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FLOOD AND STORMWATER MANAGEMENT STUDIES FOR THE FITZGIBBON DEVELOPMENT SCHEME

Urban Land Development Authority
24 July 2009

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For and on behalf of
WRM Water & Environment Pty Ltd

David Newton
Director

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EXECUTIVE SUMMARY

This report presents the results of hydrologic and hydraulic modelling studies undertaken to assess the potential impacts of flooding on development opportunities for the Fitzgibbon Urban Development Area (UDA). The Fitzgibbon UDA covers a total area of some 295 ha, mostly to the east of the North Coast Railway between Telegraph Road and Beams Road. Significant portions of the site are within the floodplain of Cabbage Tree Creek and its tributaries.

A flood modelling study of Cabbage Tree Creek and adjoining tributaries downstream of Dorville Road was undertaken to assess the flood impacts of the initial stages of development (Application 1) and the final development plan for the Fitzgibbon UDA. A TUFLOW 2D hydraulic model was used to simulate flood behaviour for existing and developed site conditions.

Existing development within the UDA is likely to be substantially affected by flooding as ongoing development occurs in the Cabbage Tree Creek catchment upstream of the UDA. The proposed development of the UDA, including construction of associated flood management infrastructure, provides an opportunity to improve a number of existing flood problems for existing development, as well as mitigating any impacts of the UDA development.

The proposed development plan for the UDA will have significant impacts on flow behaviour along Cabbage Tree Creek and its tributaries. A suite of flood mitigation works will be required to ensure no adverse flood impacts on adjoining properties and maximise the developable area of the site. Nine combinations of these management measures were modelled in TUFLOW to assess their likely impacts. Several components of the proposed flood management infrastructure are located outside of the Fitzgibbon UDA.

Flood management infrastructure investigated in the study included regional detention basins, levees and channel improvement/modification works. The preferred option for flood management infrastructure includes:

- Two major detention basins on currently vacant land within the UDA between Telegraph Road and Roghan Road,
- A flood protection levee along the upstream boundary of the railway easement between Cabbage Tree Creek and Beams Road,
- Substantial channel improvement works outside of the UDA along Cabbage Tree Creek extending from upstream of the North Coast Railway to upstream of Roghan Road.

Construction of this infrastructure will ensure no adverse impact from development of the UDA at most locations in the study area and will reduce existing flooding problems that are likely to be exacerbated by ongoing development further upstream in the Cabbage Tree Creek catchment. Construction costs for the proposed infrastructure are of the order of $5 million. Detailed design of the proposed infrastructure will require further detailed studies, including assessment of small adverse impacts at some locations, as well as potentially substantial environmental impacts.

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1 INTRODUCTION

The Urban Land Development Authority (ULDA) is currently preparing a Development Scheme for the Fitzgibbon Urban Development Area (UDA). The Fitzgibbon UDA covers an area of approximately 295ha, as shown in Figure 1.1. Most of the UDA lies to the south of Telegraph Road and to the east of the North Coast Railway. The UDA includes the existing Queensland University of Technology (QUT) campus at Carseldine, Carseldine Railway Station and a 114 ha parcel of vacant land owned by the Department of Housing (DoH), as well as a number of other land parcels in private and government ownership.

The Fitzgibbon UDA is drained by Cabbage Tree Creek and a number of its tributaries, with a substantial portion of the site located on low-lying land within the Cabbage Tree Creek floodplain. Previous development in the area has significantly modified flow paths and flood behaviour across the floodplain. As a result, flood inundation represents a significant potential constraint to development of the UDA.

This report, prepared by WRM Water & Environment Pty Ltd (WRM), presents the results of hydrologic and hydraulic modelling studies undertaken to assess flood behaviour in the vicinity of the UDA for existing conditions and with future proposed development of the UDA. A suite of flood mitigation works are also proposed to ensure no adverse flood impacts on adjoining properties and to increase the developable area of the site. In addition, this report provides an assessment of stormwater management infrastructure required to meet appropriate water quality objectives for stormwater discharges from proposed development on the UDA site.

This report is structured as follows:

- Section 2 provides a description of the drainage network in the vicinity of the UDA.
- Sections 3 identifies previous flood investigations of the area relevant to the current study.
- Section 4 presents the methodology and results of hydrologic analyses undertaken to estimate design flows along the various waterways draining the area of interest.
- Section 5 presents the methodology and results of the hydraulic modelling studies to assess flood behaviour for existing site conditions.
- Section 6 assesses the flood impacts of the initial development phase for the site, Application 1 at 253 Telegraph Road.
- Section 7 describes the potential flood impacts of the overall development and assesses the effectiveness of a range of flood mitigation infrastructure options in reducing flood impacts of the development.
- Section 8 assesses the impact of a proposed bus way on flood levels in Cabbage Tree Creek.
- Section 9 provides information on necessary stormwater management infrastructure to meet water quality objectives for stormwater discharges from the site.
- Section 10 provides estimates of indicative infrastructure costs for the various components of flood mitigation infrastructure considered in the study.
- Section 11 presents the conclusions of the study.

- Appendix A shows the hydraulic roughness across the study area.
- Appendix B shows the TUFLOW 1D structures.

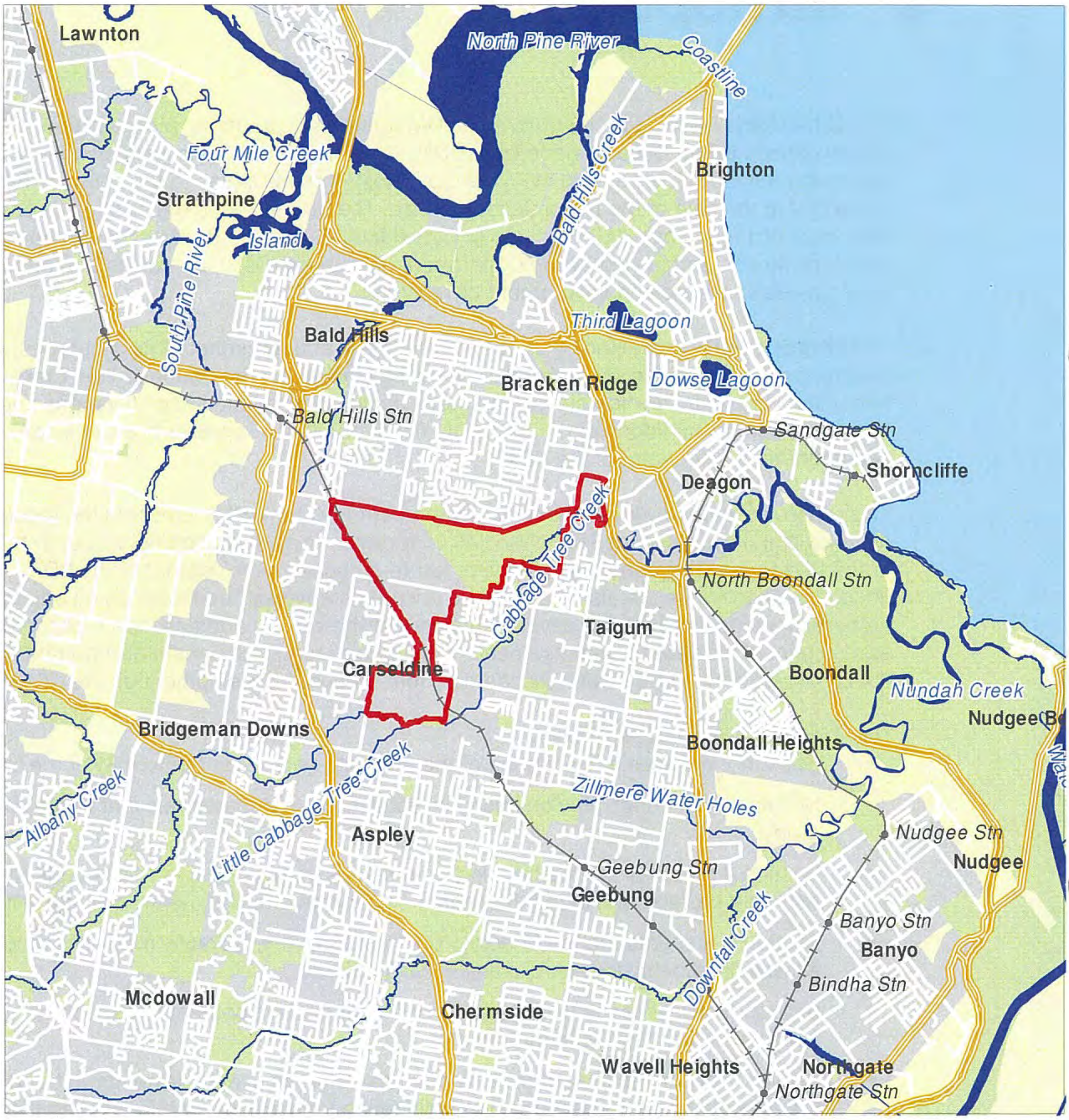

Figure 1.1 Locality Map, Fitzgibbon Urban Development Area

2 DRAINAGE NETWORK

2.1 OVERVIEW

Flooding behaviour within the Fitzgibbon UDA is influenced by three major drainage paths, as shown in Figure 2.1:

- Cabbage Tree Creek, which flows on the eastern side of the UDA;
- Fitzgibbon Drain which crosses the mid-section of the UDA; and
- Carseldine Drain which drains the northern portion of the UDA.

The following sections provide further details on the characteristics of each of these drainage paths.

2.2 CABBAGE TREE CREEK

Figure 2.1 provides an overview of the configuration of the Cabbage Tree Creek catchment. The upper reaches of the catchment extend into the Moreton Bay Regional Council local government area. Figure 2.2 shows local drainage features in the vicinity of the Fitzgibbon UDA.

Cabbage Tree Creek flows in a north-easterly direction, generally on the south-eastern side of the UDA. Cabbage Tree Creek has a catchment area of approximately:

- 19.5 km^2 to the North Coast Railway;
- 30.1 km^2 to the Gateway Arterial; and
- 42.9 km^2 to the mouth of the creek at Moreton Bay.

Little Cabbage Tree Creek, with a catchment area of 5.9 km^2, joins Cabbage Tree Creek a short distance upstream of the North Coast Railway near the upstream boundary of the Fitzgibbon UDA.

The main channel of Cabbage Tree Creek is generally incised within a wide, flat floodplain and has some mature riparian vegetation along most of the reach adjacent to the UDA. Figure 2.3 is a photograph showing a typical main channel section within the study area. The creek is tidal at its downstream end, with the tidal limit a short distance upstream of Lemke Road.

There are five major bridge structures crossing Cabbage Tree Creek within or adjacent to the UDA. These bridges are at the following locations:

- Gateway Motorway;
- Lemke Road;
- Roghan Road;
- Beams Road; and

- North Coast Railway.

Full details of the configuration of each of these bridges are provided in Brisbane City Council's Cabbage Tree Creek Flood Study (BCC, 2000).

2.3 CARSELDINE DRAIN

Carseldine Drain has a total catchment area of about 6.3 km^2 and extends to the west of Gympie Road (see Figure 2.1). The catchment topography is steep in the upper reaches flowing into a wide, flat floodplain downstream of Gympie Road.

To the immediate west of the North Coast Railway, the drain has been modified through excavation and rock lining. The drain discharges on to the Fitzgibbon UDA via a set of box culverts under the North Coast Railway. Within the UDA, the drain is poorly defined, with water spreading out to flow at shallow depth over a large area.

The natural drainage path of the Carseldine Drain catchment has been obstructed by the placement of landfill adjacent to Roghan Road and Telegraph Road (see Figure 2.2). The landfill site adjacent to Telegraph Road is now the Bill Brown Sports Fields. The flow path for water from the Carseldine Drain catchment around the Bill Brown Sports Fields is not well defined, with floodwaters flowing on both the northern and southern sides of the sports fields.

Stormwater runoff from the area to the north of Telegraph Road flows on to the Fitzgibbon UDA via culverts under Telegraph Road at a number of different locations. A significant portion of the urban area north of Telegraph Road drains to a large, shallow detention basin on the northern side of Telegraph Road. Piped outflows from the detention basin discharge to open drainage channels along the northern side of the Bill Brown Sports Fields which flow eastwards towards Cabbage Tree Creek.

2.4 FITZGIBBON DRAIN

The Fitzgibbon Drain has a catchment of 1.3 km^2. It collects stormwater runoff from an urban area on the western side of the North Coast Railway and discharges onto the Fitzgibbon UDA via a number of culverts through the railway embankment. The flow path from the railway to Cabbage Tree Creek has been heavily modified by previous urban development. Most of the drain on the eastern side of the railway has a V-shaped cross-section with a concrete-lined invert, as shown in Figure 2.4.

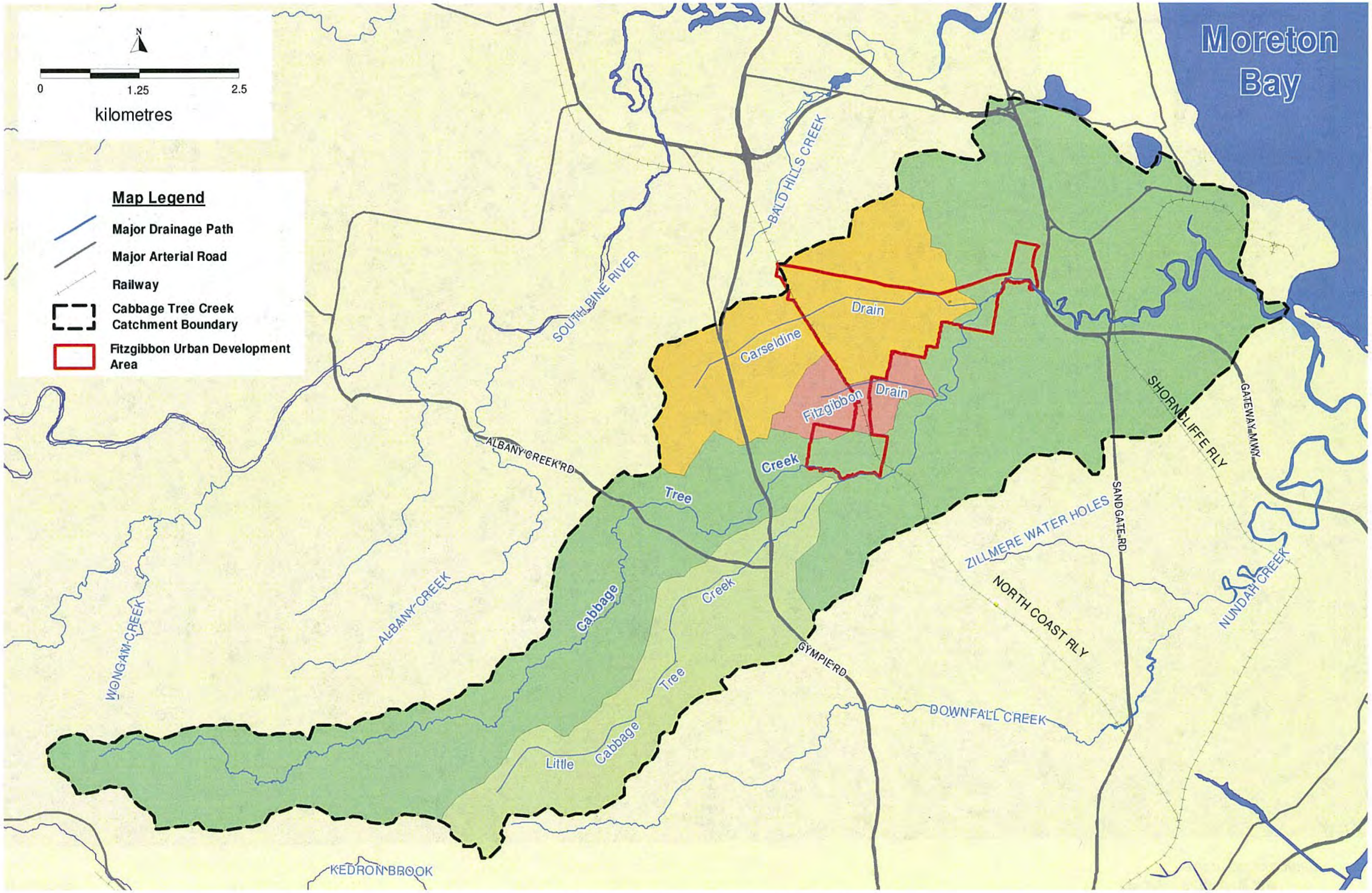

Figure 2.1 Cabbage Tree Creek Catchment

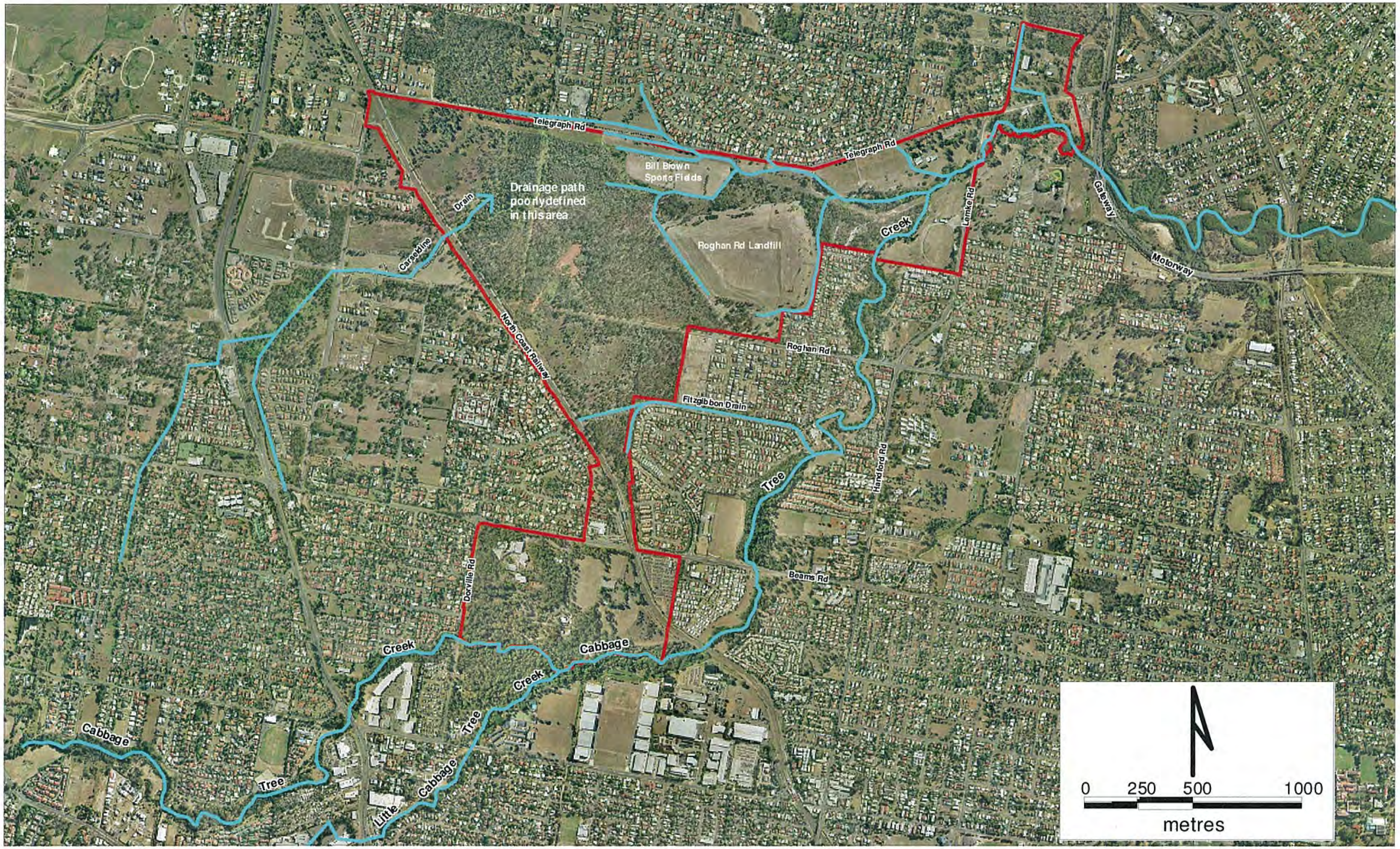

Figure 2.2 Fitzgibbon UDA Local Drainage Features

Figure 2.3 Photograph Showing Typical Cabbage Tree Creek Main Channel in Study Area

Figure 2.4 Photograph of Fitzgibbon Drain

3 PREVIOUS FLOOD INVESTIGATIONS

3.1 OVERVIEW

Numerous previous flood investigations have been undertaken of the various waterways draining the area of interest to this study. The following sections provide a brief summary of the following investigations which are of direct relevance to this study:

- Cabbage Tree Creek Flood Study Upgrade Report (BCC, 2000);
- 253 Telegraph Road Fitzgibbon, Stormwater Quantity and Quality Assessment Report (Storm, 2006);
- ULDA Fitzgibbon Development, Draft Stormwater Quantity and Quality Assessment Report (Storm, 2008).

3.2 CABBAGE TREE CREEK FLOOD STUDY

The Cabbage Tree Creek Flood Study Upgrade Report (BCC, 2000) represents the latest in a series of investigations of Cabbage Tree Creek which have been undertaken by Brisbane City Council (BCC). The study uses the URBS hydrologic model (Carroll, 2004) and the MIKE 11 unsteady flow hydraulic model to estimate design flood discharges and flood levels along Cabbage Tree Creek and Little Cabbage Tree Creek. Flood levels along Carseldine Drain and Fitzgibbon Drain are not estimated by the study. WRM's current study of the Fitzgibbon UDA has adopted BCC's calibrated URBS model to estimate flood discharges along Cabbage Tree Creek.

3.3 253 TELEGRAPH ROAD FITZGIBBON, STORMWATER QUANTITY AND QUALITY ASSESSMENT REPORT

Storm Water Consulting Pty Ltd (SWC) completed a report on the Department of Housing's property at 253 Telegraph Road, which now forms part of the Fitzgibbon UDA, in March 2006. The study assessed the Carseldine Drain catchment only, using a RAFTS model provided by Brisbane City Council, supplemented by an URBS model developed by SWC which provided more detail on the subject property. MIKE 11 was used to estimate flood levels along Carseldine Drain and its tributaries and to assess flood mitigation infrastructure required for a development proposal on the site. WRM's current study of the Fitzgibbon UDA has adopted the same RAFTS model to estimate flood discharges for Carseldine Drain.

3.4 ULDA FITZGIBBON DEVELOPMENT, DRAFT STORMWATER QUANTITY AND QUALITY ASSESSMENT REPORT

In August 2008, SWC completed a report for the ULDA which assessed the impact of proposed development of the southern portion of 253 Telegraph Road, referred to as the Application 1 area. The SWC study included an URBS hydrologic model of the Fitzgibbon Drain catchment and a MIKE 11 model of Fitzgibbon Drain. WRM's current study of the Fitzgibbon UDA has adopted the SWC URBS model of the Fitzgibbon Drain catchment on the western side of the North Coast Railway.

4 HYDROLOGIC ANALYSIS

4.1 OVERVIEW

Flood discharges and flood levels within the UDA were modelled using a detailed two-dimensional model of the entire UDA. Design inflows to the Fitzgibbon UDA hydraulic model were obtained from three existing hydrologic models, developed by others, which were modified for the purposes of this study:

- An URBS model of the entire Cabbage Tree Creek Catchment developed by BCC as part of the *Cabbage Tree Creek Flood Study* (BCC, 2000).
- An URBS model of the Fitzgibbon Drain developed by Storm Water Consulting as part of an initial flood investigation for the Application 1 area of the Fitzgibbon UDA (Storm, 2008).
- A RAFTS model of the Carseldine Drain catchment developed by BCC. Supporting documentation for this model was not provided by BCC.

Runoff from the Fitzgibbon UDA for pre-development, Application 1 development and Final development conditions was determined by applying direct rainfall over the surface of the two-dimensional model. Direct rainfall was also used over the surrounding areas to the south-east of the UDA and downstream of the North Coast Railway. Initial and continuing losses, and surface roughness were modified over development areas to represent the change in impervious area associated with the proposed development.

The extent of the three hydrologic models and inflow locations to the hydraulic model are shown in Figure 4.1.

Details of the adopted model configurations and parameters for each of the hydrologic models are provided in the following sections.

4.2 ADOPTED DESIGN RAINFALLS

Design rainfall depths and storm temporal patterns for the area were determined using standard procedures from Australian Rainfall and Runoff (IEAust, 1998).

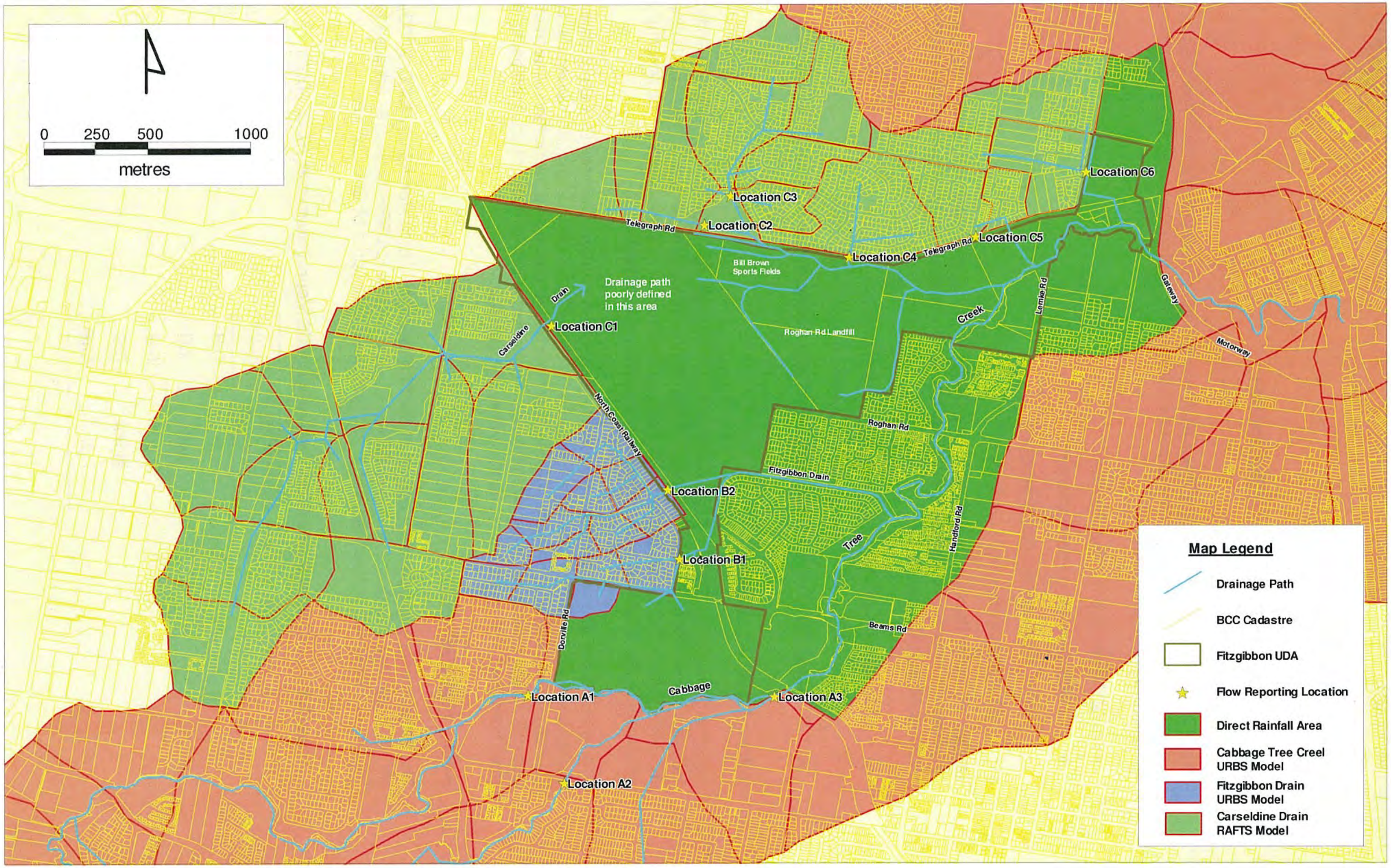

Figure 4.1 Hydrological Models and Discharge Reporting Locations across the Fitzgibbon UDA

4.3 CABBAGE TREE CREEK URBS MODEL

The BCC URBS model of Cabbage Tree Creek was used to estimate the main inflows to the two-dimensional hydraulic model. Four separate versions of the model were provided simulating the following catchment conditions:

- 1979 development conditions;
- 1992 development conditions;
- 1996 development conditions; and
- Ultimate development conditions.

Design inflows to the hydraulic model along Cabbage Tree Creek were determined using the 'ultimate development conditions' model scenario. Discharge hydrographs were produced at three locations (see Figure 4.2):

- Cabbage Tree Creek at Dorville Road (Location A1);
- Little Cabbage Tree Creek at Zillmere Road (Location A2); and
- Cabbage Tree Creek at Pineapple Street and the North Coast Railway (Location A3).

4.3.1 Model Configuration

Figure 4.2 shows the BCC Cabbage Tree Creek URBS model configuration to the North Coast Railway. It consists of 33 sub-catchment areas upstream of the North Coast Railway totalling 18.7 km^2. Table 4.2 shows the area for each sub-catchment in the model and the percent urbanisation for the 1996 and ultimate development model scenarios.

The URBS model was modified to allow for the estimation of runoff from the QUT Carseldine site using the direct rainfall method (see Section 4.6). Sub-catchments 12 and 20 overlap the direct rainfall area, so the area of these sub-catchments was set to zero and the portion of each of sub-catchment outside the direct rainfall area was added to sub-catchment 21, increasing its area from 0.88 km^2 to 1.54 km^2, as illustrated in Figure4.2.

4.3.2 Model Calibration

The URBS model was calibrated as part of the *Cabbage Tree Creek Flood Study* (BCC, 2000) to six historical flow events, as shown in Table 4.3. The calibrated URBS model was adopted for this study. Table 4.1 shows the URBS model parameters adopted by BCC (2000).

Table 4.1 Cabbage Tree Creek Calibrated URBS Model Parameters (BCC, 2000)

URBS Model Parameter	Value
m	0.8
beta	2.0
n	0.8
alpha	0.9
X	0.48

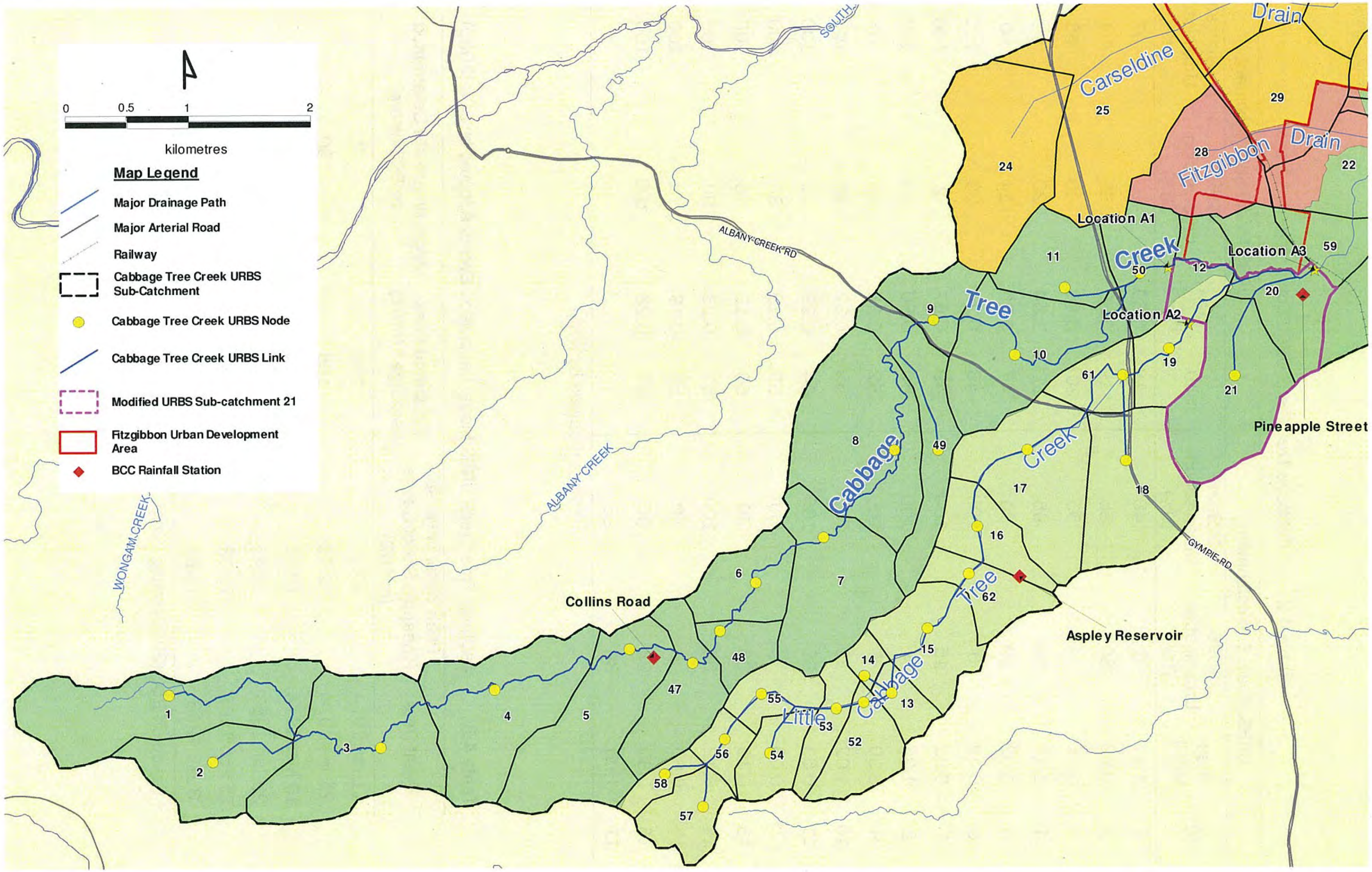

Figure 4.2 Cabbage Tree Creek URBS Model Configuration

Table 4.2 Cabbage Tree Creek URBS Sub-Catchment Areas

URBS Model Sub-catchment				URBS Model Sub-catchment			
ID	Area (km^2)	1996 Urbanisation (U%)	Ultimate Urbanisation (U%)	ID	Area (km^2)	1996 Urbanisation (U%)	Ultimate Urbanisation (U%)
1	1.17	6	40	18	0.89	97	97
2	0.63	80	85	19	0.36	55	94
3	1.18	14	95	20*	0.00	40	65
4	1.14	10	95	21*	1.54	90	92
5	1.02	20	90	47	0.60	24	90
6	0.42	0	100	48	0.24	20	100
7	0.92	15	100	49	0.67	2	100
8	1.28	4	100	50	0.50	50	100
9	0.30	7	100	52	0.35	60	70
10	1.02	30	100	53	0.32	65	100
11	0.60	95	100	54	0.29	17	100
12*	0.00	1	50	55	0.19	80	100
13	0.19	35	40	56	0.13	15	100
14	0.12	65	100	57	0.23	90	100
15	0.60	5	40	58	0.19	10	100
16	0.35	23	90	61	0.28	100	100
17	1.00	89	95				

* Area modified by WRM

Table 4.3 Cabbage Tree Creek URBS Model Calibration Events Adopted by BCC (2000)

Event Date	Peak Water Level at Pineapple Street Gauge (m AHD)	Estimated Peak Discharge [a] (m^3/s)	Approximate ARI Determined by BCC (years)
11 Jan 1974	12.10	103	3
25 Jan 1974	12.76	188	30
10 Mar 1974	12.01	93	3
22 Jun 1983	11.45	51	<2
21 Feb 1992	12.38	134	4
3 Jan 1996	11.64	66	<2

[a] Based on BCC (2000) rating curve

4.3.3 Verification Against 9 March 2001 Event

Following completion of the BCC flood study in 2000, Cabbage Tree Creek experienced a major flood event on 9 March 2001. The March 2001 flood event was used to undertake a joint verification of both the hydrologic and hydraulic models used in the current study.

Table 4.4 shows the total 1 hour, 2 hour, and 3 hour recorded rainfall depths and approximate ARI's at the Aspley Reservoir, Burralong Street, Collins Road and Pineapple Street Alert Rainfall Stations located within the Cabbage Tree Creek catchment. Figure 4.2 shows the location of these alert rainfall stations. Figure 4.3 shows the cumulative rainfall depths at these stations between 1200 hours on 9 March 2001 and 0000 hours on 10 March 2001. The following is of note:

- The estimated ARI of rainfalls recorded in to upper catchment including Aspley Reservoir, Collins Road and Pineapple Street were:
  - Equal to or greater than a 100 year event for the 2 and 3 hour duration storms; and
  - Between a 50 and 100 year event for the 1 hour duration storm;
- The estimated ARI of rainfalls recorded in the lower catchment at Burralong Street was between a 20 and 50 year ARI event for the 1, 2, and 3 hour duration storms.

Table 4.4 Total 1 hour, 2 hour and 3 hour Rainfall Depths and Estimated ARIs at Aspley Reservoir, Burralong Street, Collins Road and Pineapple Street Alert Rainfall Stations

Alert Station Name	1 Hour Rainfall Depth (mm)	2 Hour Rainfall Depth (mm)	3 Hour Rainfall Depth (mm)	Approximate ARI (years)
Aspley Reservoir	96	136	166	greater than 100
Burralong Street	83	121	127	20 to 50
Collins Road	116	152	170	greater than 100
Pineapple Street	101	148	159	greater than 100

The calibrated 1996 land use URBS model was used to estimate discharges along Cabbage Tree Creek for the 9 March 2001 event at the three inflow locations for input into the hydraulic model. Additional catchment development between 1996 and 2001 may have slightly increased peak stormwater discharges, compared to those predicted by the URBS model based on 1996 land use. Calibrating flood levels to the 2001 recorded values using discharges based on 1996 land use is a conservative assumption. To match recorded flood levels, any underestimation of flood discharges will need to be compensated for by increasing hydraulic resistance in the TUFLOW model. As a consequence, the correct (potentially slightly higher) discharges would, if anything, overestimate flood levels.

Initial and continuous losses of 70 mm and 1 mm/hr respectively where adopted for the March 2001 event. Details of the results of the joint model verification are presented and discussed in Section 5.3.

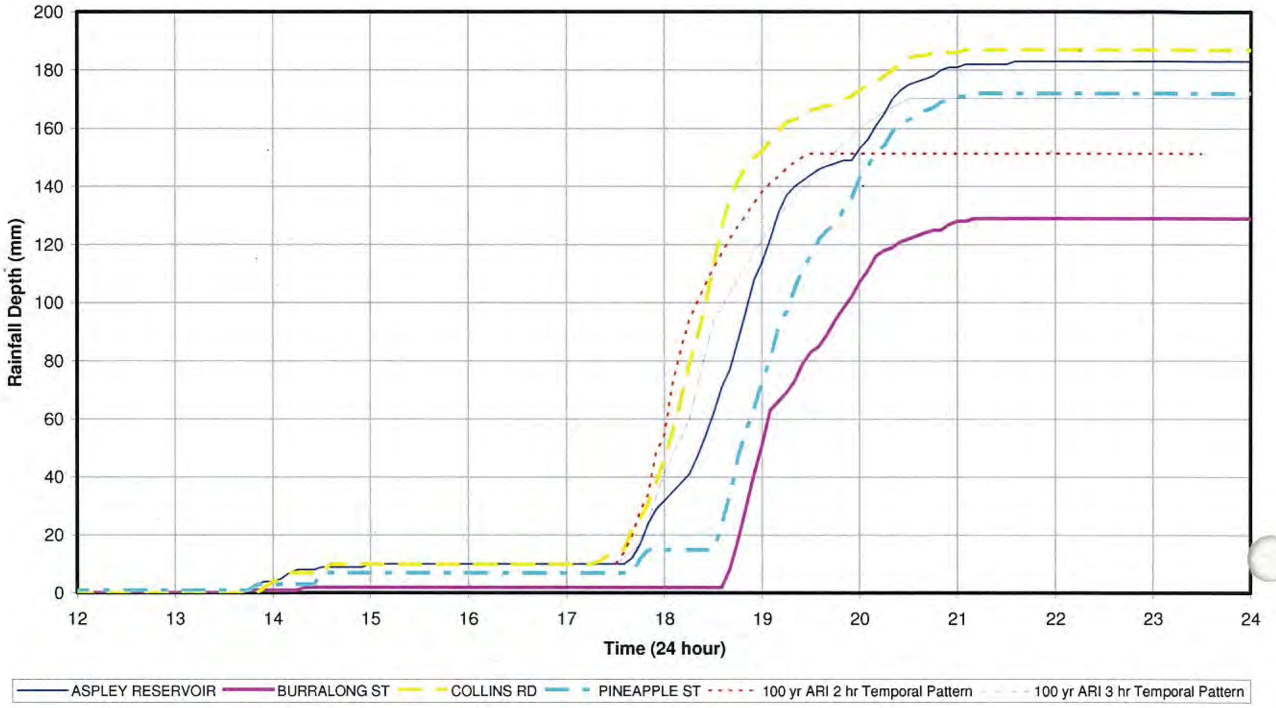

Figure 4.3 March 2001 Cumulative rainfall depths at Aspley Reservoir, Burralong St, Collins Rd, and Pineapple St Rainfall Stations and IEAust (1998) 100 yr ARI two and three hour duration storms

4.3.4 Design Discharges

Table 4.5 shows the adopted 2, 5, 10, 20, 50 and 100 year ARI discharges along Cabbage Tree Creek at Reporting Locations A1, A2 and A3 (see Figure 4.2 for locations). Note that an initial and continuing loss of 0 mm and 0 mm/hr over the entire catchment were adopted for all design events up to the 100 year ARI event.

Brisbane City Council's estimation of design discharges for the Cabbage Tree Creek catchment adopted an in-house methodology to derive design discharges. Using this method, the 100 year ARI discharges were significantly higher than the values shown in Table 4.5. Following discussions with BCC, it was agreed that assessment of development impacts for the UDA development would be undertaken using the 100 year ARI design discharges derived using the industry-standard methodology, but that final development levels would be based on a peak discharge of 264 m^3/s at the North Coast Railway Crossing of Cabbage Tree Creek (compared to 249 m^3/s from the industry standard method). Since zero rainfall losses were used to derive design discharges, the higher value was obtained by factoring up the inflow hydrographs for Cabbage Tree and Little Cabbage Tree Creeks by 1.06 (264/249).

Table 4.5 Cabbage Tree Creek Design Discharges for the 2, 5, 10, 20, 50 and 100 year ARI events at Reporting Locations A1, A2 and A3, Ultimate Catchment Development

ARI (years)	Reporting Location A1 Cabbage Tree Ck @ Dorville Rd Total Discharge (m^3/s)	Reporting Location A2 Little Cabbage Tree Ck @ Zillmere Rd Total Discharge (m^3/s)	Reporting Location A3 Cabbage Tree Ck @ North Coast Railway	
			Total Discharge (m^3/s)	Local Discharge (m^3/s)
2	52.9	35.1	89.1	18.7
5	73.5	48.6	124.3	25.4
10	86.8	57.2	146.8	29.7
20	104.7	68.7	177.4	35.5
50	126.4	83.2	215.8	42.4
100	148.7	96.3	248.9	48.6

4.4 FITZGIBBON DRAIN URBS MODEL

The URBS hydrologic model was used to estimate inflows to Fitzgibbon Drain across the North Coast Railway. The adopted model was based on the "Existing Site" URBS model developed by Storm Water Consulting (2008). The model was modified based on a more detailed assessment of catchment boundaries and flow paths. Discharge hydrographs were produced at two locations (see Figure 4.4):

- Fitzgibbon Drain (Southern Branch) at Balcara Avenue (Location B1); and
- Fitzgibbon Drain (Western Branch) at North Coast Railway (Location B2).

4.4.1 Model Configuration

Figure 4.4 shows the configuration of the Fitzgibbon Drain URBS model. It consists of 17 sub-catchments totalling 70.8 ha. The southern branch has been separated into 8 sub-catchments, and the western-branch into 9 sub-catchments.

Table 4.6 shows the area for each sub-catchment in the model. Areas for sub-catchments 104, 105 and 108 were reduced by WRM to zero because runoff from these sub-catchments was determined using the direct rainfall method (see Section 4.6).

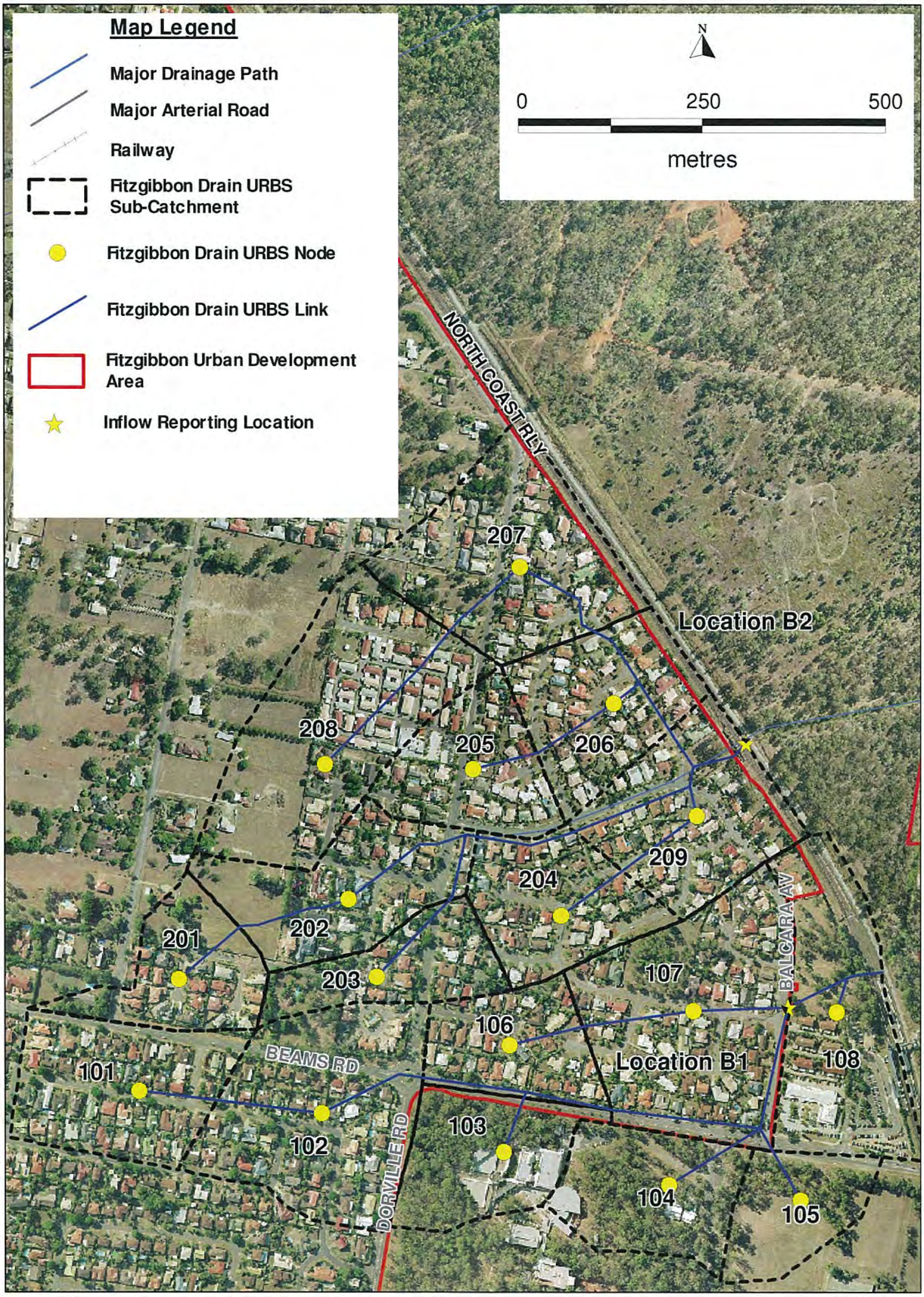

Figure 4.4 Fitzgibbon Drain URBS Model Configuration

Table 4.6 Fitzgibbon Drain URBS Sub-Catchment Areas

Fitzgibbon Drain (Southern Branch) Sub-catchment		Fitzgibbon Drain (Western Branch) Sub-catchment	
ID	Area (ha)	ID	Area (ha)
101	3.85	201	3.54
102	7.90	202	5.09
103	4.31	203	3.00
104*	0.00	204	3.68
105*	0.00	205	3.81
106	3.40	206	6.87
107	7.80	207	6.72
108*	0.00	208	4.89
-	-	209	5.93
TOTAL	27.26	TOTAL	43.53

* Area modified by WRM

4.4.2 Model Calibration

The "Existing Site" URBS model developed by Stormwater Consulting (Storm, 2008) was calibrated to Rational Method discharges for all storms up to the 100 year ARI event. The calibrated model was adopted for this study. The adopted URBS model parameters are shown in Table 4.7.

Table 4.7 Fitzgibbon Drain Calibrated URBS Model Parameters (Storm, 2008)

URBS Model Parameter	Value
m	0.8
beta	2.0
n	0.8
alpha	0.9
X	0.48

4.4.3 Design Discharges

Table 4.8 shows the peak 2, 5, 10, 20, 50 and 100 year ARI design discharges along the Fitzgibbon Drain at Reporting Locations B1 and B2 (see Figure 4.4).

Table 4.8 Fitzgibbon Drain Peak Discharges for the 2, 5, 10, 20, 50 and 100 year ARI events at Reporting Locations B1 and B2

ARI (years)	Reporting Location B1 Balcara Av Discharge (m^3/s)	Reporting Location B2 North Coast Railway Discharge (m^3/s)
2	5.46	7.33
5	7.79	10.57
10	9.28	12.68
20	11.32	15.53
50	14.52	20.02
100	16.79	22.95

4.5 CARSELDINE DRAIN RAFTS MODEL

Figure 4.5 shows the adopted RAFTS model configuration for Carseldine Drain and the adjoining catchment on the northern side of Telegraph Road. The RAFTS model supplied by BCC was originally developed by WBM Oceanics as part of the *Carseldine Drain and Taigum Master Drainage Study* (WBM, 2003). It is understood that City Design is currently undertaking further drainage investigations of the Carseldine Drain and have modified the original WBM (2003) model. Two model scenarios were supplied by City Design:

- "BCC2006Existing2" - this model is referred to as "existing conditions"; and
- "BCC2006Ultimate2_worst case" (Case 3) - this model is referred to as "developed conditions".

Design discharges along Carseldine Drain were determined using the "developed conditions" model at six locations (see Figure 4.2):

- Carseldine Drain at North Coast Railway (Location C1);
- Enbrook Heights Estate Basin West (Location C2);
- Enbrook Heights Estate Basin North (Location C3);
- Enbrook Heights Estate East A at Telegraph Road (Location C4);
- Enbrook Heights Estate East B at Telegraph Road (Location C5); and
- Hydraulics Laboratory Drain at Quinlan Street (Location C6).

The RAFTS model was extended to the east to include the catchment area discharging across Quinlan Street to the Queensland Government hydraulics laboratory. The same model parameters used in the Carseldine Drain model were adopted for the catchment drainage to the hydraulics laboratory.

4.5.1 Model Configuration

Figure 4.5 shows the BCC Carseldine Drain RAFTS model configuration. The model consists of 29 sub-catchment areas:

- 24 sub-catchment areas from the original BCC model upstream of the North Coast Railway and Telegraph Road including:
  - RAFTS sub-catchments 1 to 13 draining to Location C1;
  - RAFTS sub-catchments 16, 19 and 20 draining to Location C2;
  - RAFTS sub-catchments 21 to 27 draining to Location C3;
  - RAFTS sub-catchments 28 draining to Location C4;
- 5 additional urbanised sub-catchment areas were added to the model including:
  - RAFTS sub-catchments 35 and 36 draining to Location C5; and
  - RAFTS sub-catchments 37 to 39 draining to Location C6.

4.5.2 Model Calibration

Table 4.9 shows the area and impervious fraction for each sub-catchment in the model. The pervious fraction initial and continuing loss was 15 mm and 2.5 mm/hr respectively, while the impervious fraction was 0 mm and 0 mm/hr.

No information on the calibration of the RAFTS model was provided by BCC. In the absence of suitable recorded data, the model was calibrated by comparing "developed conditions" RAFTS model peak discharges at the North Coast Railway against the Rational Method discharges. Rational Method discharges were estimated based on the following parameters:

- Time of concentration = 29.2 minutes, comprising:
  - Standard inlet time of 10 minutes,
  - 300 m pipe flow @ 3.0 m/s = 3.33 minutes,
  - 1900 m open channel flow @ 2.0 m/s = 15.83 minutes.
- C10 = 0.8,
- I100 = 147 mm/hr.

A "B_x" factor of 1.1 was adopted to approximately match the RAFTS model 100 year ARI peak discharge (113 m^3/s) to the Rational Method peak discharge of 115 m^3/s.

4.5.3 North Coast Railway Crossing of Carseldine Drain

The substantial area of floodplain storage along Carseldine Drain upstream of the North Coast Railway embankment could have a significant impact in attenuating peak flows along Carseldine Drain. Hence, the railway culverts and upstream storage area were included in the RAFTS model as a detention basin. Stage-storage volumes were calculated from AAMHatch aerial laser survey (ALS) undertaken in 2004. The basin stage-storage characteristics are shown in Table 4.10.

The railway embankment has the following spillway and low level outlet configuration:

- A spillway at an elevation of 12.7 m AHD (Top of rail level),
- Low flow pipes: 3 x 3m (W) x 2.4m (H) box culverts at an invert level of 9.4m AHD,

The results of the RAFTS model confirmed that the railway crossing significantly attenuates peak flows along Carseldine Drain. For the 100 year ARI event, the peak flow along Carseldine Drain is reduced from 113 m^3/s to 56 m^3/s.

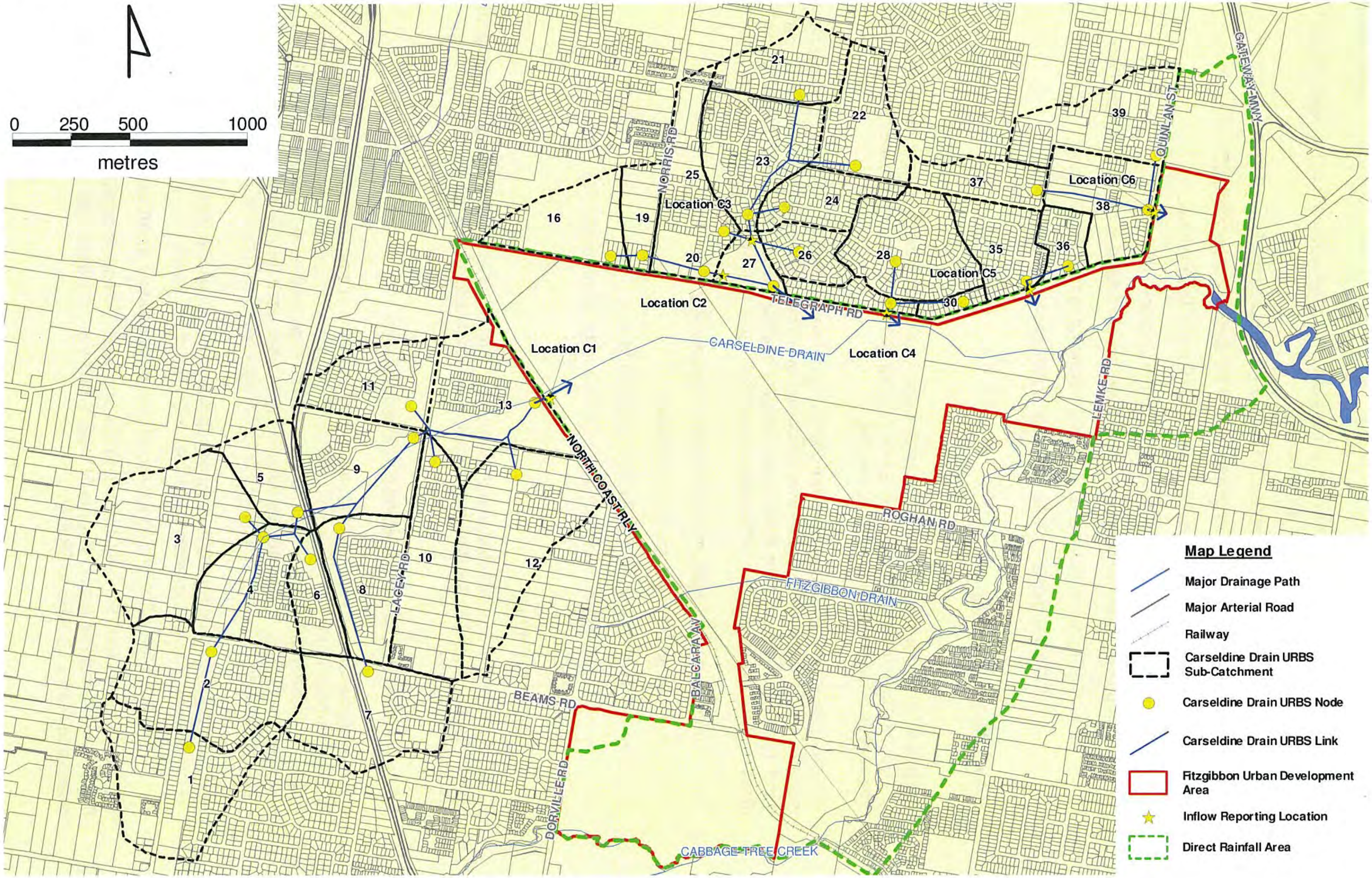

Figure 4.5 Carseldine Drain RAFTS Model Configuration and Extent of TUFLOW Model Direct Rainfall Area

Table 4.9 Carseldine Drain RAFTS Sub-Catchment Areas

RAFTS Sub-catchment				RAFTS Sub-catchment			
ID	Area (ha)	Fraction Impervious (%)	Slope (%)	ID	Area (ha)	Fraction Impervious (%)	Slope (%)
Carseldine Drain – Location C1				*Enbrook Estate Basin North – Location C3*			
1	27.3	0.45	3.0	21	14.5	0.45	8.4
2	31.1	0.45	8.8	22	15.3	0.45	8.0
3	33.0	0.75	2.2	23	20.9	0.45	2.5
4	17.2	0.75	1.9	24	10.4	0.45	4.8
5	10.0	0.75	1.1	25	13.5	0.45	2.9
6	8.4	0.75	1.6	26	7.5	0.26	4.1
7	24.1	0.45	7.2	27_Basin	4.9	0.10	0.5
8	18.0	0.45	1.8	*Enbrook Estate East A – Location C4*			
9	22.0	0.45	1.2	28	20.4	0.45	6.0
10	22.4	0.45	2.5	29_Offline	4.4	0.45	0.7
11	16.2	0.45	1.2	30	2.1	0.45	0.5
12	34.1	0.45	2.6	*Enbrook Estate East B – Location C5*			
13_Rail	25.2	0.45	1.2	35	11.9	0.45	3.0
Enbrook Estate Basin West – Location C2				36	5.5	0.45	1.0
16	15.1	0.45	1.0	*Hydraulics Laboratory – Location C6*			
19	6.7	0.45	2.0	37	9.3	0.45	1.7
20	6.2	0.6	1.3	38	16.5	0.45	1.0
				39	19.2	0.45	3.0

Table 4.10 Adopted Stage-Storage Curve for the North Coast Railway Embankment

Stage (m AHD)	Surface Area (m^2)	Volume (m^3)
9.5	0	0
10.0	191	27
10.5	3069	625
11.0	35442	9488
11.5	89468	39986
12.0	140366	97597
12.5	191759	179797
13.0	255706	292086

4.5.4 Design Discharges

Table 4.11 shows the peak 2, 5, 10, 20, 50 and 100 year ARI discharges at Reporting Locations C1, C2, C3, C4, C5 and C6. These flows include the attenuation provided by the railway embankment.

Table 4.11 Carseldine Drain Design Discharges for the 2, 5, 10, 20, 50 and 100 year ARI events at Reporting Locations C1 to C6

ARI (years)	Design Discharge (m^3/s)					
	Location C1 North Coast Railway	Location C2 Telegraph Rd Basin West	Location C3 Telegraph Rd Basin North	Location C4 Telegraph Rd West	Location C5 Telegraph Rd East	Location C6 Quinlan St
2	27.5	6.8	12.2	5.2	3.3	6.7
5	35.5	9.5	18.6	7.6	4.7	9.6
10	39.5	11.2	22.6	9.1	5.6	11.7
20	44.9	13.5	28.3	11.2	6.8	14.3
50	50.9	15.9	34.0	13.2	8.1	16.9
100	55.8	18.3	39.8	15.5	9.4	19.7

4.6 DIRECT RAINFALL

Figure 4.5 shows the TUFLOW model direct rainfall area. The TUFLOW direct rainfall method was used to determine the local runoff volumes within the Fitzgibbon UDA study area. The total rainfall depth at each time step is applied to all active cells within the rainfall boundary polygon. Initial and continuing losses are subtracted from the total depth of rainfall and the residual rainfall depth is converted to runoff.

Table 4.12 shows the impervious fraction and initial and continuing losses adopted for the land uses in the TUFLOW model. Aerial photographs of the area were used to determine the spatial location of the changes in land use. The losses were calculated based on a weighted average of the pervious and impervious fractions.

Under Application 1 and Final development conditions the proposed areas for development were modelled as Residential and High Density Residential/Commercial land uses.

Table 4.12 Adopted Land Use Fraction Impervious and Initial and Continuing Losses within the TUFLOW Model Direct Rainfall Area

Description	Fraction Impervious (%)	Initial Loss (mm)	Continuing Loss (mm/hr)
Pervious Areas	0	15	2.50
Railway Corridor	50	8	1.25
Residential	60	6.6	1.00
High Density Residential/Commercial	90	2.4	0.25
Major Road/Carpark	100	1	0.00

5 EXISTING CONDITIONS HYDRAULIC ANALYSIS

5.1 OVERVIEW

The TUFLOW fully two-dimensional hydrodynamic model (WBM, 2008) was used to estimate the 2, 5, 10, 20, 50, and 100 year ARI flood levels along Cabbage Tree Creek, Fitzgibbon Drain and Carseldine Drain across the Fitzgibbon UDA site. TUFLOW estimates flood levels on a fixed grid pattern by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow. The model automatically calculates breakout points and flow directions within the study area. A two dimensional model was considered more appropriate for the study given the complex interaction of flows between the creek, its tributaries and overbank areas.

Figure 5.1 shows the boundary extent of the Cabbage Tree Creek TUFLOW model. Model inflows were estimated as described in Section 4. Local rainfall was applied directly to the TUFLOW surface across the study area (including the development site) to account for local catchment runoff. The recorded 2001 flood event data at Pineapple Street gauge (Station No. 540122) was used to verify the estimated Cabbage Tree Creek flood levels.

5.2 MODEL CONFIGURATION

Figure 5.1 shows the extent of the Cabbage Tree Creek TUFLOW model and the location of the 2D inflow and outflow boundaries. The hydraulic model study area covers approximately 6.50 km^2 including:

- 5.24 km of Cabbage Tree Creek from the Dorville Road crossing to the Gateway Motorway crossing;
- 2.45 km of Carseldine Drain from the railway to its confluence with Cabbage Tree Creek; and
- 1.20 km of Fitzgibbon Drain from the railway to its confluence with Cabbage Tree Creek.

A 5 m grid size and a 2.5 second time step were adopted for the Cabbage Tree Creek model.

A one-dimensional reach was added downstream of the Gateway Motorway, based on cross-sections obtained from the Brisbane City Council MIKE 11 model (BCC, 2000).

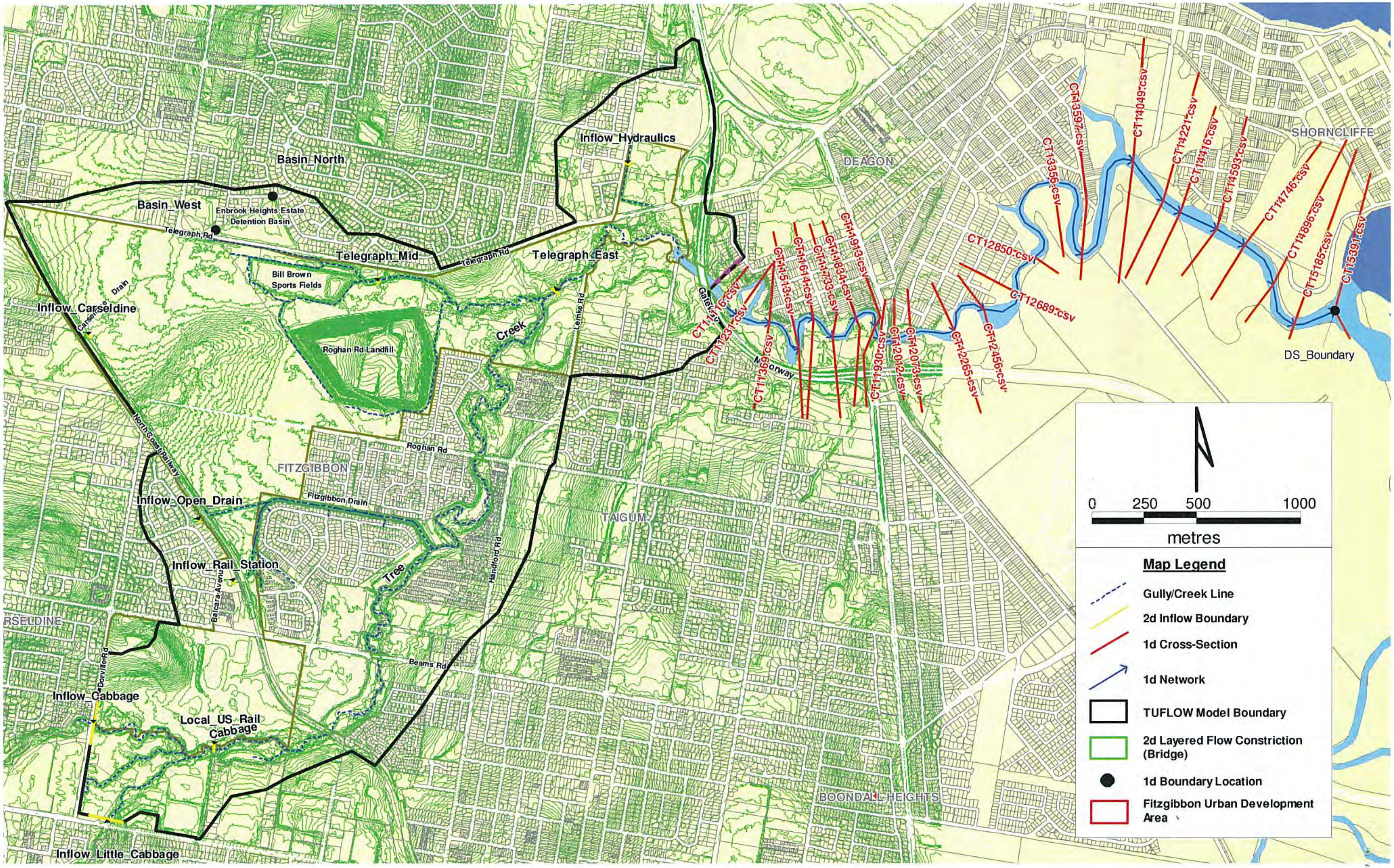

Figure 5.1 Cabbage Tree Creek TUFLOW Model Configuration

5.2.1 Topographic Data

Topographic data for the study area was provided by AAMHatch Pty Ltd. The following is of note:

- The survey was conducted using airborne laser survey (ALS);
- The survey was undertaken in June 2002; and
- The survey has a vertical accuracy of 0.15 m rms and a horizontal accuracy of 0.5 m rms.

Additional detailed ground survey, provided by Wolter Consulting Group, was used to supplement the ALS data. The detailed ground survey covered the following topographic features in the study area:

- the Fitzgibbon Drain invert and top of bank between the railway and Cabbage Tree Creek;
- the Beams Road crest level to the west of the North Coast Railway adjacent to the QUT Carseldine site; and
- the North Coast Railway top of rail level between Carseldine Station and Cabbage Tree Creek.

A number of new developments have been built in the study area since the aerial survey was undertaken. These developments have modified ground levels within the Cabbage Tree Creek floodplain. Where survey was available, these new development areas were included in the surface digital elevation model (DEM).

5.2.2 Hydraulic Roughness

Table 5.1 shows the Manning's 'n' values adopted for the land use and creek reaches in the TUFLOW model. An ortho-photograph of the area was used to determine the spatial location of the changes in land use and vegetation characteristics along the creek banks and the over bank areas. A site visit in September 2008 was used to assess the characteristics of the channel and riparian zone vegetation. The Manning's 'n' values for each land use description and creek section were first estimated according to guidelines given in Chow (1959) and subsequently revised during model calibration. Figure A1, Appendix A shows the roughness map in the TUFLOW study area.

Table 5.1 Adopted Manning's 'n' Values

Description	Manning's 'n'
Cabbage Tree Creek (Vegetated)	0.15
Fitzgibbon Drain (Grassed/Vegetated)	0.045/0.09
Carseldine Drain Channel along Telegraph Rd	0.055
Vegetation	0.10
Parks and Open Space	0.035
Roads and Car Parks	0.025
Power Link Easement	0.045

5.2.3 Hydraulic Structures

Five major bridge structures that cross Cabbage Tree Creek were added as layered flow constrictions within the 2D domain at the following locations:

- Gateway Motorway;

- Lemke Road;
- Roghan Road;
- Beams Road; and
- North Coast Railway.

Table 5.2 shows the adopted bridge characteristics at each crossing. Table 5.3 shows the adopted blockage factor and form loss co-efficient (FLC) within each layer at each structure. Four layers represent the flow across a bridge structure:

- Layer 1 represents the waterway area beneath the bridge deck;
- Layer 2 represents the bridge deck;
- Layer 3 represents the guard rail; and
- Layer 4 represents flow above the bridge (assumed to be unimpeded).

Note that Beams Road was not modelled as a 1D culvert crossing due to stability issues. The verification of the model against the March 2001 event (see section 5.3) shows that the layered flow constriction method provides a good representation of the flood behaviour across the Beams Road crossing.

Table 5.2 Adopted Bridge Crossing Properties

Description	Gateway Motorway	Lemke Road	Roghan Road	Beams Road	North Coast Railway
Bridge Deck Level (m AHD)	5.0	3.7	8.6	12.0	14.0
Deck Depth (m)	1	0.4	0.6	1.0	0.5
Approximate Bed Level (m AHD)	-1.18	-0.42	2.80	7.40	8.5
Guard Rail Height (m)	N/A	1.4	1.2	1.0	1.2
Bridge Length (m)	67.7	28.0	34.0	37.6	27.0
Number of Piers	11	1	1	9	3
Pier Diameter (m)	0.4	0.75	0.6	0.18	1.2
Approx Distance between Piers (m)	6.15	14	17	3.78	10.0

N/A - Not Applicable

Table 5.3 Layered Flow Constriction Properties, Cabbage Tree Creek Bridge Structures

Description	Gateway Motorway	Lemke Road	Roghan Road	Beams Road	North Coast Railway
Layer 1 Blockage	20	3	1	3	10
Layer 1 FLC[a]	0.3	0.1	0	0.1	0.2
Layer 2 Blockage	100	100	100	100	100
Layer 2 FLC[a]	0.3	0.2	0.05	0.3	0.3
Layer 3 Blockage	0	0	0	0	0
Layer 3 FLC[a]	0	0	0	0	0

[a] The FLC (ξ_a) is a calibration factor applied as an energy loss based on the equation: $\Delta h = \xi_a \dfrac{V^2}{2g}$

5.2.4 Inflow Boundaries

Table 5.4 shows the locations of the inflow and outflow boundaries in the TUFLOW model. The hydrological models (see Section 4) used to derive inflow hydrograph shape and the TUFLOW boundary type at each inflow location is also shown in Table 5.4, along with the 100 year ARI peak inflow discharge.

Table 5.4 TUFLOW Inflow Boundaries

Reporting Location	TUFLOW ID	Boundary Type	Hydrological Model		Q100 Peak Inflow (m³/s)
			Name	Node ID	
A1	Inflow_Cabbage	Total Flow	BCC_URBS	50	148.7
A2	Inflow_Little_Cabbage	Total Flow	BCC_URBS	19	96.3
A3	Local_US_Rail	Local Flow	BCC_URBS	21	48.6
B1	Inflow_rail_station	Total Flow	Storm_URBS	107	16.79
B2	Inflow_open_drain	Total Flow	Storm_URBS	209	22.95
C1	Inflow_carseldine	Total Flow	BCC_RAFTS	13_Rail	55.8
C2	Basin_West	Total Flow	BCC_RAFTS	20	18.3
C3	Basin_North	Total Flow	BCC_RAFTS	27_Basin	39.8
C4	Telegraph_Mid	Total Flow	BCC_RAFTS	30	15.5
C5	Telegraph_East	Total Flow	WRM_RAFTS	36	9.4
C6	Inflow_Hydraulics	Total Flow	WRM_RAFTS	39	19.7

5.2.5 Outflow Boundaries

For the downstream boundary of the 2D model, a one dimensional channel with cross sections from the BCC (2000) MIKE 11 model was extended 3km to the west of the 2D model to the mouth of Cabbage Tree Creek. A constant tailwater level of 1.75 m AHD was used at the downstream boundary of the 1D channel for all ARIs.

5.2.6 1D Network

Stormwater culverts and major stormwater pipe networks were embedded within the 2D domain of the TUFLOW model. Table B1, Appendix B shows the hydraulic characteristics for each pipe in the model. Figure B1, Appendix B shows the locations of the 1D pipes in the TUFLOW model. The ESTURY 1D hydraulic model, a built-in feature of TUFLOW, was used to undertake the hydraulic calculations of structures within the 1D domain. Minor stormwater pipes were not included in the model.

5.3 MODEL CALIBRATION

5.3.1 Overview

A substantial amount of recorded flood data is available for the Cabbage Tree Creek catchment. However, recent development of the floodplain, as well as numerous upgrades to bridge and culvert crossings in the 1990s, has changed flood behaviour in the area of interest. The March 2001 event is the largest flood on record in the Cabbage Tree Creek catchment and it also occurred after most of the significant changes to the floodplain and hydraulic structures along the creek. For this reason, the TUFLOW model was calibrated against the March 2001 flood event.

The TUFLOW model was calibrated by matching recorded water levels at the Pineapple Street stream gauge as well as Maximum Height Gauge (MHG) levels at Beams Road and Lemke Road for the March 2001 flood event. Debris levels were also recorded on the downstream side of Dorville and Rogan Roads. The water level data allows for a reasonable calibration of the Cabbage Tree Creek channel roughness characteristics. However, there is no data for the Fitzgibbon Drain or Carseldine Drain.

Model inflows for the calibration event were obtained from the hydrologic models described in Section 4, using recorded rainfalls for the March 2001 event. No revision to the model calibration of the hydrologic models was undertaken.

The current bridge configurations along Cabbage Tree Creek were upgraded prior to the March 2001 event. Hence no changes were required to the hydraulic characteristics of these structures.

5.3.2 March 2001 Recorded Rainfall Depths

Rainfall depths were recorded at 4 rainfall gauges within the Cabbage Tree Creek Catchment. The estimated ARI for the event was greater than 100 years based on rainfall data given in Australian Rainfall and Runoff (IEAust, 1998). See Section 4.3.3 for more details.

5.3.3 Pineapple Street Gauge

Figure 5.2 shows the recorded water levels at the Pineapple Street gauge and the TUFLOW model predicted water levels for the March 2001 event. Note that the recorded water levels at the Pineapple Street gauge have been increased by 0.628 m to account for a change in the datum of the gauge which may have been due to sewer construction in about 1987 (see Section 5.3 of BCC 2000). The peak water level predicted by the TUFLOW model (13.43 m AHD) is about 0.21 m higher and occurs about an hour earlier than the recorded water level at the gauge (13.22 m AHD).

Anecdotal information obtained by the ULDA indicates that during the March 2001 event, floodwaters from Cabbage Tree Creek overtopped Beams Road upstream of the North Coast Railway and flowed north inundating the Carseldine railway station car park (Phillip Kohn; email sent 7 Apr 2009). Recent detailed ground survey of levels along Beams Road in the vicinity of the railway crossing indicates a minimum road level of about 13.23 m AHD. Hence, the peak water level of 13.43 mAHD predicted by the TUFLOW model is sufficient to overtop the road, consistent with observed flooding behaviour.

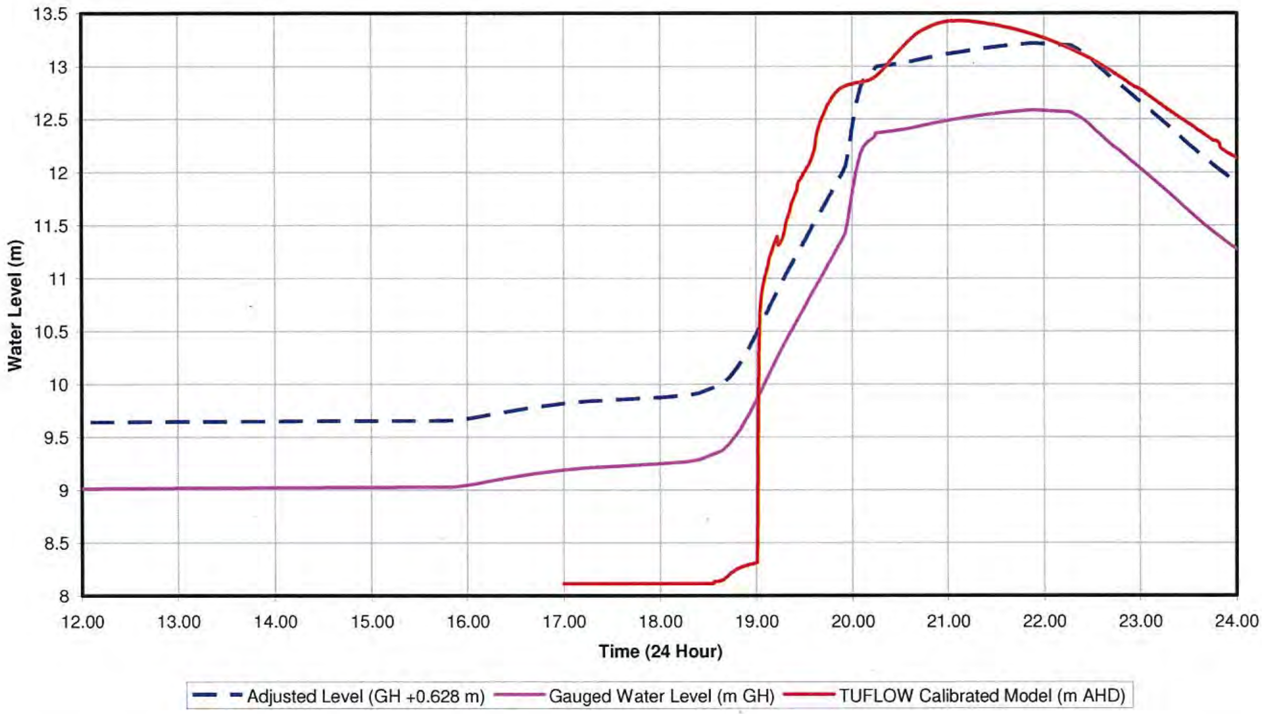

Figure 5.2 Pineapple Street Gauge Recorded Water Level and Adjusted Recorded Water Level Vs Predicted TUFLOW Model Water Levels, 9 March 2001 Calibration Event

5.3.4 March 2001 Peak Water Levels

Figure 5.3 shows a longitudinal section plot of Cabbage Tree Creek and March 2001 predicted and recorded peak water levels across the study area. Table 5.5 shows the peak water levels recorded at a number of locations along Cabbage Tree Creek within the study area. It is noted that:

- The predicted flood level peaks are generally within 0.30 m of the recorded flood level peak, except upstream of Lemke Road where the predicted water level is 0.37m higher than recorded levels; and
- Overall, the calibration of Cabbage Tree Creek across the study area is considered reasonable. It is expected that the Cabbage Tree Creek model will provide reasonable estimates of Cabbage Tree Creek design flood levels across the Fitzgibbon UDA.

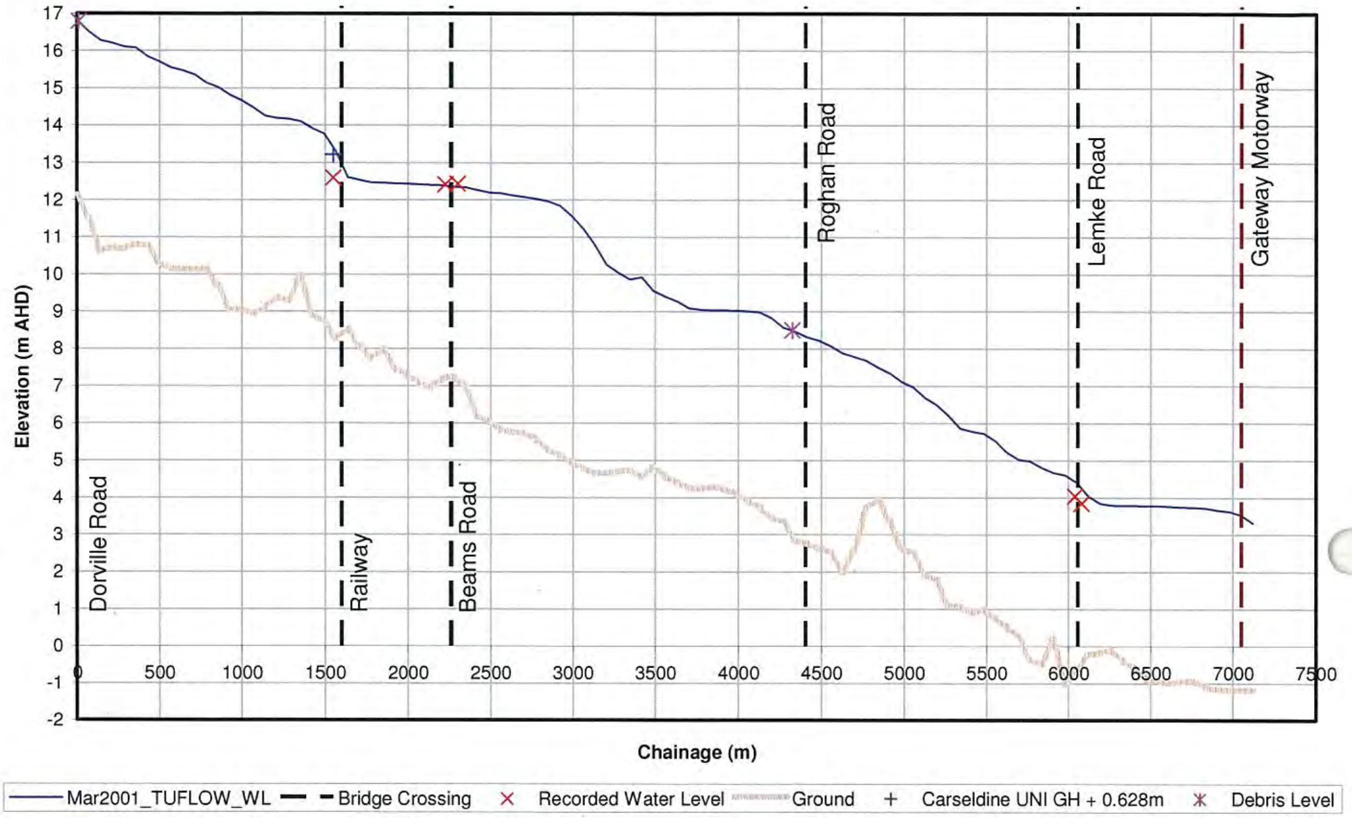

Figure 5.3 Cabbage Tree Creek Long Section Predicted and Recorded Peak Water Level, March 2001 Flood Level

Table 5.5 Recorded and Predicted Peak Water Levels, March 2001 flood event.

Location	Recorded Peak Level (m AHD)	Predicted Peak Level (m AHD)	Difference Difference in Peak Level (m)
Downstream of Dorville Road	16.79	16.81	+0.02
Pineapple Street Gauge	13.22[a]	13.43	+0.21
Upstream of Beams Road	12.41	12.39	-0.02
Downstream of Beams Road	>12.46	12.35	-0.11
Upstream of Roghan Road	8.5	8.46	-0.04
Upstream of Lemke Road	4.04	4.41	+0.37
Downstream of Lemke Road	3.83	4.04	+0.21

[a] Based on recorded Gauge Level + 0.628 m

5.4 MODEL RESULTS FOR EXISTING CONDITIONS

Figure 5.4 shows the estimated 100 year ARI flood depths and water level reporting locations in the study area for existing conditions, prior to development of the UDA. Figure 5.5 shows the 100 year ARI flood extent and 1m flood contours. Note that the hydrologic analysis is based on full development of the Cabbage Tree Creek catchment upstream of the UDA.

The 100 year ARI flooding behaviour in the study area can be summarised as follows:

- Cabbage Tree Creek overflows from its banks upstream of the North Coast Railway in a northerly and easterly direction across the eastern QUT Carseldine site.
  - The northerly flowing water overtops Beams Road and inundates the Carseldine Railway Station car park and before draining through culverts under the railway to Fitzgibbon Drain.
  - The easterly flowing water overtops the North Coast Railway (initial flow through the ballast underneath the rails may occur) and flows across the existing wreckers yards to a maximum depth of 0.4 m before flowing along Beams Road to rejoin Cabbage Tree Creek on the northern side of Beams Road.
- Beams Road is inundated for a length of 850 m up to a maximum depth of 0.7 m.
- Cabbage Tree Creek overflows from its left bank between The Big Easy Golf Range and Fitzgibbon drain, potentially affecting properties along Marigold Cl, Iris Pl, Azalea Cr, and Jarrah Pl. A natural levee hydraulically separates the Cabbage Tree Creek left bank from its main channel and right bank, as shown in Figure 5.6, resulting in flood level differences of up to 0.8 m higher on the left bank at the downstream end of this reach;
- Downstream of the confluence of the southern and western branches of Fitzgibbon drain, the peak water levels are dominated by Cabbage Tree Creek floodwaters;
- Fitzgibbon Drain overflows from its banks at Reporting Location FITZ_04 in a northerly direction across the proposed Application 1 development area along a wide and shallow flow path to a large area of undeveloped, low-lying land next to the Roghan Road landfill. Water is impounded behind the south-western landfill wall to depths of up 0.8 m within a triangular shaped storage area. Outflows from this storage area split in a northerly and easterly direction:
  - The northerly flowing water drains to Carseldine Drain adjacent to the Bill Brown Sports field;
  - The easterly flowing water splits on the southern side of the Roghan Road landfill into a northerly and easterly direction. The easterly flowing water overtops Roghan Road to Cabbage Tree Creek. The northerly flowing water is collected by a grassed drain along the eastern side of the Roghan Road landfill to Carseldine Drain 500 m downstream of the Bill Brown Sports Fields;
- Along Carseldine Drain between the railway culverts and the Bill Brown Sports field, water flows overland along a wide and shallow flowpath reaching depths of up to 1 m. Carseldine Drain overflows Telegraph Road in a northerly direction at a number of locations:
  - West of the Bracken Ridge Plaza Shopping Centre.
  - Into the south-western corner of the Enbrook Heights Estate Detention Basin. The northerly flowing water then turns eastward across the detention basin area before overflowing Telegraph Road a second time in the south-eastern corner of the detention basin, where the basin spillway is located, and rejoining Carseldine Drain.

- Telegraph Road is inundated for a length of 900 m up to a maximum depth of 0.8 m.

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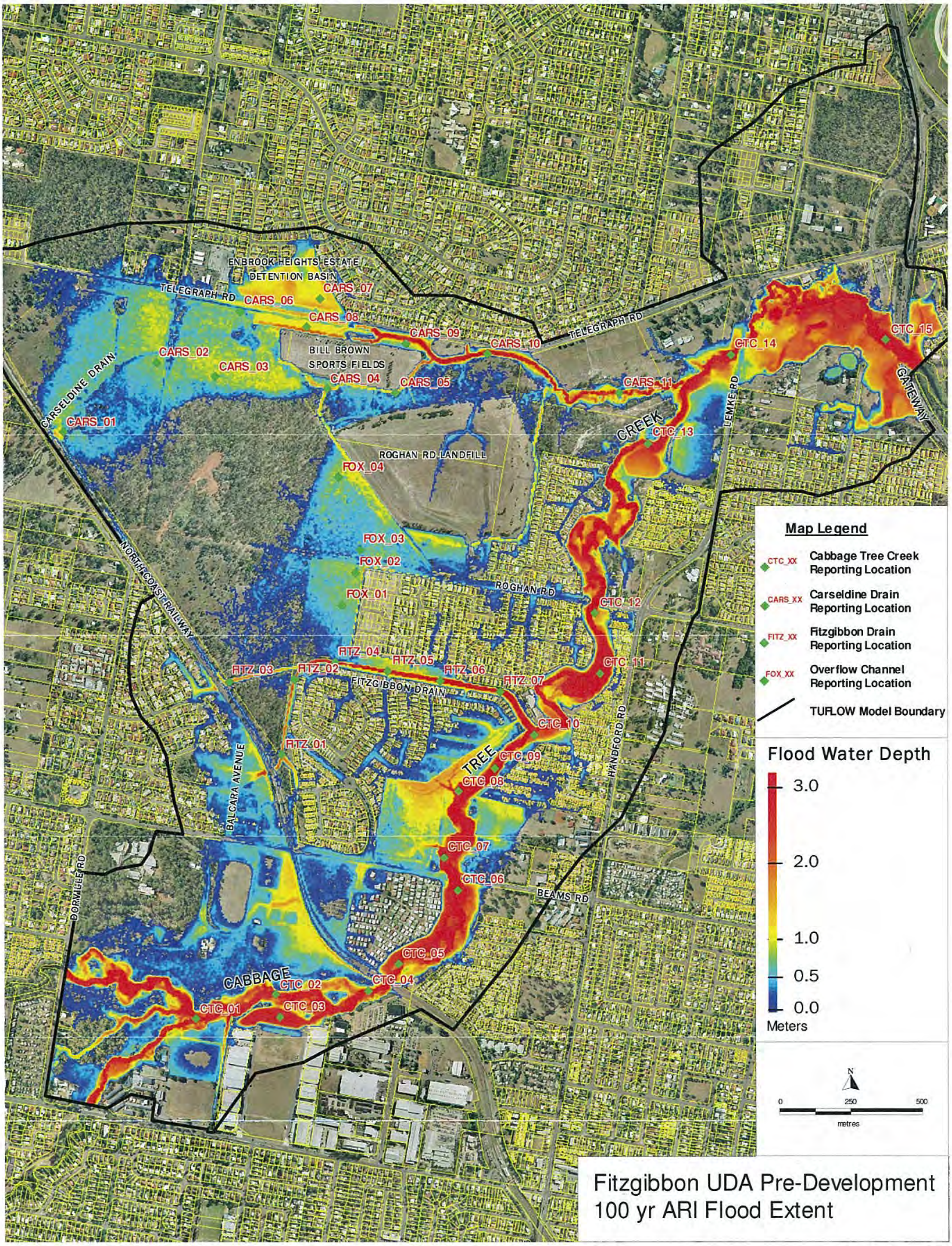

Figure 5.4 Pre-Development 100 year ARI Flood Extent and Reporting Locations, Fitzgibbon UDA site

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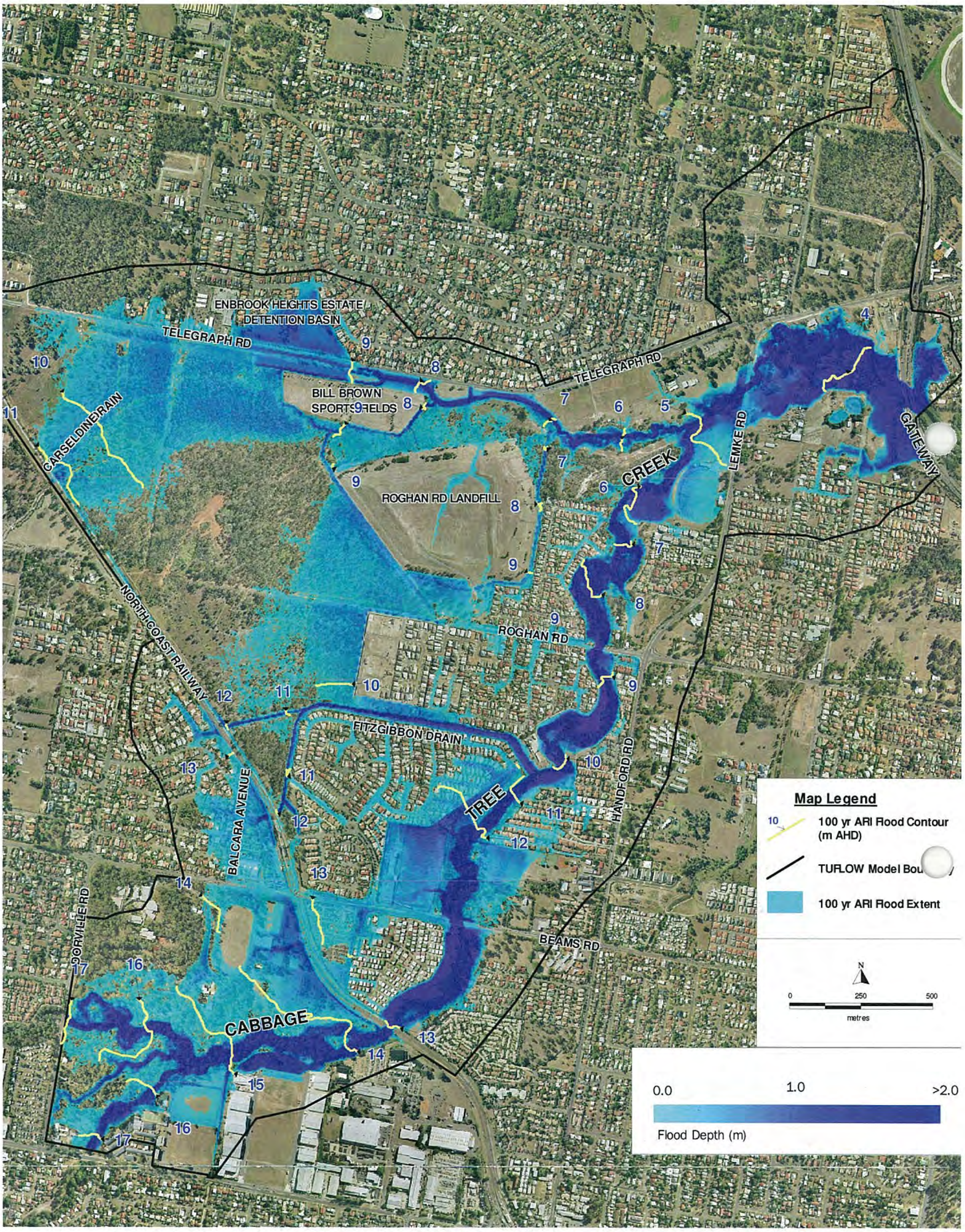

Figure 5.5 Pre-Development Cabbage Tree Creek 100 Year ARI Flood Extent and Flood Contours, Fitzgibbon UDA Site

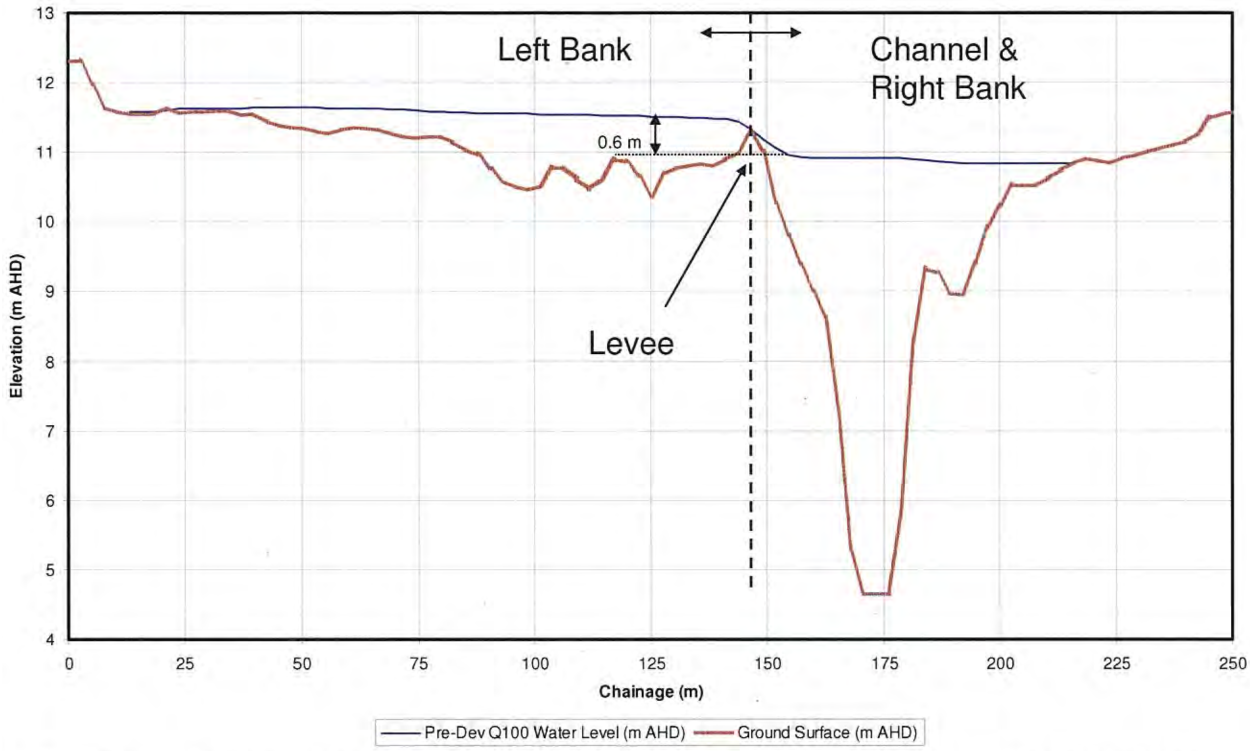

Figure 5.6 Typical Cabbage Tree Creek Cross Section between the Driving Range and Fitzgibbon Drain and 100 year ARI pre-development flood level

Table 5.6 shows the 2, 10, and 100 year ARI flood levels at a number of reporting locations within the study area (see Figure 5.4). The following is of note:

- 100 year ARI peak flood levels along Cabbage Tree Creek at the QUT Carseldine site range from 17.00 m AHD at Dorville Road (upstream end) to 13.71 m AHD at the North Coast Railway crossing;
- 100 year ARI peak flood levels along Fitzgibbon Drain at the Fitzgibbon UDA Application 1 development area range from 11.76 m AHD, and 11.93 m AHD in the southern and western branches, respectively, of the Fitzgibbon Drain (upstream end) to 10.47 m AHD at the downstream end;
- 100 year ARI peak flood levels along Carseldine Drain across the DoH land range from 11.65 m AHD at the railway culverts to 9.19 m AHD at the Bill Brown Sports Field;
- 100 year ARI peak flood levels across the wreckers yard range from 13.12 m AHD at the Railway to 12.85 m AHD at the downstream boundary;
- 100 year ARI peak flood levels along Balcara Avenue range from 13.38 m AHD at Beams Road to 13.35 m AHD at the North Coast Railway culverts;
- Beams Road is overtopped from Cabbage Tree Creek upstream of the North Coast Railway for ARI's equal to and greater than a 20 year event;
- The North Coast Railway is overtopped from Cabbage Tree Creek for ARI's equal to and greater than a 20 year event;
- Fitzgibbon Drain breaks its banks at Reporting Location FITZ_04 across the Application 1 area for ARI's equal to and greater than a 50 year event;
- Telegraph Road is overtopped from Carseldine Drain at the Enbrook Heights Estate Detention Basin for ARI's equal to and greater than a 5 year event.

Table 5.6 Existing Conditions TUFLOW Model 2, 10, and 100 yr ARI Flood Levels, Fitzgibbon UDA

Reporting Location	Pre-Development Conditions Peak Flood Level (m AHD)		
	2 yr ARI	10 yr ARI	100 yr ARI
CARS_01	11.43	11.54	11.65
CARS_02	9.39	9.46	9.55
CARS_03	8.97	9.09	9.24
CARS_04	8.84	8.93	9.08
CARS_05	8.32	8.44	8.58
CARS_06	8.92	9.02	9.19
CARS_07	8.03	8.85	9.15
CARS_08	8.66	8.85	9.15
CARS_09	7.10	7.52	8.01
CARS_10	6.71	7.07	7.47
CARS_11	5.28	5.59	5.96
CTC_01	14.52	15.06	15.48
CTC_02	13.59	14.13	14.47
CTC_03	13.39	14.00	14.37
CTC_04	12.65	13.27	13.71
CTC_05	11.74	12.30	12.65
CTC_06	11.61	12.17	12.50
CTC_07	11.50	12.02	12.38
CTC_08	10.99	11.62	12.11
CTC_09	10.43	11.01	11.56
CTC_10	9.30	9.70	10.31
CTC_11	8.10	8.58	9.26
CTC_12	7.52	7.97	8.69
CTC_13	4.91	5.37	5.95
CTC_14	4.15	4.37	4.69
CTC_15	2.57	3.06	3.90
FITZ_01	11.06	11.28	11.77
FITZ_02	9.81	10.05	10.62
FITZ_03	11.38	11.66	11.92
FITZ_04	9.35	9.76	10.47
FITZ_05	9.36	9.77	10.46
FITZ_06	9.34	9.76	10.46
FITZ_07	9.34	9.76	10.44
FOX_01	9.31	9.41	9.78
FOX_02	9.31	9.41	9.76
FOX_03	9.25	9.39	9.71
FOX_04	9.21	9.39	9.70

6 ASSESSMENT OF DEVELOPMENT IMPACTS – APPLICATION 1, 253 TELEGRAPH ROAD

6.1 PROPOSED DEVELOPMENT CONFIGURATION

Figure 6.1 shows the proposed Application 1 development on the DoH land. The following is of note:

- Application 1 will be developed in four stages and subdivided into approximately 152 lots varying in size from 250 m^2 to 1282 m^2.
- A detention basin (Db_1) will be constructed along the south-western side of the Roghan Road Landfill. An embankment (Le_2) will be constructed and low-flow culverts will be placed along the south-east and north boundary of the basin area.
- A 50 m wide overflow channel will be constructed from the Fitzgibbon Drain to the Roghan Road Landfill Detention Basin to the north. The purpose of this channel is to replicate the overflow of floodwaters from Fitzgibbon Drain to the north, as occurs under existing conditions.
- Box culverts will be placed at the northern end of the overflow channel across the proposed Roghan Road crossing. Rogan Road will be ramped up from its existing intersection with Odense Street to the culvert crossing.
- The western branch of Fitzgibbon Drain will be modified from the North Coast Railway to its confluence with the southern branch of Fitzgibbon Drain.
- Two culvert crossings will be placed under the proposed Carselgrove Avenue along the southern and western Fitzgibbon Drain branches;

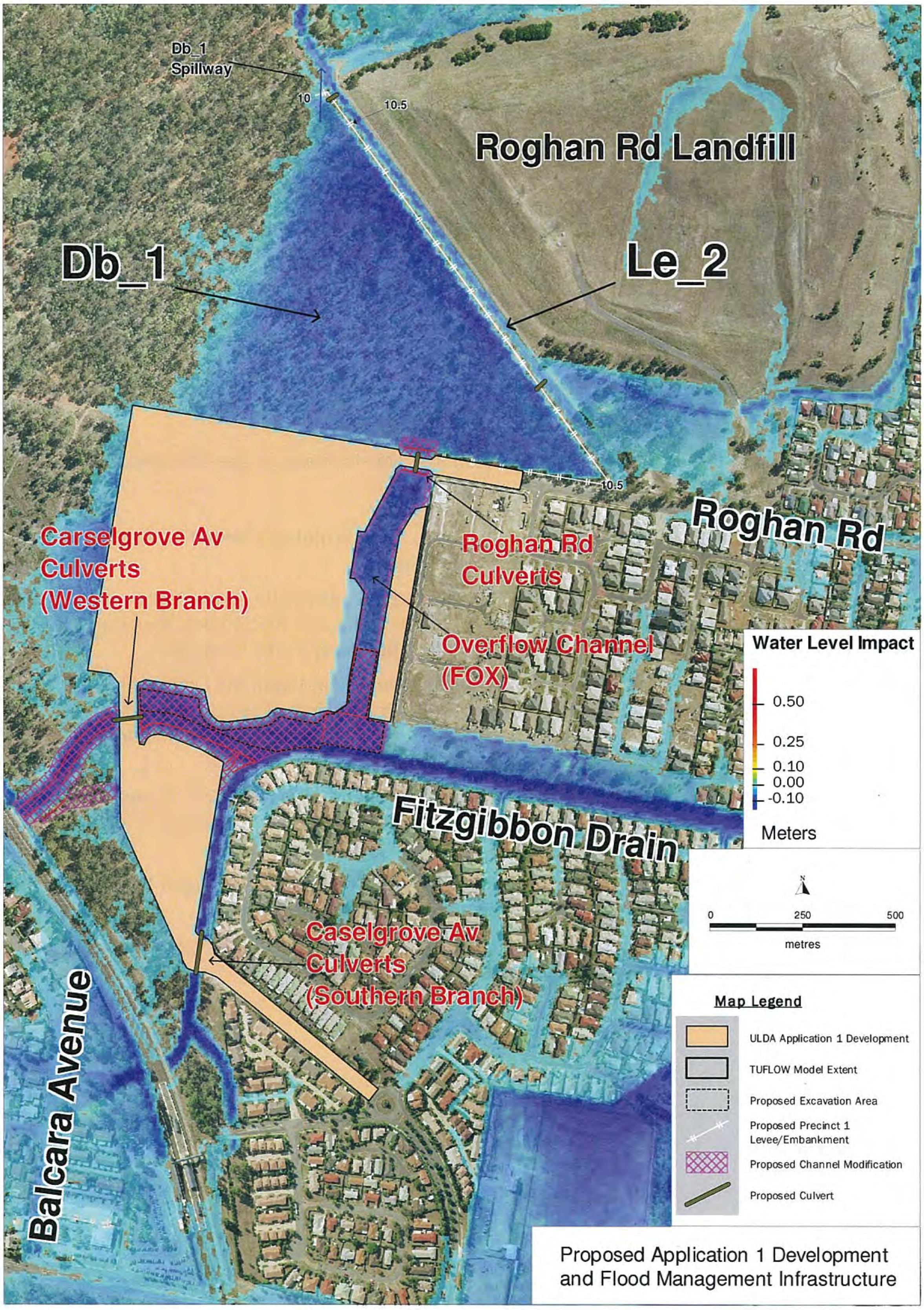

Figure 6.1 Proposed Fitzgibbon UDA Application 1 Development Extent

6.2 PROPOSED FLOOD MITIGATION INFRASTRUCTURE

6.2.1 Roghan Road Landfill Detention Basin

Figure 6.2 shows the Roghan Road Landfill Detention basin (Db_1) configuration. The detention basin will ensure that peak stormwater discharges from the development are not increased.

The basin storage area will be bounded by the Roghan Road Landfill to the north-east, Roghan Road to the south and a hill to the west. A flood protection bund (Le_2) will be constructed and low-flow culverts will be placed along the south-east and north-eastern sides of the basin to formalise the detention area. The ground surface within the detention basin will remain unaltered and the existing vegetation will remain. The basin stage-storage characteristics are shown in Table 4.10.

Table 6.1 Adopted Stage-Storage Curve - Roghan Road Landfill Detention Basin

Stage (m AHD)	Surface Area (m^2)	Volume (m^3)
8.0	0	0
8.5	370	20
9.0	26000	4200
9.5	102000	38000
10.0	115000	93000
10.5	126000	154000

The detention basin has the following spillway and low level outlet configuration:

- A 50 m wide spillway at an elevation of 10.0 m AHD;
- North wall low flow pipe: 1 x 0.9 m pipe at an invert level of 8.42 m AHD; and
- South-east wall low flow pipe: 1 x 0.9 m pipe at an invert level of 8.8 m AHD.

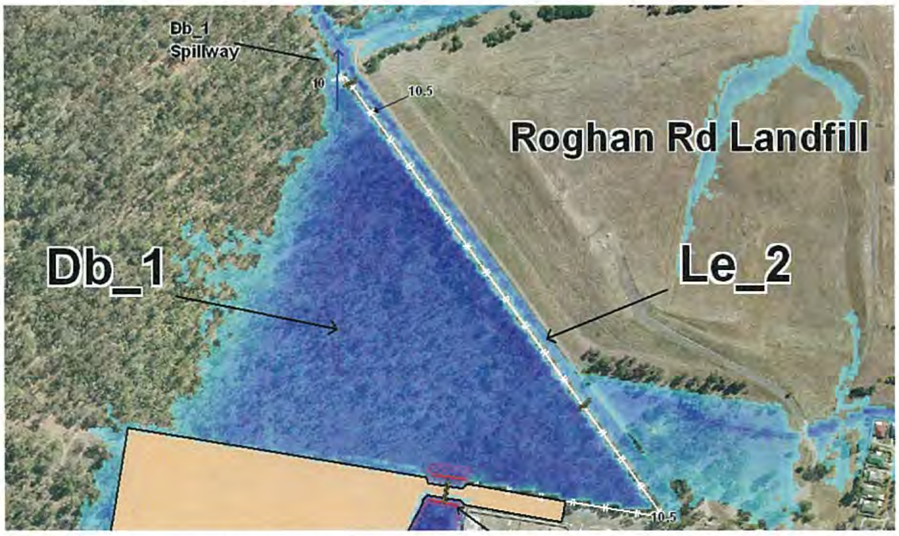

Figure 6.2 Roghan Road Landfill Detention Basin

6.2.2 Application 1 Overflow Channel

Figure 6.3 shows the proposed overflow channel through the Application 1 development. The northern part of the channel will fall in a northerly direction to Roghan Road, The existing ground levels and vegetation along this reach will remain in it current natural state. The southern end of the channel will reformed to fall south from the existing 9.5 m AHD contour to 9.0 m AHD in the Fitzgibbon Drain. A culvert crossing will be placed through the raised Roghan Road at the northern end of the channel.

The channel will be configured as follows:

- Base Width of 40 m;
- Side Batters of 1(V):6(H)to design levels;
- Maximum invert level of 9.5 m AHD; and
- Northern end: Longitudinal length of about 280 m falling to the north.
- Southern end: Longitudinal length of about 60 m falling to the south.

The Roghan Road culverts will be configured as follows:

- 8 x 2.1(W) x 0.6 (H) box culverts;
- Maximum road level of 10.5 m AHD;
- Upstream invert level of 9.05 m AHD; and
- Downstream invert level of 8.93 m AHD.

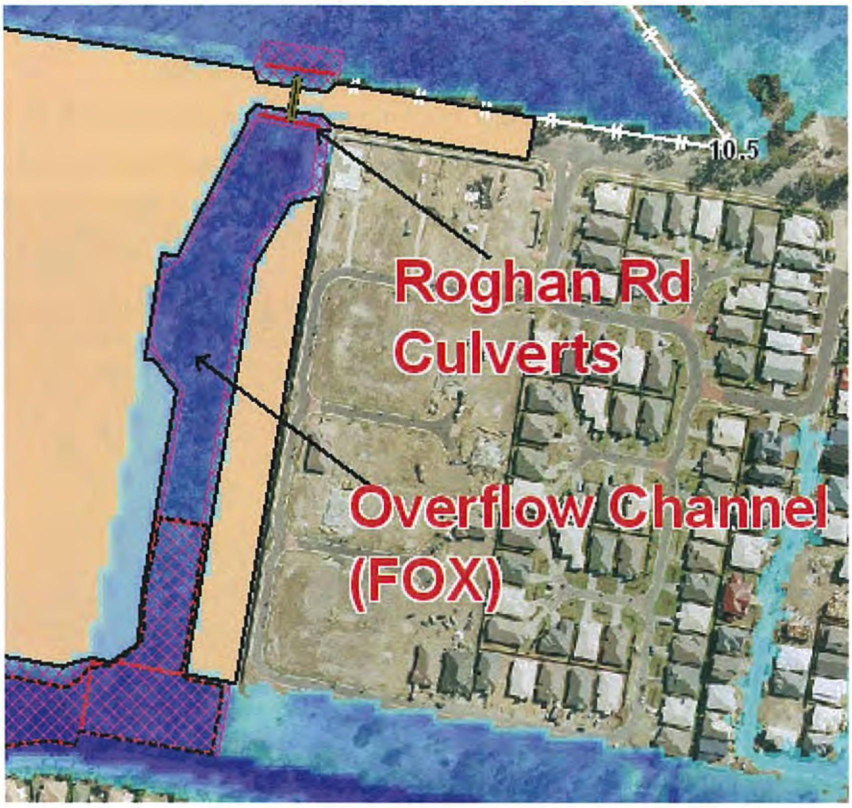

Figure 6.3 Application 1 Overflow Channel

6.2.3 Modified Fitzgibbon Drain and Flood Storage Area

Figure 6.4 shows the proposed realignment of the western branch of the Fitzgibbon Drain. The proposed realignment will be about 70 m north of its original location. A culvert crossing will be constructed under Carselgrove Avenue about 150 m downstream of the North Coast Railway.

The channel will be configured as follows:

- Base Width of 12 m;
- Side Batters of 1(V):6(H) to existing surface;
- Upstream invert of 9.51 m AHD; and
- Longitudinal length of 350 m at a slope of 0.5%.

The Carselgrove Avenue culverts will be configured as follows:

- 5 x 2.1(W) x 1.8 (H) box culverts;
- Upstream invert level of 8.87 m AHD; and
- Downstream invert level of 8.77 m AHD.

Proposed earthworks downstream of the culvert crossing will ensure that sufficient flood storage is maintained to mitigate the flood impacts of the development. The proposed flood storage area will be graded from the base of the channel to 9 m AHD.

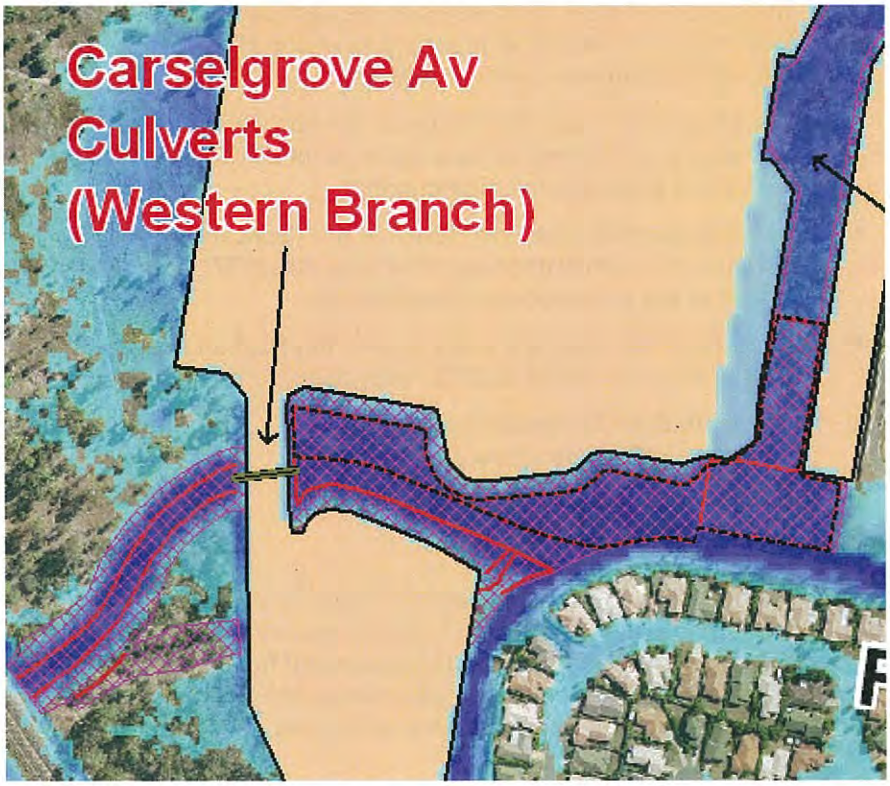

Figure 6.4 Fitzgibbon Drain (Western Branch) Realignment

6.2.4 Carselgrove Avenue Fitzgibbon Drain (Southern Branch) Culverts

The Carselgrove Avenue culvert crossing across the Southern Branch of the Fitzgibbon Drain will be configured as follows:

- 6 x 1.65 m diameter pipes;
- Upstream invert level of 9.36 m AHD; and
- Downstream invert level of 8.75 m AHD.

6.3 IMPACT ASSESSMENT OF PROPOSED DEVELOPMENT

6.3.1 Methodology

The Cabbage Tree Creek TUFLOW model (see section 5) was used to determine design flood levels and assess the impacts of the proposed Application 1 development and mitigation measures. The impacts were assessed by comparing the 100 year ARI Application 1 developed conditions flood levels to existing (pre-development) conditions.

6.3.2 2 to 100 year ARI TUFLOW Model Results

Figure 6.5 shows the Application 1 Development Conditions 100 year ARI flood depths and reporting locations. Table 6.2 shows the 2, 10, and 100 year ARI water levels at a number of reporting locations within the TUFLOW study area. The following is of note:

- The 2 year ARI peak flood levels at the Application 1 development vary from 11.07 m AHD and 10.30 m AHD at reporting locations FITZ_1 and FITZ_3, respectively, to 9.35 m AHD at the proposed overflow channel;
- The 10 year ARI peak flood levels at the Application 1 development vary from 11.48 m AHD and 10.55 m AHD at reporting locations FITZ_1 and FITZ_3, respectively, to 9.76 m AHD at the proposed overflow channel;
- The 100 year ARI peak flood levels at the Application 1 development vary from 11.73 m AHD and 11.01 m AHD at reporting locations FITZ_1 and FITZ_3, respectively, to 10.47 m AHD at the proposed overflow channel;
- The 10 and 100 year ARI water level in the Roghan Road Landfill Detention Basin are 9.44 m AHD and 10.28 m AHD, respectively; and
- Fitzgibbon Drain floodwaters overflow into the northern part of the proposed overflow channel for ARI events greater than 2 years.

6.3.3 100 year ARI Flood Impacts

Figure 6.6 shows the Application 1 Development Conditions 100 year ARI flood extent and water level impacts across the study area. Table 6.2 shows the 100 year ARI water level impacts due to the Application 1 development and the proposed flood mitigation infrastructure. The proposed Application 1 development water levels are less than or equal to pre-development conditions at all reporting locations in the study area.

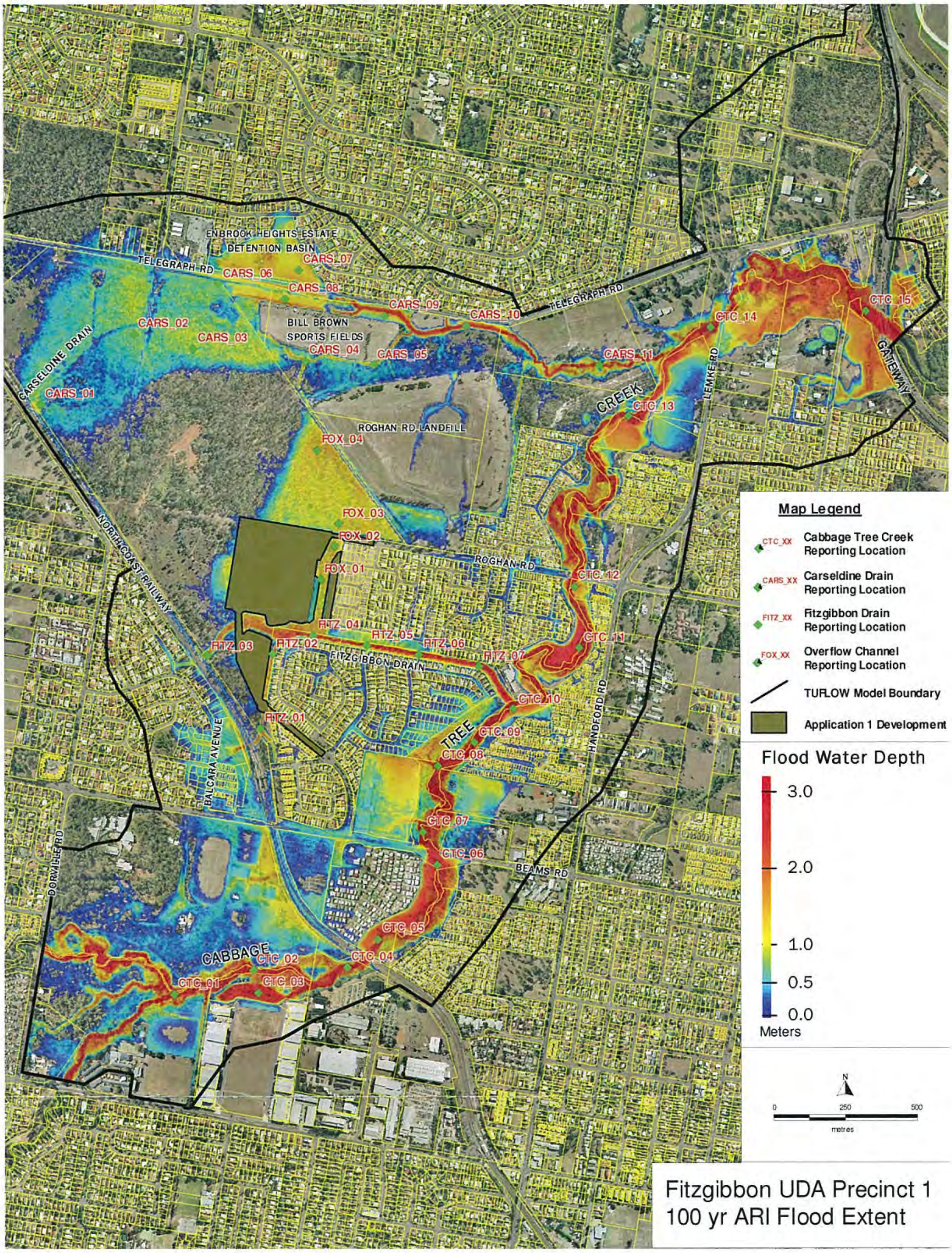

Figure 6.5 Application 1 Development 100 year ARI Flood Depths and Reporting Locations, Fitzgibbon UDA site

Table 6.2 Application 1 Development Conditions TUFLOW Model 2, 10, and 100 yr ARI Flood Levels and 100 yr ARI Flood Level Impacts

Reporting Location	Application 1 Development Conditions Peak Flood Level (m AHD)			100 yr ARI Water Level Impacts (m)
	2 yr ARI	10 yr ARI	100 yr ARI*	
CARS_01	11.43	11.54	11.65	0.00
CARS_02	9.39	9.46	9.55	0.00
CARS_03	8.97	9.09	9.24	0.00
CARS_04	8.84	8.93	9.08	0.00
CARS_05	8.32	8.43	8.57	-0.01
CARS_06	8.92	9.02	9.19	0.00
CARS_07	8.02	8.85	9.15	0.00
CARS_08	8.66	8.85	9.15	0.00
CARS_09	7.10	7.52	8.01	0.00
CARS_10	6.71	7.07	7.47	0.00
CARS_11	5.28	5.59	5.95	0.00
CTC_01	14.52	15.06	15.48	0.00
CTC_02	13.60	14.13	14.46	0.00
CTC_03	13.39	14.00	14.37	0.00
CTC_04	12.65	13.27	13.71	0.00
CTC_05	11.74	12.30	12.65	0.00
CTC_06	11.61	12.17	12.50	0.00
CTC_07	11.50	12.02	12.37	0.00
CTC_08	10.99	11.62	12.11	0.00
CTC_09	10.43	11.01	11.55	-0.01
CTC_10	9.30	9.69	10.31	-0.01
CTC_11	8.10	8.57	9.25	-0.01
CTC_12	7.52	7.96	8.69	0.00
CTC_13	4.91	5.36	5.94	-0.01
CTC_14	4.15	4.36	4.69	0.00
CTC_15	2.57	3.05	3.87	-0.03
FITZ_01	11.07	11.48	11.73	-0.03
FITZ_02	9.55	9.93	10.57	-0.05
FITZ_03	10.30	10.55	11.01	-0.91
FITZ_04	9.35	9.76	10.47	0.00
FITZ_05	9.37	9.77	10.46	0.00
FITZ_06	9.35	9.75	10.45	-0.01
FITZ_07	9.35	9.75	10.44	-0.01
FOX_01	9.31	9.50	10.36	0.58
FOX_02	9.29	9.46	10.33	0.58
FOX_03	9.26	9.44	10.28	0.57
FOX_04	9.24	9.44	10.28	0.58

* The 100 year ARI water levels in this table must **not** be used to determine development fill levels. Minimum fill and floor levels for the development must be determined using Section 6.4 water levels.

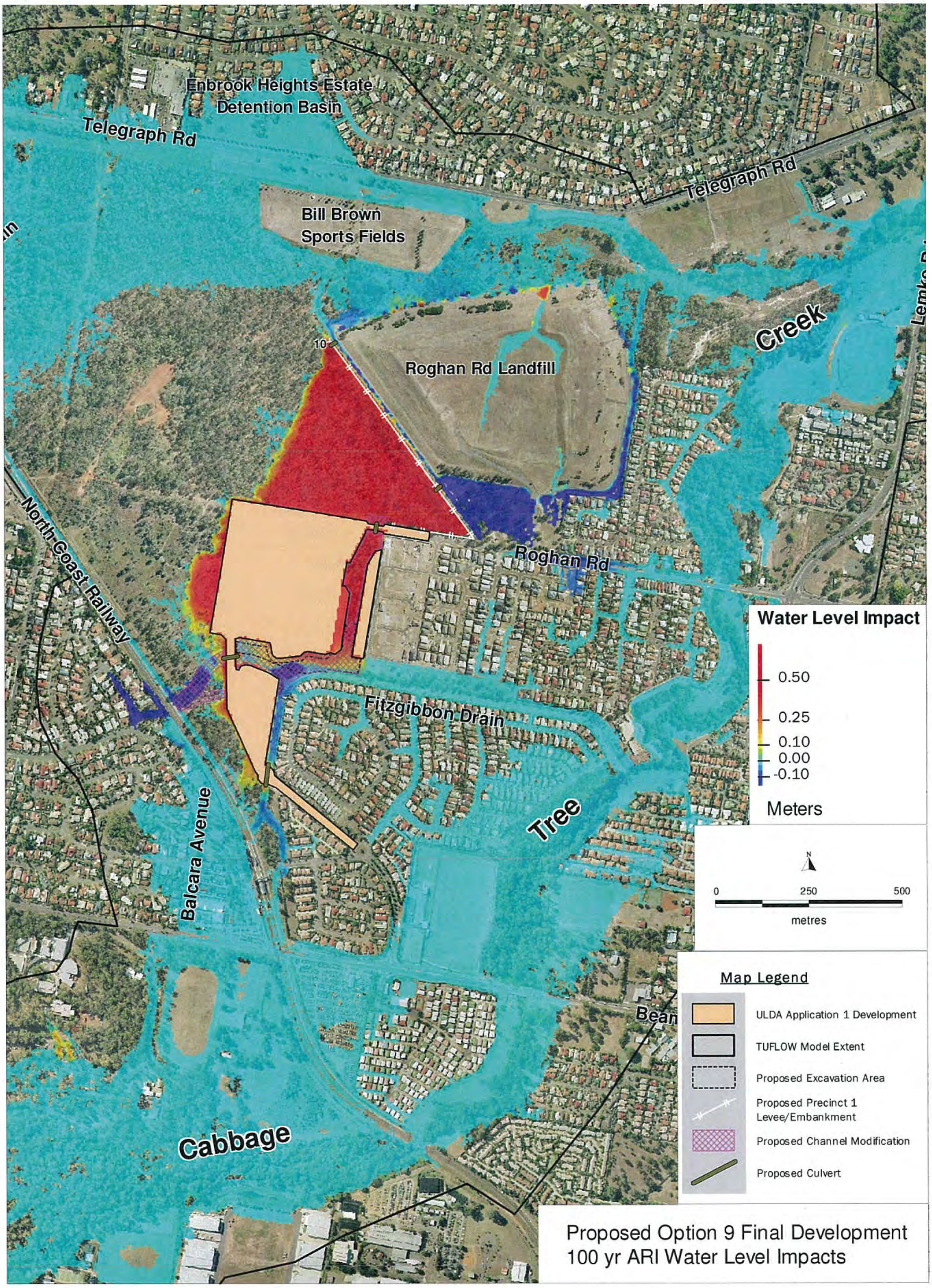

Figure 6.6 Application 1 Development 100 year ARI Flood Extent and Development Impacts, Fitzgibbon UDA site

6.4 PROPOSED FILL LEVELS

The Application 1 developed conditions Cabbage Tree Creek TUFLOW model (see previous section) was used to determine minimum fill levels around the site. BCC requested that fill levels be determined using Cabbage Tree Creek 100 year ARI peak discharge of 264 m^3/s (instead of 249m^3/s as determined by the Cabbage Tree Creek URBS model). The Cabbage Tree Creek inflow hydrographs at inflow locations A1, A2 and A3 (see Section 4.3) were factored up by 1.06 (6%).

Table 6.3 tabulates the 100 year ARI water levels for determining fill levels at a number of reporting locations around the Application 1 development site. Figure 6.7 shows the Application 1 fill reporting locations.

Table 6.3 Application 1 Development 100 year ARI Flood Levels assuming 264 m^3/s Peak Flow along Cabbage Tree Creek for Determining Fill Levels

Reporting Location	100 year ARI Flood Level (m AHD)
Fitzgibbon Main Channel	
1	10.52
2	10.53
3	10.54
4	10.54
5	10.63
6	10.78
7	11.59
New Drain	
8	10.55
9	10.60
10	11.08
11	11.13
Side Drain	
12	10.52
13	10.40
14	10.34

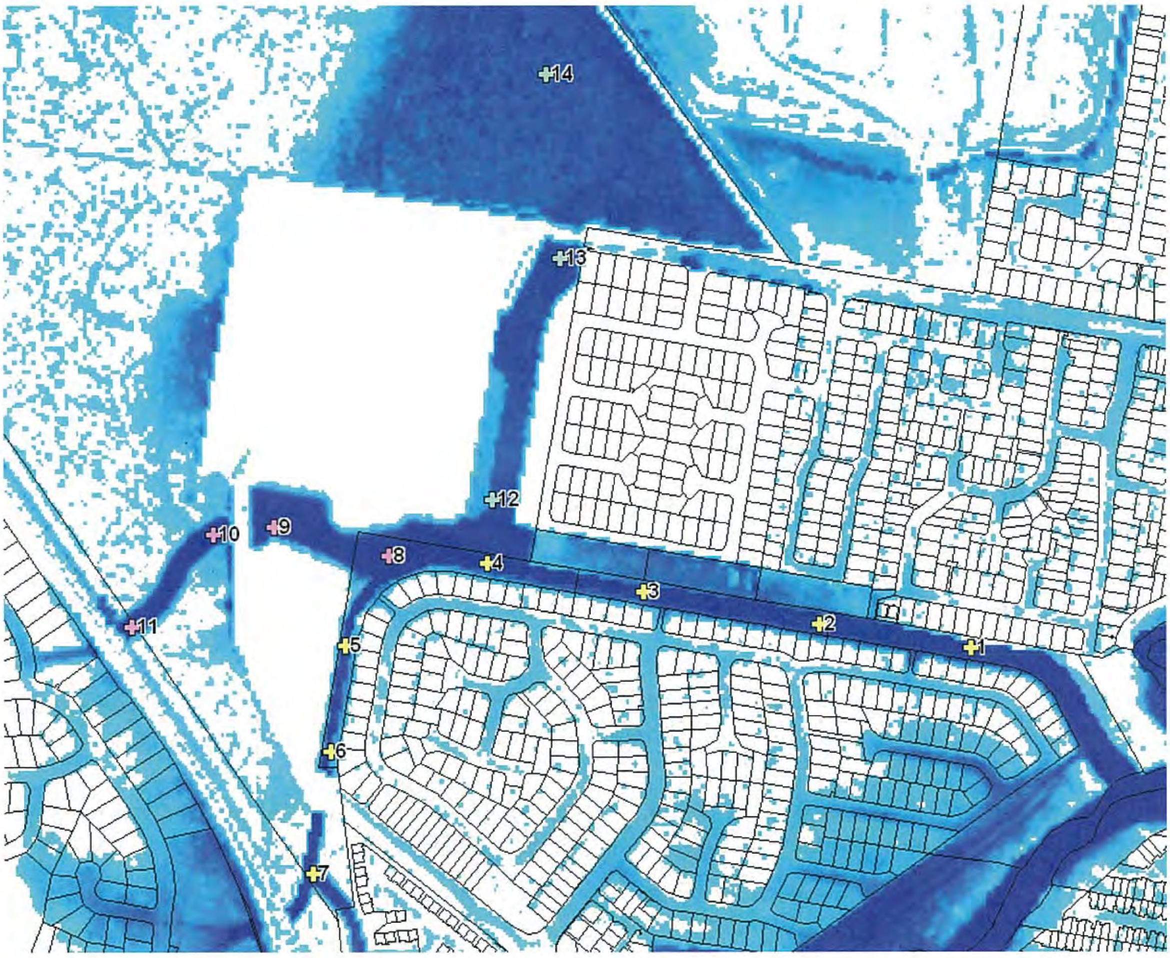

Figure 6.7 Application 1 Development Reporting Locations of 100 year ARI Flood Levels for Determining Fill Levels

7 IMPACTS OF FULL DEVELOPMENT OF THE FITZGIBBON UDA

7.1 OVERVIEW

7.1.1 Proposed Development configuration

Figure 7.1 shows the areas proposed for urban development within the Fitzgibbon UDA. A total area of 55 ha has been identified for future development. Key features of the proposed land use for the site are as follows:

- The remaining 80 ha of the DoH land (after development of the Application 1 area) will be divided into approximately 35 ha of urban residential development, while 45 ha will remain undisturbed;
- The western portion of the QUT Carseldine site (approximately 13.5 ha) is proposed to be developed into a high density residential and commercial precinct;
- Carseldine Railway Station car park (approximately 3.1 ha) is proposed to be developed for high density unit dwellings;
- The existing wrecking yard site along Beams Road (approximately 3.7 ha) has been identified as potentially suitable for high density residential development.

7.1.2 Management of Flooding and Flood Impacts

As discussed in Section 5.4, existing development within the UDA is likely to be substantially affected by flooding as ongoing development occurs in the Cabbage Tree Creek catchment upstream of the UDA. The proposed development of the UDA, and construction of associated flood management infrastructure, provides an opportunity to reduce flood problems of existing development, as well as mitigating any impacts of the UDA development.

Achieving the proposed development planned for the site will have significant impacts on the flood behaviour of Cabbage Tree Creek and its tributaries within the UDA. The most significant of these impacts is the prevention of any overflows across Beams Road and the North Coast Railway near the Beams Road railway crossing. Flood overflows through this area will be prevented by the proposed development plan. As a result, the floodwaters which would have overflowed at this location will, after development, need to travel along the main branch of Cabbage Tree Creek.

To mitigate this and other impacts of the proposed development and manage flood flows through the development will require a suite of flood management infrastructure to be constructed both within and outside the UDA. The TUFLOW model was used to assess the effectiveness of 9 different combinations of flood management infrastructure (see Figure 7.1) in conveying flood flows through the UDA and ensuring no adverse impacts on the flood immunity of existing properties in the study area.

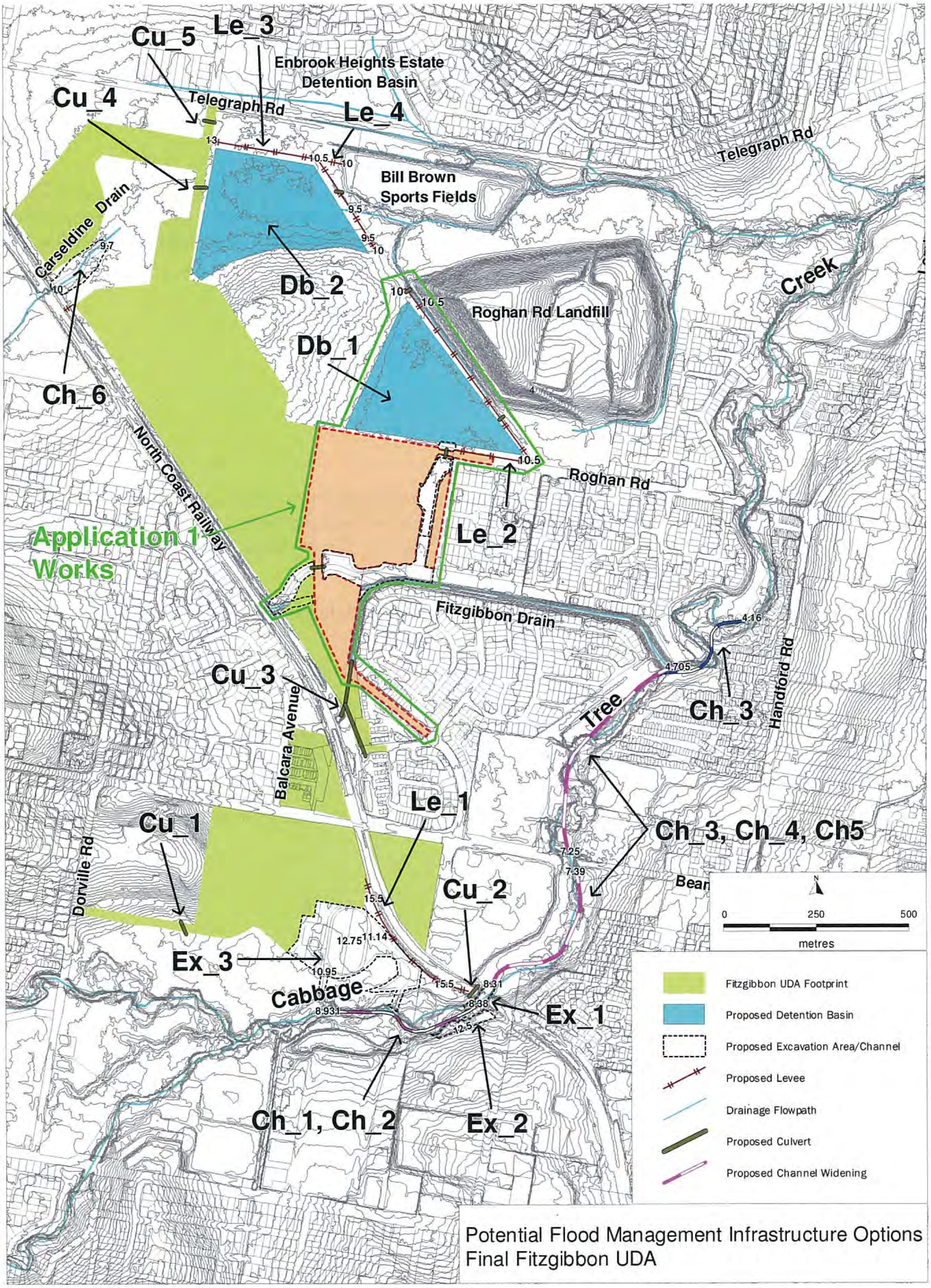

Figure 7.1 Proposed Fitzgibbon UDA Final Development Layout and Potential Flood Management Infrastructure Options

7.2 POTENTIAL FLOOD IMPACTS AND FLOOD MANAGEMENT INFRASTRUCTURE OPTIONS

Table 7.1 provides a summary of the potential impacts of the proposed development and also summarises flood management infrastructure options investigated. A wide range of potential options are available to manage flood impacts along Cabbage Tree Creek and Carseldine Drain, including:

- Channel widening;
- Excavation areas;
- Bridge/Culvert upgrades;
- Waterway clearing; and
- Levees.

The suite of flood mitigation infrastructure presented in this report does not include all options investigated in the study. Various other options were modelled, but were considered, for a range of reasons, to be less suitable for implementation. The additional options modelled but not reported include:

- Levees along the Cabbage Tree Creek bank between the North Coast Railway and the Fitzgibbon Drain;
- Excavation the golf driving range and State school land downstream of Beams Road;
- Reducing the roughness of the Cabbage Tree Creek channel; and
- Excavation on private property immediately downstream of the confluence of Fitzgibbon Drain and Cabbage Tree Creek.

Further details of flood management infrastructure investigated in this study are provided in Sections 7.3 and 7.4.

Table 7.1 Potential Flood Impacts and Flood Management Infrastructure Options

Potential Flood Impact	Flood Management Infrastructure Investigated		Potential Flood Benefits with Management Infrastructure in Place
	ID	Description	
Increased flood levels along Cabbage Tree Creek upstream of the railway line adjacent to the QUT Carseldine site due to filling of floodplain.	Ch_1, Ch_2	Channel widening/re-alignment upstream of the railway.	- Lower flood levels upstream of the railway.
	Ex_1	Excavation under the railway bridge to increase waterway area.	- Lower flood levels upstream of the railway.
	Ex_2	Excavation of the Cabbage Tree Creek channel upstream of the railway, adjacent to Pineapple Street.	- Lower flood levels upstream of the railway.
	Ex_3	Excavation of QUT sports fields.	
	Cu_1	Extra culverts jacked through the railway embankment	- Lower flood levels upstream of the railway.
Prevention of flow across Beams Rd and railway line from Cabbage Tree Creek upstream of the Railway.	Le_1	Levee along western boundary of North Coast Railway easement.	- Reduction in existing flood problems for existing development west of Beams Road. - Reduction in existing flood problems for existing development to the south of Beams Road, east of the railway. - Reduced inflows to Fitzgibbon Drain from Cabbage Tree Creek overflows.
Additional flow in Cabbage Tree Creek between railway and Fitzgibbon Drain confluence due to prevention of flow across Beams Rd and railway line.	Ch_3, Ch_4, Ch_5	Channel widening/re-alignment from the railway to the Fitzgibbon Drain/300 m downstream of the Fitzgibbon Drain.	- Lower flood levels between the railway and Fitzgibbon Drain.
Increased flood levels and discharges along Carseldine Drain due to filling of floodplain to the east of the railway line.	Ch_6	Channel excavation along Carseldine Drain immediately downstream of railway line.	- Reduced flood levels at the North Coast Railway.
	Db_2, Le_4	Detention basin and low east-west floodplain levee between the Bill Brown Sports Fields and the Carseldine Drain Detention Basin.	- Reduced flooding of Telegraph Road due to overflows from Carseldine Drain. - Reduced discharges along Carseldine Drain.

7.3 FLOOD MANAGEMENT INFRASTRUCTURE WITHIN THE UDA

The following sections provide further details of flood management infrastructure proposed within the Fitzgibbon UDA.

7.3.1 Rogan Road Detention Basin

Details of this detention basin are provided in Section 6.2.1. The Rogan Road Detention basin will be constructed as part of Application 1 development.

7.3.2 Carseldine Drain Detention Basin

An on-line detention basin will be constructed along Carseldine Drain along the downstream boundary of the DoH land. The detention basin will mitigate some of the impacts of the UDA development on flood discharges along Carseldine Drain.

The detention basin storage area will be bounded by a proposed levee along the northern boundary of the DoH land, the north-eastern boundary of the DoH land, and a hill slope to the south. An earthen embankment will be constructed and low-flow culverts will be placed along the eastern side of the basin. The ground surface within the detention basin will remain unaltered and the existing vegetation will remain. The basin stage-storage characteristics are shown in Table 7.2.

Table 7.2 Adopted Stage-Storage Curve – Carseldine Drain Detention Basin

Stage (m AHD)	Surface Area (m^2)	Volume (m^3)
8	61	3
8.5	44852	8047
9	85713	42855
9.5	98392	89170
10	109679	141447
10.5	118102	198561

The detention basin has the following spillway and low level outlet configuration:

- A 110 m wide spillway at an elevation of 9.5 m AHD; and
- Low flow pipe: 5 x 0.9 m pipe at an invert level of 8.6 m AHD.

7.3.3 Flood Protection Levees

Three flood protection levees are proposed within the Fitzgibbon UDA:

- Along the DoH land boundaries adjoining Roghan Road and the Roghan Road Landfill ranging in elevation from 10.5 m AHD to 10.0 m AHD (Le_1). This levee will form the northern, north-eastern, and part of the southern walls of the Roghan Road Landfill detention basin (see Sections 6.2.1 and 7.3.1) which will be constructed during Application 1 development.

- The upstream side of the railway to an elevation of 15 m AHD (Le_2). This levee will prevent flow across the railway line near Beams Road for a 100 year ARI event.
- Along the northern and north-western boundaries of the DoH land between the proposed development extent and the DoH boundary ranging in elevation from 13 m AHD to 10.5 m AHD (Le_3). This levee will form the northern side of the Carseldine Drain detention basin (see Section 7.3.2).
- Along Carseldine Drain downstream of the Carseldine Drain detention basin (Le_4) within BCC owned land. The levee will extend from the north-eastern corner of the Carseldine Drain detention basin to the Bill Brown Sports Fields and ranges in elevation from 10.5 m AHD to 10.0 m AHD. This levee will prevent water from Carseldine Drain flowing on to Telegraph Road.

7.3.4 Carseldine Drain Channel

A channel will be excavated along Carseldine Drain downstream of the railway culverts with the following characteristics:

- Base Width = 20 m;
- Top of Bank width = 50 to 70 m;
- Longitudinal Length = 180 m; and
- Upstream Invert = 10 m AHD and downstream Invert = 9.7 m AHD.

7.3.5 QUT Carseldine Sports Field Excavation area

The proposed excavated area adjacent to Pineapple Street has the following characteristics:

- Minimum Elevation of 11.00 m AHD;
- Maximum Elevation of 12.75 m AHD; and
- Approximate Volume of Excavation of 8000 m^3.

7.3.6 Culvert Crossings

Table 7.3 shows the configuration of the proposed culverts. The proposed culvert crossings include:

- A culvert (Cu_1) will be installed across the collector road that extends around the southern side of the QUT Carseldine development area to join with Dorville Road.
- The Carselgrove Avenue culverts (Cu_3) along the southern Fitzgibbon Drain branch will be extended upstream under the proposed development; and
- Roghan Road will be extended to the north to join with Telegraph Road. A series of box culverts (Cu_4) will be constructed under Roghan Road at the Carseldine Drain crossing.

Culverts proposed within Application 1 have been described in sections 6.2.1, 6.2.2, and 6.2.4.

Table 7.3 Final Development Culvert Crossing Configurations

Location	ID	Length (m)	US Invert (m AHD)	DS Invert (m AHD)	Dimensions (m)	Number
QUT Road Culvert	Cu_1	20	15.2	14.7	0.6 dia.	1
Fitzgibbon Drain A	Cu_3	25	9.90	9.75	1.5 dia.	4
Fitzgibbon Drain B	Cu_3	120	9.75	9.03	1.5 dia	5
Fitzgibbon Drain C	Cu_3	150	10.51	9.75	1.5 dia	1
Roghan Rd at Carseldine Drn	Cu_4	20	8.8	8.7	1.8 (W) x 0.9 (H)	15

7.4 FLOOD MANAGEMENT INFRASTRUCTURE OUTSIDE THE UDA

7.4.1 General

Due to the nature of the development proposal, mitigation of development flood impacts will require additional works outside the UDA area. The following structural measures outside of the Fitzgibbon UDA were investigated:

- Cabbage Tree Creek channel widening;
- Excavation immediately upstream of the North Coast Railway.
- Culvert Crossings; and
- Flood Protection Levee.

7.4.2 Cabbage Tree Creek Channel Widening Options

The proposed channel widening options, which would substantially mitigate flooding along Cabbage Tree Creek, involve increasing the waterway area of the Cabbage Tree Creek main channel along a number of reaches. Table 7.4 shows the proposed channel characteristics modelled in TUFLOW.

Note that the modelled channel configurations are indicative only and would require further detailed design, including assessment of environmental impacts.

7.4.3 Pineapple Street Excavation area

The proposed excavated area adjacent to Pineapple Street has the following characteristics:

- Minimum Elevation of 12.00 m AHD;
- Maximum Elevation of 12.50 m AHD; and
- Approximate Volume of Excavation of 60, 000 m^3.

Table 7.4 Proposed Channel Widening Options along Cabbage Tree Creek

Channel Reach	Flood Mitigation ID	Width (m)	Length (m)	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Slope (%)
Upstream of the Railway	Ch_1	17	440	8.93	8.38	0.13
""	Ch_2	10	440	8.93	8.38	0.13
Railway to Beams Road	Ch_3	17	445	8.31	7.39	0.21
""	Ch_4	17	445	8.31	7.39	0.21
""	Ch_5	10	445	8.31	7.39	0.21
Beams Road to 300 m downstream of the Fitzgibbon Drain	Ch_3	17	925	7.25	4.16	0.33
Beams Road to Fitzgibbon Drain	Ch_4	17	640	7.25	4.71	0.40
""	Ch_5	10	640	7.25	4.71	0.40

7.4.4 Culvert Crossings

Table 7.3 shows the configuration of the proposed culverts. The proposed culvert crossings include:

- A series of box culverts (Cu_1) will be jacked through the railway embankment next to the Cabbage Tree Creek crossing; and
- Roghan Road will be extended to the north to join with Telegraph Road. A culvert (Cu_4) will be installed under Roghan Road within the power link easement.

Table 7.5 Final Development Culvert Crossing Configurations

Location	ID	Length (m)	US Invert (m AHD)	DS Invert (m AHD)	Dimensions (m)	Number
Cabbage Tree Creek	Cu_2	20	11.50	11.35	3 (W) x 1.5 (H)	4
Roghan Road	Cu_5	20	9.21	8.75	0.6 dia	1

7.5 OPTIONS MODELLED IN TUFLOW – UDA FULL DEVELOPMENT

Table 7.6 shows the combinations of various flood management infrastructure components modelled in TUFLOW. The various infrastructure elements have been combined into 9 flood mitigation options.

Table 7.6 TUFLOW Model 100 year ARI Final Development Flood Mitigation Options

Flood Mitigation ID	Flood Mitigation Description	Op1	Op2	Op3	Op4	Op5	Op6	Op7	Op8	Op9
	Within Fitzgibbon UDA									
Db_1	Roghan Road Landfill detention basin	X	X	X	X	X	X	X	X	X
Db_2	Carseldine Drain detention basin	X	X	X	X	X	X	X	X	X
Le_1	Flood Protection Levee along the upstream boundary of the railway easement	X	X	X	X	X	X	X	X	X
Le_2	Roghan Road Landfill detention basin wall	X	X	X	X	X	X	X	X	X
Le_3	Carseldine Drain detention basin wall	X	X	X	X	X	X	X	X	X
Le_4	Flood Protection Levee along northern boundary between Carseldine Drain detention basin and the Bill Brown Sports Field	X	X	X	X	X	X	X	X	X
Ch_6	Carseldine Drain channel excavation	X	X	X	X	X	X	X	X	X
Ex_3	Excavation of the QUT sports field	X	X	X	X	X				
Cu_1, Cu_3, Cu_4, Cu_5	Road crossing culverts for QUT access road, Carselgrove Avenue (southern branch of the Fitzgibbon Drain), and Roghan Road at Carseldine Drain	X	X	X	X	X	X	X	X	X
	Outside Fitzgibbon UDA									
Ch_1	17 m wide channel upstream of the railway			X				X		
Ch_2	10 m wide channel upstream of the railway								X	
Ch_3	17 m wide channel from the railway to 300 m downstream of the Fitzgibbon Drain	X	X	X	X		X			
Ch_4	17 m wide channel from railway to the Fitzgibbon Drain					X		X		X
Ch_5	10 m wide channel from railway to the Fitzgibbon Drain								X	
Ex_1	Excavation to increase waterway area under the railway bridge				X					
Ex_2	Excavation upstream of the railway near Pineapple Street			X				X	X	X
Cu_2	Extra culverts jacked through the railway embankment		X							

7.6 IMPACT ASSESSMENT OF PROPOSED MITIGATION OPTIONS

The TUFLOW model was used to assess the impacts of the proposed development and the various flood mitigation options on the 2, 5, 10, 20, 50, and 100 year ARI flood behaviour within the study area.

Table 7.7 shows 100 year ARI water levels for existing development and final development, as well as water level impacts at a number of reporting locations in the study area (see Figure 7.2). The results of the flood modelling indicate that:

- Option 1 substantially reduces flood levels along CTC between the railway and the confluence with Fitzgibbon Drain. However, flood levels upstream of the railway adjacent to the industrial site (Location CTC_03) and downstream of the Fitzgibbon Drain are increased by up to 0.28 m and 0.02 m, respectively.
- The additional railway culverts (Option 2) reduces flood levels by 0.06 m upstream of the railway compared with Option 1.
- Channel works upstream of the railway (Option 3) will reduce flooding upstream of the railway to pre-development levels except for at the railway crossing.
- Option 4 (increasing the waterway area of the railway bridge) does not have any significant benefit upstream of the railway crossing.
- Option 5 reduces all CTC flood levels downstream of the railway crossing to below pre-development levels.
- The benefit of excavating the QUT sports field (Option 6) is a reduction in CTC flood levels by up to 0.03 m.
- Option 7 reduces Cabbage Tree Creek flood levels everywhere except at the railway crossing adjacent to state owned land (CTC_04), however, the proposed channel upstream of the railway may have significant environmental impacts.
- Option 8 reduces Cabbage Tree Creek flood levels at all locations downstream of Beams Road. However, flood levels upstream of Beams Road and the Railway are increased adjacent to existing development by up to 0.06 m and 0.11 m, respectively.
- Option 9 reduces Cabbage Tree Creek (CTC) flood levels at all reporting locations downstream of the railway crossing compared to existing development conditions. Flood levels adjacent to the existing industrial development upstream of the railway are increased by up to 0.22 m.

7.7 SUMMARY OF PREFERRED FLOOD MANAGEMENT SCENARIO - OPTION 9

Based on an assessment of flood impacts and benefits only, Option 9 represents the preferred option for managing impacts of the UDA development and reducing existing flood problems for existing development along Cabbage Tree Creek in the study area. The proposed suite of flood management infrastructure for Option 9 (in addition to Application 1 works (see section 6.2), including the Roghan Road Landfill detention basin (Db_1)and the Roghan Road Landfill detention basin wall (Le_2)) includes:

- Within the Fitzgibbon UDA:
  - A culvert across the collector road that extends around the southern side of the QUT Carseldine development area to join with Dorville Road (Cu_1).
  - A flood protection levee along the upstream boundary of the railway easement between the proposed QUT Carseldine development and the North Coast Railway crossing of Cabbage Tree Creek (Le_1);
  - Extension of the Carselgrove Avenue culverts along the southern Fitzgibbon Drain branch (Cu_3);
  - A series of box culverts across Roghan Road at the Carseldine Drain crossing (Cu_4).
  - A new channel immediately downstream of the Railway Crossing of Carseldine Drain (Ch_6);
  - A flood protection levee along the northern and north-western boundaries of the DoH land between the proposed development extent and the DoH boundary (Le_3 This flood protection levee forms the wall for the Carseldine Drain detention basin (Db_2); and
  - A flood protection levee south of Telegraph Road between the proposed Carseldine Drain detention basin and the Bill Brown Sports Field (Le_4),
- Outside the Fitzgibbon UDA:
  - A 17 m wide channel along Cabbage Tree Creek from North Coast Railway to the Fitzgibbon Drain (Ch_4);
  - Excavation along Cabbage Tree Creek upstream of the railway near Pineapple Street (Ex_2); and

7.8 OPTION 9 100 YEAR ARI FLOOD EXTENT AND IMPACT ASSESSMENT

Figure 7.2 shows the Option 9 Final Development Conditions 100 year ARI flood extent and water level impacts across the study area. This option successfully mitigates most development impacts, although there is a potential flood level increase adjacent to the existing industrial estate upstream of the railway.

Figure 7.3 shows a cross section of the pre-development and Final Development Conditions (Option 9) 100 year ARI flood levels adjacent to the existing industrial development to the south of the QUT development. The proposed Option 9 final development is expected to increase the 100 year ARI flood level at the existing industrial development by 0.23 m to 14.60m AHD. Part of the existing industrial development is within the pre-development flood extent. Based on the available survey data, it appears that the road along the industrial estate's northern boundary, which is at an elevation of 13.75 m AHD, is lower than the rest of the development which is at a minimum elevation of 14.75 m AHD. Assuming these levels are correct, only this part of the road along the industrial estate's northern boundary will be affected by the increase in flood levels. All buildings in the industrial estate will remain above the 100 year ARI flood Level and will retain existing flood free access. Refinement of flood mitigation options for the Fitzgibbon UDA should include detailed assessment of potential flood impacts in this area, including additional ground survey.

Table 7.7 Final Development 100 year ARI Flood Level Impacts for 9 Mitigation Options Modelled in TUFLOW

Reporting Location	Pre_Dev	Option 1		Option 2		Option 3		Option 4		Option 5		Option 6		Option 7		Option 8		Option 9		Op9 WL
	Water Level (m AHD)	Water Level (m AHD)	Impact (m)	Water Level (m AHD)	Impact (m)	Water Level (m AHD)	Impact (m)	Water Level (m AHD)	Impact (m)	Water Level (m AHD)	Impact (m)	Water Level (m AHD)	Impact (m)	Water Level (m AHD)	Impact (m)	Water Level (m AHD)	Impact (m)	Water Level (m AHD)	Impact (m)	264 m^3/s (m AHD)
CARS_01	11.65	11.20	-0.45	11.20	-0.45	11.20	-0.45	11.20	-0.45	11.20	-0.45	11.20	-0.45	11.20	-0.45	11.20	-0.45	11.20	-0.45	11.20
CARS_02	9.55	10.54	0.99	10.54	0.99	10.54	0.99	10.54	0.99	10.54	0.99	10.54	0.99	10.54	0.99	10.54	0.99	10.54	0.99	10.54
CARS_03	9.24	10.05	0.81	10.05	0.81	10.05	0.81	10.05	0.81	10.05	0.81	10.05	0.81	10.05	0.81	10.05	0.81	10.05	0.81	10.05
CARS_04	9.08	9.53	0.45	9.53	0.45	9.53	0.45	9.53	0.45	9.53	0.45	9.53	0.45	9.53	0.45	9.53	0.45	9.53	0.45	9.53
CARS_05	8.58	9.05	0.47	9.05	0.47	9.06	0.48	9.05	0.47	9.05	0.47	9.05	0.47	9.05	0.48	9.06	0.48	9.05	0.47	9.05
CARS_06	9.19	8.67	-0.51	8.67	-0.51	8.67	-0.51	8.67	-0.51	8.67	-0.51	8.67	-0.51	8.67	-0.51	8.67	-0.51	8.67	-0.51	8.67
CARS_07	9.15	8.76	-0.39	8.76	-0.39	8.76	-0.39	8.76	-0.39	8.76	-0.39	8.76	-0.39	8.76	-0.39	8.76	-0.39	8.76	-0.39	8.76
CARS_08	9.15	8.68	-0.47	8.68	-0.47	8.68	-0.47	8.68	-0.47	8.68	-0.47	8.68	-0.47	8.68	-0.47	8.68	-0.47	8.68	-0.47	8.68
CARS_09	8.01	7.86	-0.16	7.86	-0.16	7.86	-0.15	7.86	-0.15	7.86	-0.16	7.86	-0.16	7.86	-0.15	7.86	-0.15	7.86	-0.15	7.86
CARS_10	7.47	7.43	-0.05	7.43	-0.05	7.43	-0.05	7.43	-0.05	7.43	-0.05	7.43	-0.05	7.43	-0.05	7.43	-0.05	7.43	-0.05	7.43
CARS_11	5.96	5.91	-0.05	5.91	-0.05	5.91	-0.04	5.91	-0.05	5.91	-0.05	5.91	-0.05	5.91	-0.04	5.91	-0.05	5.91	-0.04	5.91
CTC_01	15.48	15.49	0.00	15.48	0.00	15.46	-0.02	15.49	0.00	15.49	0.00	15.49	0.01	15.47	-0.02	15.48	-0.01	15.49	0.01	15.52
CTC_02	14.47	14.68	0.22	14.63	0.17	14.39	-0.08	14.71	0.24	14.68	0.22	14.71	0.24	14.42	-0.04	14.52	0.05	14.64	0.17	14.73
CTC_03	14.37	14.66	0.28	14.60	0.22	14.34	-0.03	14.68	0.31	14.66	0.28	14.67	0.30	14.37	0.00	14.49	0.12	14.60	0.22	14.70
CTC_04	13.71	14.11	0.40	13.92	0.21	13.95	0.24	14.20	0.49	14.11	0.40	14.12	0.41	13.96	0.25	14.07	0.36	14.08	0.38	14.24
CTC_05	12.65	12.57	-0.07	12.60	-0.05	12.56	-0.09	12.55	-0.10	12.58	-0.07	12.58	-0.07	12.55	-0.10	12.70	0.06	12.58	-0.06	12.63
CTC_06	12.50	12.32	-0.18	12.34	-0.16	12.32	-0.19	12.30	-0.20	12.33	-0.17	12.33	-0.17	12.29	-0.21	12.48	-0.02	12.33	-0.17	12.37
CTC_07	12.38	12.06	-0.32	12.07	-0.30	12.05	-0.33	12.03	-0.35	12.06	-0.31	12.05	-0.32	12.06	-0.32	12.30	-0.08	12.06	-0.31	12.13
CTC_08	12.11	11.53	-0.58	11.55	-0.56	11.51	-0.60	11.49	-0.61	11.55	-0.55	11.53	-0.58	11.55	-0.56	11.92	-0.19	11.56	-0.55	11.64
CTC_09	11.56	10.93	-0.63	10.95	-0.61	10.91	-0.65	10.89	-0.67	11.02	-0.54	10.93	-0.63	11.02	-0.54	11.39	-0.17	11.03	-0.53	11.11
CTC_10	10.31	9.92	-0.39	9.93	-0.38	9.91	-0.40	9.91	-0.41	10.29	-0.02	9.92	-0.39	10.29	-0.02	10.27	-0.04	10.29	-0.02	10.35
CTC_11	9.26	9.28	0.03	9.30	0.04	9.28	0.02	9.27	0.02	9.23	-0.03	9.28	0.03	9.23	-0.03	9.23	-0.03	9.24	-0.02	9.30
CTC_12	8.69	8.73	0.04	8.74	0.05	8.72	0.03	8.73	0.04	8.68	-0.01	8.73	0.04	8.67	-0.02	8.67	-0.02	8.68	-0.01	8.75
CTC_13	5.95	5.98	0.02	5.99	0.03	5.96	0.01	5.98	0.02	5.95	-0.01	5.98	0.03	5.95	-0.01	5.94	-0.01	5.95	0.00	5.99
CTC_14	4.69	4.70	0.01	4.70	0.01	4.70	0.00	4.70	0.01	4.69	0.00	4.70	0.01	4.69	0.00	4.69	0.00	4.70	0.00	4.72
CTC_15	3.90	3.92	0.02	3.92	0.03	3.91	0.01	3.91	0.02	3.88	-0.02	3.92	0.03	3.89	-0.01	3.88	-0.02	3.89	-0.01	3.97
FITZ_01	11.77	11.61	-0.15	11.61	-0.15	11.61	-0.16	11.61	-0.16	11.61	-0.16	11.61	-0.16	11.61	-0.16	11.61	-0.16	11.61	-0.16	11.61
FITZ_02	10.62	10.25	-0.37	10.25	-0.37	10.26	-0.37	10.25	-0.37	10.47	-0.15	10.25	-0.37	10.48	-0.14	10.48	-0.14	10.46	-0.16	10.52
FITZ_03	11.92	10.85	-1.07	10.85	-1.07	10.85	-1.07	10.85	-1.07	10.85	-1.07	10.85	-1.07	10.85	-1.07	10.85	-1.07	10.85	-1.05	10.85
FITZ_04	10.47	10.00	-0.47	10.00	-0.47	10.00	-0.47	10.00	-0.47	10.36	-0.11	10.00	-0.47	10.37	-0.10	10.37	-0.10	10.37	-0.10	10.43
FITZ_05	10.46	9.97	-0.49	9.98	-0.48	9.97	-0.50	9.97	-0.50	10.37	-0.10	9.97	-0.49	10.37	-0.10	10.37	-0.09	10.37	-0.09	10.43
FITZ_06	10.46	9.97	-0.48	9.98	-0.47	9.97	-0.49	9.97	-0.49	10.37	-0.09	9.97	-0.48	10.37	-0.09	10.38	-0.08	10.37	-0.08	10.43
FITZ_07	10.44	9.97	-0.47	9.98	-0.46	9.97	-0.48	9.97	-0.48	10.37	-0.07	9.97	-0.47	10.37	-0.07	10.38	-0.07	10.38	-0.07	10.44
FOX_01	9.78	9.89	0.12	9.88	0.10	9.87	0.09	9.87	0.09	10.30	0.52	9.88	0.10	10.31	0.53	10.30	0.53	10.31	0.53	10.40
FOX_02	9.76	9.89	0.13	9.87	0.11	9.86	0.10	9.86	0.11	10.28	0.53	9.87	0.11	10.29	0.54	10.29	0.53	10.29	0.54	10.37
FOX_03	9.71	9.86	0.16	9.87	0.17	9.87	0.16	9.87	0.16	10.26	0.55	9.87	0.17	10.27	0.56	10.26	0.55	10.27	0.56	10.29
FOX_04	9.70	9.86	0.17	9.87	0.17	9.87	0.17	9.87	0.17	10.26	0.56	9.87	0.17	10.27	0.57	10.26	0.56	10.26	0.57	10.29

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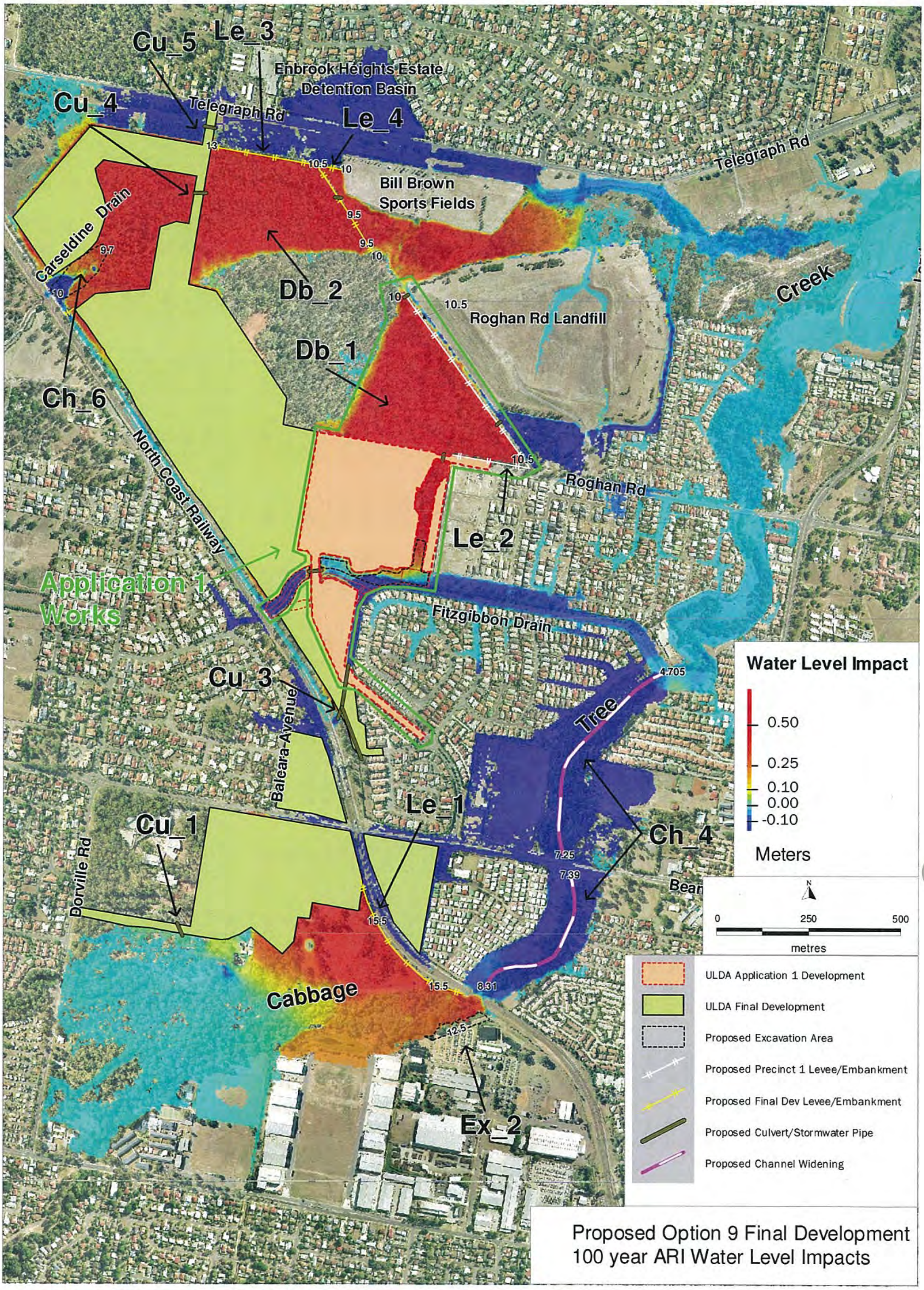

Figure 7.2 Option 9 Final Development 100 year ARI Flood Extent and Development Impacts, Fitzgibbon UDA site

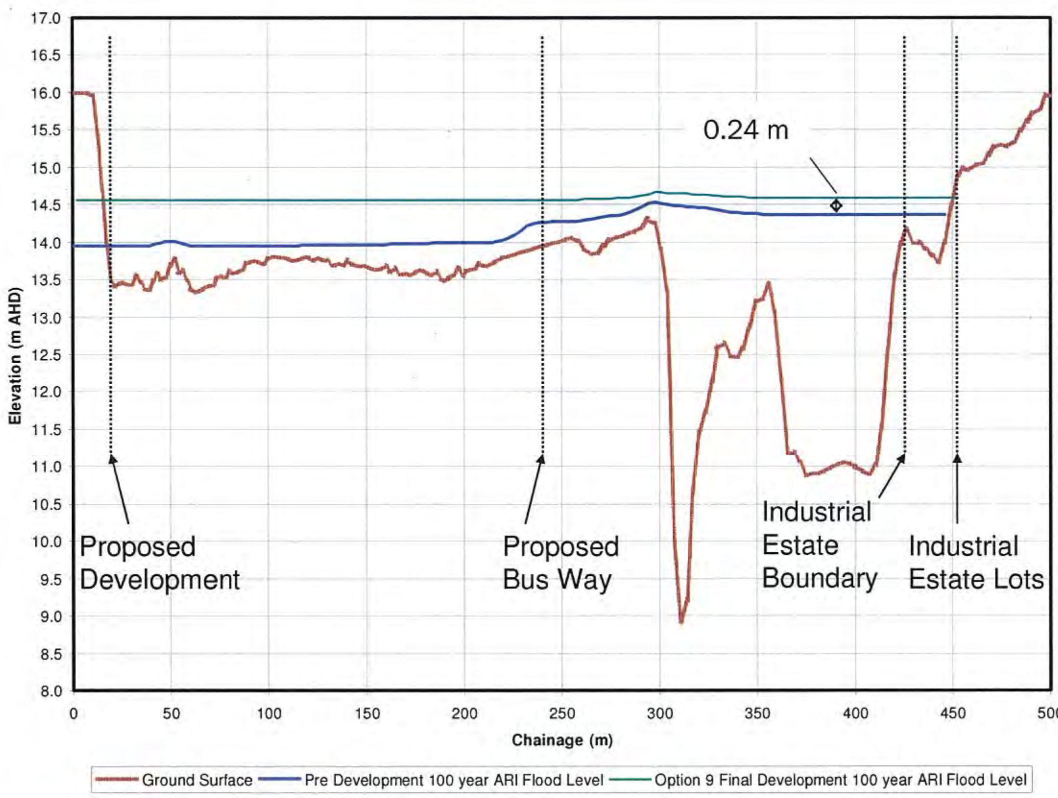

Figure 7.3 Typical Cabbage Tree Creek Cross Section at the Existing Industrial Estate and 100 year ARI for Pre-Development and Option 9 Final Development Flood Level

7.9 OPTION 9 FINAL DEVELOPMENT FILL LEVELS

The Option 9 final development conditions Cabbage Tree Creek TUFLOW model (see previous section) inflows were modified to determine conservative flood level estimates for the purpose of setting development fill levels. BCC requested that fill levels be determined using Cabbage Tree Creek 100 year ARI peak discharge of 264 m^3/s (instead of 249m^3/s as determined by the Cabbage Tree Creek URBS model). The Cabbage Tree Creek inflow hydrographs at inflow locations A1, A2 and A3 (see Section 4.3) were factored up by 1.06 (6%).

Table 7.7 tabulates the 100 year ARI water levels for determining fill levels at the reporting locations shown in Figure 6.5.

8 PROPOSED BUS WAY IMPACT ASSESSMENT

8.1 PROPOSED CONFIGURATION

The Queensland Department of Transport and Main Roads is currently investigating a bus way connection from Telegraph Road to QUT Carseldine. Figure 8.1 shows the proposed alignment of the Bus Way. The bus way will be aligned along the eastern boundary of the North Coast Railway. A flyover will be constructed to cross the North Coast Railway 14 m above the ground and an embankment constructed on the QUT Carseldine land on its descent to existing ground level. Four culvert crossings of the North Coast Railway will be extended through the bus way. These railway culvert crossings include the Southern and Western Branch of the Fitzgibbon Drain and the Carseldine Drain.

8.2 POTENTIAL FLOOD IMPACTS OF THE BUS WAY

The most significant impact of the bus way is the proposed embankment as it descends from the North Coast Railway to the QUT Carseldine development area. The proposed embankment alignment is located within the Cabbage Tree Creek 100 year ARI flood extent. The embankment will reduce the Cabbage Tree Creek flood storage and part of the active flow area which could result in increased water levels along Cabbage Tree Creek adjacent to and upstream of the embankment.

8.3 TUFLOW MODEL IMPACT ASSESSMENT

The TUFLOW model was used to assess the impacts of the bus way on the 100 year ARI flood event within the study area. The adopted hydraulic openings through the bus way embankment on the QUT site consisted of a five meter wide open channel between the proposed levee and the bus way embankment. Depending on the cost, a culvert could be installed instead.

Table 8.1 shows the 100 year ARI peak water levels for existing conditions (full development of the upstream Cabbage Tree Creek catchment), Final Fitzgibbon UDA for Option 9 (without the bus way), and Final Fitzgibbon UDA for Option 9 (with the bus way). Table 8.1 also shows the 100 year ARI water level impacts due to the final development and the Bus Way and the estimated impact due to the bus way alone. The following is of note:

- 100 year ARI peak flood levels along Cabbage Tree Creek at the QUT Carseldine site range from 15.50 m AHD at Reporting Location CTC_01 to 14.05 m AHD at Reporting Location CTC_04;

- Construction of the bus way embankment will increase the maximum 100 year ARI water level along Cabbage Tree Creek adjacent to the QUT Carseldine site by 0.06 m;
- Construction of the bus way embankment will increase water levels at the existing industrial estate by 0.05 m. The 100 year ARI flood level at the industrial estate of 14.64 m AHD is lower than the lowest point of lots on the estate by 0.11 m; and
- The 100 year ARI flood impacts of the bus way downstream of the North Coast Railway are insignificant.

8.4 FILL LEVELS

Table 8.1 tabulates the 100 year ARI water levels, including the impacts of the bus way, for determining fill levels at the reporting locations shown in Figure 6.5.

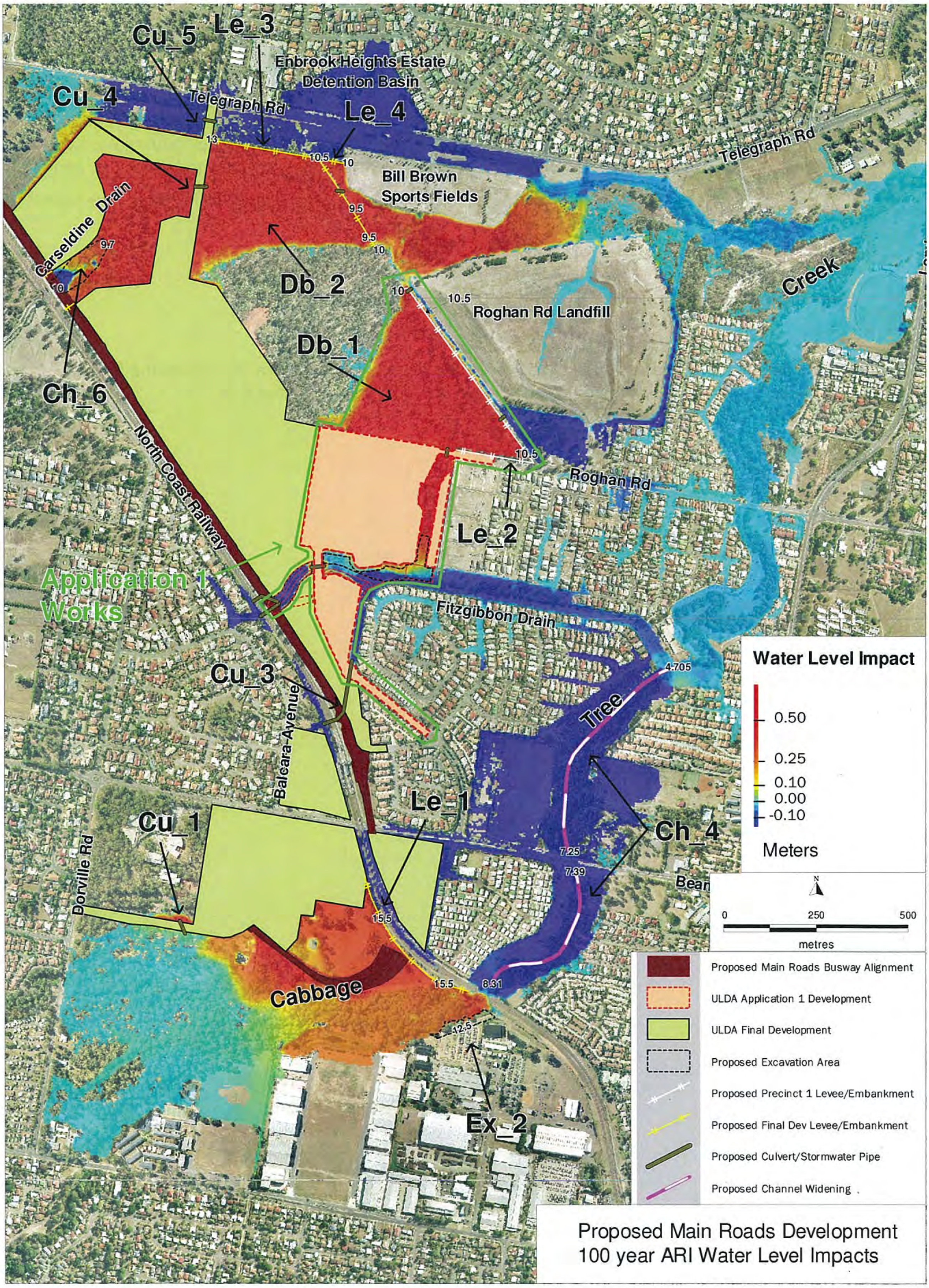

Figure 8.1 Bus Way Development 100 year ARI Flood Extent and Development Impacts, Fitzgibbon UDA site

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Table 8.1 TUFLOW Model 100 yr ARI Flood Levels and 100 yr ARI Flood Level Impacts – Pre-Development, Final Fitzgibbon UDA with and without Bus Way

Reporting Location	100 Year ARI Peak Flood Level (m AHD)			100 yr ARI Water Level Impacts (m)		100 yr ARI Water Levels for Fill Level Calculations (m AHD)
	Existing	Final Fitzgibbon UDA (without Bus Way)	Final Fitzgibbon UDA (with Bus Way)	Final Development + Bus Way	Bus Way	
CARS_01	11.65	11.20	11.21	-0.44	0.01	11.21
CARS_02	9.55	10.54	10.54	0.99	0.00	10.54
CARS_03	9.24	10.05	10.05	0.81	0.00	10.05
CARS_04	9.08	9.53	9.53	0.45	0.00	9.53
CARS_05	8.58	9.05	9.05	0.47	0.00	9.05
CARS_06	9.19	8.67	8.67	-0.52	0.00	8.67
CARS_07	9.15	8.76	8.76	-0.39	0.00	8.76
CARS_08	9.15	8.68	8.68	-0.47	0.00	8.68
CARS_09	8.01	7.86	7.86	-0.15	0.00	7.86
CARS_10	7.47	7.43	7.43	-0.04	0.00	7.43
CARS_11	5.96	5.91	5.92	-0.04	0.01	5.92
CTC_01	15.48	15.49	15.50	0.02	0.01	15.54
CTC_02	14.47	14.64	14.70	0.23	0.06	14.78
CTC_03	14.37	14.60	14.64	0.27	0.04	14.73
CTC_04	13.71	14.08	14.06	0.35	-0.02	14.20
CTC_05	12.65	12.58	12.57	-0.08	-0.01	12.61
CTC_06	12.50	12.33	12.32	-0.18	-0.01	12.36
CTC_07	12.38	12.06	12.05	-0.33	-0.01	12.12
CTC_08	12.11	11.56	11.54	-0.57	-0.02	11.63
CTC_09	11.56	11.03	11.02	-0.54	-0.01	11.10
CTC_10	10.31	10.29	10.29	-0.02	0.00	10.34
CTC_11	9.26	9.24	9.23	-0.03	-0.01	9.30
CTC_12	8.69	8.68	8.67	-0.02	-0.01	8.75
CTC_13	5.95	5.95	5.94	-0.01	-0.01	5.99
CTC_14	4.69	4.69	4.69	0.00	0.00	4.71
CTC_15	3.90	3.89	3.88	-0.02	-0.01	3.94
FITZ_01	N/A	N/A	N/A	N/A	N/A	N/A
FITZ_02	10.62	10.46	10.42	-0.20	-0.04	10.48
FITZ_03	11.92	10.85	10.94	-0.98	0.09	10.94
FITZ_04	10.47	10.37	10.36	-0.11	-0.01	10.42
FITZ_05	10.46	10.37	10.37	-0.09	0.00	10.42
FITZ_06	10.46	10.37	10.37	-0.09	0.00	10.42
FITZ_07	10.44	10.38	10.37	-0.07	-0.01	10.43
FOX_01	9.78	10.31	10.30	0.52	-0.01	10.36
FOX_02	9.76	10.29	10.29	0.53	0.00	10.35
FOX_03	9.71	10.27	10.26	0.55	-0.01	10.31
FOX_04	9.70	10.26	10.26	0.56	0.00	10.31

9 WATER SENSITIVE URBAN DESIGN

9.1 DESIGN OBJECTIVES

Development within the Fitzgibbon UDA will be designed to meet current best practice design objectives for Water Sensitive Urban Design (WSUD), including management of stormwater quantity and quality, as well as source substitution for non-potable water supply.

Current WSUD design objectives for stormwater management are provided in the South East Queensland Regional Plan Implementation Guideline No. 7: Water Sensitive Urban Design (DIP 2008). The design objectives include:

- A frequent-flow management design objective. This objective requires the first 15 mm of runoff from impervious surfaces (for sites with > 40% imperviousness) to be captured and managed to minimise the impacts on downstream ecosystems associated with the increased frequency of runoff from impervious surfaces.
- A waterway stability management design objective. The objective aims to protect downstream waterways from increases in in-stream erosion by ensuring that the peak 1 year ARI stormwater discharge from the site to the receiving waterway is not increased by the proposed development.
- A stormwater quality management design objective. This objective requires the following reductions in total load of key stormwater pollutants discharging from the site, compared to untreated stormwater runoff:
  - 80% reduction in total suspended solids,
  - 60% reduction in total phosphorus,
  - 45% reduction in total nitrogen, and
  - 90% reduction in gross pollutants.

Requirements for source substitution are provided in the South East Queensland Water Strategy (QWC 2008) which requires all new dwellings to provide 70,000 L per year from alternative (non-grid) water sources.

Design objectives for stormwater quality management and water source substitution should be met for all developable areas in the UDA. Meeting the frequent flow management and waterway stability management objectives is most important for development areas draining to tributaries of Cabbage Tree Creek, in particular Carseldine Drain. Managing the frequency and magnitude of stormwater which discharges directly to Cabbage Tree Creek will be of less benefit due to the very large impervious area already established within the Cabbage Tree Creek catchment.

9.2 PROPOSED WSUD INFRASTRUCTURE

9.2.1 Overview

Appropriate WSUD infrastructure required to meet the above design objectives for the UDA is given in Table 9.1. Table 9.1 also shows the indicative required land allocation for the various infrastructure components. Further discussion on the potential implementation of each of the infrastructure components is provided in the following sections.

Note that constructed stormwater treatment wetlands could also be used effectively on the site. However, the required footprint area is typically of the order of 5% of the contributing catchment, which is substantially more than required for bioretention basins. Stormwater treatment wetlands offer a potential advantage on flat sites since they typically produce a smaller loss of hydraulic head from inlet to outlet.

Table 9.1 Proposed WSUD Infrastructure, Fitzgibbon UDA

WSUD Design Objective	Proposed Infrastructure	Area Required Within Developable Area Footprint [a]	Location
Frequent Flow Management	Bioretention	70 - 130 m^2/ha [b] 210 m^2/ha [c]	May be implemented at a range of spatial scales depending on desired urban form and streetscape.
	Stormwater capture basins	30 - 60 m^2/ha	Adjacent or connected to bioretention basins.
Waterway Stability Management	Stormwater detention basins	Nil.	Regional detention basins north of Fitzgibbon Drain.
	Flow dissipation at stormwater outlets	Nil.	Downstream of stormwater outlets to open space areas.
Stormwater Quality Management	Swales (optional where site conditions permit)	50 - 100 m^2/ha	Distributed along road corridors.
	Bioretention	As per Frequent Flow Management	
Water Source Substitution	Option 1: Lot-scale rainwater tanks	Nil. Located within allotments.	
	Option 2: Regional rainwater tanks	0.5% (Indicative estimate only)	

[a] Required area depends on development density and whether lot-scale rainwater tanks are adopted.
[b] With lot-scale rainwater tanks.
[c] With regional rainwater tanks.

9.2.2 Bioretention

Bioretention systems collect stormwater runoff in a shallow storage area for filtration through planted filter media and are an effective method of removing particulate pollutants and dissolved nutrients from stormwater. Pre-treatment of inflows is required using either grass swales or a sediment or gross pollutant trap.

Bioretention systems can be implemented at a range of spatial scales and adapted to different types of urban development as shown in Figure 9.1. They can be used at the inlet of a stormwater system (in place of traditional gully-pit inlets), as a linear feature in road medians, or as an end-of-line treatment system. The performance of a bioretention basin increases with the surface area of the filter media. The total footprint area required for bioretention is usually larger than the required filter media area to accommodate the small embankments necessary to form the storage area. Hence the total footprint area for multiple small basins is larger than the footprint area for a smaller number of larger basins.

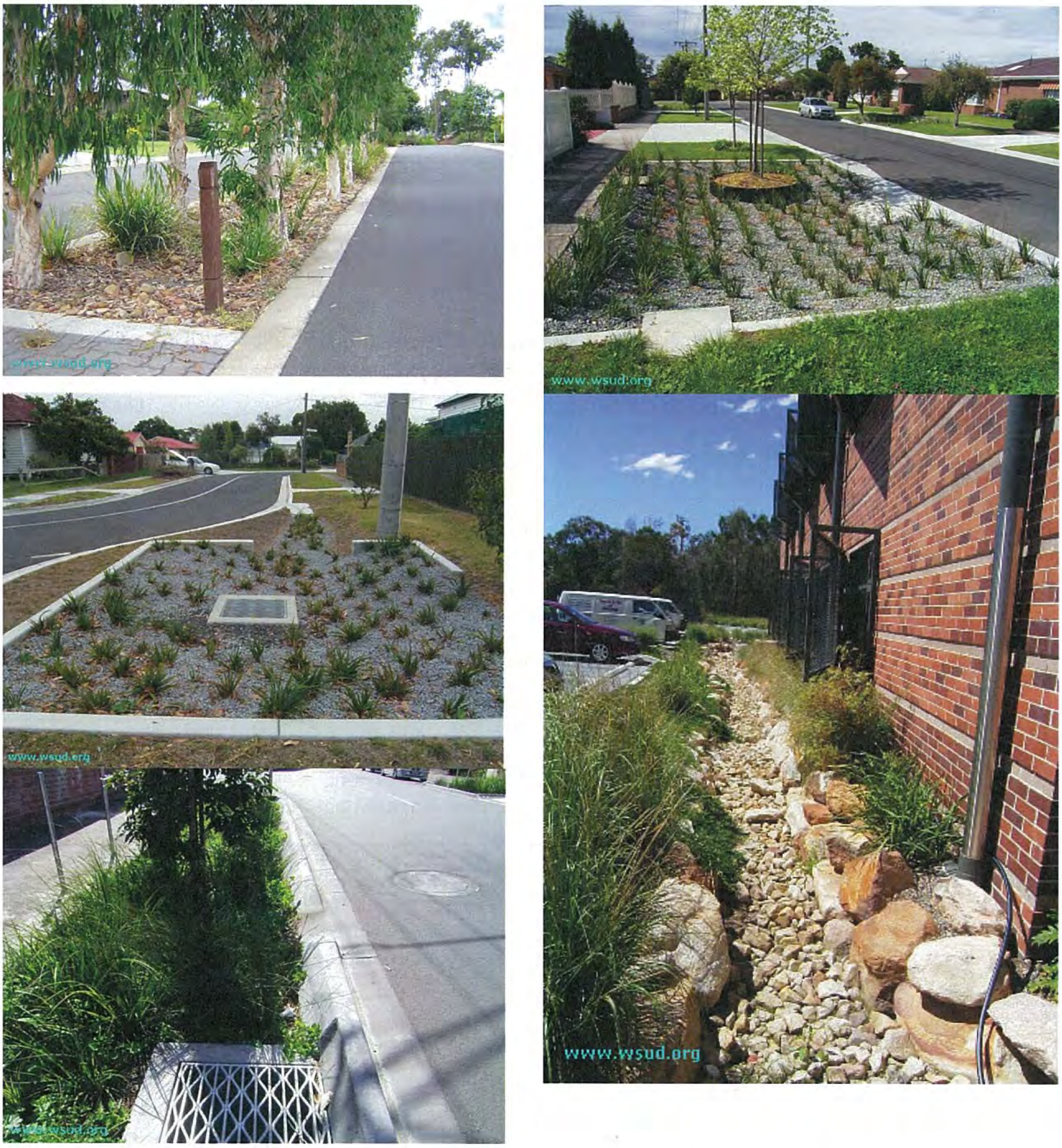

Figure 9.1 Optional Configuration of Bioretention Systems (source: www.wsud.org)

Indicative filter media areas and footprint areas for bioretention to treat stormwater from residential development within the UDA were estimated using the MUSIC model. Bioretention sizing was estimated for dwelling densities of 15 dwelling per hectare and 30 dwellings per hectare. Bioretention sizes were estimated with and without lot-scale rainwater tanks to assess the impact on bioretention sizing if a regional-scale stormwater harvesting strategy is adopted.

Under this scenario the bioretention systems would be used to pre-treat stormwater prior to further purification and storage at a regional scale for subsequent reticulation as non-potable water. The adopted parameters and model results are shown in Table 9.2.

The results of the MUSIC model show that lot-scale rainwater tanks significantly reduce the required footprint area of bioretention. Without lot-scale rainwater tanks, bioretention would require a space allocation of about 2% of the development area. With lot-scale tanks, low density development would require an area of about 1.3%, and higher density development would require only about 0.7% due to the reduction in stormwater volume from harvesting of roofwater.

Table 9.2 Indicative Bioretention Sizing for Residential Development

Parameter	15 Dwellings / ha	30 Dwellings / ha
Road impervious	15%	25%
Roof impervious	30%	40%
Other impervious	10%	5%
Pervious	45%	30%
Water demand (0.326 kL/dw/d) [a]	4.9 kL/ha/d	9.8 kL/ha/d
Rainwater tank size [b]	75 kL/ha	90 kL/ha
With individual rainwater tanks		
- Required bioretention filter area	55 m^2/ha	20 m^2/ha
- Required bioretention footprint area	130 m^2/ha	70 m^2/ha
Without individual rainwater tanks		
- Required bioretention filter area	100 m^2/ha	110 m^2/ha
- Required bioretention footprint area	200 m^2/ha	210 m^2/ha
Rainwater yield	1.6 ML/ha/yr	2.1 ML/ha/yr
	107,000 L/dwelling/yr	70,000 L/dwelling/yr

[a] Taken from GCCC, 2006
[b] Based on 5 kL per dwelling for 15 dwellings per ha and 3 kL per dwelling for 30 dwellings per ha

9.2.3 Stormwater Capture Basins

It is likely that rainwater tanks will be sufficient to meet the frequent flow management objective (capture of the first 15 mm runoff) for roof areas.

The storage available within bioretention areas can be used to capture runoff from ground-level impervious areas. However it is unlikely that this volume alone will be sufficient to meet the frequent flow management objective. Based on the assumed areas of roads and other impervious areas in Table 9.2, a capture volume of 38 m^3/ha will be required for 15 dwellings per hectare (compared to about 29 m^3/ha available in bioretention) and 45 m^3/ha for 30 dwellings per hectare (compared to about 14 m^3/ha available in bioretention). Hence an additional 10 to 30 m^3/ha will be required to achieve the frequent flow management objective.

This additional storage could be provided by enlarging bioretention basins, or by constructing separate adjoining stormwater capture basins. The stormwater capture basins would perform a similar function to bioretention, capturing low flows for slow release, but are not designed to reduce peak flow rates during large storm events. A separate stormwater capture basin provides the opportunity to increase the storage depth compared to the maximum of about 0.4 m for bioretention basins, allowing a potential reduction in footprint area. Note however that this approach requires adequate fall from the bioretention inlet to the capture basin outlet and may not be suitable in flat areas.

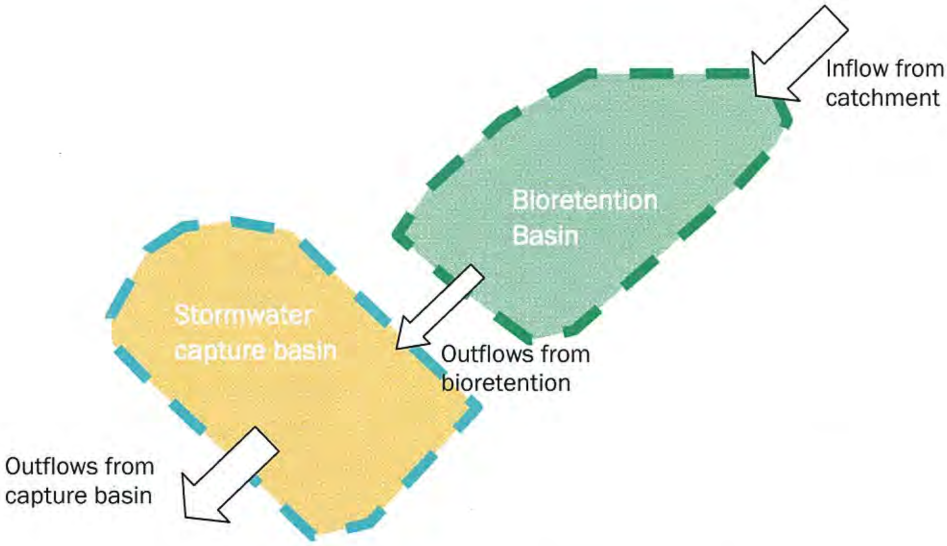

Figure 9.2 Indicative Arrangement of Stormwater Capture Basin

9.2.4 <u>Stormwater Detention Basins</u>

Stormwater detention basins are storage areas with a restricted outlet capacity designed to reduce peak flow rates during large storm events. The proposed development north of Fitzgibbon Drain will drain to two large regional detention basins (see Figure 7.1) that will ensure that peak stormwater discharges to Carseldine Drain are not increased.

9.2.5 <u>Flow Dissipation at Stormwater Outlets</u>

Appropriate energy dissipation measures should be implemented to minimise the potential for erosion at outlets from the stormwater pipe system. Particular attention is required for stormwater outlets that are concentrating stormwater discharges onto flat land (such as proposed discharges on the northern side of Roghan Road), rather than discharging to an existing channel. Appropriate treatment for these outlets would include a shallow rock-lined outlet channel, as illustrated conceptually in Figure 9.3, which would provide protection from erosion at the pipe outlet and extend far enough downstream to allow stormwater to spread over the land surface. Figure 9.3 also illustrates an alternative approach using a shorter rock apron with concrete blocks used for energy dissipation. Suitable landscape planting adjacent to the outlet works should be used to minimise visual impacts.

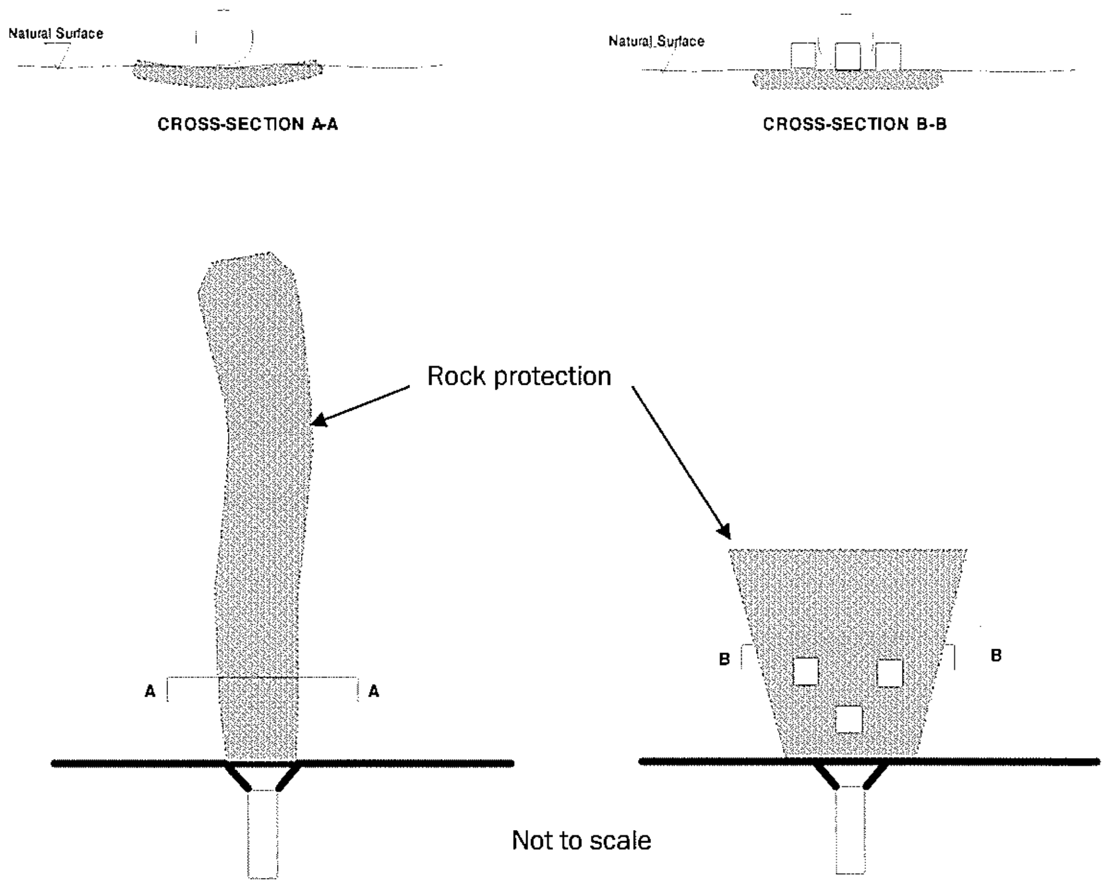

Figure 9.3 Conceptual Illustration of Erosion Protection Options for Stormwater Pipe Outlets to Flat Land

9.2.6 Swales

Swales are shallow grass-lined channels designed to remove some particulate pollutants and promote stormwater infiltration and can be useful as a pre-treatment measure for bioretention. Swales are typically incorporated in roadside drainage, replacing kerb and channel (see Figure 9.4). Since swales require additional width to be allocated to the road reserve, areas where the use of swales may be appropriate need to identified early in the planning process so that adequate space can be allocated. Swales are best suited to locations with longitudinal gradients of 2 to 5% and where the number of driveway crossovers can be minimised.

Figure 9.4 Example Applications of Swales (source: www.wsud.org)

9.2.7 Rainwater Tanks

Individual rainwater tanks are an effective method of meeting requirements for non-potable water source substitution. However, potential may also exist within the Fitzgibbon UDA for the implementation of a regional stormwater harvesting approach. Figure 9.5 illustrates a conceptual approach that could be suitable for the UDA site. Stormwater is directed to bioretention systems for treatment and then pumped to a stormwater purification facility for further treatment prior to storage in above-ground tanks. The purified stormwater is then reticulated through the development in a "third-pipe" system for non-potable use. Further investigation is required to confirm whether stormwater harvesting is a viable option for the UDA.

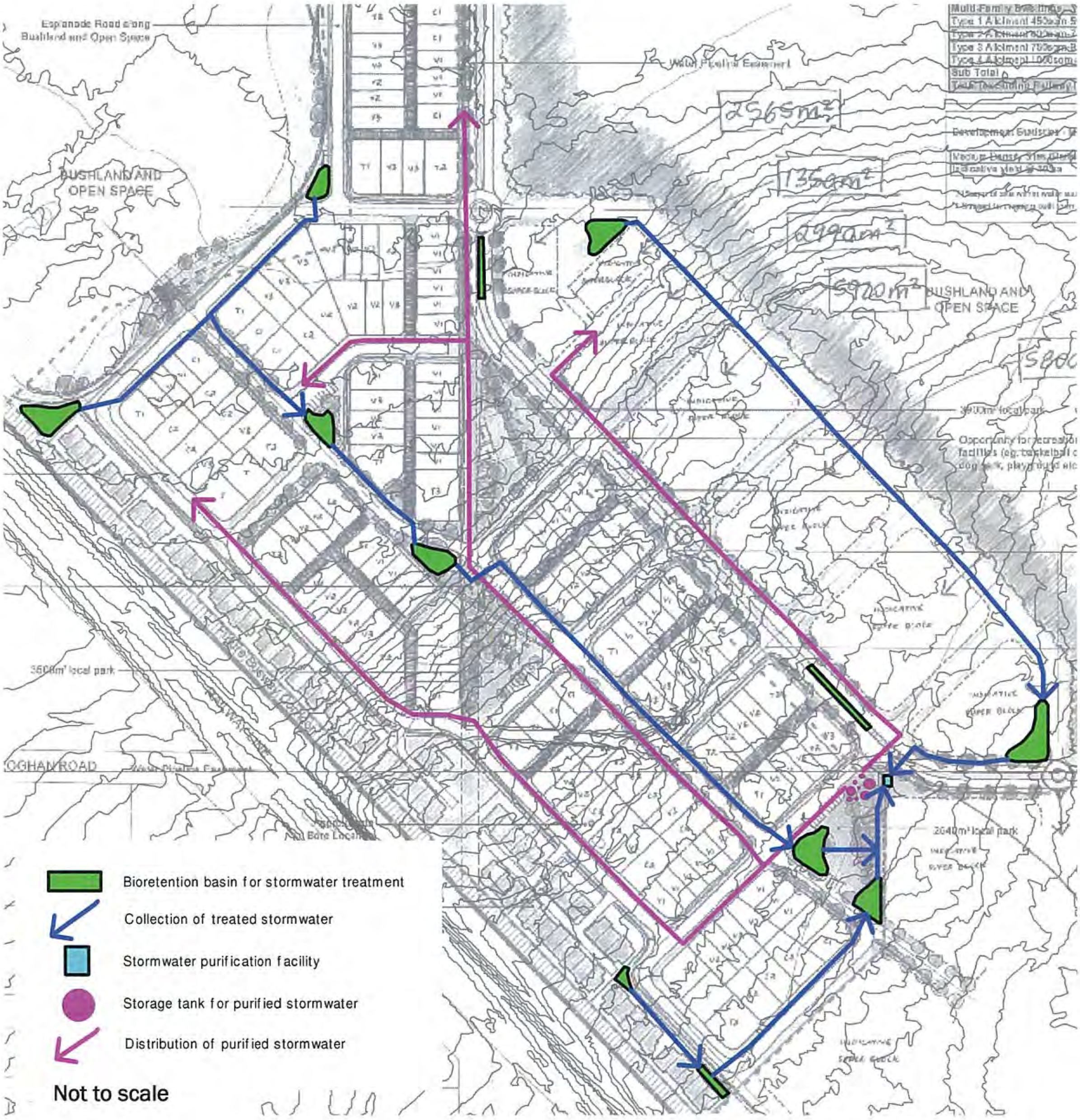

Figure 9.5 Indicative Stormwater Harvesting Concept

10 INFRASTRUCTURE COSTING

Table C1 in Appendix C provides indicative cost estimates of civil construction costs for the flood management infrastructure investigated for the Fitzgibbon UDA. The following points should be noted:

- All costs shown in Table C1 are exclusive of GST.
- The costs shown in Table C1 have been developed to assist in broad-scale planning and should be regarded as indicative only. They should not be regarded as actual construction costs.
- All costings are based on conceptual design only. All infrastructure components will be subject to detailed design that could result in substantial design changes which could, in turn, substantially change estimated costs.
- No allowance has been made for the potential offset of cut and fill costs by balancing earthworks quantities across the site. This could substantially reduce the costs associated with some infrastructure components.
- Additional costs for civil/structural design would be in the range of 7% to 9% (depending upon the complexity) of the construction cost and additional to it.
- No allowance has been made for costs of other services such as project management or environmental investigations.
- For budget purposes it is recommended that a contingency sum of up to 30% over the estimated costs be allowed for.

Table 10.1 provides indicative total construction costs for the 9 flood mitigation options considered in Section 7. Costs are provided with and without the cost of road culverts, which could be considered as general civil infrastructure for the site. The costs of any culverts associated with the Application 1 development are not included. Note also that bioretention costs are included for all options.

Table 10.1 Indicative Construction Cost Estimates for Preferred Flood Mitigation Option

Flood Mitigation Component	Indicative Construction Cost (M$) [a] Including Road Culverts	Excluding Road Culverts
Precinct 4		
Cu_3	0.59	0
Cu_4	0.69	0
Ch_6	0.21	0.21
Db_1	0.83	0.83
Db_2	0.11	0.11
Le_3	0.14	0.14
Le_4	0.03	0.03
Bioretention (40 ha)	0.80	0.80
Total Precinct 4	3.40	2.12
Precincts 1,2 & 3		
Cu_1	0.02	0
Le_1	0.22	0.22
Ex_2	0.29	0.29
Ch_4	1.18	1.18
Bioretention (20 ha)	0.40	0.40
Total Precincts 1,2 & 3	2.11	2.09

[a] Refer to notes above for basis of cost estimates

11 CONCLUSIONS

The Urban Land Development Authority (ULDA) is currently preparing a Development Scheme for the Fitzgibbon Urban Development Area (UDA) which covers an area of 295 ha. Most of the UDA lies to the south of Telegraph Road and to the east of the North Coast Railway. The UDA includes the existing Queensland University of Technology (QUT) campus at Carseldine, Carseldine Railway Station and a 114 ha parcel of vacant land owned by the Department of Housing (DoH), as well as a number of other land parcels in private and government ownership.

A flood modelling study of Cabbage Tree Creek and adjoining tributaries downstream of Dorville Road was undertaken to assess the flood impacts of the initial stages of development (Application 1) and the final development plan for the Fitzgibbon UDA. A TUFLOW 2D hydraulic model was used to simulate flood behaviour for existing and developed site conditions.

Existing development within the UDA is likely to be substantially affected by flooding as ongoing development occurs in the Cabbage Tree Creek catchment upstream of the UDA. The proposed development of the UDA, and construction of associated flood management infrastructure, provides an opportunity to reduce flood problems of existing development, as well as mitigating any impacts of the UDA development.

The proposed development plan for the UDA will have significant impacts on flow behaviour along Cabbage Tree Creek and its tributaries. A suite of flood mitigation works will be required to ensure no adverse flood impacts on adjoining properties and to increase the developable area of the site. Nine combinations of these management measures were modelled in TUFLOW to assess their likely impacts. Several components of the proposed flood management infrastructure are located outside of the Fitzgibbon UDA.

Application 1 development proposes a number of flood management infrastructure including:

- The Rogan Road detention basin will be constructed in the DoH land to the north of Application 1. The proposed detention basin ensures that post development 100 year ARI discharges to the north of the Application 1 development are equal to or less than pre-development conditions;
- A flood protection levee along the DoH land boundaries adjoining Roghan Road and the Roghan Road Landfill. This levee will form the northern, north-eastern, and part of the southern walls of the Roghan Road Landfill detention basin;
- A 50 m wide overflow channel will be constructed through the development area joining the Fitzgibbon Drain with the proposed Roghan Road Landfill detention basin;
- The western branch of the Fitzgibbon Drain will be modified between the North Coast Railway and its confluence with the southern branch of the Fitzgibbon Drain;
- Culverts will be installed along the proposed Carselgrove Avenue where the road crosses the southern and western branches of the Fitzgibbon Drain; and
- A series of box culverts across Roghan Road along the southern boundary of the Roghan Road Landfill detention basin.

Based on the results of the flood modelling undertaken for the site, the following flood mitigation infrastructure (Option 9) in addition to the Application 1 works successfully mitigates most development impacts:

- Within the Fitzgibbon UDA:
  - A culvert across the collector road that extends around the southern side of the QUT Carseldine development area to join with Dorville Road;
  - A flood protection levee along the upstream boundary of the railway easement between the proposed QUT Carseldine development and the North Coast Railway crossing of Cabbage Tree Creek;
  - Extension of the Carselgrove Avenue culverts along the southern Fitzgibbon Drain branch;
  - A series of box culverts across Roghan Road at the Carseldine Drain crossing;
  - A new channel immediately downstream of the Railway Crossing of Carseldine Drain; and
  - A flood protection levee along the northern and north-western boundaries of the DoH land between the proposed development extent and the DoH boundary. This flood protection levee forms the wall for the Carseldine Drain detention basin.
- Outside the Fitzgibbon UDA:
  - A 17 m wide channel along Cabbage Tree Creek from North Coast Railway to the Fitzgibbon Drain;
  - Excavation along Cabbage Tree Creek upstream of the railway near Pineapple Street; and
  - A flood protection levee south of Telegraph Road between the proposed Carseldine Drain detention basin and the Bill Brown Sports Field.

Detailed design of this infrastructure will require further detailed studies, including assessment of potentially substantial environmental impacts.

The Department of Transport and Main Roads have proposed a bus way linking Telegraph Road with Dorville and Beams Roads. The final Fitzgibbon UDA scenario TUFLOW model was used to assess the impacts of the bus way on Cabbage Tree Creek flood levels. The bus way embankment will increase adjacent flood levels in Cabbage Tree Creek by about 0.06 m.

12 REFERENCES

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APPENDIX A

TUFLOW ROUGHNESS MAP

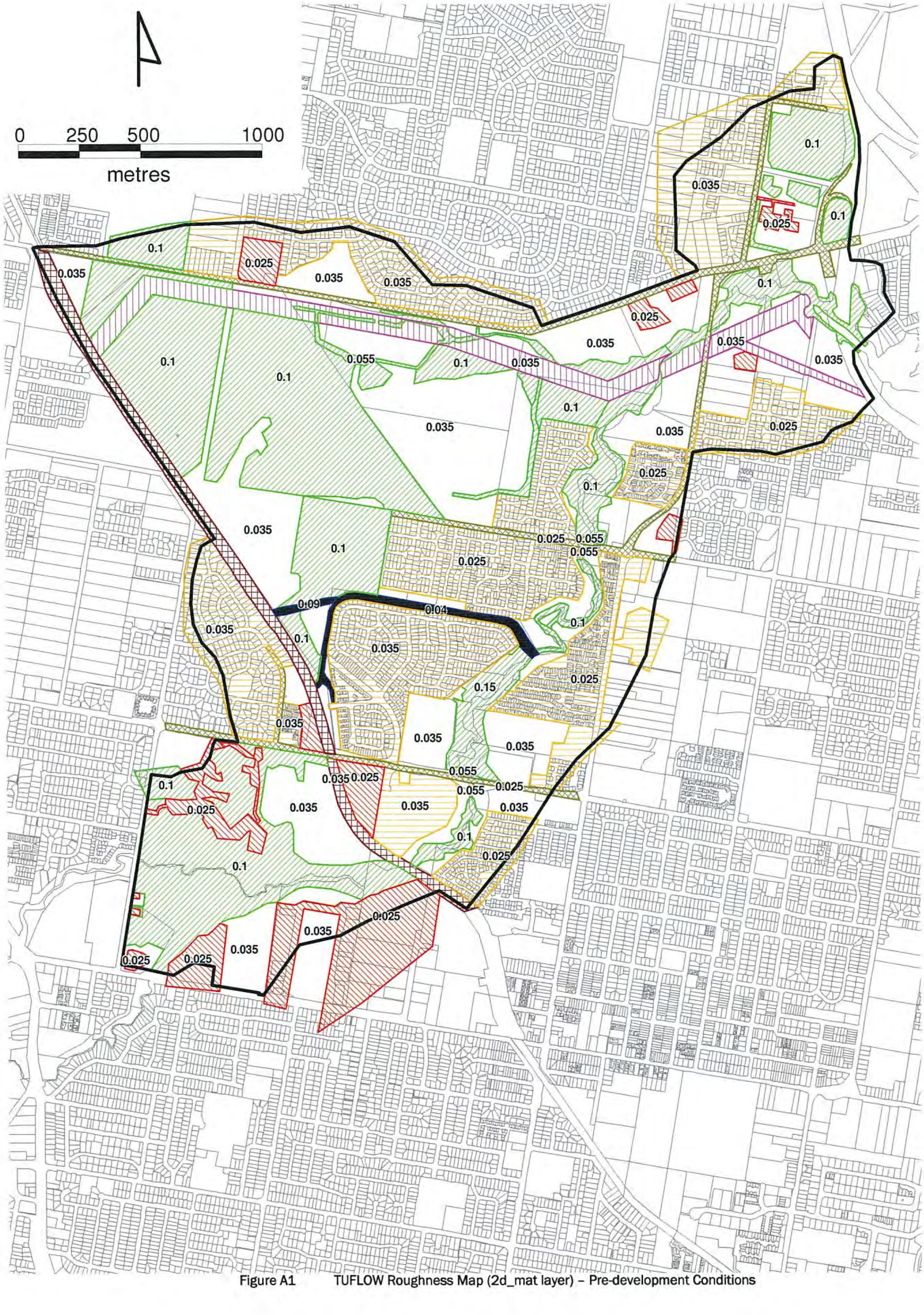

Figure A1 TUFLOW Roughness Map (2d_mat layer) – Pre-development Conditions

APPENDIX B

TUFLOW 1D NETWORK

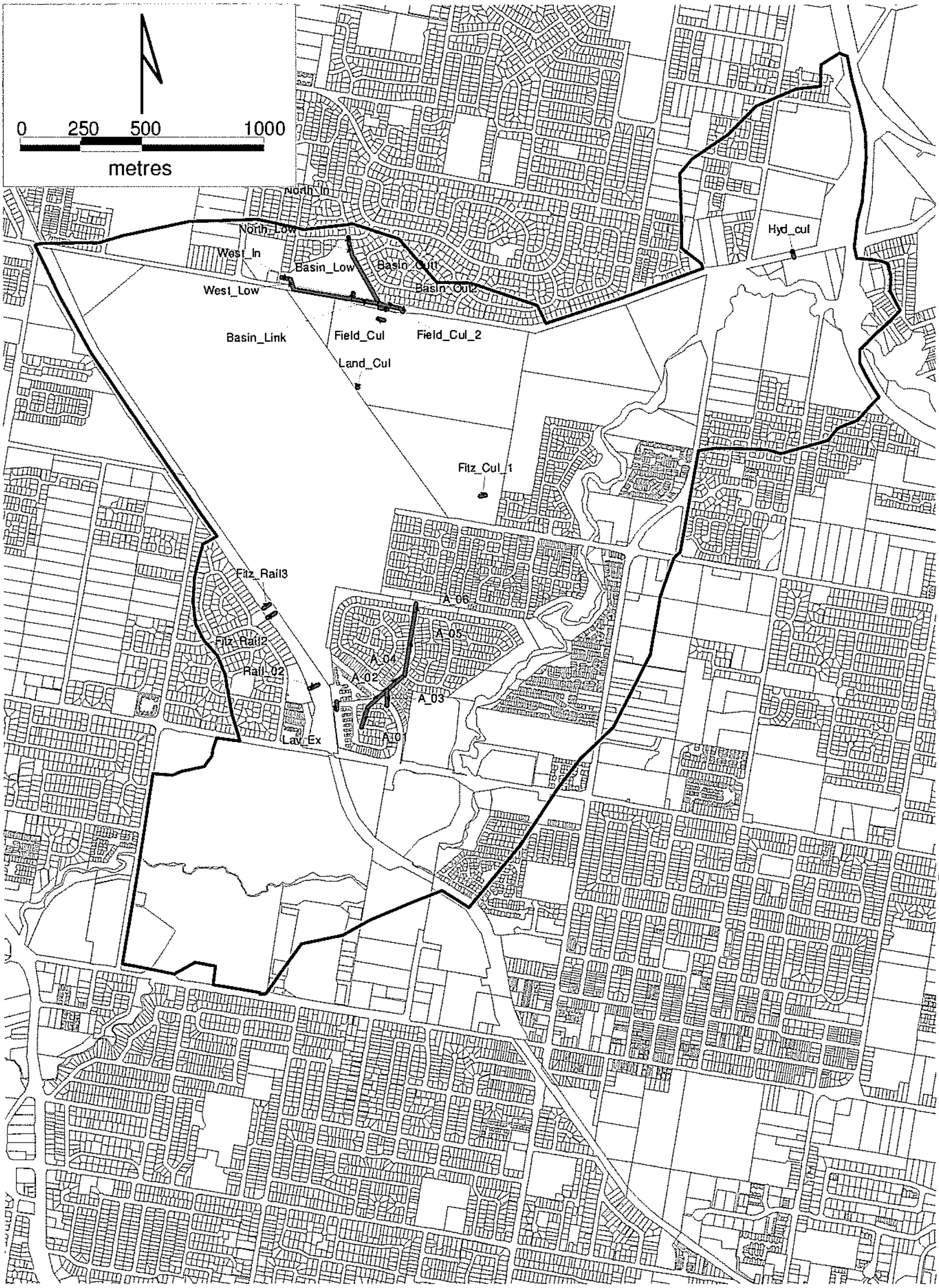

Figure B1 TUFLOW 1D Culvert Locations – Pre-development Conditions

Table B1 Details of 1D Hydraulic Structures in the TUFLOW model

ID	Channel Type	Ignore	Channel Storage at Nodes	Length or ANA	Manning's n	U/S Invert	D/S Invert	Form or Bend Loss	Blockage	Branch	Topo_ID	Xsect ID or Chainage	Diameter or Width	Weir Factor or Height	No of Culverts	Culv H Contraction Coeff	Culv W Contraction Coeff	Culvert Entry Loss	Culvert Exit Loss
A_01	C	F	T	90	0.015	10	9.7	0	0			0	1.05	0	1	0.6	0.9	0.5	1
A_01_Pit	R	F	T	0	0	-99999	-99999	0	0		SXZ	0	5	0.5	1	0.62	0.62	0.2	0.2
A_02	C	F	T	105	0.015	9.7	9.4	0	0			0	1.3	0	1	0.6	0.9	0.5	1
A_02_Pit	R	F	T	0	0	-99999	-99999	0	0		SXZ	0	5	0.5	1	0.62	0.62	0.2	0.2
A_03	C	F	T	60	0.015	9.6	9.4	0	0			0	0.9	0	1	0.6	0.9	0.5	1
A_03_Pit	R	F	T	0	0	-99999	-99999	0	0		SXZ	0	5	0.5	1	0.62	0.62	0.2	0.2
A_04	C	F	T	100	0.015	9.4	9.1	0	0			0	1.35	0	1	0.6	0.9	0.5	1
A_04_Pit	R	F	T	0	0	-99999	-99999	0	0		SXZ	0	5	0.5	1	0.62	0.62	0.2	0.2
A_05	C	F	T	250	0.015	9.1	8	0	0			0	1.65	0	1	0.6	0.9	0.5	1
A_05_Pit	R	F	T	0	0	-99999	-99999	0	0		SXZ	0	5	0.5	1	0.62	0.62	0.2	0.2
A_06	C	F	T	20	0.015	7.7	7.5	0	0			0	1.95	0	1	0.6	0.9	0.5	1
A_06_Pit	R	F	T	0	0	-99999	-99999	0	0		SXZ	0	5	0.5	1	0.62	0.62	0.2	0.2
Basin_Link	C	F	T	70	0.015	5.4	4.9	0	0			0	1.8	0	1	0.6	0.9	0.5	1
Basin_Low	C	F	T	47	0.015	5.19	5.096	0	0			0	1.05	0	1	0.6	0.9	0.5	1
Basin_Out1	R	F	T	100	0.015	4.88	4.68	0	0			0	3.3	1.5	1	0.6	0.9	0.5	1
Basin_Out2	R	F	T	30	0.015	4.66	4.6	0	0			0	3.6	1.2	1	0.6	0.9	0.5	1
Basin_Pit	R	F	F	0	0	-99999	5.15	0	0		SXZ	1	3	3	1	0.62	0.62	0.5	0.5
Field_Cul	C	F	T	25	0.015	7.7	6.9	0	0			0	0.9	0	1	0.6	0.9	0.5	1
Field_Cul_2	C	F	T	25	0.015	7.6	7.2	0	0			0	0.9	0	1	0.6	0.9	0.5	1
Fitz_Cul_1	C	F	T	15	0.015	8.8	8.5	0	0.4			0	0.6	0	2	0.6	0.9	0.5	1
Fitz_Rail2	C	F	T	30	0.015	9.61	9.52	0	0			0	1.5	0	3	0.6	0.9	0.5	1
Fitz_Rail3	C	F	T	23	0.015	11.63	11.22	0	0			0	0.6	0	6	0.6	0.9	0.5	1
Hyd_cul	R	F	T	17	0.015	3.29	3.11	0	0			0	2.4	1.5	1	0.6	0.9	0.5	1
Land_Cul	C	F	T	7	0.015	8.17	8	0	0			0	0.6	0	1	0.6	0.9	0.5	1
Lav_Ex	C	F	T	25	0.015	10.65	10.51	0	0			0	0.75	0	2	0.6	0.9	0.5	1
North_In	R	F	T	10	0.015	5.55	5.51	0	0			0	3.6	1.8	3	0.6	0.9	0.5	1
North_Low	R	F	T	282	0.015	5.504	4.9	0	0			0	2.4	1.8	1	0.6	0.9	0.5	1
North_Pit	R	F	F	0	0	8.5	5.45	0	0		SX	1	2	0.45	7	0.62	0.62	0.5	0.5
Rail_01	C	T	T	30	0.015	12.5	12.4	0	0			0	0.45	0	6	0.6	0.9	0.5	1
Rail_02	C	F	T	30	0.015	10.5	9.9	0	0			0	1.4	0	3	0.6	0.9	0.5	1
West_In	C	F	T	10	0.015	5.9	5.86	0	0			0	3.6	1.8	3	0.6	0.9	0.5	1
West_Low	C	F	T	360	0.015	5.84	5.06	0	0			0	1.65	0	1	0.6	0.9	0.5	1
West_Pit	R	F	F	0	0	-99999	5.8	0	0		SX	1	2	0.45	8	0.62	0.62	0.5	0.5
A_01	C	F	T	90	0.015	10	9.7	0	0			0	1.05	0	1	0.6	0.9	0.5	1
A_01_Pit	R	F	T	0	0	-99999	-99999	0	0		SXZ	0	5	0.5	1	0.62	0.62	0.2	0.2
A_02	C	F	T	105	0.015	9.7	9.4	0	0			0	1.3	0	1	0.6	0.9	0.5	1

APPENDIX C

INFRASTRUCTURE COSTING

Table C1 Indicative Construction Cost Estimates for Flood Mitigation Infrastructure

ID	Description	UNIT	RATE ($)	QTY	ITEM COST ($)	TOTAL
Ch_1	17 m wide channel upstream of the railway (L~ 450 m)					$ 460,000
	Earthworks - Cut to spoil	m^3	17	11500	195,500	
	Trim and profiling to banks	m^2	5	7650	38,250	
	Bank treatment / revegetation	m^2	30	7650	229,500	
Ch_2	10 m wide channel upstream of the railway (L~ 450 m)					$ 270,000
	Earthworks - Cut to spoil	m^3	17	6500	110,500	
	Trim and profiling to banks	m^2	5	4500	22,500	
	Bank treatment / revegetation	m^2	30	4500	135,000	
Ch_3	17 m wide channel from the railway to 300 m downstream of the Fitzgibbon Drain (L~1450 m)					$ 1,490,000
	Earthworks - Cut to spoil	m^3	17	37000	629,000	
	Trim and profiling to banks	m^2	5	24650	123,250	
	Bank treatment / revegetation	m^2	30	24650	739,500	
Ch_4	17 m wide channel from railway to the Fitzgibbon Drain (L~ 1150 m)					$ 1,180,000
	Earthworks - Cut to spoil	m^3	17	29000	493,000	
	Trim and profiling to banks	m^2	5	19550	97,750	
	Bank treatment / revegetation	m^2	30	19550	586,500	
Ch_5	10 m wide channel from railway to the Fitzgibbon Drain (L~ 1150 m)					$ 700,000
	Earthworks - Cut to spoil	m^3	17	17250	293,250	
	Trim and profiling to banks	m^2	5	11500	57,500	
	Bank treatment / revegetation	m^2	30	11500	345,000	
Ch_6	Carseldine Drain channel excavation					$ 210,000
	Earthworks - Cut to spoil	m^3	17	3000	51,000	
	Trim and profiling to banks	m^2	5	2000	10,000	
	Revegetation	m^2	15	10000	150,000	
Cu_1	Culvert under new road on QUT site from Dorville Rd					$ 18,000
	Concrete base	m^3	775	3	2,325	
	600mm dia. concrete pipe Class 2	m	280	30	8,400	
	End Structures(Head wall, Wing wall etc.)	No.	5500	1	5,500	
	Aprons	m^3	1100	1.5	1,650	
Cu_2	Extra culverts jacked through the railway embankment					$ 980,000
	Tunnel boring by jacking pipe	m	5000	160	800,000	
	1800mm dia. Class 4 pipe	m	800	160	128,000	
	End structures (Headwall, Wing wall etc.)	m^3	1100	40	44,000	
	Aprons	m^3	1100	8	8,800	

ID	Description	UNIT	RATE ($)	QTY	ITEM COST ($)	TOTAL
Cu_3	Trunk stormwater pipes along southern branch of Fitzgibbon Drain					$ 590,000
	1500mm dia. concrete pipe Class 2, 5 x 150 m	m	650	750	487,500	
	1500mm dia. concrete pipe Class 2, 1 x 150 m	m	650	150	97,500	
Cu_4	New culverts under Roghan Rd at Carseldine Drain					$ 690,000
	8 x 1800mm x 900mm box culvert + 7 x link slab	m	1000	450	450,000	
	End Structures(Head wall, Wing wall etc.)	m^3	1100	25	27,500	
	Base slab	m^3	775	270	209,250	
Cu_5	New culvert under Roghan Rd near Telegraph Rd					$ 37,000
	Concrete base	m^3	775	6	4,650	
	600mm dia. concrete pipe Class 2	m	280	90	25,200	
	End Structures(Head wall, Wing wall etc.)	No.	5500	1	5,500	
	Aprons	m^3	1100	1.5	1,650	
Db_1	Roghan Road detention basin					$ 830,000
	Strip, stockpile and respread topsoil (100mm thick)	m^3	15	13600	204,000	
	Earthworks - Imported fill	m^3	35	14400	504,000	
	Trim and Profiling	m^2	3	13600	40,800	
	Turfing	m^2	5	13600	68,000	
	Concrete base	m^3	775	2	1,550	
	900mm dia. concrete pipe Class 2	m	350	12	4,200	
	End Structures(Head wall, Wing wall etc.)	No.	2500	2	5,000	
	Aprons	m^3	1100	2	2,200	
Db_2	Carseldine Drain detention basin outlet					$ 107,000
	Strip, stockpile and respread topsoil (100mm thick)	m^3	15	170	2,550	
	Earthworks - Imported fill	m^3	35	2200	77,000	
	Trim and Profiling	m^2	3	1680	5,040	
	Turfing	m^2	5	1680	8,400	
	Concrete base	m^3	775	5	3,875	
	1500mm dia. concrete pipe Class 2	m	660	6	3,960	
	End Structures(Head wall, Wing wall etc.)	No.	2500	1	2,500	
	Aprons	m^3	1100	3	3,300	
Ex_1	Excavation to increase waterway area under the railway bridge					$ 23,000
	Earthworks - Cut to spoil	m^3	17	300	5,100	
	Trim and profiling to banks	m^2	5	500	2,500	
	Bank treatment / revegetation	m^2	30	500	15,000	
Ex_2	Excavation upstream of the railway near Pineapple Street					$ 290,000
	Earthworks - Cut to spoil	m^3	17	10000	170,000	
	Trim and profiling to banks	m^2	5	3400	17,000	
	Bank treatment / revegetation	m^2	30	3400	102,000	

ID	Description	UNIT	RATE ($)	QTY	ITEM COST ($)	TOTAL
Ex_3	Excavation of the QUT sports field					$ 1,350,000
	Strip, stockpile and respread topsoil (100mm thick)	m^3	15	5100	76,500	
	Earthworks - Cut to spoil	m^3	17	60000	1,020,000	
	Turfing	m^2	5	51000	255,000	
Le_1	Flood Protection Levee along the upstream boundary of the railway easement (L~425 m)					$ 220,000
	Strip, stockpile and respread topsoil (100mm thick)	m^3	15	900	13,500	
	Earthworks - Cut to fill	m^3	15	9000	135,000	
	Trim and Profiling	m^2	3	9300	27,900	
	Turfing	m^2	5	9300	46,500	
Le_2	Roghan Road detention basin wall - see Db_1					
Le_3	Carseldine Drain detention basin wall					$ 137,000
	Strip, stockpile and respread topsoil (100mm thick)	m^3	15	377	5,655	
	Earthworks - Imported fill	m^3	35	2900	101,500	
	Trim and Profiling	m^2	3	3770	11,310	
	Turfing	m^2	5	3770	18,850	
Le_4	Flood protection levee between Db_2 & Bill Brown Sports Fields					$ 33,000
	Strip, stockpile and respread topsoil (100mm thick)	m^3	15	91	1,365	
	Earthworks - Imported fill	m^3	35	700	24,500	
	Trim and Profiling	m^2	3	900	2,700	
	Turfing	m^2	5	900	4,500	
	Bioretention					$ 1,200,000
	60ha @ 50 m^2 per ha	m^2	$400	3000	1,200,000	