated to a better Brisbane

BCC.107.0012

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A message from the Lord Mayor



Following the January 2011 floods, Brisbane City Council commissioned an independent Board to undertake a review of our performance during the natural disaster.

The Board reported in May and I indicated that a plan of action for its recommendations would be developed by 30 June.

Brisbane will always be prone to flood and storm events, but this action plan to address these findings will help make sure we are better able to prepare for and respond to future natural disasters.

This document details how Council is addressing each of the recommendations from the Flood Response Review Board, and the time frames for completion.

Prior to the report, Council already had a number of initiatives in place to improve our disaster management arrangements. We recently updated the FloodWise Property Reports with the January flood levels for 60,000 homes. The Joint Flood Taskforce has reviewed flooding standards and determined interim planning measures to ensure houses are built above flood heights recorded in January, and some 200 Council employees have since been provided with further disaster management training.

These initiatives build on the positive outcomes arising from the Report of the Lord Mayor's Taskforce on Suburban Flooding, published in 2005.

Council remains committed to assisting flood-affected residents, businesses and community groups to get back on their feet as quickly as possible. However, we are not just focused on fixing the flood damage – with this action plan we are delivering for our city's future.

Graham Quirk
LORD MAYOR
24 June 2011

Affirmations

The Board affirms Council's approach to its business as usual and risk management policies. The Board recommends that:

In relation to Council activities, Information Services Branch reviews its Business Continuity Plans (BCPs) to ensure the capacity exists to maintain the data centre, including an alternative site capable of taking over without delay and to maintain Council's website at all times, particularly during significant disasters.

AFF001.1

Council's Plan	Delivery Date
• Define web demand strategy	Completed
• Implement Phase 1 of the cloud infrastructure for website	June 2011
• Approve data centre strategy	August 2011
• Review and update Information Services Branch Business Continuity Plans	September 2011
• Implement Phase 2 of web demand strategy and finalise review of key business applications utilising the data centre strategy	October 2011

Line of business managers review BCPs to ensure their ongoing robustness and to capture any lessons learnt from the flood event.

AFF001.2

Council's Plan	Delivery Date
• Review and update all Business Continuity Plans with learnings from January 2011 floods	September 2011

Contracts and arrangements be reviewed to ensure that the business continuity plans for key external outsourced service and infrastructure providers are understood, robust and able to support Council during times of emergency and disaster.

AFF001.3

Council's Plan	Delivery Date
• Review all critical outsource contracts and arrangements to include a clause in their contracts ensuring they are able to support Council during times of emergency and disaster	October 2011

In relation to the Brisbane Central Business District and high-rise residential building inundation, that Council consider hosting a symposium for all affected parties with a view to identifying best practice approaches to ensure improved flooding resilience.

AFF001.4

Council's Plan	Delivery Date
• Plan symposium and book venue and speakers	June 2011
• Issue invitations	July 2011
• Conduct symposium	September 2011

The Board affirms Council's approach to training, exercising and workforce planning in relation to disaster management preparation. The Board recommends that further emphasis be placed on:

Individual and team training, including opportunities to attend Emergency Management Australia Disaster and Emergency Response courses.

AFF002.1

Council's Plan	Delivery Date
• Plan, develop and implement the Disaster Operations 12-month training schedule	Ongoing
• Plan, develop and implement the annual legislative training requirements (e.g. Local Disaster Coordination Centre exercises at level 3 and 4, Local Disaster Management Group exercise and Immediate Action Team exercise)	Ongoing
• Deliver training programs (e.g. Introduction to Queensland Disaster Management, Incident Management Training, Australasian Inter-service Incident Management System and Local Disaster Coordination Centre Essentials)	Ongoing
• External events, conferences and exercises available as programmed (e.g. Emergency Management Australia (EMA) and Australian Emergency management Institute (AEMI) Beyond Command and Control, Design and manage activities that exercise elements of emergency management and Coordinate resources within a multi-agency emergency response)	Ongoing
• Conduct exercise between Council's Crisis Communication Team and Local Disaster Coordination Centre	August 2011
• Conduct exercise between Regional Incident Management Teams and Local Disaster Coordination Centre to ensure new Standard Operating Procedures are effective and understood.	November 2011
• Update the Disaster Operations Learning Framework	December 2011

* The above "ongoing" milestones will run from July 2011 to June 2012 and be reported on quarterly

Workforce planning to reflect a needs analysis including disaster management related job descriptions, and a specific Council term be developed to describe "internal volunteers" to avoid confusion and to reflect the professional nature of the training and tasks.

AFF002.2

Council's Plan	Delivery Date
• Identify the training needs of disaster management related employee roles and job descriptions and include these in the updated training program, including an updated definition of internal volunteers	October 2011

Annual exercises continue to be conducted with a theme of "Brisbane Ready for Summer".

AFF002.3

Council's Plan	Delivery Date
• Implement annual "Brisbane Ready for Summer" exercise program	October 2011

The Board affirms the operations and workings of the Local Disaster Coordination Centre (LDCC) and, in particular, the integration of operations (tasking), intelligence, public information, logistics and the coordination with external supporting agencies. The Board recommends that:

Further training and development occur for senior appointments including LDCC Incident Controllers and group leaders as well as for more junior appointments.

AFF003.1

Council's Plan	Delivery Date
• Identify the senior Local Disaster Coordination Centre Incident Controllers and Group Leaders, as well as more junior appointments, and deliver training	October 2011

The Disaster Intelligence Group's structure, manning and core competencies be reviewed and further staff training be conducted.

AFF003.2

Council's Plan	Delivery Date
• Review and update the Disaster Intelligence Group Standing Operating Procedures and competencies	July 2011
• Create and deliver new training material	August 2011
• Conduct training	October 2011
• Test new Standard Operating Procedures in a simulated disaster activity to ensure new procedures are effective and understood	November 2011

The Forward Planning Group's responsibilities to the Brisbane City Local Disaster Management Group (BCLDMG) and to the LDCC be examined to remove ambiguity.

AFF003.3

Council's Plan	Delivery Date
• Review and amend the Forward Planning Group Standard Operating Procedures	July 2011
• Test new Standard Operating Procedures in a simulated disaster activity to ensure new procedures are effective and understood	November 2011

Enhancements to process be implemented including:

Ensuring that Situation Reports are well drafted and widely distributed on a regular basis using multiple communications channels.

AFF003.4

Council's Plan	Delivery Date
• Update the Local Disaster Coordination Centre and Regional Incident Management Team situation report procedures and distribution lists	October 2011
• Test new Standard Operating Procedures in a simulated disaster activity to ensure new procedures are effective and understood	November 2011

Developing a readily accessible database of frequently asked questions to address "who does what" to support the LDCC staff and agencies (this could also include information available on Council's Call Centre database).

AFF003.5

Council's Plan	Delivery Date
• Develop a readily accessible database of frequently asked questions to address "who does what" to support the Local Disaster Coordination Centre staff and agencies	September 2011

Synchronising the shifts of Council and agencies staff working in the LDCC to better facilitate handover briefings.

AFF003.6

Council's Plan	Delivery Date
• Create common Standard Operating Procedures for Local Disaster Coordination Centre and business unit shifts	September 2011
• Test new Standard Operating Procedures in a simulated disaster activity to ensure new procedures are effective and understood	November 2011

Improvements to logging incoming and outgoing information and tasking.

AFF003.7

Council's Plan	Delivery Date
• Identify opportunities for improvement to logging of incoming and outgoing information and tasking	July 2011
• Update Standard Operating Procedures for logging of incoming and outgoing information and tasking	September 2011
• Test new Standard Operating Procedures in a simulated disaster activity to ensure new procedures are effective and understood	November 2011

Formalising the written briefing processes for handovers between shifts.

AFF003.8

Council's Plan	Delivery Date
• Create shift handover procedure and review email address lists for the Local Disaster Coordination Centre and Regional Incident Management Teams	September 2011
• Communicate the shift handover procedure	October 2011
• Test new Standard Operating Procedures in a simulated disaster activity to ensure new procedures are effective and understood	November 2011

The Board affirms Council's flood intelligence management and information dissemination arrangements. The Board recommends that Council undertake upgrades to the Flood Information Centre (FIC) along the following lines:

Review and update Standing Operating Procedures (SOPs), including a major update of selected Brisbane River and Creek Flooding SOPs, river flood maps and storm tide maps, property counts and critical infrastructure lists.

AFF004.1

Council's Plan	Delivery Date
• Scope the river flood maps project	July 2011
• Scope the critical infrastructure lists project	July 2011
• Revise the River Flooding Standard Operating Procedures	October 2011
• Create new Creek Flooding Standard Operating Procedures	October 2011
• Test new Standard Operating Procedures in a simulated disaster activity to ensure new procedures are effective and understood	November 2011
• Update the river flood maps, storm tide maps, property counts and critical infrastructure lists	December 2011

Upgrade the Brisbane River Flood Forecast Reporting System to the most extreme flood event (Probable Maximum Flood) and to include a flood forecast system for Brisbane creeks.

AFF004.2

Council's Plan	Delivery Date
• Complete scope of the project	October 2011
• Prepare Implementation Plan and Technological Requirements for system upgrade	June 2012
• Identify new system/processes for a Creek Flood Forecast System	June 2012
• Commence forecast reporting system	June 2013

Conduct additional training and exercises including with the LDCC and Queensland Government agencies, and develop better communications protocols.

AFF004.3

Council's Plan	Delivery Date
• Involve the Flood Information Centre in the Local Disaster Coordination Centre exercise, when Standard Operating Procedures will be tested in a simulated disaster activity to ensure new procedures are effective and understood	November 2011
• Scope requirements for a further Flood Information Centre exercise and training plan	December 2011
• Deliver the exercise and review/feedback session	June 2012
• Review and refine communication protocols where necessary	October 2012

Provide computers capable of GIS modelling tasks and 3D visualisation analysis.

AFF004.4

Council's Plan	Delivery Date
• Purchase and install computers	September 2011

Provide a dedicated flat screen television for situation awareness and news monitoring.

AFF004.5

Council's Plan	Delivery Date
• Purchase and install flat screen television	September 2011

The Board affirms Council's approach to implementing a range of early warning systems and alert measures across a number of delivery channels.

The Board recommends that Council examine and develop the range and variety of early warning systems and alert measures; including the proposed National Emergency Warning System, social media platforms and further improve the effectiveness of door knocking.

AFF005.1

Council's Plan	Delivery Date
• Identify opportunities to expand the Early Warning Alert Service	August 2011
• Investigate and implement if suitable the use of crowd-sourcing tools to improve the ability to collate, intelligently analyse and distribute information	September 2011
• Identify opportunities for improvement to alert measures and methods	October 2011
• Contract additional services if required	October 2011
• Update Standard Operating Procedures if required	October 2011

BCC.107.0022

The Board affirms the contribution of region-based RIMTs noting that they provide a critical layer in the command and control structure for dealing with the on ground situation, managing local resources and coordinating external resources allocated to them. The Board recommends that:

A senior officer be assigned to mentor each Regional Incident Management Team Manager and conduct high level discussions with the LDCC.

AFF006.1

Council's Plan	Delivery Date
• Continue to assign a senior officer to the Regional Incident Management Teams and update Standard Operating Procedures	October 2011

Dedicated Regional Incident Management Team operations rooms be established.

AFF006.2

Council's Plan	Delivery Date
• Identify and assess suitability of Regional Incident Management Team sites	August 2011
• Update the Standard Operating Procedures for Local Disaster Coordination Centre and Regional Incident Management Teams	October 2011
• Establish the ability (and facilities) to 'stand up' the Regional Incident Management Team operation room(s) at short notice	October 2011
• Test new Standard Operating Procedures in a simulated disaster activity to ensure new procedures are effective and understood	November 2011

Planning for alternative Regional Incident Management Team sites, in the event that the primary sites become unusable, be conducted.

AFF006.3

Council's Plan	Delivery Date
• Identify possible alternative Regional Incident Management Team sites	August 2011
• Assess suitability of alternative Regional Incident Management Team sites	August 2011
• Formalise arrangements with current owners of sites	September 2011
• Develop a contingency plan for relocation in the event that a Regional Incident Management Team site becomes unusable	September 2011
• Update the Regional Incident Management Team Standard Operating Procedures to include the Regional Incident Management Team site contingency plan, and complete an alternative site relocation plan	October 2011
• Approve alternative Regional Incident Management Team sites	June 2012

The Board affirms Council's planning for and implementation of evacuation centres as detailed in the Disaster Management Plan. The Board recommends that further consideration be given to refining Council's evacuation centre planning to address:

Greater decentralisation of evacuation centres, particularly for communities that are known to be prone to isolation by flooding.

AFF007.1

Council's Plan	Delivery Date
• Environmental Health Officer to audit Council-owned sites	Completed
• Environmental Health Officer to audit private-owned sites	June 2011
• Environmental Health Officer to provide an updated full information brief on each of the identified existing sites	July 2011
• Work with the locally elected officials, community groups and Queensland Police Service to consider establishing Community Support Centres / Community Information Centres	October 2011
• Complete interim Isolated Communities Sub-Plan of the Disaster Management Plan	October 2011
• Implement final Isolated Communities Sub-Plan of the Disaster Management Plan, following community and key stakeholder engagement	November 2011

Early and close liaison with Red Cross, particularly in regard to registration of evacuees and vetting of volunteers.

AFF007.2

Council's Plan	Delivery Date
• Memorandum of Understanding with Red Cross in place	Completed
• Review the Memorandum of Understanding Standard Operating Procedures for evacuee registration and volunteer/staff vetting, and amend the Memorandum of Understanding as required	October 2011

Early and close liaison with Queensland Police Service (QPS) in regard to exclusion of persons not suitable to be in a general public evacuation centre.

AFF007.3

Council's Plan	Delivery Date
• Review the Red Cross Memorandum of Understanding and update the Standard Operating Procedures regarding Queensland Police Service's role	July 2011

The special needs of frail, aged, incapacitated, nursing home and oxygen-dependant evacuees for whom separate and special arrangements need to be made.

AFF007.4

Council's Plan	Delivery Date
• Update the Evacuation & Emergency Human Services Plan and Standard Operating Procedures to include information on how to manage special needs evacuees	August 2011

Social, cultural and religious diversity of evacuees, including those with a non-English speaking background.

AFF007.5

Council's Plan	Delivery Date
• Update the Evacuation & Emergency Human Services Plan and Standard Operating Procedures	October 2011

Purchase and supply of special items such as personal hygiene kits and baby requisites.

AFF007.6

Council's Plan	Delivery Date
• Update the Evacuation & Emergency Human Services Plan and Standard Operating Procedures	October 2011

The Board affirms Council's action in rapidly increasing sandbag production to a total of more than 390,000.

The Board recommends that estimates be developed of likely sandbag demand for regions during future flood events and that the best situated potential sites for filling and distribution points in each region be identified.

AFF008.1

Council's Plan	Delivery Date
• Develop flooding scenarios (river, king tide and creek)	July 2011
• Estimate sandbag requirements based on flooding scenarios	August 2011
• Develop processes to determine how these would best be deployed	September 2011
• Amend Local Disaster Coordination Centre Standard Operating Procedures	October 2011

BCC.107.0026

The Board affirms Council's collaborative efforts with QPS and the Australian Defence Force (ADF) in providing a workable framework for overall traffic management.

The Board recommends that the Council consider developing advanced plans, in consultation with QPS, to improve traffic flow in flood recovery congested areas including converting some streets into one way, route designation for heavy vehicles and identification for residents' vehicles.

AFF009.1

Council's Plan	Delivery Date
• Procure four more radio base stations	Completed
• Work in consultation with Queensland Police Service to assist in the development of relevant and suitable Traffic Management Plans	October 2011

Recommendations

The Board recommends that the term, DFL, be used exclusively in public documents concerning flood planning levels for Brisbane, regardless of the cause of the flooding.

REC001.1

Council's Plan	Delivery Date
• Conduct a risk based review of all documents and identify critical and non-critical documents to be reviewed and amended	October 2011
• Implement the use of Defined Flood Level terminology in critical documents	December 2011
• Evaluate options and make recommendations for amendments to non-critical documents	February 2012
• Develop an implementation plan and implement amendments to non-critical documents	February 2012 onwards

The Board recommends that Council use a more readily understandable description of flood levels (to reflect BoM descriptions).

REC002.1

Council's Plan	Delivery Date
This recommendation applies to event specific communications.	
• Ensure severe weather early warning alert message services are consistent with Bureau of Meteorology alerts	July 2011
• Develop an implementation strategy to address this recommendation based on an analysis of current flood level communication issues and existing communication products	October 2011
• Develop a community engagement strategy to determine and test the most effective flood level information	December 2011
• Implement strategy	October 2012

The Board recommends that effort continue to be put into providing more localised (property, street, suburb and Ward) information regarding inundation and flood level forecasts through a range of channels including the Early Warning Alert Service EWAS, Floodwise Property Report and Flood Flag Maps (including rate notices to draw attention to the existence of the Floodwise Property Report) and flood markers.

REC003.1

Council's Plan	Delivery Date
• Incorporate a registration drive for Early Warning Alert Service as part of Council's ongoing community education programs including the "Summer Storm" campaign	Completed
• Develop interim flood level maps based on the Temporary Local Planning Instrument	Completed
• Update FloodWise Property Reports to refer to both the Defined Flood Level and the 2011 flood levels	Completed
• Include information in Council rates notices directing residents to the availability of flood information	Completed
• Provide localised information from the Brisbane River Flood Forecast Reporting System, including information for individual properties to enable property owners to determine when water may enter their property	Ongoing
• Investigate additional methods by which this information can be more widely disseminated to the community	Ongoing
• Undertake feasibility study to determine additional information to be incorporated into the existing FloodWise Property Reports, such as a king tide flood flag, creek names and two year Average Reoccurrence Interval (50% chance) flood levels for each property	September 2011
• Investigate the opportunity to reflect gauge height information for the three gauge locations at City, Jindalee and Moggill, in a range of information products including media releases, website information and amendments to the FloodWise Property Reports to link to the Brisbane River Flood Forecast Reporting System	November 2011
• Install flood markers throughout Brisbane	December 2011
• Implement additional functionality/information into FloodWise Property Reports	June 2012

The Board recommends that the Flood Flag Map be further developed to enable NearMap data obtained on the morning of 13 January 2011 to be included and accessed.

REC004.1

Council's Plan	Delivery Date
• Investigate the opportunity to display additional information on the Flood Flag Maps	November 2011

The Board recommends that Council investigate the Flood COP system and examine its utility, in conjunction with hand held devices, to improve the efficiency and effectiveness of data collection, the provision of information, the prioritisation of tasks and the deployment of resources.

REC005.1

Council's Plan	Delivery Date
• Investigate new systems/products	September 2011
• Test systems	December 2011
• Develop business case to purchase product	January 2012
• Implement then train staff in new system	June 2012

The Board recommends that Council further develop its capabilities to produce flood maps for a larger set of scenarios based on a range of 2000 to 20,000 m^3/s in electronic and hard copy format.

REC006.1

Council's Plan	Delivery Date
• Scope the project	July 2011
• Produce additional interim maps	December 2011
• Investigate improved technology solution and develop and deliver maps	June 2012

The Board recommends that Council review the disaster management arrangements for a major flooding situation as they apply to Pullenvale Ward.

REC007.1

Council's Plan	Delivery Date
• Identify opportunities for improvement	August 2011
• Develop Isolated Communities Sub-Plan of the Disaster Management Plan to include Pullenvale Ward, following engagement with locally elected officials, community groups and Queensland Police Service	November 2011

The Board recommends that Council review the disaster management arrangements for a major flooding situation as they apply to Tennyson Ward to ensure the ongoing provision of a flood-free Ward Office.

REC008.1

Council's Plan	Delivery Date
• Investigate and develop preferred option	August 2011

The Board recommends that Council examine appropriate ways for Councillors to assist during disaster events, particularly given their community leadership responsibilities and their detailed local knowledge of circumstances and capabilities that exist in their Wards, in a way which does not cut across the existing and appropriate arrangements detailed in Council's disaster management arrangements.

REC009.1

Council's Plan	Delivery Date
• Document the needs and responsibilities of Councillors	August 2011
• Update Standard Operating Procedures to include a Councillor Liaison cell in the Local Disaster Coordination Centre	October 2011
• Provide Councillor briefing	October 2011

The Board recommends that permanent flood markers be installed on key roads that are known to become flood affected to complement other public awareness and safety campaigns.

REC010.1

Council's Plan	Delivery Date
• Identify marker installation locations	August 2011
• Design and document markers	August 2011
• Manage the manufacture and installation of markers	January 2012

The Board recommends Council develop a process for handling donated goods separately from evacuation centres.

REC011.1

Council's Plan	Delivery Date
• Develop a process for handling donated goods separately from evacuation centres and incorporate in the Volunteer Guidelines	October 2011

The Board recommends Council implement strategies in relation to volunteer clean up activities for:

Development of a proforma briefing sheet for volunteers based on experience gained in this flood event.

REC012.1

Council's Plan	Delivery Date
• Develop a pro forma briefing sheet for flood volunteers	October 2011

Identification of house team leaders to liaise with residents so that clean up activity is in accordance with the residents' wishes.

REC012.2

Council's Plan	Delivery Date
• Develop Volunteer Guidelines	October 2011

Ensuring the provision of appropriate health care arrangements to accompany deployed volunteer groups.

REC012.3

Council's Plan	Delivery Date
• Develop Volunteer Guidelines	October 2011

In conjunction with QPS, developing processes to ensure the security of flooded residents' dwellings during volunteer cleanup activity.

REC012.4

Council's Plan	Delivery Date
• Develop Volunteer Guidelines	October 2011

Making provision for a co-ordination cell within the LDCC particularly for individual volunteers.

REC012.5

Council's Plan	Delivery Date
• Develop Volunteer Guidelines	October 2011

The Board recommends that Council develop a comprehensive single list of potential sites suitable for temporary waste collection, incorporate a liaison officer from the CWS team into the LDCC; and strengthen the link between procurement and waste management during a disaster by establishing a dedicated liaison officer position in the City Waste Services (CWS) team.

REC013.1

Council's Plan	Delivery Date
• Develop a comprehensive single list of potential sites suitable for temporary waste collection	October 2011
• Update Standard Operating Procedures to include City Waste Services Liaison Officer(s) in the Local Disaster Coordination Centre	October 2011

The Board recommends that, in relation to planning, Council undertake a complete Flood Risk Management analysis for the area of Brisbane affected by flooding from the Brisbane River and associated tributaries in line with National Flood Risk Advisory Group (NFRAG) and other relevant guidelines. This would require a detailed assessment of the benefits and costs of a full range of flood mitigation options.

REC014.1

Council's Plan	Delivery Date
• Council would support being a part of a State Government led project to complete a Flood Risk Management analysis for the area of Brisbane affected by flooding, as part of or following a whole of Brisbane River catchment hydrology and flood study. This is expected to be an expensive and long-term project. Council notes that the Queensland Floods Commission of Inquiry is likely to recommend a similar approach. These comprehensive studies should include a whole of Brisbane River Catchment flood study, which extends beyond the Dam catchments, and includes tributaries such as the Bremer River and Lockyer Creek along with major creek inflows such as Oxley Creek. Council considers that it is a necessary stakeholder in this process. This process will be part of the likely discussions between relevant parties arising out of the work of the Queensland Floods Commission of Inquiry.	August 2011

The Board recommends that:

Council investigate the feasibility of the installation of devices to prevent backflow from river flooding in locations such as in parts of the Central Business District (CBD) and in high rise buildings which would not have been flooded otherwise, where all those potentially affected by backflow flooding have responsibility for oversight of the maintenance of the device in working order.

No backflow prevention device should be incorporated into the stormwater network system unless a complete risk based flood management analysis has confirmed that this is the best option.

REC015.1

Council's Plan	Delivery Date
• Scope project and gather data to inform the potential application of backflow prevention technology in three case study areas being the Central Business District, Rosalie/Milton and New Farm areas	July - August 2011
• Seek community input on backflow issues in the three case study areas via Talk to Council sessions, Living in Brisbane newsletter and direct mail	September 2011
• Conduct technical investigations to assess the risks, issues and opportunities associated with backflow prevention technology in the three case study areas. There will be further community consultation in each of the case study areas at the conclusion of the technical investigations.	October 2011 - May 2012
• Concurrently, carry out a desktop review to identify other sites across the city that flooded in January 2011 which may warrant a more detailed investigation and analysis as detailed above. The desktop review will be followed by community consultation in identified areas.	August - December 2011

The Board recommends that Council investigate the feasibility and appropriateness of establishing local levees to protect areas of strategic significance such as the Rocklea Markets. This will require a complete risk based flood management analysis.

REC016.1

Council's Plan	Delivery Date
• Council supports the investigation by property owners to assess the feasibility and appropriateness of establishing levees. Council will provide a framework to be used by property owners who wish to undertake this assessment. This may include hydrological assessments to be undertaken on a user pays basis. Construction of levees would be the responsibility of the asset owner. Council will work collaboratively with areas of strategic significance, such as the Rocklea Markets, to undertake risk based flood management analysis.	October 2011

ADDENDUM 1

Queensland Floods Commission of Inquiry
Interim Report Recommendations

BCC.107.0035

A message from the Lord Mayor



On 1 August 2011, the Queensland Floods Commission of Inquiry released an interim report on the 2010/2011 flood events.

The interim report examines all levels of government and all aspects of response to the state-wide floods, and makes 175 recommendations to improve flood preparedness before the next wet season.

The Commission of Inquiry reiterates findings from the Flood Response Review, backing Council's communication with residents, including social media, the Brisbane Early Warning Alert Service and doorknocking homes before the flood.

A number of the Commission's recommendations for local government were already in place or have been acted upon as part of Brisbane City Council's Flood Response Review Action Plan.

This addendum to the Flood Response Review Action Plan lists the 74 Commission of Inquiry interim report recommendations relevant to Brisbane City Council and how they are being addressed.

A full copy of the interim report is available on the Queensland Floods Commission of Inquiry website – www.floodcommission.qld.gov.au.

The January 2011 Flood Action Plan continues Council's work to ensure that the city of Brisbane is better prepared to deal with and recover from natural disasters in the future.

Graham Quirk
LORD MAYOR
16 August 2011

BCC.107.0036

Commission of Inquiry interim report recommendations that were already in place or have been implemented by Brisbane City Council

3.4 Every local government susceptible to flooding should ensure that, before the next wet season, its local disaster management plan:

- is consistent with the *Disaster Management Act 2003*
- addresses local risks and circumstances
- can be used easily in the event of a disaster.

COI023.1

Council's Action	Delivery Date
• Continue to publish Council's Disaster Management Plan on website	Completed
• Continue the Disaster Management Plan review process	Completed

3.6 Every local government should publish its disaster management plan (and relevant sub-plans) on its website before the next wet season.

COI024.1

Council's Action	Delivery Date
• Continue to publish Council's Disaster Management Plan on website	Completed
• Continue the Disaster Management Plan review process	Completed

4.2 Councils should prepare SMS alert templates covering a range of different flood scenarios before the wet season.

COI026.1

Council's Action	Delivery Date
• Continue to use Council's pre-prepared Early Warning Alert Service and Creek Flooding Alert Service SMS templates for a range of different disaster scenarios	Completed

4.6 Individuals and businesses should be encouraged to acquire battery operated radios for use in emergencies.

COI027.1

Council's Action	Delivery Date
• Continue to incorporate into the "Brisbane Ready for Summer" campaign	Completed
• Continue to publish on Council's website	Completed

4.8 Councils that have not already done so should consider how social media may be used effectively to provide accurate information about flood levels and local conditions to residents during a flood event.

COI029.1

Council's Action	Delivery Date
• Continue to incorporate social media in crisis communications	Completed

4.11 Councils, with the assistance of the Bureau of Meteorology, should consider the susceptibility of their regions to flash flooding, and whether it is feasible and necessary to acquire and operate an automated local evaluation in real time system (ALERT system) for particular waterways.

COI031.1

Council's Action	Delivery Date
• Continue with the four creek ALERT systems currently in place	Completed
• Continue with plan to deliver six additional creek ALERT systems	June 2012

4.15 Each local disaster management group should include in its meetings a representative of the operator of any dam upstream of its region which contributes water to flooding.

COI032.1

Council's Action	Delivery Date
• Identify upstream dam operators or their representatives	Completed
• Include upstream dam operators or their representatives and the Water Grid Manager in Local Disaster Management Group meetings	Ongoing

5.1 When a local government cannot effectively manage its response to a disaster, disaster management personnel from local governments in a position to assist should be deployed to help the local disaster management group.

COI033.1

Council's Action	Delivery Date
• Continue compliance with Queensland Disaster Management Arrangements and supply personnel to other local governments as required	Completed

5.3 To ensure effective co-ordination in larger-scale disasters, deployment of personnel (and other resources) between local governments should be facilitated through the Council to Council (C2C) program.

COI035.1

Council's Action	Delivery Date
• Continue to support other councils	Completed
• Review disaster management arrangements once guidance is received from the Queensland Government regarding the incorporation of C2C into Queensland Disaster Management Arrangements	TBA

5.55 All councils should consider entering a memorandum of understanding for evacuation centres with the Australian Red Cross which clearly sets out the roles and responsibilities of the parties in planning and responding to evacuation requirements in a disaster.

COI038.1

Council's Action	Delivery Date
• Memorandum of Understanding with Red Cross in place	Completed

5.56 Each council with a memorandum of understanding with the Australian Red Cross should consider undertaking practice exercises with the Australian Red Cross to ensure both parties understand their respective roles and responsibilities.

COI039.1

Council's Action	Delivery Date
• Continue to conduct testing and annual exercises with the Local Disaster Management Group and the Red Cross	Completed

5.57 Local disaster management groups and district disaster management groups of which the Australian Red Cross is not currently a member should include the Australian Red Cross in disaster preparation and planning as well as response, whether as a member or otherwise (see also recommendation 3.1).

COI040.1

Council's Action	Delivery Date
• Red Cross continue to be a member of the Local Disaster Management Group	Completed

5.58 Local and district disaster management groups should notify the Australian Red Cross of their evacuation needs as soon as possible in a disaster.

COI041.1

Council's Action	Delivery Date
• Memorandum of Understanding with Red Cross in place	Completed

5.59 Disaster response agencies should use the National Registration Inquiry System.

COI042.1

Council's Action	Delivery Date
• Memorandum of Understanding with Red Cross in place	Completed

6.1 Local, district and state disaster management groups should include essential services providers in their disaster planning and preparation and in their meetings at an early stage during disasters.

COI050.1

Council's Action	Delivery Date
• Continue to include essential services providers in disaster planning and preparation	Completed
• Continue to include essential services providers in Local Disaster Management Group meetings at an early stage during disasters	Completed

Commission of Inquiry interim report recommendations that are not yet addressed in Brisbane City Council's Flood Response Review Action Plan

2.27 Seqwater should act immediately to establish:

1. a steering committee to oversee the long term review of the North Pine manual including senior representatives of at least DERM, Seqwater, the Water Commission, the Water Grid Manager, Brisbane City Council and the Moreton Bay Regional Council
2. a technical review committee comprised of independent experts in at least hydrology, meteorology and dam operations to examine all technical work completed as part of the review.

COI020.1

Council's Plan	Delivery Date
• Remain a stakeholder in this recommendation	As required

2.28 The steering committee should:

1. oversee the continuation of *Seqwater's North Pine Dam Acceptable Flood Study Investigations* in accordance with the scope and program of activities advised to the Commission as at 6 May 2011
2. determine whether any hydrological studies, in addition to those undertaken as part of the *North Pine Dam Acceptable Flood Study Investigations*, are required
3. ensure that modelling across a range of full supply levels and operating strategies, including variations of the gate increments and gate opening intervals is undertaken
4. ensure all of the above work is reviewed by the technical review committee.

COI020.2

Council's Plan	Delivery Date
• Remain a stakeholder in this recommendation	As required

3.13 Before the next wet season, local governments susceptible to flooding should conduct community education programs which provide local information about (at least) the following topics:

- the measures households should take to prepare for flooding
- the roles and functions of the SES and details of how to contact and join it
- whom to contact if assistance is needed during a flood
- contact details for emergency services in the area
- the types of warnings that are used in the area, what they mean and what to do in the event of a warning
- where and how to obtain information before, during and after a disaster
- what is likely to happen during a disaster (for example, power outages and road closures)
- evacuation
- measures available for groups who require particular assistance (for example, the elderly, ill and people with a disability).

COI025.1

Council's Plan	Delivery Date
• Incorporate into the "Brisbane Ready for Summer" campaign	October 2011

4.7 Councils should ensure that residents are aware of the frequency of the radio station or stations in their local area that will disseminate flood warnings and other information during disasters.

COI028.1

Council's Plan	Delivery Date
• Incorporate into the "Brisbane Ready for Summer" campaign	October 2011

4.10 Councils, with the assistance of the Bureau of Meteorology, should examine the feasability of and priorities for installing additional river height and rainfall gauges in areas of identified need.

COI030.1

Council's Plan	Delivery Date
• Scope the project and methodology	October 2011
• Undertake feasibility study for additional river height gauges within Council boundaries	January 2012

5.2 Local governments should consider adopting uniform disaster management software, to enable inter-council assistance to be given more easily and effectively.

COI034.1

Council's Plan	Delivery Date
• Engage with Local Government Association of Queensland to consider adopting uniform disaster management software	October 2011

5.10 A clear protocol should be developed for managing the participation of local and district disaster management groups in the state level teleconferences, to govern and make more efficient participation in the teleconferences.

COI036.1

Council's Plan	Delivery Date
• Engage with Emergency Management Queensland to develop protocol	October 2011

5.32 Before the next wet season, councils, SES controllers and Emergency Management Queensland should work together to identify and address deficiencies in the ability of the SES to respond effectively to flooding. At the very least, suitable flood boats and flood boat training should be provided to SES units which require them.

COI021.1

Council's Plan	Delivery Date
• Conducted initial flood boat training session in conjunction with Emergency Management Queensland	Completed
• Work with Emergency Management Queensland to conduct further flood boat training sessions	February - March 2012

5.33 The Queensland Government and councils should take measures, as soon as possible, to attract more SES volunteers, particularly in areas susceptible to flooding which do not have sufficient numbers. New SES units should be established where possible.

COI022.1

Council's Plan	Delivery Date
• Identify location for and commence work to establish new depot	July 2012

5.43 It is a matter for councils whether or not they choose to publicise the location of evacuation centres before a disaster but there is a good deal to be said for doing so, particularly in smaller communities where the options are limited. Whether or not councils publicise the location of evacuation centres before a disaster, they should include in their disaster education programs information on evacuation procedures, and how to ascertain evacuation centre locations and safe evacuation routes.

COI037.1

Council's Plan	Delivery Date
• Review and update crisis communications procedures	December 2011

5.61 Councils should include information about the National Registration Inquiry System as part of their community education.

COI025.2

Council's Plan	Delivery Date
• Incorporate into the "Brisbane Ready for Summer" campaign	October 2011

5.69 The Queensland Government and councils should ensure information about emergency preparedness, warnings and evacuation is available in the different languages of ethnic groups in the community and in Auslan.

COI044.1

Council's Plan	Delivery Date
• Investigate options and select solution	December 2011
• Implement solution	March 2012

5.70 As part of their community education strategy, councils should ensure tourists are made aware of evacuation procedures, how to ascertain evacuation centre locations and safe evacuation routes. That may be done through tourism boards, operators and accommodation providers.

COI045.1

Council's Plan	Delivery Date
• Liaise with Tourism Queensland and other stakeholders as required	December 2011
• Develop a plan	June 2012

5.71 Councils, as part of their community education program for disaster preparation, should encourage pet owners to consider what they will do with their pets if they need to evacuate.

COI046.1

Council's Plan	Delivery Date
• Incorporate into the "Brisbane Ready for Summer" campaign	October 2011
• Include standard message on disaster event specific page on Council's website	December 2011

5.72 Councils should work with the RSPCA to develop plans about transporting and sheltering pets should they need to be evacuated with their owners.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11)

COI047.1

Council's Plan	Delivery Date
• Update the evacuation sub-plan	December 2011

5.73 Animal shelters, zoos, stables, and similar facilities should develop plans for evacuating or arranging for the care of animals in consultation with their local council. Local disaster co-ordinators should be aware of what plans exist.

COI048.1

Council's Plan	Delivery Date
• Liaise with appropriate State Government agencies to determine the relevant State Government agency policy lead for zoos, stables and similar facilities	October 2011
• Update evacuation sub-plan	December 2011

5.75 Before the 2011/2012 wet season, all local and district disaster management groups should formally adopt the Queensland Re-supply Guidelines and have arrangements in place for the prompt re-supply of towns, properties and residents isolated by floodwaters.

COI049.1

Council's Plan	Delivery Date
• Liaise with the District Disaster Management Group to determine the implementation strategy	November 2011
• Incorporate Queensland Re-supply Guidelines in Disaster Management Plan	December 2011

6.7 Brisbane Markets Limited should contact the Brisbane City Council on a regular basis in the lead-up to and during flooding to seek local flood information. In response, the council should provide readily understood information which, as far as possible, explains the level of flooding to be expected at the Rocklea Markets site.

COI051.1

Council's Plan	Delivery Date
• Establish a working relationship with Brisbane Markets Limited	September 2011

6.8 The Brisbane City Council should attend to the clearing of the flood mitigation channel on the western side of the market site before the next wet season.

COI052.1

Council's Plan	Delivery Date
• Debris cleared from the flood mitigation channel	Completed
• Clear vegetation from the flood mitigation channel, subject to Queensland Government environmental approvals	TBA

Commission of Inquiry interim report recommendations that are partially addressed in Brisbane City Council's Flood Response Review Action Plan but require additional work

2.10 Seqwater should act immediately to establish:

1. a steering committee to oversee the long term review of the Wivenhoe manual including senior representatives of at least DERM, Seqwater, the Water Commission, the Water Grid Manager, Brisbane City Council, Ipswich City Council and Somerset Regional Council
2. a technical review committee comprised of independent experts in at least hydrology, meteorology and dam operations to examine all technical work completed as part of the review.

Aligns with Flood Response Review Action Plan recommendation **REC014.1** (page 20)

Additional Council Plan	Delivery Date
• Representative on Seqwater steering committee	August 2011

2.11 The steering committee should ensure the scientific investigations and modelling outlined in recommendation 2.12 and 2.13 are completed. It should also assess the need for any other work to be done, and instigate any other investigations or work considered necessary for a full and proper review of the Wivenhoe manual.

Aligns with Flood Response Review Action Plan recommendation **REC014.1** (page 20)

Additional Council Plan	Delivery Date
• Representative on Seqwater steering committee	August 2011

2.12 The following scientific investigations should be carried out prior to modelling work under the supervision of the steering committee and reviewed by the technical review committee:

1. review of the design hydrology:
   a. using a stochastic or Monte Carlo or probabilistic approach
   b. taking into account observed variability in temporal and spatial patterns of rainfall
   c. taking into account observed variability in relative timings of inflows from the dams and downstream tributaries.
2. production of a digital terrain model incorporating a bathymetric survey of all critical sections of creeks and rivers upstream and downstream of the dam relevant to flood modelling
3. assessment of the reliability of the 24 hour, the three day and the five day rainfall forecasts
4. consideration of whether and how weather radar can be incorporated into decision making
5. requesting information from the Bureau of Meteorology as to its willingness to provide ensemble forecasts
6. consideration as to whether and how ensemble forecasts can be incorporated into decision making.

Aligns with Flood Response Review Action Plan recommendation **REC014.1** (page 20)

Additional Council Plan	Delivery Date
• Representative on Seqwater steering committee	August 2011

2.13 The following modelling work should be carried out under the supervision of the steering committee and reviewed by the technical review committee:

1. modelling across the range of full supply levels, operating strategies and flood events (historical, design and synthetic) in each case assessing the consequences in terms of risk to life and safety and economic, social and environmental damage. In terms of operating strategies, using a full range of strategies including:
   a. a stepped change from W3 to W4
   b. moving to a higher rate of release earlier in W1
   c. bypassing W1
   d. altering maximum release rates under W3
   e. operating the gates in conjunction with the initiation of any of the fuse plugs in order to achieve a lower rate of discharge
2. simulations to test the robustness of relying on the 24 hour, the three day and the five day rainfall forecasts
3. development of a probability distribution for the time between closely spaced flood peaks in the catchment using historical records.

Aligns with Flood Response Review Action Plan recommendation **REC014.1** (page 20)

Additional Council Plan	Delivery Date
• Representative on Seqwater steering committee	August 2011

2.18 An accurate record should be kept of reasons for key decisions, including changes in strategy and releases. Documents relevant to key decisions should also be kept, including:

- each version of the gate operations spreadsheet which contains a different input gate operation scenario
- all graphical depictions of model runs produced
- a version of the gate operations spreadsheet which contains the gate operation scenario which will be implemented marked so that it is clear it is the one agreed to be implemented.

Aligns with Flood Response Review Action Plan affirmation **AFF004.1** (page 7)

Additional Council Plan	Delivery Date
• Update the Flood Information Centre Standard Operating Procedures	October 2011

2.21 Seqwater should produce a template situation report in consultation with the flood engineers and recipient agencies. As part of this process, consideration should be given as to whether the quality and timeliness of the dissemination of information about flood operations would be improved if a single document, rather than a situation report and a technical situation report, were used for the purpose of communicating flood operations to all concerned parties. The template situation report should include, at a minimum, dedicated space for the following:

- meteorological observations and situation, including forecasts
- identification of the current operating strategy
- the strategy, aims and objectives of the flood engineers
- actual and expected releases
- any other comments.

Aligns with Flood Response Review Action Plan affirmation **AFF004.1** (page 7)

Additional Council Plan	Delivery Date
• Update the Flood Information Centre Standard Operating Procedures	October 2011

4.1 In issuing warnings for a district or region, local and state authorities should use a range of different warning mechanisms effective for the particular district or region, including methods which do not rely on electricity.

Aligns with Flood Response Review Action Plan affirmation **AFF005.1** (page 9)

Additional Council Plan	Delivery Date
• Review and update crisis communications procedures	December 2011

4.24 The operator of any referable dam and the local disaster management group should develop a common understanding as to their respective roles in a flood event and the type and frequency of information the dam operator will provide to it and local residents.

Aligns with Flood Response Review Action Plan affirmation **AFF004.1** (page 7)

Additional Council Plan	Delivery Date
• Update the Flood Information Centre Standard Operating Procedures	October 2011

4.30 Councils should continue to take responsibility for issuing flash flooding warnings. However, where the Bureau of Meteorology becomes aware of weather conditions likely to cause flash flooding that is likely to endanger life or property in a particular council's region, it should, performing its functions in the public interest, directly communicate that information to the relevant council.

Aligns with Flood Response Review Action Plan affirmation **AFF004.1** (page 7)

Additional Council Plans	Delivery Date
• Engage the Bureau of Meteorology to determine appropriate protocol for information advice	November 2011
• Update the Flood Information Centre Standard Operating Procedures as required	December 2011

4.31 Councils should advise the Bureau of Meteorology of any information they possess about flash flooding (or the immediate prospect of it) likely to endanger life or property in their region, and of any warnings they issue about such flash flooding. The Bureau of Meteorology should consider in each case whether any such warning should be re-published (whether as a warning emanating from the Bureau itself or as attributed to the relevant council) on the Bureau's website, or whether it should provide a link to any council warning or other information regarding flash flooding provided by councils or disaster management agencies.

Aligns with Flood Response Review Action Plan affirmation **AFF004.1** (page 7)

Additional Council Plans	Delivery Date
• Engage the Bureau of Meteorology to determine appropriate protocol for information advice	November 2011
• Update the Flood Information Centre Standard Operating Procedures as required	December 2011

5.8 Where a local government forms a sub-group of its disaster management group:

- the responsibilities of the sub-group must be clearly defined within the local disaster management arrangements
- each member of the sub-group must clearly understand his or her role.

The Commission recommends that sub-groups and local disaster management groups set out their respective roles and responsibilities in writing.

Aligns with Flood Response Review Action Plan recommendation **REC007.1** (page 17)

Additional Council Plans	Delivery Date
• Implement for Local Disaster Management Group sub-committees	Completed
• Incorporate into the Isolated Communities Sub-plan	November 2011

BCC.107.0048

5.40 Each council should develop an evacuation sub-plan in accordance with the Emergency Management Queensland guidelines. This includes involving local groups and people in the planning process.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11)

Aligns with Flood Response Review Action Plan affirmation **AFF007.5** (page 12)

Additional Council Plan	Delivery Date
• Complete stakeholder consultation	September 2011

Aligns with Flood Response Review Action Plan affirmation **AFF007.6** (page 12)

Additional Council Plan	Delivery Date
• Complete stakeholder consultation	September 2011

5.41 Councils with existing evacuation sub-plans should review them to ensure they address the issues identified from the 2010/2011 floods.

Addressed by Flood Response Review Action Plan Board affirmations **AFF007.1** (page 11) and **AFF007.6** (page 12)

Aligns with Flood Response Review Action Plan affirmation **AFF007.5** (page 12)

Additional Council Plan	Delivery Date
• Complete stakeholder consultation	September 2011

5.45 That advice should be given using as many mechanisms as appropriate, including text message, radio and door knocking.

Aligns with Flood Response Review Action Plan affirmation **AFF005.1** (page 9)

Additional Council Plan	Delivery Date
• Review and update crisis communications procedures	December 2011

5.60 During a disaster, councils and the Queensland Police Service should encourage individuals to self-register with the National Registration Inquiry System.

Aligns with Flood Response Review Action Plan affirmation **AFF007.2** (page 11)

Additional Council Plans	Delivery Date
• Update Memorandum of Understanding with Red Cross	October 2011
• Review and update crisis communications procedures	December 2011

COI043.1

Council's Plan	Delivery Date
• Include standard message on disaster event specific page on Council's website	December 2011

5.62 In areas susceptible to flooding, councils should identify facilities housing people who may require assistance to evacuate. Councils should work with the operators of these facilities to ensure they have appropriate evacuation plans and that they are aware of the council's disaster management arrangements.

Aligns with Flood Response Review Action Plan affirmation **AFF007.4** (page 11)

Additional Council Plans	Delivery Date
• Develop evacuation planning tools for facilities housing people who may require assistance to evacuate	December 2011
• Hold a forum with the operators of facilities housing people who may require assistance to evacuate and organisations that provide services to people in the community	December 2011

5.63 Councils should identify the specific evacuation needs of these facilities, such as increased timeframes for withdrawal or transport by ambulance.

Aligns with Flood Response Review Action Plan affirmation **AFF007.4** (page 11)

Additional Council Plans	Delivery Date
• Develop evacuation planning tools for facilities housing people who may require assistance to evacuate	December 2011
• Hold a forum with the operators of facilities housing people who may require assistance to evacuate and organisations that provide services to people in the community	December 2011

5.64 Councils should include the location, contact details, and specific evacuation needs of these facilities in their evacuation sub-plans.

Aligns with Flood Response Review Action Plan affirmation **AFF007.4** (page 11)

Additional Council Plan	Delivery Date
• Update the evacuation sub-plan	December 2011

5.65 Councils should identify organisations (for example, Meals on Wheels and Bluecare) that provide services to people in the community who may be unable to evacuate without assistance. Councils should include the contact details of these organisations in their evacuation sub-plans.

Aligns with Flood Response Review Action Plan affirmation **AFF007.4** (page 11)

Additional Council Plans	Delivery Date
• Develop evacuation planning tools for facilities housing people who may require assistance to evacuate	December 2011
• Hold a forum with the operators of facilities housing people who may require assistance to evacuate and organisations that provide services to people in the community	December 2011
• Update the evacuation sub-plan	December 2011

5.66 Councils should work with these service providers to identify: the number of people who may require assisted evacuation; the general nature of their needs, including any necessary medical supplies and equipment; warning message formats and dissemination; increased timeframes needed for evacuation; transportation requirements; and shelter requirements. Councils should include this information in their evacuation sub-plans.

Aligns with Flood Response Review Action Plan affirmation **AFF007.4** (page 11)

Additional Council Plans	Delivery Date
• Develop evacuation planning tools for facilities housing people who may require assistance to evacuate	December 2011
• Hold a forum with the operators of facilities housing people who may require assistance to evacuate and organisations that provide services to people in the community	December 2011
• Update the evacuation sub-plan	December 2011

5.67 Facilities housing people who may be unable to evacuate without assistance should develop evacuation plans to ensure residents are provided with appropriate transportation, emergency accommodation, trained carers and medical support if necessary. Where possible, residents of those facilities should be relocated to other similar facilities or accommodation other than evacuation centres. These plans should be developed in consultation with councils and relevant agencies such as Queensland Health.

Aligns with Flood Response Review Action Plan affirmation **AFF007.4** (page 11)

Additional Council Plans	Delivery Date
• Develop evacuation planning tools for facilities housing people who may require assistance to evacuate	December 2011
• Hold a forum with the operators of facilities housing people who may require assistance to evacuate and organisations that provide services to people in the community	December 2011

5.68 Facilities housing people who may be unable to evacuate without assistance should prepare disaster recovery plans, particularly for the provision of back up power and emergency supplies, including medical oxygen and common medications, to minimise the need for evacuation where there is no direct threat from natural disaster.

Aligns with Flood Response Review Action Plan affirmation **AFF007.4** (page 11)

Additional Council Plans	Delivery Date
• Develop evacuation planning tools for facilities housing people who may require assistance to evacuate	December 2011
• Hold a forum with the operators of facilities housing people who may require assistance to evacuate and organisations that provide services to people in the community	December 2011

Commission of Inquiry interim report recommendations that have been addressed in Brisbane City Council's Flood Response Review Action Plan

3.5 Every person who is required to work under a local disaster management plan should be familiar with the plan before the next wet season.

Addressed by Flood Response Review Action Plan affirmation **AFF002.1** (page 3)

4.3 SMS alerts should direct recipients to websites or contact numbers providing more detailed information about flood locations and predictions, the location of evacuation centres and evacuation routes.

Addressed by Flood Response Review Action Plan affirmation **AFF005.1** (page 9)

4.4 Councils and Emergency Management Queensland should work together to ensure the approval process does not cause delays in delivering SMS alerts.

Addressed by Flood Response Review Action Plan affirmation **AFF005.1** (page 9)

4.5 Wherever possible, Emergency Management Queensland should consult with local disaster management groups before sending emergency alerts to residents. Emergency Management Queensland should inform the local disaster management group, as soon as it can, about any message already sent to residents in that local disaster management group's area.

Addressed by Flood Response Review Action Plan affirmation **AFF005.1** (page 9)

4.13 Councils should ensure that residents and businesses can clearly understand the impact of predicted flood levels on their property. This may include one or more of the following methods:

- information on rates notices about flooding at individual properties
- geospatial mapping, available to the public, that depicts inundation at certain river heights
- flood markers
- flood flag maps and floodwise property reports
- colour coded maps
- information that relates gauge heights with the level of flooding to be expected at a property.

Addressed by Flood Response Review Action Plan recommendations **REC003.1** (page 16), **REC004.1** (page 16) and **REC010.1** (page 18)

4.14 In the course of flood events, warnings referring to gauge heights should include information about the location of the gauge.

Addressed by Flood Response Review Action Plan recommendation **REC003.1** (page 16)

5.6 As part of their planning before the next wet season, local disaster management groups should identify communities which, because of distance, the potential for isolation by disaster, or any other reason, may require specific disaster management arrangements, and take steps to establish them. Such arrangements may include forming disaster management sub-groups in those communities.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11) and recommendation **REC007.1** (page 17)

5.7 Whatever form arrangements take, they should seek to ensure that, in the event that flooding causes isolation:

- there are lines of communication between the local disaster management group and the community
- the community has the basic resources it needs to cope with its situation
- the local disaster management group is aware of what supplies the community may need in prolonged disaster, and can respond to requests for assistance in a timely way
- potential evacuation routes and centres are known.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11) and recommendation **REC007.1** (page 17)

5.42 Where flooding is governed by a particular watercourse, the evacuation sub-plan should identify triggers in the form of those water level heights at which it is known that preparation for evacuation will be necessary.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11)

5.44 During floods, councils should as quickly as possible provide people in the relevant areas with advice as to the location of and routes to evacuation centres.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11)

5.46 Councils should identify a range of evacuation centres as part of their disaster preparation and planning.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11)

5.47 Councils should audit identified evacuation centres to ensure the facilities and location are appropriate, preferably in consultation with the Australian Red Cross and the Department of Communities.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11)

5.48 Councils should be aware of what facilities are available at each evacuation centre, at particular times of the year.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11)

5.49 Councils should identify areas that are susceptible to isolation, including locations in which community groups established informal evacuation centres during the 2010/2011 floods, with a view to incorporating evacuation centres at those locations into their evacuation sub-plans.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11) and recommendation **REC007.1** (page 17)

5.50 Councils should identify community groups who may take responsibility for establishing and operating evacuation centres in the future.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11) and recommendation **REC007.1** (page 17)

5.51 The identified groups and councils should, before the next wet season, establish cooperative arrangements as to how the centres should operate, and to ensure the centres have appropriate facilities.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11) and recommendation **REC007.1** (page 17)

5.52 Councils should recognise that community groups may establish makeshift evacuation centres during a disaster. When this occurs, councils need to identify and establish communications with the centres as soon as possible.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11) and recommendation **REC007.1** (page 17)

5.53 Councils should develop plans for the effective and timely re-supply of makeshift centres.

Addressed by Flood Response Review Action Plan affirmation **AFF007.1** (page 11) and recommendation **REC007.1** (page 17)

ADDENDUM 2

Queensland Floods Commission of Inquiry
Final Report Recommendations (pending release in early 2012)

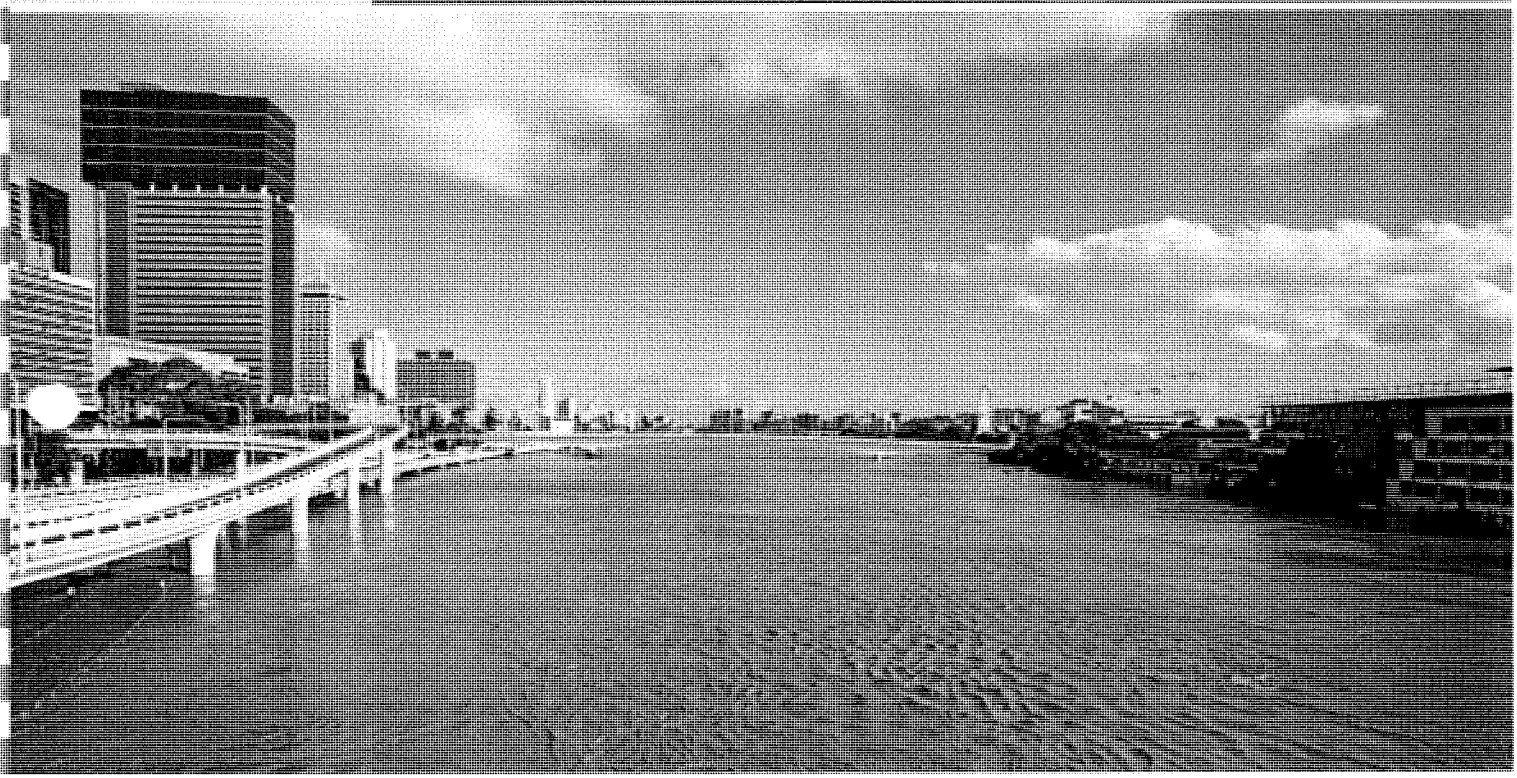
BCC.107.0056

Glossary of acronyms

ADF	Australian Defence Force
ALERT	Automated Local Evaluation in Real-Time
BCLDMG	Brisbane City Local Disaster Management Group
BCP	Business Continuity Plan
BoM	Bureau of Meteorology
C2C	Council to Council
CBD	Central Business District
COP	Common Operating Picture
CWS	City Waste Services
DERM	Department of Environment and Resource Management
DFL	Defined Flood Level
EWAS	Early Warning Alert Service
FIC	Flood Information Centre
GIS	Geographic Information System
LDCC	Local Disaster Coordination Centre
NFRAG	National Flood Risk Advisory Group
QPS	Queensland Police Service
RIMT	Regional Incident Management Team
RSPCA	Royal Society for the Prevention of Cruelty to Animals
SES	State Emergency Service
SOP	Standard Operating Procedures

BCC.107.0057

BRISBANE CITY COUNCIL





TEMPORARY LOCAL PLANNING INSTRUMENT – 01/11

BRISBANE INTERIM FLOOD RESPONSE

Dedicated to a better Brisbane

BCC 100.5847

BRISBANE CITY COUNCIL

TEMPORARY LOCAL PLANNING INSTRUMENT - 01/11

BRISBANE INTERIM FLOOD RESPONSE

1. **Short title**
This temporary local planning instrument (TLPI) may be cited as Temporary Local Planning Instrument 01/11 - Brisbane Interim Flood Response.

2. **Purpose**
The purpose of this TLPI is to introduce the Interim Residential Flood Level (IRFL) and facilitate the following:

1. Application of the Interim Residential Flood Level.
2. Where on standard lots, allow Self Assessment of Houses up to 9.5m above ground level where affected by waterway or Brisbane River Flooding (as described in Table A below).
3. Change the Level of Assessment for a House on a Small Lot to Code Notifiable where a new House or raising an existing House, and not meeting the requirements of Table 1 Building Envelope Requirements of the Residential Design Small Lot Code and affected by waterway or Brisbane River flooding.
4. Allow Houses to be raised or extended with habitable floor levels below the Interim Residential Flood Level with requirements for resilient building design and materials.
5. Introduce additional requirements for filling and excavation for Houses.
6. Allow for waterway and Brisbane River Flooding to be taken into account when assessing maximum building height for a House, Multi-Unit dwelling and Single Unit Dwelling.
7. Identify additional technical standards and requirements to complement those in the Subdivision and Development Guidelines for properties affected by waterway and Brisbane River Flooding, including building basements and essential services for commercial and residential buildings.

3. **Application**
The land to which this TLPI applies is those lots, any part of which, are affected by the Interim Residential Flood Level and/or Creek/Waterway Flooding. The terms "Interim Residential Flood Level" and "Creek/Waterway Flooding" are defined in Section 5.

Relationship with planning scheme

1. To the extent of any inconsistency between the planning scheme and the TLPI, the TLPI prevails.
2. Exempt development as listed in Chapter 3 of the City Plan is unaffected by this TLPI.
3. Building work listed under section 1 of the Residential Design Small Lot Code, Residential Design Character Code and Residential Design Single Unit Dwelling Code is unaffected by this TLPI.
4. This TLPI overrides the provisions in City Plan 2000 to the extent of matters that this instrument relates to as outlined in section 6.
5. Where raising a house to comply with the IRFL and where located within a Demolition Control Precinct, Performance Criteria 2 and Acceptable Solution A2.1 of the Residential Design – Character Code do not apply.

4. **Duration**

This TLPI has effect for a period of 1 year from the date of commencement.

5. Definitions

1.1 Terms used in this TLPI have the same meaning as in the *Sustainable Planning Act 2009*, unless otherwise defined in this TLPI or the planning scheme.

1.2 The Interim Residential Flood Level (IRFL) is the surface of floodwater in one or both of the following flood events, whichever is the highest at any point:

1. Brisbane River - January 2011 event, as described in table A
2. The Defined Flood Level (DFL) based on a Brisbane River Flood Event using a flood height profile of 3.7m AHD at the City Gauge, as described in table A.

1.3 Creek/waterway flooding is all land affected by a 100 year (Average Recurrence Interval) flood event, as described in table A

1.4 Table A below refers to the source of the mapping and data relied on for the purpose of this instrument.

Table A	
TLPI extent:	**Described in:**
The January 2011 estimated Brisbane River flood extent	Temporary Local Planning Instrument – Brisbane Interim Flood Response Map Number LGA 1000-0025-1 Sheet 1 to Sheet 22 dated 19/4/2011
Waterway/creek flood inundation extent for a 100 year ARI waterway/creek flood event; and Defined Flood Level based on a Brisbane River Flood Event using a flood height profile of 3.7m AHD at the Brisbane City Gauge	"Flood Flag Maps" and *FloodWise* Property Report, copyright Brisbane City Council as at the date of gazettal.
Flood level:	**Described in:**
The estimated January 2011 Brisbane River flood levels; and Defined Flood Level based on a Brisbane River Defined Flood Event of 3.7m AHD at the Brisbane City Gauge; and Waterway/creek 100 year ARI flood level	The *Brisbane Interim Flood Response* database, and referenced in the *FloodWise* property report copyright Brisbane City Council as at the date of gazettal.

* The TLPI does not relate to land affected solely by overland flow or tidal flooding (storm tide)

6. Effect of this Temporary Local Planning Instrument

Development specified in Table 1, Column 1 on lots, any part of which are affected by the Interim Residential Flood Level and/or creek/ waterway flooding as described in Table A, have the level of assessment specified in Table 1, Column 2 and must comply with the applicable City Plan Codes specified in Column 3 and the additional Purpose, Performance Criteria and Acceptable Solutions specified in Table 1, Columns 4, 5 and 6.

In the event of any inconsistency between the purpose, performance criteria and acceptable solutions of the applicable City Plan codes specified in column 3 and the additional purpose, additional performance criteria and additional acceptable solutions specified in columns 4,5 and 6 of table 1 the additional purpose, the additional performance criteria and additional acceptable solutions shall prevail.

BCC.100.5849

Development specified in Table 3, Column 1 on lots, any part of which are affected by the Interim Residential Flood Level and/or creek/waterway flooding as described in Table A, must comply with the requirements specified in Table 3, Column 2.

Development specified in Table 4, Column 1 on lots, any part of which are affected by the Interim Residential Flood Level and/or creek/waterway flooding as described in Table A, must comply with the requirements specified in Table 4, Column 2.

Development for demolition where the work is raising a house, except where on a small lot, where the resultant height does not exceed 9.5 metres above ground level, is exempt development. (Note: does not include any building work to enclose under the house).

Table 1: Assessment table for specific development where affected by creek/waterway and Brisbane River Flooding

Column 1 Type of Development	Column 2 Level of Assessment	Column 3 Applicable Codes	Column 4 Additional Purpose	Column 5 Additional Performance Criteria	Column 6 Additional Acceptable Solution
House where not on a Small Lot	Self Assessment where meeting the Acceptable Solutions of the House Code as varied by the additional Acceptable Solutions in Column 6	House Code	Ensure new houses, where raising a house and extensions to existing houses achieve acceptable flood immunity. Ensure houses are not subject to unreasonable hazard due to flooding.	Buildings may be higher than adjoining properties to the extent required to achieve flood immunity for Interim Residential Flood level and creek/waterway flooding. Building components and flood resilient design: • preserve structural performance during and after a flood event • prevent further post flood deterioration • minimise repair costs following a flood • ensure ease of cleaning New building work improves flood immunity and ensures safety for all persons. Filling or excavation must not impact adversely on visual amenity or local drainage. *Note: Retaining wall construction and embankment gradients will also need to comply with the Building Regulations*	Except where on a Small Lot; where an existing house is raised, extended or a new house is erected, the building height above ground level must not be greater than 9.5 metres. The minimum level for habitable and non–habitable areas (including utility areas, garage, laundry and storage room) are not less than those set out in Table 2 Where development involves raising an existing house and the modified building does not meet the requirements of Table 2, the following requirements are met: • The new habitable floor levels are above the existing habitable floor levels andany building work below the IRFL utilises water resistant materials* Where development involves enclosing under or extending an existing house and the modified building does not meet the requirements of Table 2, the following requirements are met: • The new habitable floor levels are above the existing habitable floor levels; and • Any enclosure below the IRFL must have openings that are at least 1% of the enclosed area for automatic exit of flood water for the design flood or lesser floods. Any openings are a minimum of 75mm. • floor levels are elevated above ground level, such as on stumps or fill; and • the new building work below the IRFL uses water resistant materials*; and • essential services are located above IRFL and any electrical services, including photovoltaic panels, are easily disconnected; and • the new building work below the IRFL uses corrosion free building components such as galvanised steel or aluminium.

					**Editor's Note: For a list of water resistant materials please refer to table 1- Higher water resistance - Growth Management Queensland Factsheet January 2011 – Repairing your House After a Flood* A retaining wall is set back at least half the height of the wall from any boundary of the site; and Retaining walls over 1.5m are stepped 0.75m for every 1.5m in height, terraced and landscaped; No filling, excavation or retaining works shall be carried out that cause stormwater to be concentrated or redirected from pre-development conditions, unless the stormwater is directed to a lawful point of discharge such as kerb and channel. Where in the Brisbane River Corridor: Where an existing house is raised, extended or a new house is erected, the building height above ground level, must not be greater than 9.5 metres.
House in the Demolition Control Precinct	Self Assessment	House Code Character Code	Ensure new houses, where raising a house and extensions to existing houses achieve acceptable flood immunity Ensure houses are not subject to unreasonable hazard due to flooding.	Buildings may be higher than adjoining properties to the extent required to achieve flood immunity for Interim Residential Flood Level and creek/waterway flooding. Building components and flood resilient design: • preserve structural performance during and after a flood event • prevent further post flood deterioration • minimise repair costs following a flood • ensure ease of cleaning	The minimum level for habitable and non–habitable areas (including utility areas, garage, laundry and storage room) are not less than those set out in Table 2 Where development involves raising an existing house and the modified building does not meet the requirements of Table 2, the following requirements are met: • The new habitable floor levels are above the existing habitable floor levels andany building work below the IRFL utilises water resistant materials* There development involves enclosing under or extending an existing house and the modified building does not meet the requirements of Table 2, the following requirements are met: • The new habitable floor levels are above the existing

				New building work improves flood immunity and ensures safety for all persons. Filling or excavation must not impact adversely on visual amenity, the stability of land or local drainage. *Note: Retaining wall construction and embankment gradients will also need to comply with the Building Regulations*	habitable floor levels; and • Any enclosure below the IRFL must have openings that are at least 1% of the enclosed area for automatic exit of flood water for the design flood or lesser floods. Any openings are a minimum of 75mm. • floor levels are elevated above ground level, such as on stumps or fill; and • the new building work below the IRFL uses water resistant materials*; and • essential services are located above IRFL and any electrical services, including photovoltaic panels, are easily disconnected; and • the new building work below the IRFL uses corrosion free building components such as galvanised steel or aluminium. **Editor's Note: For a list of water resistant materials please refer to table 1- Higher water resistance - Growth Management Queensland Factsheet January 2011 – Repairing your House After a Flood* A retaining wall is set back at least half the height of the wall from any boundary of the site; and Retaining walls over 1.5m are stepped 0.75m for every 1.5m in height, terraced and landscaped; No filling, excavation or retaining works shall be carried out that cause stormwater to be concentrated or redirected from predevelopment conditions, unless the stormwater is directed to a lawful point of discharge.
House on a Small Lot	Self Assessment where meeting the	House Code Residential	Ensure new houses, where raising a house and extensions to existing houses	Buildings may be higher than adjoining properties to the extent required to achieve flood immunity for Interim Residential Flood Level and	The minimum level for habitable and non–habitable areas (including utility areas, garage, laundry and storage rooms) are not less than those set out in Table 2

	Acceptable Solutions of the House Code as varied by the additional Acceptable Solutions in Column 6 Code Notifiable where not meeting the Acceptable Solution relating to the building height element of the Residential Design Small Lot Code Impact Assessment where not meeting the Acceptable Solutions of Part 1 of the Residential Design Small Lot Code	Design Small Lot Code	achieve acceptable flood immunity Ensure houses are not subject to unreasonable hazard due to flooding.	creek/waterway flooding. Building components and flood resilient design: • preserve structural performance during and after a flood event • prevent further post flood deterioration • minimise repair costs following a flood • ensure ease of cleaning New building work improves flood immunity and ensures safety for all persons. Filling or excavation must not impact adversely on visual amenity, the stability of land or local drainage. *Note: Retaining wall construction and embankment gradients will also need to comply with the Building Regulations*	Where development involves raising an existing house and the modified building does not meet the requirements of Table 2, the following requirements are met: • The new habitable floor levels are above the existing habitable floor levels andany building work below the IRFL utilises water resistant materials* There development involves enclosing under or extending an existing house and the modified building does not meet the requirements of Table 2, the following requirements are met: • The new habitable floor levels are above the existing habitable floor levels; and • Any enclosure below the IRFL must have openings that are at least 1% of the enclosed area for automatic exit of flood water for the design flood or lesser floods. Any openings are a minimum of 75mm. • floor levels are elevated above ground level, such as on stumps or fill; and • the new building work below the IRFL uses water resistant materials*; and • essential services are located above IRFL and any electrical services, including photovoltaic panels, are easily disconnected; and • the new building work below the IRFL uses corrosion free building components such as galvanised steel or aluminium. **Editor's Note: For a list of water resistant materials please refer to table 1- Higher water resistance - Growth Management Queensland Factsheet January 2011 – Repairing your House After a Flood* A retaining wall is set back at least half the height of the wall from any boundary of the site; and

					Retaining walls over 1.5m are stepped 0.75m for every 1.5m in height, terraced and landscaped; No filling, excavation or retaining works shall be carried out that cause stormwater to be concentrated or redirected from predevelopment conditions, unless the stormwater is directed to a lawful point of discharge.
House on a Small Lot and in the Demolition Control Precinct	Self Assessment where meeting the Acceptable Solutions of the House Code as varied by the additional Acceptable Solutions in Column 6 Code Notifiable where not meeting Acceptable Solution 2 of the Residential Design Small Lot Code Impact Assessment where not meeting the	House Code Residential Design Small Lot Code Residential Design Character Code	Ensure new houses, where raising a house and extensions to existing houses achieve acceptable flood immunity Ensure houses are not subject to unreasonable hazard due to flooding.	Buildings may be higher than adjoining properties to the extent required to achieve flood immunity for Interim Residential Flood Level and creek/waterway flooding. Building components and flood resilient design: • preserve structural performance during and after a flood event • prevent further post flood deterioration • minimise repair costs following a flood • ensure ease of cleaning New building work improves flood immunity and ensures safety for all persons. Filling or excavation must not impact adversely on visual amenity, the stability of land or local drainage. *Note: Retaining wall construction and embankment gradients will also need to comply with the Building Regulations*	The minimum level for habitable and non–habitable areas (including utility areas, garage, laundry and storage room) are not less than those set out in Table 2 Where development involves raising an existing house and the modified building does not meet the requirements of Table 2, the following requirements are met: • The new habitable floor levels are above the existing habitable floor levels andany building work below the IRFL utilises water resistant materials* There development involves enclosing under or extending an existing house and the modified building does not meet the requirements of Table 2, the following requirements are met: • The new habitable floor levels are above the existing habitable floor levels; and • Any enclosure below the IRFL must have openings that are at least 1% of the enclosed area for automatic exit of flood water for the design flood or lesser floods. Any openings are a minimum of 75mm. • floor levels are elevated above ground level, such as on stumps or fill; and • the new building work below the IRFL uses water resistant materials*; and • essential services are located above IRFL and any electrical services, including photovoltaic panels, are easily disconnected; and • the new building work below the IRFL uses corrosion

	Acceptable Solutions of Part 1 of the Small Lot Code				free building components such as galvanised steel or aluminium. **Editor's Note: For a list of water resistant materials please refer to table 1- Higher water resistance - Growth Management Queensland Factsheet January 2011 – Repairing your House After a Flood* A retaining wall is set back at least half the height of the wall from any boundary of the site; and Retaining walls over 1.5m are stepped 0.75m for every 1.5m in height, terraced and landscaped; No filling, excavation or retaining works shall be carried out that cause stormwater to be concentrated or redirected from predevelopment conditions, unless the stormwater is directed to a lawful point of discharge.
Single Unit Dwelling in the Low Density, Character and Low Medium Density Residential Area	No change to Level of Assessment	Residential Design Single Unit Dwelling Code	Ensure all new single unit dwellings achieve acceptable flood immunity. Ensure all new single unit dwellings are not subject to unreasonable hazard due to flooding.	Buildings may be higher than adjoining properties to the extent required to achieve flood immunity for Interim Residential Flood Level and creek/waterway flooding.	
Single Unit Dwelling in the Medium Density and High Density Residential Area and	No change to Level of Assessment	Residential Design Single Unit Dwelling Code	Ensure all new single unit dwellings achieve acceptable flood immunity. Ensure all new single unit dwellings are not	Buildings may be higher than this to the extent required to achieve flood immunity for Interim Residential Flood Level and creek/waterway flooding.	

Centres Area			subject to unreasonable hazard due to flooding.		
Multi Unit in the Low Density, Character and Low Medium Density Residential Area	No change to Level of Assessment	Residential Design – Low Density, Character and Low Medium Density Code	Ensure all new multi-unit-dwellings achieve acceptable flood immunity. Ensure all new multi-unit dwellings are not subject to unreasonable hazard due to flooding.	Buildings may be higher than adjoining properties to the extent required to achieve flood immunity for Interim Residential Flood Level and creek/waterway flooding.	
Multi Unit in the Medium Density Area	No change to Level of Assessment	Residential Design – Medium Density Code	Ensure all new multi-unit dwellings achieve acceptable flood immunity Ensure all new multi-unit dwellings are not subject to unreasonable hazard due to flooding.	Buildings may be higher than adjoining properties to the extent required to achieve flood immunity for Interim Residential Flood Level and creek/waterway flooding.	
Multi Unit in the High Density Area	No change to Level of Assessment	Residential Design – High Density Code	Ensure all new multi-unit dwellings achieve acceptable flood immunity Ensure all new multi-unit dwellings are not subject to unreasonable hazard due to flooding.	Buildings may be higher than adjoining properties to the extent required to achieve flood immunity for Interim Residential Flood Level and creek/waterway flooding.	
Mixed Use in the Centres	No change to Level of	Centre Design	Ensure all new residential or mixed	All new residential development or the residential component of Mixed Use	

Area	Assessment	Code	use development including residential development achieves acceptable flood immunity. Ensure all new multi-unit dwellings are not subject to unreasonable hazard due to flooding.	development may be higher than adjoining development to the extent required to achieve flood immunity for Interim Residential Flood Level and creek/waterway flooding.	
For infill development for lots smaller than 1000m2 in the Residential Area	No change to Level of Assessment	Subdivision Code			All lots below 1000m2 in size are located entirely above the minimum design levels for flood immunity in accordance with Council's Subdivision and Development Guidelines and this instrument. For infill development for lots smaller than 1000m2 affected by Interim Residential Flood Level and creek/waterway flooding, filling may not be required where a house could otherwise reasonably be constructed to comply with the Subdivision and Development Guidelines and this instrument. *Editor's note: It is expected that flood immunity will be achieved by a combination of limited filling, buildings on stumps or other building techniques. Over reliance on filling can lead to adverse impacts on the amenity of adjoining lands and local drainage.*

Table 2: House Flood Immunity Levels

Type of Flooding	Minimum Ground Level for House Pad after filling (where permitted)	Habitable Floor Level	Non–habitable Areas (i.e. utility areas, garage, laundry and storage room)
Brisbane River	IRFL + 300mm	IRFL + 500mm	50 year ARI + 300mm
Creek or Waterway	100 year ARI + 300mm	100 year ARI + 500mm	100 year ARI + 300mm

Table 3: Local Plan or Neighborhood Plan and Brisbane River Corridor Planning Scheme Policy

Column 1	Column 2
Residential development and the basements of commercial development included in any Local Plan or Neighbourhood Plan Area as described in Chapter 4 of the City Plan.	Where residential development, commercial development (including filling and reconfiguration for the same purpose) or mixed use development including a residential component is regulated in respect of : • Building height of houses, single unit dwellings or Multi-unit dwellings; and or • Flood immunity requirements for Interim Residential Flood Level and creek/waterway flooding the applicable Local or Neighbourhood Plan shall be read as having the following additional intent: 1. Buildings may be higher than 8.5 metres to the extent required to achieve acceptable flood immunity. These buildings must be designed to minimize the height of the side and rear walls in relation to adjoining properties and the overall height of the building. 2. Ensure all new residential development achieves acceptable flood immunity, by complying with tables 4 and 5; or The DFL whichever is the greater level of immunity
Structures in Precinct 1 and 2 – Residential Parkland of the Brisbane River	Building height may vary to the extent required to achieve flood immunity

Table 4: Subdivision and Development Guidelines

Column 1	Column 2
Any development requiring compliance with table A1.1 of the Subdivision and Development Guidelines	The minimum lot level for residential subdivision is IRFL + 300mm Filling of lots affected by Interim Residential flood Level and creek/waterway for flood immunity may produce undesirable outcomes with respect to the streetscape and boundaries to existing lots. Filling may not be required for infill subdivision affected by Interim Residential flood Level flooding where a house otherwise could be reasonably constructed to comply with this requirement. Notes; The Interim Residential Flood Level (IRFL) is the surface of floodwater in one or both of the following flood events, whichever is the highest at any point: 1. Brisbane River - January 2011 event, as mapped in table A 2. The Defined Flood Level (DFL) based on a Brisbane River Flood Event using a flood height profile of 3.7m AHD at the City Gauge, as mapped in table A. Creek/waterway flooding is all land affected by a 100 year (Average Recurrence Interval) flood event, as mapped in table A. The January 2011 Brisbane River flood event is described in the Queensland Reconstruction Authority "Interactive Reconstruction Map" 2010-2011 Interim Flood Lines. The creek/waterway flood inundation extent and level for a 100 year ARI creek/waterway flood event and the Defined Flood Level based on a Brisbane River Flood Event using a flood height profile of 3.7m AHD at the City Gauge is described in the database and mapping described as "Flood Flag Maps" and "Floodwise Property Report, Brisbane City Council".

Any development requiring compliance with table A1.2 of the Subdivision and Development Guidelines	The Minimum design floor or pavement levels for Category A is IRFL + 500mm. The Minimum design floor or pavement levels for Category B is IRFL + 300mm. Refer to Table 5 for assignment of these categories Notes; The Interim Residential Flood Level (IRFL) is the surface of floodwater in one or both of the following flood events, whichever is the highest at any point: 1. Brisbane River - January 2011 event, as mapped in table A 2. The Defined Flood Level (DFL) based on a Brisbane River Flood Event using a flood height profile of 3.7m AHD at the City Gauge, as mapped in table A. Creek/waterway flooding is all land affected by a 100 year (Average Recurrence Interval) flood event, as mapped in table A. The January 2011 Brisbane River flood event is described in the Queensland Reconstruction Authority "Interactive Reconstruction Map" 2010-2011 Interim Flood Lines. The creek/waterway flood inundation extent and level for a 100 year ARI water/creek flood event and the Defined Flood Level based on a Brisbane River Flood Event using a flood height profile of 3.7m AHD at the City Gauge is described in the database and mapping described as "Flood Flag Maps" and "Floodwise Property Report, Brisbane City Council".
Development requiring compliance with table A 1.3 of the Subdivision and Development Guidelines	Refer to Table 5

Table 5: Building Categories

BCA Building Classification*	Development Type & Design Levels	Category (3) (Refer Table 4 for applicable immunity)
Class 1 - 4	Habitable room*	Category A
	Non-habitable room - including garage, patio, private open space and courtyard	Category B
		except for Class 1a building where the 50y ARI + 0.3m applies to Brisbane River.
	Non-habitable part of a Class 2 or Class 3 building - excluding the essential services@	Category B
		Risk management approach to Brisbane River flooding is permitted. (refer Section 4)
	Parking located in the building undercroft of a multi unit dwelling	Category C
	Carport1, unroofed carpark, Vehicular manoeuvring areas	Category D
	Essential electrical services@ of a Class 2 or Class 3 building only	Category A
		Risk management approach to Brisbane River flooding is permitted (4)
	Basement parking entry#	Category C +300mm
Class 5, Class 6, Class 8	Building floor level	Category C
		Risk Management approach to Brisbane River flooding is permitted.
	Garage or carpark# located in the building undercroft	Category C
	Carport1 or unroofed carpark	Category D
	Vehicular access and manoeuvring areas	Category D
	Essential electrical services@	Class 8 - Category C Class 5 & 6 – Category A
		Risk management approach to Brisbane River flooding is permitted (4)

	Basement parking entry#	Category C
Class 7a	Refer to the relevant building class specified in this table	
Class 7b	Building floor level	Category C
		Risk Management approach to Brisbane River flooding is permitted.
	Vehicular access and manoeuvring areas	Category D
	Essential electrical services@	Category C
Class 9	Building floor level - including essential services@	Category A
	Garage or carpark# located in the building undercroft	Category C
	Carport1 or unroofed carpark	Category D
	Vehicular access and manoeuvring areas	Category D
Class 10a	Carparking facility	Refer to the relevant building class specified in this table.
	Shed2 or the like	Category D
Class 10b	Swimming pool	Category E
	Associated mechanical and electrical pool equipment	Category C
	Other structures	Flood immunity standard does not apply.

* Refer Section 2.3.3 of the Subdivision and Development Guidelines for definitions.
@ Essential services include any room used for fire control panel, telephone PABX, sensitive substation equipment including transformers, low voltage switch gear, high voltage switch gear, battery chargers, protection control and communication equipment, low voltage cables, high voltage cables, and lift controls etc.
# Basement carparks must be suitably waterproofed and all air vents, air conditioning ducts, pedestrian access and entry/exit ramps at the carpark entrance have flood immunity in accordance with this table.
1. A shelter for a motor vehicle, which has a roof and one or more open sides, and which can be built against the side of a building.
2. A slight or rough structure built for shelter and storage; or a large strongly built structure, often open at the sides or end.
3. Where a building includes a combination of uses that includes a component of classes 2, 3 or 9, the essential services for that building shall comply with the requirements of the building class with the greatest flood immunity requirement.
4. Where essential services are proposed in a basement below the specified flood immunity level in Table 5 as part of a risk management approach to Brisbane River Flooding or Creek/waterway flooding, the flood immunity of all air vents, air conditioning ducts, pedestrian access, lift shafts and entry/exit ramps at the basement entrance and any other openings into that basement must conform to Category A for Residential development, and the relevant basement entry level of all other uses. This will require a fully watertight basement design to prevent floodwaters entering the basement to ensure flood immunity.

TLPI - Raising houses in flood affected areas above 8.5 metres



BRISBANE CITY

History

- **Building heights**
  - **1978 Town Plan – 2 storeys relaxable to 3 storeys**
  - **1987 Town Plan - 7.8m – increased to 8.5 metres in 1991**
  - **Permissible Development (Impact Assessment)**
  - **Changed to notifiable code in City Plan 2000**
- **Flood levels**
  - **3.7m Brisbane Port Office Gauge**
  - **Recent Flood event – 4.5 metres**

BRISBANE CITY

Levels of Assessment

- **Existing Situation**
  - **For houses not on small lots – Notifiable code for heights over 8.5m above ground**
  - **For houses in DCP not on a small lot – Notifiable code for heights over 8.5 metres above ground**
  - **For houses on small lots – Impact (inappropriate) for houses over 7.5 metres to outer most projection**

- **Options**
  - **1:** **Code assessable to raise any house in an area shown on a map defining the extent of the 1/2011 flood.**
  - **2:** **Notifiable code to raise any house in an area shown on a map defining the extent of the 1/2011 flood.**

BRISBANE CITY

Assessment Criteria

- **Existing Situation**
  - On regular sized lots – heights assessed against amenity and aesthetics criteria – overshadowing, loss of breezes, loss of views, consistency with heights in the area
  - In Demolition Control Precincts weight given to consistency with heights of houses in the area generally
  - On Small lots – compliance with building setbacks need to be taken into account.
  - None of the applicable codes provide for consideration of the impact of flood levels on the overall height of the house

- **Options**
  - A: Make no changes to the code;
  - B: Amend the purpose of the code to include support for raising houses to achieve flood immunity;
  - C: As per option B, but include specific performance criteria in the code to detail expectations – this would be a place to specify a maximum height;
  - D: As per option C, but include specific acceptable solutions in the code – this would also be a place to specify a maximum height eg: 10 m. Note: It would be difficult to come up with detailed acceptable solutions without undertaking considerable research.

BRISBANE CITY

Recommendations

- **A combination of Option 2 – (Notifiable Code as level of assessment) and Option C (specific performance criteria) is the preferred option**
  - **Maintains a level of public consultation while ensuring assessment periods are kept to a minimum**
  - **Provides sufficient certainty for home owners who want to raise their houses without causing unreasonable impacts.**
  - **Protects Council's ability to refuse applications or negotiate alternative outcomes where a proposal may result in adverse amenity impacts.**

BRISBANE CITY

Key Questions

- Which flood level will the TLPI apply to?
  - Existing Q100
  - 1/2011 flood
  - New Defined Flood level
- How deep?
  - Any inundation
  - More than .5
  - More than 1m
- Up to what height are we prepared to compromise other aspects of residential amenity for flood immunity?
  - 0.5 metre – imperceptible
  - Up to 10 metres overall (not uncommon)
  - 9 metres to outer most projection
- Different rules for new houses vs raising houses?
  - New houses – must demonstrate cannot achieve habitable floor space without exceeding 8.5m
  - Must achieve at least one habitable floor above flood level

BRISBANE CITY

Some Examples

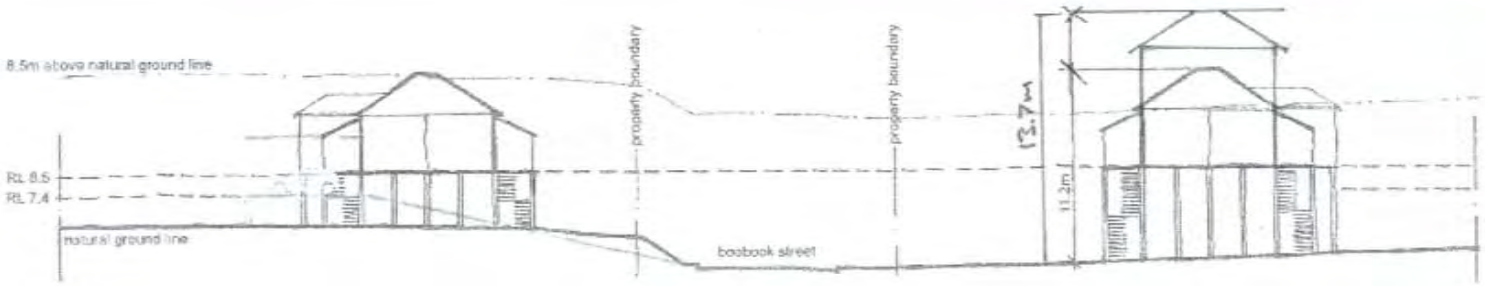


Figure 2: Section through Site A (bottom) and Site B (top)

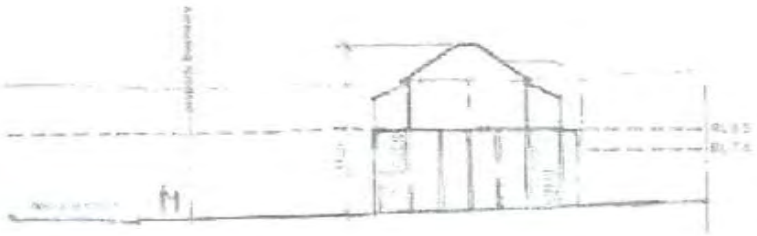


Figure 3: Streetscape scale

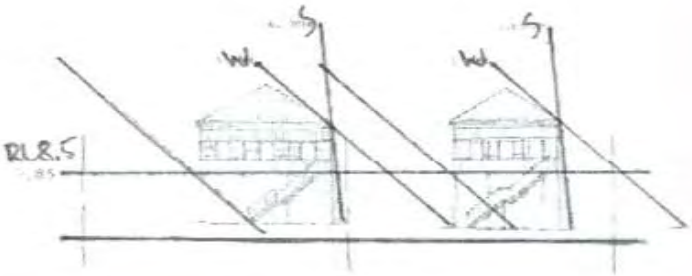
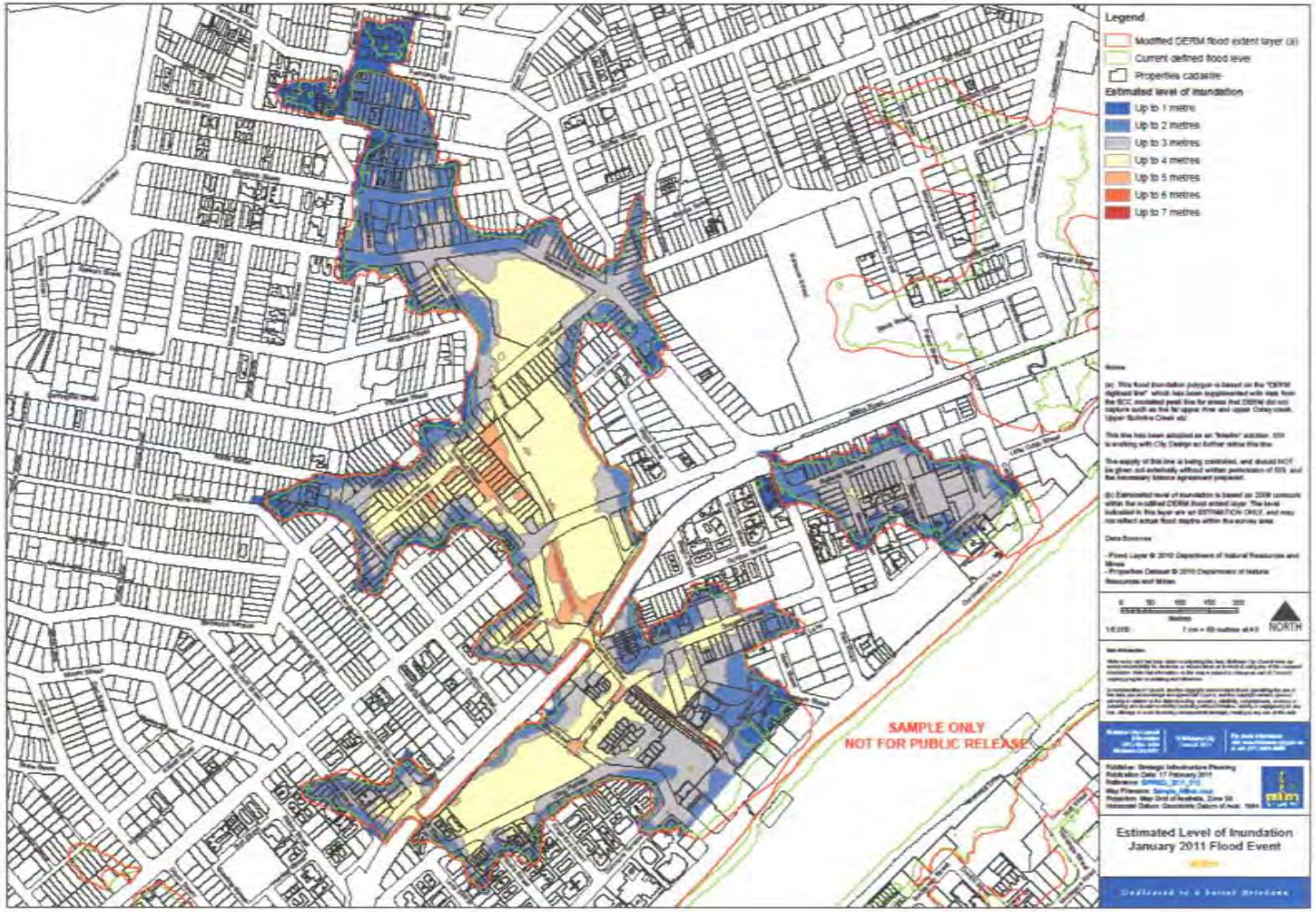


Figure 4: Overshadowing

Flood mapping example: depth



TLPI for Raising Houses

- Industry consultation
  - 3 consultants
  - Generally supportive
  - Recommended some minor changes
  - Satisfied TLPI deals with wide range of scenarios
  - Satisfied TLPI works for houses on small lots
  - Tested against a live scenario
  - Suggested adding some indicative sketches
- Next steps
  - Review by BCLP
  - Full Council Approval
  - Referral to DLGP

BRISBANE CITY

Dealing with Displaced Uses

- DA advise the volume of queries is low
- Operating procedures established
- One officer dealing with all requests
- Fact sheet published on web - 2 Feb 2011
- Using planning scheme exemption provisions
- Generally limiting to three months with option to extend
- Some are setting up as home businesses – taking "relaxed" view on compliance.
- Some businesses will need development approvals
  - Commensurate with scale an likely impacts
  - Assessed on case by case basis
  - Encouraging open communication through contact centre and email address
- DA advise no statutory actions required

- temporary buildings associated with a material change of use, building works or operational works, for no more than 2 years

Operating a business from temporary premises

Some businesses affected by the floods may be able to operate from a temporary building on the flood-affected site or from other premises for a short period while their damaged building is being repaired or restored.

Small-scale low-impact businesses may be able to operate temporarily as a home business if issues such as number of employees, signage, car parking and hours of operation are limited to minimise impacts on neighbours.

Some larger-scale businesses may have no alternative but to find another location from which to operate. This may need planning approval.

Council can provide advice on options available to businesses. To obtain advice from Council about your particular situation and the options available, email dafloodenquiries@brisbane.qld.gov.au or contact Council on (07) 3403 8888 with the details of your particular circumstances.

BRISBANE CITY

TLPI for Raising Houses

- Consultation
  - DA
  - BCLP
  - DLGP
- Latest version
- Next Actions

House Code

1 Application

This Code will apply in assessing material change of use and/or building work for a house.

2 Using this Code

In using this Code reference should also be made to Section 1.1—How to use the Codes, at the front of this Chapter.

When this Code is listed in a level of assessment table in Chapter 3 or a Local Plan in Chapter 4 as an Applicable Code for **self assessment**:

- the Code is to be read as being the Acceptable Solutions only
- a Local Plan Code may vary or include additional Acceptable Solutions
- where the proposal involves extensions or alterations to an existing house, compliance with the Acceptable Solutions will be considered in relation to those alterations and additions only

Ensure houses over 8.5m above ground level do not adversely affect outlook or views **except where in flood affected areas.**

Ensure new houses and extensions to existing houses in Flood affected areas can be erected to a height that achieves acceptable flood immunity.

- a Local Plan may include a Code that may vary or include additional Purposes, Performance Criteria or Acceptable Solutions.

Notifiable Code Assessment applications are to be publicly notified in accordance with Section 5 of this Code.

Houses in Demolition Control Precincts are also code assessable against the requirements of the **Residential Design—Character Code**.

Houses on lots of less than 450m², or with an average width less than 15m or on a rear lot less than 600m² will be self assessable or impact assessable against the requirements of the **Residential Design—Small Lot Code**. The level of assessment will depend on the house design's compliance with the Acceptable Solutions in Part 1 of the **Residential Design—Small Lot Code**.

Note: Although not considered as part of the development application, the Environmental Protection Act 1994 also sets residential amenity and nuisance standards in relation to residential activities.

3 Purpose

The purpose of this Code is to:

- ensure that houses and ancillary development are compatible with surrounding development
- ensure the height of a house allows reasonable access to daylight and sunlight for neighbouring houses and their open space
- ensure houses over 8.5m above ground level do not adversely affect outlook or views
- ensure that houses do not impact adversely on amenity, natural features or flooding
- ensure that houses are located where impacts on the natural environment and water supply catchment values are minimised
- ensure that houses are not subject to unreasonable hazards or noise because of their location
- ensure that house design along the Brisbane River Corridor and other waterways is compatible with the landscape character and values of the waterway.

4 Performance Criteria and Acceptable Solutions

4.1 General requirements

Performance Criteria		Acceptable Solutions	
P1	Buildings on a house lot must have the appearance and bulk of a single house with ancillary outbuildings	A1.1	A lot is used for no more than one main dwelling and one secondary dwelling
		A1.2	Any secondary dwelling is no larger than 70m² in gross floor area and is used by one or more members of the household group in accordance with A8
		A1.3	Any secondary dwelling is not further than 20m from the main dwelling

Performance Criteria		Acceptable Solutions	
P2	Building height must not create overbearing development for dwellings and open space on neighbouring properties Building height must be consistent with those heights prevailing in the immediate area	A2	No part of the house is more than 8.5m above ground level. Non-load bearing aerials, antennas, flues, roof ventilators, and chimneys are not considered part of the house for the purpose of determining building height
P3	Building height over 8.5m above ground level are consistent with and repeated in the form of surrounding development Any additional part of the building over 8.5m above ground level must not result in reduced visual amenity of an area, particularly where the site is on a prominent ridgeline	A3	No Acceptable Solution is prescribed as this provision does not apply to self assessable
P4	Residents' vehicles must be accommodated on site	A4	A minimum of 1 vehicle space is provided on site for a house without a secondary dwelling OR A minimum of 2 vehicle spaces are provided on site if the house has a secondary dwelling
P5	House must be protected from adverse flooding and must not significantly interfere with the passage, storage or quality of stormwater or the natural functions of a waterway	A5.1	House and ancillary structures are not within a waterway corridor (as shown on the Planning Scheme Maps)
		A5.2	Design and construction of the house complies with Council's **Erosion and Sediment Control Standard**
P6	Habitable rooms, non-habitable areas (e.g. utility areas, garage, laundry and storage room) have acceptable levels of flood immunity	A6.1	Where the lot is subject to a resolution about minimum floor levels of habitable rooms under the *Building Regulation*, the floor level of all new rooms satisfied the level determined in the resolution OR Where the house is on floodable land but the lot is not subject to a resolution about minimum floor levels of habitable rooms under the *Building Regulation*, the floor level of all habitable rooms is not less than those set out in *Table 1*
		A6.2	Where a lot is on floodable land, the minimum levels for non-habitable areas (including utility areas, garage, laundry and storage room) are not less than those set out in *Table 1*

"Buildings exceeding 8.5 metres to achieve improved flood immunity in the area shown on Map A must be designed to minimize the height of the side and rear walls in relation to adjoining properties and the overall height of the building.

"Where a house is being raised or erected in the area defined on Map A, a maximum building height of 8.5 metres above ground level at the side and rear walls."

BRISBANE CITY

2

BCC.013.0969

4.2 Houses within the Brisbane River Corridor

These additional requirements apply to land wholly or partly within the Brisbane River Corridor. House location requirements do not apply to extensions of existing houses unless the extensions intrude into the Brisbane River Corridor.

The **Brisbane River Corridor Planning Scheme Policy** provides guidance on the assessment of applications that do not meet the Acceptable Solutions.

Note: The Brisbane River Corridor Precincts referred to in this part of the Code are indicated on The Strategic Plan—Brisbane Green Space System—Map C and Planning Scheme Map 2 of 3—Waterways and Wetlands.

The Building Regulation should be consulted to identify if any building work listed below is exempt or self assessable and therefore not subject to the provisions of the City Plan.

Performance Criteria		Acceptable Solutions	
P1	The siting and design of houses must contribute to the desired character of the Brisbane River Corridor precinct in which the site is located. Materials used must complement surrounding buildings, the visual character of the area and the character of the precinct Houses in Precinct 1 must maintain the rural and natural character of the precinct, maintain the same setback as surrounding buildings, and be obscured from view from the Brisbane River by topography or vegetation Houses in Precincts 2, 3, 4 and 5 must be set back no less than buildings sharing a common boundary. In these circumstances houses must be of a similar height and bulk to these adjoining buildings, substantially shielded from view of the Brisbane River by vegetation and ancillary structures between the house and the river must be restricted to minimise impacts on the Brisbane River's landscape values	A1.1	~~The house has a maximum height of 8.5~~ metres, with any unenclosed under croft or unscreened columns not exceeding 3m of ~~this total 8.5m~~
		A1.2	The house is set back a minimum of: • 20m horizontal distance from high water mark OR • 30m horizontal distance from high water mark for land in the Environmental Protection or Rural Areas in Precinct 1 OR • no closer than the average setback of adjoining dwellings where there are adjacent riverfront dwellings within 10m of one or more side property boundaries
P2	Valued habitats, remnant riparian vegetation and mature examples of appropriate planted tree species must be conserved and protected		high water mark for land in the Environmental Protection or Rural Areas OR • within 20m horizontal distance from high water mark for other land
P3	The size, material, design and appearance of minor structures associated with houses must not adversely affect the potential accessibility or attractive appearance of the Brisbane River and its banks when viewed from the Brisbane River and sites adjacent to the Brisbane River In Precinct 1 minor structures must only locate in the corridor where there is no other alternative site on the lot, and where designed to be unobtrusive and take into account the surrounding landscape values	A3	Minor structures are not located within 20m horizontal distance of the Brisbane River high water mark, except for: • barbecues and fixed outdoor furniture (not roofed) • play equipment (not roofed) • temporary shade shelters, including umbrellas *Note: minor structures include:* • *greenhouses, bush houses, shade houses* • *decks, gazebos, poolside shelters and garden pavilions*

"Where a house is being raised or erected in the area defined on Map A, a maximum building height of 8.5 metres above ground level at the side and rear walls."

Next Actions

- **BCLP to scrutinise**
- **Continue liaison with DLGP**
- **E&C by end of March**

BCC.013.0970

Pontoons - Code of Practice

- Met with CEO of Marine Queensland
- Receptive to the idea - aligned with the charter of MQ.
- Members would see CoP and/or accreditation as a benefit to their businesses as they continually seek to promote professional conduct, customer service and reputation of industry.
- MQ could facilitate a consultation process with their members and non-members.
- Brisbane Boat Show (August) – opportunity to promote.

Actions

- MQ to send BCC initial thoughts and ideas on a CoP.
- BCC to refine CoP - MQ for distribute to pontoon designers and installers for comment.

BRISBANE CITY

Minutes
Town Planning Sub-Committee
Friday 18 February
8.30 – 9.30 am
Brisbane Square, Level 10, Room 1a – 1b

COMMITTEE MEMBERS PRESENT:
Cr Amanda Cooper, Chair, Town Planning Sub-Committee
Cr Krista Adams, Deputy Chair, Town Planning Sub-Committee
[redacted] Divisional Manager, CPaS
[redacted], Manager, Water Resources
[redacted] Manager, Major Development Projects
[redacted]ger, City Planning
[redacted]Manger, Development Assessment
[redacted]air, Urban Futures Brisbane
[redacted]ncipal Planner, City Design (delegate for Coenraad Groenewald)
[redacted]ior Commercial Manager, City Property
[redacted]ritus Professor, University of Queensland
[redacted] Centre Place Manager, City Hall Restoration Project
[redacted] Team Leader, City Plan Implementation, City Planning
[redacted] Asset Manager Central West Network Performance, Energex

OTHER ATTENDEES:
[redacted]oject Manager, City Plan 2012, Secretariat
[redacted] Senior Program Officer, Strategic Planning, City Planning, Secretariat
[redacted] Project Support Officer, City Planning, Secretariat
[redacted]Research Officer, Urban Futures Brisbane, City Planning
[redacted] Policy Liaison Officer to the Chairman

APOLOGIES:
[redacted], Product Manager Planning and Sustainability, City Design
[redacted]Urban Planner, Natural Environment & Sustainability, Secretariat

MINUTES: [redacted]

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1 **Meeting Open** – Cr Cooper
Cr Cooper welcomed all attendees and thanked them for their participation.

2 **Minutes of Previous Meeting** – Cr Cooper
Minutes of the previous meeting held on 11 February 2001 were confirmed.

3 **FloodWise Property Report Update** – [redacted]

3.1 Property Buy-Back Scheme Update

- House count for flood-affected residences is continuing; when finalised, will provide sound basis for assessment
- Data will be updated, following which Cr Matic will be consulted as draft recommendations are formulated for the Sub-committee
- Interim projections based on data from 2005 Lord Mayor's Flood Task Force
- Projections indicate that only at the 20-year ARI will any river flood affected properties begin to be captured
- Options for raising houses under consideration, noting the relative costs involved in raising houses versus buy-back scheme.

- Concerns remain with respect to owners of raised houses might subsequently enclose ground levels via simple DA processes – may require legislative change to avoid such outcomes
- Noted that Council facilitating improved flood immunity has potential to produce large increases in property values
- NSW Government previously provided large financial contribution to buy-back schemes on floodplains in that state; role also exists for Federal Government in financing buy-back schemes
- Propose that Council write to Prime Minister and Qld Premier seeking financial support and partnership for Brisbane's buy-back scheme; draft letter distributed for comment
- Council is not proposing to extend buy-back scheme until advice received from State and Federal Governments
- Agreed that correspondence should also refer to other flood frequencies, including for creek flooding, and offer potential scheme expansion as both partnership and public infrastructure opportunities
- Important to consider future use of land after purchase by Council, especially likely resistance of local community to uses that might be perceived as intrusive
- Opportunity for Council to convert sites to other uses, or to build contemporary, exemplars of flood-resilient housing, perhaps also contributing to social / community housing stock
- **Action: [redacted] to liaise with Cr Cooper's office re forwarding of correspondence from Lord Mayor to Qld Premier and Prime Minister**

3.2 Floor Level Survey

- Cost estimates for options relate to river flood only
- Acknowledged that costs would be substantially higher with desirable inclusion of creek flooding data
- Council's existing *Virtual Brisbane* 3D model offers general spatial accuracy to a margin of 0.5m, although current coverage is only Brisbane's inner 5kms
- Citywide mapping exists but has not yet been incorporated into Virtual Brisbane
- With additional funding, it may be appropriate for Council to expand the model to cover the relevant areas
- Agreed that it is crucial to address creek flooding as well as river flooding, to recognise the higher danger of the former to residential property
- Mapping and data will require ongoing maintenance beyond the initial task
- **Action: [redacted] to seek advice from the Virtual Brisbane Team re costs of expanding the model to include appropriate areas for accurate mapping of floor levels, and to provide results to Shane Hackett**
- **Action [redacted] to submit to a future meeting revised proposal including updated cost estimates, based on wider Virtual Brisbane modelling and inclusion of creek flooding**

3.3 Inclusion of Floor Levels

- Options currently being assessed
- Cost estimates in the range of $250k to $350k
- Revised proposal will be brought to a future meeting
- Noted that information will be required for public release before the end of 2011
- **Action: [redacted] to provide an updated proposal to a future meeting**

3.4 Two Reports: Technical & General

- Content of Reports to be managed to cater for different audiences – technical and general public
- Cost estimates range between $250k and $650k
- Drafts will factor in advice from Richard Sivell re appropriate content improvements
- Agreed to proceed with commissioning mock-ups
- **Action: [redacted] to provide an updated proposal to a future meeting**

3.5 Historic Flood Level Information

- Current cost estimates between $380k and $480k
- Inclusions yet to be resolved, options considered include:
  - January 2011 event level
  - 1974 flood level (both pre- and post- dam construction)
  - Creek flooding event levels, especially from 1974
  - Actual floor and ground levels (when available from Virtual Brisbane)
- Members agreed that too much detail will only lead to confusion or misinterpretation
- Rates Notices will not have information as an attachment, but will provide brief explanation directing people to FloodWise Reports
- People currently seeking guidance re defined levels to inform reinstatement of jetties, pontoons etc; appears to be a lack of understanding of current availability of information
- Need to ensure that industry is aware of existing data
- **Action: [redacted] to discuss with [redacted] appropriate inclusions to ensure that information is meaningful to people's situations**

3.6 Flood Markers

- Two options proposed
  - Park installations at approx 20 locations, with estimated cost of $350k
  - Bridge and local signage at approx 20 of each location, with estimated cost of $117k
- Costs include manufacture and installation of signage as well as public awareness / marketing activities
- Agreed to proceed with bridge and local signage option
- Specific locations to be subject of continuing discussions
- Noted that structures such as power poles should not be used in areas where they may be subject to replacement or otherwise of a potentially temporary nature
- **Action: [redacted] to provide future meeting with list of proposed bridge and local signage locations**

3.7 Draft Flood Communications Strategy

- Draft Strategy distributed for information and comment
- **Action: Draft Flood Communications Strategy to be listed for discussion at next week's meeting**

4 Habitable Floor Levels – [redacted]

4.1 Industry Reference Group Discussions

- General acknowledgement that people accept that Brisbane is a flood-prone city, although there are likely to be some short-term impacts on property values in affected areas
- Discussion noted need for building designs to address resilience, including use of appropriate materials

- IRG attendees highlighted importance of understanding the nature and likely frequency of 2011 flood event in determining future priorities
- Extensive discussions re commercial buildings with basement flooding; raising car-parking is not considered a long-term solution; alternative measures need investigation
- Location of key services needs review and investigation
- Concerns re response from Insurance Council who state that current flood level is perceived as inadequate in "preventing" floods
- Insurance Council proposes flood level that factors in maximum levels for rainfall, tidal conditions and upstream water release from Wivenhoe Dam, plus a margin; Serious concerns that this view is extreme and unrealistic
- Agreed that while Insurance Council has a role as a stakeholder, it should not be represented in future deliberations of the IRG
- Joint workshop to be convened on 28 February for IRG, Technical reference Group and Joint Flood Taskforce

4.2 Discussions with Royal Australian Institute of Architects

- RAIA sponsoring design-related blog "Flood of Ideas"
- Council will partner with RAIA to support and promote the blog and other relevant activities
- Expectation that the blog should be in place by 1 March

4.3 Options to Capture Levels through DA/BA process

- Data will be fed into Water Resources Branch investigations and research
- Need to establish mechanisms to capture data from private certifiers at a sufficiently early stage – noted that relying on copies of certified plans is too late in the process
- Accuracy of information from private certifiers is also critical – need to convey that requirement to the industry in clear terms

4.4 Dealing with DAs for Flood-Affected Properties

- Activation of ground floors and use of attractive designs being encouraged
- Pursuing options that enable people to achieve minor lift in building height, but necessarily above flood levels
- Key to outcomes is appropriate habitable floor levels coupled with streetscape solutions focussing on flood resilience
- Noted that a clear message must state that City Plan standards still apply, although the State's Commission of Inquiry will ultimately decide the ongoing standards
- Council is pursuing interim standards that are consistent with City Plan's performance-based approach while enabling flood resilient outcomes

5 Draft Temporary Local Planning Instrument - [redacted]

- Purpose of TLPI is to allow houses to exceed 8.5m height in flood-affected areas
- Existing levels of assessment highlighted
- No current provisions in place for flood immunity or reliance to be used as a factor in building heights
- Key questions raised for drafting of TLIP:
  - Appropriate flood level for application of TLPI?
  - At what inundation depth should the TLPI be applied?
  - Up to what height is Council prepared to comprise other amenity aspects to achieve flood resilience?
  - Should different rules apply to new and existing housing?
- Data is currently being gathered re depth of inundation across city

- Challenge exists to address variety of inundation circumstances where some properties were only partly flooded and some of those did not have any water inside the building
- Prescriptive approach re minimum height levels may be problematic for some people, especially re cost implications
- Need to consider range of potential solutions and assess issues each scenario may raise for local amenity, streetscape etc
- Discussion ensued re determining appropriate height, either at overall height or outermost projections – need to understand roofing forms likely to emerge under those possibilities
- May be necessary to adopt a standard that combines both measurements in order to avoid undesirable outcomes
- Also important to have measures that constrain ground floor uses, and to clarify that the ground floor is not to be a habitable level
- Key factor to consider implications for provision of services to higher houses – Council will liaise closely with external agencies
- [redacted] and team congratulated on quality of work to date; progress reports to follow at future meetings

6 Reporting/Actions Register – [redacted]

- Spreadsheet circulated for information, noting that delivery dates are generally locked-in
- Calendar of delivery dates will also be circulated
- Actions are generally on track
- Timeline for building basements task discussed; agreed that recommendations will be available for consideration by Sub-committee by 25 March, and will then be subject to consultation with appropriate stakeholders, following which the final recommendations will be completed by the end of April

7 General Business

7.1 Inclusion of Services Aspects in DA Processes

- Practical opportunities sought to embed services aspects more securely in DA processes
- [redacted] will provide a presentation on key priorities at the meeting in two weeks' time
- **Action: [redacted] to provide presentation at meeting on 4 March**

7.2 Pontoon Rebuilding & Maintenance

- DERM has proposed a general exemption for rebuilding of pontoons
- DERM has also offered a broad interpretation of "maintenance" work to enable appropriate action to be fast-tracked
- Members welcomed DERM's positive actions in this regard

7.3 Establishment of Qld Reconstruction Authority

- Legislation to create QRA includes very strong powers affecting local governments, including:
  - Power to direct local governments re DA timeframes
  - Power to take over DA assessment
  - Power to direct changes to planning schemes
  - Exemptions from judicial review
- Concern expressed re extent of proposed powers, especially if applied to Brisbane

Meeting was closed at 9.40 am.

The next meeting is scheduled for **Friday, 25 February, 08.30 – 09.30 am**, at Brisbane Square, Level 10, Rooms 1a & 1b.

4 Feb 2011	Action	Responsible	Due	Status
#1	Contact Russ Howard about joining the TPSC with Cr Cooper's agreement	[redacted]		[redacted]
#2	Draft letters to be sent out on Monday to (JFT) Industry Reference Group			
#3	Committee members to familiarise themselves with the FloodWise Report	Committee Members		
#4	Present the FloodWise Report at the next meeting to establish if messages are clear	[redacted]		
#5	Circulate terminology (to be sent out by Secretariat)			
#6	Secretariat to establish and circulate a central email for TPSC	Secretariat		Underway with IDiv.
#7	Secretariat to liaise with DA to prepare letter to Reconstruction Authority for signature by Cr Cooper regarding reinstatement of private pontoons. This letter will need to reference existing work by BCLP, City Design and the Infrastructure Committee in connection with City Cat Terminals.	Secretariat / DA		[redacted]
#8	Secretariat to request CaRS to investigate scope of temporary living structures issue and report back to TPSC	Secretariat		Not yet commenced
#9	SH to present the options for an enhanced FloodWise report at the next meeting	[redacted]		[redacted]

11 Feb 2011	Action	Responsible	Due	Status
#1	Provide a one page proposal outlining the options to Council	[redacted]	Fri 18 Feb	
#2	Setup calendar of deliverables and circulate to members		Fri 18 Feb	
#3	Investigate FWRP and Rates notice options by next meeting		Fri 18 Feb	
#4	Talk to RAIA regarding habitable floor levels by next meeting		Fri 18 Feb	
#5	Development Assessment to report on suggestions to capture levels through the DA/BA process at the next meeting		Fri 18 Feb	

18 Feb 2011	Action	Responsible	Due	Status
#1	Liaise with Cr Cooper's office re forwarding of correspondence from Lord Mayor to Premier and Prime Minister	[redacted]	Fri 25 Feb	
#2	Seek advice from the Virtual Brisbane Team re costs of expanding the model to include appropriate areas for accurate mapping of floor levels, and to provide results to [redacted]		Fri 25 Feb	

#3	Submit to a future meeting revised proposal including updated cost estimates, based on wider Virtual Brisbane modelling and inclusion of creek flooding	[redacted]	Fri 25 Feb	
#4	Provide an updated proposal for the Flood wise property report to a future meeting		Fri 25 Feb	
#5	Discuss with [redacted] appropriate inclusions to ensure that information is meaningful to people's situations		Fri 25 Feb	
#6	Provide future meeting with list of proposed bridge and local signage locations		Fri 25 Feb	
#7	Draft Flood Communications Strategy to be listed for discussion at next week's meeting		Fri 25 Feb	
#8	Provide presentation at meeting		4 March	

Note: *Shaded area = Action is closed*

Action on track and being attended to

Action progressing with some more work yet to be achieved

Action delayed or on hold

City Planning & Development Assessment Flood Response

Flood Response Review Board

Thursday 24 February 2011

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- Planning in Brisbane
- Flood controls under Town Plans/ City plan
- Lord Mayor's Suburban Flooding Taskforce
- Impacts of January Floods

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Planning layers



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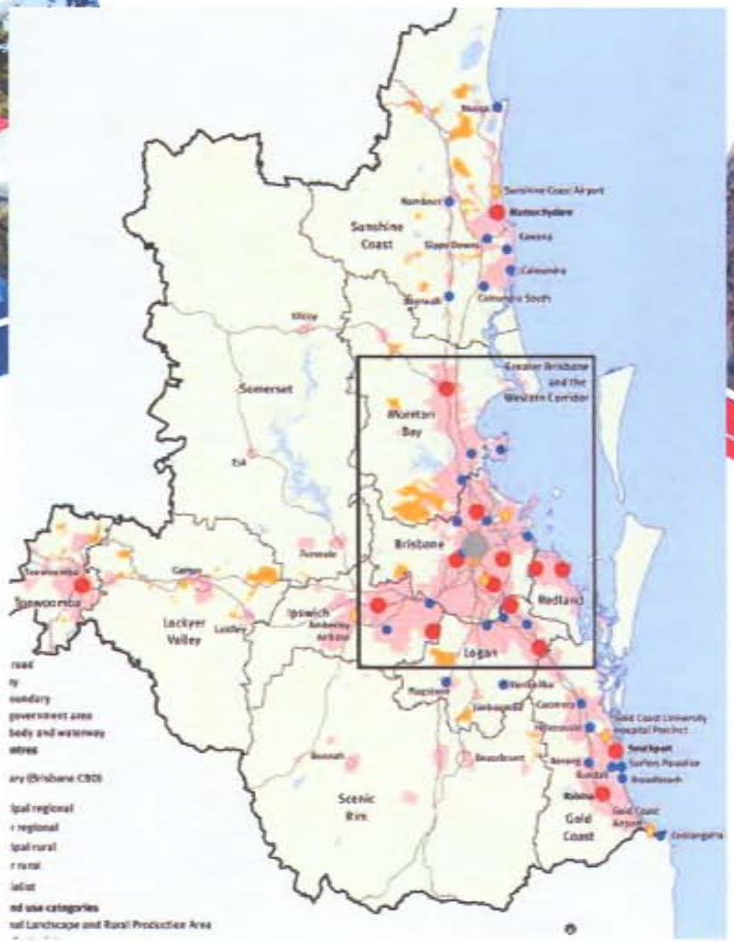



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Forward Planning

- The SEQ regional plan sets a target of 150,000 new dwellings for Brisbane by 2031
- Some of this will be new development – Rochedale & Oxley Wedge
- 138,000 dwellings will be infill in areas like South Brisbane, Milton, Woolloongabba
- Brisbane currently preparing a new City Plan based on accommodating this growth

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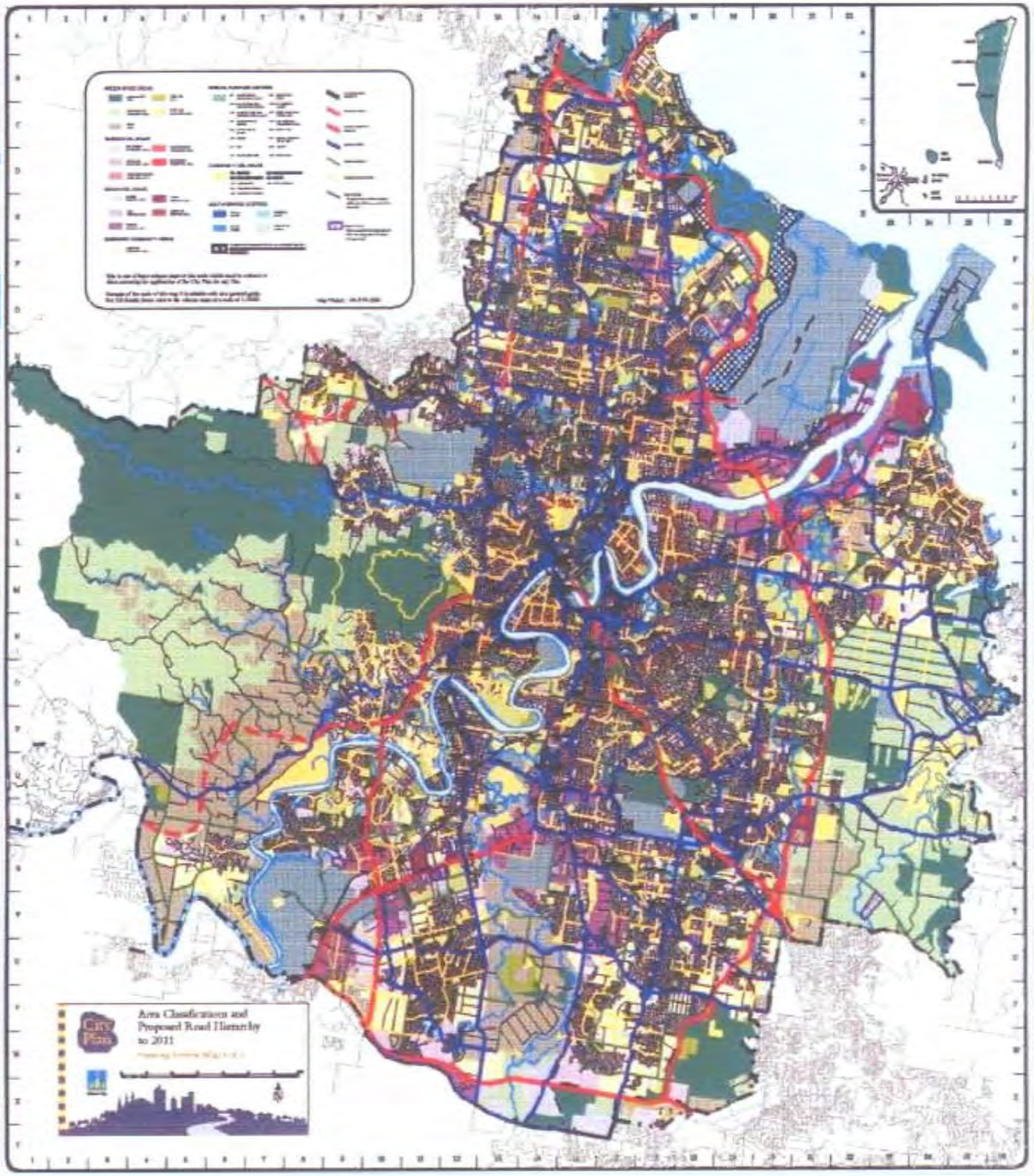

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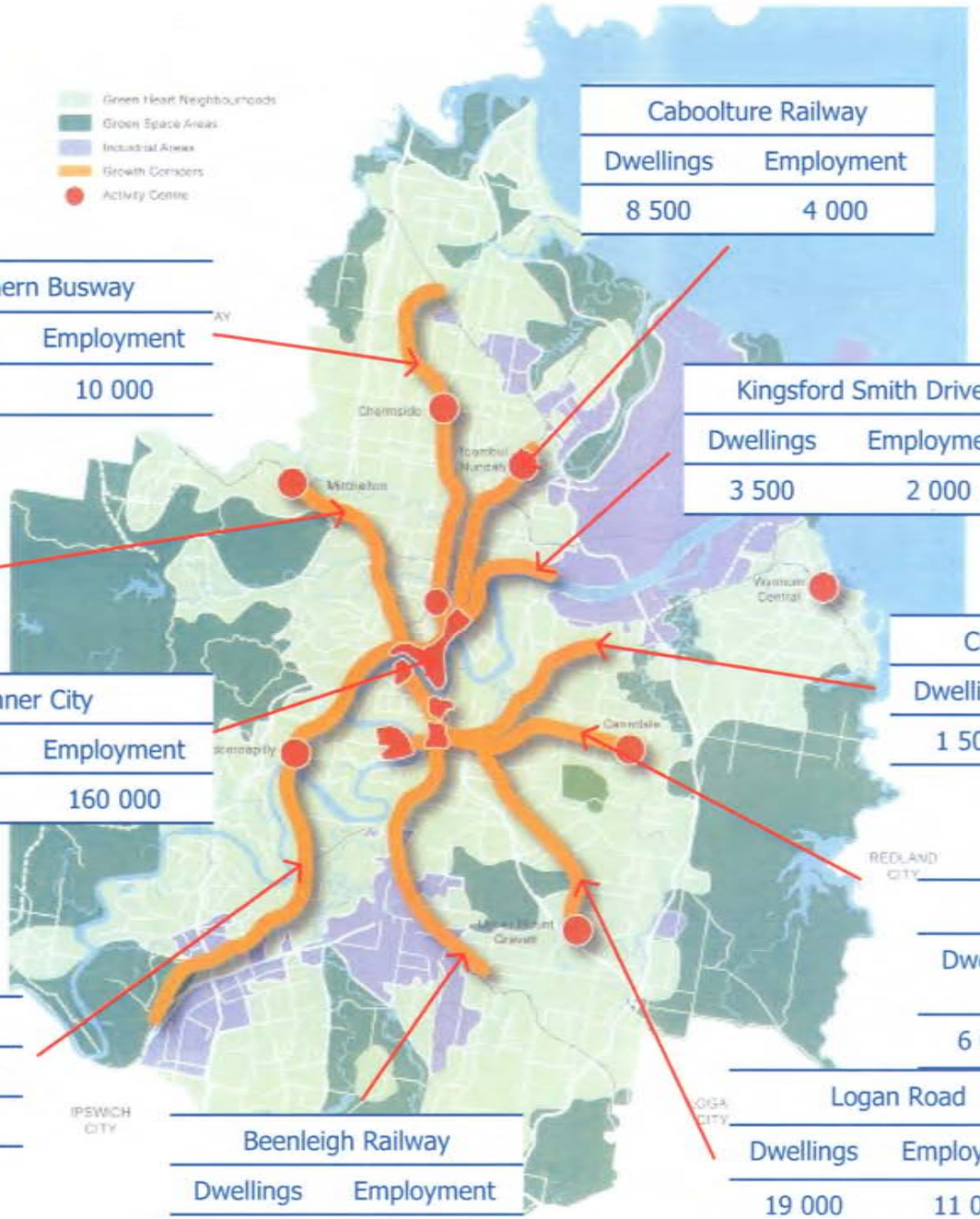
Growth options



Caboolture Railway	
Dwellings	Employment
8 500	4 000

Northern Busway	
Dwellings	Employment
30 000	10 000

Kingsford Smith Drive	
Dwellings	Employment
3 500	2 000

Ferny Grove Railway	
Dwellings	Employment
8 000	4 000

Cleveland Railway	
Dwellings	Employment
1 500	2 000

Inner City	
Dwellings	Employment
40 000	160 000

Eastern Busway	
Dwellings	Employment
6 000	5 500

Ipswich Railway	
Dwellings	Employment
18 000	17 000

Logan Road	
Dwellings	Employment
19 000	11 000

Beenleigh Railway	
Dwellings	Employment
14 000	3 500

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