LandCorp

Broome North Structure Plan Stage 2
Local Water Management Strategy

December 2016

Government of **Western Australia**
Department of **Water**

looking after all our water needs

Your ref: 61/27856/00
Our ref: RF6302-09
PA9122
Enquiries: Amber Briggs (9166 4114)

Kelsey Hunt
GHD
PO Box 3106
PERTH WA 6832

Dear Kelsey

RE: BROOME NORTH STRUCTURE PLAN STAGE 2 – REVISED LOCAL WATER MANAGEMENT STRATEGY (DECEMBER 2016)

Thank you for the referral, received in our office on 9 December 2016, of the revised Local Water Management Strategy (December 2016) (LWMS) to support the Broome North Structure Plan Stage 2.

The Department of Water (DoW) has reviewed the response to comments and the revised LWMS and has no further changes. The DoW hereby endorses the LWMS.

If you have any queries in relation to the above matters please contact Amber Briggs on (08) 9166 4114.

Yours sincerely

Duncan Palmer

District Manager
Kimberley Region

11/1/2017

Copied to:
Ertan Barkman, LandCorp (by email)
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Executive summary

GHD Pty Ltd was commissioned by LandCorp to prepare a Local Water Management Strategy (LWMS) for the Broome North Structure Plan Stage 2 (SP Stage 2) area. The Broome North SP Stage 2 area is bounded by Broome Road to the east, the ecological cultural corridor (ECC) that dissects the northern and southern components of the Broome North development to the south, Fairway Drive and remnant vegetation to the north, and the alignment of the future Magabala Drive to the west.

The proposed Structure Plan for Broome North SP Stage 2 area builds on design elements and key learnings from the development of Broome North Local Development Plan 1 and 3 areas, while acknowledging the interface of the area with the environmental and cultural values of the Yawuru managed land.

The following table summarises the objectives, strategy and outcomes of the LWMS.

Component	Objectives and criteria	Strategy	Outcome
Water conservation	Sustainable management of all aspects of the water cycle within the development and achieve efficient use of potable water	Install 5 Star Plus provisions for all new fittings. Best practice landscaping design and maintenance Non-potable dust suppression water	Water efficient demand of potable water supply
Stormwater quantity	Maintain discharge volume and peak flow relative to pre-development conditions.	Detention basins and swales to attenuate peak flows from impervious surfaces	Pre-development peak flow rates and volumes maintained at each outlet
Stormwater quality	Maintain and, if possible, improve the quality of water leaving the development area	Infiltration in drainage corridors and public areas Erosion and sediment control during construction and post-development Water Sensitive Urban Design	Stormwater quality protected
Groundwater levels	Maintain groundwater levels	Infiltration in drainage corridors and public areas	Groundwater recharge maintained
Groundwater quality	Protect groundwater quality	Capture and treat stormwater prior to infiltration	Groundwater quality protected

Checklist

The following checklist summarises the LWMS content for quick reference

Local water management strategy item	Deliverable	Ref	Comment
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements & requirements for BMPs and critical control points	ES	
Introduction			
Total water cycle management – principles & objectives Planning background Previous studies		3 1.2 1.4	
Proposed development			
Structure plan, zoning and land use. Key landscape features Previous land use	Site context plan Structure plan	2, Fig 3 Fig 4	
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape Plan	2.1.2 5.2 7, Figs 6-10	
Design criteria			
Agreed design objectives and source of objective		3	
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		4	
Site Conditions - existing topography/ contours, aerial photo underlay, major physical features	Site condition plan	4.1 Fig 4	
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	4.2 App B	
Environmental - areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	4.4, 4.6, 4.7, 4.8 Fig 5	
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	4.8	
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	4.9	

Water use sustainability initiatives			
Water efficiency measures – private and public open spaces including method of enforcement		5.4	
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		5.2	
Wastewater management		5.1.2	
Stormwater management strategy			
Flood protection - peak flow rates, volumes and top water levels at control points,100 year flow paths and 100 year detentions storage areas	100yr event Plan Long section of critical points	6.2,6.3, 6.4 App G	
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5yr event Plan	6.2,6.3, 6.4 App G	
Protect ecology – detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1yr event plan	6.2,6.3, 6.4, 6.5 App G	
Groundwater management strategy			
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoils areas/exclusion zones	Groundwater/ subsoil plan	N/A	
Actions to address acid sulfate soils or contamination		N/A	
The next stage – subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design.		8.2	
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		8.1	
Implementation			
Developer commitments		8.3	
Roles, responsibilities, funding for implementation		8.3	
Review		8.3	

Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 Broome North Structure Plan Stage 2

The Broome North Structure Plan Stage 2 (SP Stage 2) area is located within the north-eastern portion of the Broome North development area, approximately 4 km from the Broome town centre (Figure 2). The site comprises an area of 94.01 ha and is bounded by Broome Road to the east, the ecological cultural corridor (ECC) that dissects the northern and southern components of the Broome North development to the south, Fairway Drive and remnant vegetation to the north, and the alignment of the future Magabala Drive to the west.

1.2 Planning context

The *Broome North District Water Management Strategy* (DWMS) (GHD and SKM 2009) was prepared to address total water cycle management across the 700 ha Broome North District Development Plan (DDP) area.

The Broome North SP Stage 2 Local Water Management Strategy (LWMS) has been prepared to further develop and refine the findings from the investigations undertaken during the DWMS, and progressive development of the Broome North development area.

This LWMS has been prepared in accordance with S*tate Planning Policy 2.9: Water Resources* (WAPC 2006) and *Better Urban Water Management* (WAPC 2008), on advice from the Department of Water (DoW) and Shire of Broome. The planning framework for land and water planning is illustrated in Figure 1.

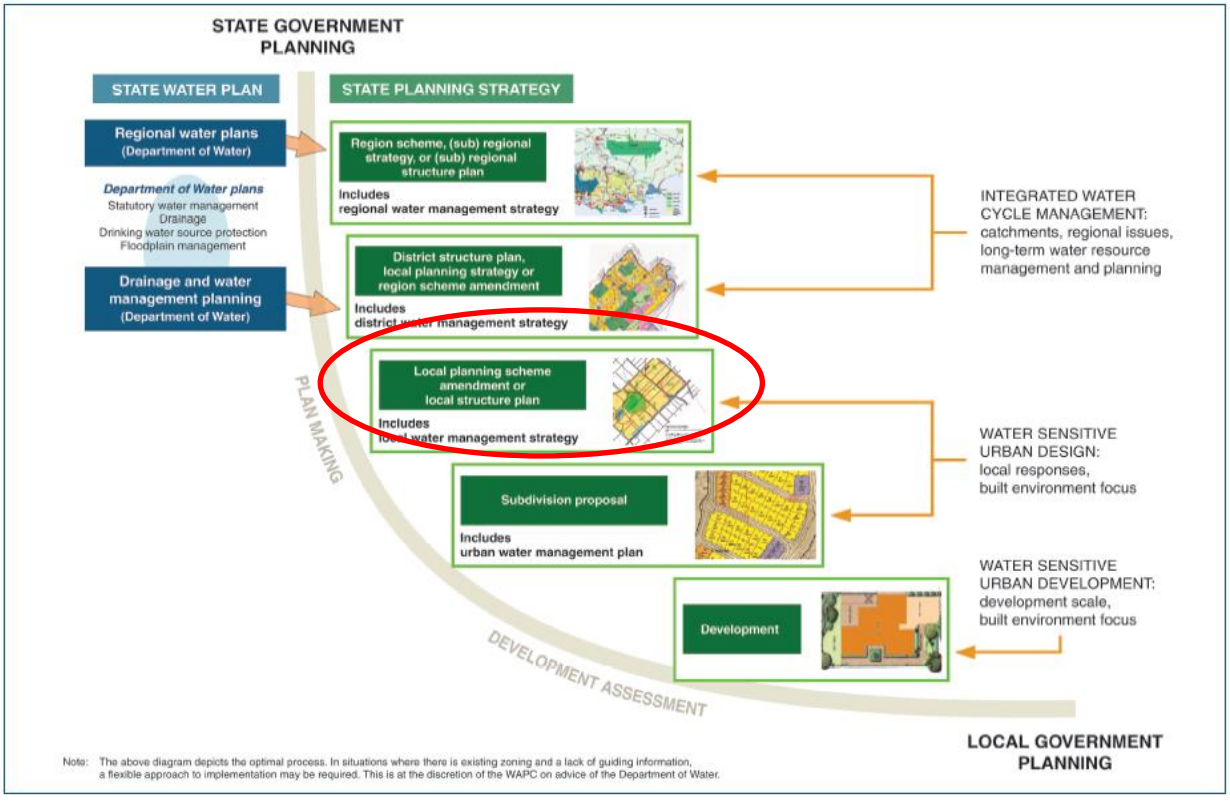
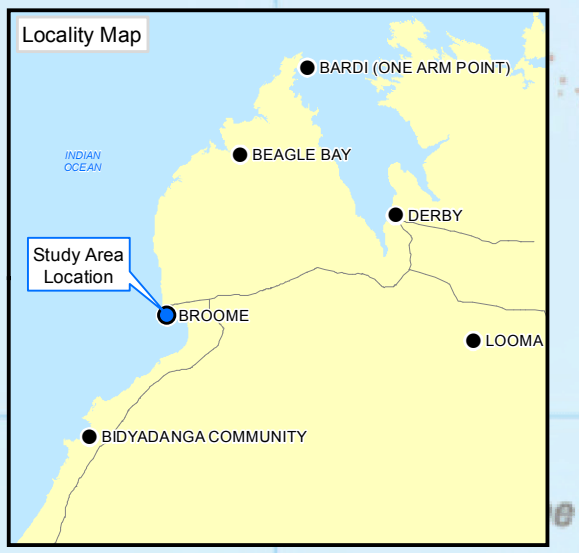


Figure 1 Framework for integrating water planning with land planning



Local Water Management Strategy (LWMS) Study Area

LEGEND

LWMS Study Boundary

Paper Size A3

0 0.5 1 2 3 4 5

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

Landcorp
Broome North Structure Plan Stage 2

Job Number 61-27856
Revision 0
Date 26 Jul 2016

Locality Map

Figure 1

G:\61\2785600\GIS\Maps\MXD\612785600_001_Rev0_Fig1Locality.mxd

999 Hay Street Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com W www.ghd.com

Data source: Landgate: Topo 250K Raster 2005 - 20120316; GHD: Study Boundary - 20160726; GA: Topo 250k Series 3- March 2006. Created by:mmikkonen

1.3 Purpose of this report

This LWMS has been prepared to support a revised development plan for the Broome North SP Stage 2 area. The development plan and LWMS have been revised based on key learnings from the Broome North Broome North Local Development Plan 1 and 3 areas.

The strategy identifies characteristics of the study area, and identifies key principles, design criteria and development requirements, and additional guidance to support development in the study area.

1.4 Previous studies and relevant guidelines

In addition to the planning documents identified in Section 1.2 the following documents have been used to inform the water management principles and design criteria outlined in this LWMS.

Broome North District Water Management Strategy

The Broome North District Water Management Strategy (GHD and SKM 2009) details the key principles for water management at the district scale for the whole of the Broome North development area.

Broome North Local Development Plan No. 3 Flora and Fauna Assessment

The *Broome North Local Development Plan No. 3 Flora and Fauna Assessment* (GHD 2013) report presents the results of site specific flora and fauna survey for the LDP3 area, located west of the SP Stage 2 area. The vegetation and flora survey identified one vegetation association, Pindan shrubland, within the survey area consistent with previous reporting. One introduced species, listed as a Declared Pest and Weed of National Significance (Bellyache bush, *Jatropha gossypiifolia*) was identified within the northern section of the survey area. The fauna survey results identified a fauna diversity similar to that recorded in previous surveys of the broader area, with no threatened fauna species recorded. One Northern Brushtail Possum was recorded on infra-red camera. Recommendations were identified for management of the study area during development.

Broome North Local Water Management Strategy

The *Broome North Local Water Management Strategy* (GHD and SKM 2010) details the requirements for total water cycle management for the LDP1 area, the first local structure plan area developed within the Broome North area. LDP1 area lies to the south of the current SP Stage 2 study area.

Broome North LDP3 Local Water Management Strategy

Broome North LDP3 Local Water Management Strategy (GHD 2012) report details the total water cycle management for the LDP3 Area that is located west of LDP1.

Study for Broome Groundwater Management Plan Review – Final

The *Study for Broome Groundwater Management Plan Review – Final*, (Groundwater Consulting Services 2008) report was provides an assessment of the groundwater resources in the Broome area, and was prepared for the Department of Water.

Geotechnical Investigation for Broome North – Lots 3150 and 304

The *Report on Geotechnical Investigation for Broome North – Lots 3150 and 304* (Coffey Geotechnics 2009) provides an assessment of the overall geotechnical conditions on the site and also a desktop hydrological investigation. The report also includes chemical testing of the existing soils on the site for nitrogen and phosphorus.

Broome North Acid Sulphate Soil Desktop Investigation

The *Broome North Acid Sulphate Soil Desktop Investigation* (GHD 2009) report investigates the potential for acid sulphate soils in the region and presents the findings of the desktop investigation and recommended actions. The report identified that the site has a low risk of acid sulfate soil on the basis of both desktop and site investigations.

Broome North Development Area, Targeted fauna Survey

The *Broome North Development Area, Targeted fauna Survey (*GHD 2009) report presents the results of a survey to undertaken to target conservation significant species and determine the risks to fauna from proposed development.

Preliminary Environmental Impact Assessment and Biological Survey – Southern Portion (Area A)

The *Preliminary Environmental Impact Assessment and Biological Survey – Southern Portion (Area A)* (GHD 2009) was a combined PEIA and Biological Survey completed to characterise the study area and determine and assess the potential environmental impacts of the proposed works within the project area.

Preliminary Site Investigation (PSI) – Broome North Redevelopment,

The Preliminary Site Investigation (PSI) – Broome North Redevelopment (GHD 2009) report investigates the land use history of the site to identify existing or past practises that have the potential to cause contamination of soil and/or groundwater at the site.

Draft Shire of Broome Environmental Management Strategy 2012-2017

The *Draft Shire of Broome Environmental Management Strategy 2012-2017* (Shire of Broome 2013) was developed by the Shire of Broome to provide strategic direction for the management of the unique Broome environment. The strategy identifies key objective including:

- Undertake and promote water sensitive urban design appropriate for North West climate conditions to better manage stormwater and its impact on natural areas.
- Improve the Shire's understanding of water quality issues and its impact on natural areas.
- Ensure the Council manages it water use appropriately through efficiency and conservation measures and the use of alternative water sources.

The management strategy identifies a number of actions relating to total water cycle management and their time frame and priority for completion.

Shire of Broome Structure Plan and Subdivision Standards; Local Planning Policy 8.32

Local Planning Policy 8.32 (Shire of Broome 2015) emphasises early consideration of urban water management early in the Structure Plan/urban design within the Broome area.

The policy outlines the key requirements for stormwater management within the Broome area, supporting documentation for development and review processes.

1.5 Scope and limitations

This report has been prepared by GHD for LandCorp and may only be used and relied on by LandCorp for the purpose agreed between GHD and the LandCorp as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person other than LandCorp arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.6 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by LandCorp and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.6 Assumptions

GHD has prepared this LWMS relying on information provided by the client (LandCorp) and other consultants undertaking work for the Broome North SP Stage 2 area. It has been assumed that the following sources provided correct and relevant information and that design of the site will not change:

- Roberts Day (Planning)
- Tabec (Stormwater design and modelling)
- UDLA (Landscape design)

2. Proposed development

2.1 Key elements

The Broome North development area has been progressively developed with regard to the approved District Water Management Strategy, as well as Local Water Management Strategy and Urban Water Management Plans prepared for the various stages of the LDP1 development.

The proposed Local Development Plan for Broome North SP Stage 2 builds on the design elements of the Broome North LDP1 area to the south, as well as the environmental and cultural values of the Yawuru managed land.

The following proposed land uses have been identified within the Broome North SP Stage 2 area:

- Residential – Comprising predominantly Urban Living and Neighbourhood Living.
- Schools
- Public open space – Provision of neighbourhood parks along the main east-west multiple use corridors, and civic park and local park spaces.
- Drainage –Provision of linear swales in multiple use corridors and dedicated drainage reserves.
- Ecological cultural corridor and A Class Reserve – Retention of existing culturally significant bushland.

The Local Structure Plan for Broome North SP Stage 2 area is displayed in Figure 3.

Since the inception of the Broome North development one of the key design elements has been the incorporation of linear swale detention drainage within the landscape with the intention of creating linear multi-use corridors for active and passive recreation, while activating the water sensitive urban design treatment train high in the catchment.

The SP Stage 2 area continues the linear swale drainage elements, with the drainage incorporated into the key street typologies and adjacent to formalised recreation spaces, including park facilities. Linkages are also provided to the environmental cultural corridor (ECC), which provides an important east west linkage across the Broome Peninsula from Cable Beach through to Dampier Creek and Roebuck Bay.

2.1.1 Environmental cultural corridor

The environmental cultural corridor (ECC) is a 150 m wide tract of naturally vegetated land that will be retained for environmental and cultural purposes. The ECC provides a naturally vegetated corridor linking the proposed A class reserve adjacent to the dunal system of Cable Beach to the mangroves of Roebuck Bay. The width and alignment of the ECC was agreed with the Traditional Owners during the development of the DDP.

2.1.2 Landscaping and drainage

The landscaping concepts for the Broome North SP Stage 2 area have been informed by the developing experiences of the landscape consultant UDLA within the region, and the local social, cultural and environmental conditions. The primary landscape typologies include neighbourhood parks and the east-west multiple-use corridors, a key feature of which are the linear drainage swales.

The landscape design uses best management practices suited to the north-west region including provision of formal and informal public open space areas, and vegetated linear swale

drainage system to minimise runoff from hard surfaces within the development catchment area. Best management practices that are suited to the climate such as mulch, lawn or vegetated surfaces provide the opportunity for overland flows to be retarded, therefore greater percentage to be infiltrated. The use of local mulch or slashing generated during development construction has also proven to provide an immediate seed bank for revegetation, especially following the first wet season.

Further detail regarding the stormwater drainage system are detailed in Section 6 and landscape concept plans are detailed in Section 7.

INDICATIVE ALIGNMENT OF MAGABALA ROAD EXTENSION

BUCKLEY ROAD RESERVE TO BE CLOSED

FAIRWAY DRIVE

HP

Lot 360

Lot 2605

Lot 2606

PS / HS

Lot 365

Pt Lot 9007

PAW

MAGABALA ROAD

BROOME ROAD

N

R20

R25 - R40

18m Road Reserve

14m Road Reserve

40m Road Reserve

30m Road Reserve

24m Road Reserve

LEGEND

- STRUCTURE PLAN BOUNDARY
- EXISTING LOT BOUNDARY
- PROPOSED LOT BOUNDARY (INDICATIVE)

LOCAL SCHEME RESERVES

- PARKS, RECREATION & DRAINAGE
- ENVIRONMENTAL CULTURAL CORRIDOR
- PUBLIC PURPOSE
  DENOTED AS FOLLOWS:
  PS / HS — PRIMARY SCHOOL / HIGH SCHOOL
  HP — HORIZON POWER

ZONES

- RESIDENTIAL

OTHER

- R CODES
- INTEGRATOR ARTERIAL B
- NEIGHBORHOOD CONNECTOR
- MAJOR ACCESS STREET
- LOCAL ROADS
- PEDESTRIAN ACCESS WAY
- LEFT-IN / LEFT-OUT INTERSECTION
- SWALE

LANDCORP

BROOME NORTH

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planning·design·place

CADASTRAL INFORMATION
SOURCE:
YYMMDD:
DWG REF:
PROJECTION:

AERIAL PHOTOGRAPHY
SOURCE: NA
YYMMDD: NA

SIZE A3
1:5000
0 metres 50 100 150 200 250

REV	DESCRIPTION	YYMMDD	DRAWN	APPR'D
C	PLAN UPDATES	160722	RF	DP
B	DESIGN MODIFICATIONS	160705	RF	DP
A	PLAN BASE RD1 112F	160630	RF	DP

STRUCTURE PLAN - STAGE 2: PLAN 1
Broome North
Shire of Broome

REF NO.	DRAW NO.	REV.
LAN BRO	**RD1 200**	**C**

3. Design principles and objectives

Water management for the Broome North development is based on best practice water sensitive urban design that is suitable for the Broome climate and geomorphology. The design criteria adopted for this local water management strategy have been based on the design objectives outlined in *Better Urban Water Management* (WAPC 2008) with consideration of the specific challenges for water management presented by urban development in the Kimberley region.

In recognising the specific challenges for stormwater management in the Kimberley during the wet season (episodic rainfall events resulting in large volumes of water, large sediment loads), and the requirement for specific infrastructure designed to handle it, the *Kimberley Regional Water Plan* (DoW 2010) recommended a review of the *Stormwater management manual for Western Australia* (DoW 2004-2007).

In the absence of this review the stormwater management principles presented within this LWMS are built on the water management principles initially presented within the *Broome North DWMS* (GHD and SKM 2009). These water management principles have been progressively refined to local conditions during development and planning for the Broome North LDP1, SP Stage 2 and LDP3 areas, in consultation with the Department of Water, Shire of Broome and Yawuru.

The criteria for water conservation, stormwater management and groundwater management are summarised in the following sections. Further details of the strategies to achieve the design objectives are outlined in Section 5 for water conservation, Section 6 for water quantity and Section 6.5 for water quality.

3.1 Water conservation

The overall intention of this LWMS is to achieve the sustainable management of all aspects of the water cycle within the development and achieve efficient use of potable water. Specifically the objectives for integrated urban water management for the development are:

- Potable water use outside of buildings should be limited and as efficient as possible.
- Encourage the installation of 5 Star Plus provisions for all new fittings.
- Encourage the planting of native gardens.
- Use of endemic species within the development area that require similar water and soil conditions as provided by the local environment.
- Minimising water use in public open space through use of low water use landscaping treatments, hydrozoning of turf areas according to active and passive uses and retention of native vegetation where possible.

3.2 Water quantity management

The principle for water quantity management is the maintenance of discharge volume and peak flow relative to pre-development conditions.

To achieve this principle the following criteria have been incorporated:

- *Ecological Protection* – The stormwater drainage system begins high in the catchment to retain flows near source. In particular, for the critical one year average recurrence interval (ARI) event, the design of the stormwater drainage system attempts to maintain post

development discharge volume and peak flow rates relative to pre-development conditions in all parts of the catchment.

- *Flood management* – The stormwater drainage system has been designed to manage the catchment runoff for the critical duration 50 year ARI event in the development area to pre-development peak flows.
- *Protect infrastructure and assets from inundation and flooding* – The stormwater drainage system has been designed to ensure the system conveys flows and ensures protection of infrastructure and assets during flooding events.

3.3 Water quality management

The principle for water quality management is to maintain and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the sub catchment in which the development is located. To achieve this principle the following criteria have been incorporated:

- The stormwater drainage system has been designed to treat flows in linear vegetated swales near the source of flows.
- Ensure that all runoff contained in the drainage infrastructure network receives treatment prior to discharge to a receiving environment consistent with the Stormwater Management Manual (Department of Water, 2004-2007).
- Development of a monitoring program to measure the water quality of the development, with comparison to ambient conditions, where achievable, and relevant water quality guidelines. Protect groundwater as a resource.

4. Pre-development environment

4.1 Climate

Broome has a tropical climate characterised by two distinct seasons; 'the wet season' and 'the dry season'. The wet season usually extends from December to March and the dry season for the remainder of the year. The closest weather station to the proposed development area is Broome Airport. The mean annual minimum temperature range varies between 13.7 ^{o}C in July and 26.5 ^{o}C in December, and mean annual maximum temperature range varies between 28.8 ^{o}C in July and 34.3 ^{o}C in April (Bureau of Meteorology 2014).

Mean annual rainfall in Broome is 606.3 mm with 35.4 mean rain days. Average monthly rainfall is shown in Table 1.

Table 1 Mean monthly rainfall Broome Airport (1941-2013)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean rainfall (mm)	181.6	179.8	101.7	26.2	27.3	19.9	7.1	1.7	1.4	1.5	9.2	57.7

4.1 Site conditions and topography

A ridge line traverses the whole of the Broome North site in a south-west to north-east direction, with the western site grading to the base of the dune system to the west and the eastern side of the site grading toward Dampier Creek.

The SP Stage 2 Area is located east of the ridgeline and the topography of the site is generally flat, with the majority of the SP Stage 2 Area less than 1% grade, and a few areas up to 1.5% grade. The high point occurs within the north-west corner of the SP Stage 2 Area with an approximate level of 14.6 mAHD. The low point of the site occurs within the south-east corner of the site in the ECC with an approximate level of 6 mAHD, with the low point of the proposed development area along the northern boundary of the ECC at approximately 6.6 mAHD.

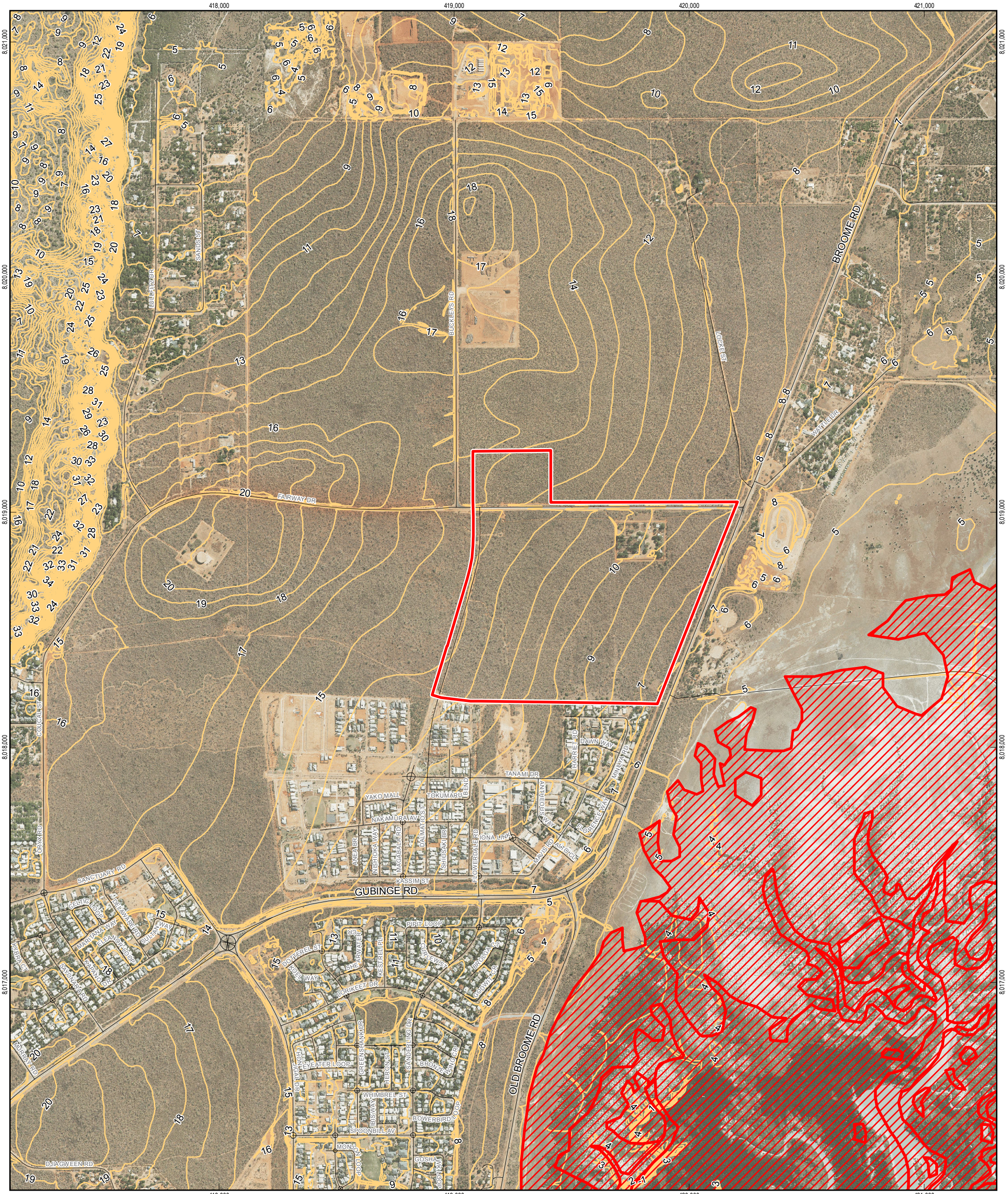
The topography of the Broome North development area is shown in Figure 4 and Appendix A.

4.2 Geotechnical conditions

4.2.1 Geology and soils

The proposed development is situated on a flat to gently undulating plain of the Dampier Peninsula, which is underlain by the ancient (Pre-Cambrian) rocks of the Canning Basin. The Geological Survey of Western Australia (1982) indicates that the geology comprises "red sand, fine to medium, minor silt: Aeolian".

The principle soil type of the Dampier Peninsula is the Pindan, identified as red earthy sands which are of windblown origin (Kenneally *et al*. 1996). Within the Broome area the Pindan is often overlain by a layer of more recent, coarser and unconsolidated sand, which assists in water penetration, plant establishment and growth (Kenneally *et al*. 1996).



LEGEND

- Roads
- Contour (1m)
- LWMS Study Boundary

Acid Sulfate Soil Risk Category

- High to moderate risk

Paper Size A3

0 100 200 400 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

Landcorp
Broome North Structure Plan Stage 2

Job Number	61-2785600
Revision	0
Date	26 Jul 2016

Topography and Acid Sulfate Soils

Figure 4

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Data source: Landgate: Broome Townsite July 2015 Mosaic, Roads - 20120313, Contours - 20160516; DER: Acid Sulfate Soils - 20140922; GHD: LWMS Study Boundary - 20160726. Created by:mmikkonen

4.2.2 Geotechnics

Coffey (2009) completed a geotechnical survey with a study area boundary immediately west of the SP Stage 2 development area, with access limited to existing roads and tracks in the Broome North development area.

The Broome North development area has a general subsurface strata summarised as silty clayey SAND, fine to medium coarse, dense, red to brown, weakly cemented (Coffey, 2009).

The Pindan sand was encountered to the test pit termination depth of 2.5m BGL in test pits TP6 and TP7 which occur on the western boundary of the SP Stage 2 area. Little variation laterally or over depth was encountered across the study area (Coffey, 2009). On this basis, perched groundwater is unlikely to occur.

Falling head permeability tests were completed within a range of test pits, resulting in a recommended design value of permeability of 0.1 m/day.

Further information is provided in Appendix B.

4.2.3 Acid sulfate soils

Mapping of acid sulphate soils by the Western Australian Planning Commission in the Shire of Broome is very limited with no data available for the majority of the shire. No acid sulphate soils data is available for the proposed development however it is located within approximately one kilometre of land designated as high to moderate risk of acid sulphate soils occurring within 3 m of natural soil surface, which is potentially related to the influence of Dampier Creek (Figure 4).

An acid sulphate soil investigation of the Broome North area, comprising a desktop investigation as well as targeted sampling, concluded that the risk of ASS occurrence in the Broome North area is inherently low (GHD 2009d). Given the findings of the investigation, it is considered that no further ASS investigations or management is likely to be required prior to development of the Broome North area assuming that excavation works are limited to Pindan Soils and dewatering is not required.

4.2.4 Contaminated sites

The DEC Contaminated Sites Database presents information on known or suspected contaminated sites that have been classified by the DEC within the following categories:

- Contaminated - remediation required;
- Contaminated - restricted use; or
- Remediated for restricted use.

The DEC Contaminated Sites Database does not provide details of sites that are listed as 'Possibly contaminated – investigation required'.

A search of the DEC Contaminated Sites Database shows that the Site and surrounds have not been reported as known contaminated sites at the time of the search (11 May 2016).

Broome North Preliminary Site Investigation

The *Broome North Preliminary Site Investigation* (PSI) (GHD 2009c) investigated the historical and current land uses within the study area in order to determine if there is any potential soil or groundwater contamination present. The lot identified as the Anglican school site is identified within the *Broome North PSI* as containing a former poultry farm. The *Broome North PSI* included a review of soil sampling completed across the Anglican school site, with three locations noted to exceed the assessment levels (for zinc and TPH). A site walkover did not identify any areas of significant contamination.

The *Broome North PSI* also observed many areas of illegal dumping along unsealed tracks were identified across the Site. Dumped wastes included white goods, cans, bottle, drums and other household wastes, generally limited to unsealed tracks across the Site.

Except for the minor and localised dumping of waste materials, the *Broome North PSI* concluded that no significant contamination issues were observed within the study area. However, this conclusion is subject to the timeframes for the development and whether dumping of waste continues to occur and potentially cause contamination in the future.

In accordance with the conclusions and recommendations of the *Broome North PSI* (GHD 2009c), prior to development of the Anglican school site further investigation and mapping of zinc and TPH levels is recommended. No additional investigations or monitoring are proposed for the remainder of the development.

A copy of the Broome North PSI (GHD 2009c) is included as Appendix C.

4.3 Aboriginal heritage

The Aboriginal site register is held under Section 38 of the State Aboriginal Heritage Act 1972. It protects places and objects customarily used by, or traditional to, the original inhabitants of Australia. A search of the Department of Aboriginal Affairs database identified two registered Aboriginal sites within the proposed development. The details of these sites are summarised in Table 2.

Table 2 Registered Aboriginal Heritage sites within the study area

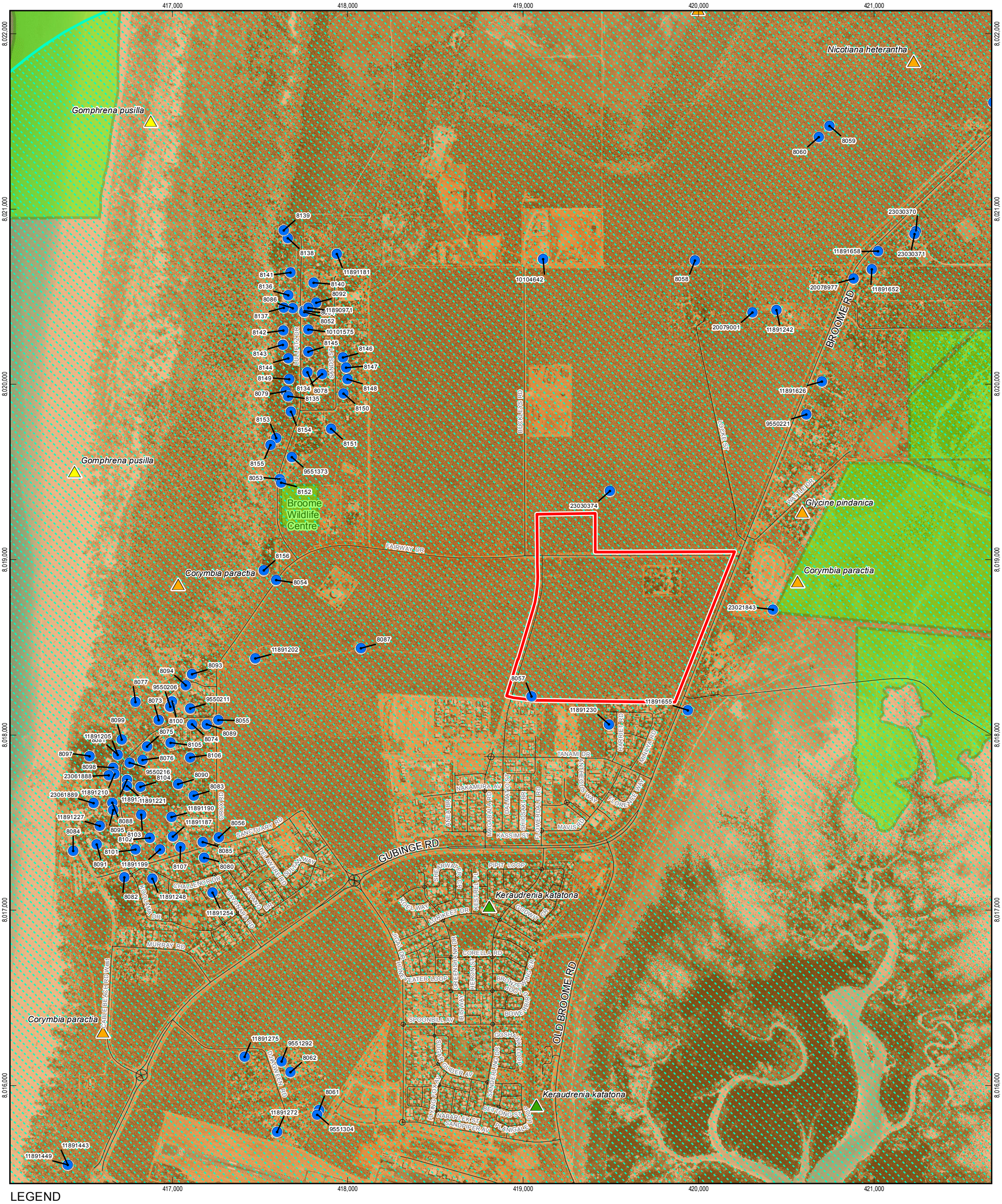
Site ID	Site name	Type	Additional information
12839	Billingurru	Ceremonial, Mythological	Camp
21408	Broome Crocodile Farm	Ceremonial, Mythological	Camp

Figure 5 identifies the location of the registered Aboriginal heritage sites within the vicinity of the study area. A Search of the Department of Aboriginal Affairs database does not comprise of a full assessment under the Aboriginal Heritage Act (1972). This would require consultation with Aboriginal people with knowledge of the area, and an archaeological survey to ascertain whether any previously unrecorded archaeological sites are within the proposed works area.

Under the Aboriginal Heritage Act (1972), it is an offence to disturb an Aboriginal heritage site whether it is registered or not. Where an activity disturbs an Aboriginal site or object an application for permission to disturb those sites will need to be submitted under Section 18 of the Aboriginal Heritage Act (1972). Where an area of previously unknown Aboriginal heritage is to be disturbed, it is advised that a detailed anthropological and archaeological survey is undertaken to find if there are any sites of objects of significance in that area.

4.4 Environmentally sensitive areas

The Department of Environment and Regulation Clearing Regulations – Environmentally Sensitive Areas dataset was reviewed to determine the location of any environmentally sensitive areas (ESAs) within the Study Area, as declared by a notice under Section 51B of the Environmental protection act 1986. The Study Area, the surrounding Broome Peninsula and a substantial portion of the coastline to the north and south, occurs within an Environmentally Sensitive Area. This is mapped in Figure 5.



LEGEND

Declared Rare & Priority Flora

- (R) Declared Rare Flora - Extant Taxa
- Priority 1 - Poorly Known Taxa
- Priority 2 - Poorly Known Taxa
- Priority 3 - Poorly Known Taxa
- Priority 4 - Rare Taxa

- WIN Sites (2016)
- Roads
- LWMS Study Boundary
- TEC Buffers
- DPaW Managed Land and Water
- Environmentally Sensitive Area

Paper Size A3

0 100 200 400 600 800 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

Landcorp
Broome North Structure Plan Stage 2

Job Number	61-2785600
Revision	0
Date	26 Jul 2016

Environmental Constraints and WIN Sites

Figure 5

G:\61\2785600\GIS\Maps\MXD\612785600_005_Rev0_Fig5EnvironmentalConstraints.mxd

999 Hay Street Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com W www.ghd.com

Data source: Landgate: Broome Townsite July 2015 Mosaic, Roads - 20120313; GHD: LWMS Study Boundary - 20120313; DoW: WIN Sites - 20160516; DEC: Declared Rare & Priority Flora - 20120321, TEC Buffers - 20120321; DER: Environmentally Sensitive Areas - 20151210; DPaW: Managed Lands and Water - 20160323. Created by:mmikkonen

4.5 Reserves and conservation areas

Reserves and conservation areas in proximity to the Broome North SP Stage 2 area are shown in Figure 5.

The DPaW-managed reserve is a Wildlife Veterinary Clinic that undertakes care and rehabilitation of wildlife. The reserve is vested with the Conservation Commission of Western Australia and is located approximately 1,200 m west of the Project area.

Yawuru Indigenous Land Use Agreement (ILUA) Conservation Estate occurs to the south-east of the SP Stage 2 area, within the fringing mangroves of Roebuck Bay.

The Yawuru conservation estate is classified as an ILUA in-Town reserve, and is classified as A-class reserve to protect cultural and natural heritage. Any effort to amend an A-class reserves purpose, or to alter its boundary, requires approval from Parliament (CCS Strategic, 2013).

The *Broome Coastal Reserves Master Plan* (CCS Strategic, 2013), includes outcomes proposed for ILUA reserves, and applicable to the Yawuru conservation estate:

- To restore, protect and sustainably manage the cultural and natural values for the enjoyment and benefit of present and future generations;
- To provide recreational facilities and activities consistent with the reserve's A-class status;
- To preserve and promote Aboriginal cultural and heritage values, archaeological values and natural environmental values including indigenous flora and fauna;
- To facilitate public utilisation of the spaces and promote the concept that the public's wise usage is an important part of the management matrix;
- To facilitate Yawuru access for purposes consistent with Yawuru Culture and tradition and to preserve and sustain recognised native title rights and interests;
- To make available employment, service provision and training opportunities for the Yawuru People for planning and management;
- To facilitate commercial and economic opportunities for the Yawuru Community and the Yawuru RNTBC, subject to such activities being consistent with the management of the Conservation Estate; and
- To monitor and report on the effectiveness of implementing the Management Plan.

4.6 Vegetation and flora

The study area is situated in the Northern Botanical Province of Western Australia (Beard 1990), within the Dampierland bioregion and the Pindanland sub-region as described by the Interim Biogeographic Regionalisation of Australia (IBRA) (DotE 2013b).

The vegetation of the Dampier Peninsular has been described by Kenneally *et al.* (1996) who recognise 11 (ten terrestrial and one marine) plant communities on or around the Dampier Peninsular. Kenneally *et al*. (1996) note that the vegetation is predominantly Pindan 'a grassland wooded by scattered trees, generally eucalypts, with a variably dense middle layer of wattles'. Fire is the controlling agent of the Pindan with the variety in the vegetation, particularly wattles, relating directly to a fire-regeneration cycle (Kenneally *et al.* 1996).

4.6.1 Threatened ecological communities

A search of the Department of Environment and Conservation threatened ecological communities database was undertaken for known occurrences of threatened ecological communities and/or priority ecological communities within the proposed development area. No

threatened ecological communities or priority ecological communities were located within the boundaries of the proposed development.

The Environment Protection and Biodiversity Conservation Act 1999 protected matters search tool (DotE 2016) identified one federally listed TEC, the Monsoon (vine) thickets on coastal sand dunes of Dampier Peninsula, within 10 km of the development area, however this does not occur within the boundaries of the proposed development area.

No threatened ecological communities or priority ecological communities were identified as being present on the site during a field survey conducted by GHD in June 2008 (GHD 2009b).

4.6.2 Conservation significant flora

Species of significant flora are protected under both State and Commonwealth Acts. Any activities that are deemed to have a significant impact on species that are recognised by the EPBC Act and the State *Wildlife Conservation Act 1950* (WC Act) can trigger referral to DSEWPaC and/or the EPA.

The EPBC Act Protected Matters Report (DotE 2016), identified one conservation significant flora species as potentially occurring within 10 km of the Study area. The Department of Parks and Wildlife database query, *NatureMap*, identified an additional 15 conservation significant flora species as being previously recorded within 10 km of the Study Area. Conservation significant species are shown in Table 3.

Table 3 Conservation significant flora species potentially occurring in the study area

Species	Status	
	State	Federal
Keraudrenia exastia	Threatened	Critically Endangered
Acacia sp. Broome (B.R. Maslin 4918)	Priority 3	
Acacia sp. Riddell Beach (T.Willing 71)	Priority 3	
Corymbia paractia	Priority 1	
Eriachne sp. Dampier Peninsula (K.F. Kenneally 5946)	Priority 3	
Glycine pindanica	Priority 1	
Gomphrena pusilla	Priority 2	
Goodenia byrnesii	Priority 1	
Jacquemontia sp. Broome (A.A. Mitchell 3028)	Priority 1	
Keraudrenia katatona	Priority 3	
Nicotiana heterantha	Priority 1	
Phyllanthus aridus	Priority 3	
Polymeria distigma	Priority 3	
Pterocaulon sp. A Kimberly Flora (B.J. Carter 599)	Priority 3	
Thespidium basiflorum	Priority 1	
Triodia acutispicula	Priority 3	

4.7 Fauna

Fauna species of significance are protected under both State and Commonwealth Acts. Any activities that are deemed to have a significant impact on species that are recognised by the EPBC Act and the *Wildlife Conservation Act* can trigger referral to the DSEWPaC and/or the EPA.

GHD conducted a Level 1 fauna assessment (reconnaissance survey) of the study area in June 2008 (GHD 2009a), with the purpose of the survey to target conservation significant species and determine the likely risks to fauna from the prosed development.

No fauna species of conservation significance were recorded during the field survey. Eight marine and/or migratory species were recorded but are considered vagrants to the sites and will opportunistically use the area.

Northern Brushtail Possums were recorded in an area of Eucalyptus woodland with hollows. During the development of the LDP1 area DPaW requested that a relocation program be undertaken of Northern Brushtail Possums in the project site prior to clearing.

A follow up Level 1 fauna assessment of the adjacent LDP3 area in 2013 (GHD 2013) did not identify any fauna species of conservation significance.

4.8 Surface water

The Department of Water's Geographic data atlas identifies that the proposed development is located in the Cape Leveque Coast drainage basin. The study area is not located in a proclaimed surface water management area (Department of Water 2009).

Surface drainage is poorly developed over much of the Dampier Peninsula, with surface flow predominantly occurring as sheet flow. In response to the surface drainage there are no wetlands or watercourses located within the study area boundary.

4.8.1 Surface water quality

Due to the sheet flow nature of natural surface drainage there is limited opportunity to collect baseline surface water samples from the site. Opportunistic grab samples were collected from a surface runoff a low point crossing of Broome Highway near the SP Stage 2 area on five occasions. Grab sampling event dates and corresponding rainfall volumes (from Bureau of Meteorology weather station at Broome Airport, Station No 003003) are summarised in Table 4.

Table 4 Sampling event dates and rainfall data

Sampling date	Rainfall (mm)	Rainfall (mm) – preceding 3 days
20/01/2013	17.4	4
25/02/2013 and 26/02/2013	50.2	2.4
29/12/2013	31.2	0.0
22/01/2014	170.2	19.4

Sample field observations note that samples were collected from water flowing alongside or across Broome Highway near to the proposed SP Stage 2 area outlet, and flowing water was observed to be turbid. The range and median of observed water quality data is summarised in Table 5. Note that metals are total metals and are compared to guidelines for dissolved species.

Table 5 Surface water quality

Parameter	ANZECC Guideline - Tropical lowland river (ANZECC 2000)	Median value	Observed range	Count
pH (Lab)	6-8	6.93	3.28 -7.23	5
TSS (mg/L)		24	20 - 451	5
Total nitrogen (mg/L)	0.3	0.7	0.4 - 9.9	5
Ammonia-N (mg/L)	0.01	0.06	0.02 - 0.1	5
Nitrite+Nitrate-N (mg/L)	0.01	0.03	0.02 - 9.44	5
Dissolved organic N (mg/L)		0.2	0.2	2
Total phosphorus (mg/L)	0.01	0.105	<0.05 - 0.13	5
Filterable reactive P (mg/L)	0.004	0.015	<0.01 - 0.02	5
Arsenic (mg/L)	0.013	0.0015	<0.001 - 0.003	5
Cadmium (mg/L)	0.0002	0.0001	<0.0001 - 0.0001	5
Chromium (mg/L)	0.001	0.004	0.002 - 0.013	5
Copper (mg/L)	0.0014	0.002	0.002 - 0.013	5
Nickel (mg/L)	0.011	0.005	0.002 - 0.008	5
Lead (mg/L)	0.0034	0.0015	<0.001 - 0.004	5
Zinc (mg/L)	0.008	0.012	0.007 - 0.153	5
Mercury (mg/L)	0.00006	<0.0001	<0.0001	5

4.8.2 Wetlands

The Department of the Environment (2013) identifies Roebuck Bay, an internationally significant wetland (RAMSAR listed site), within 5 km of the study area.

Surface water from proposed development is not expected to impact on the water quality or quantity in the Ramsar wetland area due to the distance to it and the drainage management that is proposed in this LWMS and further refinements to the drainage design in the subsequent UWMPs to support subdivision for this area. The treatment processes will be designed to detain the majority of water on site in suitably sized swale detention basins within the site.

4.8.3 Public drinking water source areas

The Department of Water's Geographic Data Atlas indicates that there are no public drinking water source areas within the vicinity of the study area. The nearest public drinking water source is approximately 5 km north east of the site.

4.9 Groundwater

4.9.1 Regional groundwater

The study area falls within the Cable Beach Groundwater sub area.

The regional groundwater resources of the Broome area (1:250,000 map sheet SE516, GSWA 1982) comprise both confined and unconfined aquifers of significant extent. The hydrogeology of the Broome area is documented by Laws (1991). The most utilised aquifer is the Broome sandstone that comprises fine to coarse grained sandstone with minor beds of pebble conglomerate, grey siltstone and claystone. The Broome sandstone is unconfined and is separated from the underlying (confined) aquifers, Alexander formation and the Wallal sandstone, by an aquiclude, the Jarlemai siltstone.

4.9.2 Local groundwater

Groundwater in the Broome area moves under the influence of gravity down the hydraulic gradient west toward the ocean and south toward Roebuck Bay (WRC 2001). The Broome Groundwater Management Plan Review (Groundwater Consulting Services 2008), prepared for the Department of Water, presented groundwater levels for the Broome region, with levels for the Broome North area less than 3 mAHD. The geotechnical investigation over the study area (Coffey Geotechnics 2009) reported that groundwater was not encountered during test pitting over the study area to 2.5 m below ground level, and estimated an average annual maximum groundwater level (AAMGL) based on DoW WIN bores within 2 km of the site of 2.5 mAHD.

A search of the Department of Water WIN database identifies one bore along the southern boundary of the study area with groundwater level data for the period 1986 to 2011 (WIN bore 8057, Figure 5). Other WIN bores within the vicinity of the site have limited discrete water quality data however no groundwater level data. The range of groundwater levels for WIN bore 8057 is reported in Table 6. Based on site contours for the study area (Figure 4) the clearance to groundwater is approximately 9.5 m from maximum groundwater levels within the vicinity of WIN bore 8057.

Table 6 Groundwater levels for bores in proximity to SP Stage 2 area

Groundwater parameter	WIN bore 8057
Period of record	1986-2011
Minimum (mAHD)	1.171
Median (mAHD)	2.191
Maximum (mAHD)	3.491
Count	27

5. Water use and conservation strategy

5.1 Existing servicing

5.1.1 Potable water

The existing town of Broome is currently supplied by groundwater from the local Water Corporation production bore field in Reserve 25716 located to the north east of the Broome Township. A Safe Yield of 10.6GL/annum was determined in 1994 within the *Broome Groundwater Management Plan* (WAWA 1994).

5.1.2 Wastewater

In Broome, wastewater is collected via a traditional gravity sewer and transferred to the wastewater treatment plant owned and operated by the Water Corporation. Expansion of the existing gravity system to include the Broome North SP Stage 2 area will be required.

Collected wastewater will be transferred to the new Water Corporation wastewater treatment plant (WWTP) constructed to the north east of the town at Crab Creek. The wastewater will be treated at this WWTP and treated wastewater will be managed by irrigating Rhodes Grass adjacent to the new WWTP. Water Corporation plans to undertake a review of wastewater management options for the longer term prior to the implementation of Stage 2 of the WWTP (in approximately 2021).

5.2 Water sources

5.2.1 Groundwater supply scheme

Review of the *Broome Groundwater Management Plan* supported the expansion of the town water supply borefield in a northerly direction to meet future potable water demand for Broome townsite (Groundwater Consulting Services, 2008). The review also identified that future growth projections for Broome would result in a total water demand of about 9.5 GL/annum by 2030, with increased demand if horticultural expansion occurred (Groundwater Consulting Services 2008).

This is the preferred water source for Broome North SP Stage 2 Area since there is sufficient sustainable yield to provide for the development with substantial existing infrastructure in place. Groundwater supply is recognised as the most economically viable water supply option for towns within the Kimberley (DoW 2010).

Appendix D presents correspondence with Water Corporation for securing this supply, negotiated during the approvals for the Broome North LDP3 area. The Water Corporation identify that if only scheme water is available a target figure for Broome will need to be established. Water Corporation also note that potable water supply for POS irrigation is possible in the short term however a significant lead time is required to assess supply in the long term for reasons relating to pumping and water distribution rather than limitations of the borefield or aquifer.

5.2.2 Wastewater reuse

Wastewater reuse is viable when the flows into the wastewater treatment plant:

- Reach a level that is sufficient to justify the capital investment in infrastructure.
- Produce sufficient flows to supply the required non-potable demand.

In order to reuse wastewater for non-drinking purposes, treatment, storage and distribution infrastructure will be required. The advantage of treated wastewater is that it will be a continuous and reliable source and is independent of the future climate. To implement treated wastewater as a non-drinking water source, additional distribution and treatment infrastructure will be required.

5.2.3 Rainwater

Due to the seasonal nature of rainfall within Broome rainwater is not a reliable year round water source.

Individual lot owners may choose to install rainwater tanks for private use, however this is considered a decision made at the discretion of the individual landowner and is not considered further in this document.

5.2.4 Water source recommendations

It is understood that the Shire of Broome is currently investigating fit-for-purpose water supply options for the Broome's Public Open Space irrigation. Preliminary advice from the Shire of Broome indicates that wastewater reuse is likely to be identified as a viable option for the Broome North development area, subject to adoption by the Shire of Broome.

A potential approach for the required storage and distribution infrastructure may include adoption of a Developer Contribution Plan for a wastewater resue scheme.

Given the preliminary nature of the advice from the Shire of Broome LandCorp is supportive of the development of wastewater reuse scheme that will achieve sustainable outcomes for Broome, and provide commitment to equitable contribution towards the scheme for the Broome North development area.

5.3 Water balance modelling

A conceptual water balance was developed for the study area using the Water Corporation H_2Options tool. The water balance has been based on potable water supply for both residential indoor and outdoor use, and POS irrigation supply from the Broome town water supply borefield. The water balance excludes Lots 2605 and 2606 which are identified as the Anglican School site as the development of this lot is uncertain.

The required potable water supply for the Broome North SP Stage 2 development area is summarised in Table 7 and the water balance is included as Appendix E.

Table 7 Broome North SP Stage 2 water balance

Land use type	Demand (kL/year)	Required Drinking water supply (kL/year)
Residential indoor	85,960	85,960
Residential outdoor	36,618	36,618
Residential total	122,578	122,578
Public open space	114,646	114,646

5.4 Water efficiency measures

5.4.1 Potable water

Water efficiency is enabled through the use of technology and by changing behaviour to use less water. The Western Australian Government has introduced a range of measures to ensure

that new houses built in Western Australia meet minimum standards for energy and water efficiency including:

- All tap fittings must be minimum 4 stars WELS rated;
- All showerheads must be minimum 3 stars WELS rated;
- All sanitary flushing systems must be a minimum 4 stars WELS rated dual flush;
- Water using appliances installed (such as washing machines and dish washers) are 4 stars WELS rated or better.

The Broome North SP Stage 2 development area is committed to the above water conservation measures and new development areas will have water efficient fittings and appliances installed as identified by the Building Code of Australia and WA's "5-Star Plus Stage 1 supplement" provided as Appendix D.

5.4.2 Irrigation and landscaping

Commitment to water conservation is a key element in the design and management of streetscapes and POS areas across the Broome North development area, with further refinement within SP Stage 2. The water management strategies for landscaped and POS areas in SP Stage 2 include:

- Investigate opportunities to optimise the frequency and timing of irrigation so that peak irrigation demands do not correspond to peak potable demands.
- Use of endemic species within the development that require a local climate based low water-use and nutrient use regime.
- 80% of planting is mostly revegetation with drip irrigation turned off once planting is established (2 years).
- Lawn areas are minimised. The lawn species is indigenous to the Broome Peninsula (Roebuck Bay Couch) and has low water and nutrient use requirements.
- The irrigation schedule for most planting is daily during a 13 week establishment period and then reduced to irrigating twice a week, or less, as required.
- During the maintenance period the assessment of water needs of the plants will be amended on a regular basis and the watering adjusted accordingly.
- Irrigation of street trees to be established as part of a residential rebate package and will be the responsibility of the residence for watering and establishment.
- The irrigation systems will be designed in accordance with Shire of Broome requirements and specification.

5.4.3 Construction

Water from non-potable sources will be used to roads during construction.

6. Stormwater management strategy

The modelling of the stormwater drainage system was completed by TABEC Civil Engineering Consultants using the surface water modelling package XP-SWMM 2016. The following sections outline the assumptions made and results calculated from TABEC's drainage modelling.

6.1 Existing conditions

The Broome North SP Stage 2 Area is located on the plains of the Dampier Peninsula. Surface runoff at the site during episodic rainfall events occurs as sheetflow towards the upper reaches of Dampier creek. The lowest natural surface within the SP Stage 2 Area of approximately 6 mAHD occurs within the ecological cultural corridor (ECC) located along the southern edge of the SP Stage 2 Area.

The study area is located in the lower areas of the existing catchment, and adjacent to the proposed culvert crossings of Broome Road, as identified in the *Broome North DWMS* (GHD and SKM 2009). The site stormwater runoff currently overtops Broome Road, and ultimately discharge into Roebuck Bay. Culverts crossing Broome Road will need to be constructed at two locations as identified in the DWMS to Main Roads standards (see Section 6.4.5 for further detail on the discharge outlets).

6.2 Proposed stormwater management strategy

In accordance with the principals and objectives of the *Broome North DWMS* (GHD and SKM 2009) the proposed development will attempt to maintain the predevelopment stormwater discharge rates for the critical duration of 1 Year and 50 Year ARI events, and be protected from flooding in the 100 year ARI event.

The stormwater management strategy has also been developed with consideration of the key principles of the Shire of Broome *Stormwater Management Policy* (Shire of Broome 2009) in particular the design of the linear swale drainage system that acts as a treatment train to detain and retain and treat flows close to source. The concept details of the drainage swale detention system are provided in Section 6.4.

A key design principle for stormwater management in Broome uses the roads to carry the majority of flow for all events. Overland flow is used in preference to a piped system to slow flows, enable some infiltration and some treatment of stormwater through vegetative uptake and contact with sediment, and prevent pipe blockage. Runoff is discharged from lots into the road system, from where it is discharged into the open unlined swale/detention drainage system as high as possible within the catchment in order to manage flood events and improve water quality.

Roads are kerbed adjacent to residential lots to contain the 10 yr ARI event, with flush kerbing used on roads adjacent to public open space (POS), multiple use corridors (MUC) and the ECC. The intention of flush kerbing is to reduce flow velocity, compared to kerbed roads which efficiently transport stormwater runoff into the drainage system. Critical road reserves at the end of the catchment will be kerbed, with kerb openings to direct discharge into the swale drainage system (Plate 2). At these locations the swales will require rock protection to reduce flow velocities and manage scour.

Gullies and pipes are only used to manage the 10 yr ARI flow where it cannot be carried in the road between the kerbs. Where appropriate, pipes are also used for low flow drains from detention basins.

Stormwater conveyed within the road reserve discharges into an open unlined swale/detention drainage system as high as possible in the catchments. This is to ensure that the road system is not overtopped and the water quality treatment train is activated as soon as possible. Through the use of weirs within the unlined swale/detention drainage system and culverts at road crossings, the post development flow rates will be reduced to pre-development rates.

The surface water management will be based on the following principles:

- The primary function of the detention system is to attempt to maintain the 1yr 1hr flow regime and keep flow velocities below 0.5 m/s to assist in achieving water quality objectives.
- The development will aim to have a detention system so that peak flow from 50 yr ARI and 100 yr ARI events are not significantly greater than that which would occur under pre-development conditions.
- Finished floor levels for the buildings on all lots are to be at least 0.5 m above the crown of the road to ensure that no flooding of the residences occurs.
- All events up to the 100 yr ARI events are to be contained within the road reserve and the 10 yr ARI event is to be contained within the kerbs.
- A minimum of 0.3 m freeboard is required between the critical 100 Year ARI flood level and the finished floor level of all buildings on the site.

A summary of the stormwater strategy for the different stormwater events is identified below.

1 year ARI event

- Impervious areas within lots will drain to roads.
- Roads and POS will drain into the swale detention system.
- Weirs will detain flows within the swale to pre-development peak discharge.

10 year ARI

- Lots, roads and POS will drain to the swale detention system.
- Weirs with low flow outlets, and culverts at road crossings will detain flows within the swale system.

100 year ARI

- Lots, roads and POS will drain to the swale detention system.
- Lot levels set higher than peak flood levels.
- A minimum of 0.3 m freeboard required between the flood level and the finished floor level of all buildings on site.

6.3 Stormwater management design

Preliminary surface water modelling of the drainage system was undertaken using the surface water modelling software XPSWMM to provide details of the required detention volumes for the catchments. The stormwater model considers the development proposed within the Broome North SP Stage 2 (dated June 2016) and also considers future development within the upstream catchment. Future local water management strategies to the west of this SP Stage 2 area will still be required to make provision for storage within the development area.

Detailed modelling, using XPSWMM, will be undertaken during the design phase of the project which will provide further details of water levels, detention volumes and velocities for the critical

storms once the design has progressed. This information will be detailed in the UWMPs submitted at the time of subdivision approvals.

6.3.1 Catchment areas

Pre-development catchment areas

The study area is intersected by two larger catchments that fall from west to east. The study area is located near the discharge location of both catchments areas, with Broome Road acting as a barrier to overland flow paths. Drawing 2287-SP Stage 2-SK007A (Appendix G) shows the pre-development sub-catchments areas within and outside of the study area.

The catchment areas are relatively flat with an average slope of 0.7% and well vegetated with localised depressions. There are no natural streams or channels apparent from the contours of the area suggesting that overland flow is characterised by wide sheet flow.

A number of roads and paths within the study area have interrupted the natural flow path, particularly for the northern catchment area. The roads, in particular Fairway Drive and Magabala Road act as both barriers and conveyors of stormwater.

The estimated total catchment area based on Whelans Survey information is 219.5 Ha.

Post-development catchment areas

This stormwater management strategy will focus on contributing sub-catchments to MRWA's Culvert 1.

Drawing 2287-LDP2-SK004B (Appendix G) shows the post development sub-catchment areas within the study area. All of the residential area will contribute to the discharge at Culvert 1. The school area will ultimately discharge to Culvert 2 but may discharge to Culvert 1 until the catchments outside the study area, to the north of Fairway Drive, are developed.

6.3.2 Pre-development flows

XPSWMM modelling software was used to estimate the predevelopment runoff from the study area. The estimated peak discharge rate for 1 Year and 50 Year ARI events are subsequently used for the preliminary sizing of the post development storage requirements in accordance with Shire of Broome requirements. The 100 Year ARI event is checked against clearance to the proposed development levels. It was identified that the critical storm duration for this study area is 6 hours.

The Kinematic Wave runoff routing method was used to determine the peak predevelopment flow rates from the study area. A Manning's roughness of 0.075 was used for the pre-development catchment areas. A Uniform Loss model was applied to the catchment, with Initial Loss of 10 mm and a Continuing Loss of 4.16 mm/hr.

The existing topography of the site suggests that runoff from the 219.5 Ha predevelopment catchment will overtop a low point along Broome Road, situated at the south east corner of the study area, adjacent to the Environmental Cultural Corridor.

The peak pre-development flows over Broome Road are as shown in

Table 8.

Table 8 Peak pre-development flow rates over Broome Road

Storm Event	Critical Storm Duration	Time of Concentration (hour)	Max Flow (m^3/s)	Max Flow per Ha (L/s/ha)	Max Velocity (m/s)	Max Depth (mm)
1 Year	6 Hour	2.5	0.99	4.5	0.21	50
50 Year	6 Hour	4	12.98	59.1	0.46	140
100 Year	6 Hour	2.5	16.22	74.1	0.49	150

MRWA road planning currently proposes two relatively large culvert crossings under Broome Road which will prevent major storm events from overtopping Broome Road, and will be better suited to manage stormwater runoff from future developments.

It is estimated that a northern catchment area of 83 Ha will drain towards proposed Culvert 2, and the southern catchment area of 136 Ha will drain towards proposed Culvert 1. The estimated catchment area for this scenario is demonstrated in Figure 2287-LDP2-SK007C (Appendix G).Based on the proposed MRWA culvert design, the peak predevelopment flows under Broome Road are as shown in Table 9.

Table 9 Peak pre-development flow rates under Broome Road

Location	Catchment Area (ha)	1Y6H Max Flow, Q (m^3/s)	50Y6H Max Flow, Q (m^3/s)	100Y6H Max Flow, Q (m^3/s)
Culvert 1	136	0.32	6.91	7.79
Culvert 2	83	0.35	5.75	8.63

6.4 Detention system

The stormwater drainage system for the Broome North SP Stage 2 area follows a similar approach to the LDP1 area, with the incorporation of linear swale detention throughout the development with the intention of activating the water sensitive urban design treatment train high in the catchment.

The linear swale detention system is designed to retard flows high in the catchment, and are vegetated to stabilise the swale system, increase roughness, slow velocities and encourage sedimentation. All of the swales and retarding structures will be used to control the ultimate flow rate at the culverts at Broome Road. The Manning's roughness coefficients used in the modelling within swales was set at 0.03, and a value of 0.016 was used for roads.

Key elements of the drainage system will generally include:

- Detention areas are to be shallow and wide with 1:6 side slopes generally but up to 1:8 where achievable. The maximum water depth will be 1.2 m.
- Swales and detention areas are to be integrated with the major access street as multiple-use corridors, and within POS and ECC areas and be designed as part of the overall landscape planning.
- The swales and detention areas will be designed to integrate into the existing landscape and POS area and form natural creeks and streams adjacent to the green spaces.
- Drop structures will be used to minimise the longitudinal grade of swales and reduce the flow velocity to minimise the transportation of silt.

- Swales are vegetated with endemic species to stabilise bases and batters, and provide natural drainage roughness to reduce sediment loads.
- The use of weirs and flow width restrictions will be used to control flow and create detention areas upstream.
- 100 yr ARI flood width to include adjacent roads, but not overtop kerbs on the opposite side of the road from the POS.
- Overland flow will occur to the ECC in large storm events to maintain the hydrology of the natural system.

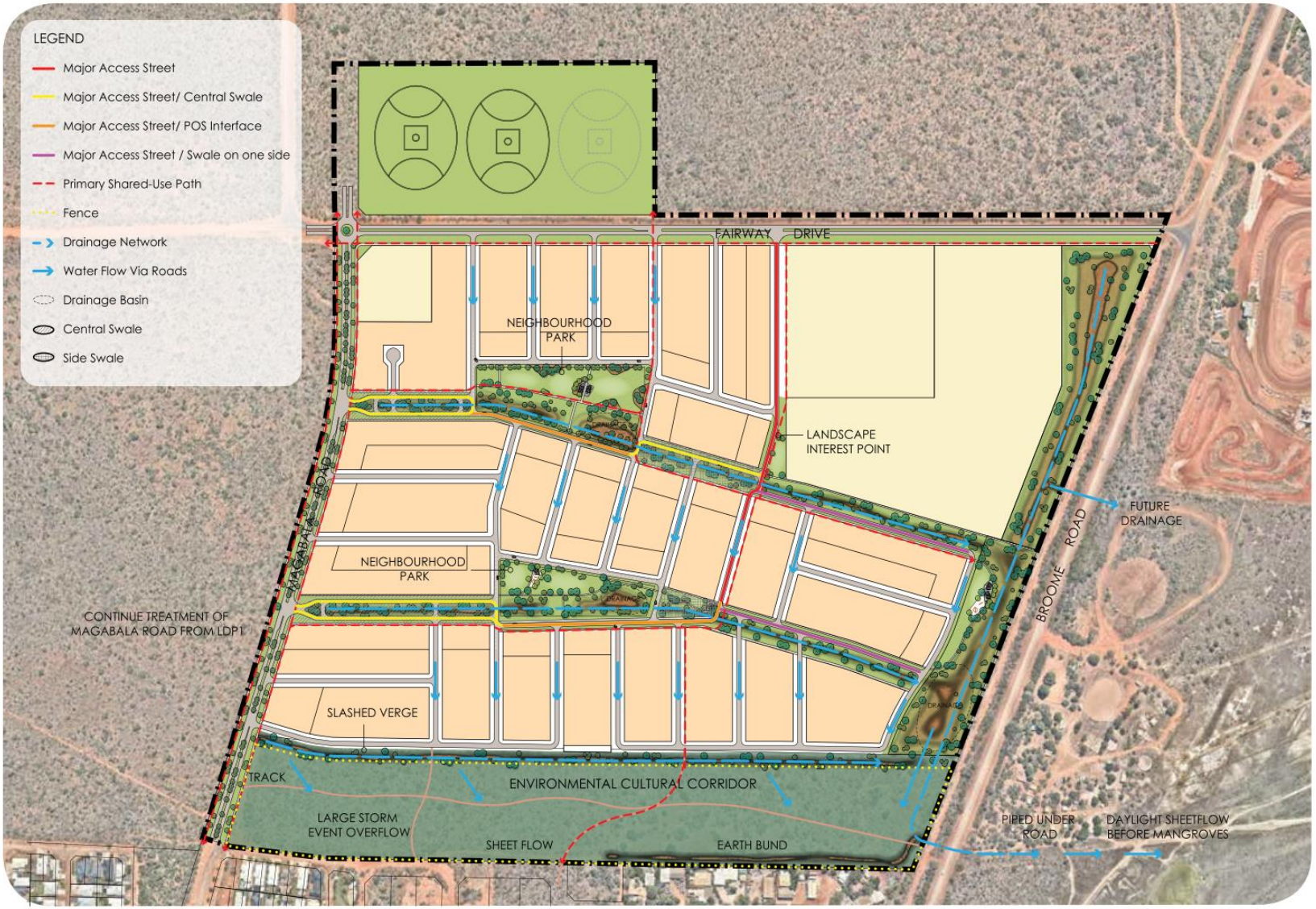


Figure 6 Broome North SP Stage 2 stormwater drainage system (Source UDLA 2016)

6.4.1 Multiple-use corridors

The linear swale system has been incorporated into the major access road streetscapes to create primary east-west multiple-use corridors. The linear swale system will occur as two main typologies within the major access roads as either a central swale system (Figure 7) or the swale system to one side of the streetscape (Figure 8).

Figure 7 Multiple-use corridor section through major access street with central swale (Source UDLA 2016)

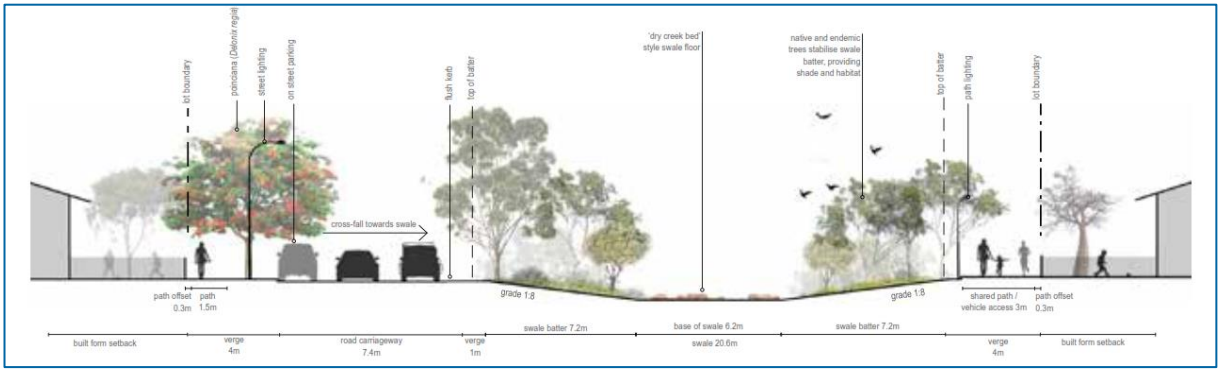


Figure 8 Multiple-use corridor section through major access street with swale to one side (Source UDLA 2016)

6.4.2 Environmental cultural corridor

The ECC is a 150m wide corridor running east-west across the site providing a buffer between development and significant cultural areas, while also maintaining important habitat and cultural and community connection to 'country'. The traditional owners of the land, the Yawaru people, have provided permission for overland drainage to be contained within the ECC, with a swale and bund situated along the boundaries to direct water. The swale is to negotiate existing significant vegetation and to be a nominal width of 20 m, similar to the Janaburu Six Season precedent.

6.4.3 Storage

The preliminary storage volume required for the study area was calculated using XPSWMM. The total storage volume required for the study area are based on matching the predevelopment flow rate per hectare of catchment area, 4.5L/s/ha and 59.1L/s/ha for the 1 Year and 50 Year ARI events, respectively.

Total storage required

- 1yr 6hr: 19,920 m^3

- 50yr 6hr: 59,880 m^3

Following detailed design, the model will be amended to incorporate the design elements, which may lead to the detention area sizes and capacities being modified. More detailed storage requirements will be included in the UWMPs submitted at the time of subdivision applications.

6.4.4 Post development flows

During the preliminary modelling of the proposed development the post-development flows were determined by applying parameters shown in Table 10 to the Hydrology module of XPSWMM using the Laurenson runoff routing method. The ECC is included in the post-development flow at the outlet using the same parameters as the pre-development model.

Plans showing the post-development flow paths, inundation areas, flow rates, flood levels and flow depths at various critical points are included in Appendix G. Long sections of the northern, central and southern swales for the 100 year ARI event, and cross sections for the 50 year ARI event are also included in Appendix G.

Preliminary post-development flow rates at Culvert 1 are shown in Table 12 based on the concept stormwater drainage design presented in Drawing 2287-LDP2-SK004B (Appendix G). Due to the uncertainty of the form of the future development north of Fairway Drive post development flow rates are not provided for Culvert 2.

Detailed design of the stormwater drainage system will be undertaken to support subdivision application, and provided in the urban water management plan.

Table 10 Post-development pervious and impervious ratio

Land Use	Pervious	Impervious
Lots	0.1	0.9
Roads	0.3	0.7
POS	0.6	0.4
School	0.6	0.4

Table 11 Post-development Uniform Loss Model

Land Use	Mannings 'n'	Initial Loss (mm)	Continuing Loss (mm/hr)
Pervious	0.035	10	4.16
Impervious	0.016	1.5	4.16

Table 12 Indicative post-development flow rate at Culvert 1

Location	1 Year 6 Hour (m^3/s)	50 Year 6 Hour (m^3/s)	100 Year 6 Hour (m^3/s)
Culvert 1	0.51	6.66	12.09

6.4.5 Discharge outlets

Existing pre-development outlets from the Broome North SP Stage 2 area occur at two low points along Broome Road. These locations were identified within the *Broome North DWMS* (GHD and SKM 2009) as the locations for upgrading of the outlets for future development of the SP Stage 2 area (Appendix H).

Culvert 1, the southernmost culvert (Appendix G), will be constructed to Main Roads Western Australia (MRWA) standards as part of the early Stage s of the development by the developer (refer Table 14– Roles and Responsibilities). As noted in Section 6.3.1 Culvert 1 will take flows from the whole of the Broome North SP Stage 2 area until such time that the area to the north of Fairway Drive is developed. At this time Culvert 2 will be constructed to MRWA standards by the proponent of the new development and the Anglican School site will drain through this outlet location.

The proposed Broome North SP Stage 2 Culvert 1 design features 3 x 600 (h) x 1200 (w) culverts, with the design intended to avoid the requirement to raise the level of Broome Road and minimise excavation required to daylight the drainage swale east of Broome Road. The proposed design is subject to final MRWA approval.

As noted in Section 6.4.4 the drainage design for the outlets for the Broome North SP Stage 2 area will discharge flows at pre-development rates under the existing Broome Road (see Table 9). The discharge from the site will flow into a drainage swale that will be gently graded to drain towards the natural outlet, and will feature stone pitching at the outlet to reduce erosion and reduce flow velocities. An indicative plan of the outlet treatment is shown in Appendix H.

Liaison with MWRA regarding the future Broome Highway upgrade indicates the intention to formalise the drainage outlets in the vicinity of Culvert 1 and Culvert 2. MRWA have provided a concept design for the outlets at Culvert 1 and 2 that features 3 x 1800 (h) x 900 (w) culverts (Appendix I). Construction of culverts based on the MRWA concept design will require the lifting of Broome Road and construction of a drainage swale that extends some 350 m east of the existing Broome Road.

Where development of Broome North SP Stage 2 Area precedes the upgrade of Broome Highway by Main Roads, culverts will be installed under the road at the identified locations to MRWA standards.

The final design of the culvert outlet will be subject to approval by Yawaru, Shire of Broome and MRWA, with detail of the final culvert design provided in the UWMP submitted at the time of subdivision approval.

6.5 Stormwater quality

Stormwater quality issues which may require management within the Broome North SP Stage 2 Area include:

- Sediment load: Erosion caused by high flow velocity can result in loss of soil and increased sediment load to the receiving water body.
- Nutrient load: Over application of fertilisers to landscaped areas may result in increased nutrient loading to the receiving water body.
- Gross, suspended and dissolved pollutants: Including rubbish, hydrocarbons and dissolved metals.

Best management practices (BMPs) are strategies incorporated into design to assist in the management of total suspended solids, gross pollutants and suspended or dissolved pollutants. As the majority of pollutants are transported in minor events up to the 1 yr ARI storm, it is these

frequent rainfall events which are targeted using at source, in-transit and end-of-catchment BMPs to improve water quality. BMPs considered appropriate for the Broome North SP Stage 2 Area development are listed in Table 13.

Table 13 Recommended stormwater quality BMPs

Development scale	Best management practice
Residential construction	Mulching of lot and road verges to prevent silt runoff from sites under construction onto the roads and into the drainage system. Temporary bunds and silt fences to prevent Pindan silt runoff from sites under construction into the drainage system. Litter and waste storage bins to prevent litter to be blown by wind or washed away by rainfall. Establishing a washing-down area behind the bund or silt fence. Provide a stabilised entry and exit point to prevent vehicle tracking of soil from the building site onto roads. Position sand and soil stockpiles to prevent material being tracked, washed, or blown into roads, and then into the stormwater systems.
Lot scale	Promote on-lot infiltration for all pervious areas up to the 1yr ARI storm. Use of low water soluble fertiliser. Water-wise and nutrient-wise landscaping, including minimising lawns.
Street scale	Construction of channels and dry/ephemeral detention swales using weirs and low flow drain system, to reduce flow velocity, thus reducing erosion and sediment mobilisation, allowing sedimentation, reduce total flow discharged from site, and allowing infiltration to groundwater. Planting and regeneration of low-lying native vegetation in swale drains for filtering of particulates and uptake of dissolved nutrients.
Development scale	Maximising infiltration by adopting a stormwater detention system to detain the 1 yr ARI storm. Keep flow velocities below 0.5 m/s to assist in achieving water quality objectives. The linear swale detention system is designed to reduce peak flow rates, maximise the deposition of suspended sediment and promote infiltration. Sediment traps are located immediately upstream of weirs to promote sedimentation. Maintenance of the stormwater drainage

	system, including street sweeping and removal of silt build up.

In accordance with the conclusions and recommendations of the Broome North PSI (GHD, 2009c), prior to development of the AAC site, further investigation and mapping of zinc and TPH levels are recommended. No additional investigations or monitoring are proposed for the remainder of the development.

6.6 Disease vector and nuisance insect management

The Shire of Broome does not accept permanent water bodies within the drainage system. All detention basins are required to grade out and discharge over a period of time not exceeding 72 hours

7. Landscaping concepts

The landscaping concepts for the Broome North SP Stage 2 area is summarised in the *Broome North Local Development Plan 2 Landscape Report* (UDLA 2016). The landscaping concepts for the Broome North SP Stage 2 area have been informed by the developing experiences of the landscape consultant UDLA within the region, and the local social, cultural and environmental conditions.

The primary landscape typologies include neighbourhood parks and the east-west multiple-use corridors, a key feature of which are the linear drainage swales.

Major bushland tracts define the greater Broome North development area, including a 150m wide Environmental Cultural Corridor (ECC) that runs east-west, connecting Roebuck Bay to Cable Beach.

The interface of the development area with the ECC to the south has also been considered.

7.1 Multiple-use corridors

The multiple-use corridors comprise a combination of retained existing vegetation, drainage swales, vegetated buffers and parkland (Figure 9). The multiple-use corridors provide a number of functions including:

- Urban drainage and flood management including holistic management of upstream and downstream conveyance;
- Flora and fauna habitat and linkages; and
- Passive and active open space with informal (grassed kick-about) areas and formal open space areas (built play areas, dual use paths).

The design of the multiple-use corridors ensures drainage requirements sit aside from formalised recreation spaces, including park facilities.

Figure 9 Multiple-use corridor concept (Source UDLA 2016)

7.2 Public open space

7.2.1 Neighbourhood parks

Two neighbourhood parks are proposed with the main east-west multiple-use corridors to provide a strong linking amenity central within the development area. The function of the neighbourhood parks is the provision of both formalised play areas, as well as active and informal recreational areas. The neighbourhood parks also feature the following amenity (Figure 10):

- Grassed open space areas for active and passive recreation;
- Strong path networks;
- Areas of retained mature remnant vegetation; and
- Drainage swale adjacent to the park, with separation from the main lawn areas and formalised facilities.

Figure 10 Neighbourhood Park section (Source UDLA 2016)

7.2.2 Civic Park and Local Park

A civic park will be located within the central neighbourhood park to provide a centrepiece for official and informal community activities.

A smaller local park will be located on the eastern drainage reserve to ensure all residents are within walking distance to a formalised recreation area. While being smaller in area the local park will include similar facilities to the neighbourhood park.

7.3 Plant palette

The plant palette for the Broome North SP Stage 2 area have been identified based on species that are suitable and adapted to the unique Broome climate, soil and water conditions of the Broome region. The selected species require less ongoing management and maintenance and are locally proven (UDLA 2016).

The selected species will complement and supplement the retained endemic vegetation. Significant individual trees and vegetation areas have been identified, surveyed and where possible, integrated into the design of the public open space, verge, drainage reserve and lot areas (UDLA 2016).

Details of the selected plant palette are provided in *Broome North Local Development Plan 2 Landscape Report* (UDLA 2016).

8. Implementation plan

8.1 Monitoring plan

8.1.1 Groundwater

As there will be minimal impact on groundwater no groundwater monitoring is proposed.

8.1.2 Surface water

Pre-development monitoring has been completed as discussed in Section 3.3.

Surface water monitoring will commence following stabilisation of the drainage swales. Due to the ephemeral nature of surface runoff in the Kimberley surface water monitoring will be undertaken opportunistically during or following rainfall events where conditions are considered safe to sample.

Monitoring locations

Monitoring locations within the drainage features will comprise the inflow (start of swale), mid-swale and outlet structures of the drainage swales within the SP Stage 2 Area in order to capture variation in water quality along the swale extent.

- Inflow (start of swale): Collected from a suitable location where overland flow paths converge to enable sample collection. Should aim to be representative of upstream, undeveloped runoff where possible.
- Mid-swale: Collected from mid-way along the swale system to capture variation in water quality along the linear extent of the swale.
- Outlet: Collected at the outlet of the swale system from the SP Stage 2 area.

Due to the episodic nature of surface flow events in the Kimberley a number of health and safety issues need to be considered when undertaking monitoring near open channel flows, including sampling at night. Where occupational health and safety allow the monitoring program will make all reasonable attempts to:

- Capture the first flush event, which is considered to be an event that generates surface flow within the drainage system.
- Undertake consecutive sampling (3 samples from each sample location) during the event to demonstrate the effectiveness of the swale system at different stage s of an event.

Monitoring frequency and parameters

Monitoring should be undertaken at least three times per wet season (typically November-March). The water quality samples should be collected for analysis of the following parameters:

- Physiochemical parameters (ph, total suspended solids, electrical conductivity).
- Nutrients (total nitrogen, total Kjeldahl-N, nitrate-N, nitrite-N, ammonia-N, dissolved organic-N, total phosphorous, filterable reactive phosphorous).
- Heavy metals (As, Cd, Cr, Cu, Pb, Ni, Zn, Hg).

The monitoring will be undertaken for a period of three years, with initial monitoring commencing following stabilisation of the linear drainage swale system.

8.2 The next stage – Urban Water Management Plan

The next stage of subdivision planning will require the development of an urban water management plan. This will include progressing conceptual designs to detailed designs. Specifically, the following issues will need to be addressed within the urban water management plan:

- Determining the infrastructure requirements and land required to fit the infrastructure for the detailed design, including drainage and development requirements for stormwater management.
- Flow rates and water levels at critical locations for the 1-, 5- and 100-year ARI events.
- Location, level and dimensions of the drainage structures such as open channels and weirs.
- Management of subdivision works.
- Implementation plan, including roles and responsibilities.
- Identification of monitoring locations and reporting timeframes.

8.3 Responsibilities

Table 14 sets out the roles and responsibilities for the actions outlined for the future planning for the development area.

Table 14 Roles and responsibilities

Role	Responsibility	Requirement and Period
Prepare an urban water management plan	Developer	Prior to commencement of subdivision works
Design and construction of surface drainage system demonstrating compliance with this LWMS	Developer	Prior to commencement of subdivision works Constructed drainage infrastructure to be handed over to Shire of Broome at practical completion
Obtain approvals from Yawuru, Shire of Broome and MRWA for design and construction of Culvert 1	Developer	Prior to commencement of subdivision works
Obtain approvals from Yawuru, Shire of Broome and MRWA for design and construction of Culvert 2	Developer	Prior to commencement of subdivision works of future development located north of Fairway Drive
Maintenance of culvert outlets	Developer	Maintenance of culvert outlets will be undertaken by the developer for a period of two years from practical completion
Implementation of post-development monitoring	Developer	Commencing for a period of three years following construction of the linear

Role	Responsibility	Requirement and Period
program		drainage swale system and practical completion of the development area
Non-structural controls *Land use and management*	Developer	Sediment and erosion control during construction
Non-Structural Controls: *Street Sweeping and waste management*	Developer Shire of Broome	Street sweeping to be undertaken as required following rainfall events, with frequency agreed to within the UWMP As needed following the maintenance period

This strategy is based on the Broome North Structure Plan Stage 2 prepared by Roberts Day in July 2016 (Rev C). Should the Structure Plan be altered the LWMS will be reviewed.

9. References

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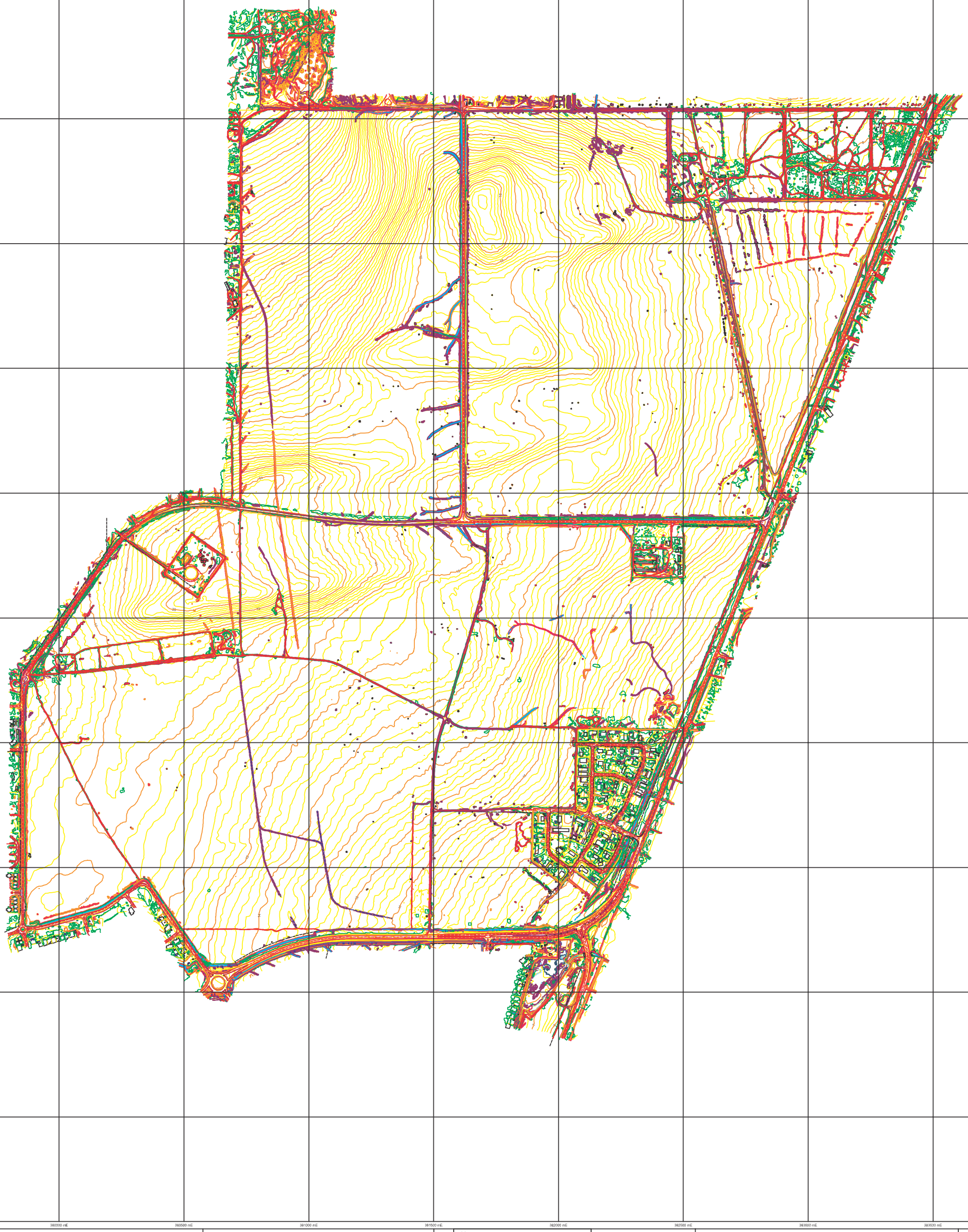
Appendices

Appendix A - Survey

Whelans (2009)

380000 mE 380500 mE 381000 mE 381500 mE 382000 mE 382500 mE 383000 mE 383500 mE

221000 mN 220500 mN 220000 mN 219500 mN 219000 mN 218500 mN 218000 mN 217500 mN 217000 mN 216500 mN 216000 mN



SCALE: 1:5000 @ A1 SHEET SIZE	all distances are in metres
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JOB No: 13367	VERTICAL DATUM: AHD
WORK DIR: s:\projects\13367\cnthn\	PHOTOGRAPHY DATE: n/a
CAD REF: 13367-016.dgn	DRAWN: NDW
	PLAN No: 13367-016

whelans
133 Scarborough Beach Road, Mount Hawthorn WA 6016
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Broome North Mapping

PLAN 16

Appendix B – Geotechnical report

Coffey (2009) provided on CD

Appendix C – Broome North PSI

GHD (2009) provided on CD

Appendix D – Water Corporation liaison

Nicholas Deeks

From: Frank Kroll <Frank.Kroll@watercorporation.com.au>
Sent: Friday, 20 December 2013 8:30 AM
To: Brian Farrell
Subject: Water & Wastewater Servicing for Broome North LDP3 Area
Attachments: 201312110819.pdf; 201312110821.pdf

Hi Brian

With reference to your enquiry dated 16 December 2013, whether the Broome North LDP3 area, as shown on your plan, can be serviced with a scheme water and wastewater service.

The area has existing planning that covers the site, hence in principle it will be able to be served, pending augmentation and upgrades to specific headworks components (pump stations and mains 300mm and over), and reticulation mains (under 300mm). Subject to orderly planning, staging, and scheduling of works, the Corporation will fund headworks, and the developer will be responsible for funding reticulation works.

A plan of the existing water and wastewater infrastructure is attached.

Water Supply:-

A water supply scheme covers the proposed development area. Cable Beach Tank that services the Cable Beach zone where the proposed development is located. Upgrading of mains from the borefield and additional storage tanks are proposed, as development and demand proceeds. An additional pipeline is proposed along Fairway Drive in the short term. Additional land will be required in approximately 2015 to expand the Tank site. When a suitable structure plan is available for the development area, a reticulation plan will need to be prepared, with water sourced from the DN450 in the west.

Wastewater:-

A wastewater scheme plan covers the proposed development area. The scheme shows two catchment areas gravitating towards the two existing pump stations Broome No. 5 pumping to South Broome No. 3, from whence wastewater is pumped to the Broome North WWTP. This will guide detailed reticulation planning. A portion of the wastewater scheme is attached showing the catchment areas.

Planning Reviews:-

The existing planning would need to be reviewed once further information of development in terms of no. of development lots is provided, and staging of development is known so that our works are able to be scheduled.

Water Efficiency:-

It is our expectation that the principles of Better Urban Water Management (Department of Water) will be followed – 100 kl/person/year with 40-60 kl/person/year from scheme water, the remainder being made up with non-potable water. If only scheme water is available, a target figure for Broome will need to be established.

Should you require further information, do not hesitate to contact me. Please note that I will be on leave from COB today till 29 January 2014. If the matter is urgent please contact Peter Howard.

Regards

Frank Kroll
Senior Development Planner
Development Services Branch

Water Corporation
Planning & Capability Group

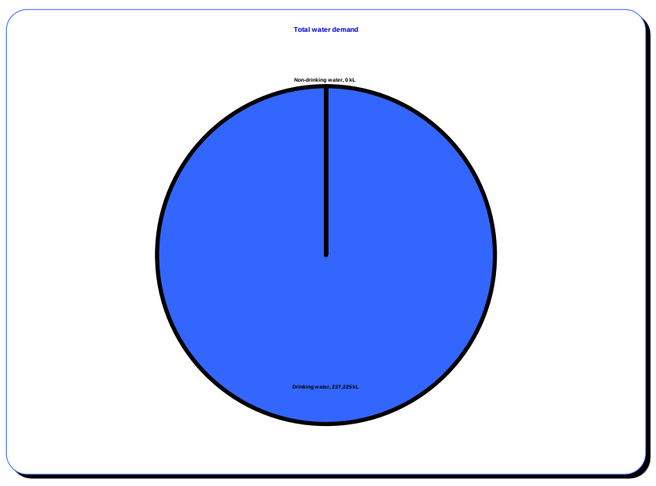
629 Newcastle Street Leederville 6007
Telephone: (08)9420 2221
Fax: (08)9420 3193
Email: frank.kroll@watercorporation.com.au

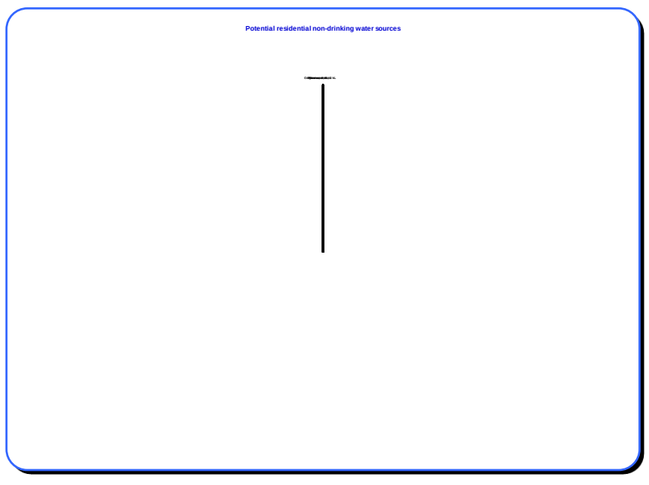
Appendix E – Site Water Balance

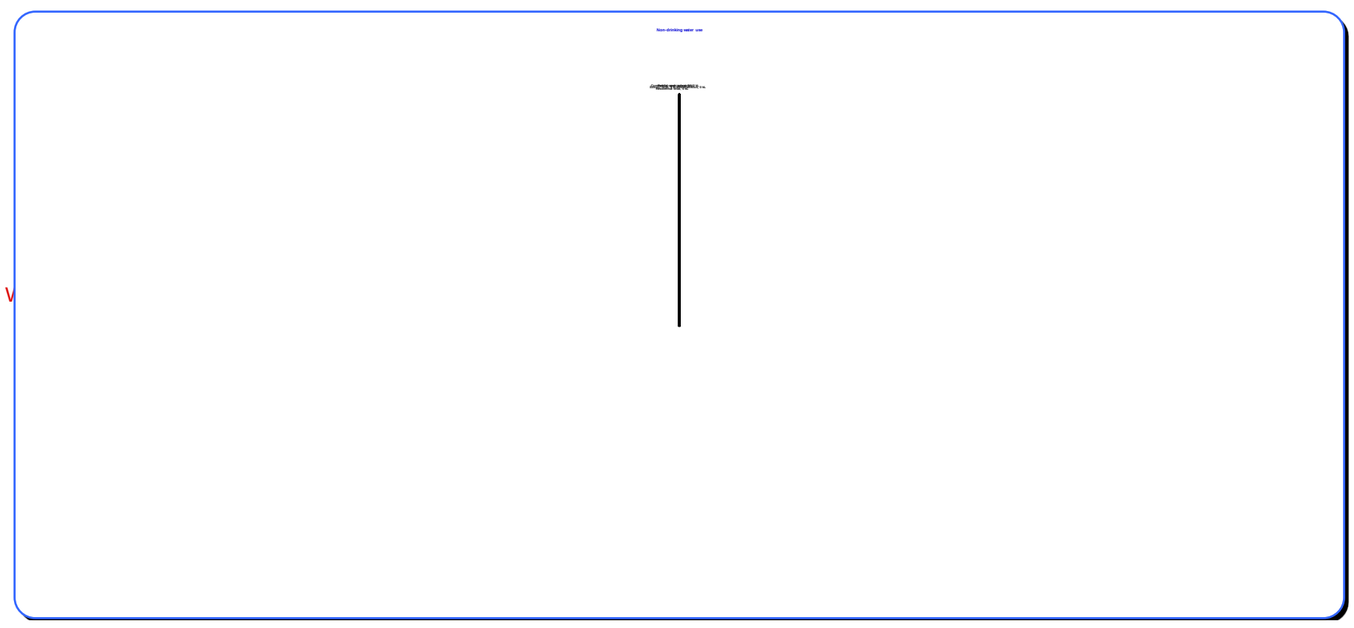
Water Balance Results

Name of developer	**LandCorp**
Name of development	**Broome North LDP2**
Date of entry	**12 July 2016**
Location of development	**Broome WA**
Total development area (m²)	**849,000**

	DEMAND (kL/year)	REQUIRED SUPPLY (kL/year)		
		Drinking water	Non-drinking water	Potential residential non-drinking water sources (kL/year)
				Rainwater / Greywater / Other sources
Residential indoor	85,960	85,960	0	
Residential outdoor	36,618	36,618	0	
Residential total	**122,578**	**122,578**	**0**	► **0 / 0 / 0**
School irrigation	0	0	0	
School non-irrigation	0	0	0	
School total	**0**	**0**	**0**	
Commercial and industrial	**0**	**0**	**0**	
Public open space	**114,646**	**114,646**	**0**	
Miscellaneous	**0**	**0**	**0**	
Development total	**237,225 kL**	**237,225 kL**	**0 kL**	
kL / person / year	**154.54**			







Appendix F – 5 Star Plus – Water Use in Houses Code

Department of Housing and Works
Government of Western Australia

5 Star Plus

Energy Use in Houses Code
Water Use in Houses Code

Playing our part in building better communities for Western Australia

Introduction

In May 2006, Western Australia adopted the minimum 5 Star energy efficiency provisions of the Building Code of Australia for all new homes. Now the Government has gone further and introduced 5 Star Plus – that builds on the energy efficiencies from 5 Star with the added benefits of water reduction measures for all homes right across the State.

5 Star Plus is based around two new Codes:

The Energy Use in Houses Code - confirms the existing 5 Star provisions for house design and construction and adds requirements for energy efficient water heating.

The Water Use in Houses Code - aims to reduce the consumption of water in residential homes by requiring water efficient fittings, minimising the wastage of water and facilitating the appropriate use of alternative sources of water such as grey water and rain water.

5 Star Plus will be applicable to new homes approved for construction after 1 September 2007, however, existing home owners can also use these Codes to improve energy and water efficiency in their homes. During 2008, the Government will investigate measures to apply the 5 Star Plus provisions to existing homes.

The Energy Use in Houses Code and Water Use in Houses Code are written to supplement the Building Code of Australia (BCA) and adopt BCA definitions and format for consistency. The Codes are published together for the convenience of builders, plumbers and certifiers who may need a convenient reference on site.

The Codes are available online at **www.5starplus.wa.gov.au**

Energy Use in Houses Code

Application

This Code applies to all new buildings classified as Class 1 and 10 buildings by the Building Code of Australia.

Interpretation

"The Building Code of Australia" means the latest edition of the Building Code of Australia published from time to time by, or on behalf of, the Australian Building Codes Board, but not including explanatory information published with that Code.

Objective

The objective of this Code is to reduce greenhouse gas emissions.

Functional Statement

In order to reduce greenhouse gas emissions, a building, including its services, is to be capable of efficiently using appropriate sources of energy.

Compliance With This Code

A building will comply with this Code if its construction satisfies all the Performance Requirements. Compliance with the Performance Requirements can be shown by:

(a) Complying with the Deemed-to-Satisfy provisions as listed in the Acceptable Construction Practice; or

(b) Formulating an alternative solution that is shown to be equivalent to the Deemed-to-Satisfy provisions; or

(c) Formulating an alternative solution that is verified using an acceptable verification method; or

(d) Formulating an alternative solution that is based on expert judgement or supported by suitable evidence in accordance with clause 1.2.2 of the Building Code of Australia; or

(e) Any combination of the above.

Energy Use in Houses Code

Performance Requirements

PR1 – Building

A building must comply with the Building Code of Australia Performance Requirement P2.6.1.

PR2 – Services

A building's domestic services including any associated distribution system and components must have features that comply with the Building Code of Australia, Performance Requirement P2.6.2.

PR3 – Hot Water Systems

A building's hot water systems including any associated components must have features that produce low levels of greenhouse gases when heating water.

Acceptable Construction Practice

(a) Compliance with all of the Deemed-to-Satisfy provisions of DTS1 satisfy the Performance Requirement PR1 for a building.

(b) Compliance with all of the Deemed-to-Satisfy provisions of DTS2 satisfy the Performance Requirement PR2 for a building.

(c) Compliance with all of the Deemed-to-Satisfy provisions of DTS3 satisfy the Performance Requirement PR3 for a building.

Deemed to Satisfy Provisions

DTS 1 – Thermal Comfort

The building must comply with the provisions of Part 3.12 of the Building Code of Australia for Building Fabric, External Glazing, Building Sealing and Air Movement.

DTS 2 – Services

The building must comply with the provisions of Part 3.12 of the Building Code of Australia for Services.

DTS 3 – Hot Water Systems

A hot water system must be either:

(i) a solar hot water system, complying with AS 2712-2002, that has been tested in accordance with AS 4234-1994, and achieves a minimum energy saving of 60% for a hot water demand level of 38MJ per day for climate zone 3; or

(ii) a gas hot water system, complying with AS 4552-2005 that achieves a minimum energy rating of "5 stars"; or

(iii) a heat pump hot water system, complying with AS 2712-2002 that has been tested in accordance with AS 4234-1994, and achieves a minimum energy saving of 60% for a hot water demand level of 38MJ per day for climate zone 3.

Explanatory Notes:

1. **BCA Performance Requirement P2.6.1**

   A building must have, to the degree necessary, a level of thermal performance to facilitate the efficient use of energy for artificial heating and cooling appropriate to –

   (a) the function and use of the building; and
   (b) the internal environment; and
   (c) the geographic location of the building; and
   (d) the effects of nearby permanent features such as topography, structures and buildings; and
   (e) solar radiation being—
      (i) utilised for heating; and
      (ii) controlled to minimise energy for cooling; and
   (f) the sealing of the building envelope against air leakage; and
   (g) the utilisation of air movement to assist cooling.

2. **BCA Performance Requirement P2.6.2 – Services**

   A building's domestic services including any associated distribution system and components must have features that, to the degree necessary, facilitate the efficient use of energy appropriate to –

   (a) the domestic services and its usage; and
   (b) the geographic location of the building; and
   (c) the location of the domestic services; and
   (d) the energy source.

3. **AS 2712-2002** details the design and construction of solar and heat pump water heaters.

4. **AS 4234-1994** sets out the method of testing and calculation of energy consumption for domestic solar water heaters and heat pumps.

5. **AS 4552-2005** details the design of gas forced water heaters for hot water supply and/or central heating.

Water Use in Houses Code

Application

This Code applies to all new buildings classified as Class 1 and 10 buildings by the Building Code of Australia.

Interpretation

"The Building Code of Australia" means the latest edition of the Building Code of Australia published from time to time by, or on behalf of, the Australian Building Codes Board, but not including explanatory information published with that Code.

"Alternative Internal Water Supply" refers to a water supply such as collection of rainwater on site, external third pipe non-potable water source, on-site bores or the like, other than potable water supplied by a licensed water service provider, and approved for use inside a dwelling.

"Alternative External Water Supply" refers to a water supply such as collection of rainwater on site, external third pipe non-potable water source, re-cycled grey water, on-site bores or the like, other than potable water supplied by a licensed water service provider, and approved for use outside a dwelling.

"Potable Water" refers to water intended for human consumption supplied by a licensed water service provider.

Objective

The objective of this Code is to reduce water demand by efficiently using water, and minimising the wasting of water, and facilitating the appropriate use of alternative sources of water.

Functional Statement

To reduce potable water demand a building must:

(a) enable the efficient use of potable water; and
(b) prevent excessive loss of potable water; and
(c) have the capacity to connect to alternative sources of water supply; and
(d) use alternative sources in situations of high water demand or restricted availability of potable water.

Compliance With This Code

A building will comply with this Code if its construction satisfies all the Performance Requirements. Compliance with the Performance Requirements can be shown by:

(a) complying with the Deemed-to-Satisfy provisions as listed in the Acceptable Construction Practice; or
(b) formulating an alternative solution that is shown to be equivalent to the Deemed-to-Satisfy provisions; or
(c) formulating an alternative solution that is verified using an acceptable verification method; or
(d) formulating an alternative solution that is based on expert judgement or supported by suitable evidence in accordance with clause 1.2.2 of the Building Code of Australia; or
(e) any combination of the above.

Explanatory Notes:

Stage 1 of the Code will be prescribed in the Building Regulations to apply from 1 September 2007.

Stage 2 of the Code will be prescribed in the Building Regulations to apply from date to be determined.

Implementation of Stage 2 of the Code is dependent on further consultation and research to determine areas of application and on amendments to plumbing regulations and processes as well as ensuring compliance with health regulations and policies.

Stage 1 - To apply from 1 September 2007

Performance Requirements

PR1 – Water Use Efficiency

A building must have features that, to the degree necessary, facilitate the efficient use of potable water appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for the building; and
(c) the function and use of the building.

PR2 – Water Loss Prevention

A building, including any water holding structures, must have features that, to the degree necessary, prevent the excessive loss of potable water appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for the building; and
(c) the function and use of the building; and
(d) the effects of permanent features such as topography, structures and buildings.

PR3 – Hot Water Use Efficiency

A building must have features that, to the degree necessary, facilitate the efficient use of hot water appropriate to:

(a) the geographic location of the building; and
(b) the available hot water supply for the building; and
(c) the function and use of the building.

Acceptable Construction Practice

(a) Compliance with all of the Deemed-to-Satisfy provisions of DTS1 satisfies the Performance Requirement PR1 for a building.
(b) Compliance with all of the Deemed-to-Satisfy provisions of DTS2 satisfies the Performance Requirement PR2 for a building.
(c) Compliance with all of the Deemed-to-Satisfy provisions of DTS3 satisfies the Performance Requirement PR3 for a building.

Deemed to Satisfy Provisions

DTS 1 – Water Use Efficiency

(a) all tap fittings other than bath outlets and garden taps must be minimum 4 stars WELS rated.
(b) all showerheads must be minimum 3 stars WELS rated.
(c) all sanitary flushing systems must be a minimum 4 stars WELS rated dual flush.

DTS 2 – Swimming Pool Covers and Blankets

An outdoor private swimming pool or spa associated with a Class 1 building must be supplied with a cover, blanket or the like that:

(a) is designed to reduce water evaporation; and
(b) is listed on the Smart Approved Watermark Scheme.

DTS 3 – Hot Water Use Efficiency

All internal hot water outlets (taps, showers, washing machine water supplies) must be connected to a hot water system or a recirculating hot water system with pipes installed and insulated in accordance with AS/NZS 3500:2003. Plumbing and Drainage, Part 4 Heated Water Services. The pipe from the hot water system or recirculating hot water system to the furthest hot water outlet must not exceed 20 metres in length or 2 litres of internal volume.

Explanatory Notes:

The Smart Approved Watermark Scheme is implemented through the National Water Commission as a simple identification label about water efficient products. Further information can be obtained from www.nwc.gov.au

Stage 2 - To apply from (date to be determined)

Performance Requirements

PR4 – Alternative Water Supply Use Capacity

A building, including any associated plumbing, must have features that, to the degree necessary, facilitate the future use of alternative water supplies appropriate to:

(a) the geographic location of the building; and
(b) the function and use of the building; and
(c) the soil type and ground condition; and
(d) the available alternative sources of water; and
(e) the size and type of external landscaping.

PR5 – Grey Water Use Capacity

A building including any associated plumbing, located on a lot of a size and in a location suitable for recycling of grey water, must have features that, to the degree necessary, facilitate the future use of grey water recycling appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for landscaping; and
(c) the function and use of the building; and
(d) the soil type and ground condition; and
(e) the available alternative sources of water; and
(f) the size and type of external landscaping.

Acceptable Construction Practice

(a) Compliance with all of the Deemed-to-Satisfy provisions of DTS4 satisfies the Performance Requirement PR4 for a building.
(b) Compliance with all of the Deemed-to-Satisfy provisions of DTS5 satisfies the Performance Requirement PR5 for a building.

Deemed to Satisfy Provisions

DTS 4 – Alternative Water Supply Use Capacity

All sanitary flushing systems and washing machines must be able to be connected at a later date, to an appropriate alternative water supply without the need to break, or cut into the fabric of the building to run new pipes.

DTS 5 – Grey Water Use Capacity

All shower, bath, laundry trough and washing machine drains must be able to be connected at a later date to an appropriate grey water diversion system without the need to break, or cut into the fabric of the building to run new pipes.

Explanatory Notes:

1. Health regulations apply to the use of alternative water supplies and will, amongst other things, limit the alternative water sources suitable for various uses.
2. The DTS 4 provisions do not require rainwater tanks. They require buildings to be able to be connected to such alternative water supplies relatively easily at a later date (i.e. the buildings are to be alternative supply 'ready'). Subject to health regulations and policies, alternative water supplies could also include bore water, third pipes, and the like.
3. All plumbing work associated with these requirements must be carried out by licensed plumbers and in accordance with all relevant plumbing regulations.

Water Use in Houses Code

Performance Requirements

PR6 – Alternative Internal Water Supply

A building with more than two showers or two WC facilities must use alternative internal water supplies for internal uses appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for the building; and
(c) the function and use of the building; and
(d) the available alternative sources of water.

PR7 – Alternative External Water Supply

A building located on a lot of a size and in a location likely to use significant potable water for landscaping use must use alternative internal or external water supplies appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for the building; and
(c) the function and use of the building; and
(d) the soil type and ground condition; and
(e) the available alternative sources of water; and
(f) the size and type of external landscaping.

Deemed to Satisfy Provisions

DTS 6 – Alternative Internal Water Supply

All sanitary flushing systems and clothes washing facilities must be connected to an alternative internal cold water supply.

DTS 7 – Alternative External Water Supply

(a) All external garden taps and irrigation systems must be connected to an alternative external water supply; or
(b) all shower, bath, laundry trough and washing machine drains must be connected to an approved grey water diversion and recycling system.

Acceptable Construction Practice

(a) Compliance with all of the Deemed-to-Satisfy provisions of DTS6 satisfies the Performance Requirement PR6 for a building.
(b) Compliance with all of the Deemed-to-Satisfy provisions of DTS6 or DTS7 satisfies the Performance Requirement PR7 for a building.

Explanatory Notes:

1. Houses required to be "grey water ready" under PR5 are those on large enough lots to allow drains carrying appropriate water to be run outside the house before connection to other waste pipes, and where there is likely to be enough landscaped area to adequately dilute the grey water.
2. Lots where houses are required to comply with PR7 will be identified through regulations. Further research is needed with relevant stakeholders to resolve which lots will be subject to this requirement.
3. Health regulations apply to the use of alternative water supplies and will, amongst other things, limit the alternative water sources suitable for internal or external use in different localities. For example most private bore water, whilst it may be suitable for garden use, may be inappropriate for use internally.
4. Alternative water supplies can include but is not limited to, rainwater tanks, bore water, third pipes, and the like.
5. Subject to health regulations an acceptable alternative internal water supply is an appropriately sized rainwater tank harvesting the rainwater runoff from the roof.
6. Subject to health regulations an acceptable alternative external water supply is a domestic bore.
7. All plumbing work associated with alternative water supplies must be carried out by licensed plumbers and in accordance with all relevant plumbing regulations.
8. The Water Use in Houses Code is implemented in two stages to allow amendment of plumbing regulations and training of licensed plumbers to ensure alternative water supplies are appropriate and safe, and that there is no risk of cross contamination with potable water supplies.

Further information

These Codes are intended to supplement the Building Code of Australia and will be called up by the Building Regulations 1989

For further information about 5 Star Plus please visit our website at www.5starplus.wa.gov.au

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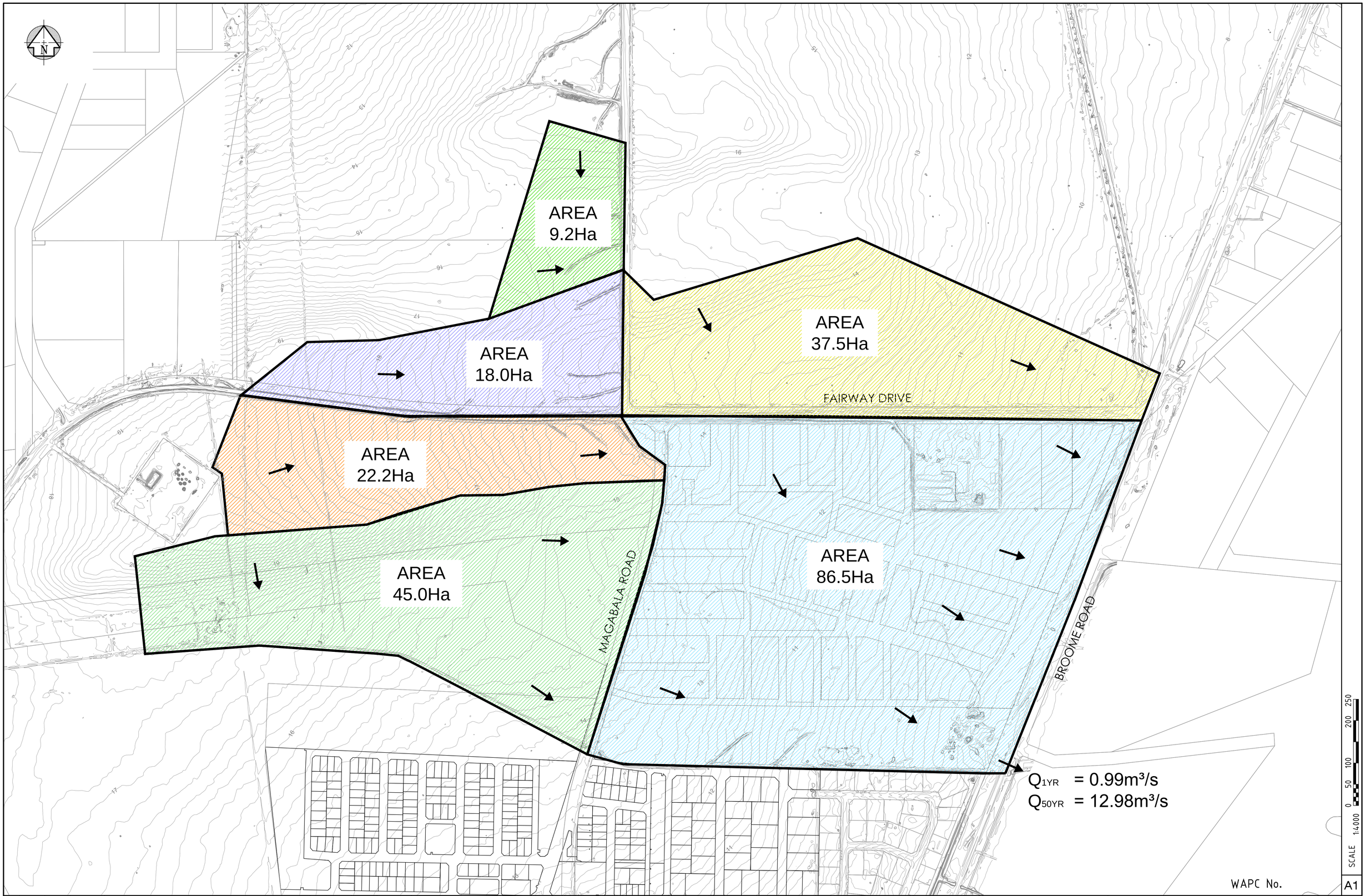
108 Adelaide Terrace,
East Perth WA 6004

Appendix G – Catchment plans



No.	DATE	DRAWN	APPROVED	AMENDMENT
D	30.06.16	KS	×BBF	PRECAL REVISED, CATCHMENTS UPDATED
C	17.12.12	KS	×BBF	PRECAL AMENDED
B	21.11.12	KS	×BBF	PRECAL AMENDED
A		KS	×BBF	ISSUED FOR INFORMATION

No.	DATE	DRAWN	APPROVED	AMENDMENT

CLIENT: LANDCORP · WARANYJARRI ESTATE · BROOME NORTH

DESIGNED	CHECKED	APPROVED
DRAWN KS	CHECKED	DATE

TABEC Civil Engineering Consultants
TABEC PTY LTD
ACN 090 796 204
14 Wickham Street, East Perth WA 6004
t 08 9425 5900 e info@tabec.com.au
www.tabec.com.au

PROJECT: BROOME NORTH - LDP2

TITLE: PRE-DEVELOPMENT CATCHMENTS & FLOWS

DRAWING NUMBER: 2287-LDP2-SK007A

ISSUE: D

AREA
82.3Ha

AREA
136.2Ha

FAIRWAY DRIVE

MAGABALA ROAD

BROOME ROAD

○ Culvert 2 (3x1800x900 R.C.B)

Q_{1YR} = 0.35m³/s

Q_{50YR} = 5.75m³/s

○ Culvert 1 (3x1800x900 R.C.B)

Q_{1YR} = 0.32m³/s

Q_{50YR} = 6.91m³/s

SCALE 1:4000 0 50 100 200 250

WAPC No.

A1

No.	DATE	DRAWN	APPROVED	AMENDMENT
A	30.06.16	KS	xBBF	ISSUED FOR INFORMATION

No.	DATE	DRAWN	APPROVED	AMENDMENT

This plan shall not to be used for construction unless issued as rev 0 and signed as approved.

CLIENT: LANDCORP · WARANYJARRI ESTATE · BROOME NORTH

DESIGNED	CHECKED	APPROVED
DRAWN KS	CHECKED	DATE

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PROJECT: BROOME NORTH - LDP2

TITLE: PRE-DEVELOPMENT CATCHMENTS & FLOW PROPOSED MRWA CULVERTS

DRAWING NUMBER: 2287-LDP2-SK007C

ISSUE: A

LEGEND

OPEN SPACE/DRAINAGE

DIRECTION OF FLOW

FAIRWAY DRIVE

MAGABALA ROAD

BROOME ROAD

FUTURE DEVELOPMENT 1
AREA = 15.935 ha
ALLOWABLE FLOW = 0.93 m³/s
STORAGE REQUIRED = 15,180 m³
(ASSUME 30% PERVIOUS & 70% IMPERVIOUS POST DEVELOPMENT)

FUTURE DEVELOPMENT 2
AREA = 32.180ha
ALLOWABLE FLOW = 1.94 m³/s
STORAGE REQUIRED = 30,850 m³
(ASSUME 30% PERVIOUS & 70% IMPERVIOUS POST DEVELOPMENT)

LDP2 - PART 1
AREA = 63.642 ha
ALLOWABLE FLOW = 3.71 m³/s
STORAGE REQUIRED = 59,880 m³
PERVIOUS AREA = 25.55 ha
IMPERVIOUS AREA = 58.58 ha

MRWA CULVERT 1
TOTAL POST DEVELOPMENT
CATCHMENT AREA = 112.72 ha
ALLOWABLE OUTFLOW = 6.57 m³/s

SCALE 1:3000 0 50 100 150

WAPC No.

A1

No.	DATE	DRAWN	APPROVED	AMENDMENT
D	01.07.16	KS	×BBF	PRECAL UPDATED, CATCHMENTS REVISED
C	17.12.12	KS	×BBF	PRECAL AMENDED
B	02.11.12	KS	×BBF	PRECAL UPDATED
A		KS	×BBF	ISSUED FOR INFORMATION

CLIENT: LANDCORP / WARANYJARRI ESTATE / BROOME NORTH

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DRAWN KS	CHECKED	DATE

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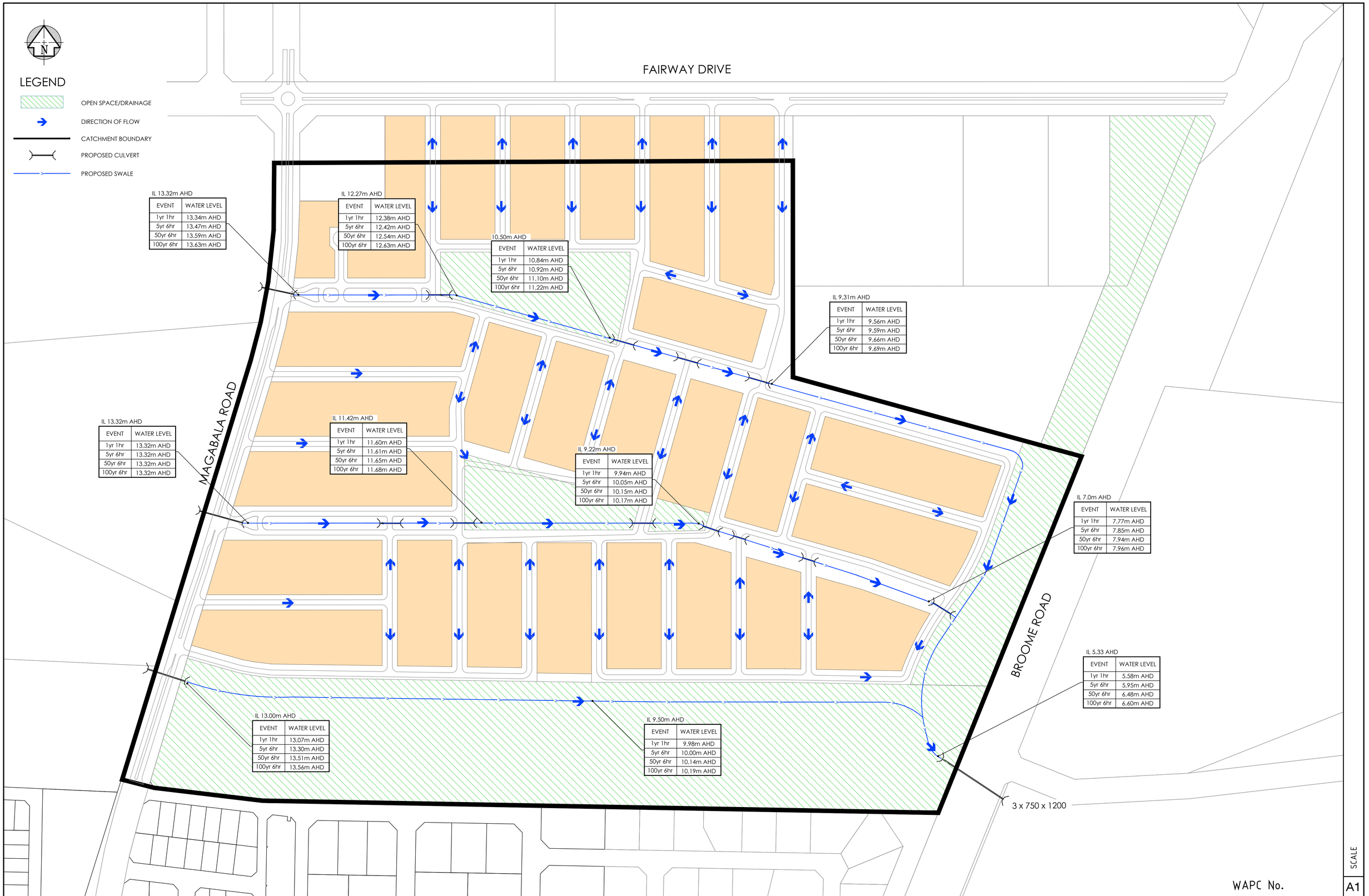
www.tabec.com.au

PROJECT: BROOME NORTH - LDP2

TITLE: POST DEVELOPEMENT CATCHMENTS, FLOW & STORAGE REQUIREMENT FOR CRITICAL 50Y 6H ARI EVENT

DRAWING NUMBER: 2287-LDP2-SK004B

ISSUE: D



No.	DATE	DRAWN	APPROVED	AMENDMENT
A	06.10.16	KS	xBBF	ISSUED FOR INFORMATION

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DESIGNED	CHECKED	APPROVED
DRAWN: KS	CHECKED	DATE

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www.tabec.com.au

PROJECT: BROOME NORTH - LDP2

TITLE: POST DEVELOPEMENT WATER LEVELS

DRAWING NUMBER: 2287-LDP2-SK016A

ISSUE: A

SCALE: A1

WAPC No.

LEGEND

- OPEN SPACE/DRAINAGE
- DIRECTION OF FLOW
- CATCHMENT BOUNDARY
- PROPOSED SWALE
- PROPOSED WEIR
- PROPOSED CULVERT

FAIRWAY DRIVE

MAGABALA ROAD

BROOME ROAD

	5Y	50Y	100Y
Q_{MAX}	0.70	1.86	2.34
V_{MAX}	0.44	0.47	0.47
D_{MAX}	0.62	1.20	1.20

	5Y	50Y	100Y
Q_{MAX}	1.24	2.15	2.86
V_{MAX}	1.82	2.54	0.96
D_{MAX}	0.48	1.02	1.16

	5Y	50Y	100Y
Q_{MAX}	1.44	2.39	2.94
V_{MAX}	0.68	0.77	0.82
D_{MAX}	0.51	0.70	0.76

	5Y	50Y	100Y
Q_{MAX}	2.21	3.33	3.75
V_{MAX}	0.78	0.89	0.93
D_{MAX}	0.86	0.94	0.96

	5Y	50Y	100Y
Q_{MAX}	0.49	0.73	0.84
V_{MAX}	0.46	0.49	0.51
D_{MAX}	0.47	0.69	0.76

	5Y	50Y	100Y
Q_{MAX}	2.26	3.74	4.37
V_{MAX}	1.07	1.20	1.28
D_{MAX}	0.62	1.15	1.27

	5Y	50Y	100Y
Q_{MAX}	2.78	5.06	6.16
V_{MAX}	1.10	1.30	1.37
D_{MAX}	0.51	0.74	0.69

	5Y	50Y	100Y
Q_{MAX}	1.52	2.24	2.57
V_{MAX}	0.76	0.82	0.83
D_{MAX}	0.78	0.85	0.87

OUTFALL
Q_1 = 1.21m³/s
Q_5 = 4.09m³/s
Q_{50} = 6.68m³/s
Q_{100} = 8.65m³/s

WAPC No.

SCALE A1

No.	DATE	DRAWN	APPROVED	AMENDMENT
A	06.10.16	KS	×BBF	ISSUED FOR INFORMATION

CLIENT: LANDCORP · WARANYJARRI ESTATE · BROOME NORTH

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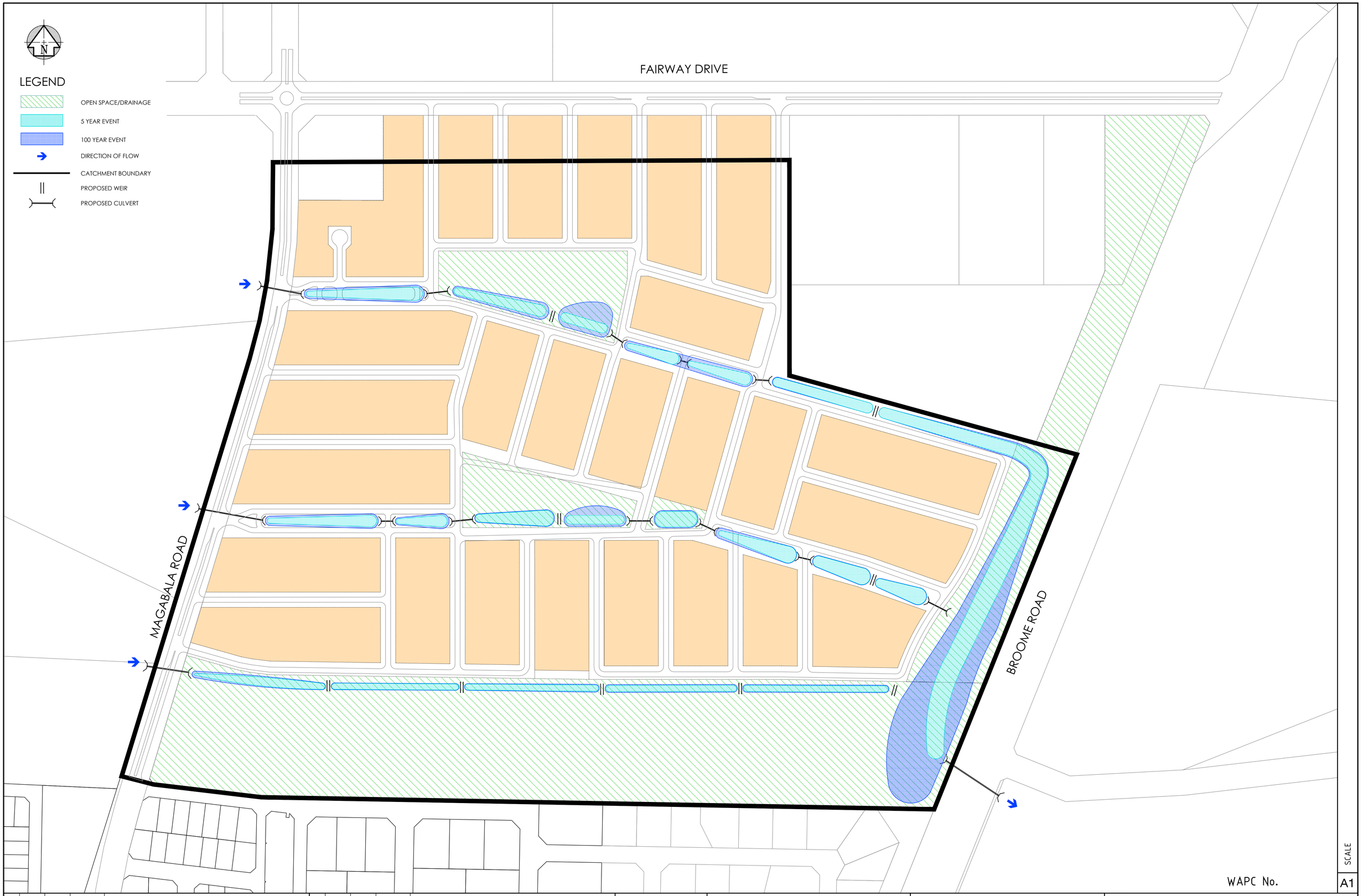
PROJECT: BROOME NORTH - LDP2

TITLE: POST DEVELOPEMENT FLOW INFORMATION

DRAWING NUMBER: 2287-LDP2-SK016B

ISSUE: A



WAPC No.

SCALE A1

No.	DATE	DRAWN	APPROVED	AMENDMENT
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CLIENT: LANDCORP · WARANYJARRI ESTATE · BROOME NORTH

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PROJECT: BROOME NORTH - LDP2

TITLE: POST DEVELOPEMENT FLOW INFORMATION 5YR AND 100YR EVENT PLAN

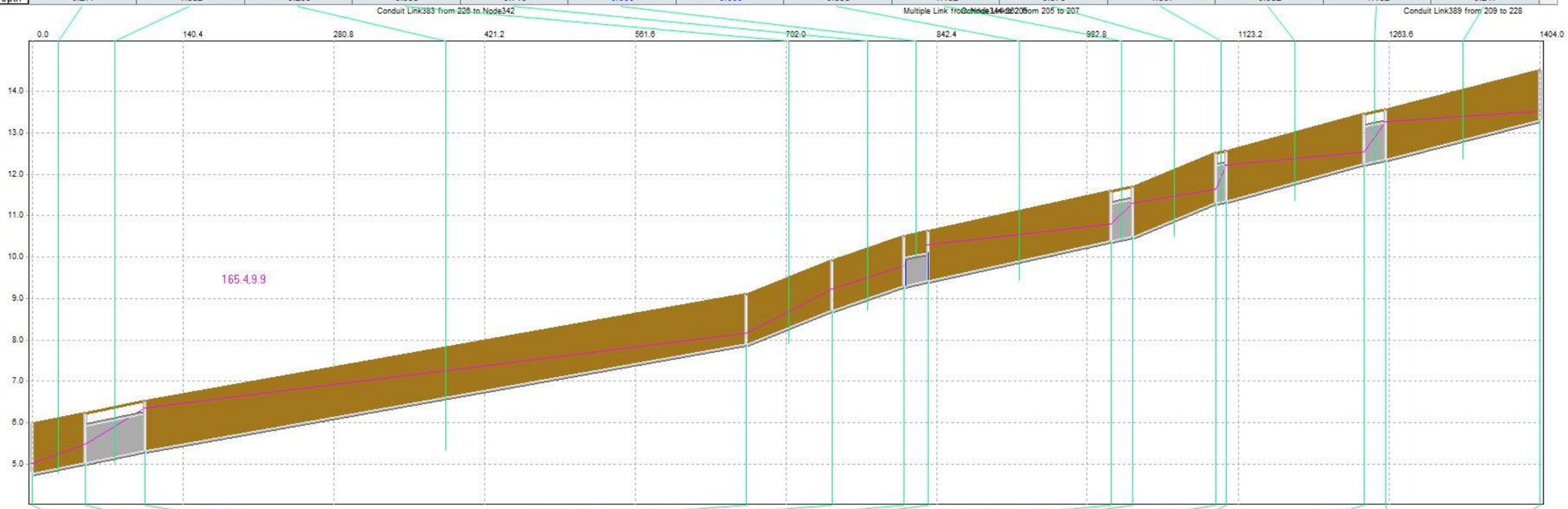
DRAWING NUMBER: 2287-LDP2-SK016C

ISSUE: A

Northern Swale Long Section, 100 Yr 6H event (Tabec 2016)

aaa | Link Data & Results

	Link384	Link375	Link383	Link391	Link363	205 C	205 OF	Link362	Link393	Link361	Link385	Link376	Link390	Link389
Storm	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h
Max Velocity	0.810	2.550	0.710	1.460	1.440	0.000	0.000	0.880	2.420	1.050	2.390	0.710	2.050	0.460
Max Volume	555.390	196.010	4297.030	85.540	278.910	0.000	0.000	1135.730	21.340	466.990	4.950	733.260	6.950	933.660
Max Flow	11.762	11.762	6.195	7.051	6.672	0.000	0.000	3.906	3.327	3.589	1.712	1.971	1.189	1.189
Max Depth	0.446	1.032	1.032	0.516	0.516	0.000	0.000	0.873	0.808	0.808	0.857	0.857	0.916	0.916
Max Velocity * Depth	0.277	1.882	0.299	0.558	0.713	0.000	0.000	0.558	1.462	0.579	1.367	0.362	1.132	0.247



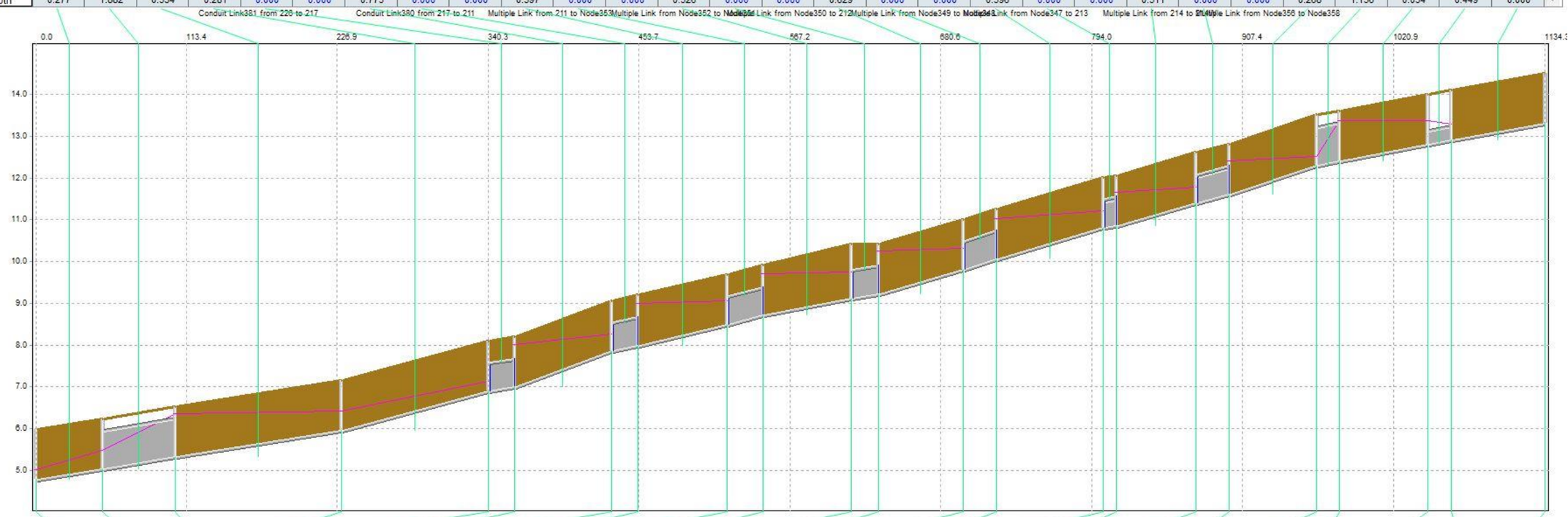
	C1Out	Node331	226	Node342	204	Node344	205	207	Node345	208	208W	Node346	209	228
Storm	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h
Invert Elevation	4.780	5.030	5.330	7.900	8.715	9.314	9.429	10.400	10.500	11.315	11.365	12.265	12.365	13.315
Max Water Elevation	5.023	5.476	6.362	8.158	9.230	9.788	10.302	10.804	11.306	11.647	12.222	12.535	13.281	13.524
EGL Elevation	5.056	5.807	6.372	8.261	9.336	10.223	10.341	11.103	11.357	11.904	12.240	13.247	13.291	13.524
Max Volume	0.297	0.544	20647.580	0.315	0.630	0.578	1.065	0.494	0.986	0.405	1.045	404.832	458.114	0.255

Node Data

Central Swale Long Section, 100 Yr 6H event (Tabec 2016)

aaa | Link Data & Results

	Link384	Link375	Link381	Link380	211C	221OF	Link401	351C	351OF	Link399	212C	212OF	Link397	348P	348OF	Link395	213C	213OF	Link366	214C	214OF	Link365	358C	358OF	Link407	Link406	Link405	Link404	Link403
Storm	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h
Max Velocity	0.810	2.550	1.070	0.860	0.000	0.000	1.090	0.000	0.000	0.760	0.000	0.000	0.650	0.000	0.000	0.830	0.000	0.000	0.940	0.000	0.000	0.880	0.000	0.000	0.570	2.010	0.140	-1.050	0.000
Max Volume	555.390	196.010	3188.790	535.930	0.000	0.000	752.880	0.000	0.000	806.000	0.000	0.000	842.140	0.000	0.000	752.560	0.000	0.000	738.220	0.000	0.000	385.270	0.000	0.000	338.810	5.720	739.630	1.330	0.000
Max Flow	11.762	11.762	15.087	6.569	0.000	0.000	5.486	0.000	0.000	5.502	0.000	0.000	5.271	0.000	0.000	5.283	0.000	0.000	4.196	0.000	0.000	3.449	0.000	0.000	1.196	1.205	-0.442	-0.074	0.000
Max Depth	0.446	1.032	1.032	0.469	0.000	0.000	1.018	0.000	0.000	0.995	0.000	0.000	0.995	0.000	0.000	1.020	0.000	0.000	0.967	0.000	0.000	0.799	0.000	0.000	0.806	0.964	0.964	0.566	-9e+099
Max Velocity * Depth	0.277	1.882	0.534	0.281	0.000	0.000	0.773	0.000	0.000	0.597	0.000	0.000	0.526	0.000	0.000	0.629	0.000	0.000	0.596	0.000	0.000	0.511	0.000	0.000	0.268	1.156	0.034	0.449	0.000



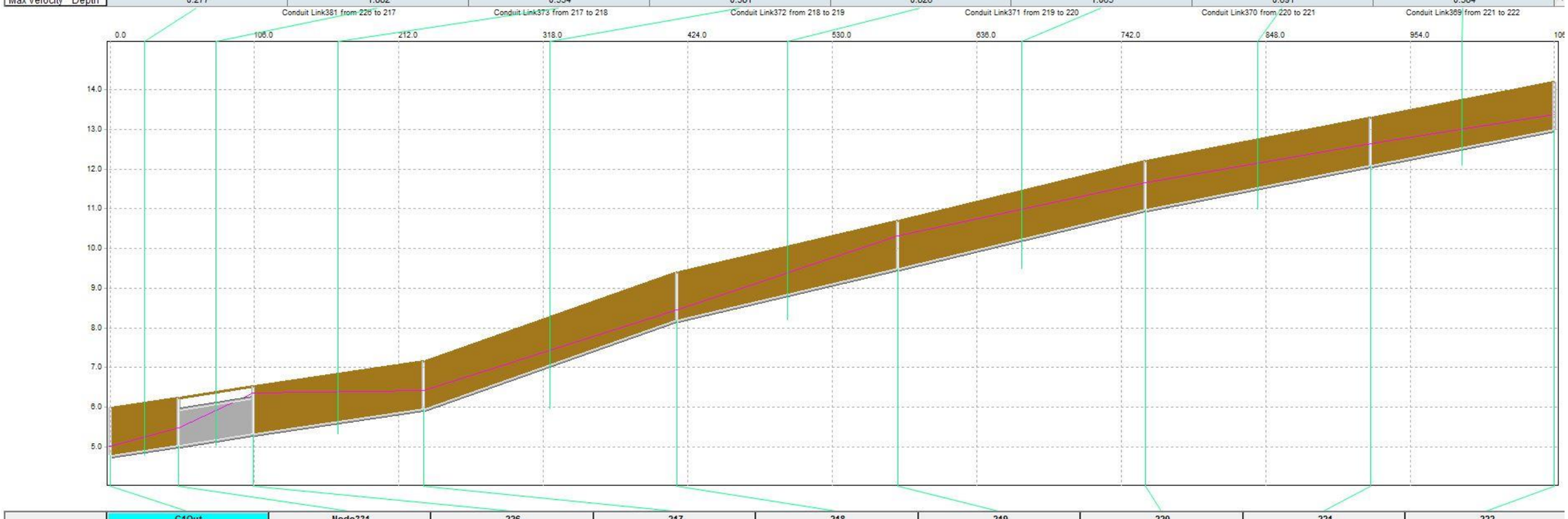
	C1Out	Node331	226	217	211	Node353	Node352	Node351	Node350	212	Node349	Node348	Node347	213	214	214W	Node356	Node358	Node357	215	Node355	Node354	223
Storm	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h
Invert Elevation	4.780	5.030	5.330	5.955	6.900	7.000	7.865	8.000	8.495	8.715	9.125	9.225	9.815	10.065	10.815	10.865	11.415	11.615	12.315	12.415	12.815	12.915	13.315
Max Water Elevation	5.023	5.476	6.362	6.424	7.122	8.018	8.264	8.994	9.069	9.710	9.762	10.245	10.325	11.032	11.212	11.664	11.791	12.421	12.507	13.379	13.381	13.293	13.315
EGL Elevation	5.056	5.807	6.372	6.453	7.991	8.079	8.958	9.024	9.608	9.731	10.217	10.279	10.903	11.071	11.583	11.702	12.475	12.436	12.712	13.379	13.436	13.293	13.315
Max Volume	0.297	0.544	20647.580	4689.202	0.271	1.243	0.487	1.213	0.701	1.214	0.777	1.244	0.623	1450.248	0.486	0.974	0.459	0.983	0.235	1.176	0.690	0.462	0.000

Node Data

Southern Swale Long Section, 100 Yr 6H event (Tabec 2016)

aaa | Link Data & Results

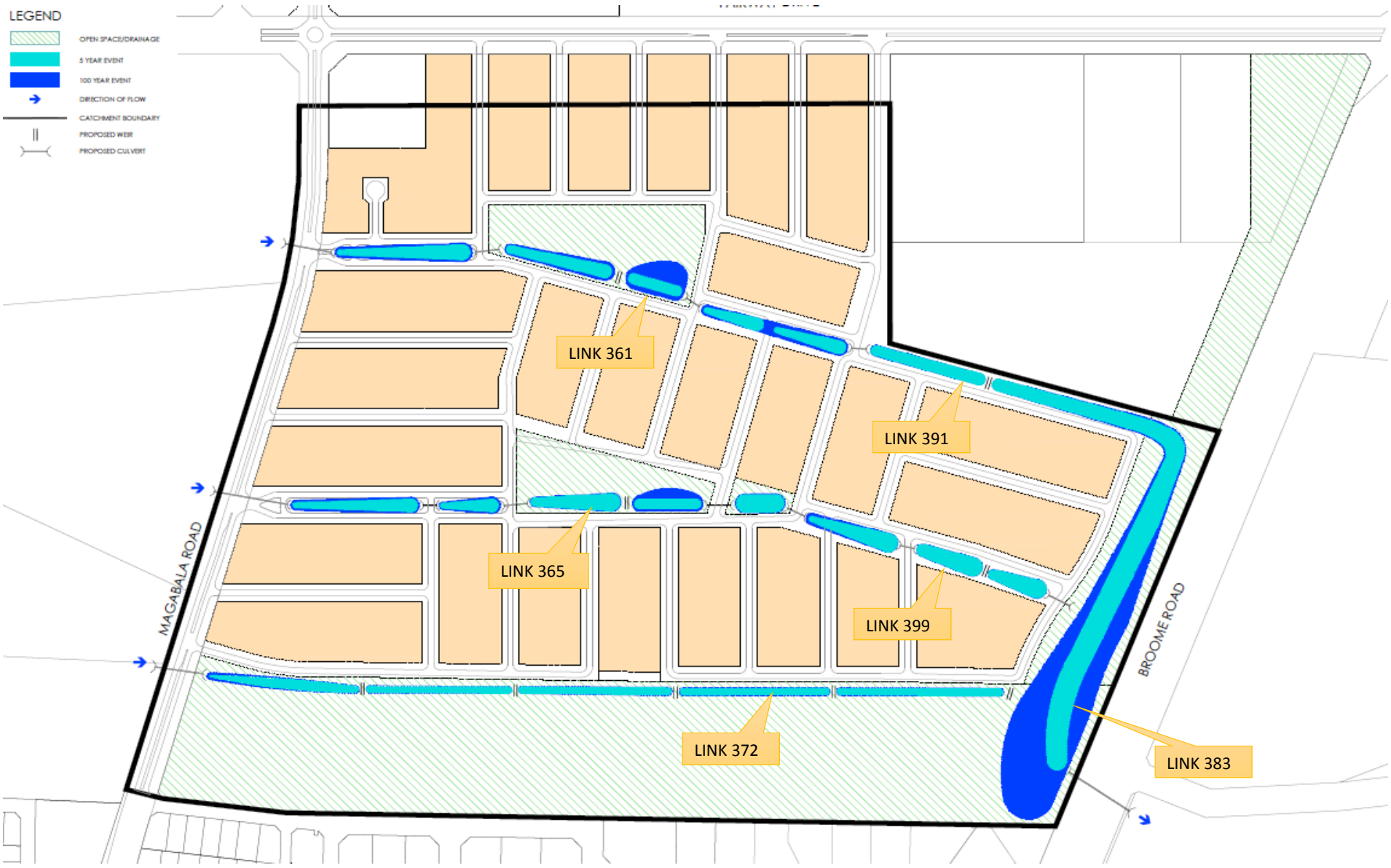
	Link384	Link375	Link381	Link373	Link372	Link371	Link370	Link369
Storm	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h
Max Velocity	0.810	2.550	1.070	1.160	1.530	1.450	1.160	0.990
Max Volume	555.390	196.010	3188.790	380.730	84.410	433.480	285.390	106.440
Max Flow	11.762	11.762	15.087	9.882	7.470	5.325	2.974	1.334
Max Depth	0.446	1.032	1.032	0.469	0.822	0.822	0.653	0.537
Max Velocity * Depth	0.277	1.882	0.534	0.381	0.826	1.065	0.691	0.384

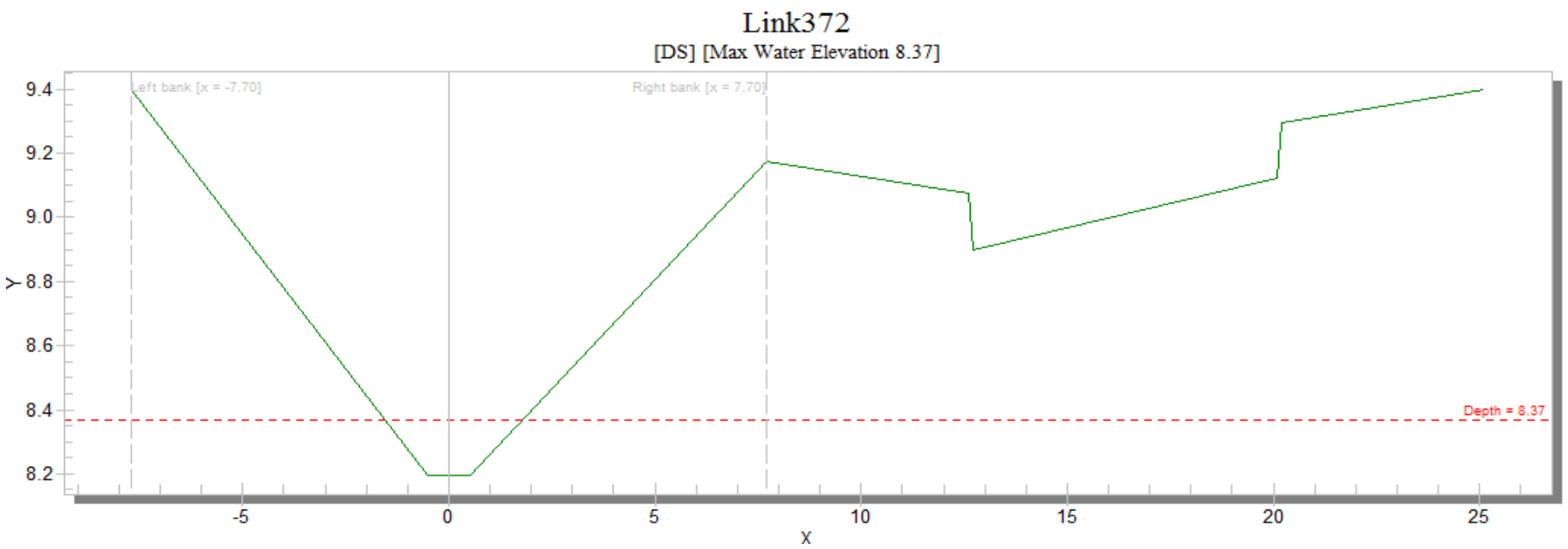


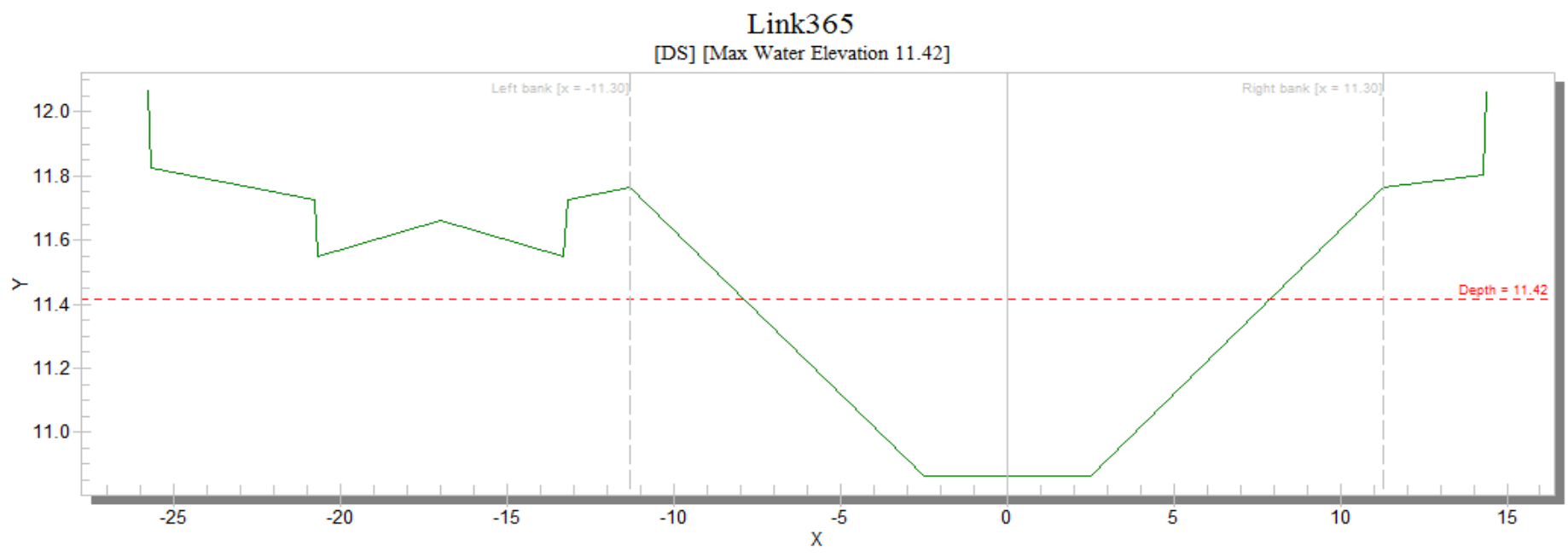
	C1Out	Node331	226	217	218	219	220	221	222
Storm	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h	100y1h
Invert Elevation	4.780	5.030	5.330	5.955	8.197	9.497	10.997	12.097	12.997
Max Water Elevation	5.023	5.476	6.362	6.424	8.453	10.319	11.650	12.632	13.377
EGL Elevation	5.056	5.807	6.372	6.453	8.904	10.425	11.719	12.646	13.377
Max Volume	0.297	0.544	20647.580	4689.202	0.314	1.002	0.796	0.655	0.464

Node Data

BROOME NORTH - Oct 2016 XP SWMM MODEL: CROSS-SECTIONS 50 YEAR 6 HOUR ARI

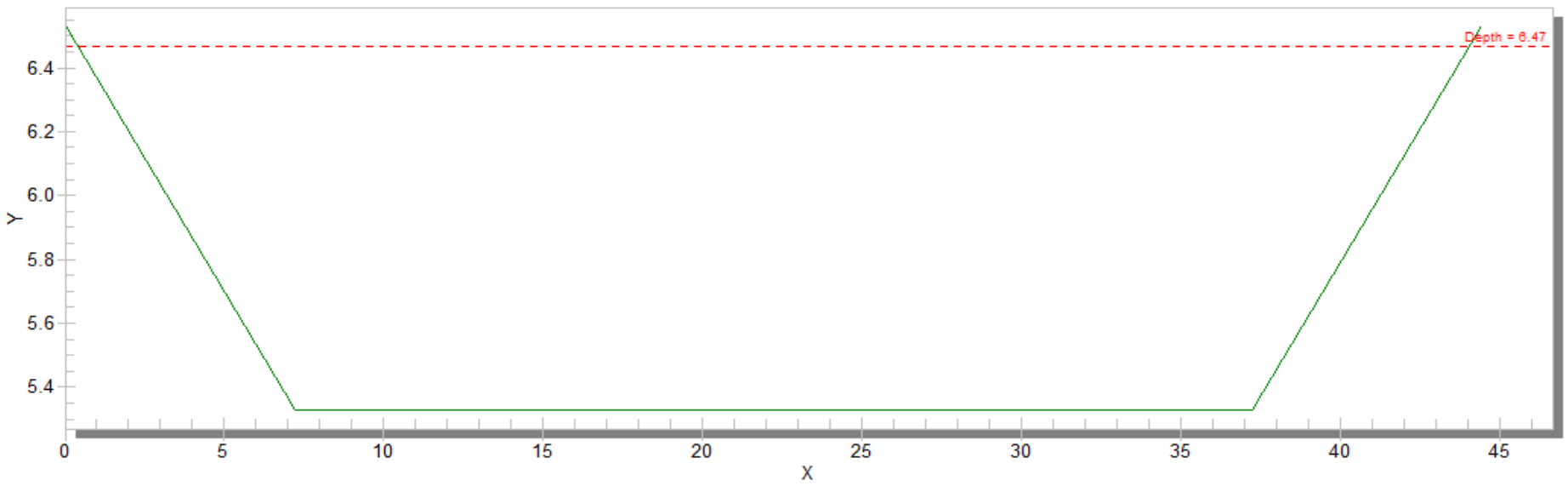






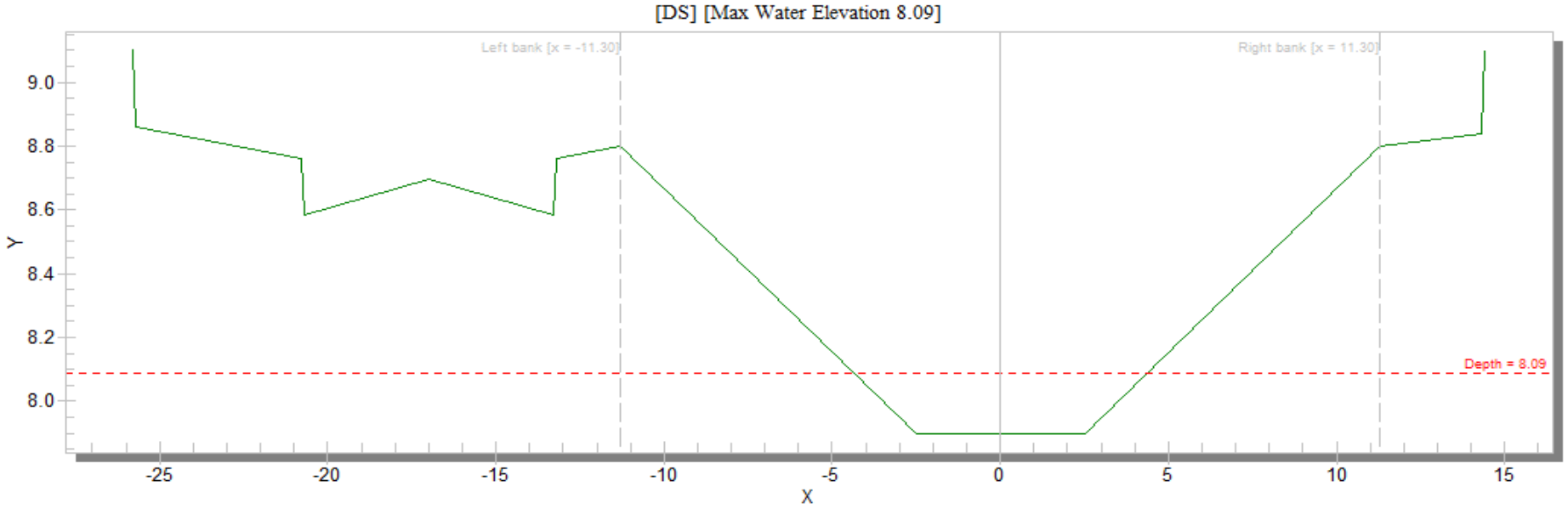
Link383

[DS] [Max Water Elevation 6.47]



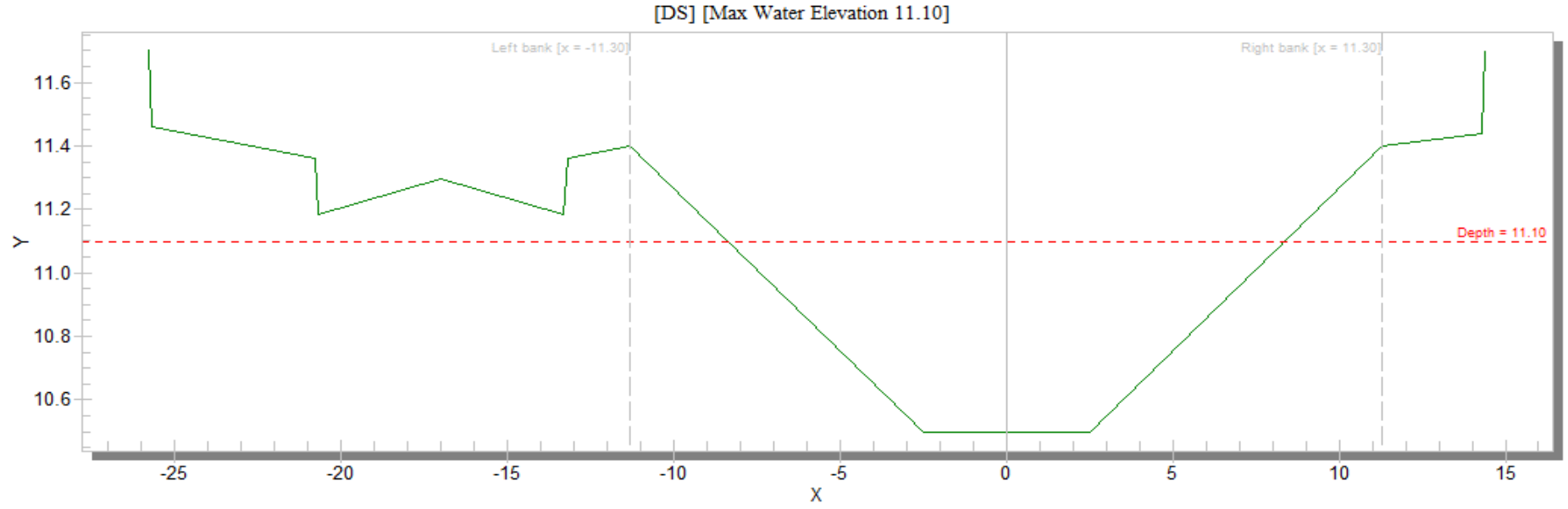
Link391

[DS] [Max Water Elevation 8.09]



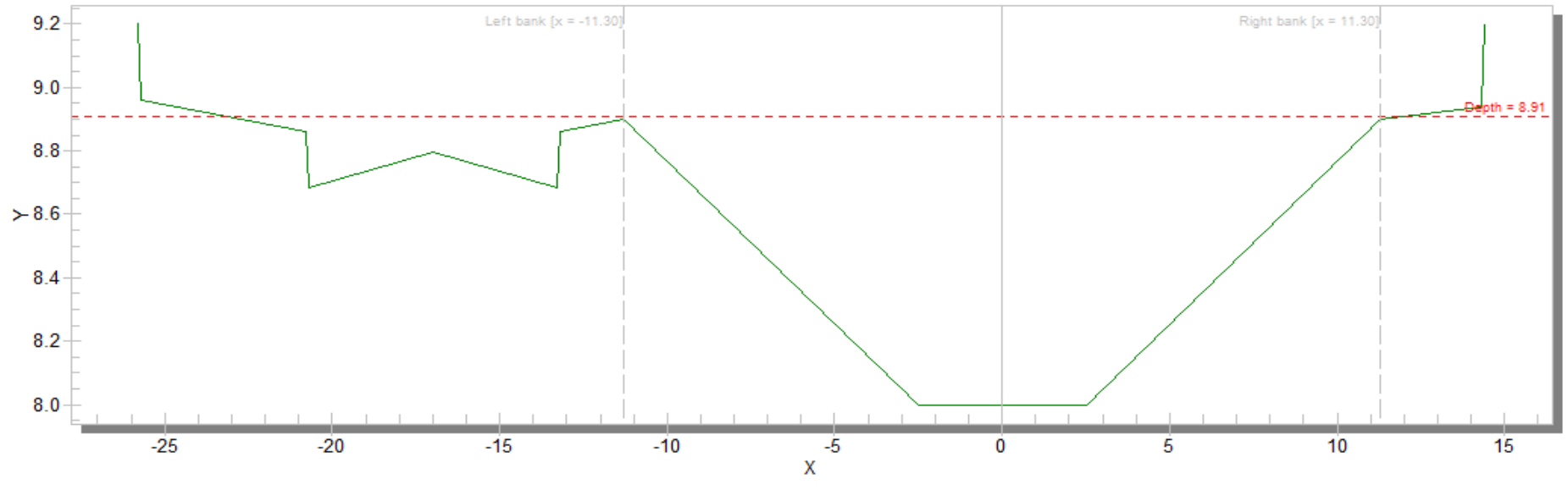
Link361

[DS] [Max Water Elevation 11.10]

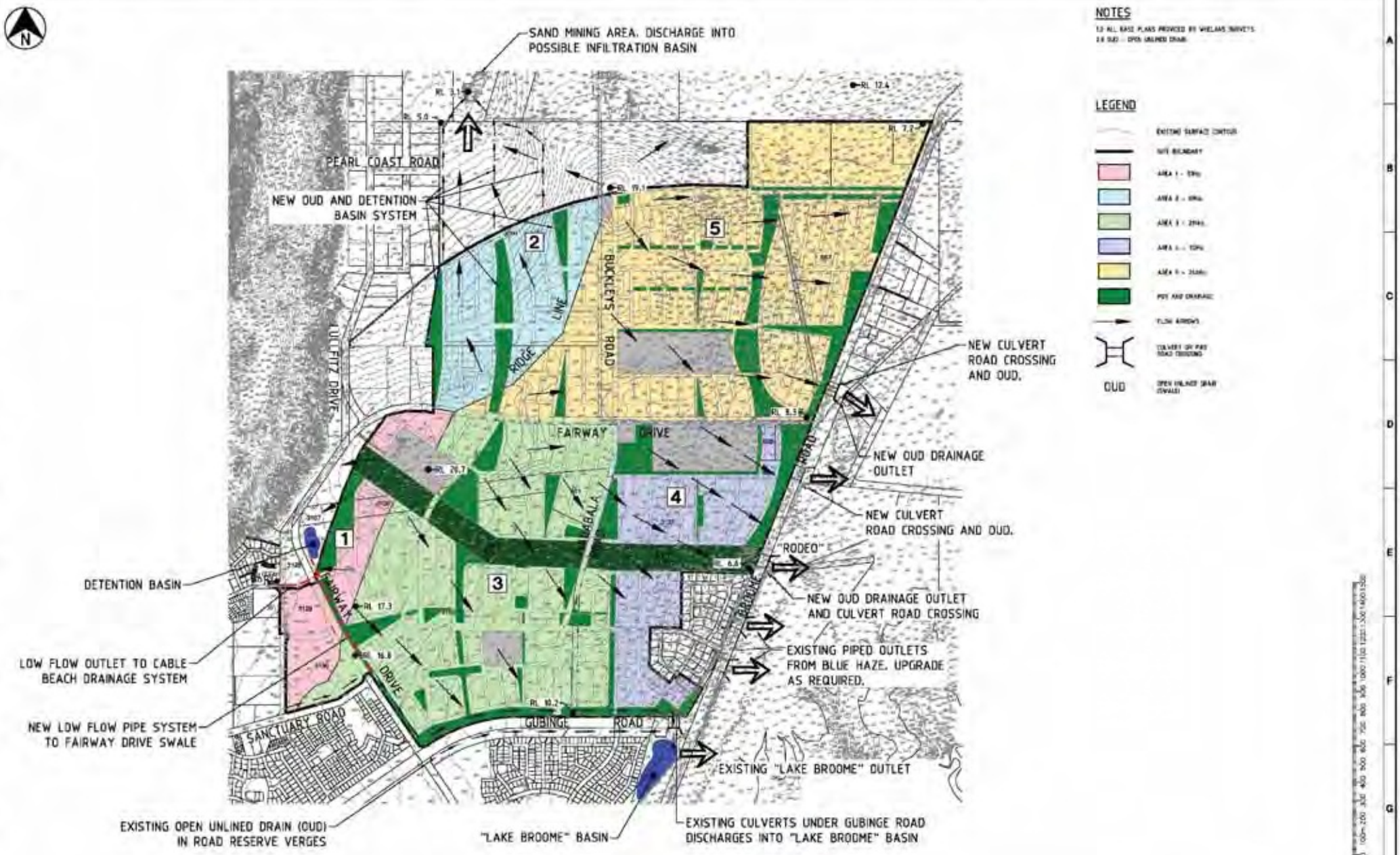


Link399

[DS] [Max Water Elevation 8.91]



Appendix H – Catchment outlets



C	03.10.07	ISSUED FOR ENGINEERING REPORT		
B	17.09.07	ISSUED FOR INFORMATION		
A	29.03.07	INITIAL ISSUE FOR REVIEW		
No.	DATE	AMENDMENT DETAILS	DES'D	APP'D

No.	DRAWING NUMBER	REFERENCE DRAWING TITLE

SKM

LANDCORP

CLIENT	LANDCORP
PROJECT	BROOME NORTH
DRAWING STATUS	
DESIGNED P.OLIVER	DRAWN E.MATHEW
CHECKED	PROJECT MANAGER
APPROVED	PROJECT DIRECTOR

TITLE: DEVELOPMENT PLAN - DRAINAGE CATCHMENT PLAN

SCALE 1:10000	SKM PROJECT No. PB50119	DRAWING No. C011	REV C

No.	DATE	DRAWN	APPROVED	AMENDMENT
B	19.12.12	KS	*BBF	DRAIN ALIGNMENT AMENDED
A		KS	*BBF	ISSUED FOR INFORMATION

CLIENT: LANDCORP · WARANYARRAK · BROOME NORTH

DESIGNED	CHECKED	APPROVED
DRAWN: KS	CHECKED	DATE

TABEC
Civil Engineering Consultants
TABEC Pty Ltd ACN 090 796 204
14 Wickham Street, East Perth WA 6004
Telephone 9225 4100, Fax 9225 4188
Email info@tabec.com.au

PROJECT: BROOME NORTH - LDP2

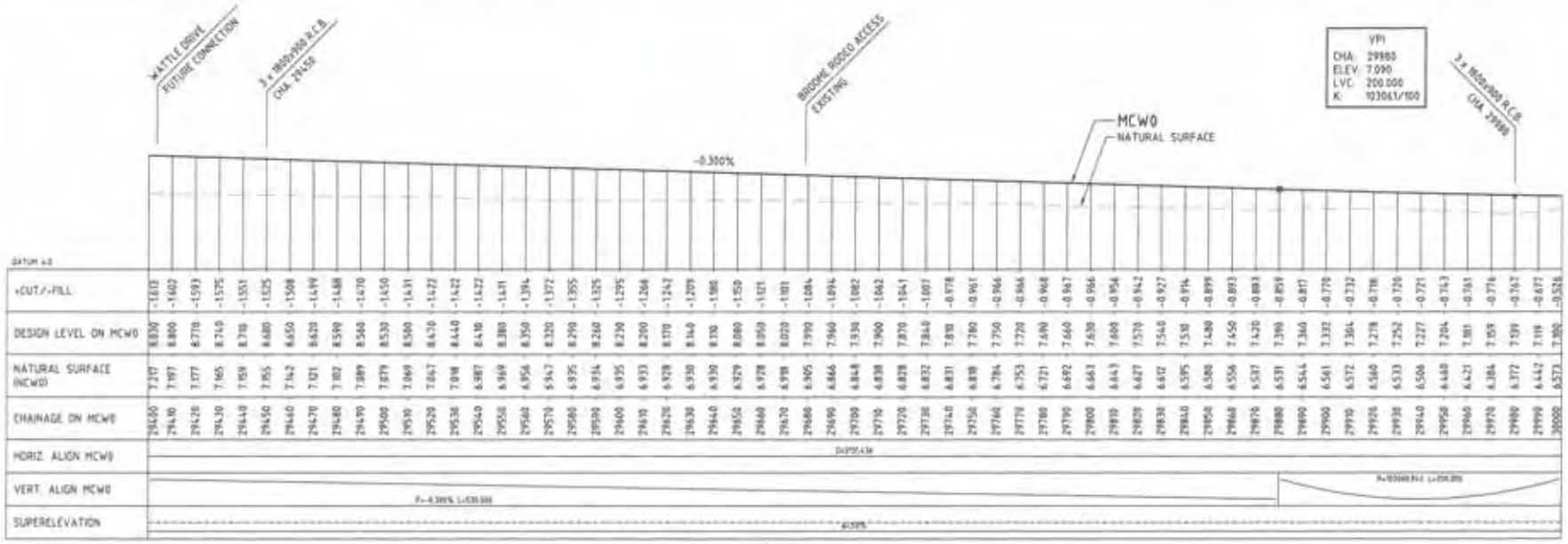
TITLE: BROOME DRAIN

DRAWING NUMBER: 2287-LDP2-SK013

ISSUE: B

Appendix I – MRWA concept design

Concept design for Broome Highway culvert upgrade



PROFILE

SCALE: HORIZ. 1:1000 & VERT. 1:100

AMENDMENTS

No.	DESCRIPTION	APPROVED & DATE

NOTES

LEGEND

- EXISTING ROAD
- SEALED
- UNSEALED
- MEDIAN & VERGE
- BATTERS
- PRINCIPAL SHARED PATH
- TRAFFIC ISLAND
- DRAINAGE
- PROPOSED MINOR CULVERT
- CADASTRAL BOUNDARY
- LAND REQUIREMENT

METADATA

GROUND SURVEY STANDARD:	N/A
DATE OF CAPTURE:	
MAPPING SURVEY STANDARD:	N/A (LANDGATE DATA)
DATE OF CAPTURE:	
MAIN ROADS PROJECT ZONE:	BRD94
HEIGHT DATUM:	A.H.D.

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KIMBERLEY REGION
WOODHOUSE STREET DERBY WA 6728
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FILE NUMBER

DESIGNED / DRAWN: Z. BATEN/K. SMITH - MAY 2012

CHECKED: B.Elwood 11/5/12

APPROVED:

VERTICAL 1:100 HORIZONTAL 1:1000 SCALE A1

BROOME HIGHWAY (H042)

CAPE LEVEQUE ROAD TO OLD BROOME ROAD SECTION

19.85 SLK - 31.76 SLK

PLAN AND PROFILE

CHA. 29400 TO CHA. 30000

LOCAL AUTHORITY: SHIRE OF BROOME

MRWA DRAWING NUMBER

201106-0179

GHD

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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Rev 1	K Hunt	N Deeks	NDeeks	N Deeks	NDeeks	9/12/2016

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