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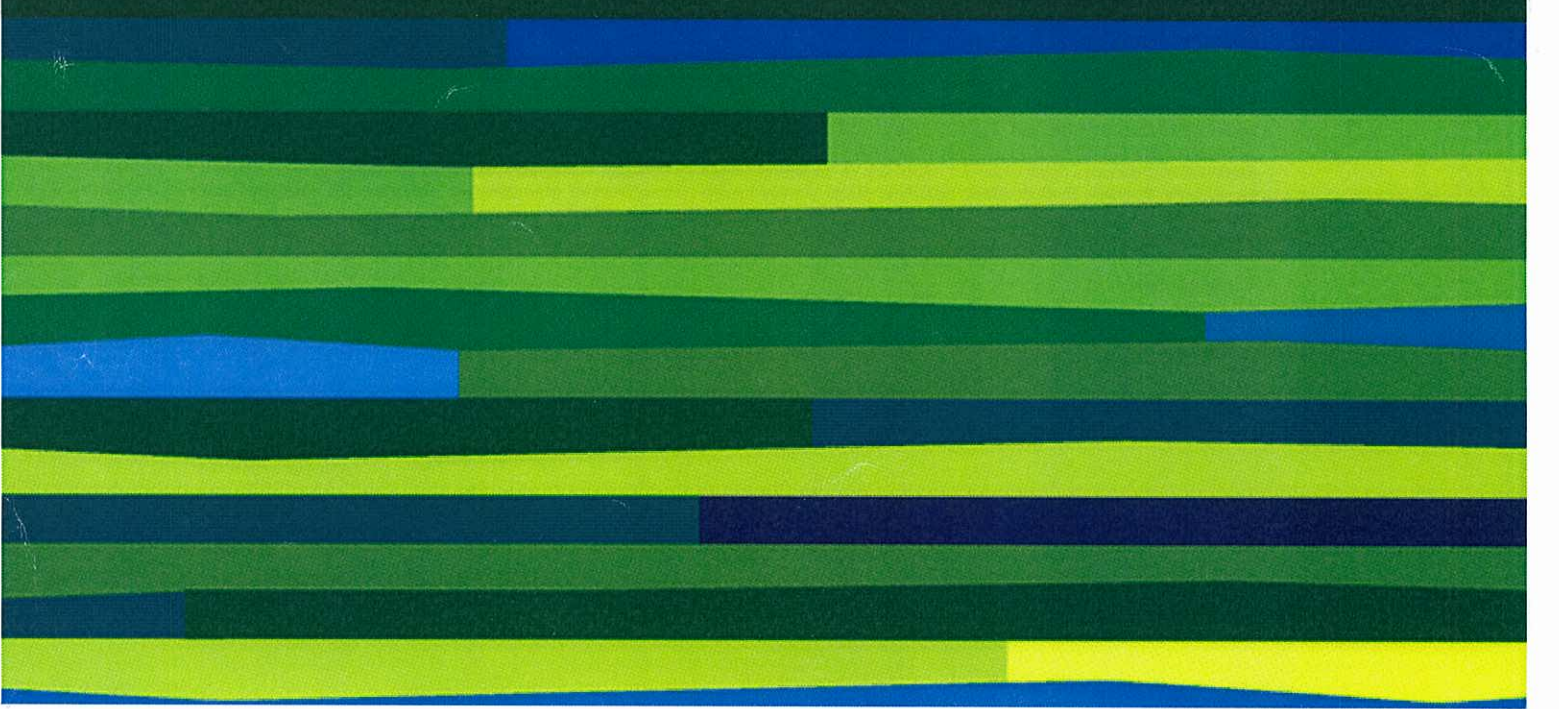
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Yarrabilba Precinct 1

Stormwater Management Plan

Yarrabilba Precinct 1
Stormwater Management Plan
Approved by the Council of the
Shire of Yarrabilba

DesignFlow
Prepared for Delfin Lend Lease
February 2011



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Document Control Sheet

Report Title:	Yarrabilba Precinct 1 Stormwater Management Plan
Suggested Reference:	DesignFlow, 2011. "Yarrabilba Precinct 1 Stormwater Management Plan"
Version:	Version 1 (Draft)
Client:	Delfin Lend Lease
Author(s):	Ralph Williams, Shaun Leinster
Reviewed By:	Shaun Leinster
Approved By:	Shaun Leinster
Signed:	
Date:	25/02/2011
File Location:	S:/Projects/4147
Circulation:	Electronic Copies:
	Printed Copies:

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Inherent natural variability in soils and plants

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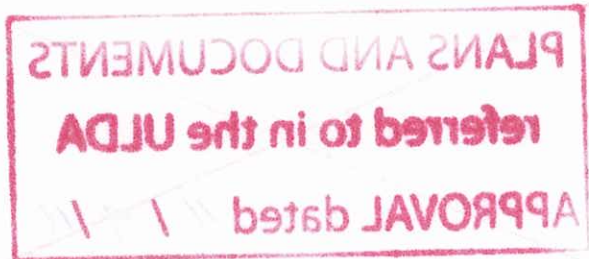
Acknowledgements:

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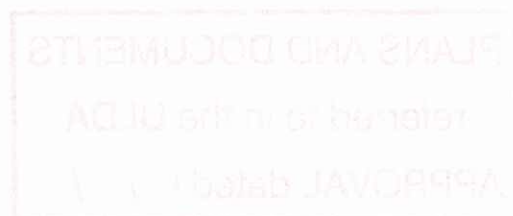


Appendix A: Photo Log

Appendix B: MUSIC Modelling

Appendix C: Detailed Bioretention Concepts – Northern Waterway

Appendix D: Flood Study – Stormwater Quantity Management Plan



The Yarrabilba Urban Development Area (UDA) is located within the Logan City Council area and occupies a former pine plantation. The Yarrabilba UDA has been declared by regulation under Part 2 Division 1 Section 7 of the Urban Land Development Act. Yarrabilba is part of a regional growth area identified in the South East Queensland Regional Plan 2009-2031, which identifies a need for a further 70,000 dwellings in the Logan council area by 2031. The Yarrabilba development aims to provide 20,000 dwellings for a population of approximately 50,000.

The land, under management of Delfin Lend Lease (Delfin), is located east of Waterford-Tamborine Road, south of Logan Village. The intention of the development is to create a community development complimentary to its natural environment that achieves a diverse and healthy community drawing upon innovative design initiatives. The development will be guided by principles of Water Sensitive Urban Design (WSUD). It is envisaged that WSUD will be used extensively to create a development zone that promotes sustainable and integrated management of land and water resources, and incorporates best practice stormwater management, water conservation/reuse and environmental protection.

To meet these principles Delfin commissioned DesignFlow to develop a WSUD strategy with the objective of ensuring that all forms of development incorporate WSUD to minimise any impact on aquatic ecosystems, enhance the natural and created landscape and maximize water re-use opportunities. This report presents the Stormwater Management Strategy for Precinct 1 (first 500 lots) of the development (refer Figure 1). The document focuses primarily on stormwater quality treatment, waterway stability, stormwater re-use and frequent flow management. Stormwater quantity and flood management is presented in a separate report *Yarrabilba Northern Development Area – Precinct 1 and Whole of Catchment* (Water Technology, 2011) and is included as an appendix to this report. Key findings of the flood report are summarised in the main body of this report.

The stormwater management strategy has been established on the basis of delivering sound urban design and landscape outcomes through collaboration with the Delfin Lend Lease and the design team. The WSUD principles adopted support the requirements outlined in the Yarrabilba Urban Development Area Interim Land Use Plan and are consistent with the SEQ Regional Plan Implementation Guideline No 7 and Logan City Council Draft Interim Standards for Stormwater, Overland Flow and Flood Plain Management.



Figure 1: Overall Yarrabilba development site and Precinct 1 (Proposed Site)

1.1 OTHER RELEVANT DOCUMENTS

This Stormwater Management Plan should be read with the following documents:

- Precinct A Water Sensitive Urban Design Preliminary Advice (DesignFlow, January 2011)
- Yarrabilba Northern Development Area Stormwater Quantity Management Plan (Water Technology, February 2011) provided as an appendix to this report.
- Broad scale Geotechnical Investigation Report for the Yarrabilba Development (Bowler Geotechnical, February 2004)

1.2 INTERIM LAND USE PLAN REQUIREMENTS

The Yarrabilba Urban Development Area Interim Land Use Plan identifies a number of key principles and requirements of development to contribute to the environment and sustainable development. The principles identified for development, applicable to stormwater management, are:

- Management of emissions of water to natural water systems
- Protection from flood risk
- Efficient use of land resources
- Protection of amenity, ecological values and natural systems

Specific requirements outlined in the Interim Land Use Plan are summarised in Table 1 with reference to where each requirement has been addressed in this report and related reports.

Table 1: Yarrabilba UDA Interim Land Use Plan development requirements – stormwater and waterway management

Requirements	Outcome	Reference
Maintain and enhance the functioning and characteristics of the hydrological network including the riparian ecology	Specific stormwater and flood management objectives have been established in relation to stormwater quality, stream stability and ecological disturbance from frequent flows. These objectives are consistent with the SEQ Regional Plan Implementation Guideline No.7 and the recently released State Planning Policy for Healthy Waters.	• Section 3 and 4 (this report)
Maintain and enhance the environmental values of the receiving waters and wetlands by sound catchment management practices	The stormwater and flood strategy has been design to achieve these objectives.	
	Riparian corridors have been maintained along internal drainage	• Section 3.3 (this report)

Requirements	Outcome	Reference
	lines within Precinct 1.	
	Waterway stabilisation and rehabilitation is proposed for the site	• Ongoing Investigation
Incorporate total water cycle management and water sensitive urban design (WSUD) principles	WSUD objectives have been established for the site based on SEQ Regional Plan Implementation Guideline No.7 and the recently released State Planning Policy for Healthy Waters. The stormwater and flood strategy has been specifically design to achieve these objectives.	• Sections 3 and 4 (this report)
	Rainwater tanks on each residential lot for local reuse, 3 rd pipe supply from regional storwater harvesting	• Sections 4.1.2 and 5.5 (this report)
	All stormwater treated to best practice targets through bioretention and wetland systems prior to discharge	• Sections 3.2 and 4.0 (this report)
Appropriately manage floodwater and stormwater	Flood detention basins incorporated into Precinct 1 design to maintain pre-developed flood frequencies	• Sections 3.5 and 4.5 (this report) • Appendix D Flood Management Plan – Yarrabilba Precinct 1
Maintain and enhance significant vegetation and provides appropriate landscaping	Riparian corridors have been incorporated into the development layout	• Sections 4.1.1 and 4.1.2 (this report)
	Stormwater treatment measures incorporated into the development edge without compromising riparian corridor or urban footprint	• Sections 4.3 (this report) and Appendix C
	Dual use of water quality and flood management areas, where applicable	• Sections 4.3 and 4.4 (this report) and Appendix C
Retain vegetation where possible along streets and within park networks	• Urban design and stormwater treatment measures designed around riparian corridor and existing vegetation (where feasible)	• Sections 4.1 and 4.3 (this report) and Appendix C • Tree survey was completed as part of this design and significant trees retained in the concept designs.
	• Stormwater treatment measures integrated into public open spaces with appropriate landscaping	• Sections 4.1 and 4.3 (this report) and Appendix C



2 SITE DESCRIPTION

2.1 THE SITE

The Yarrabilba Urban Development Area is currently zoned for residential and commercial development and covers an area of just over 2,000 hectares. The site is bounded by the Waterford-Tamborine Road to the west, Plunkett Road to the South, existing rural residential areas to the north and Plunkett Conservation Park to the east.

The focus of this study is Precinct 1 which covers an area of approximately 83ha (including waterways) and is located in the northern part of the Yarrabilba UDA. The Precinct 1 area is located within a broad catchment (225ha) which drains to the northern boundary of the Yarrabilba site. In order to properly consider the stormwater outcomes for Precinct 1, a conceptual stormwater strategy was developed for the whole northern catchment zone (called Northern Structure Plan) with specific details resolved for the Precinct 1 site. Figure 2 presents the extent of the Precinct 1 site within the context of the whole northern catchment.

To assist in clarifying site details for the reader a photo log across the site and downstream is provided in Appendix A.



Figure 2: Precinct 1 in the context of the whole northern catchment considered as part of this SMP

2.2 CLIMATE

Annual rainfall in the Logan Village area (just north of the proposed development) is typically around 900-1,000mm per year with the highest rainfall months falling in the summer period. As shown in Figure 3 monthly evapotranspiration rates mostly exceed rainfall throughout the year inferring that natural aquatic ecosystems downstream of the site experience drying conditions periodically.

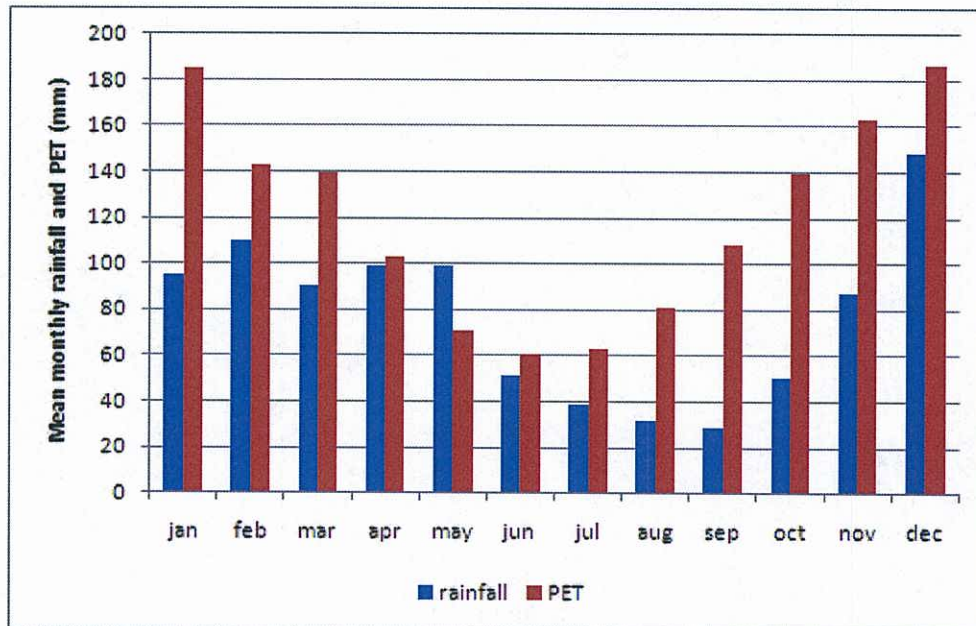


Figure 3: Mean monthly climate statistics for Yarrabilba (Logan Village Tamborine Road station 40766)

2.3 TOPOGRAPHY AND SITE DRAINAGE

As illustrated in Figure 4, the Precinct 1 site is defined by ridgelines on the east, south and western sides. These ridgelines effectively mean the Precinct 1 site and the whole northern catchment is self contained (i.e. there are no significant external catchment inflows). An internal ridge line from the south west to northern boundary separates internal drainage to two main waterways: the main waterway and the northern waterway (Figure 4).

Grade across the site is moderate (~2-6%). This supports the adoption of precinct scale stormwater management systems that accept flows from conventional stormwater drainage (pipe and pit).

Drainage is typically in an east to north direction before discharging into private land downstream of the northern site boundary. The total catchment area to the downstream boundary is approximately 225 ha, of this Precinct 1 represents approximately 83 ha.



The main waterway and northern waterway are characterised by flat, wide and undefined sandy channels (refer photo log in Appendix A). Longitudinal slopes within the waterways are in the order of 2% in the upper reaches before reducing to less than 1% at the downstream end. These waterways are typically ephemeral and do not appear to maintain water for any extended period of time. Permanently ponded water was observed at a couple locations where road crossings have crossed flow paths, preventing longitudinal drainage.

The development layout for Precinct 1 and the associated WSUD strategy aims to maintain these current catchments as far as practical and provide appropriate water quality and flood detention infrastructure at key discharge locations. The main waterway and northern waterway corridors are to be maintained as part of the development and revegetated.

2.4 DOWNSTREAM DRAINAGE

Stormwater from the catchments draining from Precinct 1 discharge to private property at the northern boundary of the Yarrabilba site (refer Figure 4 and 5). Flows travel approximately 1.5 km downstream from the Yarrabilba UDA boundary through private property to Quinzeh Creek and then ultimately the Logan River.

Immediately downstream of the Yarrabilba boundary there is no defined waterway within the private property (refer Figure 5), just a flat wide ephemeral waterway. This waterway will currently flow only during moderate rainfall events and there is a need to manage the frequency of nuisance flooding within this private property following development of Yarrabilba.

Once the waterway reaches Georgina Drive, it passes under the road via a large set of culverts to enter a small constructed channel. Although the capacity of the channel is limited (<100-200L/s), it conveys smaller flows all the way through a number of private properties to Quinzeh Creek.

As stormwater must travel through private property downstream of the of the Yarrabilba site before discharging to Quinzeh Creek, the stormwater strategy must considered a number of key management objectives:

- maintaining peak flows over the range of ARIs (1 year to 100 year)
- minimising the impacts of increased flow frequency due to the development
- managing stormwater quality to the required minimum levels
- preserving the method by which stormwater enters the downstream properties (i.e. sheet flow)

These objectives are described in more detail in this report and form a fundamental part of the WSUD for Precinct 1.

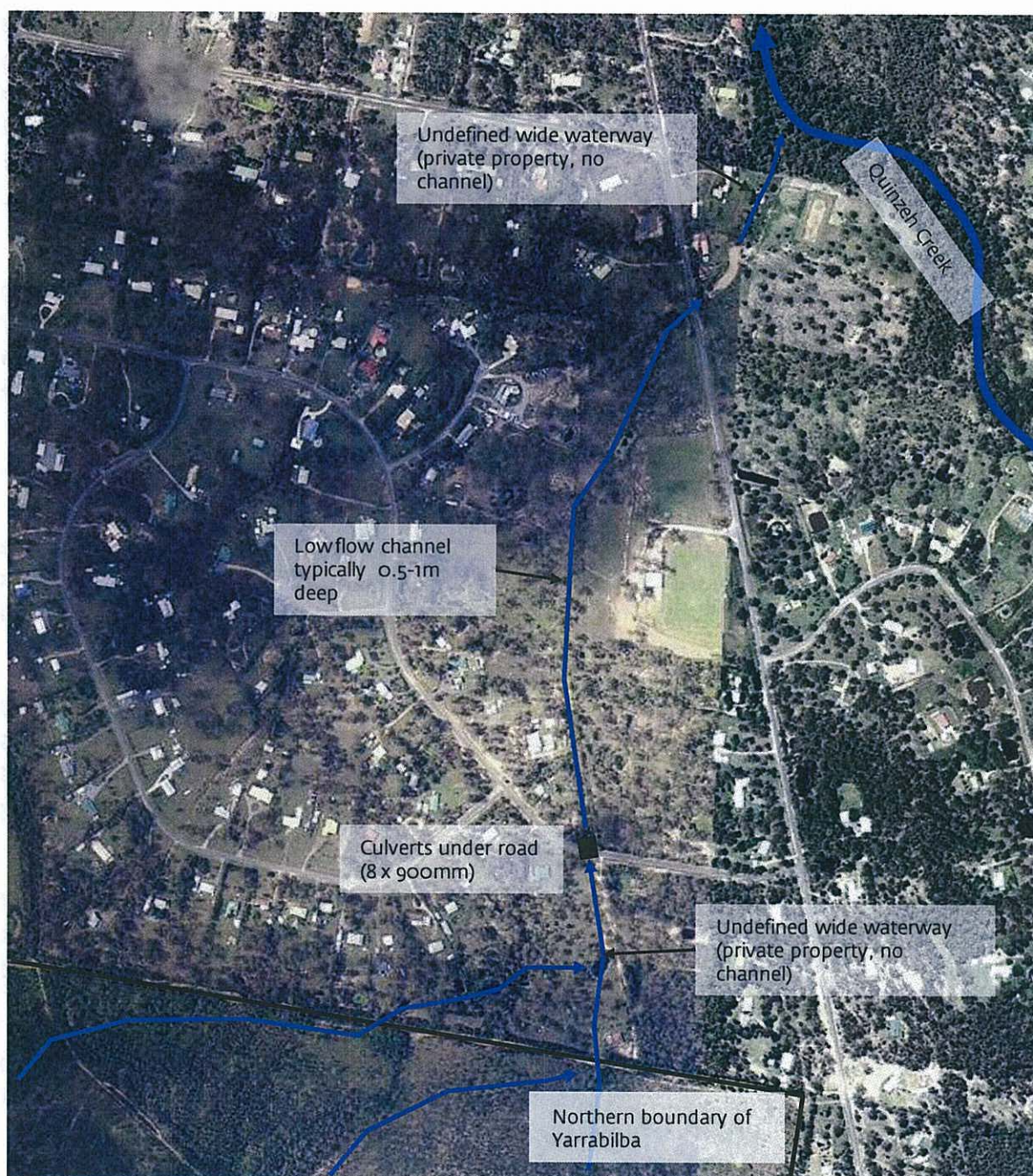


Figure 5 Drainage downstream of Northern Yarrabilba and Precinct 1

2.5 QUINZEH CREEK

Quinze Creek ultimately accepts all stormwater from the northern catchments of Yarrabilba including Precinct 1. Detailed ecological assessment of the creek has not been completed as part of this investigation, however site inspections indicate the creek exhibits a range of conditions. Some of the riparian zones to the creek are in a healthy condition whereas others are affected by weed and vegetation clearing. There is some evidence of erosion within the waterway whereas there are other sections of the creek that are stable and healthy.

In terms of protecting the creek from hydrologic and water quality change, the stormwater management objectives outlined in the SEQ Regional Plan - Implementation Guideline No. 7 have been applied to the Precinct 1. In relation to the frequent flow objective there is no evidence that this objective should be applied to the site (subject to further ecological assessment). Rather than strictly apply the frequent flow objective, which would require a comprehensive regional stormwater harvesting strategy that is subject to discussion with Allconnex, the stormwater strategy has aimed to minimise the change in frequent surface flows downstream of the site. This will be achieved through stormwater harvesting. Any excess frequent flows, not managed by the stormwater harvesting strategy, are managed through wetland and bioretention treatment to minimise the change in hydrology entering Quinze Creek

2.6 SOILS

The general geology of the site area is characterised by sandstone, siltstone, shale and conglomerate of the Woogaroo sub-group of the Bundamba group. These consist typically of weathered and cemented sequences of fine grained sedimentary rock. Surficial soils above these weathered sequences are typically silty sands, which tends to thicken toward the bottom of slopes and around drainage lines (Bowler, 2004). Clayey lenses have also been observed from field investigations.

Inspection of the site identified a sandy topsoil layer throughout Precinct 1 of varying depth (100-400 mm), underlaid by cemented sandstone and clays. The soil was observed to be erosive when devoid of vegetation. A number erosion gullies were observed in the steeper parts of the catchment along the northern waterway where earthen tracks were present (no vegetation).

From the view point of stormwater management:

- The sandy surficial soils are likely to dry out quite rapidly as a result of evapotranspiration and convey a portion of flows sub-surface to waterway depressions. The topography means that perched water tables may exist in flat depressions. Springs or discharge points at the foot of slopes were noted at a number of locations. The stormwater strategy will aim to preserve the water balance in these soils by allow treated stormwater to infiltrate to ensure the water balance associate with retain vegetation is preserved.
- Careful consideration to erosive velocities will be required and waterway stablisation will be required in areas where erosion is already observed, or where potential erosive velocities may occur post development. The erosive nature of the soils also mean careful erosion and sediment control is required.

Further detailed testing of the soils is currently being undertaken within Precinct 1 to inform detailed design of the erosion and sediment control strategy, stormwater strategy and waterway revegetation.



Photos: erosion at head of northern waterway (L) and ponded water at road crossing (R)

2.7 VEGETATION

The majority of the site was previously as pine plantation and most of the vegetation in the proposed development area consists of pine and eucalypt/acacia re-growth with little or no value. Vegetation along sections of waterway within the development has been mapped as Essential Habitat under the Vegetation Management Act. Good value vegetation, including melaleuca and larger eucalypts, has been noted in a number of locations along waterways, particularly along the main waterway which will form part of the main park precinct for Precinct 1 (refer Figure 6). Other areas of good value vegetation were noted in isolated locations at the downstream end of the Urban Development Area and on the northern boundary of the northern internal waterway.

A tree survey has recently been completed along the main waterway sections of the Precinct 1 development, particularly in areas nominated for stormwater treatment systems (wetlands and bio-retention). Areas where good value or essential habitat has been identified will be preserved. Stormwater treatment systems such as wetlands and bioretention systems can be within the zones of pine vegetation to improve the ecological function of the waterways. Other parts of the waterways will be enhanced through revegetation.



Figure 6 Existing vegetation

2.8 PROPOSED DEVELOPMENT

Precinct 1 comprises 500 lots and new roads within a footprint of 83 hectares. The development will be accessed via an extension to the Camp Cable Road. Figure 7 shows the proposed layout for Precinct 1 and associated landuse breakdown.

The main and northern waterway corridors have been preserved (minimum 50m) along with the significant existing vegetation.



Figure 7: Precinct 1 development layout

2.9 DESIGN CONSIDERATIONS

The conceptual design of Yarrabilba Precinct 1 aims to optimise the urban layout while being sensitive to the site constraints, particularly the existing waterways and vegetation as well as the downstream private properties. Key design considerations identified for the site are provided in Table 2.

Table 2: Design considerations

Design Factor	Considerations
Site drainage	Main internal waterways through the site are to be preserved and comprehensively revegetated. Appropriate hydrologic management is required to avoid instability within the waterways and where required localised stabilisation may be required. Discharge to adjoining private property (north) to be managed to minimise any increase in frequent flows and manage flood flows.
Soils and erosion	The erosive nature of the soils means construction must be carefully delivered to minimise the export of sediment from the site. Furthermore the stability of the drainage lines and other overland flow paths must be carefully considered to limit scour.
Ecological Protection	Corridors are to be retained along major waterways. Vegetation retention/enhancement, particularly good value vegetation. Prevent/rehabilitate active erosion/scour. Stream stability protection (from urban runoff).
Flood Management	Flood flows within and downstream of the site must not increase as a result of the development
Landscape integration	Integrate stormwater management measures with open space and provide improved amenity along waterway corridor. Limit the removal of good value trees for stormwater management infrastructure



3 STORMWATER MANAGEMENT OBJECTIVES

3.1 CONSTRUCTION PHASE WATER QUALITY

The primary focus of stormwater management during the construction phase is erosion and sediment control. The stormwater management objectives for the construction phase take the form of best-practice concentration-based discharge standards. The performance criteria are limited to those parameters that are directly linked to construction site activities. As the criteria are discharge standards, they apply to runoff events or pumped discharges (during dewatering of siltation basins) from the development site. The criteria for stormwater discharged from the site during the construction phase are listed in Table 3 and represent our understanding of the construction phase objectives for medium-large scale construction sites in Queensland which will be presented in the State Planning Policy for Healthy Waters.

This document does not propose erosion and sediment control measures for meeting these objectives. These will be developed as part of the operational works design.

Table 3: Criteria for Stormwater Discharged from Site during construction phase for medium-large construction sites

POLLUTANT/ISSUE	STORMWATER DESIGN OBJECTIVES ¹
Coarse sediment	Retain coarse sediment on site
Fine sediment (Total Suspended Solids - TSS)	Reasonable and practical measures should be taken to capture runoff from disturbed areas. Concentrations of TSS in water discharged (either by runoff or dewatering of siltation basins) should be less than 50mg/l.
Turbidity ²	Turbidity in discharge waters should be <10% higher than receiving water turbidity (measured directly upstream of discharge point).
Nutrients (eg. N and P)	Construction phase nutrient management should occur via appropriate sediment management.
pH	Subject to the mobility of specific elements that may be present on site, pH of waters discharged from site must be between 6.5 and 8.5.
Dissolved oxygen	Dissolved oxygen concentration > 80% saturation.
Litter and gross pollutants	Prevent discharge of litter from site entering stormwater system/internal watercourses by - Minimising litter production - Containing litter on site by the provision and maintenance of rubbish bins with appropriate lids
Hydrocarbons and other contaminants ³	Discharge of hydrocarbons and other contaminants should be prevented from site by: - At-source control of contaminants. - Preventing entry of contaminants into stormwater system or internal watercourses. - Disposing of waste must to authorised facilities. - Storing hydrocarbons according to Australian Standard AS1940. - Ensuring that discharged waters have no visible oil or grease sheen
Wash down areas	Prevent entry of wash down water into stormwater system or internal watercourses that discharge from site.
Stormwater Quantity	Take all reasonable and practical measures to minimise changes to the hydrology of the receiving environment. Protection of in stream habitat and flood characteristics by: - managing peak flows for the 1-year and 100-year ARI event - managing run-off volumes entering receiving waters - preventing uncontrolled release of contaminated stormwater.

¹ Compliance release limits for rainfall events less than the design storm event – (based on the 80%ile 5 day rainfall depth).

² Site-specific calibration of turbidity must be performed.

³ Refer to the contaminant list in the *Environmental Protection Regulation 1999*.

3.2 OPERATIONAL PHASE WATER QUALITY

The stormwater quality management objectives that apply to the operational phase of Precinct 1 have been established considering:

- Yarrabilba Urban Development Area Interim Land Use Plan
- Logan City Council Stormwater Quality Conceptual Design Guidelines
- Draft Interim Standards for Stormwater, Overland Flow and Floodplain Management – Logan City Council 2010
- SEQ Regional Plan – Implementation Guideline No. 7
- State Planning Policy for Healthy Waters (DERM, 2010) which applies the load-based objectives specified in the Urban Stormwater Best Practice Environmental Management Guidelines (DERM, 2009)

The stormwater quality objectives contained in the above policy are the load based objectives presented in Table 4. The stormwater management strategy for Yarrabilba Precinct 1 has been designed to achieve these objectives.

Table 4: Stormwater quality objectives

Pollutant	Discharge Criteria (% reduction in mean annual load)
Total suspended solids (TSS)	80%
Total phosphorus (TP)	60%
Total nitrogen (TN)	45%
Gross Pollutants (GP)	90%

3.3 WATERWAY STABILITY

Given the erosive nature of the surficial soils and waterways on and downstream of the site, the management of erosion potential of waterways is critical. This is achieved for the proposed Yarrabilba development by:

- limiting changes in flow rate and flow duration within the receiving waterway (i.e. controlling the magnitude and duration of erosion-generation and sediment transporting flows)
- stabilising and rehabilitating waterway reaches which have undergone impact as a result of land use change or will be impacted upon as a result of land use change

The focus of the waterway stability assessment for Precinct 1 has been to ensure the development of this component of the site achieved the following objective as defined by:

- SEQ Regional Plan – Implementation Guideline No. 7 ; and
- State Planning Policy for Healthy Waters (DERM, 2010):

The waterway stability objective contained in the above policy, and which have been applied to the site, are presented in Table 5. This objective has been applied to both waterways internal to the Yarrabilba site and the discharge point at the northern boundary.

Table 5 Waterway stability design objective

Criterion	Design Objective
To reduce the impacts of urban development on channel-bed and bank erosion by limiting changes in flow rate and flow duration within the receiving waters	Limit the post-development 1-year average recurrence interval (ARI) event discharge within the receiving waters to the pre-development peak one-year ARI event discharge

3.4 FREQUENT FLOW

In urban catchments the average number of surface runoff 'events' per year can increase markedly from say 10 events per year for pre-developed (i.e. fully pervious) conditions to as many as 90 events per year when impervious surface are introduced to the catchment and directly connected to the stream. To address this, the frequent flow objective has been incorporated into the SEQ Regional Plan - Implementation Guideline No. 7 and State Planning Policy for Healthy Waters and associated documents to minimise the impact of changes in frequent flow hydrology. The objectives are summarised in Table 6.

The objective is applicable where runoff from the site passes through or drains to an unlined no-tidal watercourse or wetland which is in healthy condition (not degraded). Where a receiving watercourse or wetland is degraded, the local or state authority may choose not to require compliance with this objective.

Table 6 Frequent flow design objective (contained in Implementation Guideline No. 7)

Criterion	Design Objective
To reduce the frequency of disturbance to aquatic ecosystems from urban development by managing the volume and frequency of surface runoff during small rainfall events	From the proposed development, capture and manage: • The first 10 mm of runoff from impervious surface where the total impervious surface is 0% to 40% • The first 15 mm of runoff from impervious surfaces where the total impervious surface is greater than 40%. Note: the capacity to capture runoff must be restored within 24 hours of the runoff event.

As outlined in Section 2.5, the health of Quinze Creek downstream of the site is variable and is not clear whether the application of the frequent flow objective is justified. Further ecosystem assessment of the downstream reaches to Quinze Creek is required to confirm whether this objective should actually apply and whether the current form of the objective is correct.

Furthermore, recent work completed by DesignFlow for DERM, Water by Design and Gold Coast City Council has found the current form of the frequent flow objective and the associated compliance criteria has a number of issues. Strict compliance with the objective requires a comprehensive regional stormwater harvesting strategy that is unrealistic in most situations because it requires support and adoption by the water supply authorities (Allconnex). Discussions are ongoing with Allconnex regarding water reuse for Yarrabilba but the current position is that stormwater harvesting will only be supported for parkland irrigation and industrial uses.

Given the above considerations, an alternative frequent flow objective has been applied to Yarrabilba Precinct 1 site. The objective is provided in Table 7 below and focuses on managing the number of "surface flow days" through the downstream private properties. Managing surface flow days has been adopted because:

- this is likely to be a noticeable impact within the downstream private properties if not managed appropriately (i.e. increase in frequent nuisance flooding)
- the management of surface flow days (or flow disturbance) is accepted by contemporary research as being critical of protection of healthy in-stream ecosystems (Walsh et al., 2010).

Table 7 Frequent flow design objective adopted for Yarrabilba

Criterion	Design Objective
To reduce the frequency of nuisance flooding downstream and minimise disturbance to aquatic ecosystems from urban development by managing the frequency of surface runoff during small rainfall events	Minimise the change in uncontrolled flow following development (i.e. minimise the change in surface flow frequency as a result of development)

NOTE: DesignFlow has been involved in the review of this objective for DERM, Water by Design and Gold Coast City Council. The focus of the review is to:

- identify wording changes in the objective to provide flexibility in compliance;
- confirm where the frequent flow does and does not apply; and
- identify compliance methods.

The review is ongoing and it is expected the findings of the work will be applied to future stages of Yarrabilba.

3.5 FLOOD MANAGEMENT

The introduction of impervious surfaces with the Yarrabilba development site will result in increase in flood flows leaving the site.

The flood management objectives applied to the Yarrabilba development site are consistent with Logan City Council policy and Queensland Urban Drainage Manual and are presented in Table 8.

Table 8 Flood management design objective

Criterion	Design Objective
Preserve the peak flood behaviour downstream of the site to ensure conveyance and safety is maintained	Limit the post-development peak 2 to 100 average recurrence interval (ARI) event discharges at the boundary of the site and downstream to the pre-development peak discharges.



4 STORMWATER MANAGEMENT STRATEGY

4.1 SUMMARY

Collaboration between Delfin, WSUD specialists (DesignFlow), flood engineers (Water Technology), civil engineers (KN Group) and urban designers/landscape architects (Delfin) has ensured that the development plan for Precinct 1 is suitably informed by WSUD. As a result, the stormwater quality and quantity management elements have been integrated into the conceptual design of the roads, drainage infrastructure, earthworks, landscape and public open spaces to ensure that the stormwater quality and quantity objectives as set out in Section 3 are achieved.

The stormwater management strategy has been resolved at two scales for Yarrabilba:

- Northern Structure Plan Strategy
- Precinct 1 Strategy

This ensured the strategy for Precinct 1 properly considered the future development within the total catchment to the northern boundary of the Urban Development Area. By adopting this approach, the strategy at both a precinct scale and a regional scale could be optimised (i.e. best solution was resolved given the site characteristics) and ensured appropriate space and infrastructure was allowed within Precinct 1 to support this strategy.

A description of these strategies and the associated elements are provided in the following sub-sections. Yarrabilba Northern Development Area Stormwater Quantity Management Plan (Water Technology, February 2011) provides details on flood storage requirements (see Appendix D).

4.1.1 Northern Structure Plan Strategy

Figure 8 presents the details of the post development catchments for the Northern Structure Plan. Table 9 and Figure 9 present the general location and size of the of the proposed stormwater management elements in the Northern Structure Plan (i.e. Precinct 1 and the adjacent future development zones within the Urban Development Area northern boundary). The location of the stormwater elements outside of Precinct 1 are general only and subject to refinement as part of further design, however it is expected these elements will not change significantly.



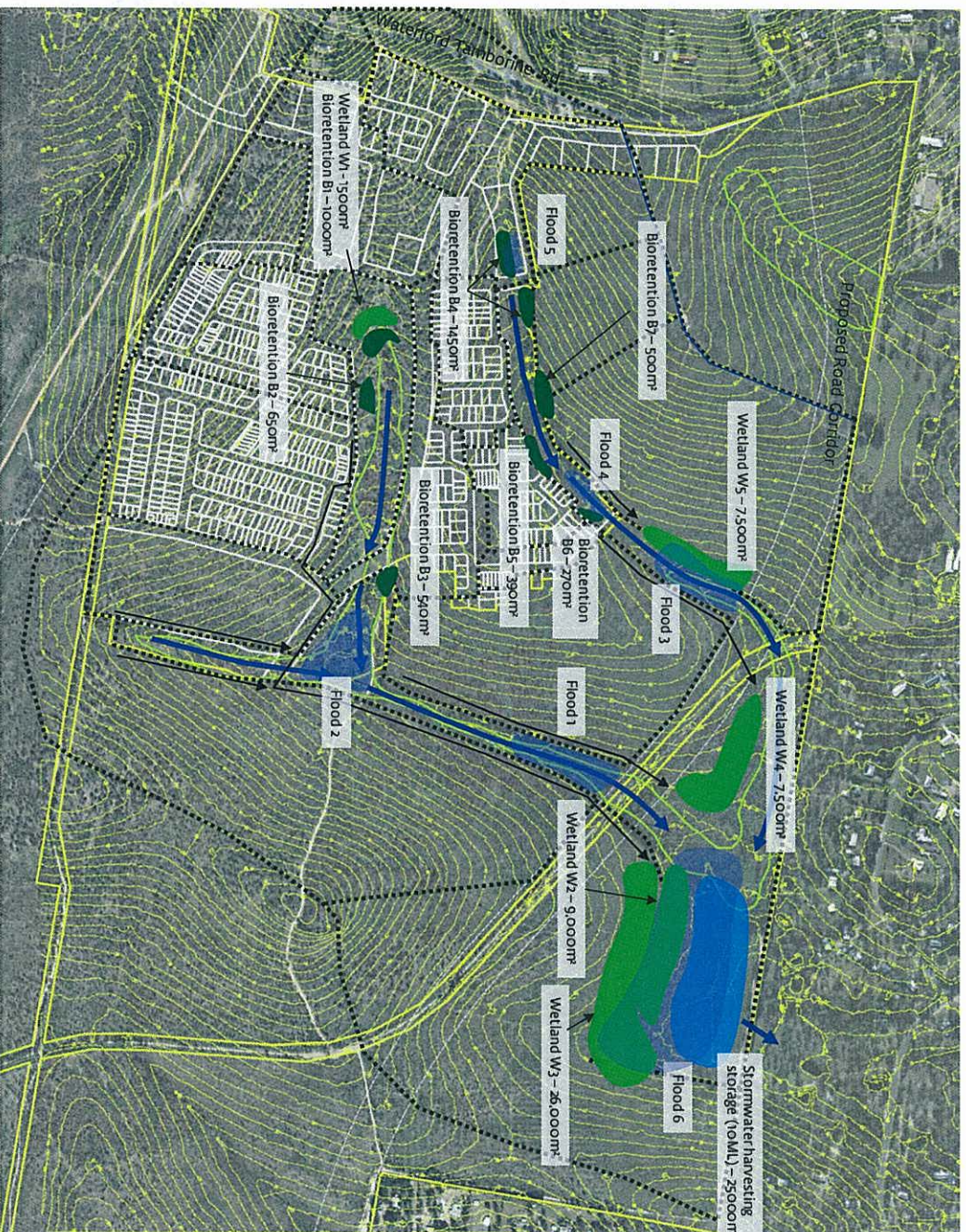
Table 9: Northern Structure Plan Stormwater Management Strategy (including Precinct 1)

Sub-catchment ID	Area (ha)	Land use	Water savings	Stormwater quality		Flood Detention (including waterway stability storage)		Stormwater Harvesting
				Treatment type and ID	Area	Flood detention ID*	Volume*	
A	8.3	Commercial	Rainwater tanks	Bioretention B1	1,00m ²			
B	1.1	Commercial	Rainwater tanks					
C	3.4	sportsfields	Rainwater tanks	Wetland W1	1,500 m ²			
D	8.0	Residential	Rainwater tanks	Bioretention B2	650m ²	Flood Basin 1 Flood Basin 2 Flood Basin 6	24,1300m ³ 21,300m ³ 52,750m ³	
E	6.0	Residential	Rainwater tanks	Bioretention B3	540m ²			
F	13.8	Residential	Rainwater tanks					
G	8.2	School	Rainwater tanks	Wetland W2	9,000 m ²			
H	34.7	Residential	Rainwater tanks			Flood Basin 1 Flood Basin 6	24,1300m ³ 52,750m ³	
I	29.9	Residential	Rainwater tanks	Wetland W3	26,000m ²	Flood Basin 6	52,750m ³	
J	17.9	Residential	Rainwater tanks			Flood Basin 1,3 Flood Basin 6	24,130m ³ /11,800m ³ 52,750m ³	Downstream harvesting considering a 10 ML holding storage for irrigation re-use within the development (20ha irrigation or 120ML/a) Potential to supply external catchments is still being considered
K	1.0	Residential	Rainwater tanks	Wetland W4	7,500m ²	Flood Basin 3 Flood Basin 6	11,800m ³ 52,750m ³	
L	8.7	Commercial	Rainwater tanks			Flood Basin 5 Flood Basin 6	5,530m ³ 52,750m ³	
M	3.6	Residential	Rainwater tanks	Bioretention B4	1,450m ²			
N	4.1	Residential	Rainwater tanks	Bioretention B5	390m ²			
O	2.9	Residential	Rainwater tanks	Bioretention B6	270m ²	Flood Basin 4 Flood Basin 6	7,580m ³ 52,750m ³	
P	5.3	Residential	Rainwater tanks	Bioretention B7	500m ²			
Q	19.2	Residential	Rainwater tanks	Wetland W5	7,500m ²	Flood Basin 3 Flood Basin 6	11,800m ³ 52,750m ³	

* Flood detention storage accept flood flows from a number of catchments. In some cases the flood detention storage catchment is different from the stormwater quality catchments due to low flow diversions. Flood Basins 1 to 5 focus on managing the 1yr ARI up to 1-5yr ARI whereas Flood Basin 6 focus on managing the large flood flows >5yr ARI to 100 yr ARI. Internal flood basins 1-5 still provide attenuating effects for the large flood flows, thus reducing the size of the downstream basin. Volumes presented are at 100 year maximum water level.



Figure 8: Northern Structure Plan and Precinct 1 stormwater catchments



Northern Structure Plan Strategy

Involves creating stormwater treatment systems at logical locations within topography. Generally this will involve treatment at top of waterways for landscape interest and to allow low flows into the waterway to preserve existing hydrology. The remainder of the catchments will be diverted to downstream treatment and flood storage. This ensures easier stormwater harvesting.

Traditional drainage within development catchments.

Diversion of flows up to 0.5yr ARI) longitudinally along waterways. These flows are delivered to regional stormwater treatment and flood detention systems at the end of the waterways. The diversion strategy ensures untreated stormwater does not enter the local waterways and preserves the 1yr ARI flows within the waterways. The diversion would occur in the form of a 0.5-1yr ARI pipe along both sides of the waterways.

Rehabilitate waterways involving revegetation, as a megaluca waterway and preservation of existing tree.

Bioretention systems located at the top end of the waterways to accept local stormwater flows and treat before discharge to waterways.

Constructed wetlands located at the downstream end of the waterways to accept and treatment local development catchments as well as diverted flows from further upstream.

Flood detention storages located within the waterways ponding over retained vegetation or revegetation zones. The smaller upstream storages will focus on managing the 1yr ARI flows with the large downstream storages focusing on the larger events up to 100yr ARI.

Stormwater harvesting storage to capture treated stormwater and reuse for parkland irrigation. The storage and reuse is sized to minimise the risk of nuisance flood downstream (minimise the change in surface flow frequency).

Figure 9: Northern Structure Plan Stormwater Strategy

4.1.2 Precinct 1 Strategy

Table 10 and Figure 10 present the confirmed location and size of the of the stormwater management elements that have been integrated into the Precinct 1 layout. The location and form these systems have been well defined through tree survey and detailed discussion with the design team.

For the purposes of this Stormwater Management Plan we have developed detailed concepts for the proposed bioretention and wetland systems in Precinct 1. These concepts have been provided to illustrate that there is available space in the development for the bioretention basins and wetland systems, that the catchments can drain to the treatment systems and there is enough level through the treatment systems to function effectively. The detailed concepts are provided in the following figures:

- **Figure 11: Main Waterway Concept** – This figure presents a landscape concept plan for the top end of the main waterway corridor which incorporates two bioretention systems and a wetland. The western end of the parkland is to be created as a key parkland feature containing a series of active parkland spaces including a market square, amphitheatre and junior/youth play zones. The bioretention and wetland systems have been carefully placed in the central zone of the parkland to accept stormwater from the development catchments while providing important landscape features. The systems have been design to avoid significant trees (as marked). Adequate space has been allowed in the design for batters associated with the treatment systems and in some cases small concrete walls (<1m) may be used to create an urban feel to the systems (subject to design).

A conceptual earthworks plan has not been generated for the main waterway at the time of writing this report because the landscape design for the park area was still in a state of flux. However this area does not pose any significant constraints for the bioretention and wetland systems as there is good elevation available for drainage and space to fit the basins without impacting on good value vegetation.

- **Figure 12: Northern Waterway Concept** – This figure presents a landscape concept plan for the northern waterway corridor. The waterway corridor is to be created as a linear landscape feature building on the existing trees (which are to be retained). The invert of the waterway is to be retained and revegetated in the form of a melaleuca waterway. Where velocities require, scour protection will be provided but the aim is to minimise this requirement by ensuring the flood detention system located along the waterway (upstream of road crossings) preserves the 1yr ARI flow at pre-development levels. A series of bioretention systems have been placed along the edge of the waterway in vegetation free zones to accept and treat stormwater from the development catchments which enter the waterway laterally.

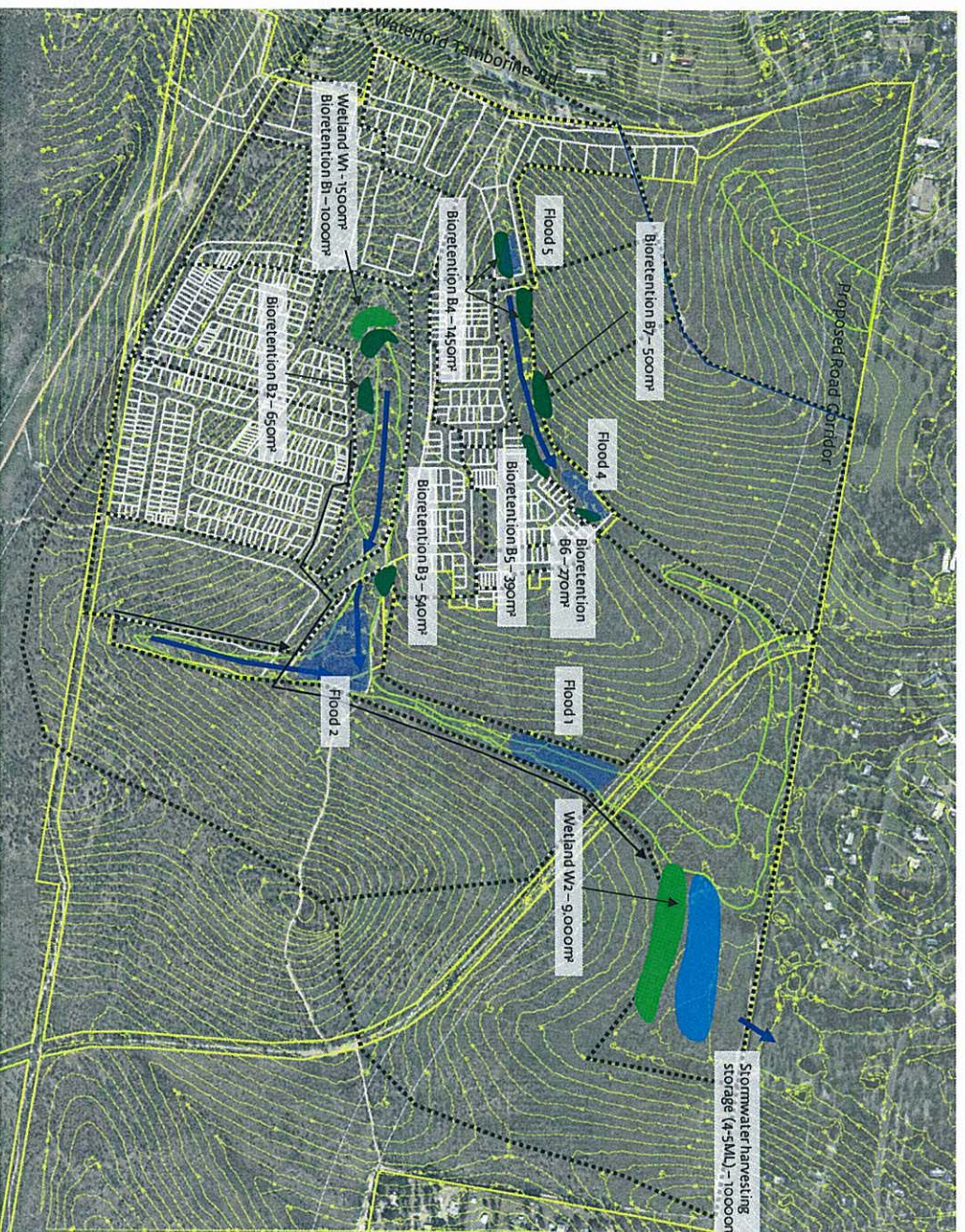
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- **Appendix C: Northern Waterway Conceptual Earthworks** – To illustrate the earthworks, levels and spatial requirements have been properly considered in the design of the waterway, a conceptual earthworks plan for the northern waterway has been developed. The plans are conceptual only and are provided in Appendix C. The plans illustrate the level of design that has been considered for each of the stormwater system across Precinct 1.

The plans in Appendix C also illustrate that the conceptual stormwater drainage layout (pit and pipes) have been designed to ensure the correct catchments drain to the relevant stormwater treatment systems in Precinct 1

Table 10: Precinct 1 Stormwater Management Strategy

Sub-catchment ID	Area (ha)	Land use	Water savings	Stormwater quality	Treatment type and ID	Area	Flood detention ID*	Volume*	Stormwater Harvesting
A	8.3	Commercial	Rainwater tanks	Bioretention B1		1,00m²			Downstream harvesting considering a 4-SML holding storage for irrigation re-use within the development (8-10ha irrigator or 60ML/a)
B	1.1	Commercial	Rainwater tanks	Wetland W1		1,500 m2			
C	3.4	Sportsfields	Rainwater tanks						
D	8.0	Residential	Rainwater tanks	Bioretention B2		650m2	Flood Basin 1 Flood Basin 2	21,880m³ 18,915m³	
E	6.0	Residential	Rainwater tanks	Bioretention B3		540m2			
F	13.8	Residential	Rainwater tanks						
G	8.2	School	Rainwater tanks	Wetland W2		9,000 m2			
L	8.7	Commercial	Rainwater tanks	Bioretention B4		1,450m2	Flood Basin 5	5,530m³	
N	4.1	Residential	Rainwater tanks	Bioretention B5		390m2			
O	2.9	Residential	Rainwater tanks	Bioretention B6		270m2	Flood Basin 4	7,580m³	

* Flood detention storages accept flood flows from a number of catchments. In some cases the flood detention storage catchment is different from the stormwater quality catchment due to low flow diversions. For the full development situation (Northern Structure Plan Area) Flood Basins 1 to 5 focus on managing the 1% ARI up to 1.5% ARI whereas Flood Basin 6 focuses on managing the large flood flows > 5% ARI to 100 yr ARI. However, given development of Precinct 1 covers only a portion of that area, only Flood Basins 1, 2, 4 and 5 are required to manage all flood events from the 1% ARI to the 100yr ARI. Volumes presented are at 100 year maximum water level.



Precinct1 Strategy

This strategy is essentially a interim stage of the ultimate strategy for the Northern Structure Plan. All of the bioretention systems required for Precinct 1 will be delivered and part of the downstream wetland/stormwater harvesting/flood detention system will be constructed.

Traditional drainage within development catchments.

Diversion of flows up to 0.5yr ARI longitudinally along waterways. These flows are delivered to regional stormwater treatment and flood detention systems at the end of the waterways. The diversion strategy ensures untreated stormwater does not enter the local waterways and preserves the 1yr ARI flows within the waterways. The diversion would occur in the form of a 0.5-1yr ARI pipe along both sides of the waterways.

Rehabilitate waterways involving revegetation, as a melaleuca waterway and preservation of existing tree.

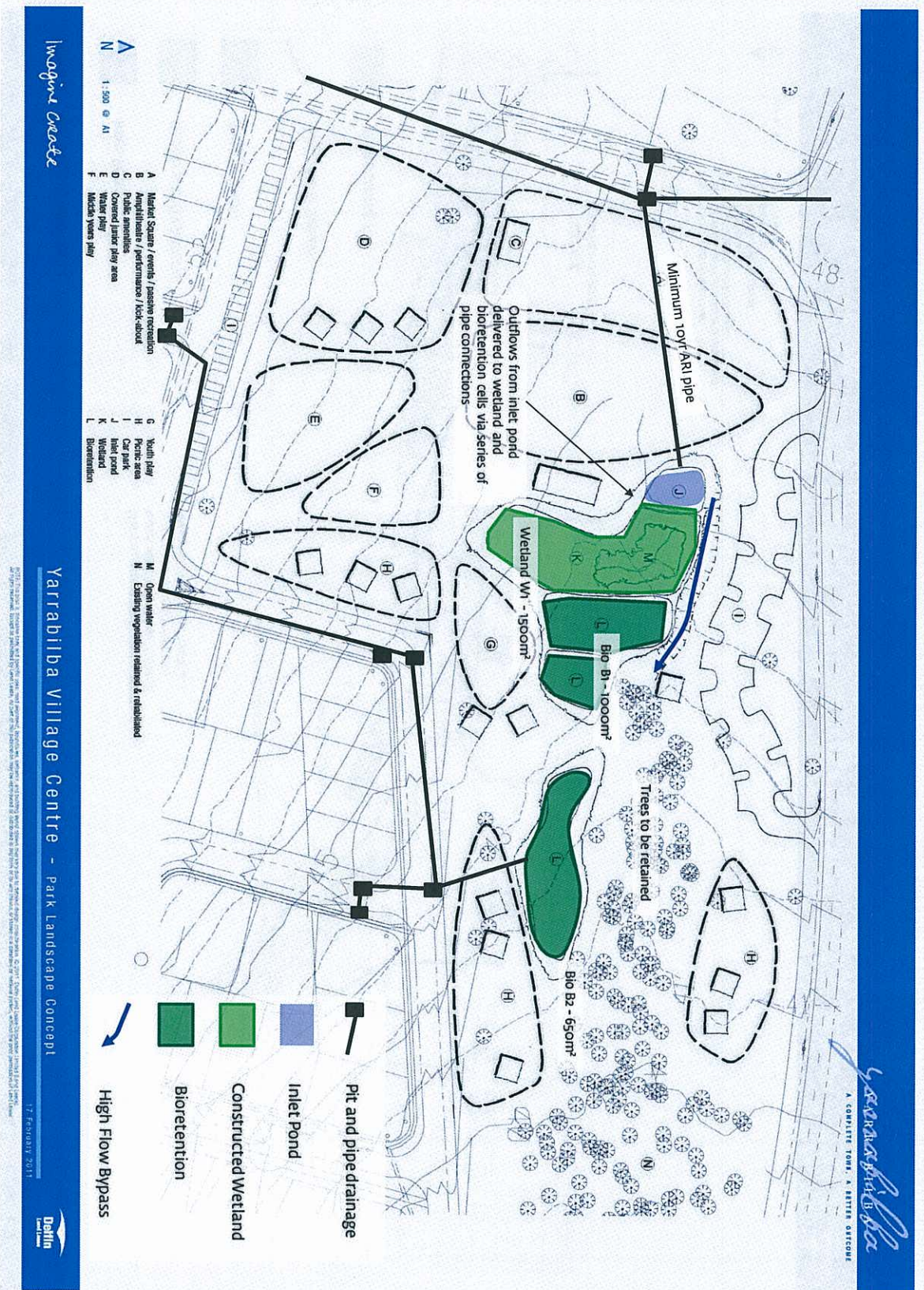
Bioretention systems located at the top end of the waterways to accept local stormwater flows and treat before discharge to waterways.

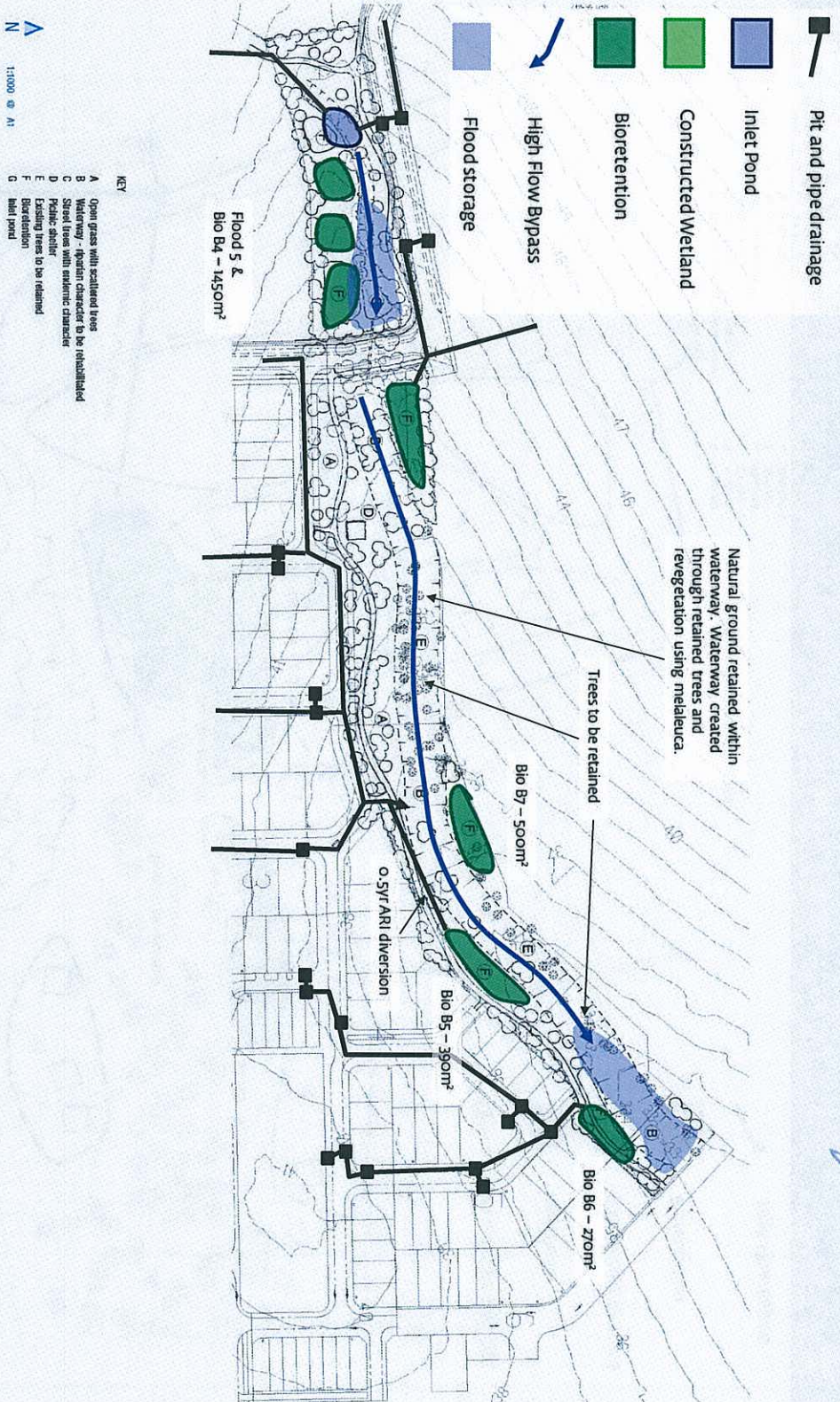
Constructed wetlands located at the downstream end of the waterways to accept and treatment local development catchments as well as diverted flows from further upstream.

Flood detention storages located within the waterways ponding over retained vegetation or revegetation zones. The smaller upstream storages will focus on managing the 1yr ARI flows with the large downstream storages focusing on the larger events up to 100yr ARI.

Stormwater harvesting storage to capture treated stormwater and reuse for parkland irrigation. The storage and reuse is sized to minimise the risk of nuisance flood downstream (minimise the change in surface flow frequency).

Figure 10: Precinct 1 Stormwater Strategy





Imagine Create

Yarrabilba Village Centre - Northern Linear Park Landscape Concept

15 FEBRUARY 2011



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Figure 12: Northern Waterway Concept Plan

4.2 RAINWATER TANKS

All dwellings will be provided with a rainwater tank in accordance with the Queensland Development Code. Tanks will be connected to washing machine cold water, toilets and outdoor taps. Due to the rainfall patterns experienced in the Logan area, tanks will be supplied with trickle top-up or backup to ensure internal connected uses can continue during dry periods. Minimum tank volumes for the relevant dwelling types described in the Code are provided in Table 11.

Table 11: Rainwater tank capacity requirements

Dwelling Type	Minimum Tank Capacity	Minimum Connected Roof Catchment
Attached dwellings and medium density dwellings	3kL	50% or 100m ²
Detached dwelling	5kL	

While the primary objective for installation of rainwater tanks is water conservation, the capture and reuse of roof runoff from each dwelling provides an overall reduction in the pollutant load discharged from the site, thus reducing the overall stormwater treatment size. For example, bioretention sizes for a typical residential catchment are reduced from approximately 1.6% to 0.9% of the contributing catchment by including allotment rainwater tanks.

4.3 BIORETENTION BASINS

Bioretention basins will provide the major stormwater treatment function for Precinct 1. The bioretention basins are located along the waterway to accept and treat pipe drainage outlets from Precinct 1 sub-catchments. Saturate zone bioretention systems (Figure 12) are likely to be adopted for Yarrabilba due to the drying conditions in Logan and the need to retain a source of water within the systems for plant health. The size of the bioretention basins through precinct 1 are summarised in Table 10 and Figure 10. Key design parameters assumed in the design and associated MUSIC modelling are summarised below:

- Filter media depth = 600mm (deeper when planting trees)
- Hydraulic conductivity = 200mm/hr
- Extended detention depth = 300mm
- Saturated zone depth = 400mm (minimum)

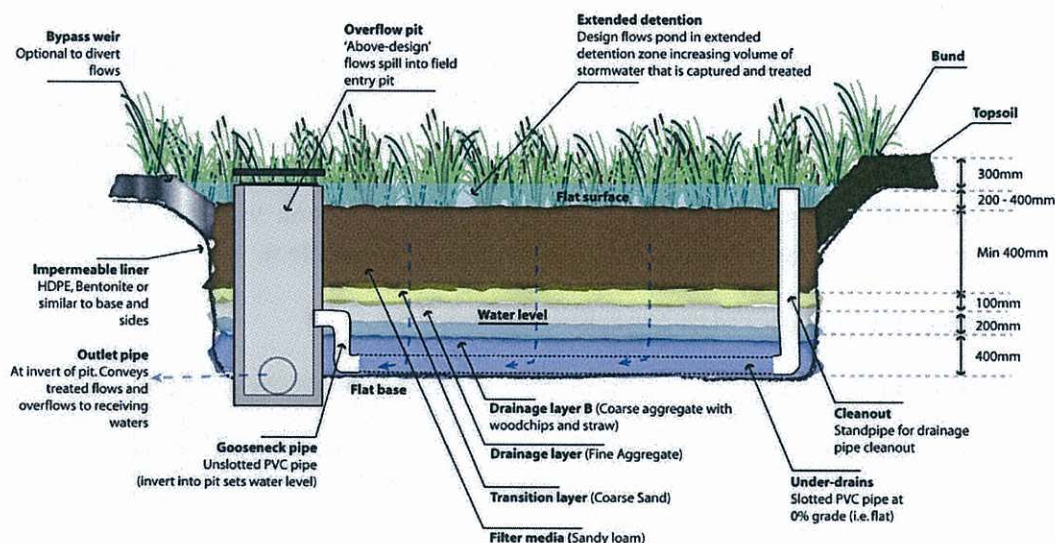


Figure 13 Typical section through a bio-retention basin with a saturated zone

Some points to note:

- Bio-retention basins are typically located within the waterway vegetation corridor. The basins have been located to minimise the removal of existing good value vegetation. In some cases regrowth vegetation may be removed for the bio-retention systems and the bio-retention systems will be created to compliment the buffer/corridor function
- The bioretention areas indicated in Figure 10 are the filter media only. The total footprint of the bio-retention basins needs to consider the filter area, batters, sediment forebay(s), maintenance access and discharge structures. As illustrated in Appendix C this typically requires the total footprint to be approximately 3 times the filter area. This total footprint area has been provided in the development and waterway/parkland layouts for the systems.
- Bio-retention basins B4 (part of) and B6 (see Figure 10) are co-located with local flood storages to manage Precinct 1 flows. The flood storage will operate for only short periods (less than 1 day) of time and will not result in extended wet periods that can impact on the bio-retention basin plant health. This basin size has been minimised by configuring the internal drainage system to mostly discharge to upstream basins outside the flood storage footprint. The bio-retention basins will be located above the waterway 1 year ARI level to ensure that the integrity of the performance including plant health, scour and clogging will be managed appropriately.
- The discharges from the bio-retention basins will be managed to minimise the risk of erosion at the interface with the receiving waterway. This will be generally achieved using approaches outlined in *Brisbane City Councils Stormwater Outlets in Parks and Waterways (version 2)*. This includes reducing energy with the outlet pit by deepening to the pit to ensure flows enter the

waterway close to the invert level and providing stabilisation to the bed and backs of the discharge interface with the waterway.

- Given the sandy nature of existing soils (top 200-400mm) and the desire to preserve the water balance within this sandy profile, the drainage outlets from the bioretentions systems are to be configured to allow treated stormwater to infiltrate into the native soils (i.e. infiltration trenches along the contour). Field investigations are proposed to review the potential for in-situ soils to allow infiltration.
- Bio-retention cells are chosen at no more than 1,500 m² to allow sufficient underdrainage capacity. Maximum cell widths are taken at 20 m to allow filter media to be placed using an excavator from the cell edges.
- The IPWEAQ standard drawings for bioretention basins (with saturated zones) will be adopted for the site.

There is a reasonable amount of flexibility regarding the size, shape and location of the systems. As such, there are opportunities to integrate bio-retention systems as landscape features throughout the urban environment. Some examples are shown in Figure 14.



Figure 14 Examples of bio-retention in urban settings

4.4 WETLANDS

A number of constructed wetlands will treat stormwater from Precinct 1 and the broader North Structure Plan catchments.

Wetlands consist of an inlet zone (sedimentation basin to remove coarse sediments), a macrophyte zone (a shallow heavily vegetated area to remove fine particulates and uptake soluble pollutants) and a high flow bypass channel (to protect the macrophyte zone from scour and vegetation damage). Figure 15 shows the key elements of constructed wetland systems. Figure 16 shows some examples of constructed wetlands from around Australia.

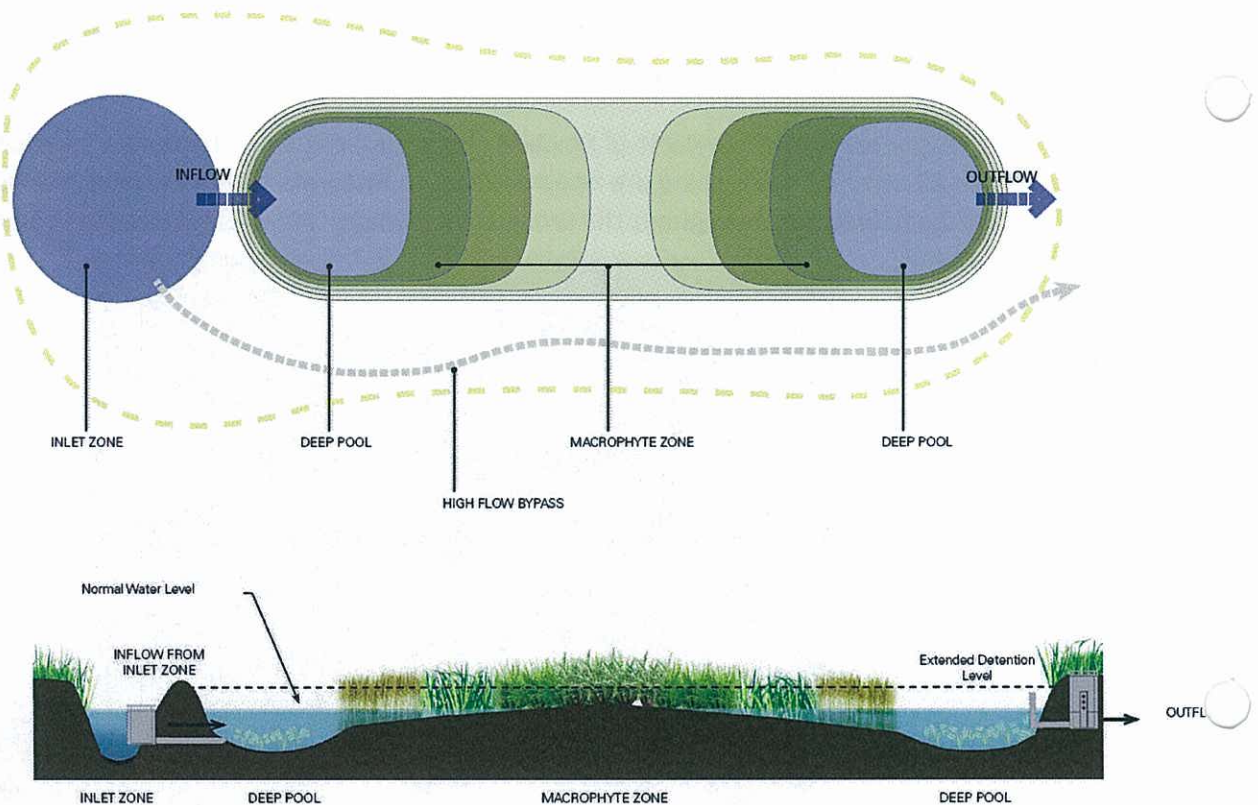


Figure 15 Typical wetland details (from Water by Design wetland training package)



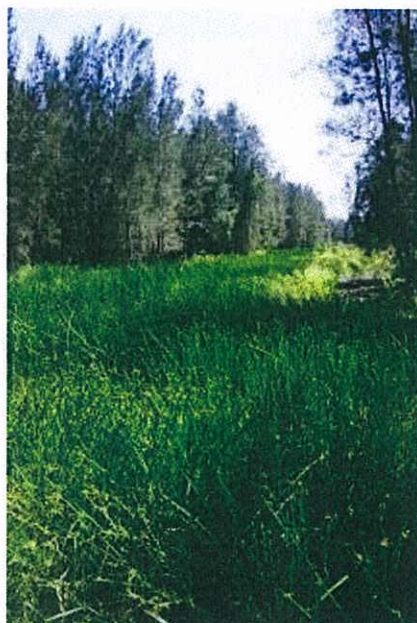
Southport, Golf Coast



North Lakes, Brisbane



Coomera Waters, Gold



Coomera Waters, Gold



Royal Park, Melbourne

Figure 16 Examples of constructed wetlands across Australia



Wetlands take up a greater land take than bioretention cells to achieve the treatment objectives, although they can provide high amenity features in urban development's allowing recreational opportunities and a refuge for flora and fauna. They are mostly suited to areas of flat topography and have the capacity to treat larger catchment areas.

For the Yarrabilba site wetlands are mostly incorporated at the downstream end of the Precinct 1 and the Northern Structure Plan where the site becomes wide and flat (Wetlands W2, W3, W4 and W5). At this location they can be incorporated with flood detention storage and can also be used as a storage buffer in combination with stormwater storages for stormwater harvesting. A small wetland (Wetland W1) is also proposed in the main park land area of Precinct 1 to provide amenity values and well as treatment.

Key wetland design parameters assumed in the design and associated MUSIC modelling are summarised below:

- Extended detention depth = 500mm
- Notional detention time = 48 hours
- Average permanent pond depth = 0.3m
- No seepage
- 80% + vegetation cover
- Inlet pond sized at 5% of the macrophyte zone

4.5 FLOOD DETENTION

A total of six flood detention storages are considered for management of Precinct 1 flows and the ultimate Northern Structure Plan zone. The basins are intended to meet the waterway stability objective (1 yr ARI) for internal and external waterways and flood management objectives (2 to 100yr ARI) at the northern discharge point to the private properties. Typically basins have been located at road crossing along the waterways.

The configuration of the basins (height vs area/storage) is provided in Figure 17. Further details of the flood detention storages and preliminary outlets are presented in Yarrabilba Northern Development Area Stormwater Quantity Management Plan (Water Technology, February 2011) in Appendix D. The conceptual earthworks plans provided in Appendix C for the northern waterway illustrate the form and configuration of the Storages 4 and 5.

The size of the flood storages has considered 100 year flood levels at each basin ideally in the order of 1.5 m deep. Appendix D provides more details on the results of the flood management modelling and preliminary size of basins and outlets.

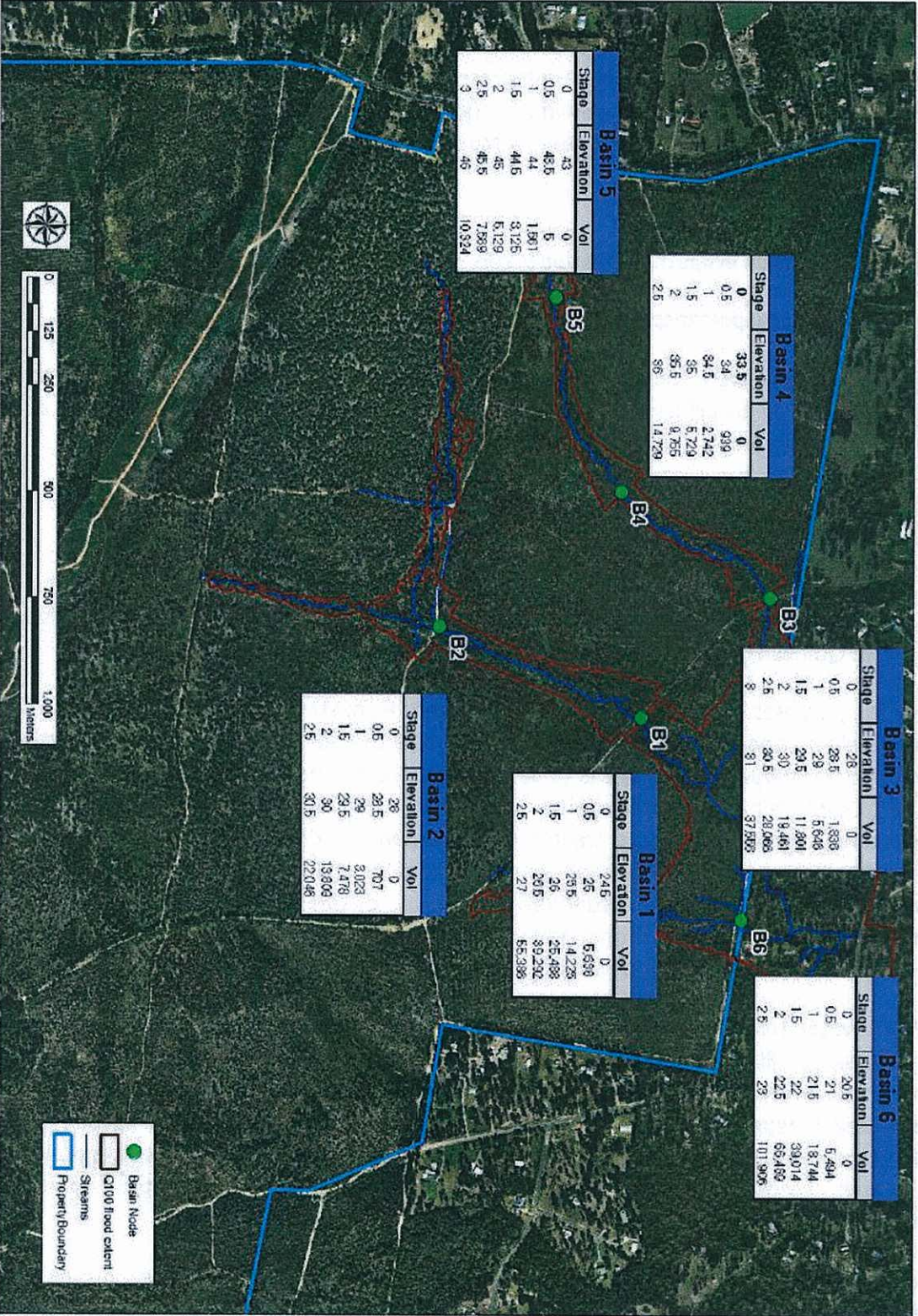


Figure 17 Detention storages (figure to be updated with new flood map and development layout)

4.6 FREQUENT FLOW MANAGEMENT (STORMWATER HARVESTING)

A number of initiatives have been integrated into the stormwater strategy to meet the frequent flow objective (i.e. minimise change in surface flows downstream). These initiatives promote the "loss" or "reuse" of stormwater and include:

- Rainwater tanks
- Bioretention evapotranspiration losses
- Wetland evapotranspiration losses

These initiatives were found to partly reduce frequent flows downstream but not to the degree required to achieve the objective. In order to achieve the objective, one of the following is required:

- Stormwater harvesting and reuse (preferred)
- Storage and diversion of excess frequent flows directly to Quinzeh Creek
- Storage and discharge of excess frequent flows through downstream private property to Quinzeh Creek via the constructed low flow channel

For the purposes of this Stormwater Management Plan, stormwater harvesting is proposed for Precinct 1 and the Northern Structure Plan area to meet the frequent flow objective. A stormwater harvesting storage is to be placed at the northern boundary of the Yarrabilba site to capture and store stormwater from the entire Northern Structure Plan area. The harvested stormwater will be treated (i.e. filtration and disinfected) to meet Class A for irrigation purposes. The potential irrigation demands include public open space or other irrigation demands in the broader Yarrabilba site (i.e. turf farm, nursery). Ultimately the harvested stormwater can form part of the broader reuse strategy for say farmland or industrial reuse in the vicinity of the Yarrabilba site.

Wastewater treatment and reuse is also proposed for the Precinct 1 site. The treated wastewater will also be irrigated to parkland or other irrigation demands. For the purposes of this Stormwater Management Plan it has been assumed the wastewater reuse system operated independently of the stormwater reuse system. However, as part of design development the concept of operating these systems as a combined strategy will be explored. For now, the volumes and irrigations as for wastewater and stormwater have been separated.

In the event Delfin, Allconnex and ULDA consider the stormwater harvesting strategy as the incorrect water supply solution, the diversion and low flow channel options will be explored. Furthermore, additional technical work is required to explore the benefit of the proposed infiltration systems at the outlet of the bioretention system. These infiltration

systems will act to reduce frequent flows but it is not clear by how much until further soil testing and technical assessment/modelling is completed.

5 STORMWATER QUALITY & FREQUENT FLOW PERFORMANCE ASSESSMENT (MUSIC MODELLING)

MUSIC modelling has been conducted to quantitatively assess the performance of the proposed stormwater quality strategy. The model developed has also allowed review of re-use strategies and frequent flows and a result of the development. MUSIC version 4.0 was used for the assessment and the parameters have been established in accordance with the MUSIC Modelling Guidelines for South East Queensland (Water by Design, 2010).

The interim bio-retention node (Version 3) has been used in the model as advised by Water by Design due to the current revisions occurring to the V4 bio-retention node. This node does not specifically model the saturated zone in bio-retention systems and therefore provides a conservative result if a saturated zone is present.

5.1 MODEL STRUCTURE

MUSIC model parameters were adopted according to the Logan City Council Stormwater Conceptual Design Guidelines and Water By Design (2010) MUSIC Modelling Guidelines for South East Queensland.

The modelling was undertaken using 10 years (1990-2000) of modified Shailer Park meteorological data. Six minute rainfall data and monthly average evapotranspiration data was used. The Shailer Park station was selected for adaption as it is the closest rainfall station to the site with 6 minute data. The rainfall data set was modified to generate a data set closer representing Logan Village rainfall. Mean annual rainfall for Shailer Park is estimated at 1179 mm (Station 040715), whereas Logan Village is 994 mm (Station 040766).

To test the appropriateness of using the Shailer Park rainfall, a double mass curve analysis between Shailer Park and Logan Village rainfall data sets was completed over common years of available rainfall data (1988-98) and demonstrated that rainfall distributions were similar. The Shailer Park 6 minute rainfall was reduced by 0.849 to produce a rainfall data set with the same annual total to Logan Village for the period considered.

The parameters adopted for the MUSIC model are outlined below with further detail provided in Appendix B.

Table 12 MUSIC parameters

Parameter	Value
Source Data	
Rainfall data set	1990-2000 - Modified Shailer Park Station 040715.
Modelled time step	6 minute
Mean annual rainfall 1990-2000	950 mm
Potential evapotranspiration	1,446 mm
Soil properties (runoff generation parameters)	Table 3.7 Music Modelling Guidelines for SEQ (urban residential and commercial)
Pollutant concentrations (base and storm flow concentration parameters)	Table 3.8 Music Modelling Guidelines for SEQ (urban residential and commercial where appropriate)
Treatment Devices	
Bio-retention	Filter media – sandy loam 200mm/hr 0.5 mm mean particle size, Filter media depth = 0.6 m Extended detention depth = 0.3 m Seepage = 0 mm/hr
Wetland	Extended detention depth = 0.5 m Permanent pool = 0.3 m Notional detention time = 48 hr Evaporative loss 125% of PET Seepage = 0 mm/hr

5.1.1 Catchment Data

The Precinct 1 development has been split into six urban residential sub-catchments (total area 35.8ha), three commercial sub-catchment (total area 18.1 ha), a school area (8.2 ha), sportsfield (3.6ha) and waterways. Future urban areas to be developed contributing to the downstream discharge point at the Urban Development Boundary were also included in the model for assessment.

For the purposes of water quality assessments, only those areas under development were included. Waterways and external areas not within the urban development boundary were excluded. Exclusion of waterways is considered a conservative approach, as re-vegetation and stabilisation will likely add to water quality improvements through in-stream processes.

Urban residential and commercial sub-catchments and re-use assumptions are based on values presented in the SEQ Music Modelling Guidelines and have considered the following:

Table 13 Urban and Commercial sub-catchment assumptions

ITEM	AMOUNT
Urban residential	
Housing density	14.4 houses per ha
Average occupancy (detached dwelling)	2.8
Lot area	495m ² per house
Roof area	247.5m ² (50% connected to tank and 50% connected to drainage)
Road reserve area	2,500m ² /ha at 60% impervious
Other ground level (lot ground level and parklands)	3,940 m ² /ha at 20% impervious
Tank size	5 kL per house
Non-potable in-house re-use (toilet and laundry 47L/p/d)	132L/house/d
Domestic irrigation	81.3kL/house/yr (75% of pervious lot area at 0.548m/a)
Commercial	
Lot area	7,000m ² /ha
Lot size	1,000m ²
Road reserve area	3,000m ² /ha at 75% impervious
Roof area	5,000m ² /ha
other	2,000m ² /ha at 20% impervious
Connected roof area	50m ² per toilet
Number of toilets	4 per allotment
Tank size	1.5kL per toilet
Non-potable indoor re-use (40L/toilet/d)	1.12 kL/d
Outdoor irrigation	164.4kL/yr (75% of pervious area at 0.548m/a)

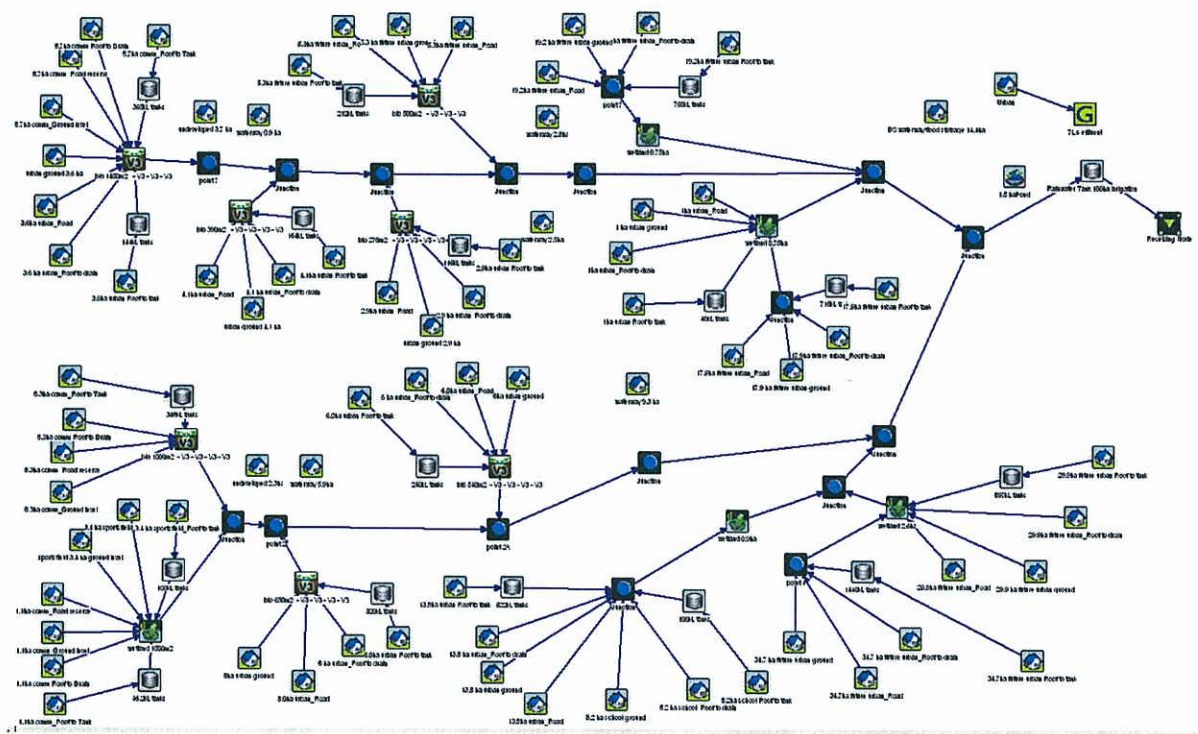
A split catchment approach as per SEQ Music Modelling Guidelines has been followed for both urban residential and commercial areas. Roof area connected to the rainwater tank has been separated in the model to allow on-site re-use to be analysed. Based on the above, the percent impervious for the overall urban residential catchment nodes is 58% percent, and 89% for the commercial nodes. These are within the acceptable range of Table 3.6 of the SEQ Music Modelling Guidelines for lumped urban residential catchments.

In-house non-potable re-use considers values published in the *MUSIC Modelling Guidelines for South East Queensland (Water by Design, 2010)* and considers in-house use for toilet flushing (21L/p/d) and laundry (26L/p/d), with full water conservation devices installed. An average occupancy of 2.8 persons per dwelling was adopted.

Commercial re-use will be dependent on each commercial configuration, however for the purposes of this modelling the requirement of the Queensland development code for commercial areas was considered, namely 1.5kL tanks per toilet and 50 m2 of connected roof per tank. Four toilets per commercial allotment were considered (1,000 m2 lots) with a daily use of 40L per toilet. Additional re-use was considered for outdoor garden area associated with commercial lots.

5.1.2 Bioretention and Wetland Systems

5.1.3 Model Layout



5.2 STORMWATER QUALITY RESULTS

The results of the MUSIC modelling for the proposed development are presented in Table 14. The results in Table 14 present the total load outcomes associated with Precinct 1 and also the whole Northern Structure Plan zone. Further details are provided in Appendix B.

Table 14 Music Modelling Summary Results

Catchment		Treatment			Pollutant load Reductions (%)		
ID	Area (ha)	ID	Area (m2)	% of catchment	TSS	TP	TN
PRECINCT 1							
A	8.3	B1	1,000	1.2	84.3	72.0	45.3
B	1.1	W1	1,500	3.3	74.6	68.2	50.5
C	3.4						
D	8.0	B2	650	0.8	81.3	68.1	47.8
E	6.0	B3	540	0.9	82.1	69.2	48.9
F	13.8	W2	9,000	4.1	77.2	69.2	50.8
G	8.2						
L	8.7	B4	1,450	1.2	85.5	72.6	46.2
M	3.6						
N	4.1	B5	390	0.95	84.1	70.0	49.3
O	2.9	B6	270	0.9	84.1	69.1	48.9
TOTAL PRECINCT 1					82	71	48
FUTURE DEVELOPMENT							
H	34.7	W3	26,000	4.0	75.1	67.5	49.6
I	29.9						
J	17.9	W4	7,500	4.0	75.2	66.7	49.7
k	1.0						
P	5.3	B7	500	0.94	83.5	69.8	49.3
Q	19.2	W5	7,500	3.9	75.7	67.3	49.7
TOTAL NORTHERN STRUCTURE PLAN							
Without downstream stormwater harvesting					79	69	49
With downstream stormwater harvesting					80	70	53

The results indicate that the proposed stormwater strategy meets the design objectives for pollutant load reduction from Precinct 1 and the Northern Structure Plan zone. In some cases individual treatments may not strictly meet minimum load reduction objectives, however when considered with other treatments at key waterway points throughout the development minimum objectives are maintained (i.e. some systems over under-sized slightly and some over-sized).

5.3 STORMWATER REUSE

The overall reuse strategy considered for Yarrabilba is a combination of on-site tanks (5kL) for domestic irrigation, toilet flushing and laundry and a third pipe supply to provide open space irrigation supply. Opportunities for effluent re-use are still being considered, however for the purposes of this report third pipe supply considers stormwater reuse for parkland irrigation within the development footprint only. This provides an opportunity to minimise the overall impact of increase flow volumes to downstream properties (refer to Section 5.6).

Stormwater harvesting and reuse modelling was undertaken for the whole Northern Precinct Structure Plan. The assessment assumed the collection of treated stormwater (from the waterways) and third pipe supply for irrigation reuse within the Northern Precinct development (assumed at 20 ha). The key aim of the stormwater harvesting strategy is to minimise the increased in frequent flows exiting the site as described in Section 4.5.

There exists opportunities to supply this harvested stormwater to demands external the Northern Structure Plan area. The stormwater harvesting and reuse model was used to test a number of these external demand scenarios as well. Further discussion and review of these external supply options is required.

A summary of the overall development water demands and re-use opportunities are presented in Table 15. The assumptions used are indicated. Water demands are based on typical values presented in Music Modelling Guidelines for South East Queensland (Table 4.4, Water by Design, 2010) and consider full water saving devices. Open space irrigation is considered at approximately 20 ha within the development, representing approximately 50% of the total open space area to be provided (including waterways).

The storage size was optimised by adopting the economic limit of performance of the storage as indicated by the diminishing rate of return in accordance with the Stormwater Harvesting Guidelines (Water by Design, 2009).

Table 15 Water re-use summary of options assessed

Development water demands

housing density	14.4 houses/ha	
total developed area	184 ha	
occupants per house	2.8	
Total domestic demand (in-house and irrigation)	548.7	ML/a
open space irrigation (20 ha)	120	ML/a
TOTAL DEVELOPMENT WATER DEMAND	668.7	ML/a

Development non-potable demands

on-site tanks	5kL	
in-house non-potable demand (toilet flushing/laundry)	131.6 L/house/d	
domestic irrigation (non-potable)	81kL/house/a	
open space irrigation	120	ML/a
TOTAL RE-USE NON-POTABLE DEMAND	462	ML/a

Scenario	DS holding storage ML	Amount requested ML/a	Amount supplied ML/a	Reliability of supply %	% of total non-potable re-use demand	% reduction in potable water supply
Rainwater tanks only for toilet flushing, laundry and irrigation	NA	281.1	138.8	49.4%	30.0%	20.8%
Stormwater harvesting for open space irrigation (20 ha)	10	120	98.1	81.8%	21.2%	14.7%
On-site tanks with stormwater harvesting (20ha parkland irrigation)	10	401.1	236.9	59.1%	51.3%	35.4%

Harvesting for external irrigation re-use

Scenario	DS holding storage ML	Amount requested ML/a	Amount supplied ML/a	Reliability of supply %
20 ha parkland irrigation re-use (within development)	10	120	98.1	81.8%
40 ha irrigation re-use	25	240	192.1	80.0%
60 ha irrigation re-use	50	360	284	78.9%
80 ha irrigation re-use	75	480	358	74.6%
100 ha irrigation re-use	125	600	447.3	74.6%

The above indicates that 50-55% reductions in non-potable demands can be achieved with on-site tanks plus a third pipe strategy for open space irrigation. Overall reduction in total potable demands are in the order of 35-40%. Stormwater re-use for open space irrigation within the development can achieve just over 80% reliability with a 10 ML holding storage.

When adopting stormwater harvesting to supply parkland irrigation demand within the Northern Structure Plan area a stormwater storage in the order of 10 ML is required. This can be combined with the 3.5 ha downstream wetland to reduce overall footprint requirements. This holding storage is anticipated to take the form of an urban lake in the order of 2-2.5 m deep, whereby an active holding storage is considered in the top 0.4 m. Additional active storage in the wetland can be considered at 0.1 m. The resulting footprint will consist of a 1.5-2ha lake area and a 3-3.5 ha wetland. Top-up water to provide 100% reliability of supply could be derived from treated effluent.

To minimise any potential algal growth issues and maintain good quality lake water, the total lake volume is considered to be recycled through the wetland during periods of low rain. A recycling rate in the order of 30L/s is considered to provide adequate turnover (15 days) of the full volume of the holding lake and sufficient contact time with the wetland (>5 days).

The stormwater harvesting strategy presented above and the associated water balance results are preliminary only. Further discussion with ULDA, Allconnex and Council is required to confirm a range of issues associated with the strategy.

5.4 FREQUENT FLOW RESULTS

The stormwater harvesting model was interrogated to understand the change in surface flow days as a result of development and the proposed stormwater strategies. The full range of scenarios was assessed from pre-developed level to full development and the subsequent stormwater strategies. The work was completed to investigate how various scenarios influence the frequency of surface flow days at the outlet from the development (refer frequent flow objective).

For modelling purposes the undeveloped rural catchment has been modelled in MUSIC with soil parameters equivalent to those suggested for the pervious component of urban residential catchments (SEQ Music Modelling Guidelines). Key soil parameters include:

- Soil store: 500mm
- Field capacity: 200mm
- Daily recharge rate: 28%
- Daily baseflow rate: 27%
- Daily deep seepage rate: 0%

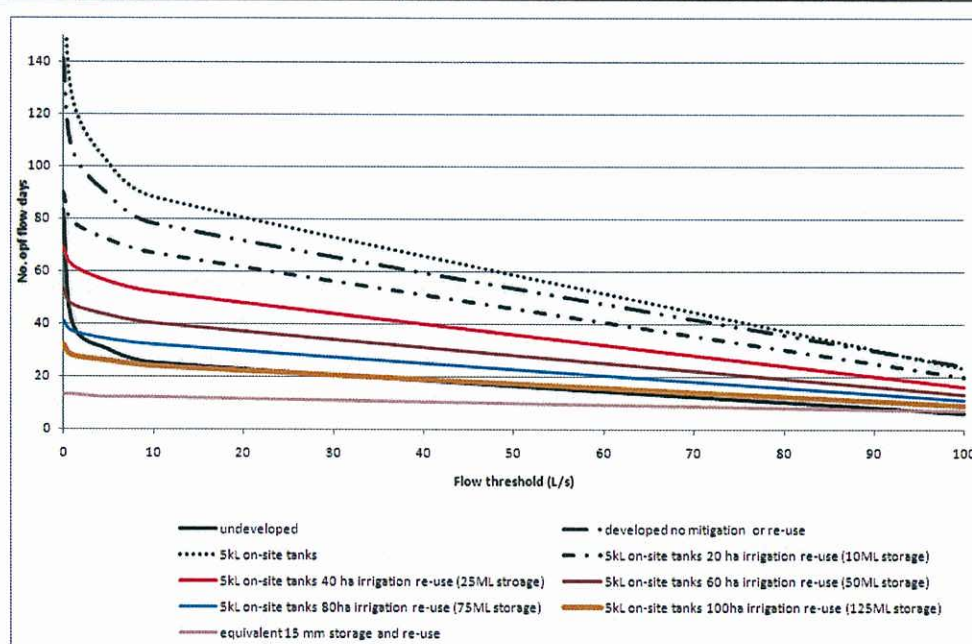
No gauged flow data is available to calibrate the rural runoff component, however the above parameters are considered a good representation of the soil conditions observed on site, where an approximate 200mm-500mm sandy soil layer overlies a relatively impervious weathered and cemented sandstone formation. This allows good storage of rains prior to

surface runoff and permits a relatively fast baseflow discharge rate. Deep seepage would be considered negligible in this case.

Various flow thresholds have been reviewed to investigate how flow days vary considering a minimum outflow volume. It is estimated that the 10L/s threshold is related to baseflow conditions in the pre-developed state (i.e. subsurface flow within the sand), whereas flows larger than this are most likely related to surface runoff events. Annual outflow volumes at the outlet are also presented together with the 90% flow value at the outlet.

Table 16 Frequent flow - flow day summary

Scenario	no of flow days flow threshold (L/s)					90% (m3/s)	Annual outflow volume (ML)
	0	1	5	10	100		
undeveloped	83	40	30	25	6	0.11	384
developed no mitigation or re-use	141	106	89	78	24	0.366	1070
5kL on-site tanks	178	126	101	88	23	0.15	870
5kL on-site tanks 20 ha irrigation re-use (10ML storage)	90	79	72	67	20	0.16	750
5kL on-site tanks 40 ha irrigation re-use (25ML storage)	69	62	56	52	16	0.18	655
5kL on-site tanks 60 ha irrigation re-use (50ML storage)	53	47	43	40	13	0.196	565
5kL on-site tanks 80ha irrigation re-use (75ML storage)	41	37	34	32	11	0.22	484
5kL on-site tanks 100ha irrigation re-use (125ML storage)	32	28	26	24	9	0.25	411
equivalent 15 mm storage and re-use	13	13	12	12	7	4.28	396



The above indicates that there are a large number of flow days in the rural undeveloped case with relatively minor flows (<1L/s), suggesting a trickle feed of baseflow to the internal waterways following rain events. Baseflows in the undeveloped case are most likely associated with flows to approximately 10L/s, as this approximately corresponds with the number of rain days greater than 15mm (18 events per year with rainfall>15mm), when surface runoff from rural areas could be expected.

A fully developed catchment with no mitigation or re-use is observed to significantly increase the number of flow days and the annual volume of outflow is also seen to increase by a factor of 2.75.

A re-use strategy with only onsite tanks and bioretention/wetland systems is observed to increase the number of flow days from the unmitigated case. This is mostly associated with delayed outflows from wetlands and bio-retention. This difference is seen to converge with the unmitigated case for high flow thresholds. Annual outflow volumes however are reduced.

A re-use strategy with on-site tanks and downstream stormwater harvesting for 3rd pipe parkland irrigation supply within the development is noted reduce the number of flows days from the unmitigated case and the annual outflow volume. Whilst this is still greater than the undeveloped case, the overall benefit of including the stormwater harvesting system is significant (surface flow days and annual volume is double that of pre- development rather than three fold).

To investigate further the impact of irrigation re-use on the number of flows days, various irrigation demands were considered. To achieve close to the pre-developed flow regime an irrigation area of 100 ha total (20 ha internal and 80 ha external) would be required. This represents an equivalent area in the order of 50 football ovals.

As a comparison, the current form of the frequent flow objective (capture and manage the 15mm of rainfall) was simulated and presented. The annual outflow volumes are noted to approximate the rural case, however it is noted that this approach has significantly reduced the number of flow days in the lower flow threshold range. This indicates that when flow does occur it is more associated with large event where high flows could be expected. This may not be a desirable outcome from a waterway health perspective, reducing the number of flow days with minor flows from the rural case. The practicalities of achieving a 15mm compliance target is also questionable as this requires massive demands to be available to provide the required storage volume, as per the compliance condition (i.e. the 15 mm stored volume must be emptied within 24 hours).

As an example for the Yarrabilba Northern Structure Plan area , a 15 mm storage and re-use equivalent volume is estimated at 14.5ML (considering a development area of 185ha). Daily non-potable demand for the development is estimated at less than 0.25ML/d (considering toilet and laundry, 131L/house/day). Although irrigation demand is considered as part of the re-use strategy, it is unlikely to be required during rain periods, thus restricting this component of demand to manage the stored volumes. As a result an additional non-potable demand equivalent to 60 times the development would be required to manage the flows. Achieving this objective appears unfeasible unless as massive external demand and storage is resolved with ULDA and Allconnex.

6 WATERWAY STABILITY AND FLOOD PERFORMANCE ASSESSMENT

Flood modelling was completed by Water Technology to confirm the stormwater strategy meets the waterway stability objective (1yr ARI) and flood management objectives (preserving the 2 to 100yr ARI).

Please refer to Appendix D for details of the flood modelling and results. Summary detention storage requirements for management of 1 and 100 year flows for both the Precinct 1 development and the Northern Structure Plan have been presented previously in Tables 9 and 10 and Figures 9 and 10. A staged approach to detention storage installation can be considered, with four of the six proposed basins required to manage Precinct 1 flows (Basins 1,2,4 and 5, refer to Figures 10 and 17) up to the 100 year ARI at the downstream boundary of the Urban Development Area.

7 CONCLUSION

A stormwater management strategy has been developed for Yarrabilba Precinct 1 that delivers best practice objectives for urban stormwater quality improvement, waterway stability and frequent flow management and opportunities for stormwater reuse to irrigation parkland zone.

The Precinct 1 strategy generally complies with the environmental and sustainable development requirements set out in the Yarrabilba Urban Development Area Interim Land Use Plan and is particularly focussed on delivering sustainable outcomes not only for the development but protection of downstream waterways.

The proposed stormwater management systems have been designed to integrate with the flood management (refer to the Flood Management Plan – Yarrabilba Precinct 1, Water Technology, February 2011).

A preliminary earthworks plan has been developed for bio-retention basins proposed in the Northern Waterway of Precinct 1 providing a level of certainty that there is sufficient space for the basins and to illustrate that stormwater can drain into and out of the basins.

The primary outcome of the stormwater and flood management strategy for Precinct 1 is that the stormwater quality, waterway stability, frequent flow and flood management objectives are achievable. Therefore the development of Precinct 1 can occur in the knowledge that the waterway within and downstream of the site is protected.

However, Delfin do recognise that the broader Yarrabilba site requires an integrated stormwater, waterway and flood management strategy to ensure these objectives are achieved for the whole site. Therefore, ongoing investigations are occurring for the broader Yarrabilba site beyond Precinct 1 to ensure the combined impact of staged development is assessed appropriately and mitigation strategies developed early to guide further conceptual and detailed design of these areas.

It is expected that minor adjustments to the Precinct 1 stormwater management designs may occur as part of detailed design for the Operational Works certification process. Any changes will be clearly identified and explained in the form of "WSUD Functional Design Reports" for each of the development stages. The reports will provide detailed description of the design and associated calculations along with detailed MUSIC modelling.

Design development and detailed design of the WSUD Strategy will be undertaken in accordance with WSUD Technical Design Guidelines for SEQ. In addition to the landscape and civil drawings the following documentation will be produced as part of the design development and detailed design for Operational Works certification:

- WSUD Design Report OR Detailed Stormwater Management Plan
- A description of key functional elements
- Refined modelling

- Relevant WSUD Specifications and calculations
- Detailed Sediment and Erosion Control Plan
- WSUD Construction, Establishment and Handover Methodology
- WSUD Maintenance Plans for the specific WSUD elements

8 REFERENCES

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Photo 1



Photo 2



Photo 3



Photo 4



Photo 5



Photo 6



Photo 7



Photo 8



Photo 9



Photo 10



Photo 11



Photo 12



Photo 13



Photo 14

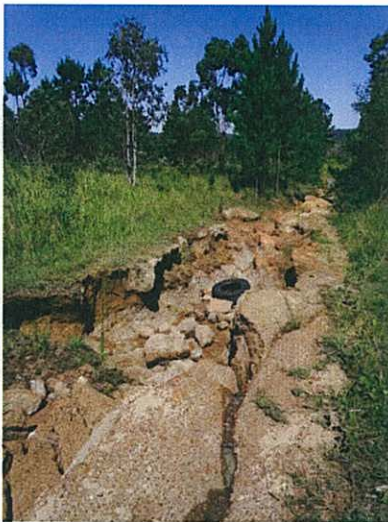


Photo 15



Photo 16



Photo 17



Photo 18

APPENDIX B MUSIC MODEL

The following tables provide the relevant data used in the MUSIC model for Precinct 1. These reporting tables are in accordance with the *MUSIC Modelling Guideline for South East Queensland* (Water by Design, 2009).

Table A1: Meteorological and rainfall runoff data reporting table

Input	Data used in modelling
Rainfall station	Modified Shailer Park (Station 040715)
Time step	6 minute
Modelling period	1990 to 2000
Mean annual rainfall (mm)	950 mm (1990-2000)
Evapotranspiration	1,446
Rainfall runoff parameters	Urban Residential and Commercial (Table 3.7 Water by Design, 2009)
Pollutant export parameters	Urban Residential and Commercial (Table 3.8 Water by Design, 2009)

Table A2: Catchment definition reporting table

Catchment ID	Area (ha)	Land use	Total impervious (%)
A	8.3	Commercial	89%
B	1.1	Commercial	89%
C	3.4	sportsfield	20%
D	8.0	Urban Residential	58%
E	6.0	Urban Residential	58%
F	13.8	Urban Residential	58%
G	8.2	School	30%
H	34.7	Urban Residential	58%
I	29.9	Urban Residential	58%
J	17.9	Urban Residential	58%
K	1	Urban Residential	58%
L	8.7	Commercial	89%
M	3.6	Urban Residential	58%
N	4.1	Urban Residential	58%
O	2.9	Urban Residential	58%
P	5.3	Urban Residential	58%
Q	19.2	Urban Residential	58%
TOTAL	176.1*		59%

* Remainder of the 225ha total catchment is mostly waterway corridor (not developed) or external catchment (minor only)

Table A3: Catchment split reporting table

Catchment ID	Area (ha)	Surface Type	Fraction impervious (%)
A	2.49	Road Reserve	75%
	1.16	Roof to tank	100%
	2.98	Roof to drain	100%
	1.66	Ground level	80%
B	0.33	Road Reserve	75%
	0.15	Roof to tank	100%
	0.39	Roof to drain	100%
	0.22	Ground level	80%
C	-	Road Reserve	75%
	0.18	Roof to tank	100%
	0.18	Roof to drain	100%
	3.4	Ground level	10%
D	2.0	Road Reserve	60%
	1.42	Roof to tank	100%
	1.42	Roof to drain	100%
	3.15	Ground level	20%
E	1.5	Road Reserve	60%
	1.06	Roof to tank	100%
	1.06	Roof to drain	100%
	2.37	Ground level	20%
F	3.45	Road Reserve	60%
	2.46	Roof to tank	100%
	2.46	Roof to drain	100%
	5.42	Ground level	20%
G	-	Road Reserve	60%
	0.5	Roof to tank	100%
	0.5	Roof to drain	100%
	7.2	Ground level	20%
H	8.67	Road Reserve	60%
	6.19	Roof to tank	100%
	6.19	Roof to drain	100%
	13.65	Ground level	20%
I	7.47	Road Reserve	60%
	5.33	Roof to tank	100%
	5.33	Roof to drain	100%
	11.77	Ground level	20%
J	4.47	Road Reserve	60%
	3.19	Roof to tank	100%
	3.19	Roof to drain	100%
	7.04	Ground level	20%

Catchment ID	Area (ha)	Surface Type	Fraction impervious (%)
K	0.25	Road Reserve	60%
	0.17	Roof to tank	100%
	0.17	Roof to drain	100%
	0.40	Ground level	20%
L	2.61	Road Reserve	75%
	1.22	Roof to tank	100%
	3.13	Roof to drain	100%
	1.74	Ground level	80%
M	0.9	Road Reserve	60%
	0.64	Roof to tank	100%
	0.64	Roof to drain	100%
	1.41	Ground level	20%
N	1.02	Road Reserve	60%
	0.73	Roof to tank	100%
	0.73	Roof to drain	100%
	1.61	Ground level	20%
O	0.72	Road Reserve	60%
	0.52	Roof to tank	100%
	0.52	Roof to drain	100%
	1.14	Ground level	20%
P	1.32	Road Reserve	60%
	0.94	Roof to tank	100%
	0.94	Roof to drain	100%
	2.09	Ground level	20%
Q	4.8	Road Reserve	60%
	3.42	Roof to tank	100%
	3.42	Roof to drain	100%
	7.57	Ground level	20%
TOTAL	176.1*		59%

* Remainder of the 225ha total catchment is mostly waterway corridor (not developed) or external catchment (minor only)

Table A4: Bioretention Basin node reporting table

Parameter	B1	B2	B3	B4	B5	B6	B7
Surface area (m2)	1,000	650	540	1,450	390	270	500
Has the filter area been calculated appropriately?	Yes, equal surface area method						
Extended Detention Depth (m)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Filter area (m2)	1,000	650	540	1,450	390	270	500
Saturated hydraulic conductivity (mm/hour).	200	200	200	200	200	200	200
Filter depth (m)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Filter Median Particle Diameter (mm)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Overflow weir width (m)	10	10	10	10	10	10	10
Seepage Loss (mm/hr)	0	0	0	0	0	0	0
Confirmation that K and C* remain default?	Y	Y	Y	Y	Y	Y	Y

Table A5: Wetland node reporting table

Parameter	W1	W2	W3	W4	W5
Inlet pond vol (m3)	150	900	2,600	750	750
Macrophyte surface area (m2)	1,500	9,000	26,000	7,500	7,500
Has surface area been calculated correctly (Sec4.3.2)	Y	Y	Y	Y	Y
Extended det depth (m)	0.5	0.5	0.5	0.5	0.5
Permanent pool vol (m3)	450	2,700	7,800	2,250	2,250
Exfiltration rate (mm/hr)	0	0	0	0	0
Evaporation loss as % of PET	125	125	125	125	125
Equivalent pipe dia (mm)	51	125	214	114	114
Over flow weir length (m)	3.0	10.0	10.0	3.0	3.0
Notational det time (hrs)	48.6	48.6	47.9	48.6	48.6
Number of CSTR cells	5	5	5	5	5
Confirmation K and C* remain default (Y/N)	Y	Y	Y	Y	Y

Table A6: Rainwater tank node reporting table

Tank Parameter	A_Tanks	B_Tanks	C_Tanks	D_Tanks	E-Tanks	F-Tanks
Volume below overflow (kL)	348	462	100	460	344	796
Depth above overflow (m)	0.2	0.2	0.2	0.2	0.2	0.2
Depth below overflow and pipe scaled appropriately?	Y	Y	Y	Y	Y	Y
Surface area (m2)	174	231	50	230	172	398
Overflow pipe diameter (mm)	1524	555	90	1072	927	1411
Stored water used for irrigation/other purposes?	Y	Y	Y	Y	Y	Y
Indoor connections	Laundry and toilet					
Indoor demand (kL/day)	9.3	1.2	-	15.1	11.3	26.2
Outdoor demand scaled by PET - Rain (kL/yr)	1364	181	10980	9358	6998	16194
Confirmation that K and C* remain the same?	Y	Y	Y	Y	Y	Y
Tank Parameter	G_Tanks	H_Tanks	I_Tanks	J_Tanks	K-Tanks	L-Tanks
Volume below overflow (kL)	100	2000	1724	1032	56	365
Depth above overflow (m)	0.2	0.2	0.2	0.2	0.2	0.2
Depth below overflow and pipe scaled appropriately?	Y	Y	Y	Y	Y	Y
Surface area (m2)	50	1000	862	516	28	183
Overflow pipe diameter (mm)	90	2236	2076	1606	374	1561
Stored water used for irrigation/other purposes?	Y	Y	Y	Y	Y	Y
Indoor connections	Laundry and toilet					
Indoor demand (kL/day)	4.0	65.8	56.7	33.9	1.8	9.7
Outdoor demand scaled by PET - Rain (kL/yr)	10980	40689	35073	20995	1139	1430
Confirmation that K and C* remain the same?	Y	Y	Y	Y	Y	Y

Tank Parameter	M_Tanks	N_Tanks	O_Tanks	P_Tanks	Q-Tanks	
Volume below overflow (kL)	208	236	168	304	1104	
Depth above overflow (m)	0.2	0.2	0.2	0.2	0.2	
Depth below overflow and pipe scaled appropriately?	Y	Y	Y	Y	Y	
Surface area (m2)	104	118	84	152	552	
Overflow pipe diameter (mm)	721	768	648	872	1661	
Stored water used for irrigation/other purposes?	Y	Y	Y	Y	Y	
Indoor connections	Laundry and toilet					
Indoor demand (kL/day)	6.8	7.7	5.5	10.0	36.3	
Outdoor demand scaled by PET - Rain (kL/yr)	4231.6	4801.3	3417.9	6184.7	22460.3	
Confirmation that K and C* remain the same?	Y	Y	Y	Y	Y	

Additional assumptions used in determining water demands (Water by Design, 2009)

- 2.8 people per detached dwelling
- 47 l/p/day demand (toilet/laundry) for full water saving devices installed
- Outdoor irrigation of 548 mm/yr (average of 1.5mm/day) applied to 75% of pervious area of lots.
- Outdoor reuse scaled by PET-rain
- Each house provided with 5kL tank as per QDC MP 4.2 and 4.3, 1 kL provided for trickle top up
- Modelled overflow pipe diameter as per SEQ MUSIC Guidelines (Water by Design, 2009)

Table A6: Stormwater quality modelling results reporting table

Catchment ID	Pollutant	Inflows (kg/yr)	Outflows (kg/yr)	Reduction (kg/yr)	Reduction achieved (%)	Water Quality Objective (%)	
PRECINCT 1							
A	TSS	17700	3130	14570		Water quality objectives apply to combined site discharge	
	TP	39.3	11	28.3			
	TN	211	118	93			
B/C	TSS	3900	991	2909			
	TP	8.9	2.84	6.06			
	TN	51.9	25.5	26.4			
D	TSS	7310	1370	5940			
	TP	15.5	4.94	10.56			
	TN	95.7	50.0	45.7			
E	TSS	5470	978	4492			
	TP	11.5	3.54	7.96			
	TN	71.2	36.4	34.8			
F/G	TSS	17100	3900	13200			
	TP	36.8	11.3	25.5			
	TN	262	111	115			
L/M	TSS	21500	3130	18370			
	TP	49.0	13.4	35.6			
	TN	268	144	124			
N	TSS	3650	582	3068			
	TP	7.93	2.38	5.55			
	TN	48.9	24.8	24.1			
O	TSS	2560	406	2154			
	TP	5.63	1.74	3.89			
	TN	34.8	17.8	17.0			
TOTAL PRECINCT 1	TSS	79190	14487	64703	82		
	TP	174.6	51.1	123.4	71		
	TN	1007.5	527.5	480	48		
FUTURE DEVELOPMENT							
H/I	TSS	57100	14400	42700			
	TP	124	40.3	83.7			
	TN	773	390	383			
J/K	TSS	17100	4230	12870			
	TP	37.5	12.5	25.0			
	TN	229	115	114			
P	TSS	4780	786	3994			
	TP	10.2	3.08	7.12			
	TN	64	32.4	31.6			
Q	TSS	16800	4080	12720			

	TP	36.3	11.9	24.4		
	TN	225	113	112		
TOTAL NORTHERN STRUCTURE PLAN	TSS	174970	36614	138355	79	80
	TP	382.6	118.9	263.6	69	60
	TN	2298.5	1177.9	1120.6	49	45

Sensitivity Analysis

The results below show the performance of the overall WSUD strategy when all bioretention basin saturated hydraulic conductivities are reduced from 200 mm/hr to 50 mm/hr. The results taken from the total catchment discharge show only minor changes to the overall treatment efficiency compared to the results in Table A6. Precinct 1 discharges are still seen to meet water quality objectives. The total northern structure plans is slightly below TSS objectives, however this result does not include in-stream water quality improvements from re-habilitation of the main waterways, and increases in TSS removal from stormwater re-use. These will be refined for the next stage of the project once the future development scenario is further developed.

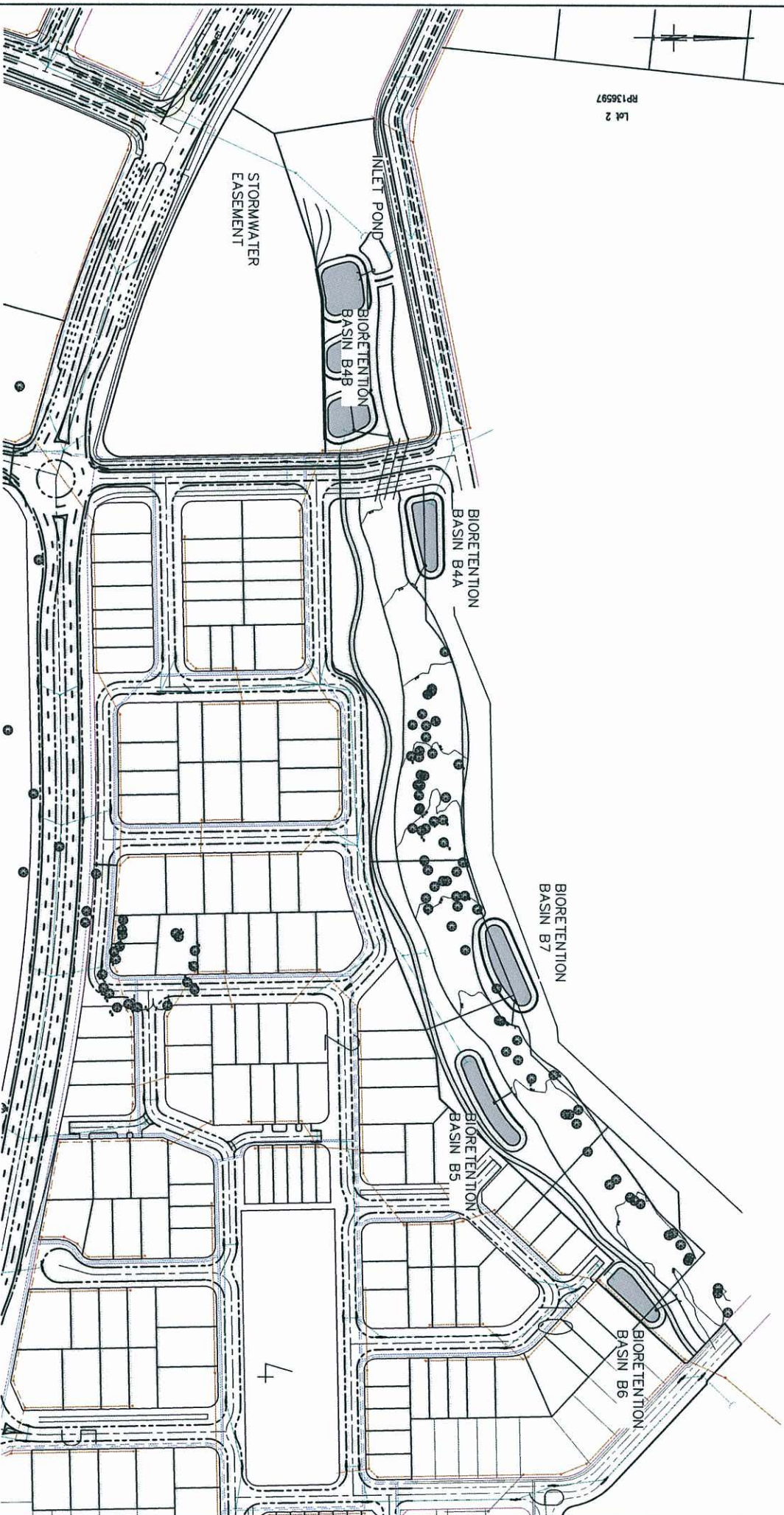
Table A7: Bioretention sensitivity reporting table

Catchment ID	Pollutant	Inflows (kg/yr)	Outflows (kg/yr)	Reduction (kg/yr)	Reduction achieved (%)	Water Quality Objective (%)
TOTAL Precinct 1	TSS	79190	15949	63241	80	80
	TP	174.6	51.2	123.3	71	60
	TN	1007.5	530.4	477.1	47	45
Total Northern Structure Plan	TSS	174970	36614	138355	77	
	TP	382.6	118.9	263.6	69	
	TN	2298.5	1177.9	1120.6	49	

APPENDIX C DETAILED BIORETENTION CONCEPTS – NORTHERN WATERWAY

YARRABILBA VILLAGE

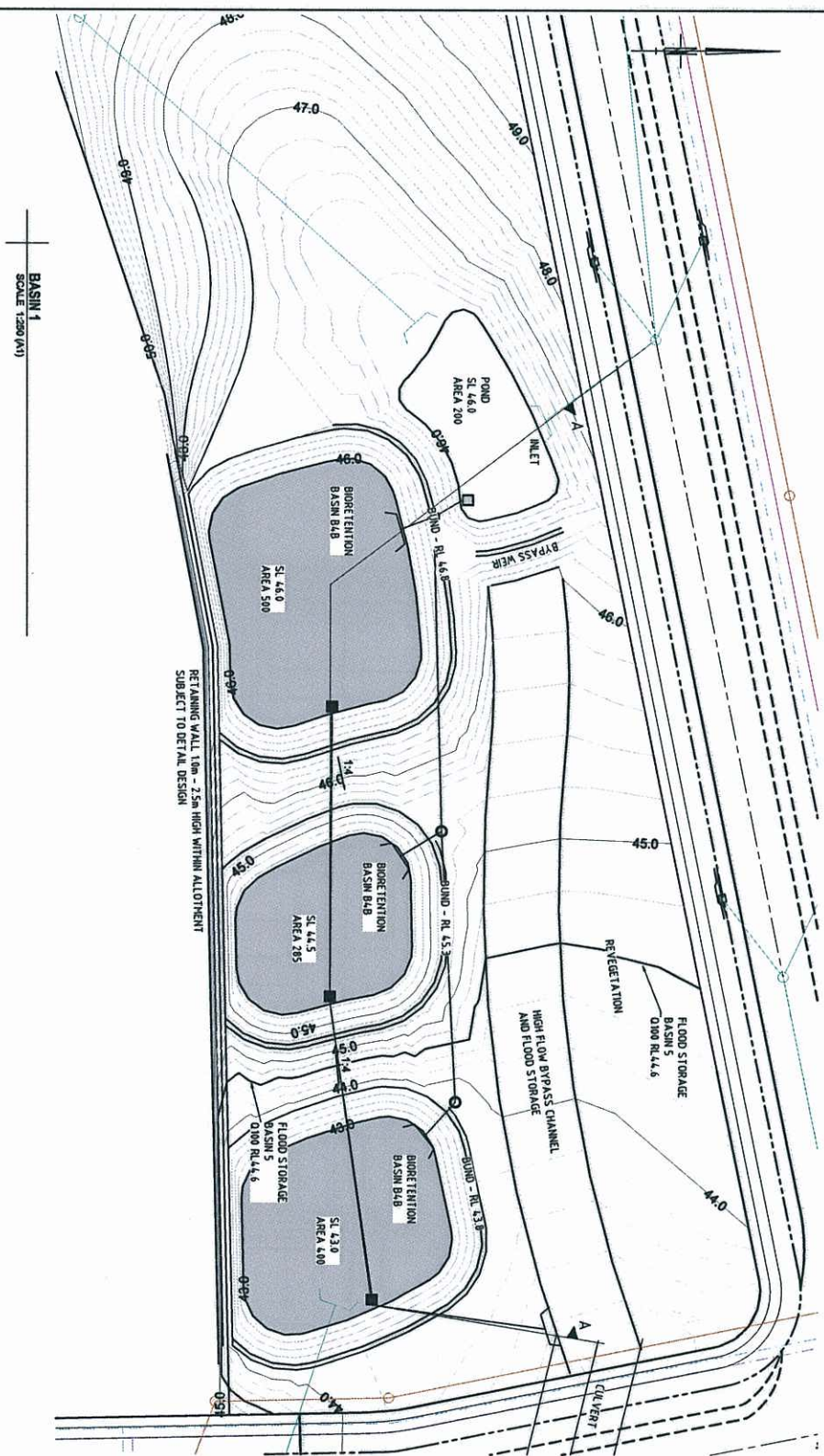
Lot 2
RP136597



SITE PLAN
SCALE 1:1000 (A1)

Client				Project			
DELFIN LEND LEASE				YARRABILBA PRECINCT 1			
Associated Consultants				NORTH VILLAGE WATERWAY			
DesignFlow				CONCEPTUAL DESIGN			
10/10/2010 10:00 AM				OVERALL PLAN			
REV. 01/03/11				DC			
REV. 01/03/11				SK-001			
REV. 01/03/11				A			

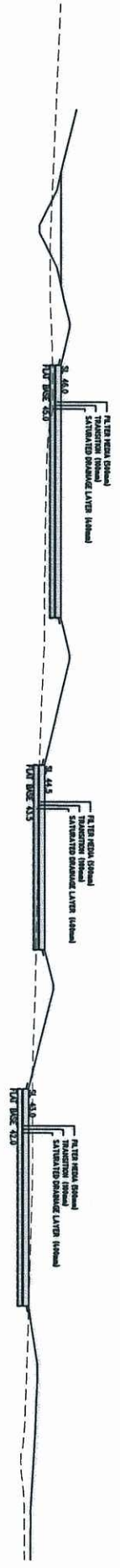
YARRABILBA VILLAGE



- NOTE**
1. THESE ARE CONCEPT DRAWINGS ONLY. SHAPE AND FUNCTION ARE TO BE REFINED AS PART OF DETAILED DESIGN FOR OPERATIONAL WORKS.
 2. STORMWATER PIPES & PITS SHOWN ARE INDICATIVE ONLY. LOCATION AND SIZE OF PIPES SUBJECT TO DETAILED DESIGN.
 3. BIORETENTION DESIGN TO BE CONSISTANT WITH WSDO DESIGN GUIDELINES FOR SOUTH EAST QUEENSLAND.
 4. BIORETENTION DESIGN TO INCLUDE PIPELAD DRAWINGS WSDO-002, WSDO-004, WSDO-005 AND WSDO-006.
 5. SURROUNDING ROAD LEVELS ARE CONCEPTUAL.
 6. ALL BATTERS TO BE 1:1 OR FLATTER AND VEGETATED.
 7. ALL DESIGN CONTOUR INTERVALS ARE 0.2m AND ALL ROAD AND NATURAL GROUND CONTOURS ARE 10m.

BASIN 1
SCALE 1:200 (A1)

SECTION A-A
1:200



Client				Project			
DELFIN LEAD LEASE				YARRABILBA PRECINCT 1			
Associated Consultants				NORTH VILLAGE WATERWAY			
DesignFlow				CONCEPTUAL DESIGN			
DESIGNER				DRAWN			
DATE				DATE			
APPROVED				APPROVED			
DATE				DATE			
REV				REV			
DESCRIPTION				DESCRIPTION			
A				A			
ORIGINAL ISSUE				ORIGINAL ISSUE			
01/03/11				01/03/11			
SL				SL			
01/03/11				01/03/11			
SK-002				SK-002			
A				A			

BIORETENTION
BASIN B/A
ST 42.0
AREA 375

EXISTING GROUND TO BE RETAINED
AND REVEGETATED

PATH

TREES TO BE RETAINED

SCALE 1"=125'

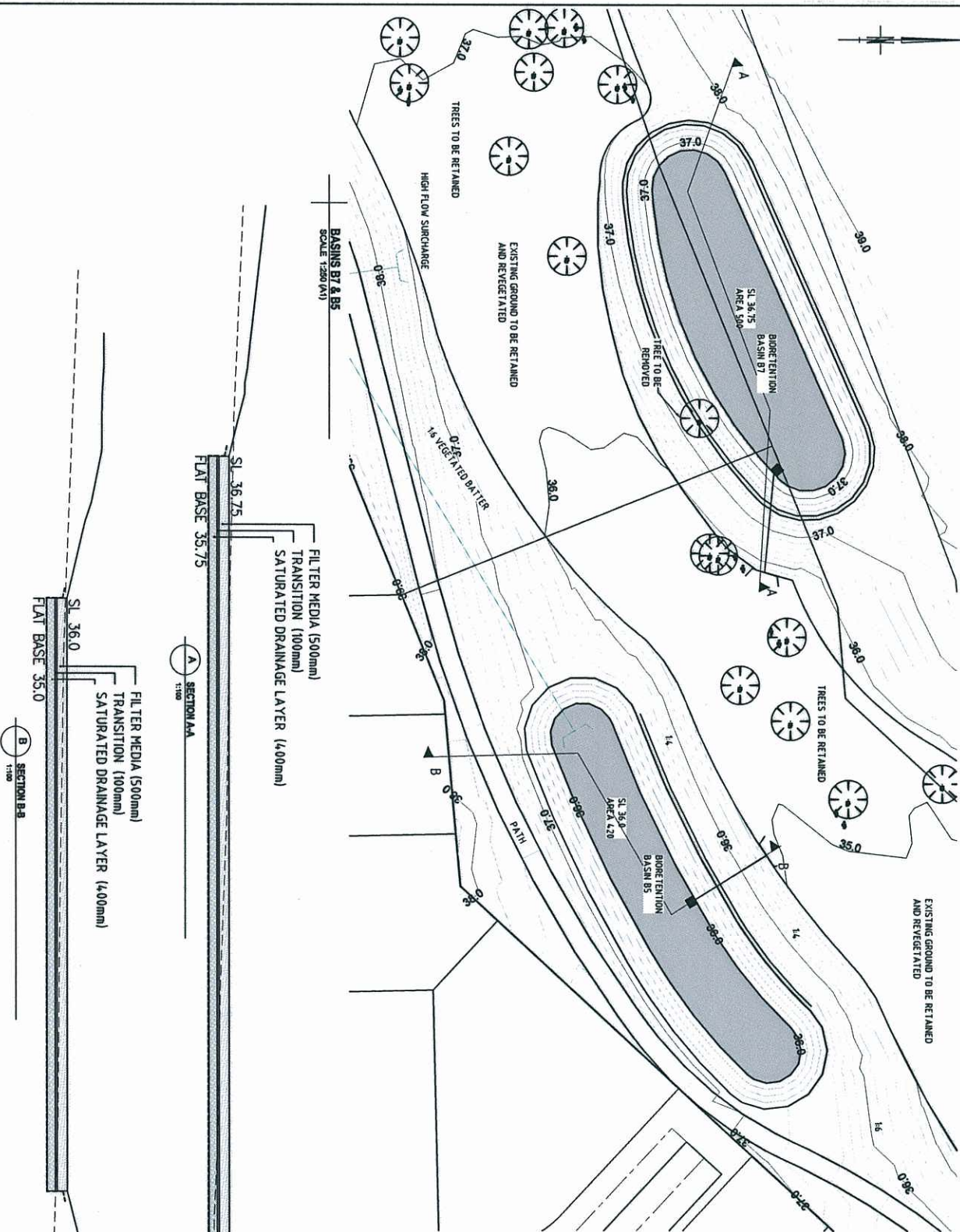
1. THESE ARE CONCEPT DRAWINGS ONLY. SHAPE AND FUNCTION ARE TO BE REFINED AS PART OF DETAILED DESIGN FOR OPERATIONAL WORKS
2. STORMWATER PIPES & PITS SHOWN ARE INDICATIVE ONLY. LOCATION AND SIZE OF PIPES SUBJECT TO DETAILED DESIGN.
3. BORE TENTION DESIGN TO BE CONSISTANT WITH WSDO DESIGN GUIDELINES FOR SOUTH EAST QUEENSLAND.
4. BORE TENTION DESIGN TO INCLUDE PIPEWAD DRAWINGS WSDO-002, WSDO-004, WSDO-005 AND WSDO-006.
5. SURROUNDING ROAD LEVELS ARE CONCEPTUAL.
6. ALL BATTERS TO BE 1:4 OR FLATTER AND VEGETATED.
7. ALL DESIGN CONTIGUOUS INTERVALS ARE 0.2m AND ALL ROAD AND NATURAL GROUND CONTOURS ARE 10m.

A cross-sectional diagram of a drainage system. The layers are labeled from top to bottom: FILTER MEDIA (500mm), TRANSITION (100mm), SATURATED DRAINAGE LAYER (400mm), SL 42.0, and PLAT BASE 41.0. The diagram shows the relative positions and thicknesses of these components.

SECTION A-A
1:100

Original sheet size A

YARRABILBA VILLAGE



- NOTE**
1. THESE ARE CONCEPT DRAWINGS ONLY. SHAPE AND FUNCTION ARE TO BE REFINED AS PART OF DETAILED DESIGN FOR OPERATIONAL WORKS.
 2. STORMWATER PIPES & PITS SHOWN ARE INDICATIVE ONLY. LOCATION AND SIZE OF PIPES SUBJECT TO DETAILED DESIGN.
 3. BIORETENTION DESIGN TO BE CONSISTANT WITH WSUD DESIGN GUIDELINES FOR SOUTH EAST QUEENSLAND.
 4. BIORETENTION DESIGN TO INCLUDE PNEUMATIC DRAINAGE WSUD-002, WSUD-004, WSUD-005 AND WSUD-006.
 5. SURROUNDING ROAD LEVELS ARE CONCEPTUAL.
 6. ALL BATTERS TO BE 1:1 OR FLATTER AND VEGETATED.
 7. ALL DESIGN CONTOUR INTERVALS ARE 0.2m AND ALL ROAD AND NATURAL GROUND CONTOURS ARE 10m.

Client				Project			
DELFIN LEND LEASE				YARRABILBA PRECINCT 1			
Associated Consultants				NORTH VILLAGE WATERWAY			
DesignFlow				CONCEPTUAL DESIGN			
DESIGNER'S NAME AND SIGNATURE AND DATE				Designed			
DATE				Drawn			
DATE				DC			
DATE				07/03/11			
DATE				Scale of A1			
DATE				AS SHOWN			
Rev.				Drawing No.			
Rev.				SK-004			
Rev.				A			

YARRALIBA PRECINCT 1



- NOTE**
1. THESE ARE CONCEPT DRAWINGS ONLY. SHAPE AND FUNCTION ARE TO BE REFINED AS PART OF DETAILED DESIGN FOR OPERATIONAL WORKS
 2. STORMWATER PIPES & PITS SHOWN ARE INDICATIVE ONLY. LOCATION AND SIZE OF PIPES SUBJECT TO DETAILED DESIGN
 3. BIORETENTION DESIGN TO BE CONSISTANT WITH WSDO DESIGN GUIDELINES FOR SOUTH EAST QUEENSLAND.
 4. BIORETENTION DESIGN TO INCLUDE PAVED DRAWINGS WSDO-002, WSDO-004, WSDO-005 AND WSDO-006.
 5. SURROUNDING ROAD LEVELS ARE CONCEPTUAL.
 6. ALL BATTERS TO BE 1:4 OR FLATTER AND VEGETATED.
 7. ALL DESIGN CONTOUR INTERVALS ARE 0.2m AND ALL ROAD AND NATURAL GROUND CONTOURS ARE 10m.

Client				Project			
DELFIN LEND LEASE				YARRALIBA PRECINCT 1			
Associated Consultants				NORTH VILLAGE WATERWAY			
DesignFlow				CONCEPTUAL DESIGN			
Approved				Designed			
Rev.				Drawn			
A				DC			
01/03/11				Date			
01/03/11				Scale of A1			
AS SHOWN				SK-005			
A				A			

APPENDIX D FLOOD STUDY – STORMWATER QUANTITY MANAGEMENT PLAN

APPENDIX D:

YARRABILBA NORTHERN DEVELOPMENT AREA

STORMWATER QUANTITY MANAGEMENT PLAN

MARCH 2011

Prepared for:

DesignFlow

REPORT NO: 1746-01-G Yarrabilba.docx

REPORT TITLE: Yarrabilba Northern Development Area Stormwater Quantity Management Plan

Revision Number	Report Date	Author	Reviewer
1	2 March, 2011	Stephen Reynolds	Steve Clark

For and on behalf of
Water Technology Pty Ltd

Stephen Reynolds
Senior Environmental Engineer

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1 INTRODUCTION

DesignFlow has requested Water Technology to undertake a flooding and water quantity management assessment of the Yarrabilba Precinct 1 and whole of catchment area for the Yarrabilba Northern Structure Plan area. This report provides a review of the key assumptions and results for the proposed flood storage basins based on XP-RAFTS modelling for the subject site. Two scenarios are considered, with the first scenario representing a fully developed catchment for the Yarrabilba Northern Structure Plan area (whole of catchment) and the second scenario representing the first proposed stage of development only (Precinct 1). Please refer to the Design Flow (2011) Stormwater Management Plan for details of the Precinct 1 development.

2 GENERAL METHODOLOGY

The XP-RAFTS hydrological model was used to model the pre and post development catchment behaviour, and to design the flood storage basins. XP-RAFTS was calibrated against the pre-development Rational Method peak discharge estimates at the downstream model boundary.

Initial estimates of post-development peak flow rates using the Rational Method were considered as being too conservative (too low) based on Water Technology's experience with similar developments in Queensland, and the XP-RAFTS generated post development flows were instead adopted as a more accurate simulation of likely post development flows on the subject site. Channel routing was effected using actual channel cross sections and the standard Muskingum-Cunge procedure within the XP RAFTS engine.

The following objectives were adopted for design of the flood storage basins:

- Preserve existing 1, 2, 5, 10, 20, 50 and 100 year ARI flow regimes at the northern boundary of the site; and
- Preserve existing 1 year ARI flows within the onsite internal water ways.

3 MODEL DEVELOPMENT

3.1 Site Layout

Figure 1 shows the proposed detention basin layout and stage-storage relationships.
Figure 2 shows the RAFTS catchment layout.

3.2 Catchment Land Use

Table 1 shows the adopted catchment physicals used in this study.

3.2.1 Existing Conditions – Northern Structure Plan

The following land uses were adopted for the pre-development scenario:

- The existing developed areas north of the development (RAFTS catchments 4 and 18) are rural residential (20% impervious); and
- The remainder of the catchment area is undeveloped (0% impervious).

3.2.2 Developed Conditions – Northern Structure Plan

- The small area west of the Waterford-Tamborine Road (RAFTS catchment 00) remains undeveloped (0% impervious);

- The existing developed areas north of the development (RAFTS catchments 4 and 18) remain rural residential (20% impervious); and
- The remainder of the entire development area within the catchment (i.e. not just Precinct 1) was developed to an average density of 15 lots/ha and some commercial zones (60% impervious).

3.2.3 Developed Conditions – Precinct 1

The whole of catchment land use parameters for the following catchments were adjusted to simulate development of Precinct 1 catchment areas only as part of a staged approach to development:

- Catchments B1, B3, 10 & 14-16 – revert to undeveloped conditions;
- Catchment 08 – 13.26 ha developed / 1.87 ha undeveloped;
- Catchment 09 – 11.1 ha developed / 12.01 ha undeveloped;
- Catchment 12 – 0.9ha developed / 16.07 ha undeveloped; and
- The remainder of the catchments remained unchanged from the whole of catchment post development scenario.

3.3 Model Calibration

Table 2 provides the key assumptions for the Rational Method and RAFTS modelling. **Table 4** through **Table 6** provides a comparison of the post development versus pre-development flows for both unmitigated and mitigated scenarios (Northern Structure Plan and Precinct 1). Channel routing in both the pre-development and post development models was effected by using representative channel and flood plain cross sections extracted from the available survey. The survey data was interrogated to determine channel slopes for each representative channel link, and the XP RAFTS engine was used to calculate routing parameters using the standard Muskingum-Cunge procedure. This routing approach ensures that selection of routing parameters is based on actual cross section data and site topography.

Primary focus was given to ensuring that the pre-development XP RAFTS model matched the Rational Method peak flow estimates for the full range of ARI storm events. A 100 year ARI pre-development Rational Method peak flow of **59.1 m³/s** at the downstream model boundary was adopted as the design flow for calibration purposes. This equates to 0.23 m³/s/ha and is considered appropriate for the pre-development environment. The XP RAFTS predevelopment model was calibrated to within 10% of the Rational Method figures for all modelled ARI storm events. The 100 year XP RAFTS predevelopment peak flow was modelled at 62.1 m³/s.

The initial Rational Method estimate of post-development peak flow of 77 m³/s was considered as being too low, and the pre-development calibrated XP RAFTS model was updated to simulate the post development environment and used to provide a more realistic estimate of likely unmitigated post development flows. An XP RAFTS generated post development unmitigated design peak flow of **101.6 m³/s** equates to 0.40 m³/s/ha and is considered an appropriate conservative figure for the fully developed scenario.

3.4 Detention Basins

Six detention basins were included in the design. Five internal catchment basins (B1 – B5) provide distributed detention and storage in upper catchment areas, while a larger downstream basin (B6) has been positioned in the vicinity of the proposed wetland treatment area. A combination of standard dimension circular culvert pipes and box culverts was used to manage outflows from the basins. Basin 6 represents the ultimate downstream discharge point from the subject site.

All six basins were modelled for the whole of catchment development scenario, while iterative model runs for Precinct 1 conditions confirmed that Basins 3 and 6 were not required to maintain an acceptable post development hydrological regime for the Staged development approach. **Table 3** provides a summary of the key assumptions and results for basin modelling at the subject site under all simulated scenarios

4 RESULTS

4.1 Modelled Basin Performance

Table 3 provides a summary of the modelled basin water levels for each of the design ARI storms. Where possible, a maximum design water depth of 1.5m for the 100 year ARI storm event was targeted. Under the whole of catchment (fully developed) scenario, this design water level target was achieved for Basin 1 (1.44m) and Basin 3 (1.49m), while Basin 5 (1.60m), Basin 4 (1.73m) and Basin 6 (1.75m) were marginally above the preferred maximum water level. The maximum water level in Basin 2 (2.39m) is above the preferred design level. Various combinations of weir widths, weir heights and culvert configurations were tested to determine the basin configuration that minimised the water levels in Basin 2 while ensuring that 1 year ARI post-development outflows from the basin do not greatly exceed the pre-development flows. Under the whole of catchment scenario, with a weir height of 1.5m, Basin 2 receives runoff from just under 75ha of developed land and is rapidly filled during the 1 year storm to a height of 1.79m. Twin 300mm x 300mm box culverts, in conjunction with the 1.5m weir, effectively control the 1 year flows to around 120% of the pre-development flows.

Dropping the maximum water level further in Basin 2 will necessitate the release of additional flows for all ARI events and will push the post-development 1 year flows to in excess of 250% of pre-development flows for the immediate downstream reach between Basin 2 and Basin 1. As a result of this limitation, it is not considered practical to limit the water level in Basin 2 to 1.5m. Note that review of the hydrograph for Basin 2 shows that water levels are in excess of 1.5m for approximately 1.5 hours during the peak of the 100 year event. Under Precinct 1 staged development conditions, Basins 3 and 6 are not required. **Table 3** also provides a summary of the modelled basin water levels in Basins 1, 2, 4 and 5 for each of the design ARI storms for the Precinct 1 scenario.

It is understood that Basin 2 is to be located within an area that includes existing vegetation that is to be retained, and in which revegetation will take place. It is further understood that engineering batter design for Basin 2 will provide for ease of access and egress from the basin.

4.2 Detention Basins

Table 3 shows the adopted basin design details and peak water depths for the full range of ARI storm events for all basins under both the Northern Structure Plan (fully developed) and Precinct 1 (staged development) scenarios. **Table 4**, **Table 5** and **Table 6** show the comparison of pre and post development (mitigated) discharges at each basin location (including the DS Basin location) for the modelled scenarios.

4.3 Flood Extents

A HEC-RAS model has been constructed for the subject site based on available survey and contour data. The whole of catchment (fully developed) scenario was used as the basis for determining the 100 year flood extents for the subject site. **Figure 3** shows the 100 year ARI flood extent for the site. **Figure 4** provides the HEC-RAS channel cross section locations, while **Figure 5** provides the 100 year ARI post development water level, flow and velocity outputs at each modelled node from the HEC-RAS modelling.

Table 1 Yarrabilba Catchment Parameters

Name	Area (ha)	Average Slope (%)	RAFTS Impervious % (Pre / Post)
00	4.7	4.06	0 / 0
B5	15.24	4.06	0 / 50
B4	21.64	2.25	0 / 50
B3	21.36	2.0	0 / 50
04	13.87	1.41	20 / 20
06	8.76	4.74	0 / 50
07	19.84	3.23	0 / 50
08	15.13	2.49	0 / 50
09	23.11	3.37	0 / 50
10	8.04	4.66	0 / 50
12	16.97	2.4	0 / 50
B1	13.17	1.8	0 / 50
14	23.09	0.93	0 / 50
15	18.71	3.2	0 / 50
16	11.91	1.61	0 / 50
18	18.00	1.26	20 / 20
Total	253.54		

Table 2 Adopted Rational Method and RAFTS Parameters *(refer Table 6 for Modelled Peak Flows)

	Land Use		
	Undeveloped	Rural Residential	Fully Developed
<u><i>Rational Method</i></u>			
Imperviousness (%)	0	20	60
Runoff Coeff. C_{10}	0.62	0.68	0.79
<u><i>RAFTS</i></u>			
Modelled Impervious (%)	0	20	50
IL – 1+2yr (mm)	8.0	6.8	6.5
CL – 1+2yr (mm/hr)	2.25	1.65	1.5
IL – 5yr (mm)	7.5	5.9	5.5
CL – 5yr (mm/hr)	2.25	1.65	1.5
IL – 10yr (mm)	7.0	4.6	4.0
CL – 10yr (mm/hr)	2.25	1.65	1.5
IL – 20yr (mm)	6.5	3.9	3.25
CL – 20yr (mm/hr)	2.25	1.65	1.5
IL – 50yr (mm)	4.5	2.9	2.5
CL – 50yr (mm/hr)	2.0	1.2	1.0
IL – 100yr (mm)	3.0	2.2	2.0
CL – 100yr (mm/hr)	2.0	1.2	1.0

Table 3 Adopted Basin Design Details

Basin Parameter	Basin No					
	5	4	3	2	1	6 ¹
Spillway Height (m)	1.0	1.0	0.8	1.5	0.45	0.9
Spillway Width (m)	10	20	20	22.5	10	30
<i>Lower Level Pipes (at basin floor)</i>						
• Diameter (m)	0.45	0.45	0.60	0.3 x 0.3	0.45	1.2 x 0.9
• No of Pipes / Box Culverts	2	2	3	2	1	5
• Upstream invert above stream invert (m)	0	0	0	0	0	0
<i>Upper Level Pipes (300mm above floor)</i>						
• Diameter (m)	0.45	0.6	-	-	-	-
• No of Pipes	1	3	-	-	-	-
• Upstream invert (m)	0.3	0.3	-	-	-	-
<u><i>Northern Structure Plan Area</i></u>						
Q1Peak Water Depth (m)	1.10	1.14	0.98	1.79	0.74	0.99
Q5 Peak Water Depth (m)	1.34	1.43	1.20	2.06	1.04	1.31
Q10 Peak Water Depth (m)	1.40	1.50	1.26	2.13	1.13	1.40
Q20 Peak Water Depth (m)	1.48	1.57	1.33	2.22	1.23	1.52
Q50 Peak Water Depth (m)	1.54	1.57	1.68	2.31	1.35	1.63
Q100 Peak Water Depth (m)	1.60	1.73	1.49	2.39	1.44	1.75
<u><i>Precinct 1 Staged Scenario</i></u>						
Q1Peak Water Depth (m)	1.10	1.14	-	1.74	0.69	-
Q5 Peak Water Depth (m)	1.34	1.43	-	1.99	0.97	-
Q10 Peak Water Depth (m)	1.40	1.50	-	2.06	1.04	-
Q20 Peak Water Depth (m)	1.48	1.57	-	2.14	1.14	-
Q50 Peak Water Depth (m)	1.54	1.57	-	2.23	1.25	-
Q100 Peak Water Depth (m)	1.60	1.73	-	2.31	1.34	-

Notes: 1) Downstream basin at site boundary

Table 4 XP RAFTS Pre & Post Development Discharges – Basin Locations 5 & 4

Basin 5 Location					Basin 4 Location				
ARI	Peak Discharge (m3/s)				ARI	Peak Discharge (m3/s)			
	RAFTS Existing	Developed	Mitigated	Difference (m3/s)		RAFTS Existing	Developed	Mitigated	Difference (m3/s)
Northern Structure Plan Area					Northern Structure Plan Area				
1	1.63	3.54	1.78	0.15	1	2.77	6.92	2.71	0.06
2	2.45	4.87	3.11	0.66	2	4.16	9.38	5.11	0.95
5	3.46	6.46	4.81	1.47	5	5.95	11.98	8.18	2.40
10	4.10	7.33	5.83	1.85	10	7.04	13.44	9.99	3.09
20	5.00	8.57	7.18	2.26	20	8.57	16.32	11.85	3.41
50	6.08	9.68	8.37	2.45	50	10.63	18.54	14.89	4.1
100	7.05	10.95	9.55	2.50	100	12.44	20.86	16.76	4.32
Precinct 1 – Basins 1, 2, 4 & 5 Active					Precinct 1 – Basins 1, 2, 4 & 5 Active				
1	1.63	3.54	1.78	0.15	1	2.77	6.92	2.71	0.06
2	2.45	4.87	3.11	0.66	2	4.16	9.38	5.11	0.95
5	3.46	6.46	4.81	1.35	5	5.95	11.98	8.18	2.23
10	4.10	7.33	5.83	1.73	10	7.04	13.44	9.99	2.95
20	5.00	8.57	7.18	2.18	20	8.57	16.32	11.85	3.28
50	6.08	9.68	8.37	2.29	50	10.63	18.54	14.89	4.26
100	7.05	10.95	9.55	2.50	100	12.44	20.86	16.76	4.32

Note: "red" numerals indicate post development discharge > predevelopment discharge

Table 5 XP RAFTS Pre & Post Development Discharges – Basin Locations 3 & 2

Basin 3 Location					Basin 2 Location				
ARI	Peak Discharge (m3/s)				ARI	Peak Discharge (m3/s)			
	RAFTS Existing	Developed	Mitigated	Difference (m3/s)		RAFTS Existing	Developed	Mitigated	Difference (m3/s)
	Northern Structure Plan Area					Northern Structure Plan Area			
1	3.82	9.57	3.41	0.41	1	5.18	13.70	6.22	1.04
2	5.78	12.98	6.01	0.23	2	7.79	18.86	10.75	2.96
5	8.27	16.69	9.68	1.41	5	11.05	25.27	16.69	5.64
10	9.80	19.15	11.82	2.02	10	13.10	28.58	19.88	6.78
20	11.94	22.72	14.33	2.39	20	15.99	32.99	24.19	8.20
50	14.92	25.97	15.94	1.02	50	19.82	36.70	28.68	8.86
100	17.54	29.33	20.99	3.45	100	23.10	41.07	32.97	9.87
Precinct 1 – Basins 1, 2, 4 & 5 Active					Precinct 1 – Basins 1, 2, 4 & 5 Active				
1	3.82	7.55	3.75	0.07	1	5.18	11.08	5.06	0.12
2	5.78	10.41	6.66	0.88	2	7.79	15.15	8.85	1.06
5	8.27	13.75	10.41	2.14	5	11.05	20.48	14.11	3.06
10	9.80	15.56	12.50	2.70	10	13.10	23.32	16.69	3.59
20	11.94	18.76	14.94	3.00	20	15.99	27.51	20.41	4.42
50	14.92	21.68	18.72	3.80	50	19.82	31.38	24.66	4.84
100	17.54	24.70	21.53	3.99	100	23.10	35.50	28.60	5.50

Note: "red" numerals indicate post development discharge > predevelopment discharge

ARI	Basin 1 Location				ARI	Basin 6 Location (Discharge Outlet From Site)				
	Peak Discharge (m3/s)			Difference (m3/s)		Peak Discharge (m3/s)			Difference (m3/s)	
	RAFTS Existing	Developed	Mitigated			Rational Method Existing	RAFTS Existing	Developed		Mitigated
	Northern Structure Plan Area					Northern Structure Plan Area				
1	6.78	16.81	5.65	1.13	1	14.9	13.38	31.51	7.82	5.56
2	10.21	22.85	9.95	0.26	2	20.3	20.44	43.88	15.20	5.24
5	14.54	30.74	15.99	1.45	5	28.4	29.21	58.61	25.41	3.80
10	17.35	34.97	19.34	1.99	10	33.4	35.02	67.09	31.38	3.64
20	21.09	40.73	23.75	2.66	20	40.1	42.00	79.22	39.24	2.76
50	26.32	44.74	29.28	2.96	50	51.1	53.37	88.27	47.23	6.14
100	30.67	51.41	34.08	3.41	100	59.1	62.13	101.64	56.47	5.66
	Precinct 1 – Basins 1, 2,4 & 5 Active					Precinct 1 – Basins 1, 2,4 & 5 Active				
1	6.78	11.52	4.32	2.46	1	14.9	13.38	21.16	9.03	4.35
2	10.21	16.33	8.09	2.12	2	20.3	20.44	31.27	15.94	4.5
5	14.54	22.26	13.29	1.25	5	28.4	29.21	41.41	26.88	2.33
10	17.35	25.48	15.98	1.37	10	33.4	35.02	49.84	32.71	2.31
20	21.09	30.37	19.86	1.23	20	40.1	42.00	59.66	40.36	1.64
50	26.32	35.04	24.99	1.33	50	51.1	53.37	69.81	52.45	0.92
100	30.67	39.94	29.26	1.41	100	59.1	62.13	79.88	61.17	0.96

Note: "red" numerals indicate post development discharge > predevelopment discharge

Table 7 XP RAFTS Pre & Post Development Discharges – Culgoa Crescent

Downstream Location – Culgoa Crescent (XP-RAFTS Node 18)					
ARI	Peak Discharge (m3/s)				
	RAFTS Existing	Developed	Mitigated	Difference (m3/s)	
	Northern Structure Plan Area				
1	14.04	33.05	8.07	5.97	
2	21.49	46.16	15.56	5.93	
5	30.70	61.82	26.39	4.31	
10	36.98	70.89	32.65	4.33	
20	44.21	83.70	40.89	3.32	
50	56.43	93.56	49.37	7.06	
100	65.63	107.76	59.18	6.45	
Precinct 1 – Basins 1, 2, 4 & 5 Active					
1	14.04	22.47	9.29	4.75	
2	21.49	33.31	16.53	4.96	
5	30.70	44.03	28.11	2.59	
10	36.98	53.17	34.26	2.72	
20	44.21	63.59	42.43	1.78	
50	56.43	74.51	55.29	1.14	
100	65.63	85.26	64.54	1.09	

Figure 1 Detention Basin Layout and Stage Storage Relationships (from Design Flow)

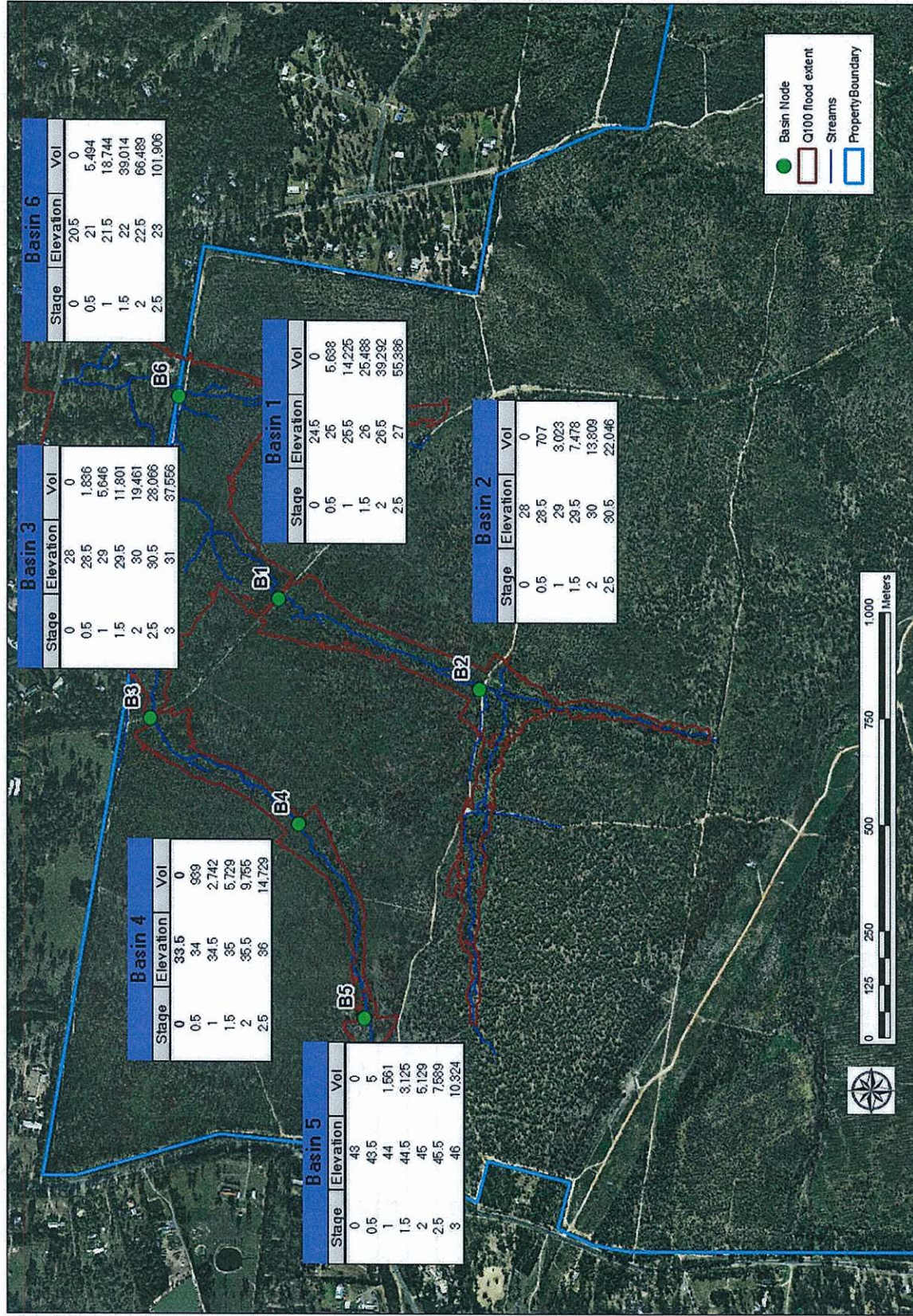


Figure 2 RAFTS Catchment Diagram

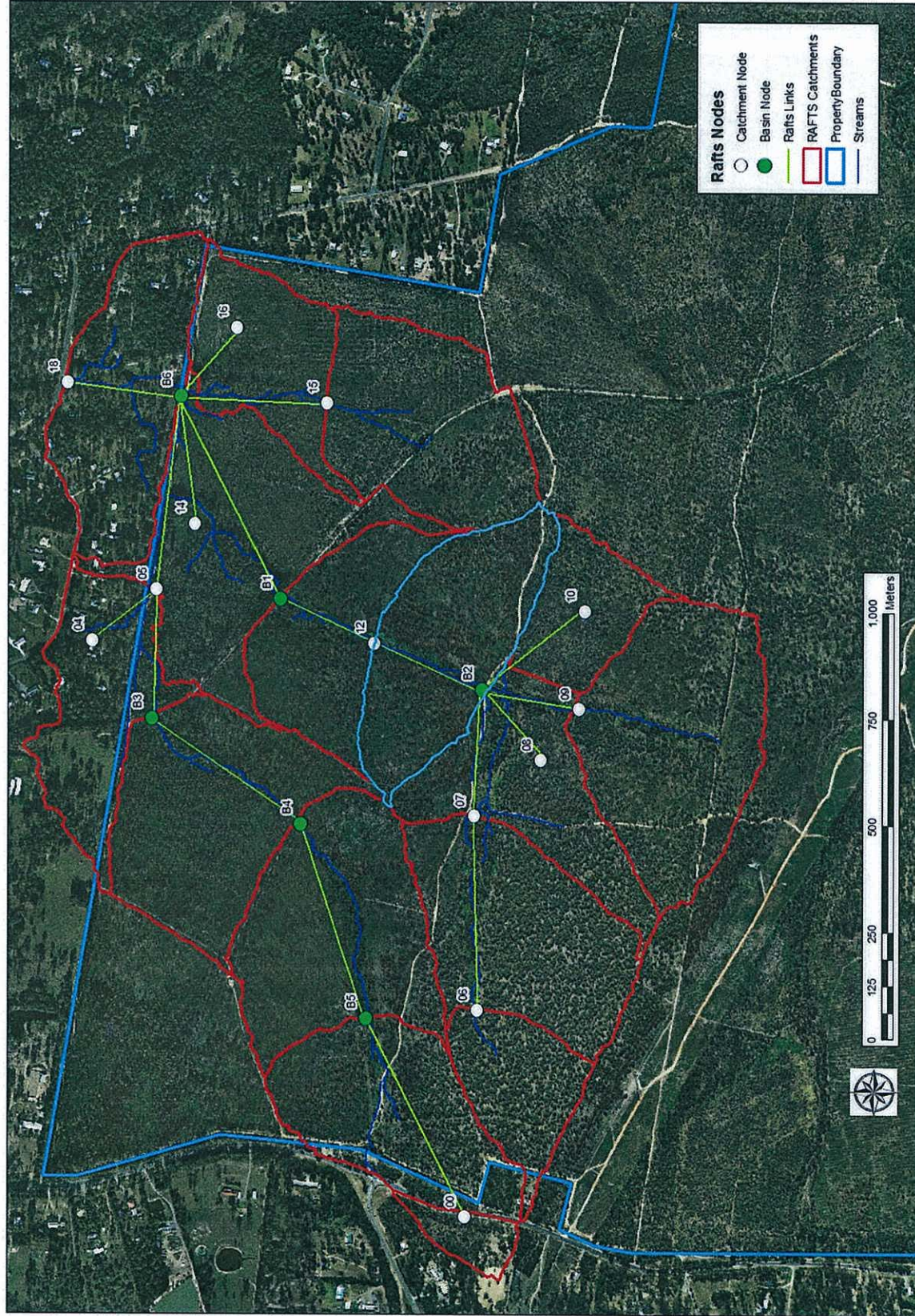


Figure 3 100 Year ARI Flood Extent Whole Catchment

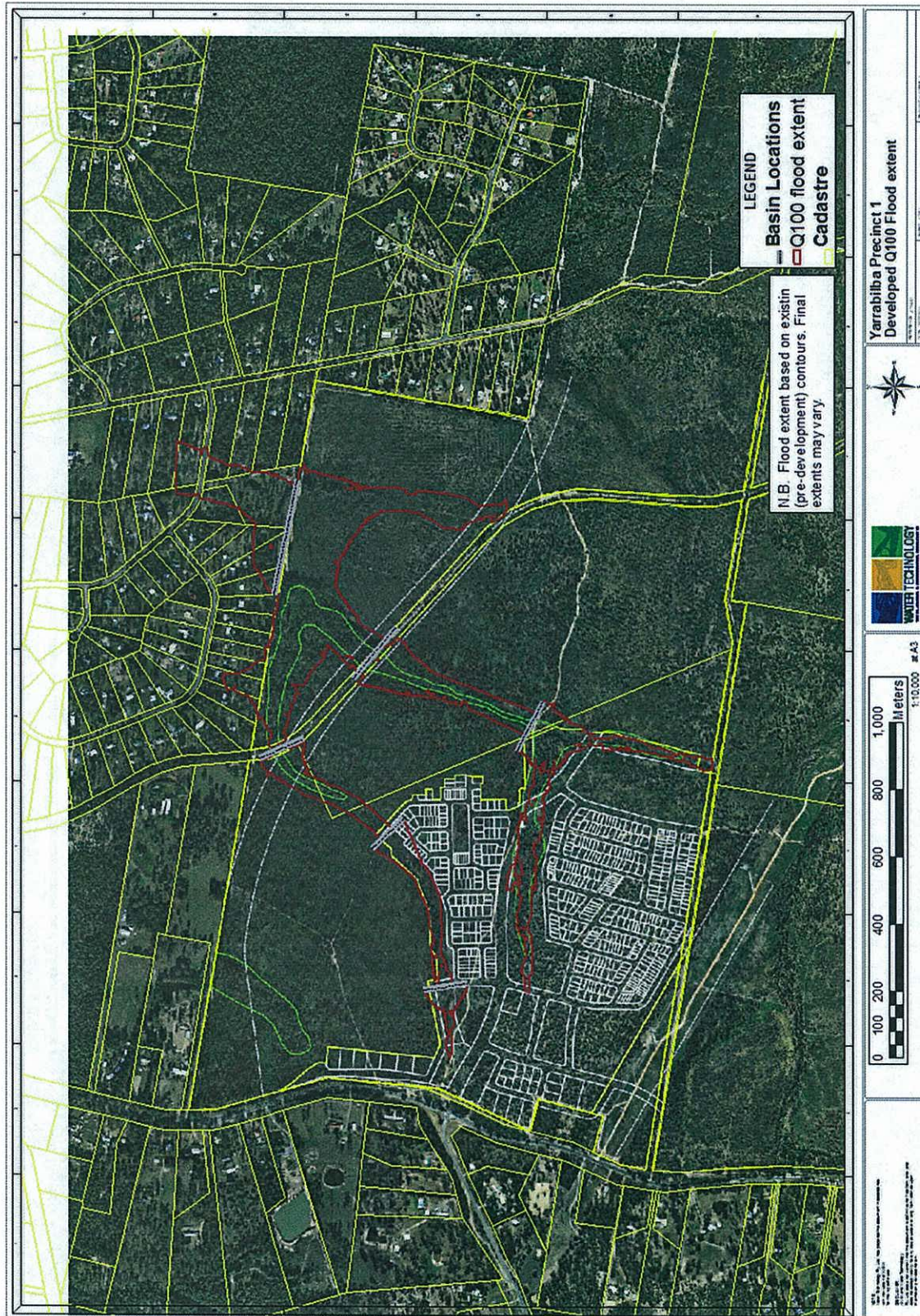


Figure 4 HEC-RAS Cross Section Locations

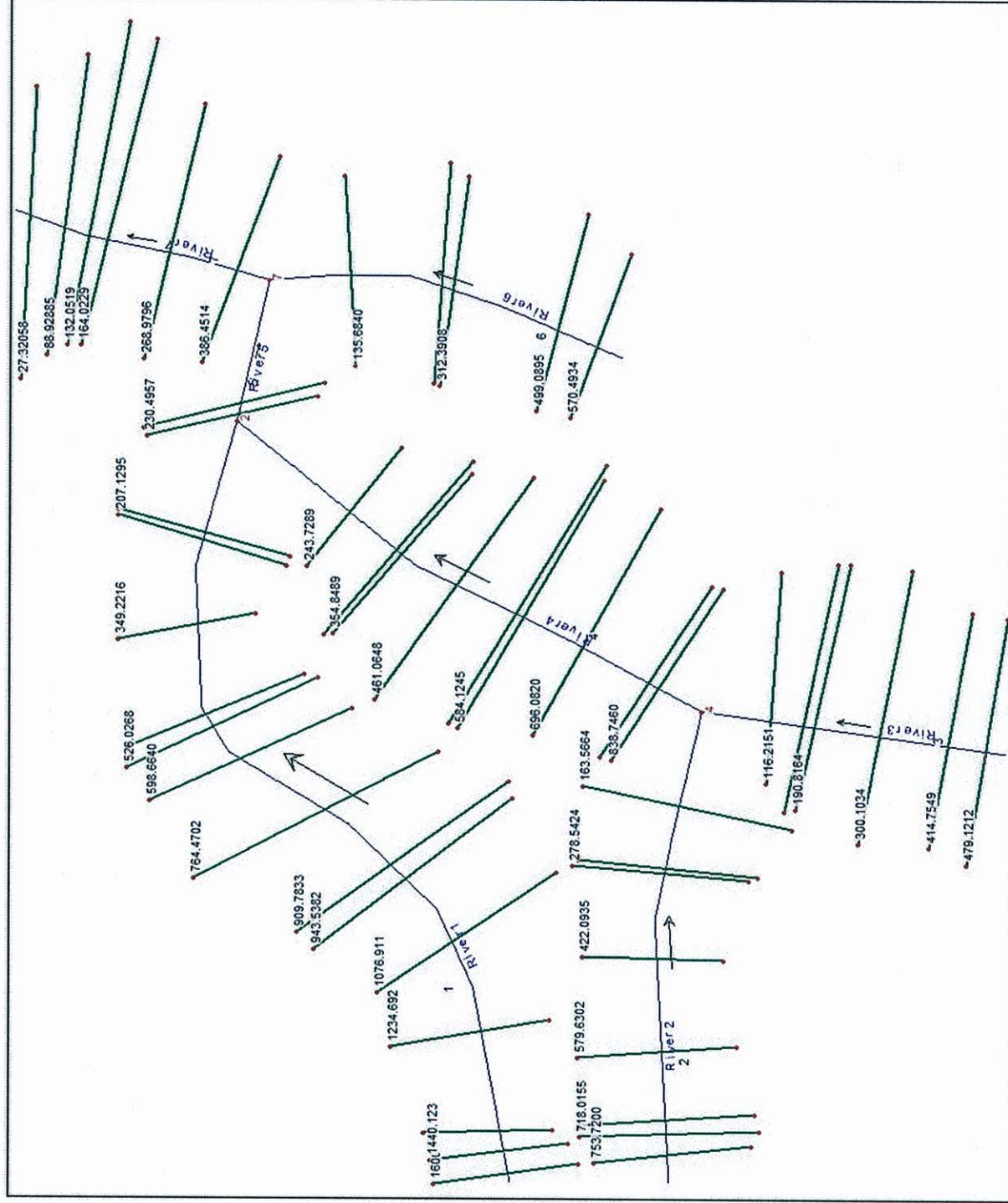


Figure 5 HEC-RAS Output Table 100 year ARI Whole Catchment

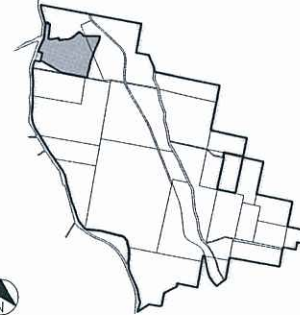
River	Reach	River Station	Q Total (m ³ /s)	Min Channel Elevation (m)	W.S. Elevation (m)	E.G. Elevation (m)	E.G. Slope (m/m)	Channel Velocity (m/s)	Flow Area (m ²)	Top Width (m)	Froude Number
River7	7	386.4514	67.07	20.04	20.7	19.67	0.008483	0.78	85.93	187.99	0.37
River7	7	268.9796	56.47	18.55	19.64	18.55	0.009750	0.82	68.48	153.07	0.39
River7	7	164.0229	56.47	17.73	18.85	18.85	0.005937	0.77	73.1	124.24	0.32
River7	7	132.0519	56.47	17.41	18.57	18.62	0.011685	0.98	57.67	114.01	0.44
River7	7	88.92885	56.47	17.16	18.23	18.26	0.006088	0.73	77.09	144.62	0.32
River7	7	27.32058	56.47	16.85	17.63	17.67	0.016801	0.95	59.2	160.01	0.5
River6	6	570.4934	10.88	31.95	32.35	32.4	0.033788	0.94	11.55	53.73	0.65
River6	6	499.0895	10.88	28.26	28.63	28.73	0.087217	1.35	8.05	44.35	1.01
River6	6	312.3908	10.88	23.38	23.9	23.92	0.009697	0.6	18.14	65.17	0.36
River6	6	291.474	10.88	23.03	23.36	23.45	0.088640	1.3	8.37	49.56	1.01
River6	6	135.684	17.13	20.98	21.74	21.75	0.004951	0.54	32	82.25	0.27
River5	5	230.4957	62.20	19.92	21.81	21.83	0.002631	0.53	118.17	193.58	0.22
River5	5	212.7761	62.20	20.22	21.76	21.77	0.003103	0.54	115.71	208.02	0.23
River4	4	838.746	41.07	27.68	28.57	28.63	0.014464	1.08	38.07	76.49	0.49
River4	4	820.0751	32.97	27.55	28.4	28.43	0.006855	0.78	42.24	78.76	0.34
River4	4	696.082	32.97	26.31	27.48	27.52	0.007872	0.89	37.21	63.58	0.37
River4	4	584.1245	32.97	25.4	26.62	26.66	0.007646	0.86	38.44	67.47	0.36
River4	4	570.1072	38.35	25.37	26.39	26.47	0.022522	1.27	30.27	66.54	0.6
River4	4	461.0648	38.35	24.46	25.52	25.55	0.004310	0.68	56.18	90.38	0.28
River4	4	354.9489	41.14	24.14	24.99	25.01	0.005909	0.68	60.24	122.73	0.31
River4	4	343.8894	34.08	24.15	24.93	24.95	0.005342	0.62	55.37	122.25	0.29
River4	4	243.7289	34.08	23.13	23.47	23.58	0.083095	1.45	23.55	112.96	1.01
River3	3	479.1212	2.00	40.35	40.49	40.53	0.110989	0.94	2.13	24.24	1.01
River3	3	414.7549	2.00	38.05	38.4	38.42	0.012890	0.46	4.32	28.34	0.38
River3	3	300.1034	2.00	34.94	35.19	35.26	0.093843	1.2	1.66	11.53	1.01
River3	3	190.8164	13.37	32.25	33.04	33.07	0.009224	0.76	17.5	42.05	0.38
River3	3	171.6218	13.37	31.88	32.83	32.86	0.013045	0.8	16.63	48.01	0.44
River3	3	116.2151	13.37	30.78	31.26	31.42	0.071759	1.78	7.52	23.68	1.01
River2	2	753.72	5.59	47.06	47.74	47.78	0.015909	0.89	6.31	18.2	0.48
River2	2	718.0155	5.59	46.23	46.57	46.66	0.086253	1.37	4.09	22	1.01
River2	2	694.4421	5.59	45.31	45.91	45.93	0.010731	0.64	8.72	30.56	0.38
River2	2	579.6302	5.59	42.74	43.09	43.18	0.093465	1.28	4.38	27.73	1.02
River2	2	422.0935	5.59	39.05	39.44	39.45	0.008579	0.39	14.5	92.22	0.31
River2	2	278.5424	15.15	34.66	35.09	35.17	0.063960	1.21	12.55	64.91	0.88
River2	2	269.4884	15.15	33.89	34.93	34.96	0.010739	0.67	22.69	74.72	0.39
River2	2	169.5664	15.15	31.78	32.35	32.47	0.085054	1.5	10.09	46.58	1.03
River1	1	1600	1.91	42.92	44.18	44.18	0.000076	0.07	26.61	60.95	0.03
River1	1	1477.778	10.95	42.92	43.91	43.95	0.017938	0.85	12.89	43.49	0.5
River1	1	1440.123	9.55	42.19	42.95	43	0.040607	1	9.59	47.1	0.7
River1	1	1406.069	9.55	41.49	42.32	42.34	0.011099	0.64	15.03	54.75	0.39
River1	1	1234.692	9.55	37.79	38.11	38.2	0.086325	1.38	6.94	36.99	1.01
River1	1	1076.911	9.55	34.44	35.31	35.33	0.005902	0.56	16.95	46.05	0.3
River1	1	943.5382	18.34	32.9	33.77	33.82	0.017659	1	18.42	48.34	0.51
River1	1	909.7833	16.76	32.5	33.34	33.37	0.009813	0.8	21.06	49.85	0.39
River1	1	764.4702	16.76	30.7	31.13	31.18	0.026078	0.94	17.75	67.73	0.59
River1	1	598.664	16.76	28.06	28.85	28.88	0.008542	0.74	22.56	53.33	0.36
River1	1	526.0268	22.62	27.38	28.08	28.12	0.012329	0.86	26.41	66.47	0.43
River1	1	502.4145	21.00	27.04	27.6	27.67	0.033937	1.19	17.6	57.63	0.69
River1	1	349.2216	21.00	24.48	25.63	25.64	0.006907	0.51	41.47	148.58	0.31
River1	1	207.1295	29.21	23.53	24.3	24.32	0.011778	0.66	44.45	160.54	0.4
River1	1	194.0955	29.21	23.48	23.92	23.99	0.085802	1.22	23.94	151.78	0.98

Attachment 4 – Amended Road Cross Sections

DO NOT SCALE THIS DRAWING
IF IN DOUBT - ASK!



KEY PLAN



REVISIONS

No	Description	Date	By
A	COUNCIL APPROVAL	15/11/10	GBG

Client



Project

Yarrabilba
A COMPLETE TOWN, A BETTER OUTCOME

YARRABILBA
RESIDENTIAL PRECINCT



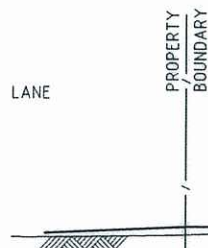
LEVEL 2 - 71 GREY STREET
SOUTH BRISBANE
QUEENSLAND 4101
PHONE 07 3017 1900
FAX 07 3017 1911
EMAIL kng@knpl.com.au
ABN 35 112 053 611

Approved Director - RPEQ 1988

Drawing Title

TYPICAL EARTHWORKS
SECTIONS

Drawn SM	Designed JB	Checked GBG	Date NOV 10
Scale NTS	PW No	Sheet 42 of 42	Revision
A3	Drawing No 10-175-42	Revision A	



TYPICAL LOT FR

RFACE

RFACE

BOUNDARY

BOUNDARY

1 IN

LOT

LOT

1 IN 100

LOT

LANE

Attachment 5 – Yarrabilba Traffic Impact Assessment Precinct One

