PLANS AND DOCUMENTS
referred to in the ULDA
APPROVAL dated 23/12/11

Paradise Waters
Deebing Heights
Precinct A

Stormwater Management Plan

DesignFlow
Prepared for Stockland
October 2010

Document Control Sheet

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Inherent natural variability in soils and plants
Where particular types of soils are recommended, such recommendations are based on information provided by soils suppliers, laboratories and published industry guidelines. There can be inconsistencies in the behaviour of soils under field conditions compared to laboratory conditions, and, for both natural and blended soils, many soils are non-homogenous and properties and behaviour can be variable. Where particular plant species have been recommended, such recommendations are based on botanical knowledge and observations of similar species growing in similar, but not identical conditions. Plants can be sensitive to subtle changes in climate, hydrology, soil and surrounding ecological conditions. Further to this, plant health is often closely linked to the level of maintenance provided. No warranty or guarantee, whether explicit or implied is made with respect to the suitability or performance of soils or plant species recommended in this report

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1 INTRODUCTION

The Paradise Waters development is located within Precinct 7 of the Ripley Valley Urban Development Area Interim Land Use Plan as defined by the Urban Land Development Authority (ULDA) pursuant to the *Urban Land Development Authority Act 2009*. This land being located on South Deebing Creek Road, Deebing Heights. As indicated in Figure 1, the site sits either side of the upper reaches of Deebing Creek. The site is owned by Stockland Developments and the intention is to create a residential development characterized by its natural environment that achieves a diverse and healthy community drawing upon innovative design initiatives.

As part of Stockland's commitment to environmental sustainability, the Paradise Waters residential development is to be guided by the 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 Stockland commissioned DesignFlow to develop a WSUD Strategy for the Paradise Waters development with the objective of ensuring that all forms of development incorporate WSUD controls to minimise any impact on the adjacent aquatic ecosystems. This report presents the Stormwater Management Strategy for Precinct A of the development (refer Figure 1). **The document focuses primarily on stormwater quality treatment and frequent flow management.** Stormwater quantity and flood management is dealt with by the *Flood Management Plan - Paradise Waters Precinct A* (Water Technology, 2010). Initial waterway stabilisation assessment has been undertaken and is provided in *Preliminary Waterway Stability Assessment – Paradise Waters Precinct A* (DesignFlow and Water Technology, November, 2010).

The following sections of the document outline:

- site context and characteristics (Section 2)
- quantitative design objectives adopted for the site (Section 3)
- stormwater quality management strategy proposed (Section 4)
- quantitative MUSIC modelling assessment undertaken to confirm the strategy meets the proposed objectives (section 6).

The stormwater management strategy has been established on the basis of delivering sound urban design and landscape outcomes through collaboration with the urban designers. The WSUD principles adopted support the requirements outlined in the *Ripley Valley Urban Development Area Interim Land Use Plan* and are consistent with the *Ripley Valley Structure Plan, SEQ Regional Plan Implementation Guideline No 7* and Ipswich City Council Policy. As outlined in Section 1.2 below, additional investigations are ongoing regarding waterway stability (i.e. stabilisation of the upper reaches of Deebing Creek) and flood modeling.

1.1 OTHER RELEVANT DOCUMENTS

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

- *Flood Management Plan – Paradise Waters Precinct A* (Water Technology, October 2010)
- *Preliminary Waterway Stability Assessment – Paradise Waters Precinct A* (DesignFlow and Water Technology, November, 2010)
- *Ecological Assessment Precinct A – 'Paradise Waters', South Deebing Creek Road, Deebing Heights* (RPS, October 2010)

1.2 ADDITIONAL INVESTIGATIONS

Stockland and DesignFlow are in the process of developing a waterway and stormwater management strategy for the whole Paradise Waters site. These investigations aim to deliver an integrated range of waterway and stormwater management and landscape infrastructure that will be supported by the urban design for the site. The following investigations are being undertaken:

- Waterway Stabilisation Plan
- Master WSUD and Stormwater Management Plan
- Master Flood Study

1.3 INTERIM LAND USE PLAN REQUIREMENTS

The *Ripley Valley 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:

- Minimal emissions to water
- Protection from flood risk
- Efficient use of land and 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 relation to stormwater and flood management with in this report and related reports.

Table 1: *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 of Deebing Creek and its secondary tributaries Maintain and enhance the environmental values of the receiving waters and wetlands by sound catchment management practices	• 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. • The stormwater and flood strategy has been design to achieve these objectives.	• Section 3 and 4 (this report)
	• Riparian corridors have been maintained either side of the creek as per current Ripley Valley Structure Plan.	• Section 2.4 (this report)
	• 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.	• Section 3 and 4 (this report)
	• Rainwater tanks on each residential lot for local reuse	• Section 4.2 (this report)
	• All stormwater treated to best practice targets through bioretention systems prior to discharge	• Section 4.3 (this report)
Appropriately manage floodwater and stormwater	• Local flood detention basin incorporated into Precinct A design • Precinct A results in very little change in flooding in Deebing Creek.	• *Flood Management Plan – Paradise Waters Precinct A*
	• A Master Flood Study is being developed for the broader development site.	• Ongoing investigation (*Master Flood Study*)

Requirements	Outcome	Reference
Maintain and enhance significant vegetation and provides appropriate landscaping	• Riparian corridors have been incorporated into the development layout in accordance with the Ripley Valley Structure Plan.	• Section 2.4 (this report)
	• Stormwater treatment measures incorporated into the development edge without compromising riparian corridor or urban footprint	• Section 4.3 (this report) and Appendix B
	• Dual use of water quality and flood management areas	• Section 4.3 (this report) and Appendix B
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)	• Section 4.3 (this report) and Appendix B
	• Stormwater treatment measures integrated into public open spaces with appropriate landscaping	• Section 4.3 (this report) and Appendix B

2 SITE DESCRIPTION

2.1 THE SITE

It is proposed to develop four lots described as Lot 207 on CH31135 and part of an existing unconstructed road reserve within the Ipswich suburb of Deebing Heights. The site is currently zoned for residential development and covers an area of approximately 249.07 hectares plus 0.796 hectares of road. The focus of this study is Precinct A which is 14.024 hectares. It is bounded by an existing rural residential area to the west, to the south by 'Defence Purpose Land' and to the east by similar parcels of land zoned as future residential/conservation. The Centenary Highway extension passes downstream of the development.

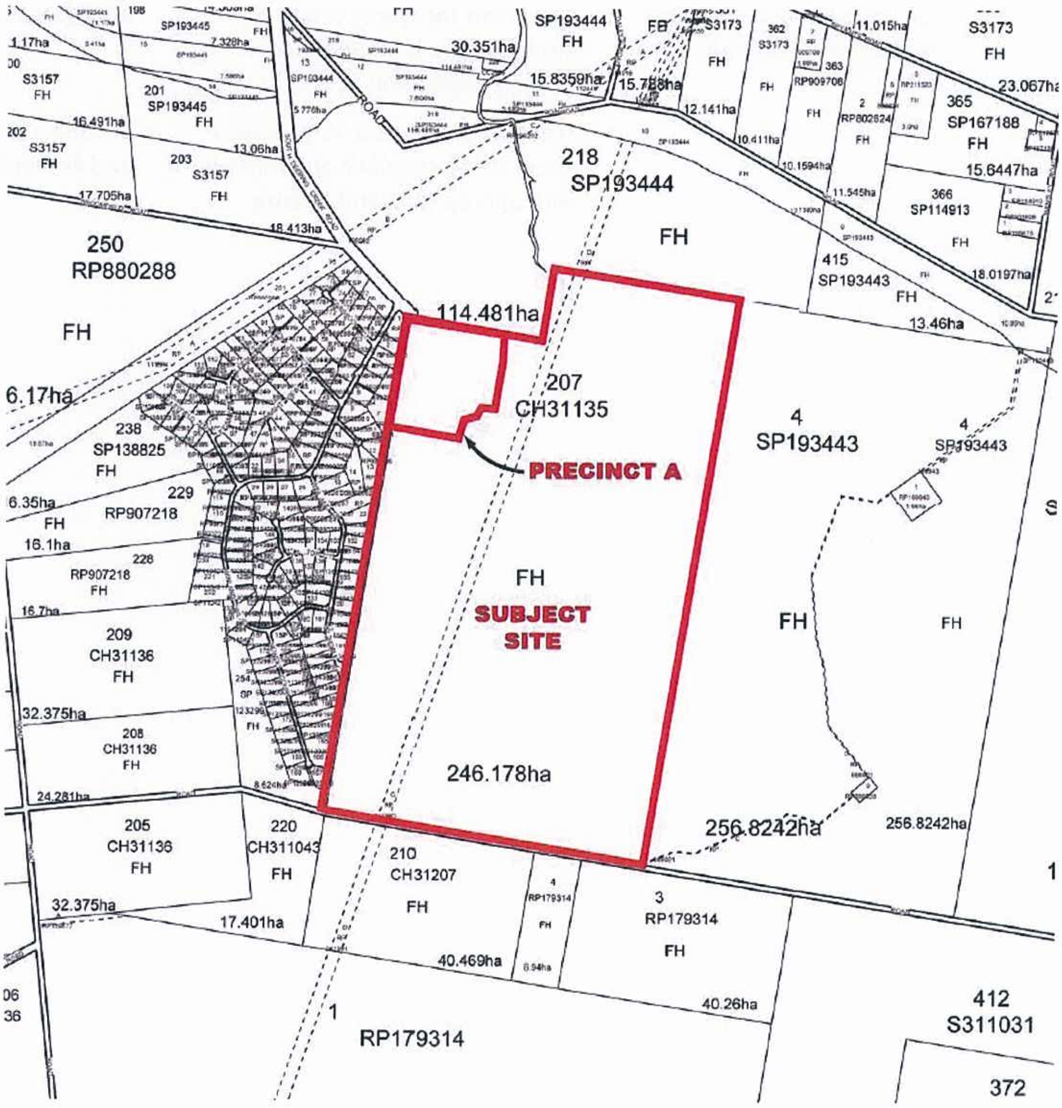


Figure 1: Overall Paradise Waters development site and Precinct A (Proposed Site)

2.2 CLIMATE

Annual rainfall in the Ipswich area is typically around 800-900mm per year with around 40% of this falling in the summer months. As shown in Figure 2 monthly evapotranspiration rates exceed rainfall throughout the year inferring that natural aquatic ecosystems downstream of the site in. Deebing Creek experience drying conditions periodically.

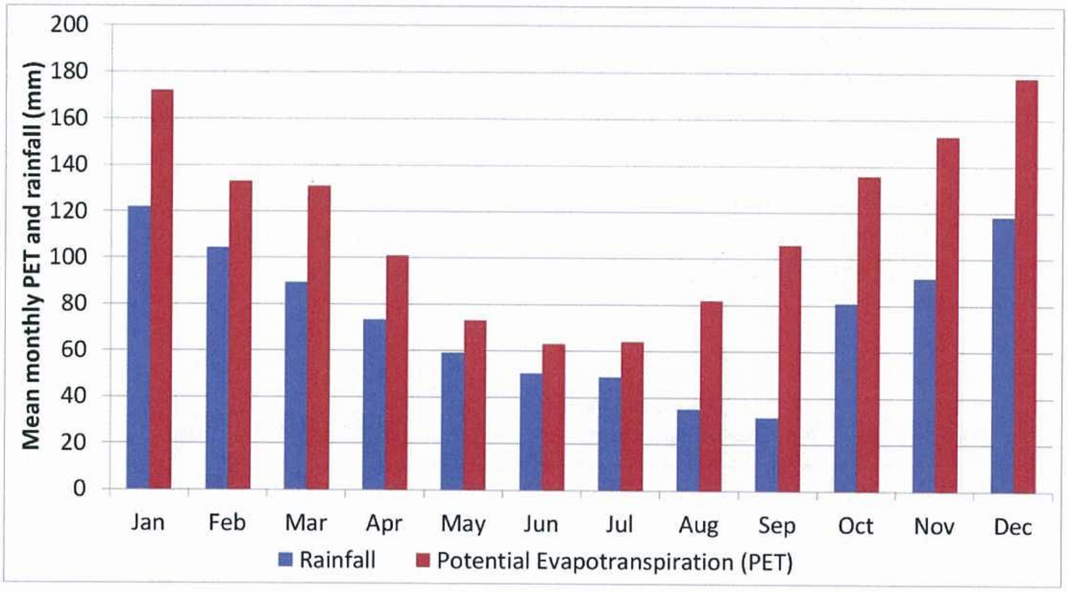


Figure 2: Mean monthly climate statistics for Deebing Heights (Amberley AMO station 40004)

2.3 TOPOGRAPHY AND SITE DRAINAGE

The proposed Precinct A site is defined by a ridgeline that runs north-south creating a local catchment divide as shown in Figure 3. The north west portion of the site (4 ha) drains northward via an existing gully which combines with overland flow from the existing development to the west plus flows from the lower end of South Deebing Creek Road to discharge into the adjoining property to the north.

The remainder of the Precinct A site (10ha) drains east towards the waterway corridor at the upper reach of Deebing Creek (refer Section 2.4). Post development drainage aims to maintain these current catchments as far as practical and provide appropriate water quality and flood detention infrastructure at key discharge locations.

The upstream catchment draining into Deebing Creek in the vicinity of Precinct A is around 480 hectares. A significant portion of this catchment enters the existing farm dam which, under high flow conditions, bypasses flow directly downstream to the channel adjacent to Precinct A as shown in Figure 4.

2.3.1 Legal point of discharge

The legal point of discharge for the catchments draining east is the upper reach of Deebing Creek.

The legal point of discharge for the catchments draining north west is also Deebing Creek but the stormwater from Precinct A needs to drain through the property to the north of Precinct A. This site is currently owned by Deebing Developments Pty Ltd. As part of the development application for this site, allowance has been made for stormwater discharge from Precinct A. Please refer to *Flood Assessment Deebing Creek Road, Deebing Creek* (Water Technology, 2010 for Deebing Developments) and *Deebing Creek Road, Deebing Creek Stormwater Management Plan* (WRM, 2007 for Deebing Developments) for details. Discussions had not yet commenced with Deebing Developments Pty Ltd at the time of writing this document. Therefore, a conservative approach of managing the peak flow and quality of stormwater before it discharges from the Precinct A site has been adopted.

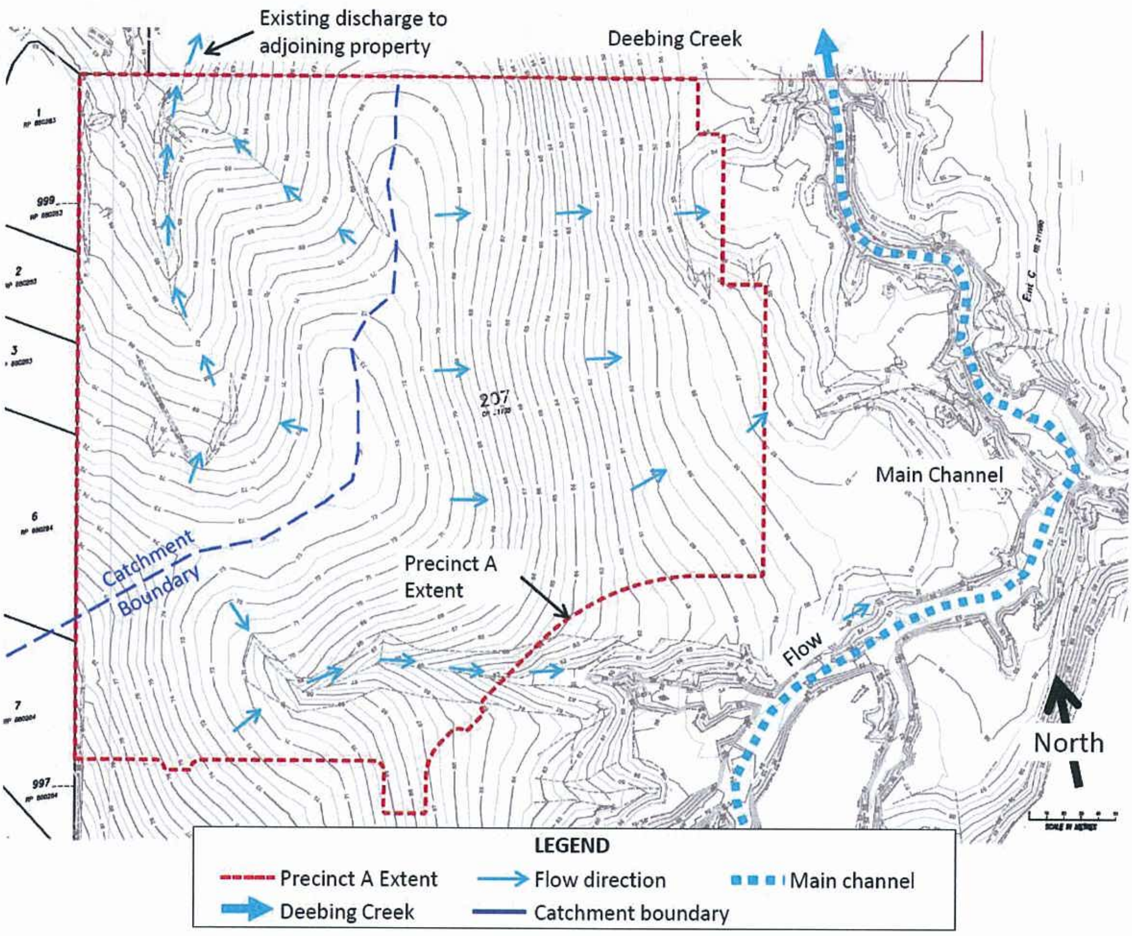


Figure 3: Existing Precinct A drainage

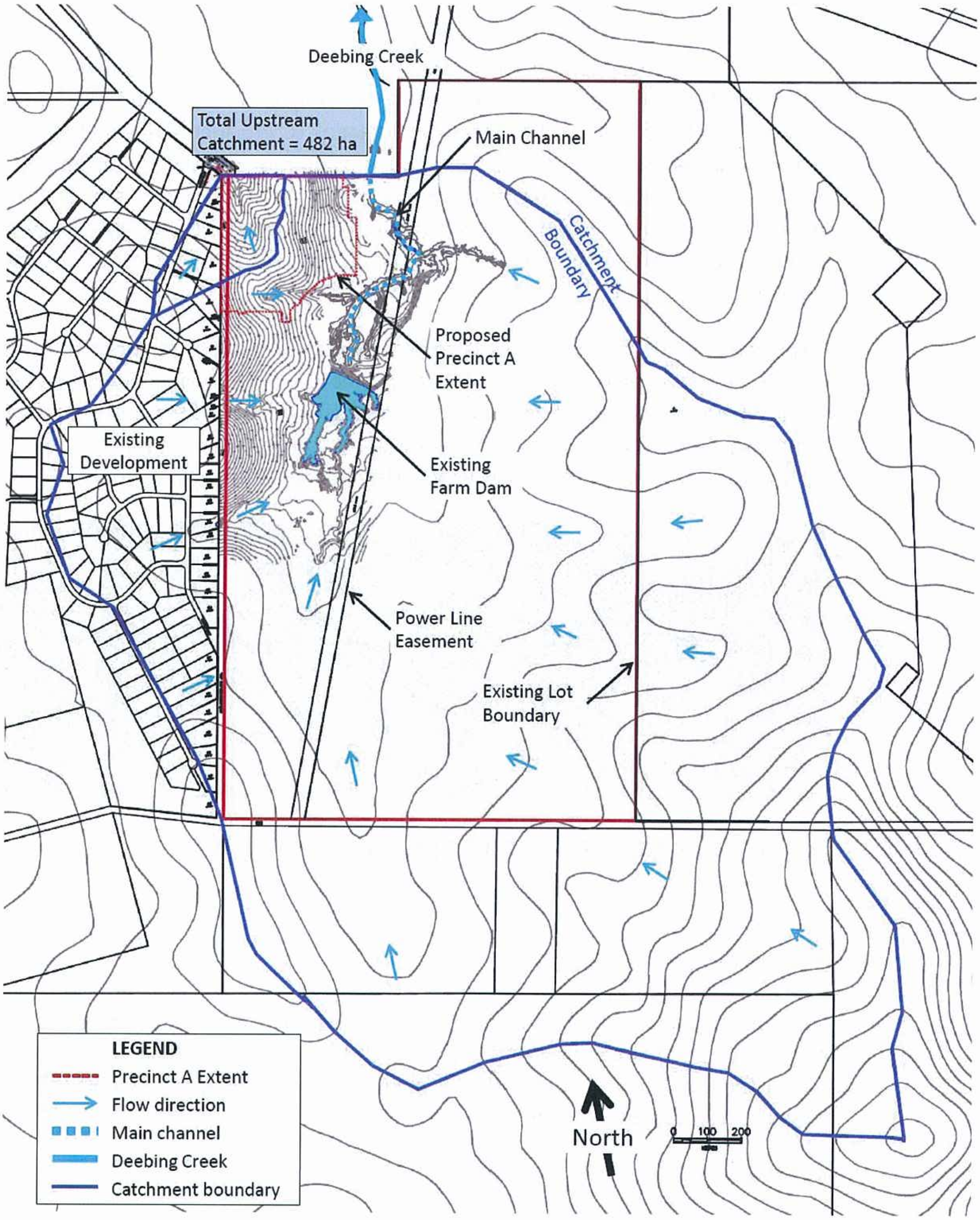


Figure 4: Overall Paradise Waters catchments

2.4 DEEBING CREEK

The site lies at the upper reach of Deebing Creek as defined in the Ripley Valley Structure Plan. The main waterway invert varies from around 55mAHD to 48mAHD in the vicinity of Precinct A. The waterway adjacent to Precinct A has undergone bed incision and bank erosion in the past. This erosion has exposed the dispersive soils which exist on site resulting in large changes in channel depth and width. The waterway adjacent to Precinct A has stabilised, however, there is active creek erosion occurring just upstream of the Precinct A location (adjacent to Precinct B) as shown in Figure 5.

Stabilisation of the creek and management of regular flows is required to minimise the risk of further erosion in the waterway. This is the focus of a broader waterway stabilisation investigation being undertaken by Stockland. Please refer to *Preliminary Waterway Stability Assessment – Paradise Waters Precinct A* (DesignFlow and Water Technology, October, 2010) for the very initial findings of this assessment.

Figure 5: Active channel erosion upstream of Precinct A

Watercourse Designation

DERM has advised that Deebing Creek ceases to be a designated waterway (under the Water Act 2000) at the northern boundary of the subject site. Therefore any works within the watercourse south of this point on the Paradise Waters site does not trigger a riverine protection permit.

Waterway Corridors

DERM vegetation mapping identifies the main waterway adjacent to the Precinct A as a 3rd and 4th order stream. The Ipswich City Council Ripley Valley Structure Plan mapping identifies the upper portion of Deebing Creek as a river and this extends to the existing dam.

In accordance with the Ripley Valley Structure Plan, the following waterway corridors have been applied:

- 50m vegetation protection and rehabilitation buffer/corridor has been applied (from surveyed top of bank) either side of the waterway to the existing dam
- 30m either side of the waterway centreline upstream of the existing dam

2.5 SOILS

The Broad Assessment of Slope Stability (Morrison Geotechnic Pty Ltd, 2010) provides the following summary of site geology:

> *The geology of the site generally comprises a layer of slopewash or residual soils up to 0.5m to 1.5m thick underlain by weathered sandstone rock in the elevated portions of the site and generally comprises an interlayered alluvial sand and clay sequence to depths of 3.0m in the low lying portions of the site within the creek gully at the centre of the site.*

Inspection of the site identified shallow topsoil overlaying a highly dispersive subsoil along the much of the main waterway corridor adjacent to Precinct A. Upper and mid slopes appear stable with little evidence of erosion while the lower slopes and drainage gullies are currently undergoing erosion which is quite severe on the eastern bank of the waterway (Deebing Creek) across from Precinct A. As outlined in Section 2.4, this erosion is the focus of a broader waterway stabilisation investigation being undertaken by Stockland.

2.6 VEGETATION

Please refer to *Ecological Assessment Precinct A – 'Paradise Waters', South Deebing Creek Road, Deebing Heights* (RPS, October 2010) for details of vegetation.

The broader site has been partly cleared of vegetation with scattered trees and grasses these areas. Regrowth vegetation exists along the lower slopes adjacent to the main waterway corridor. This vegetation is currently partially mapped as high value regrowth vegetation, however much of this is at risk from destruction due to the major erosion occurring in this location.

The trees in the vicinity of the proposal stormwater treatment bioretention basins have been surveyed. The larger trees have been preserved as part of the proposed bioretention designs (refer Section 4.3 and Appendix B).

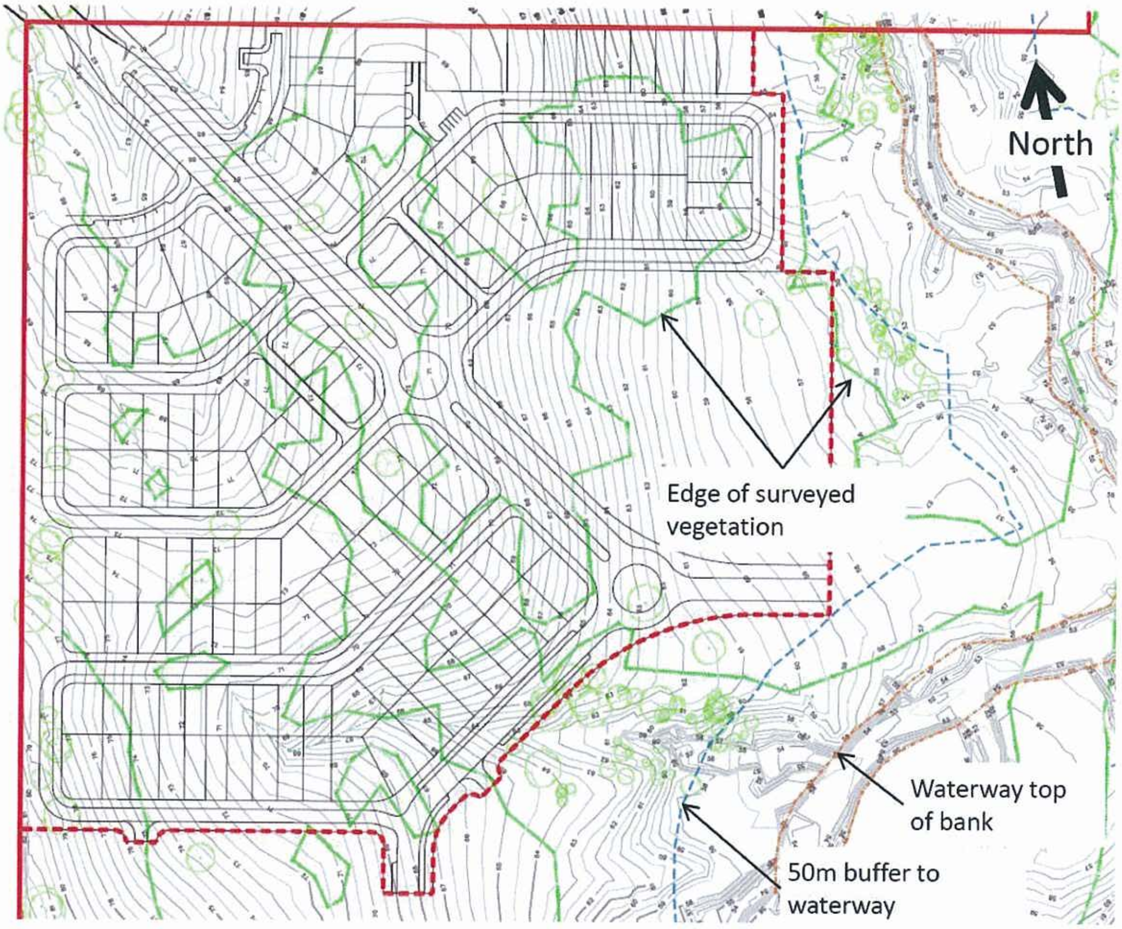
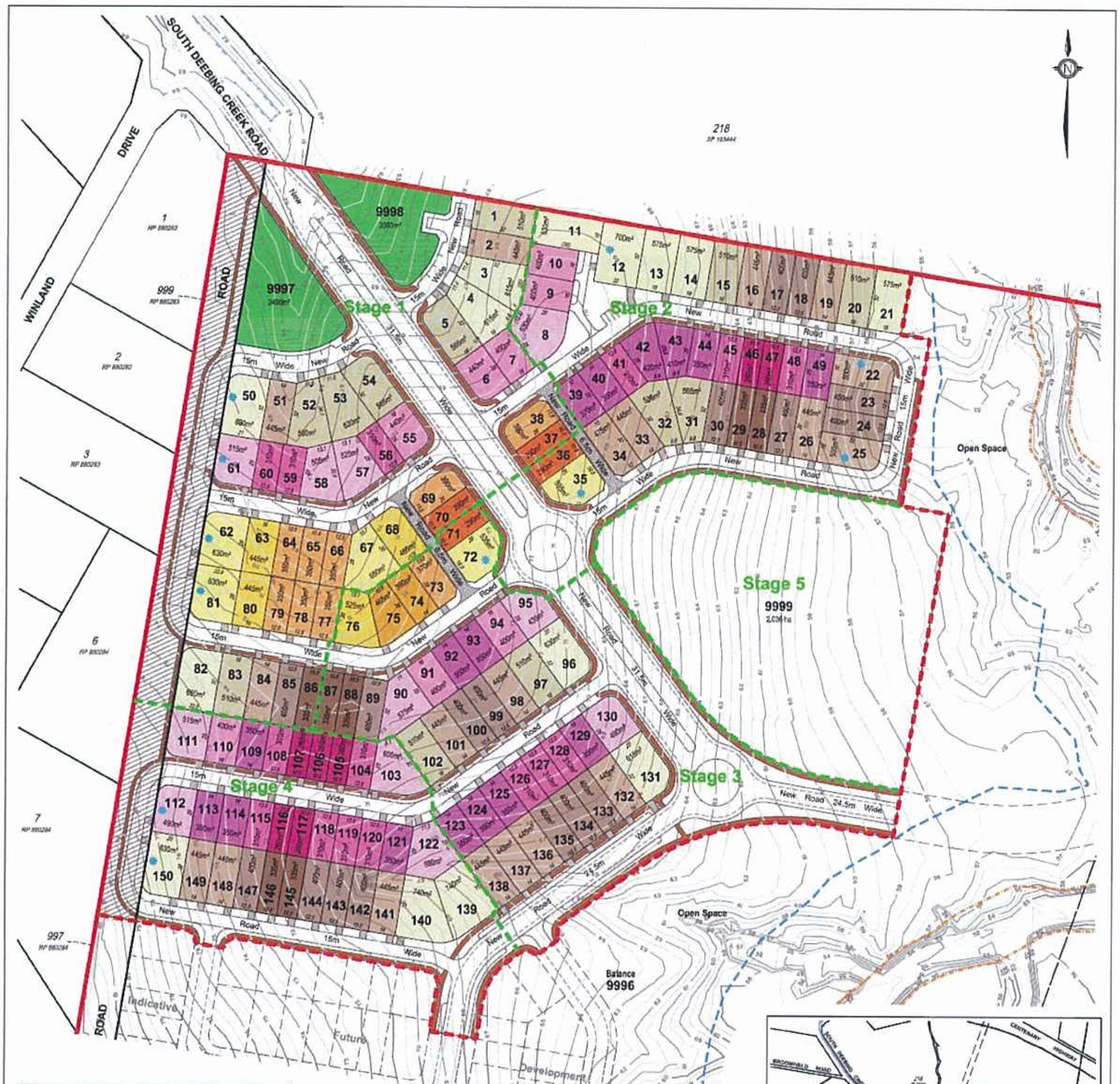


Figure 6: Existing vegetation and waterways

2.7 PROPOSED DEVELOPMENT

Precinct A comprises 150 lots, new roads and balance lot (Lot 9999 – future neighbourhood centre) within a footprint of 14.024 hectares. Precinct A will be accessed via an extension to the existing South Deebing Creek Road. Figure 6 shows the proposed layout and lot types for Precinct A.



DEVELOPMENT STATISTICS PRECINCT A			
Allotment Type		Number of Allotments	Allotment %
Single Family Dwellings			
25m Deep Lots	Typical Lot		
Villa Allotment	10.5 x 25m	7	4.7%
Premium Villa Allotment	12.5 x 25m	15	10.0%
Courtyard Allotment	14 x 25m	16	10.7%
Traditional Allotment	15 x 25m	8	5.3%
Premium Traditional Allotment	18 x 25m	11	7.3%
Sub Total		57	38.0%
28m Deep Lots	Typical Lot		
Villa Allotment	10.5 x 28m	4	2.7%
Premium Villa Allotment	12.5 x 28m	9	6.0%
Courtyard Allotment	14 x 28m	2	1.3%
Traditional Allotment	15 x 28m	4	2.7%
Premium Traditional Allotment	18 x 28m	5	3.3%
Sub Total		24	16.0%
32m Deep Lots	Typical Lot		
Villa Allotment	10.5 x 32m	7	4.7%
Premium Villa Allotment	12.5 x 32m	17	11.3%
Courtyard Allotment	14 x 32m	19	12.7%
Traditional Allotment	15 x 32m	12	8.0%
Premium Traditional Allotment	18 x 32m	14	9.3%
Sub Total		69	46.0%
Total Single Family Dwellings		150	100.0%

Density Calculation	dw/ha
Net Residential Density (excluding Balance Allotment)	17.5*

* Density assuming all multi-family dwellings are constructed

LAND USE BUDGET PRECINCT A		
Land Use Budget	Area (ha)	Percentage
Area of Precinct A	14.024	100.00%
Saleable Area		
Single & Multi-Family Lots	6.495	46.31%
Balance Allotment	2.036	14.52%
Total Area of Allotments	8.531	60.83%
Road		
Trunk Collector Road	1.973	14.07%
Existing Road to be Constructed	0.796	5.68%
Local Roads	2.268	16.17%
Total Area of New Road	5.037	35.92%
Open Space		
Detention / Stormwater Drainage / Park	0.456	3.25%
Total Open Space	0.456	3.25%

Road Type	Length (m)
Total Length of New Road	2415
6.5m Wide New Road	114
15m Wide New Road	1362
24.5m Wide New Road	292
31.5m Wide New Road	394
Existing Road 6.5m Pavement	253

Legend

General Details

- Site Boundary
- Proposed Precinct Boundary
- Proposed Stage Boundary
- Existing Road to be Constructed
- Possible Multi-family dwelling (Duplex and Triplex Lots Only)

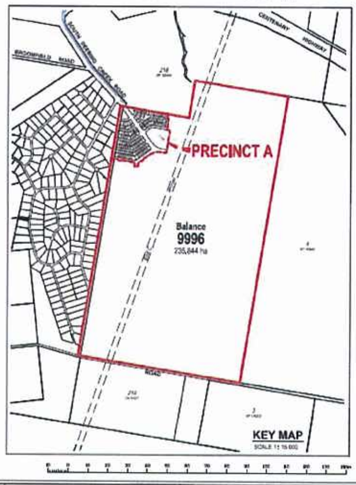
Open Space

- Proposed Detention & Park
- Waterway Top of Bank
- Waterway 50m Buffer

Road

- Indicative Footpath Location
- Indicative 3.5m Wide Driveway

Note
All dimensions and areas are approximate only, and are subject to survey and Council approval.
Dimensions have been rounded to the nearest 0.1 metres.
Areas have been rounded down to the nearest 5m².
The boundaries shown on this plan should not be used for final detailed engineers design.



REVISION
A: 27/09/2010 Lot Recoding
B: 28/09/2010 Add future layout, amend stats & notes
C: 29/09/2010 Add Waterways
D: 08/10/10 Amend Entry Area and Stats
E: 20/10/10 Amend Lots by swapping 32's and 28's
F: 25/10/10 Amend Lots 23-49 and stats
G: 26/10/10 Add Parking Bays, Driveways & Footpaths
H: 27/10/10 Add New Detail Survey & edit Staging Bdy

Level Datum		Date	27 October 2010
Approval Authority. URBAN LAND DEVELOPMENT AUTHORITY		Comp By.	WW
		DWG Name.	104527_Prop
		Local Authority	IPSWICH CITY COUNCIL
Scale 1:1000/1:2000	Sheet A1/A3	Locality	DEEBING HEIGHTS
		Job Reference	104527

CLIENT
STOCKLAND

PROPOSED SUBDIVISION
PRECINCT A
OVER LOT 207 ON CH 31135 & EXISTING ROAD

PROJECT
PARADISE WATERS

Plan Ref **104527 - 30** Rev **H**

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Figure 7: Precinct A development layout and lot statistics

2.8 DESIGN CONSIDERATIONS

The conceptual design of Precinct A aims to optimise the urban layout while being sensitive to the site constraints. Key design considerations identified for the site are provided in Table 2.

Table 2: Design considerations

Design Factor	Considerations
Site drainage	Main flow channel (waterway) Discharge to adjoining property (north) Inflows from external catchments
Ecological Protection	Riparian corridor buffer Vegetation retention/enhancement Prevent/rehabilitate active erosion/scour Stream stability protection (from urban runoff)
Flood Management	Flood flows within and downstream of the site
Landscape integration	Integrate stormwater management measures with open space and provide improved amenity along waterway corridor

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 Draft 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.
Cations and anions	As required under an approved Acid Sulfate Soil Management Plan, including aluminium, iron and sulphate.
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 A have been established considering:

- *Ripley Valley Urban Development Area Interim Land Use Plan*
- *Ripley Valley Structure Plan*
- *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 Paradise Waters Precinct A 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 soils and waterways on and downstream of the site, the management of erosion potential of waterways is critical. This is achieved on Paradise Waters 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

DesignFlow and Water Technology are current in the process of development a Waterway Stabilisation Strategy for the whole site to achieve the above.

The focus of the waterway stability assessment for Precinct A 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):

> **Limit the post-development peak 1-year Average Recurrence Interval (ARI) event discharge <u>within</u> the receiving waterway to the pre-development peak 1-year ARI event discharge.**

Please refer to *Preliminary Waterway Stability Assessment – Paradise Waters Precinct A* (DesignFlow and Water Technology, November, 2010) for details of how this waterway stability objective is achieved.

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 as follows:

> **Capture and manage the following design run-off capture depth (mm/day) from all impervious surfaces of the proposed development:**
>
> - **with a total fraction impervious 0% to 40%: Capture first 10 mm of run-off from impervious surfaces**
> - **with a total fraction impervious >40%: Capture first 15 mm of run-off from impervious surfaces.**
>
> **Management' of the frequent flow management volume (i.e. 15 mm multiplied by the impervious area on the site) can occur by either infiltration, evapotranspiration or discharge via bioretention (or a combination of these). The management volume is to be fully available each day i.e. the storage volume needs to be drawn down in 24 hours.**

DesignFlow has been involved in the review of this objective for DERM 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.

For the purposes of this assessment the current form of the frequent flow objective is applied to Paradise Waters, even though it is not clear whether the objective should apply given the state of Deebing Creek downstream. The compliance method outlined in *SEQ Regional Plan – Implementation Guideline No. 7* and the *Business Case for WSUD* (Water by Design, 2009) has been used. Further ecosystem assessment of the downstream reaches of Deebing Creek is required to confirm whether this objective should actually apply for the creek and whether the current form of the objective is correct.

4 STORMWATER MANAGEMENT STRATEGY

4.1 SUMMARY

Collaboration between Stockland, WSUD specialists (DesignFlow), flood engineers (Water Technology), civil engineers (Bradlees) and urban designers/landscape architects (RPS) has ensured that the development plan for Precinct A suitably informed by WSUD. As a result, the stormwater quality 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 objectives as set out in Section 3 are achieved.

The stormwater management strategy has been resolved at three scales for Paradise Waters:

- **Structure Plan Strategy** – Figure 8 presents the general location of the proposed stormwater management elements across the whole site. The plan illustrates regional and local scale stormwater management systems as well as flood extent, potential flood management locations and waterway corridor locations. This strategy is being refined as part of future technical investigations.

- **Context Plan (Precinct A and B) Strategy** – Figure 9 presents further detail of the stormwater management strategy for Precinct A and B. The plan presents our initial thinking in relation to stormwater management and flooding, waterway corridors. Importantly the existing dam adjacent to Precinct B is to be drained and revegetated as a waterway that integrates with stormwater management and flood detention.

- **Precinct A Strategy** – Figure 10 presents the details of the stormwater management systems for Precinct A including catchment areas, location and size.

Table 5 summarises the key elements of the Precinct A stormwater management strategy (as illustrated in Figure 10).

Further details of these elements are provided in the following sections. The *Flood Management Plan – Paradise Waters Precinct A* (Water Technology, November 2010) provides details on flood storage requirements.

Table 5: Stormwater quality management strategy elements

Sub-catchment ID	Area (ha)	Land use category	Water savings	Water quality
A	4.07	Urban residential	Rainwater tanks	Bioretention (Bio A)
B	2.48	Urban residential	Rainwater tanks	Bioretention (Bio B)
C	2.03	commercial	To be confirmed at detailed design	Bioretention (Bio C)
D	0.29	Road reserve	-	
E1	5.16	Urban residential	Rainwater tanks	Bioretention (Bio E)
E2	4.00	Urban residential	Rainwater tanks	

Figure 8: Structure Plan Management Strategy

Figure 9: Precinct A & B Stormwater Management Strategy

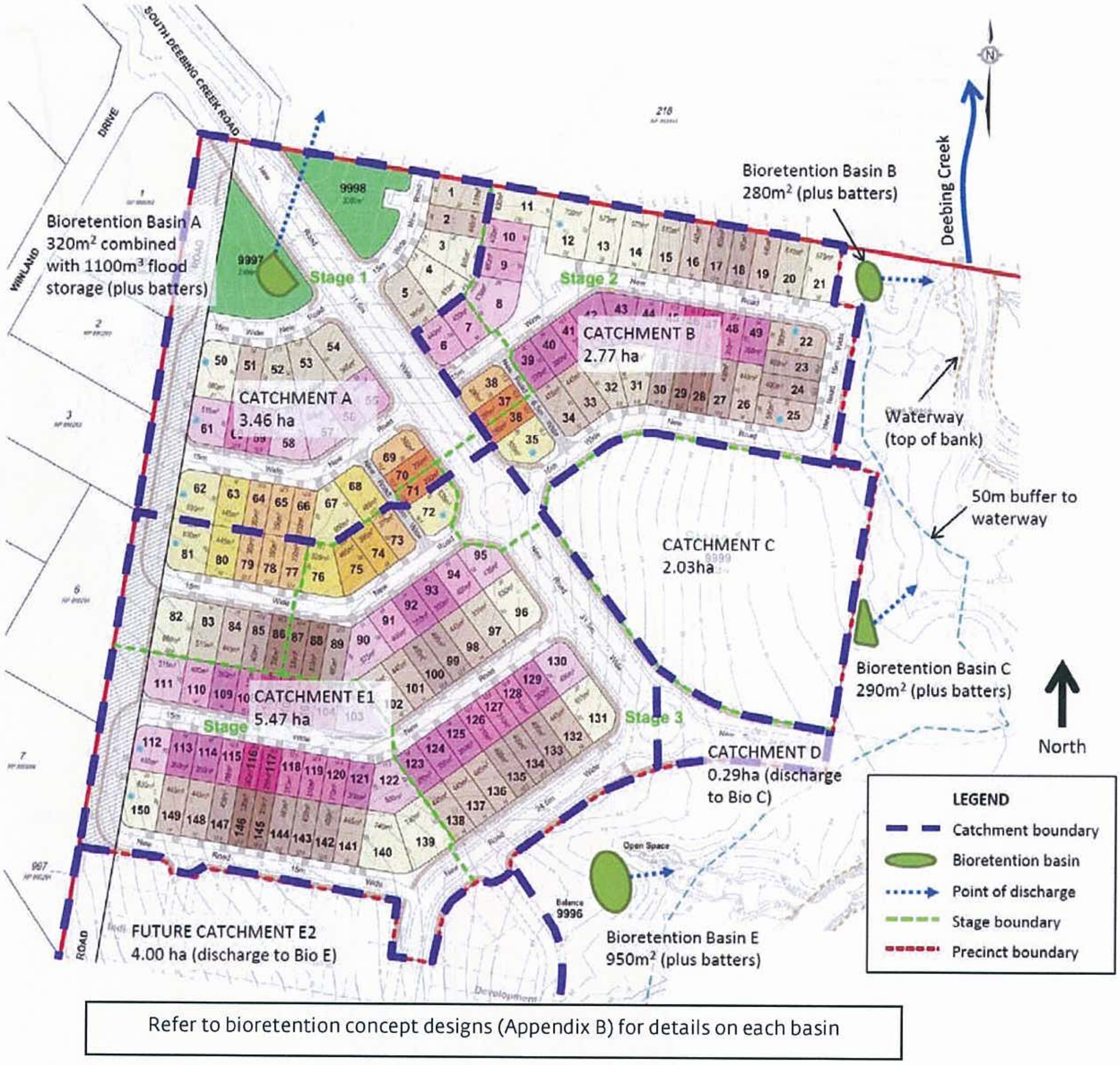

Figure 10: Precinct A Stormwater Quality Management Strategy

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 Ipswich, tanks will invariably 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 in Precinct A are provided in Table 6.

Table 6: 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.

4.3 BIORETENTION BASINS

Bioretention basins will provide the stormwater treatment and frequent flow management for Precinct A. Preliminary bioretention design has been based on the *WSUD Technical Design Guidelines for SEQ* (Water by Design, 2006). Key design parameters for each of the basins are provided in Table 7. MUSIC modelling of these basins confirms the performance to meet the water quality objectives for the site as described in Section 5.

Table 7: Bioretention design parameters

Parameter	Bioretention Basin			
	Bio A	Bio B	Bio C	Bio E*
Filter area (m2)	448	248	244	916
Extended detention depth (m)	0.3	0.3	0.3	0.3
Filter depth (m)	0.5	0.5	0.5	0.5
Hydraulic conductivity (mm/hr)	200	200	200	200

* This bioretention may be split into two systems subject to detailed concept design

The bioretention basins are located at the low point within each sub-catchment and will accept flows from piped drainage networks serving each of these catchments. The areas provided in Table 7 are the filter media only. The total footprint of the bioretention basins needs to consider the filter area, batters, sediment forebay(s), maintenance access and discharge structures.

For the purposes of this Stormwater Management Plan we have developed detailed concepts and sections for all the bioretention basins. This has been provided to illustrate that there is available space in the urban design for the bioretention basins, the catchment can drain to the basins, there is enough level through the bioretention system to function effectively and how flows will enter the receiving waterway.

Some points to note:

- The basins have been located to minimise the removal of existing vegetation. In some cases regrowth vegetation may be removed for the bioretention systems.

- Bioretention A is co-located with a flood storage. Initial assessment of the bioretention system and flood storage indicates a total footprint of ~1500-2000m^2 including surrounding batters. There is 2300m^2 provided in the urban design for these system.

- Bioretention B may be partly located within the 50m waterway vegetation corridor. However, there is no vegetation present at this location and the bioretention system will be created to compliment the buffer/corridor function.

- The discharges from the bioretention 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.

5 PERFORMANCE ASSESSMENT (MUSIC MODELLING)

MUSIC modelling has been conducted to quantitatively assess the performance of the proposed stormwater quality strategy. 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, 2009) as shown below.

5.1 MODEL STRUCTURE

The model adopts the split catchment approach which accounts for the variability of pollutant generation from different surfaces. Table 8 provides a summary of the data on which the model is based.

Table 8: MUSIC model data summary

Input	Data used in modelling
Rainfall station	Amberley AMO (Station 40004)
Time step	6 minute
Modelling period	1990 to 1999
Mean annual rainfall	854 mm
Evapotranspiration	Monthly Mean PET
Rainfall runoff parameters	Urban Residential
Pollutant export parameters	Urban Residential

All information above has been sourced from Water by Design, 2009

5.1.1 Catchment Data

The development has been split into 5 sub-catchments representing Precinct A plus a portion of the future stage to the south which will ultimately drain to the Precinct A bioretention basin. Each of the sub-catchments has been assigned areas and imperviousness based on measurements from the development layout plans. Roof area within each of the catchments has been assumed to represent 50% of the lot area in absence of any measurable area. Summary catchment data is provided in Table 9 with full catchment split details provided in Appendix A. The MUSIC model layout and catchment delineation is shown in Figure 11.

Table 9: MUSIC catchment data

Catchment ID	A	B	C	D	E1	E2	Total
Catchment (ha)	3.46	2.77	2.03	0.29	5.47	4.00	**18.03**
Lot count	27	44	-	-	79	58	**204**
Imperviousness (%)	53	60	89	60	60	60	**62**

Note: Precinct A comprises 150 lots. Lots numbers for future stage (catchment E2) are scaled directly from E1 based on area.

Bioretention systems have been sized to meet pollutant load reduction targets from the subject development only. Therefore no external catchments are included in the MUSIC analysis. Where external catchments discharge into Precinct A, pipes and hydraulic structures will need to be sized accordingly to manage additional flows. These flows will still enter the bioretention basins but the basins have sized to achieve the objectives for the Precinct A development catchments only. This will result in treatment of the small untreated external catchments as well, therefore, providing a higher protection to Deebing Creek.

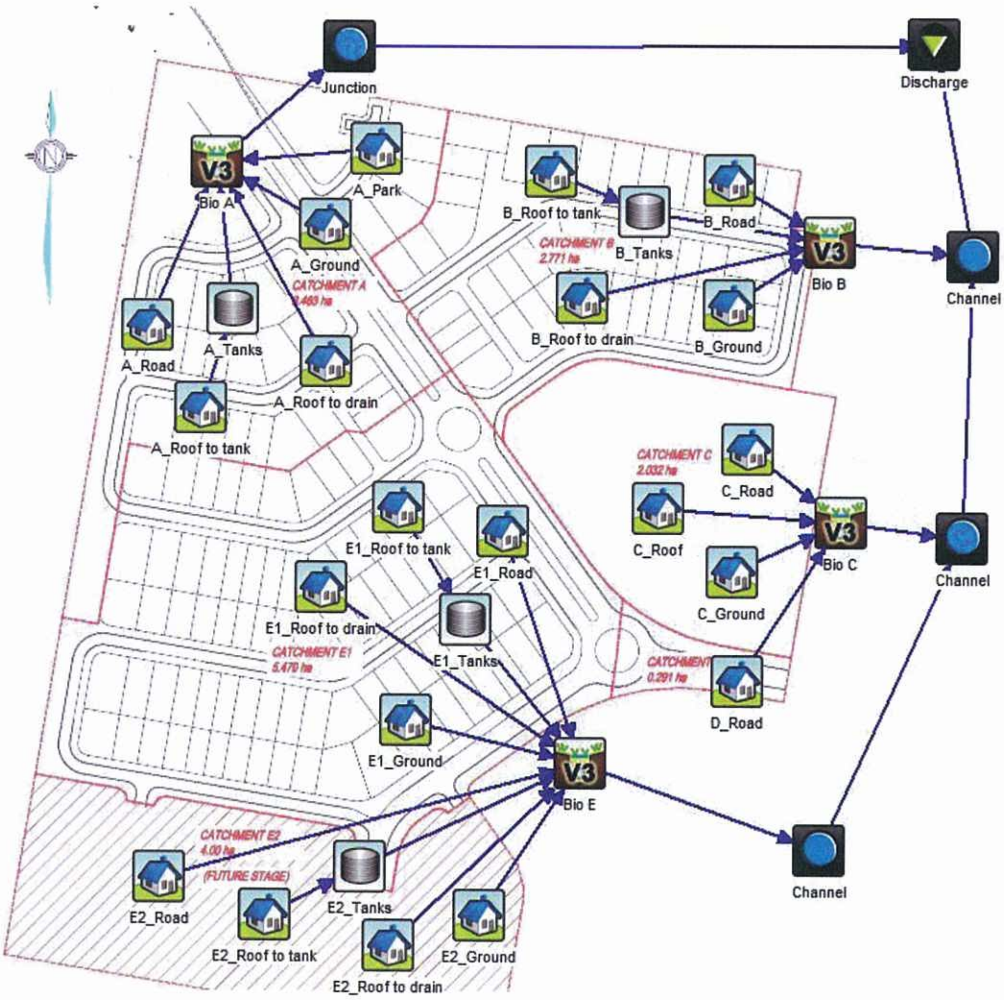

Figure 11: MUSIC catchment delineation and model layout

5.1.2 Rainwater Tanks

The derivation of demand from rainwater tanks within each lot has adopted the assumptions in Table 10 based on data provided in the *MUSIC Modelling Guidelines for South East Queensland (Water by Design, 2010).*

Table 10: Rainwater tank demands

Data	Value	Comment
Occupancy - single dwelling lots - multi-dwelling lots	 2.8 p/dwelling 2.0 p/dwelling	 Detached dwellings Attached dwellings
Daily indoor demand	47 L/p/d	Assumes full use of water saving devices
Annual outdoor demand	548 mm/yr	Applied to 75% of outdoor pervious area of lots only

Rainwater tank volumes were combined for the respective sub-catchments in accordance with the procedure detailed in the *SEQ MUSIC Guidelines*. This accounts for the different size tanks for attached/detached dwellings. In addition, the indoor demands were assigned on a per dwelling basis while the outdoor demands were on a per lot basis only. Full details area provided in Appendix A.

In the current conceptual model, no rainwater tanks have been used in the balance lot (future neighbourhood centre) nodes (Catchment C) as there are no details available on the type or sizing of this development. The bioretention sizing in this catchment therefore provides the most conservative conceptual design. Future design of this site will require compliance with the Queensland Development Code Mandatory Part 4.3.

All other model parameters for rainwater tanks are provided in Appendix A and generally represent the combined tank volume for the respective catchments in accordance with the methods in the *SEQ MUSIC Guidelines*.

5.1.3 Bioretention Basins

The bioretention basins were modelled in accordance with the *MUSIC Modelling Guidelines for South East Queensland* (Water by Design, 2010).

5.2 STORMWATER QUALITY RESULTS

The results of the MUSIC modelling for the proposed development are shown in Table 11 with full details of the model provided in Appendix A.

The results indicate that the proposed WSUD strategy for stormwater management meets the design objectives for pollutant load reduction from urban residential sites.

Table 11: MUSIC model results – stormwater quality

Catchment		Stormwater Treatment				Pollutant Load Reduction (%)		
ID	Area (ha)	Treatment	Extended Detention (m)	Filter Area (m^2)	% Catchment area	TSS	TP	TN
A	4.07	Bio A	0.3	320	1.0	88.6	74.2	48.2
B	2.48	Bio B	0.3	280	1.0	90.2	76.7	53.0
C	2.03	Bio C	0.3	290	1.25	86.6	72.2	43.3
D	0.29							
E1	5.16	Bio E	0.3	950	1.0	90.0	76.9	52.1
E2	4.00							
					Total Site Reduction (%)	**89.3**	**75.5**	**49.5**
					Site Objective (%)	**80**	**60**	**45**

5.3 FREQUENT FLOW RESULTS

Compliance

The frequent flow objective requires the first 10 or 15 mm of rainfall that falls on impervious surfaces to be captured and managed. The capture and storage volume must be available each day (drained within 24hours) through a combination of management approaches:

- reuse
- diversion
- infiltration
- evapotranspiration
- discharge via bioretention[1]

For most development situations in Queensland, reuse (with the exception of rainwater tanks), diversion, infiltration and evapotranspiration of this volume of

[1] Note that the management method involving disposal of the capture volume by discharge through a bioretention system to the receiving waterway is an acceptable solution as defined by *WSUD: Developing design objectives for urban development in South East Queensland* (SEQ HWP, 2006), *Queensland Best Practice Environmental Management Guidelines - Urban Stormwater Technical Note: Derivation of Design Objectives* (DERM and EDAW, 2009) and agreed by Dr Chris Walsh (Monash University). Recent research indicates that discharging the capture volume through a bioretention system does provide some level of hydrologic management but may not provide a suitable level of management to ensure protection high environmental value ecosystems which are sensitive to frequent flows (Walsh et al., 2009). Further technical investigation of frequent flow objective and compliance requirements is underway.

water is not practically possible without connection to external locations (e.g. piped to other high water users, pipe diversion or connection to an aquifer system).

Therefore for Precinct A we have adopted the bioretention compliance approach plus inclusion of allotment rainwater tanks. It is noted however that this compliance methodology while an accordance with current guidance, is likely to change in the near future following a current review of the frequent flow objective and compliance approaches

The bioretention compliance approach requires that a volume of water, equivalent to the first 15mm runoff from impervious areas in a day, passes through the filter media of the bioretention system. In order to ensure the correct volume of water is able to infiltrate, storage in the form of extended detention is provided above the bioretention system's surface.

Bioretention systems drain rapidly because the saturated hydraulic conductivity of bioretention filter media is generally around 200 mm/hour. This is faster than the draw-down rate required to drain the frequent flow volume in 24 hours. If the volume can be drained faster than over 24 hours, the storage size can decrease to achieve the same outcome.

Modelling

Modelling was undertaken to determine how bioretention systems, sized to meet the stormwater quality objectives for their respective catchments, would perform (in conjunction with rainwater tanks) in meeting the frequent flow objective. Testing was conducted as per the steps outline below using MUSIC model described in the previous section.

The following steps were used in the modelling:

1. The percentage of annual runoff that the first 15 mm of daily runoff from impervious surfaces represents was calculated.
2. The volume of roof water captured and reused from rainwater tanks was determined.
3. The proportion of annual runoff that passed through the filter media a bioretention system sized to meet best practice stormwater quality objectives was calculated.
4. If the percentage of annual runoff that is captured in rainwater tanks and passed through the bioretention system filter media was greater than the volume calculated in step 1, the frequent flow management objective is deemed to have been met.
5. If the frequent flow objective was not met, additional storage above the bioretention system must be provided.

Results

The results of the modelling are shown in Table 12 which indicates the frequent flow objective is achieved via the bioretention approach. While rainwater tank capture results have also been included, the bioretention systems alone provide sufficient management of frequent flows. As mentioned previously the compliance methodology associated with the frequent flow objective is being reviewed at the moment but as it stands the bioretention basins (plus rainwater tanks) in Precinct A ensure compliance with the current method.

Table 12: MUSIC model results – frequent flow

Scenario		Catchment				
		A	B	C/D	E1/E2	TOTAL
Total runoff generated from developed catchment	(ML/yr)	14.0	12.4	14.2	42.3	**82.9**
Developed flow generated less first 15mm	(ML/yr)	6.89	5.42	5.98	18.5	**36.8**
1. Required capture/treatment volume (first 15mm)	(ML/yr)	7.11	6.98	8.22	23.8	**46.1**
(% of total runoff generated)	%	*51%*	*56%*	*58%*	*56%*	***56%***
2. Rainwater tank capture	(ML/yr)	1.35	2.15	0	6.54	**10.04**
(% of total runoff generated)	%	*10%*	*17%*	*0%*	*15%*	***12%***
3. Volume treated through bioretention	(ML/yr)	10.46	8.55	11.51	30.14	**60.66**
(% of total runoff generated)	%	*75%*	*69%*	*81%*	*71%*	***73%***
Is captured/treated volume (Step 2 + 3) > Objective (Step 1)?		Yes	Yes	Yes	Yes	**Yes**

6 CONCLUSION

A stormwater management strategy has been developed for Paradise Waters Precinct A that delivers best practice objectives for urban stormwater quality improvement and frequent flow management, thereby affording appropriate protection to Deebing Creek.

The Precinct A strategy generally complies with the environmental and sustainable development requirements set out in the *Ripley Valley Urban Development Are Interim Land Use Plan* and is particularly focussed on delivering sound outcomes for the protection of Deebing Creek ecology and waterway stability.

Detailed concepts of the proposed bioretention basins have been developed to provide certainty that there is sufficient space for the basins and to illustrate that stormwater can drain into and out of the basins. The proposed stormwater management systems have been designed to integrate with the flood management and initial waterway stabilisation considerations for the site. Refer to the following for details of flood and waterway stability:

- *Flood Management Plan – Paradise Waters Precinct A* (Water Technology, October 2010)
- *Preliminary Waterway Stability Assessment – Paradise Waters Precinct A* (DesignFlow and Water Technology, November, 2010)

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

However, Stockland do recognise that the broader Paradise Waters 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 Paradise Waters site beyond Precinct A 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. Specific investigations include:

- Waterway Stabilisation Plan
- Master WSUD and Stormwater Management Plan
- Master Flood Study

The findings of these broader investigations are likely to be available in about 4-5 weeks from the date of this report and will be presented to Urban Land Development Authority in the coming months.

It is expected that minor adjustments to the Precinct A 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 *South East Queensland WSUD Engineering Guidelines*. 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

7 REFERENCES

Cooperative Research Centre for Catchment Hydrology (CRCCH) (2005). *Model for Urban Stormwater Improvement Conceptualisation (MUSIC) User Guide*, Version 4, CRCCH, Monash University, Victoria

Engineers Australia (2005), *Australian Runoff Quality*, Wong, T.H.F. (ed).

Water by Design - Healthy Waterways (August 2006), *WSUD Technical Design Guidelines for South East Queensland*

Water by Design - Healthy Waterways (2010), *MUSIC Modelling Guideline for SEQ*

QUDM (2007) *Queensland Urban Drainage Manual*. Second Edition 2007. Department of Natural Resources and Water

APPENDIX A MUSIC MODEL

The following tables provide the relevant data used in the MUSIC model for Precinct A. 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	Amberley AMO (Station 40004)
Time step	6 minute
Modelling period	1990 to 1999
Mean annual rainfall (mm)	854 mm
Evapotranspiration	Monthly Mean PET (Water by Design, 2009)
Rainfall runoff parameters	Urban Residential (Water by Design, 2009)
Pollutant export parameters	Urban Residential (Water by Design, 2009)

Table A2: Catchment definition reporting table

Catchment ID	Area (ha)	Land use	Total impervious (%)
A	3.46	Urban Residential	53%
B	2.77	Urban Residential	60%
C	2.03	Commercial*	89%
D	0.29	Urban Residential	60%
E1	5.47	Urban Residential	60%
E2	4.00	Urban Residential (future)	60%
TOTAL	18.03		62%

* Future neighbourhood centre.

Table A3: Catchment split reporting table

Catchment ID	Area (ha)	Surface Type	Fraction impervious (%)
A	1.359	Road Reserve	60%
	0.304	Roof to tank	100%
	0.304	Roof to drain	100%
	0.607	Ground level	20%
	0.623	Park	20%
B	0.870	Road Reserve	60%
	0.492	Roof to tank	100%
	0.492	Roof to drain	100%
	0.984	Ground level	20%
C	0.610	Road Reserve	75%
	0.508	Roof to tank	100%
	0.508	Roof to drain	100%
	0.406	Ground level	80%
D	0.291	Road Reserve	60%
E1	2.406	Road Reserve	60%
	0.816	Roof to tank	100%
	0.816	Roof to drain	100%
	1.632	Ground level	20%
E2	1.697	Road Reserve	60%
	0.576	Roof to tank	100%
	0.576	Roof to drain	100%
	1.151	Ground level	20%
TOTAL	*18.026*		*62%*

Table A4: Bioretention Basin node reporting table

Parameter	Bio A	Bio B	Bio C	Bio E
Surface area (m2)	320	280	290	950
Has the filter area been calculated appropriately?	Yes, equal surface area method			
Extended Detention Depth (m)	0.3	0.3	0.3	0.3
Filter area (m2)	320	280	290	950
Saturated hydraulic conductivity (mm/hour).	200	200	200	200
Filter depth (m)	0.5	0.5	0.5	0.5
Filter Median Particle Diameter (mm)	0.45	0.45	0.45	0.45
Overflow weir width (m)	4.8	4.8	4.8	4.8
Seepage Loss (mm/hr)	0	0	0	0
Confirmation that K and C* remain default?	Y	Y	Y	Y

Table A5: Rainwater tank node reporting table

Tank Parameter	A_Tanks	B_Tanks	E1_Tanks	E2_Tanks
Volume below overflow (kL)	108	176	316	224
Depth above overflow (m)	0.2	0.2	0.2	0.2
Depth below overflow and pipe scaled appropriately?	Y	Y	Y	Y
Surface area (m2)	54	88	158	112
Overflow pipe diameter (mm)	520	663	889	748
Stored water used for irrigation/other purposes?	Y	Y	Y	Y
Indoor connections	Laundry and toilet			
Indoor demand (kL/day)	3.55	5.79	10.4	7.37
Outdoor demand scaled by PET - Rain (kL/yr)	1863.2	2917.4	5068.7	3706.6
Confirmation that K and C* remain the same?	Y	Y	Y	Y

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

- 2.8 people per detached dwelling

- 2.0 people per attached 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 70% of pervious area of lots.

- Outdoor reuse scaled by PET-rain

- Each house provided with 3 or 5kL tank as per QDC MP 4.2 and 4.3

- 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 (%)
A	TSS	3000	343	2657.0	88.6	Water quality objectives apply to combined site discharge
	TP	6.05	1.56	4.49	74.2	
	TN	28.1	14.5	13.6	48.2	
B	TSS	2840	278	2562	90.2	
	TP	5.47	1.27	4.20	76.7	
	TN	25.7	12.1	13.6	53	
C/D	TSS	2890	388	2502	86.6	
	TP	7.71	2.14	5.57	72.2	
	TN	45.3	25.7	19.6	43.3	
E1/E2	TSS	9210	921	8289	90	
	TP	18.4	4.25	14.15	76.9	
	TN	87.5	41.9	45.6	52.1	
TOTAL	TSS	17900	1930	15970.0	**89.3**	80
	TP	37.6	9.22	28.38	**75.5**	60
	TN	187	94.2	92.8	**49.5**	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.

Table A7: Bioretention sensitivity reporting table

Catchment ID	Pollutant	Inflows (kg/yr)	Outflows (kg/yr)	Reduction (kg/yr)	Reduction achieved (%)	Water Quality Objective (%)
TOTAL	TSS	17700	2280	15420	**87.1**	80
	TP	37.5	8.8	29	**76.5**	60
	TN	188	94.8	93	**49.5**	45

APPENDIX B DETAILED BIORETENTION CONCEPTS

CATCHMENT PLAN
SCALE 1:3000 (A1)

DRAWING INDEX

DRAWING No	DESCRIPTION
SK-001	LAYOUT PLAN AND DRAWING INDEX
SK-002	CONCEPTUAL DESIGN
SK-003	CONCEPTUAL DESIGN
SK-004	CONCEPTUAL DESIGN
SK-005	CONCEPTUAL DESIGN

REV.	DESCRIPTION	DATE	APP'D.	REV.	DESCRIPTION	DATE	APP'D.
A	ORIGINAL ISSUE	28/10/10	NS				

Client

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Project
PARADISE WATERS - PRECINCT A
WATER SENSITIVE URBAN DESIGN

BIORETENTION BASIN
LAYOUT PLAN AND DRAWING INDEX

Designed	NS	Approved	
Drawn	ST	RPEQ	Date
Date	28/10/10	Drawing No.	Rev.
Scale at A1	AS SHOWN	4134-SK-001	A

Original sheet size A1