

DISTRICT WATER MANAGEMENT STRATEGY

Lots 1797 & 1798 Matison St
Southern River

Revision No 1
December 2019



Green Values Australia

www.Greenvalues.com.au

District Water Management Strategy

**Lots 1797 and 1798 Matison Street
Southern River**

Issue No. 1

December 2019

Document Control

Green Values Australia 75 Empire Avenue CITY BEACH WA 6015			
Telephone:	(+61) 0447 988 886	File Reference:	https://greenvalues-my.sharepoint.com/personal/rhys_greenvalues_com_au/Documents/GREEN VALUES/PROJECTS/2018/180009_URB_Matison River/Final/DWMS Rev1/180009_DWMS_1797 and 1798 Matison Rd Southern River Rev1.docx
email:	rhys@greenvalues.com.au	Issue:	December 03, 2019
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Title:	District Water Management Strategy Lots 1797 and 1798 Matison Street, Southern River
Author(s):	Rhys Houlihan
Status:	Issue 1 – Final; amended from a DWMS
Synopsis:	This document details the management of urban water at Lots 1797 and 1798 Matison Street, Southern River, City of Gosnells, and has been compiled in accordance with <i>Liveable Neighborhoods Edition 4</i> , the <i>Stormwater Management Manual for Western Australia</i> , <i>Urban Water Management Plans: Guidelines for Preparing Plans and Complying with Subdivision Conditions</i> and <i>Better Urban Water Management</i> .

Issue No	Issued by:	Approved by	Distributed to	Number of Copies
1 Dec 2019	R. Houlihan Dec 04 2019	Rhys Houlihan	City of Gosnells Urbanism	1 + Electronic Copy 1 + Electronic Copy

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District / Local Water Management Strategy Checklist

District Water Management Strategy Requirement	Completed	Relevant Section
Executive Summary		
Describe proposed water management objectives and how the objectives will be met.	Y	Executive summary provides detailed on the water management objectives and how they will be met.
Proposed development / Planning background and previous studies		
Map the location of the site	Y	Figure 2 provides the location and site context plan
State which planning document the strategy is supporting	Y	Section 2.1 outlines the structure plan and zoning requirements
Provide references to the key state and/or local policies, guidelines, strategies and their relevance.	Y	Section 1.3 outlines the policy framework associated with this proposal.
Design Criteria		
Recognise water management principles, objectives and design criteria	Y	Section 3 outlines the design criteria for the project
Design objectives from previous water strategies and/or plans	Y	Section 3 outlines the design criteria for the project Section 1.3 outlines the policy framework associated with this proposal.
Pre-development environment		
Describe site characteristics: provide preliminary desktop assessments and/or field investigations	Y	Figure 4 provides the feature survey of the site.
Describe climate	Y	Sections 4.2 and 4.3 outline the climate and topography information for the site
Describe and map topography, landform and geotechnical conditions	Y	Section 4.4 outlines the geology, soils and geotechnical information for the site
Describe existing land use Describe environmental assets and their significance	Y	Section 4.6 describes the environmental values associated with the site.
Describe the hydrogeology and hydrogeology of the area: Surface water Groundwater Water-dependent ecosystems Water resources issues	Y	Section 4.8 outlines pre-development groundwater scenario, including groundwater levels
Detail the social, cultural and heritage considerations	Y	Section 2.1 outlines the site context. No heritage, social or cultural constraints were identified as part of this project.
Describe existing drainage infrastructure and other infrastructure likely to affect management of water resources	Y	Section 4.7.1 identifies the regional drainage strategy associated with the project, (e.g. forrestdale main drain arterial study)

District Water Management Strategy Requirement	Completed	Relevant Section
Water Sustainability initiatives		
Calculate indicative water balance	Y	Section 5 provides a water use sustainability initiatives.
Describe potable water supply: Options including details of technical, environmental and regulatory feasibility Regulatory approvals, technical investigations and any obtained written approvals Recommendations for water efficiency and conservation	Y	Section 5.4 outlines potable water supply
Identify wastewater servicing: Options including preferred option, location, treatment process, level of treatment, disposal, buffers and infrastructure Approvals and investigations required and any obtained written approvals Recommendations for water efficiency and conservation	Y	Section 5.5 outlines wastewater management
Identify non-potable (fit-for-purpose) water supply: Non-potable water source options. Highlight preferred option with consideration of pre- and post- development water balance Approvals and investigations required and any obtained written approvals Recommendations for water efficiency and conservation	Y	Sections 5.1 and 5.2 outline non-potable water management options
Stormwater management strategy		
Identify the proposed broad scale management strategies that will address water resource issues and meet the objectives and design criteria	Y	Section 6 outline stormwater management strategies for the site. Appendix 4 provides the 1% AEP flood plan
Describe the impacts to water resources and/or impacts to proposed change in land use from water issues.	Y	Section 6.5 outlines street levels water management Appendix 4 provides the 63% AEP flood plan
Surface water: Estimate land requirements for water management Identify water quality issues and scope for improvement Describe proposed strategy for management of small, minor and major surface flows	Y	Tables 14 and 15 of detail the indicative raingarden sizes and connected impervious areas
Groundwater management strategy		
Describe groundwater levels, use, management and maintenance	Y	Section 7 outlines the groundwater management strategy for the site. Figure 18 shows the finished lot levels over the site, with further commentary of the separation between groundwater and lot levels detailed in section 7.1
Identify contamination issues – high risk acid sulfate soils, contaminated sites or areas with historical high nutrient and/or non-nutrient	Y	Section 4.5 outlines the details of the site.

District Water Management Strategy	Completed	Relevant Section
contaminants		
Identify water-dependent ecosystems	Y	Section 4.6.3 outlines the wetlands and waterways associated with the site. No impact is proposed from the construction of the subdivision
Implementation		
Describe commitments and obligations for the next stage of the planning process Identify issues that need specialised investigation and management for the subsequent LWMS Make recommendations for implementing the DWMS	Y	Section 10 outlines the implementation plan for the project.

Executive Summary

Pacelin Pty Ltd plan to develop Lots 1797 and 1798 Matison St, Southern River. The Study Area is located in the suburb of Southern River approximately 20km to the south east of the Perth CBD. The lots occupy 8.0938ha and are bounded by Matison Street to the north-west and Woongan Street (unconstructed) to the north-west. Design objectives are outlined in Section 3 and further detailed below.

Protection of environmental assets from the potential impacts of development	
Surface water management to protect receiving environments and infrastructure	
Water Conservation	
Integrate water and land use planning Minimise the use of potable water	Clearly outline possible alternatives for the development to achieve a potable water consumption target of less than the State Water Policy requirements of 100kL/person/year and take due cognisance of the aspirational target of not more than 40 to 60kL/person/year for new developments.
Ground Water	
Maintain and restore ground water regimes to protect water resources, ecosystems and infra-structure	Manage ground water levels: import clean fill and/or provide free-draining subsurface drainage to ensure a minimum 1.2m separation between Finished Lot Levels (FLL) and ground water. City of Gosnells has advised that if more that 2m separation is provided between the MGL and the FLL, that no lot connections or overflows will be required on soakwells. Set inverts of bio-retention systems and drainage at or above the ground water level although existing drainage inverts may remain. Maintain ground water quality at pre-development levels (median winter conditions) and, if possible, improve the quality of water leaving the development.
Surface Water	
- Mimic natural hydrological processes to achieve best economic, social and environmental outcomes - Prevent and reduce pollution through the application of non-structural and structural controls and the management of runoff from small rainfall events - Integrate stormwater management systems in the urban form to enhance urban amenity - Integrate stormwater management in the land and water planning process so that the necessary investigations	Apply the principles of water sensitive urban design (WSUD). Retain and protect water bodies with environmental and social values: minimise impact to the CCW Retain and plant vegetation wherever possible. Minimise the 'effective imperviousness' of a development area. Manage small rainfall event runoff at-source: design swales and catchment areas for 2% of the total imperviousness of the developed site. Provide overland flow paths where possible. Maintain a minimum of 300mm freeboard between the local 1% AEP flood level and finished lot levels and 500mm between the regional 1% AEP flood level and finished lot levels. Achieve pollutant load reduction in the average annual load by adopting a treatment train approach including non-structural measures, bio-retention structures/systems sized at 2% of the connected constructed impervious areas (WAPC 2008)). Structural and non-structural best management practices (BMP's) to

are undertaken to inform decisions at each stage of the land and water planning stage • Design site-responsive stormwater management systems that respond to constraints or challenging parameters and that reflect the economic, social and environmental outcomes sought for the site	implement source controls to prevent pollution or treat stormwater as high up in the catchment as possible and provide/install in-transit measures to treat stormwater throughout the conveyance system. Implement end-of-pipe measures to mitigate any contaminants remaining in the stormwater prior to discharging to receiving environments. Ensure that the design of constructed drainage measures do not contribute to mosquito breeding. Provide ongoing maintenance, management and monitoring of the stormwater system to ensure that it continues to operate as designed.
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1. Introduction

1.1 Background

This District Water Management Strategy (DWMS) was prepared by Green Values Environmental (GVA) on behalf of Pacelin Pty Ltd in support of the Local Structure Plan (LSP) for Lots 1797 and 1798 Matison Street South River, Gosnells, herein referred to as the Study Area (Figure 1).

The DWMS provides the framework for the application of total water cycle management to the proposed urban structure, consistent with the Department of Water and Environment Regulation (DWER) principles of Water Sensitive Urban Design (WSUD), described in the Stormwater Management Manual (DoW, 2007) and Better Urban Water Management (DoW, 2008).

A DWMS checklist for developers has been included at the start of this document.

1.2 Identification of Land

The Study Area is located in the suburb of Southern River approximately 20km to the south east of the Perth CBD. The lots occupy 8.0938ha and are bounded by Matison Street to the north-west and Woongan Street (unconstructed) to the north-west. Figure 2 provides a location and site context plan, while the layout of the subdivision is depicted in Figure 1.

1.3 Policy Framework

The plan has been developed in accordance with *State Planning Policy 2.9: Water Resources* (Government of Western Australia, 2006) and uses the following documents to define its key principles and objectives:

- Stormwater Quality Management Manual for WA (Department of Water, 2007);
- Better Urban Water Management (WAPC, 2008); and
- Liveable Neighbourhoods Edition 4 (WAPC, 2009).
- Decision Process for stormwater Management in Western Australia (DWER, 2017)

A summary of the guidance obtained through key design principles and objectives from these documents is summarised below.

1.3.1 Stormwater Quality Management Manual for WA (DoW, 2007)

The Water and Rivers Commission, now the Department of Water and Environment Regulation (DWER), released *A Manual for Managing Urban Stormwater Quality in Western Australia* in 1998 to define Best Management Practices (BMP's) necessary to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also provides guidelines for the incorporation of water sensitive design principles into urban planning and design, to promote the improvement of water quality from urban development. The document was released to provide a guideline for best planning and management practices for use by Water and Rivers Commission, other State and Local Government Authorities and sectors of the urban development industry. DWER completed a major review of the Manual in consultation with a working team comprising industry and government representatives, published in August 2007. Principle objectives for managing urban water in Western Australian are stated as:

Water Quality: To maintain or improve the surface and groundwater quality within the Study Area relative to pre-development conditions.

Water Quantity: To maintain the total water cycle balance within the Study Area relative to the predevelopment conditions.

Water Conservation: To maximise the reuse of stormwater.

Ecosystem Health: To retain natural drainage systems and protect ecosystem health.

Economic Viability: To implement stormwater systems that are economically viable in the long term.

Public Health: To minimise the public risk, including risk of injury or loss of life to the community.

Protection of Property: To protect the built environment from flooding and waterlogging.

Social Values: To ensure social, aesthetic and cultural values are recognised and maintained when managing stormwater.

Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

1.3.2 Better Urban Water Management (WAPC, 2008)

The guideline document Better Urban Water Management (WAPC, 2008), focuses on the process of integration between land use and water planning and specifying the level of investigations and documentations required at various decision points in the planning process, rather than the provision of any specific design objectives and criteria for urban water management. This DWMS complies with the BUWM process.

1.3.3 Liveable Neighbourhoods (WAPC, 2009)

The DWMS has been developed in accordance with regional and local principles and objectives of Integrated Urban Water Management (IUWM) established in the guideline document, Liveable Neighbourhoods (WAPC, 2009). IUWM (also known as total water cycle management) is defined as promoting 'management of the urban water cycle as a single system in which all urban water flows are recognised as a potential resource and where the interconnectedness of water supply, stormwater, wastewater, flooding, water quality, waterways, estuaries and coastal waters is recognised'. IUWM also promotes water conservation measures, reuse and recycling of water and best practice in stormwater management.

The objectives in the DWMS are consistent with Liveable Neighbourhoods.

1.3.4 Decision Process for Stormwater Management in Western Australia (DWER, 2017)

The DWMS has been developed in accordance with the stormwater management approaches as outlined in the decision process for stormwater management (2017). The important elements of the stormwater management approach incorporated into this DWMS are:

- Mimic natural hydrological processes to achieve best economic, social and environmental outcomes
- Prevent and reduce pollution through the application of non-structural and structural controls and the management of runoff from small rainfall events

- Integrate stormwater management systems in the urban form to enhance urban amenity
- Integrate stormwater management in the land and water planning process so that the necessary investigations are undertaken to inform decisions at each stage of the land and water planning stage
- Design site-responsive stormwater management systems that respond to constraints or challenging parameters and that reflect the economic, social and environmental outcomes sought for the site.

1.4 Regional and Local Studies

This document takes due cognisance of the following:

- Environmental Assessment Lots 1796, 1797 & 1798 Matison Road, Southern River, Aurora Environmental, 2018.
- Civil Engineering and Infrastructure Report for Lots 1797 & 1798 Matison Street, Southern River, Francesco Lombardo Consulting, 2018
- Geotechnical Investigation Report, proposed Residential Development Lot 1797 and 1798 Matison St Southern River WA
- Southern River Integrated Land and Water Management Plan, Department of Water, 2009.
- Southern River/Forrestdale/Brookdale/Wungong Structure Plan, Urban Water Management Strategy, JDA, 2002.
- Forrestdale Main Drain arterial drainage strategy (2009)



Figure 1: Subdivision Plan



1797 & 1798 Matison St Southern River



FIGURE 2: SITE LOCATION

2. Proposed Development

2.1 Structure Plan and Zoning

The site is located in the Southern River Structure Plan Sub-Precinct 3C area which encompasses approximately 365 hectares of land bound by Southern River Road, Ranford Road, the kennel zone, Passmore Street and the Southern River. A broad, district-scale planning framework was established for Southern River by the Western Australian Planning Commission (WAPC) in 2001 through a DSP – Southern River/Forrestdale/Wungong DSP. The DSP (Appendix 1) identified potential development areas, road networks, major community facilities and land for public open space, drainage and conservation.

The main land use elements for Sub-Precinct 3C described in the DSP included: the provision for urban development, open space and conservation sites, some light industrial and mixed business/commercial centres, a primary school site, a potential bus route and retention of the kennels zone.

The City of Gosnells has adopted a policy for Southern River which sets out a precinct-based planning approach to the planning and development of the land within Precinct 3. The Policy divides Precinct 3 into six sub-precincts. A Local Structure Plan (LSP) for the whole of Precinct 3 has been prepared by the City of Gosnells (Appendix 2) and was supported by an Environmental Review commissioned by the local authority and completed by ENV Australia (2006).

The next step in the planning process is the preparation of an Outline Development Plan (ODP) (or Structure Plan) for Sub-Precinct 3C. The intent of the ODP is to demonstrate how the sub-precinct will be developed in a way that is consistent with the higher-level plans and how it responds appropriately to key constraints such as certain environmental factors (e.g. conservation significant vegetation, wetlands, etc.).

The Study Area is zoned **urban deferred** under the Metropolitan Region Scheme (WAPC, 2015). This document has been developed in accordance with consultation with the regulators, to form a combined DWMS. The document provides guidance on the following:

- Land area requirements for conveyance of flood flows and protection of future development from peak flood events.
- Drainage design strategy appropriate for local conditions in the Study Area that incorporates best practice water sensitive urban design measures.
- Hydrological regime of the CCW, and ensure that proposed development for the site does not negatively impact the landscape and CCW.
- Design criteria for water quantity and water quality for each catchment.
- Hydrologic and hydraulic framework parameters that subsequently develop the overall drainage network concept.
- A framework for implementation for the drainage design objectives; and
- Monitoring programs for water quantity and water quality at pre-development, development and post-development stages. Hydraulic performance monitoring will also be needed over the lifetime of the drainage structures.

Preparation of the DWMS is to support the Local Structure Plan (LSP), currently in development by Urbanism. The LSP layout is shown as Figure 1.

The LSP comprises entirely residential lots, ranging from R20 to R40 zoning. A Conservation Category Wetland (CCW) is located over the majority of the site with total Study Area being 8.0938ha. Local open space is considered between the CCW and development area. It is understood that the buffer between the development area and the CCW (being an area 50m wide) be considered as Local Open Space and suitable for the purposes of Public Open Space in this proposal.

Key elements of the Structure Plan related to urban water management include:

- Use of existing wetland for stormwater attenuation;
- Bio-retention treatment swales and storages for detention and treatment of stormwater;
- Retention of existing Conservation Category Wetland (CCW) and hydraulic capacity through the site; and
- The extensive use of local native plant species in open spaces, streetscapes and vegetation buffers.

3. Design Criteria

3.1 Total Water Cycle Management – Principles & Objectives

The objectives for the Study Area are based on the principles and objectives detailed in the Southern River Integrated Land and Water Management Plan (DoW, 2009), Stormwater Management Manual (DoW, 2007), *Decision process for stormwater management in Western Australia* (2017), *Forrestdale Main Drain Arterial Drainage Strategy* (2009) and Better Urban Water Management (DoW, 2008).

Table 1 provides a summary of the objectives and design criteria incorporated into this development.

Table 1: Objectives and Design Criteria

Protection of environmental assets from the potential impacts of development	
Surface water management to protect receiving environments and infrastructure	
Water Conservation	
Integrate water and land use planning Minimise the use of potable water	Clearly outline possible alternatives for the development to achieve a potable water consumption target of less than the State Water Policy requirements of 100kL/person/year and take due cognisance of the aspirational target of not more than 40 to 60kL/person/year for new developments.
Ground Water	
Maintain and restore ground water regimes to protect water resources, ecosystems and infra-structure	Manage ground water levels: import clean fill and/or provide free-draining subsurface drainage to ensure a minimum 1.2m separation between Finished Lot Levels (FLL) and ground water. City of Gosnells has advised that if more that 2m separation is provided between the MGL and the FLL, that no lot connections or overflows will be required on soakwells. Set inverts of bio-retention systems and drainage at or above the ground water level although existing drainage inverts may remain. Maintain ground water quality at pre-development levels (median winter conditions) and, if possible, improve the quality of water leaving the development.
Surface Water	
- Mimic natural hydrological processes to achieve best economic, social and environmental outcomes - Prevent and reduce pollution through the application of non-structural and structural controls and the management of runoff from small rainfall events - Integrate stormwater management systems in the urban form to enhance	Apply the principles of water sensitive urban design (WSUD). Retain and protect water bodies with environmental and social values: minimise impact to the CCW Retain and plant vegetation wherever possible. Minimise the 'effective imperviousness' of a development area. Manage small rainfall event runoff at-source: design swales and catchment areas for 2% of the total imperviousness of the developed site. Provide overland flow paths where possible. Maintain a minimum of 300mm freeboard between the local 1% AEP flood level and finished lot levels and 500mm between the regional 1%

Protection of environmental assets from the potential impacts of development

Surface water management to protect receiving environments and infrastructure

urban amenity - Integrate stormwater management in the land and water planning process so that the necessary investigations are undertaken to inform decisions at each stage of the land and water planning stage - Design site-responsive stormwater management systems that respond to constraints or challenging parameters and that reflect the economic, social and environmental outcomes sought for the site	AEP flood level and finished lot levels. Achieve pollutant load reduction in the average annual load by adopting a treatment train approach including non-structural measures, bio-retention structures/systems sized at 2% of the connected constructed impervious areas (WAPC 2008)). Structural and non-structural best management practices (BMP's) to implement source controls to prevent pollution or treat stormwater as high up in the catchment as possible and provide/install in-transit measures to treat stormwater throughout the conveyance system. Implement end-of-pipe measures to mitigate any contaminants remaining in the stormwater prior to discharging to receiving environments. Ensure that the design of constructed drainage measures do not contribute to mosquito breeding. Provide ongoing maintenance, management and monitoring of the stormwater system to ensure that it continues to operate as designed.
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4. Pre-Development Environment

4.1 Existing Landuse

The land is predominantly native vegetation, with an existing small horse shelter located on the north-east corner of the property.

4.2 Climate

The Southern River locality experiences a Mediterranean climate, characterised by hot dry summers and mild wet winters.

Climate data has been sourced from the Bureau of Meteorology (BOM) averages for the Gosnells City Station (009106) for the period 1961 to 2017 (BOM, 2018; Figure 3). Rainfall in the Gosnells area is seasonal and is generally confined to the winter months (June to August). Mean monthly rainfall is highest in June at 165.2 mm, with an average of 12.2 rain days. The lowest mean monthly rainfall is 11.3 mm in January, with an average of 1.5 rain days. The average annual rainfall is 818.4 mm, with an average of 79.4 rain days per year.

The average annual pan evaporation for Armadale is approximately 1900mm (Luke et al, 1988).

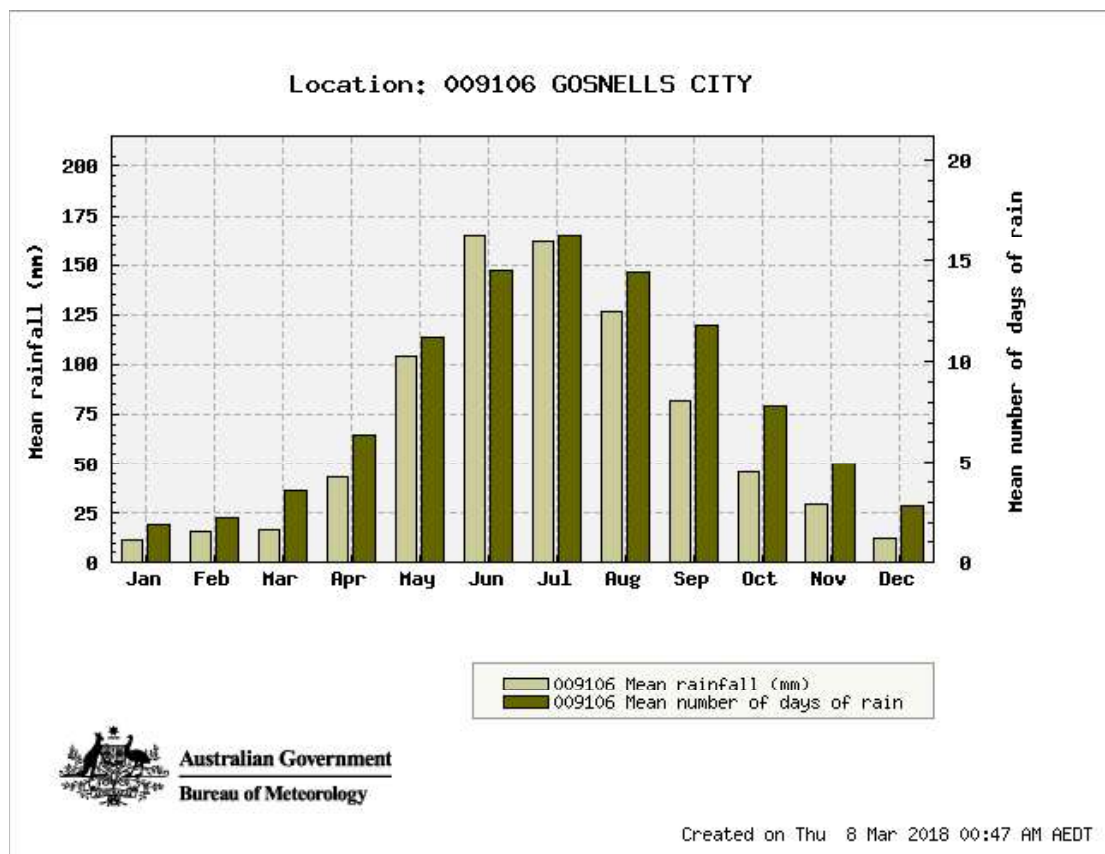


Figure 3: Mean Rainfall and number of days of rain, Gosnells City Station 009106 (Bom, 2018)

4.3 Topography

A feature survey was completed by MNG (refer Figure 4). The survey indicates that the site is relatively flat. The highest elevation at approximately 22m Australian Height Datum (AHD) generally occurs along Matison Street and gently slopes down to approximately 19-20m AHD in the southeast portion of the site.

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4.4 Geology, Soils and Geotechnical Information

The site is located within the Swan Coastal Plain (SCP). The SCP is generally a flat, low-lying belt approximately 23 km wide in the south and 34 km wide in the north. It comprises a series of distinct and forms, aligning roughly parallel to the coast. These units consist of three dunal formations (Quindalup Dunes, Spearwood Dunes and Bassendean Dunes) of aeolian origin, followed by an alluvial zone known as the Pinjarra Plain, which consists of a clayey alluvium that has been transported by rivers and streams from the adjacent Darling Scarp.

Geological mapping indicates that the Study Area is located in a transitional area between Bassendean Sand [Unit 212Bs_B1] and the Pinjarra Plain [Unit 213Pj_P1b] (Table 2). Bassendean Sand mapping unit is described as extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale-yellow B horizon or a weak iron organic hardpan at depths generally greater than 2m. The Pinjarra Plain sub-unit is described as flat to very gently undulating plain with deep acidic mottled yellow duplex soils. They have moderately deep pale sand to loamy sand over clay and are imperfectly drained (Figure 5).

The Armadale 1:50,000 Environmental Geology map (Jordan, 1986) indicates that the site is located in a transitional area between two units comprising units S8 or S10. Unit S8 is known as Bassendean Sands and is described as white to pale grey at surface and yellow at depth and is of eolian origin. The unit S10 is described as unit S8 over sandy clay to clayey sand of the Guildford Formation and is also of eolian origin.

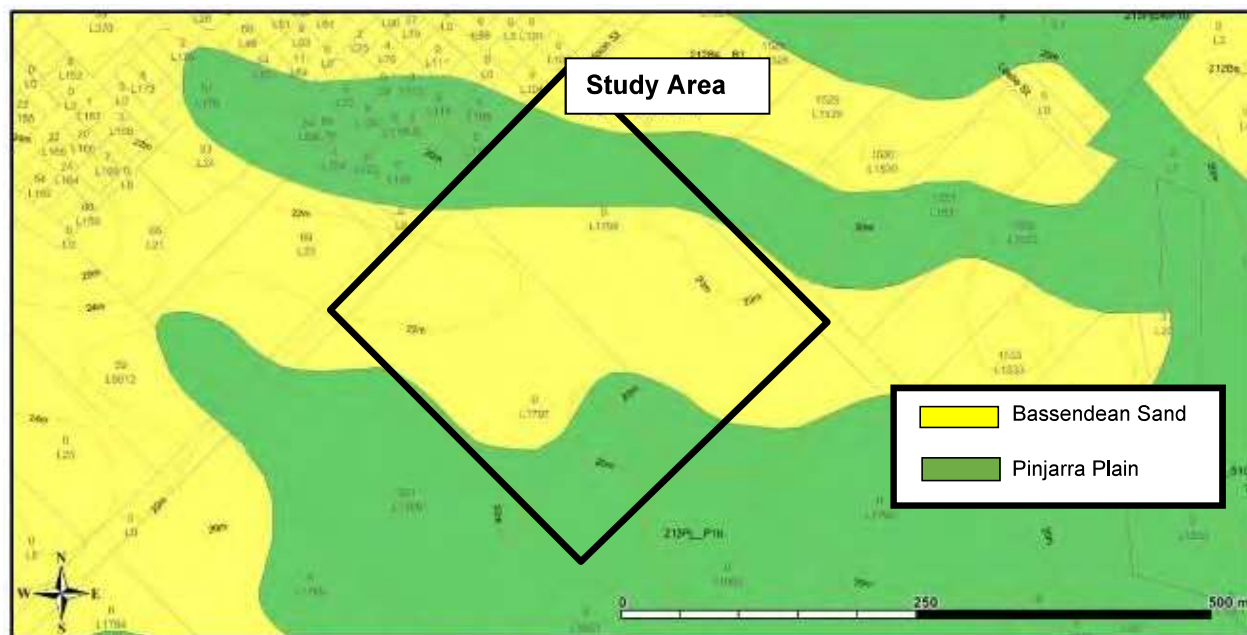
Table 2: Geological units of the Study Area (Aurora, 2018)

Geological Unit	Description	Depth (m)
Bassendean Sand	White to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, sub-angular to sub-rounded sand, minor heavy minerals, of Aeolian origin.	~4 to 8 m
Pinjarra Plain	flat to very gently undulating plain with deep acidic mottled yellow duplex soils. They have moderately deep pale sand to loamy sand over clay and are imperfectly drained.	~4 to 8 m

A geotechnical investigation was completed over the site by Geotechnical and Geological Consultants (GGC) on the 14th January 2019. The works comprised the following:

- Site walkover by a Senior Engineering Geologist from GGC;
- Eight test pits (TP1 to TP8) advanced using a rubber tyred backhoe to depths of between 2.6m and 3.0 m below existing ground level;
- Recovery of samples for geotechnical laboratory testing;
- Perth Sand Penetrometer (PSP) Testing adjacent to each test pit to depths of 1.05m below ground level;
- Hand auger boreholes and infiltration testing at four locations across the site; and
- On-site logging by a Senior Engineering Geologist from GGC.

The geotechnical report is provided as Appendix 3 to this report. The following sections detail the key outcomes of the geotechnical assessment.



Source: Western Australian Local Government Association's *Environmental Planning Tool*

Figure 5: Geological Mapping Units over development

4.4.1 Infiltration Testing

Four infiltration tests (I1 to I4) were completed in hand augured boreholes adjacent to TP1, TP2, TP4 and TP8. The locations were selected to provide infiltration rates which are generally considered representative of the site as a whole. The infiltration tests were completed using the "Inverse Auger Hole Method" described by Cocks (2007). The results of the infiltration testing are summarised in Table 3.

Table 3: Summary of Falling head infiltration tests

Test Reference and Location	Stratigraphy	Depth to base of test (m ¹)	Minimum Unsaturated Permeability, k (mm/day) ²
I1 (TP1)	Sand	0.89	>10 ³
I2 (TP2)	Sand	0.80	7
I3 (TP3)	Sand	0.80	5
I4 (TP4)	Sand	0.87	10

¹ All depths are relative to existing ground surface. Hand auger boreholes were completed to about 1.0m depth, however upon infiltration testing material washed into the base of the borehole resulting in a depth to base of test less than 1.0m as shown in the table above.

² Minimum unsaturated permeability estimates shown were recorded at the end of the test when head pressure lowest

³ Permeabilities in excess of 10m/day are not reported due to inaccuracy of the test method at very high permeability

4.4.2 Encountered subsurface condition

The subsurface conditions encountered during the GGC investigation fieldwork were generally consistent with the published information and client supplied information and are as follows:

- A thin Topsoil layer was encountered from the ground surface to depths of between 0.1m and 0.4m below ground level within the test pit completed across the site;
- Bassendean Sand (SW), typically fine to coarse grained, moist to wet, to depths of between 1.2 m and the maximum depth of the test pits (2.8m) was encountered directly beneath the Topsoil layer within all test pits across the site;
- The Bassendean Sand was typically underlain by Clayey Sand (SC) of the Guildford Formation typically comprising fine to coarse grained Sand and low plasticity Clay, moist to wet; and
- Ferricrete Rock (Coffee Rock) typically comprising, fine to coarse grained, iron cemented sand, very low to medium strength rock was generally encountered at the Bassendean Sand/ Guildford Formation interface or within the Bassendean Sand within all test pits at depths of between 1.2m to 2.6m.

4.5 Acid Sulphate Soils

Acid Sulphate Soils (ASS) is the common name given to soils and sediments containing iron sulfides. When exposed to air due to drainage or disturbance, these soils produce sulfuric acid, often releasing toxic quantities of iron, aluminium and heavy metals.

A search of the WA Atlas was undertaken to determine the risk of ASS. The study area is mapped as 'Class 2' – moderate to low risk of ASS being present within 3m of the natural soil surface.

Excavation or the lowering of the local groundwater table (via drainage or dewatering) has the potential to expose ASS material to oxygen leading to the production of sulfuric acid, potentially releasing toxic quantities of iron, aluminium and heavy metals to the environment. Site investigations will be needed to confirm the presence or absence of ASS materials at the site. If present, an ASS management plan may be needed.

4.6 Environmental Characteristics

4.6.1 Vegetation

The Site is located in the South West Botanical Province in the Darling Botanical District. This region typically consists of forest country with related woodlands and is divided into four sub-regions or botanic districts. Precinct 3 is located in the Swan Coastal Plain sub-region in the Drummond Botanical sub-district, which consists mainly of the following vegetation communities:

- Banksia low woodland on leached sands and Melaleuca swamps in poorly drained areas;
- Woodland of Tuart (*Eucalyptus gomphocephala*); and
- Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) on the less leached soils (Beard 1990).

The study area is mapped as Beard Vegetation Association 1001 which is described as 'medium very sparse woodland comprising Jarrah, with low woodland of Banksia and Casuarina'. The representation of Beard Vegetation Association 1001 is presented in Table 4.

Table 4: Vegetation Types (Aurora, 2018)

Reference	Description of Community	Inferred Floristic Community Type
3	Low Open Woodland of <i>Melaleuca preissiana</i> , <i>Eucalyptus todtiana</i> and <i>Corymbia calophylla</i> over <i>Regelia ciliata</i> , <i>Astartea affinis</i> , <i>Xanthorrhoea preissii</i> , <i>Schoenus efoliatus</i> , <i>Patersonia occidentalis</i> , <i>Phlebocarya ciliata</i> and <i>Euchilopsis linearis</i> .	4
9	Low Woodland of <i>Melaleuca raphiophylla</i> and <i>Melaleuca preissiana</i> over <i>Melaleuca incana</i> subsp. <i>incana</i> , <i>Regelia ciliata</i> , <i>Meeboldina cana</i> and various introduced species	4
16	Open Woodland of <i>Eucalyptus todtiana</i> , <i>Corymbia calophylla</i> , <i>Melaleuca preissiana</i> over <i>Jacksonia sternbergiana</i> , <i>Regelia ciliata</i> , <i>Xanthorrhoea preissii</i> , <i>Phlebocarya ciliata</i> , <i>Hibbertia hypericoides</i> , <i>Hybanthus calycinus</i> and <i>Dasypogon bromeliifolius</i> .	4?
17	Low Woodland of <i>Melaleuca preissiana</i> and <i>Nuytsia floribunda</i> over <i>Astartea affinis</i> , <i>Regelia ciliata</i> , <i>Kunzea glabrescens</i> , <i>Hypolaena exsulca</i> , <i>Phlebocarya ciliata</i> and <i>Schoenus efoliatus</i> .	4
19	Woodland of <i>Eucalyptus todtiana</i> , <i>Corymbia calophylla</i> and <i>Nuytsia floribunda</i> over <i>Melaleuca thymoides</i> , <i>Xanthorrhoea preissii</i> , <i>Phlebocarya ciliata</i> , <i>Leucopogon conostephioides</i> , <i>Eremaea pauciflora</i> var. <i>pauciflora</i> , <i>Dasypogon bromeliifolius</i> and <i>Lyginia imberbis</i> .	23a

4.6.2 Fauna

ENV (2006) mapped two habitat types on Lots 1796-1798: Melaleuca Open Woodland and Eucalypt Open Woodland (generally Eucalyptus todtiana dominated), with some areas mapped as cleared or highly degraded.

One habitat tree containing a hollow potentially suitable for use by Black Cockatoos was recorded on Lot 1797 during ENV (2006) survey. However, there was no evidence that this tree was used for breeding by conservation significant species such as Black Cockatoos (ENV, 2006). ENV (2006) concluded that the habitat in the Precinct 3 project area provides foraging resources for the three black cockatoo species. However, the foraging value of the vegetation on Lot 1797 and 1798 is considered low given the degraded nature of the vegetation. Furthermore, a significant proportion of Lots 1796-1798 is mapped as wetland vegetation which provides limited if any foraging value to black cockatoos.

The fauna survey included trapping over three days during October 2015. A trapping array was established outside of the site, but on Lot 1795. A total of 92 species were recorded during the field survey in Precinct 3. The greatest diversity of species was recorded near the site and generally associated with the adjacent Bush Forever Site 464. This diversity is most likely a result of the significant area of native vegetation protected in the Bush Forever site.

4.6.3 Wetlands and Waterways

DBCA's Geomorphic Wetlands of the Swan Coastal Plain dataset is provided in Figure 6. It indicates a large portion Lot 1797 is a Conservation Category Wetland (CCW) which also encroaches into the southern corner of Lot 1798. This wetland (Unique Feature Identifier (UFI) 15961) which is known as Bradley Street wetland and extends over an area much larger than Lots 1797 and 1798 (Figure 7).

Aurora (2018) identified the following key aspects in relation to the CCW:

- The Precinct 3 Environmental Review by ENV (2006) reported that Wetland UFI 15961 is of variable condition with the remnant vegetation ranging between Good and Excellent condition. Aurora (2018) noted that the portion of this wetland on Lots 1797 and 1798 was fragmented, showed signs of disturbance and were being used as a horse paddock and could be considered to be of lesser conservation value than the majority of the wetland, however the vegetation is in Good condition.
- the existing mapped boundary was inaccurate in places and provided a revised wetland boundary representing a minor deviation from the boundary in the Geomorphic Wetlands of the Swan Coastal Plain dataset.
- ENV (2006) noted that this wetland was listed as being protected by the Environmental Protection (Swan Coastal Plain Lakes) Policy (EPP) 1992. A review of this dataset by Aurora Environmental did not indicate that Lots 1797 and 1798 were constrained by an EPP wetland designation and therefore the statement by ENV (2006) is considered inaccurate.
- DBCA's Wetlands Section supported the redefined boundary and amended the mapping on 29 January 2018, as a minor realignment - refer to Appendix 5 of Aurora Environmental Assessment; 3 February 2018.

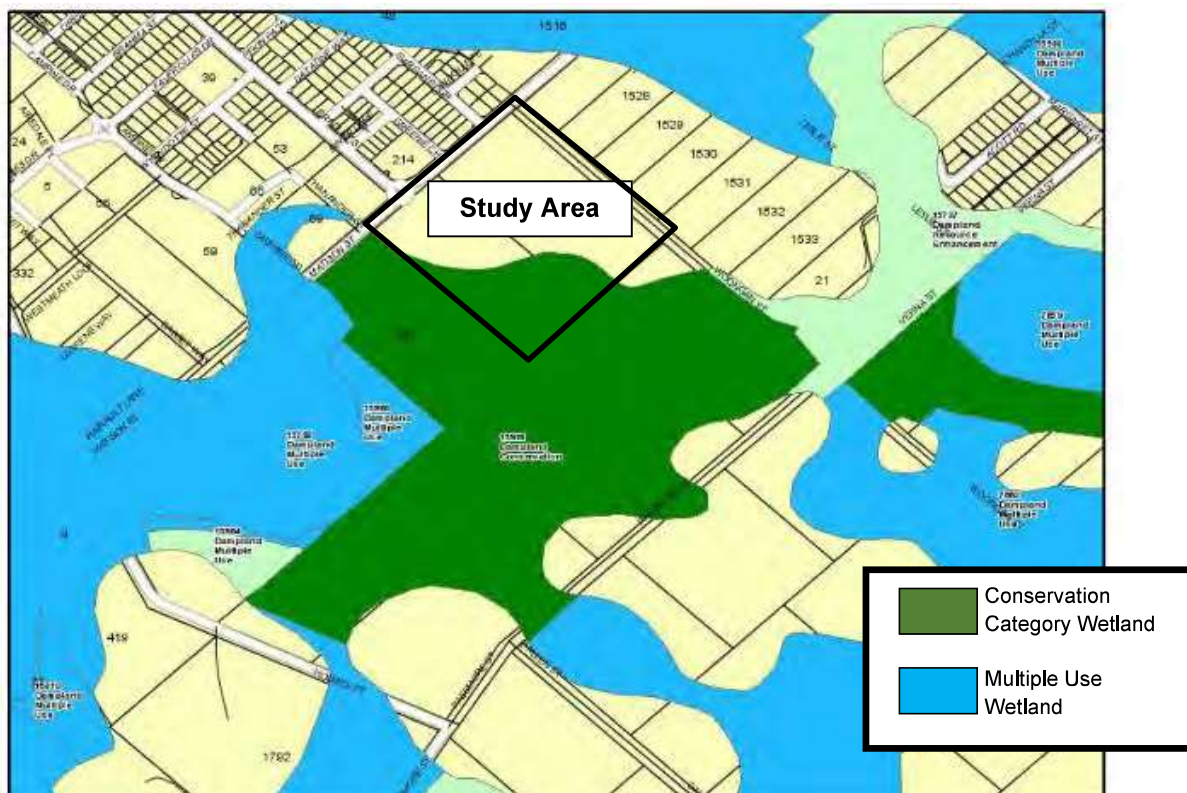


Figure 6: Geomorphic Wetlands over the Study Area

The Aurora Environmental Assessment of 13 February 2018 stated that a protective buffer is established to mitigate potential adverse impacts on the wetland. The extent of the buffer required will be determined by the conservation values - a typical buffer for a CCW is 50m. The proposed structure plan V4 and dated 28 March 2018 for Lots 1797 and 1798 adopted a 50m buffer, measured from the wetland boundary.

The Bushfire Management Report associated with the proposed structure plan accommodated a 20m wide revegetated strip within the 50m wetland buffer, with the remaining 30m buffer area being maintained in a low fuel state. DBCA did not support a partial revegetation of the 50m buffer. This approach was not supported by DBCA and the adoption of the LSP included a Condition 16, requiring the Bushfire Management Plan (BMP) to accommodate the requirements for a fully vegetated buffer. The requirements of DBCA in this respect is documented in the Council Minutes of 28 August 2018.

The BMP has since been updated to reflect the fully vegetated buffer and was presented to the Department of Planning Lands and Heritage in March 2019. The report assumes a 50m revegetated wetland buffer as a Woodland Class B to meet the requirements of DBCA and the conditional adoption of the draft structure plan.

Aurora Environmental supplemented the February 2018 environmental assessment report in consultation with DBCA to update flora and vegetation mapping and conduct a targeted black cockatoo habitat assessment. The assessment of the site was conducted by Dr Paul van der Moezel on 6 July 2018. This updated report was issued via the City of Gosnells in the final deliberation of the draft structure plan with DBCA and prior to its adoption by the Council and to satisfy the requirements. This report is provided as Appendix 5 to this document.

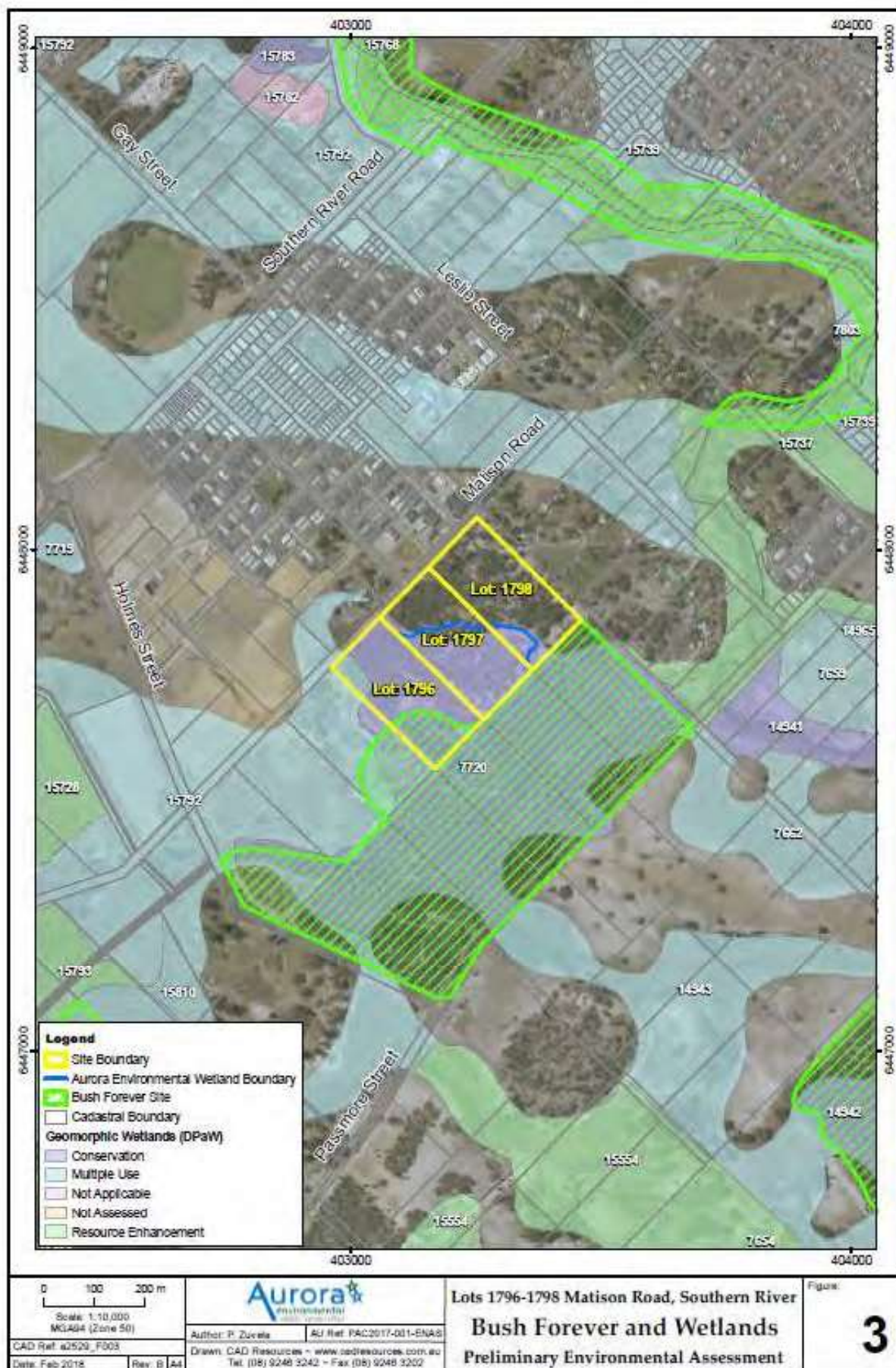


Figure 7: Bush Forever and Wetlands (Aurora, 2018)

4.6.4 Contaminated Sites

A search of the Contaminated Sites database (<https://secure.dec.wa.gov.au/idelve/css/>) indicates the Site is not a registered site under the Contaminated Sites Act 2003. This does not exclude the potential for contamination being present, it only indicates that it has not been reported and registered as a contaminated site.

The nearest registered contaminated site is at 1767 and 1768 Matison Road, Southern River which is approximately 2km south-west of the Site. These sites have been remediated for restricted uses. The contamination on the site was due to the presence of hydrocarbons in the soil and groundwater, as well as chlorinated hydrocarbons in groundwater associated with a liquid waste disposal facility that operated on Lot 1768. A 1.5km groundwater protection buffer has been identified with the former contaminated site.

4.7 Surface Water

The Study Area is located in the Forrestdale Main Drain sub-catchment within the catchment of the Southern River. A branch of the Southern River is approximately 200m south-east of the site. The Southern River begins at the confluence of Wungong Brook and Neerigen Brook and flows into the Canning River near Burslem Drive Bridge in Gosnells. Floodplain mapping by the DWER for the Southern River indicates that the site is not impacted by the 1% AEP flood levels of the Southern River (Figure 8).

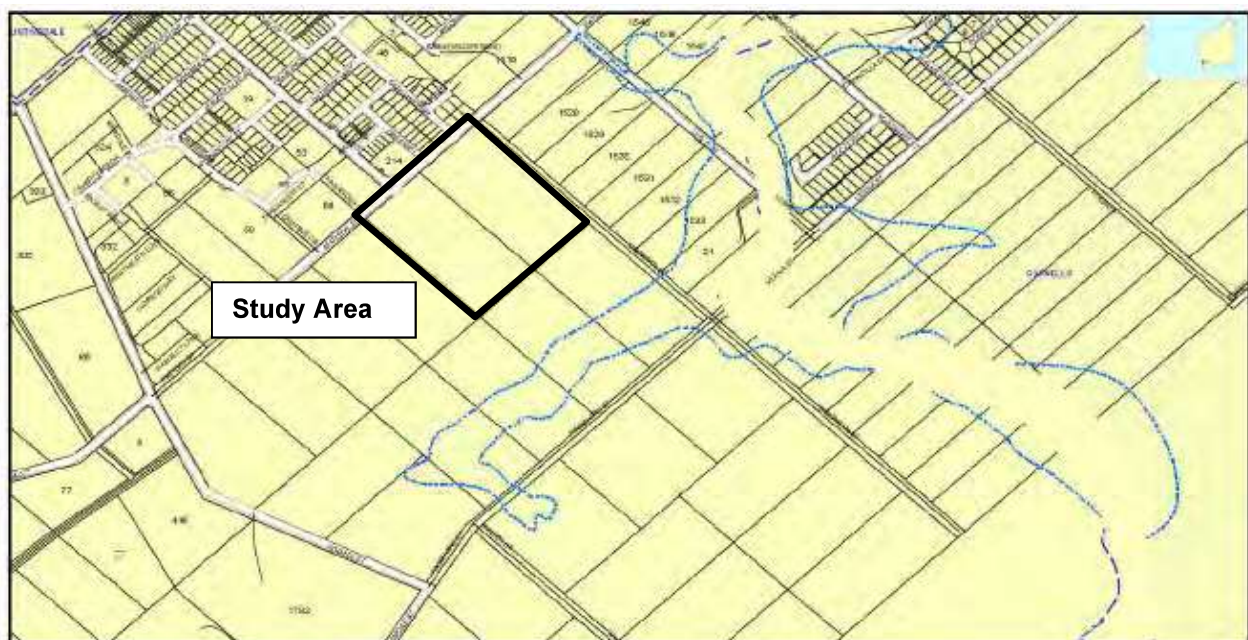


Figure 8: 1 in 100 Year (1% AEP) Floodway and Flood Fringe Area

A new subdivision located to the north-west of the Study Area has incorporated a pre-development-controlled outlet from the drainage detention basin. This outlet runs north-east along Matison Road, ultimately discharging into the Southern River drain. As the upstream pipework has not been constructed [currently an open drain], a bubble-up structure has been constructed on the along the frontage of Lot 1798 (classified as “pre-development and emergency 100-year overflow discharge pipe”), that discharges as overland flow into the Study Area and to the CCW. The contributing flows are considered nominal as the primary discharge flow path provides sufficient storage.

Consultation with the City of Gosnells has identified that this emergency overflow shall be moved

as part of the engineering report south-east along the internal road structure and discharge into the CCW.

A low relief runs west-east along the Study Area, with all pre-development flows discharging from the site in the south-east corner of the property at RL19.50. This is a key consideration for the post-development model, and suitable drainage options are considered in Section 5.

4.7.1 Forrestdale Main Drain Arterial Drainage Study

The Forrestdale Main Drain Arterial Drainage Study (FMD ADS) (DoW, 2009) provides a detailed strategy for stormwater management for the Forrestdale main drain catchment, and the Department's guidance on water management issues for this area.

Figure 10a of the FMD ADS shows an overland flow path occurring over the study area (Figure 9), with the discharge being at location FDA002. It should be noted that this flow path is mapped as outside of the proposed development area for the lots, and therefore this flow path would be retained without any impact on the subdivisional layout.



Figure 9: FMD ADS – Existing Flow Paths

The FMD ADS Adopted Strategy shows a piped drainage structure along Matison St, with the overland flow path through the lots to node FDA002. This arterial drainage is still located outside of the proposed subdivisional footprint (Figure 10). Relevant values for the adopted strategy at node FDA002 are shown in Table 5 below and delineate the downstream criteria for the surface water management of the site.

Table 5: FMD ADS FDA002 relevant details

AEP	ARI	HGL (mAHD)	Invert level (mAHD)	Max Flow (m ³ /sec)
10%	10	18.24	17.16	7.26
1%	100	19.96	17.16	8.87



Figure 10: FMD ADS – Adopted Strategy Flow Paths

4.7.2 Surface Water Pre-Development Modelling

XP-Storm was used to delineate the pre-development catchments for the 63%, 1% and 1% Annual Exceedance Principle (AEP) scenarios. The following inputs for the model were used:

- Catchment Area – 8.095ha
- Loss Model – Green Ampt Loss Model (refer Table 6).
- Soil Type – Moderately deep pale sand to loamy sand over clay: imperfectly drained and moderately susceptible to salinity in limited areas⁴.

It should be noted that as this proposal only impacts the northern catchment of the lot, only this area has been modelled for assessment. Peak flow results for this area is shown in Table 7.

Model results are provided as Figures 11 – 13.

⁴ Source: <http://www.asris.csiro.au/mapping/viewer.html>

Table 6: Estimation of Green-Ampt infiltration parameters

Estimation of Green-Ampt Infiltration Parameters

(SWMM RUNOFF Variables SUCT, HYDCON, SMDMAX)

Provisional Values Suitable for Design Storm Events Where More Detailed Soils Data Is Not Available

USDA Soil Texture Classification	SUCT Avg. Capillary Suction		HYDCON Saturated Hydraulic Conductivity		SMDMAX Initial Moisture Deficit for Soil (Vol. of Air / Vol. of Voids, expressed as a fraction)	
	(in)	(mm)	(in/hr)	(mm/hr)	Moist Soil Climates (Eastern US)	Dry Soil Climates (Western US)
Sand	1.95	49.5	9.27	235.6	.346	.404
Loamy Sand	2.41	61.3	2.35	59.8	.312	.382
Sandy Loam	4.33	110.1	0.86	21.8	.246	.358
Loam	3.50	88.9	0.52	13.2	.193	.346
Silt Loam	6.57	166.8	0.27	6.8	.171	.368
Sandy Clay Loam	8.60	218.5	0.12	3.0	.143	.250
Clay Loam	8.22	208.8	0.08	2.0	.146	.267
Silty Clay Loam	10.75	273.0	0.08	2.0	.105	.263
Sandy Clay	9.41	239.0	0.05	1.2	.091	.191
Silty Clay	11.50	292.2	0.04	1.0	.092	.229
Clay	12.45	316.3	0.02	0.6	.079	.203

Table 7: Pre-development flow and volume outputs

AEP	ARI	Flow (m ³ /sec)	Volume (m ³)
		Pre	Pre
63%	1	0.03	1.7
10%	10	0.34	22.7
1%	100	0.66	34.2

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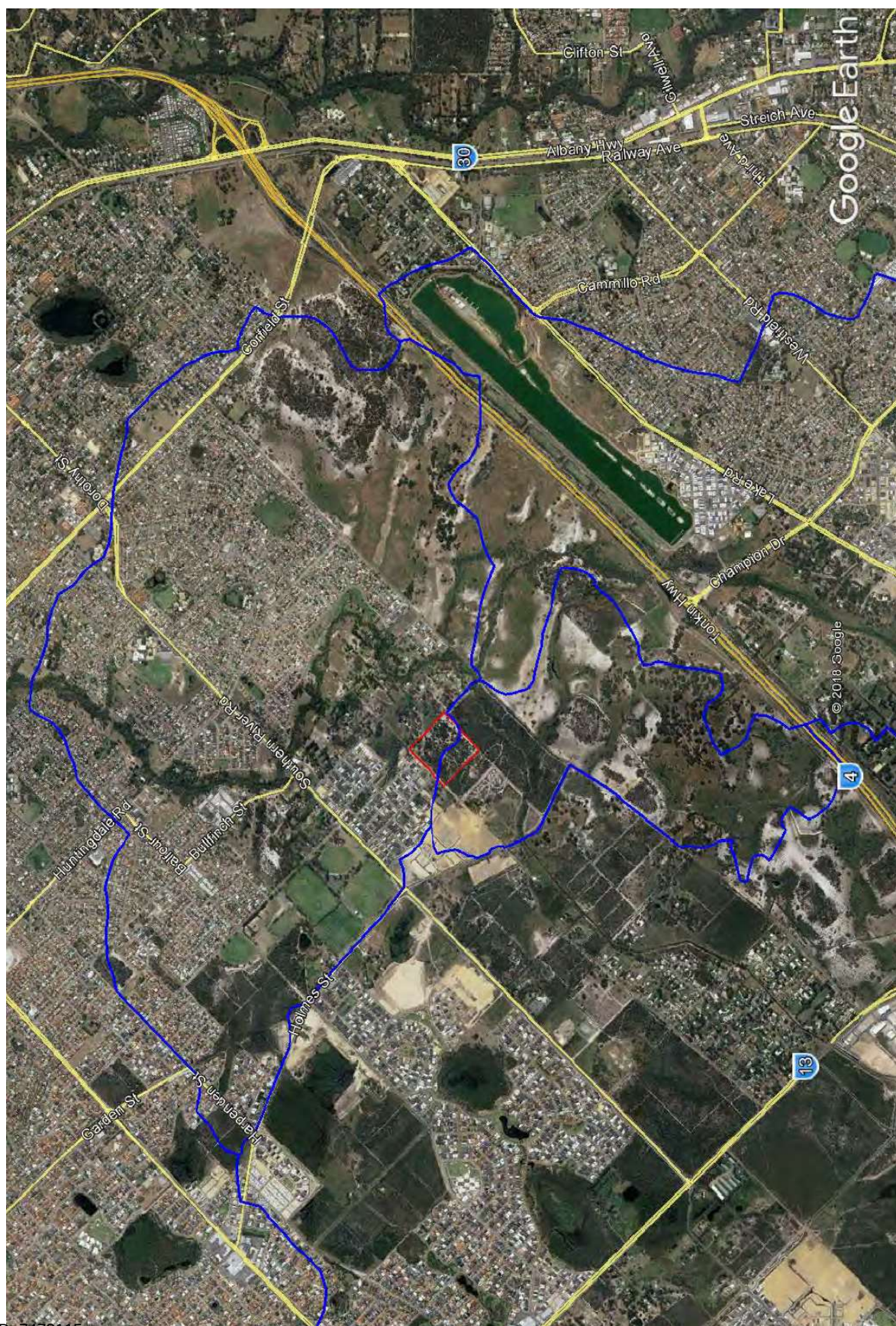
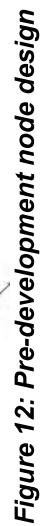


Figure 11: Pre-development catchment area



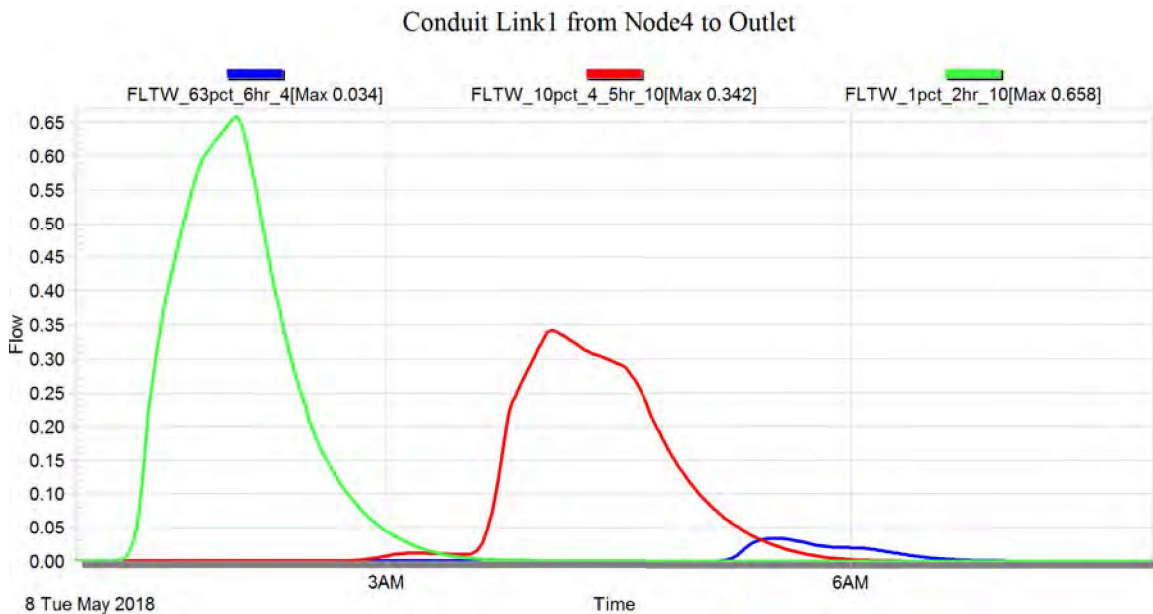


Figure 13: Pre-Development Model results

4.8 Ground Water

4.8.1 General - Ground Water

The site is located within the City of Gosnells groundwater subarea of the Perth Groundwater Area. Groundwater resources below this region feature three separate aquifer systems:

- Unconfined Superficial Swan aquifer.
- Leederville (semi-confined to confined).
- Yarragadee (confined) aquifer.

The Superficial Swan is the shallowest aquifer beneath the site. It is recharged via direct infiltration of rainfall, which migrates downward to the water table or less permeable layers. The Leederville Aquifer is a large confined aquifer and is a major groundwater source for the Perth region. The deeper Yarragadee aquifer is also confined but is found at much greater depths. It is also used as groundwater source for the Perth region.

A review of Perth Groundwater Map (<https://maps.water.wa.gov.au/#/webmap/gwm>) indicates that historical maximum groundwater levels are at 20m AHD which is approximately 1m below the natural surface level (Figure 14). Groundwater levels fluctuate seasonally and therefore, the actual levels may vary from 0.5m and 3m on a seasonal basis. Groundwater flows in an easterly direction, with water levels controlled by Southern River. No specific monitoring sites occur on the Study Area.

Groundwater salinity varies between 500 and 1,000mg/L, with a low iron staining risk. The groundwater is considered unsuitable for garden bores.

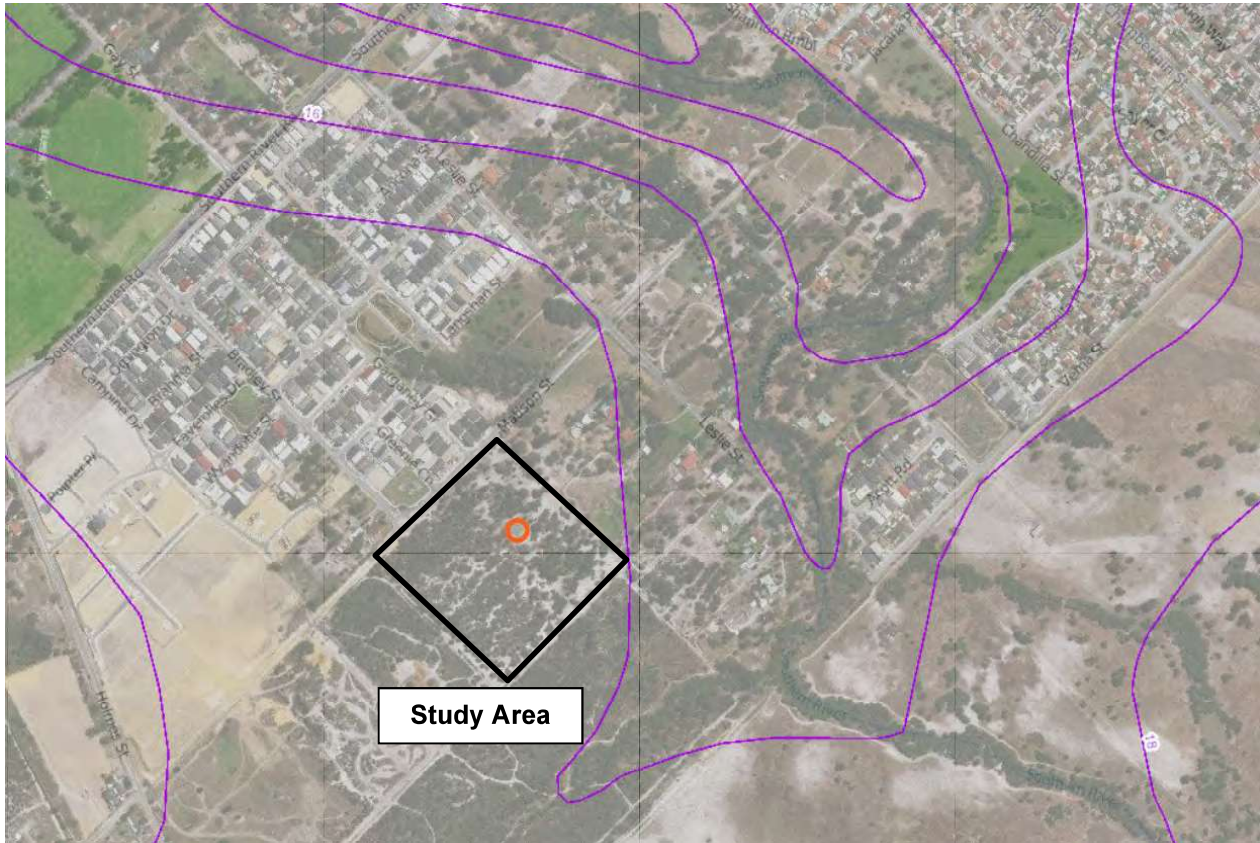


Figure 14: Minimum Groundwater Levels (WIR)

4.8.2 Ground Water Monitoring

Groundwater bores were installed on the site in June 2018 and have been monitored on a monthly basis to capture groundwater data. Groundwater bore locations are shown in Figure 15. Tables 8 and 9 provide a summary of monitoring bore details.

Initial groundwater monitoring shows that the groundwater levels vary between 0.47m below ground level in winter, through to 3.40m in Summer. Bores 2 and 3 have shown depth to groundwater over Winter less than 1.2m, whilst all other bores have shown a minimum depth to groundwater of at least 1.7m.

Comparison to regional bores shows that regional monitoring bore 61610539, located approximately 1.75 km north of the site sits on the mapped minimum groundwater contour (WIR website) that runs along the western boundary of the lot; the closest monitoring bore on the lot is Bore 4, on the eastern edge of the lot.

In comparison of the October 2018 reading for monitoring bore 61610539 is fairly consistent with Bore 4 [being 18.97mAHD for 61610539; compared to 18.53mAHD for bore 4].

Based on this, the Maximum Groundwater Level for the site has been developed using data from this regional monitoring bore. Utilising data from 61610539 for the period between 1975 to 2018, an average annual maximum groundwater level (AAMGL) for this site is 18.78mAHD, with a maximum groundwater level (MGL) of 19.167m AHD was observed in October 1978.

Extrapolated groundwater contours for the subject site are provided as Figure 16. Using the MGL for bore 61610539, a MGL between 19.5m to 20mAHD has been placed over the site. This level provides a 0.5m buffer over the measured MGL at 61610539. It is proposed that this MGL

may be refined, based on additional groundwater monitoring data as provided during the onsite groundwater monitoring, and amended in the UWMP.

As per communications with the City of Gosnells and the Department of Water and Environment Regulation, the proponent shall continue to monitor groundwater for a minimum of 18 months (including two winters), with the final groundwater levels and a delineated Maximum Groundwater level provided as part of the Urban Water Management Plan for the subdivision.

Table 8: Groundwater Monitoring Summary, Depth to Groundwater (mbgl)

	Bore1	Bore2	Bore3	Bore4	Bore5
Easting	403,073	403,199	403,305	403,440	403,290
Northing	6,447,865	6,447,988	6,447,919	6,447,850	6,448,108
RL	21.76	19.75	19.90	20.52	21.00
Casing Height	0.46	0.59	0.55	0.78	0.47
Date					
3/07/2018	2.29	1.41	1.45		
3/08/2018	2.08	0.76	1.35	2.08	2.07
4/09/2018	1.76	0.47	0.97	1.71	1.88
15/10/2018	1.96	0.72	1.27	1.99	1.95
2/11/2018	2.08	0.89	1.38	2.06	2.26
7/12/2018	2.31	1.21	1.65	2.38	2.51
7/01/2019	2.55	1.55	1.95	2.68	2.77
6/02/2019	2.78	1.96	2.48	3.06	2.99
2/03/2019	2.95	2.24	2.97	3.40	3.00
1/04/2019	3.12	2.15	3.37	3.41	3.11
1/05/2019	3.24	2.22	3.50	3.48	3.10
1/06/2019	3.32	2.76	3.53	3.55	3.10
30/06/2019	2.78	1.86	2.35	2.83	2.93
12/08/2019	2.34	1.17	1.53	2.23	3.35
1/09/2019	2.14	0.88	1.25	1.88	2.16
30/09/2019	2.20	1.05	1.39	1.98	2.26
3/11/2019	2.36	1.26	1.63	2.31	2.39
1/12/2019	2.64	1.60	1.88	2.44	2.65

NOTE: shaded cells show the highest groundwater levels

Table 9: Groundwater Levels, mAHD

	Bore1	Bore2	Bore3	Bore4	Bore5
	west	centre	BIOF area	existing	on street
Date	RL	RL	RL	RL	RL
3/07/2018	19.47	18.34	18.45		
3/08/2018	19.68	18.99	18.55	18.44	18.93
4/09/2018	20.00	19.28	18.93	18.81	19.12
15/10/2018	19.80	19.03	18.63	18.53	19.05
2/11/2018	19.68	18.86	18.52	18.46	18.74
7/12/2018	19.45	18.54	18.25	18.14	18.49
7/01/2019	19.21	18.20	17.95	17.84	18.23
6/02/2019	18.98	17.79	17.42	17.46	18.01

	Bore1	Bore2	Bore3	Bore4	Bore5
	west	centre	BIOF area	existing	on street
Date	RL	RL	RL	RL	RL
2/03/2019	18.81	17.51	16.93	17.12	18.00
1/04/2019	18.64	17.60	16.53	17.11	17.89
1/05/2019	18.52	17.53	16.40	17.04	17.90
1/06/2019	18.44	16.99	16.37	16.97	17.90
30/06/2019	18.98	17.89	17.55	17.69	18.07
12/08/2019	19.42	18.58	18.37	18.29	17.65
1/09/2019	19.62	18.87	18.65	18.64	18.84
30/09/2019	19.56	18.70	18.51	18.54	18.74
3/11/2019	19.40	18.49	18.27	18.21	18.61
1/12/2019	19.12	18.15	18.02	18.08	18.35



1797 & 1798 Matison St Southern River

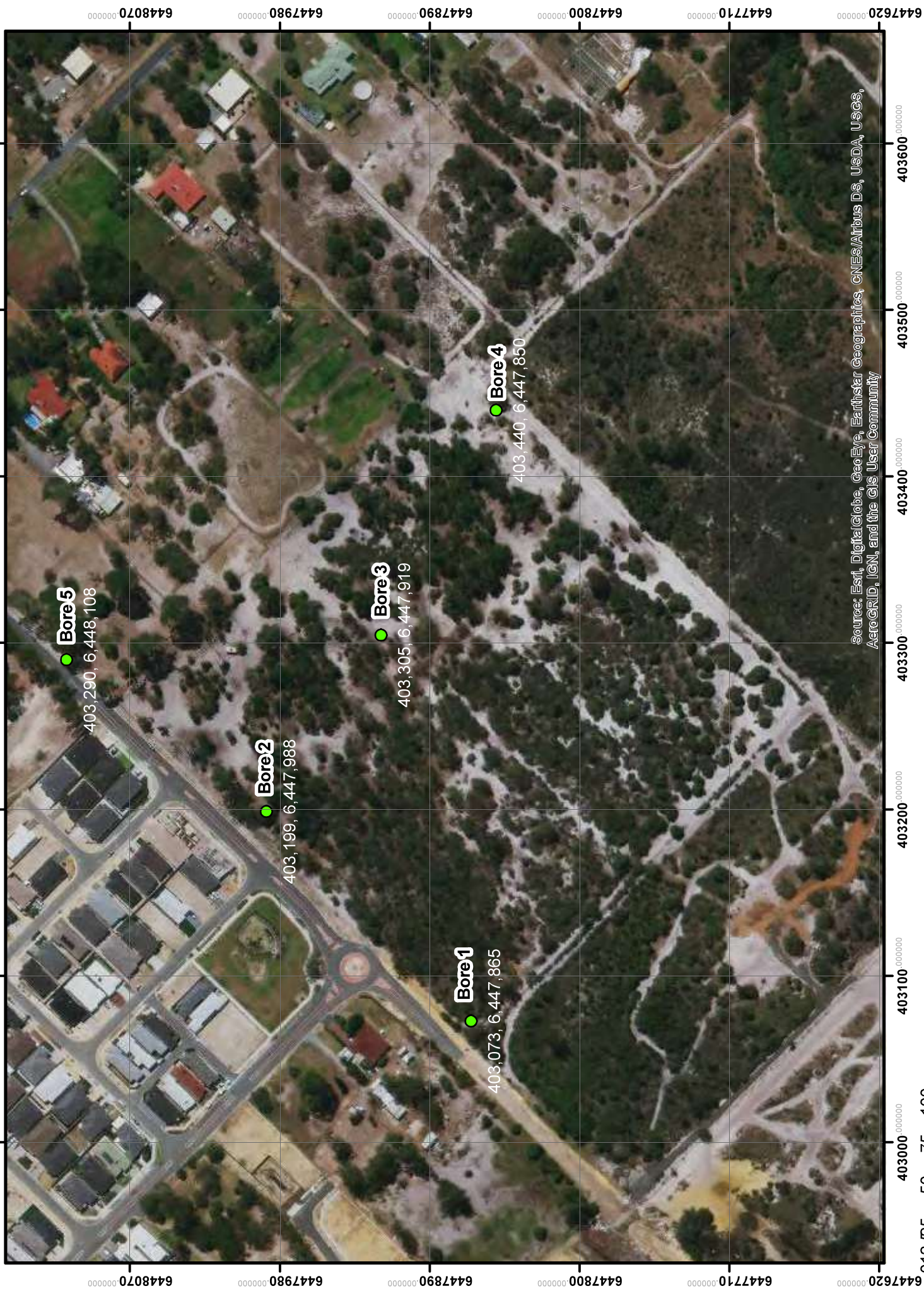


FIGURE 15. GROUNDWATER MONITORING LOCATIONS

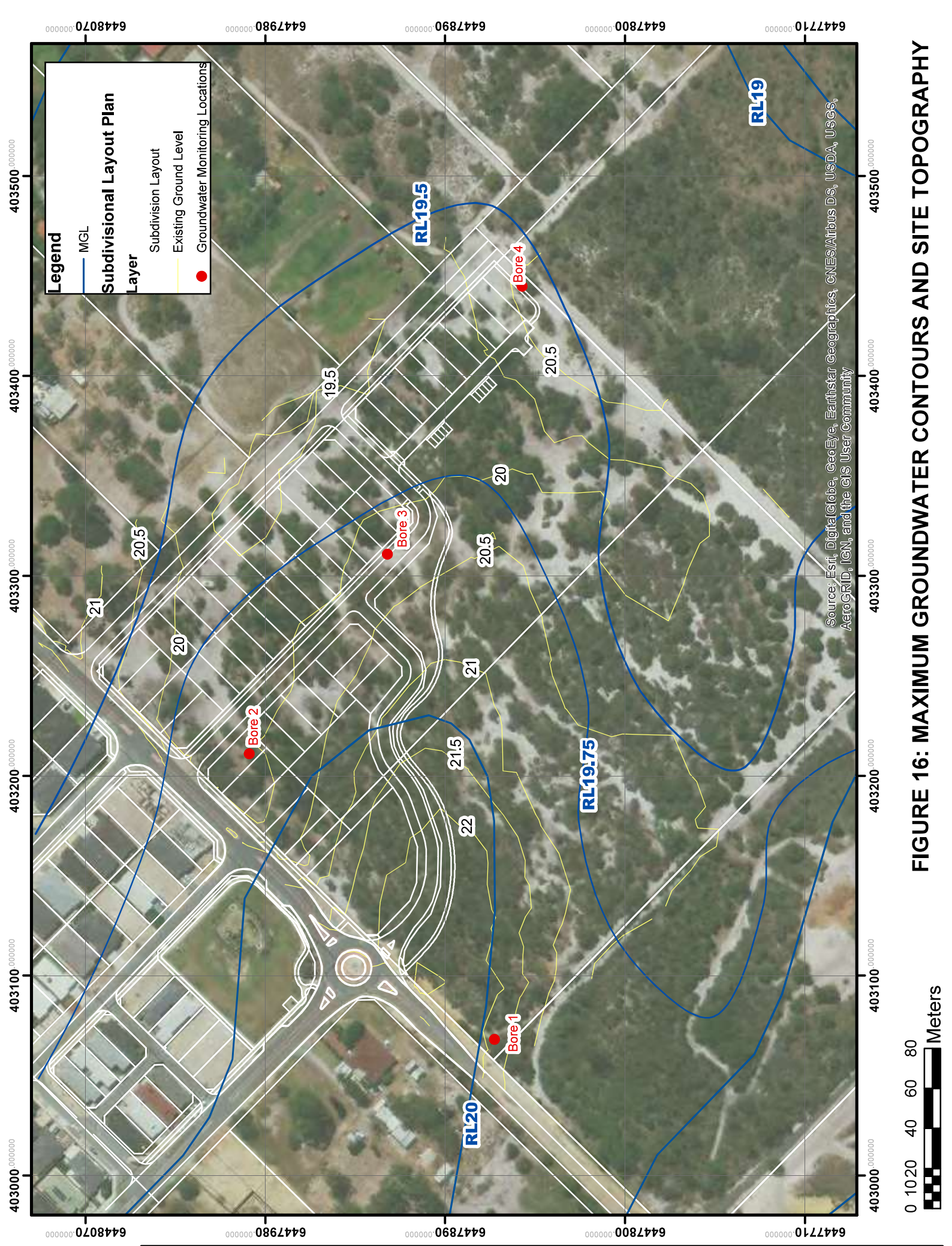


FIGURE 16: MAXIMUM GROUNDWATER CONTOURS AND SITE TOPOGRAPHY

4.8.3 Geotechnical Recommendations - Ground Water

The following recommendations were made by GGC (2019) with respect to the groundwater management for the site:

- Soak wells are traditionally used in suitable free draining sands where the ground surface is at least 1.5m above the Average Annual Maximum Groundwater Level (AAMGL). Drainage design will therefore need to consider the depth to groundwater across the site, as soakwells typically become less efficient where groundwater is within 1m of the base of the soakwell. Should the base of any soakwells be within 1 m of the groundwater, permeability rates should be expected to reduce (possibly significantly) during and following storm events and in winter months.
- Annual Maximum Groundwater Level (AAMGL) and the base of the soakwells are at least 1.0m above groundwater design level, the site is generally suitable for on-site disposal of stormwater by infiltration using soakwells.
- Based on assessment of site infiltration rates, a recommended design permeability value (k) for insitu sand soils of no greater than 5m/day to allow for the variability in materials and reduced permeabilities.
- Soakwells should be positioned a minimum distance of 2 m from footings and ground bearing slabs (subject to council regulations). Discharge from soak wells can cause local densification of loose sandy soils, leading to settlement of footings and slabs overtime.
- If soakwells are positioned closer than 2 m to building footings and slabs, consideration can be given to wrapping the soak well with a non-woven separation geotextile, but the specification for the geotextile must be provided by an experienced geotechnical engineer.
- A minimum separation spacing of at least 10 m between individual soak wells. This minimum distance is intended to reduce the potential for reducing the local permeability and interaction between the soak wells that may reduce the effectiveness of soakage.

Cemented materials and Ferricrete (coffee rock)

It is important to note that cemented materials and ferricrete (coffee rock) were identified in test locations across the site. These materials are considered relatively impermeable and unsuitable for soakwell installation.

It is recommended that a depth of at least 1 m of Sand with less than 5% fines be present beneath the base of all soak wells and that the base of soak wells are at least 1 m above the groundwater table.

Where cemented materials and ferricrete (Coffee Rock) material is present above this depth, it should be over-excavated to the full depth of influence and replaced with approved free draining granular fill prior to installation of soak wells.

Imported Sand Soils

A required design permeability value (k) for imported sand soils be least of 10 m/day is recommended.

General

In situ infiltration testing be conducted following bulk earthwork operations and prior to soak well installation to assess the soak well suitability at the site.

5. Water Use Sustainability Initiatives

Water sustainability involves reducing water consumption, increasing the availability for higher value purposes and/or achieving greater productivity from the same amount of water. The key components to water sustainability are conservation, recycling and reuse. Using an integrated approach to the planning, design, implementation and operation will result in beneficial outcome in both the economical and environmental aspects of the future re-zoning and development of the Gosnells district.

In line with the overall water management strategy and Water Sensitive Urban Design (WSUD) principles which will be implemented as a part of the development, this report assesses various water conservation and sustainability initiatives and the potential to implement them within the development. The focus will be on the efficiency of alternative potable water supplies throughout the development, as well as the maximisation of water re-use capabilities due to the scarcity of water as a vital natural resource.

WSUD principles promote maximising infiltration through source control Best Management Practices (BMPs), and minimising connected impervious area on the subject site. Consequently, the adoption of appropriate surface and groundwater management strategies is vital to the viability of total water cycle management and its requirements to maximise water conservation, recycling and reuse. The water use management strategy is therefore a whole system approach that seeks to reduce pressure on potable supplies through the application of the following principles:

- More efficient use of the existing water resource through demand management;
- Apply water of an appropriate quality for its various uses;
- An effective increase in supply through the replacement of potable water supplies with alternative sources such as harvested rainwater; and
- Adoption of WSUD measures in order to reduce pollutant impact upon the receiving waterways, and natural peak environmental flow rates.

In order to quantify water conservation on the Study Area site, a water balance has been undertaken.

5.1 Water Demand Management

5.1.1 Internal Water Demand

The BCA 5 star Plus initiative implemented by the Government of Western Australia requires new homes to have water efficient hot water systems, showerheads, taps and toilets.

A water balance was undertaken to ascertain water use within a four-member residence and the quantity of water that can be saved using water efficient devices. The guiding document *Domestic Water Use Study (Water Corporation, 2003)* was used for indicative consumptive rates. The results are tabulated in Table 10

Table 10: House Water Consumption

No	Appliances	Type of Appliances	Assumption	Water Consumption (kL/year)	Water Saving (kL/year)
1	Shower Head	Conventional shower head	One 7.5 minute shower per person per day	99	-
		AAA rated shower head		77	22
2	Flushing	Conventional single flush toilet	Three flushes per person per day	48	-
		Duel flush toilet		31	18
3	Washing Machine	Conventional top loader	One load per household per day	53	-
		AAAA rated front loader		15	38
4	Taps	Conventional	16% of all water used in the home is used via taps	32	-
		Water saving		16	16
Total		Conventional Devices		232	-
		Water Saving Devices		138	94

(Data Source: Domestic Water Use Study, Water Corporation, 2003, and Household Water Use Calculator, Melbourne Water).

The demand for scheme water can be reduced further by altering water use practices such as shortening durations of showers, not leaving the tap running while brushing teeth or shaving, only run washing machines with a full load, etc.

5.1.2 External Water Demand

The average home in Perth uses 707L/day or 260kL/year on gardens, equating to 56% of lot water consumption (Water Corporation, 2003). The Water Corporation's Waterwise Display Village program recommends the following water wise principles and garden water saving techniques (Water Corporation, 2006):

- Soils can be improved with soil conditioner certified to Australian Standard AS4454 to a minimum depth of 150mm where turf is to be planted and a minimum depth of 300mm for garden beds (for entry statement only).
- Irrigation systems can be designed and installed according to best water efficient practices. The controller must be able to irrigate different zones with different irrigation rates. Emitters must disperse coarse droplets or be subterranean.
- Entry statements to include a 1:1 mix of hardstand areas to turf and garden beds.
- The adoption of xeriscaped POS gardens where garden beds within POS and community areas are landscaped using water wise plants i.e. local native species from similar climates that require less water than exotic species.
- The use of turf is to be limited and using species of a genotype endorsed by the UWA Turf Industries Research Steering Committee (e.g. Couch grass *Cynodon dactylon*).
- Garden beds are to be mulched to 75mm with a product certified to Australian Standard AS4454.

Using water saving techniques such as those detailed above can reduce external water use by between 40% and 50% (Water Corporation, 2006 and Melbourne Water, 2008) i.e. a decrease in consumption from 260kL/year to 115kL/year (at an average of 45%).

5.2 Water Supply Management

The use of potable water should be minimized where drinking water quality is not essential, particularly for irrigation and external uses to achieve the highest value use of fit-for-purpose water. This means that water should be of a quality suitable for its intended use. This will ultimately minimise the stress on drinking water supply and ensure that water management strategy measures are in place throughout the development.

Such measures include:

- The utilization of rainwater harvesting from covered roofed areas for internal use, landscaping and fire fighting purposes.
- The potential utilization of groundwater harvesting for landscaping and fire fighting purposes; and
- The utilization of treated Grey water from showers, kitchen sinks and laundries for internal use, landscaping and fire fighting purposes.

Detailed modelling has been conducted on the development site, to assess the possibility of supply substitution through rainwater tanks. Rainwater tanks supply substitution and rainwater re-use opportunities vary greatly depending on the style and type of development category for which they will be installed. Commercial and industrial sectors offer opportunities such as re-use for manufacturing, and the main supply substitution opportunities for residential dwellings are in the toilet and laundry.

The modelling of rainwater tank sizes for the site was based upon historical rainfall data. This carries with it an inherent risk, as future rainfall patterns may not necessarily mirror those of the past. Predictions indicate that with the advent of Global Warming rainfall patterns will become less stable and drop in many areas.

This section recommends rainwater tank sizes and usage for the different residential density areas within the development through the following parameters:

- 52 years of daily rainfall and evaporation data (1957 to 2008)
- Rainwater tank modelling has been undertaken for:
 - o Low and medium residential density lots (R20 and R30) with single dwellings.
- If tanks are to be installed on the site, it is proposed that the rainwater tanks will have a trickle top up system, providing supplementary water from the reticulated town water supply with a minimum storage being selected based upon the internal water demand.
- It is recommended by the Water Corporation, Western Australia, runoff from only approximately 50% of an average house can be collected by the tank.
- Information sourced from The Water Corporation of Western Australia – Domestic Water Study in Perth, Western Australia (1998-2001) was used as a basis for determining the water use and sewage production at the proposed residential development.

Two options for rainwater use have been analysed: rainwater use either for toilet only and or for toilet and gardening. Results of the rainwater tank modelling are provided in Table 11.

Table 11: Rainwater Tank Modelling Results.

Development Category	Assumed Roof Area per Lot (m ²)	Assumed Lot Size (m ²)	Supply Substitution (L/ET/day)		Trickle top up Volume (L)	Preliminary Tank Size per lot (L)	% Total Daily water usage supplied by Tank
			Toilet	Gardening			
R20	180	350	110	0	110	1x3,500	56%
			110	103	110	1x8,000	52%

From the above it is recommended that a minimum volume of 3,500 L tank per ET is the most viable for option 1 and will supply 56% of the houses total daily toilet requirements.

If option 2 was to be chosen for the site, a higher minimum volume 5,000L tank is recommended, and will supply 52% of the total daily toilet and gardening requirements for an R20 density development in Gosnells.

5.3 Lot Water Consumption Summary

The above water balance analysis indicates that a typical four-person family house:

- Without water saving measures uses 492kL/year: 232kL in-house and 260kL outside. This equates to 123kL/person/year which is greater than the State Water Plan target.
- With demand management water saving measures uses only 253kL/year: 138kL in-house and 115kL outside. This equates to approximately 63kL/person/year - well below the State Water Plan target.
- With rainwater tanks as a supply alternative for toilet use only uses 237kL/year: 122kL in-house and 115kL outside. This equates to approximately 59kL/person/year.
- With rainwater tanks as a supply alternative for both toilet and garden watering uses 178kL/year: 120kL in-house and 58kL outside. This equates to approximately 44kL/person/year.

Whilst authorities and developers can assist in providing lot owners with information (raising awareness through education) pertaining to the implementation of water conservation methods, this is not enforceable, and therefore the responsibility ultimately rests with home owners. Therefore, as a conservative measure, inclusion of rainwater tanks has not been included within in either the detailed water quality or quantity calculations (section 6).

5.4 Potable Water Supply

Potable water shall be provided from the Water Corporation's supply main, located on Matison St. initial consultation with Water Corporation has identified sufficient supply is available to service the lot.

5.5 Waste Water Management

The development is to be connected to the Water Corporation's regional sewer infrastructure.

5.6 Public Open Space Irrigation Requirements

Figure 17 provides the proposed Public Open Space (POS) plan for the proposed subdivision.

The Conservation Category Wetland (CCW) is a major influence on the land use planning. Almost all of Lot 1796, a significant proportion of Lot 1797 and the south-western portion of Lot 1798 is mapped as a CCW. The mapped wetland boundary was ground proofed by Aurora Environmental and the revised mapping, as surveyed, has been endorsed by the DBCA.

The structure plan adopts a generic 50m buffer to the CCW in accordance with current guidelines. A Wetland Management Plan will be prepared at subdivision stage for the CCW buffer area and in consultation with the City of Gosnells. The management plan will address revegetation of the buffer area, control of pedestrian and vehicle access; and the management of bushfire risks, weeds and dieback.

The local open space provision is guided by Liveable Neighbourhoods (LN), which requires a 10% land contribution for unrestricted Local Public Open Space. The methodology for the calculation of POS contribution is in accordance with Draft Liveable Neighbourhoods 2015 as follows:

- LN requires the POS calculation on the basis of 10% of the Gross Subdivisional Area. The CCW does not contribute towards the provision of POS but is off-set from the total Site Area to define the Gross Subdivisional Area (51,688m²). The POS requirement for the site is calculated to be 5,168m².
- LN specifies that the CCW buffer may only contribute a maximum of 20% of the POS requirement. Although the CCW buffer measures 19,693m², its contribution towards the POS is 1,033m².
- The CCW and its 50m buffer area measures approximately 4.9ha and will be retained as woodland.
- The total POS provision under the LSP Plan is 8,179.3m², which constitutes a POS provision of 15% to exceed the requirement under Draft Liveable Neighbourhoods 2015.
- The CCW buffer constitutes 20% credit of the POS provision, therefore Local POS requirement is 7,145.50m²
- The POS provision as a percentage of Gross Subdivisible Area is 15.8% and will be vested in the Crown and managed by the local government.

The 7,145m² of Local Open Space will accommodate drainage swales for the development. Areas not affected by drainage will be maintained as a low fuel grassland, in a natural state, and it is not intended to introduce landscaping other formal recreational activities.

The POS is to be provided in accordance with the Structure Plan and will be refined at the subdivision stage to meet obligations.

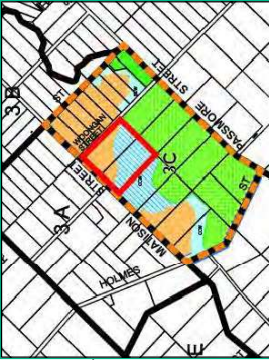
POS Irrigation Requirements

It is anticipated that the entire area shall be irrigated for permanency and establishment. Based on a POS area of 7,145.5m² and standard calculations as defined in *Water Efficiency Auditing Practitioners Guide* (Diver, 2012), a total water irrigation requirement for the POS was calculated as 15,023L/annum. In consideration and average water holding capacity of the soil (sandy loam), this value is consistent. Calculations are provided as Table 12 below.

Table 12: Water Irrigation Requirements

	Factor	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Ave Monthly Evaporation		mm	327	281	241	136	89	63	60	87	110	161	221	303	2079
Ave Monthly Rainfall		mm	11	15	17	42	102	165	161	126	81	46	29	12	804.6
Assumed Effective Monthly Rainfall	0%	mm	0	0	0	0	89	63	60	87	110	0	0	0	409
Ave net Monthly requirement		mm	327	281	241	136	0	0	0	0	0	161	221	303	1670
Weekly Requirement		mm	76	65	56	31	0	0	0	0	0	37	51	70	386
Adjusted for Crop Factor	107%	mm/wk	81	69	60	34	0	0	0	0	0	40	55	75	413
Irrigation Efficiency	0.85	mm/wk	95	82	70	40	0	0	0	0	0	47	64	88	486
Water Irrigation Requirement		L/mth	2,942	2,528	2,168	1,223	-	-	-	-	-	1,448	1,988	2,726	15,023

**Lots 1797 & 1798 Matison Street,
Southern River, City of Gosnells**



Developable Area

Conservation Category Wetland (CCW)

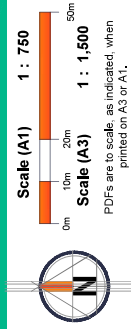
CCW Buffer

ELEMENT	MEASURE
LOT AREA	
Lot 1797	40,489.0m ²
Lot 1798	40,469.0m ²
Total Site Area	80,938.0m²
POS CALCULATION	
Less: CCW Area	29,249.6m ²
Gross Subdivisional Area	51,688.4m ²
POS Required (10%)	5,168.8m²
POS PROVIDED	
CCW Buffer (Credit 20% max.)	1,033.8m ²
Local POS	7,145.5m ²
Total POS Contribution	8,179.3m²
POS Provision (%)	15.8%

Note:
CCW boundary defined by Aurora Environmental
on 12/10/2017 and surveyed by NMG on Feature
Survey 101081-DE-001-A, dated 26/10/2017.

(Draft LN 2015 Calculation)

Date: 21/01/2019 Ver: 5.0

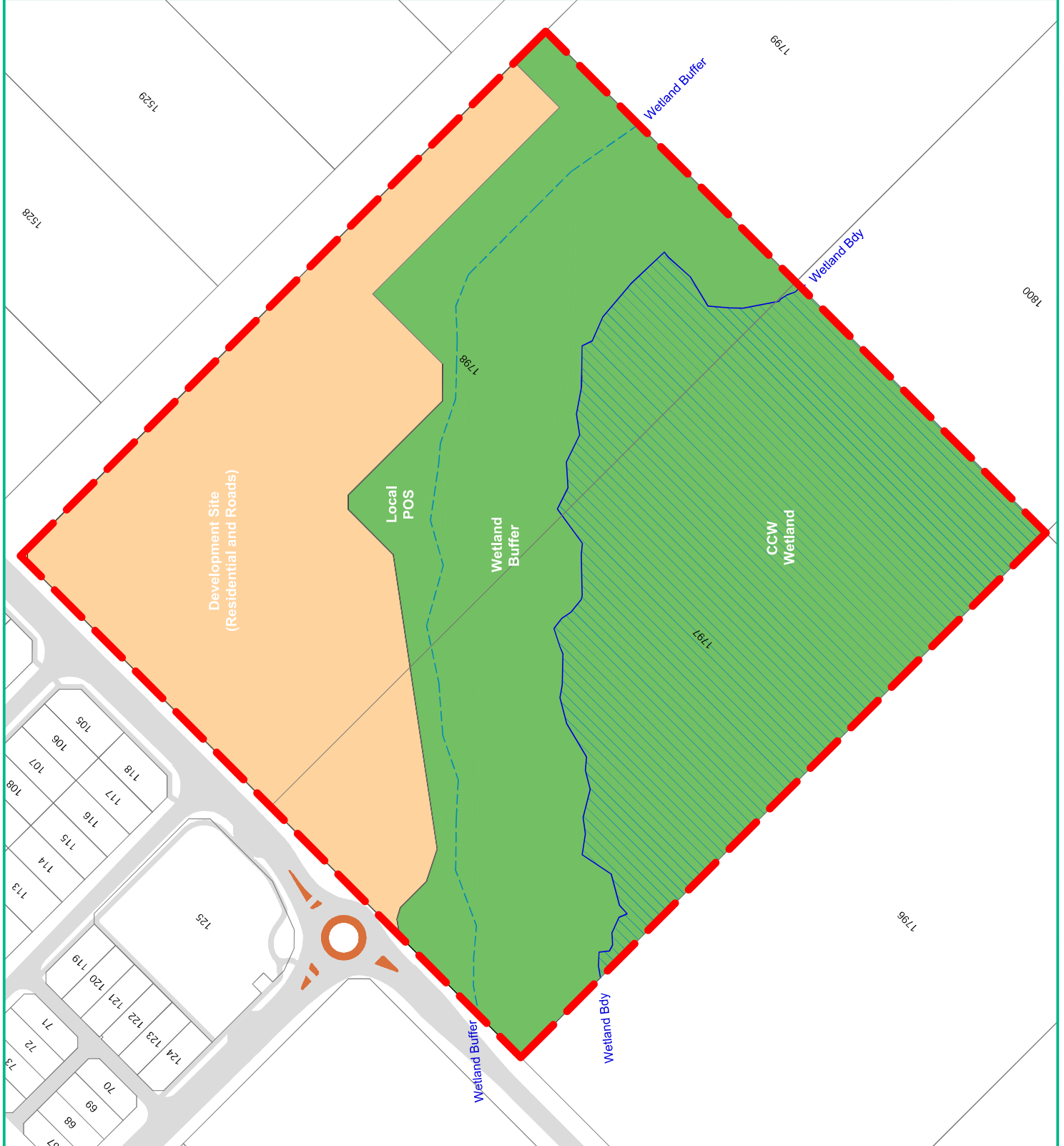


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6. Stormwater Management Strategies

The proposed water management strategy for the Study Area is consistent with WSUD best practice and meets the key design principles and objectives as detailed in Section 3. This document entails urban water management across the entire development.

Consultation with the City of Gosnells has confirmed the following aspects of the surface water strategy:

- 2% of the connected construction impervious area shall discharge into a biofiltration swale, running between the CCW and development area. Water shall run as overland flow into this treatment mechanism.
- Indicative locations are shown in Figure 19.
- The Biofilter basin shall convey flow easterly to a drainage point, where an overflow pipe will allow excess water to overflow to Woongan St. The water from Woongan st would result in discharging into the FMD at node FDA002.
- All lots shall maintain stormwater flows within the lots through soak wells.
- Fill levels for lots shall provide a minimum of 1.2m separation between the AAMGL and finished lot level. No subsoil drainage is anticipated at this stage.

6.1 Surface Water Management Strategy

Stormwater management principles employed on the site are consistent with the principles of WSUD as well as the design principles and objectives detailed in Section 3 of this document. This DWMS has been prepared to address the water quantity and quality issues of the development.

A breakdown of the storm water management techniques used on the site includes:

- **Lot runoff:** the use of drainage soakwells to reduce direct runoff to the street conveyance system. This will increase detention periods, minimise peak flow rates and enhance runoff quality.
- **Bio-retention pockets/Raingardens:** provide bio-retention pockets close to runoff source areas where possible, to treat and infiltrate 2% of the connected construction impervious area.
- **Retention/Detention:** provide adequate storage to attenuate post-development flow rates within the boundary of the CCW. Ensure that the required freeboard to finished lot levels is achieved.

6.2 Structural and Non-Structural BMPs

Structural and non-structural best management practices (BMPs) are to be used in combination to achieve appropriate stormwater treatment outcomes.

6.3 Structural BMPs

Table 13: Structural BMPs.

Scale	Ownership and Maintenance	Best Management Practice
Lot	Lot Owner	Infiltration: Soakwells
Street	Developer	Infiltration: Raingardens

6.4 Lot Level Management (Soakwells)

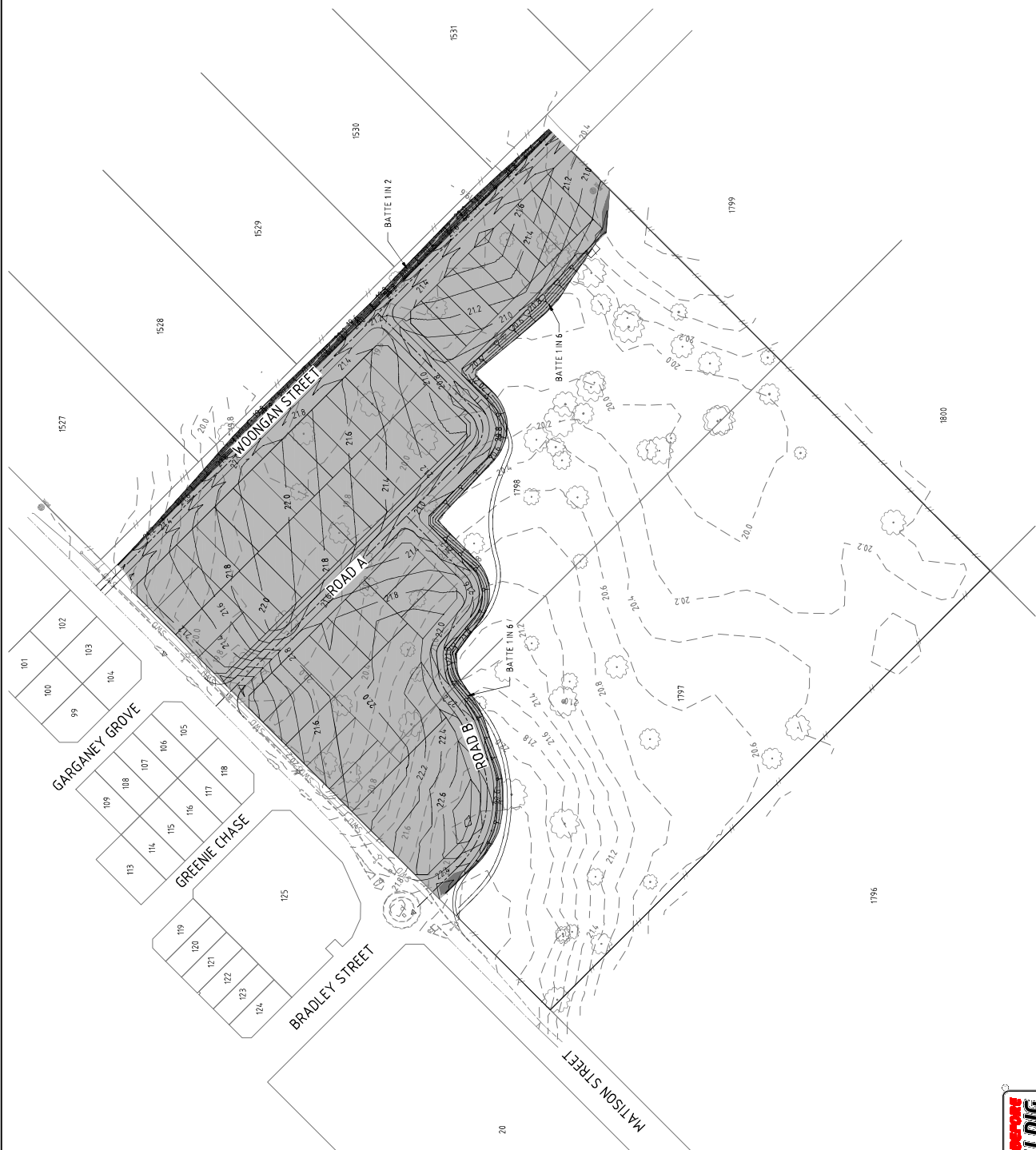
Soak wells are widely used for direct infiltration of stormwater. They consist of a vertical perforated liner, with stormwater entering via an inlet pipe at the top of the device. The base of the soak well is open or perforated and usually covered with a geotextile. Alternatively, pervious material, such as gravel, can be used to form the base of the soakwells which is to be at least 0.5m above the ground water level.

The combination proposed for the development consists of 3 soak wells (1.8m dia x 0.9m deep) for an average 200m² roof. This will infiltrate the 1% AEP event roof runoff.

As per City of Gosnells (COG) requirements, the functionality of installed soakwells is highly dependent on their interaction with groundwater levels. Therefore, as per COG recommendations, if Finished Lot Levels (FLL) for a site which is proposing soakwells, provide less than 2m separation to the Controlled Ground Water Levels (CGWL)/ MGLs (whichever is higher) then an overflow must be provided on the soak well. This overflow can be discharged either:

- Down the driveway, where adequate fall is achievable from the FLL to the street
- Into a street-side bio-retention system
- Into a lot connection pit which is connected to the stormwater pipe network.
- Requirements for overflow for each lot shall be determined at the completion of groundwater monitoring over the site.

Proposed FLL is provided as Figure 18. The plan shows an average of 1.2 – 2.0m of clean fill to be placed over the site. In comparison of the groundwater levels as currently measured, this amount of fill over the lot will provide sufficient localised drainage through soakwells.



EARTHWORKS SUMMARY

CUT - 0m3
 FILL - 47,000m3

LEGEND

- | | |
|--|----------------------------|
| | EXISTING CONTOUR AND LABEL |
| | EXISTING FENCE |
| | EXISTING ROAD |
| | EXISTING STORMWATER |
| | EXISTING TREE |
| | EXISTING LIGHT POLE |
| | EXISTING SIGN |
| | PROPOSED CONTOUR AND LABEL |
| | PROPOSED BATTER |
| | PROPOSED AREA IN FILL |
| | PROPOSED AREA IN CUT |

CONCEPT EARTHWORKS PLAN
SCALE 1:1000

Signature _____ **Date** _____

I, the undersigned, certify that the foregoing is a true and correct copy of the original document and that the document is a true and correct copy of the original document.

Signature _____ **Date** _____

I, the undersigned, certify that the foregoing is a true and correct copy of the original document and that the document is a true and correct copy of the original document.

Francesco Lombardo Consulting PTY LTD ABN 306 097 428 878
Innovative, Cost Effective & Consulting Engineering.

URBANISM

PROJECT:	LOTS 1797 & 1798 MATISON STREET, SOUTHERN RIVER
DRAWING TITLE:	CONCEPT EARTHWORKS PLAN

SCALE	AS SHOWN	FILE	-	THIS PLAN IS NOT TO BE USED FOR CONSTRUCTION UNLESS NOTED BELOW
HORIZONTAL	-	DESIGN	DCD	
VERTICAL	-	DRAWN	DCD	
SURVEY DATUM	AHD	CHECKED	FL	
WAPC No		DATE	MARCH 18	APPROVED
WADOF FILE NAME		DRAWING No.		
				REV.
				C200
				A

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6.5 Street Level Management

Street level stormwater management entails the following:

- 2% Impervious connected catchment is to be retained and infiltrated in raingardens adjacent to roads. Flows shall be as sheet flow, with the raingardens located abutting the CCW buffer.
- 10% AEP and 1% AEP from the subdivision is conveyed as overland flow to the southeast corner of the lot. At this location, water shall be discharged via a pipe to Woongan st, where it will connect with the FMD.

6.5.1 Retention of Site Flows within Raingardens

Bio-retention pockets will be installed at several locations throughout the development. The raingardens will treat and infiltrate runoff from the roads to capture 2% of the total impervious interconnected system. The detailed design of the rainwater gardens shall be completed once detailed engineering design has been completed. Indicative raingarden locations are shown in Figure 5.

The construction of the raingardens is to be consistent with current best practice and the basic components of the system are as follows:

- An extended detention depth above the floor of the garden which can hold a volume of water to be infiltrated,
- Amended soil (Gin Gin Loam) within the garden bed to absorb and retain nutrients to improve water quality,
- Plants within the garden to uptake the nutrients collected by the soil,
- A transition layer of sand underneath the amended soil, ensure all fine particles are collected and do not leave the system,
- An overflow, to convey events greater than a 63% AEP into the minor/major stormwater network.

Details of the shape and sizing of the raingardens are provided in Table 14.

Overflows from the bio-pockets passing directly through the raingardens (as sheet flow) and into the CCW buffer.

Typical cross-sections for the raingardens located throughout the residential areas are shown in Plate 1.

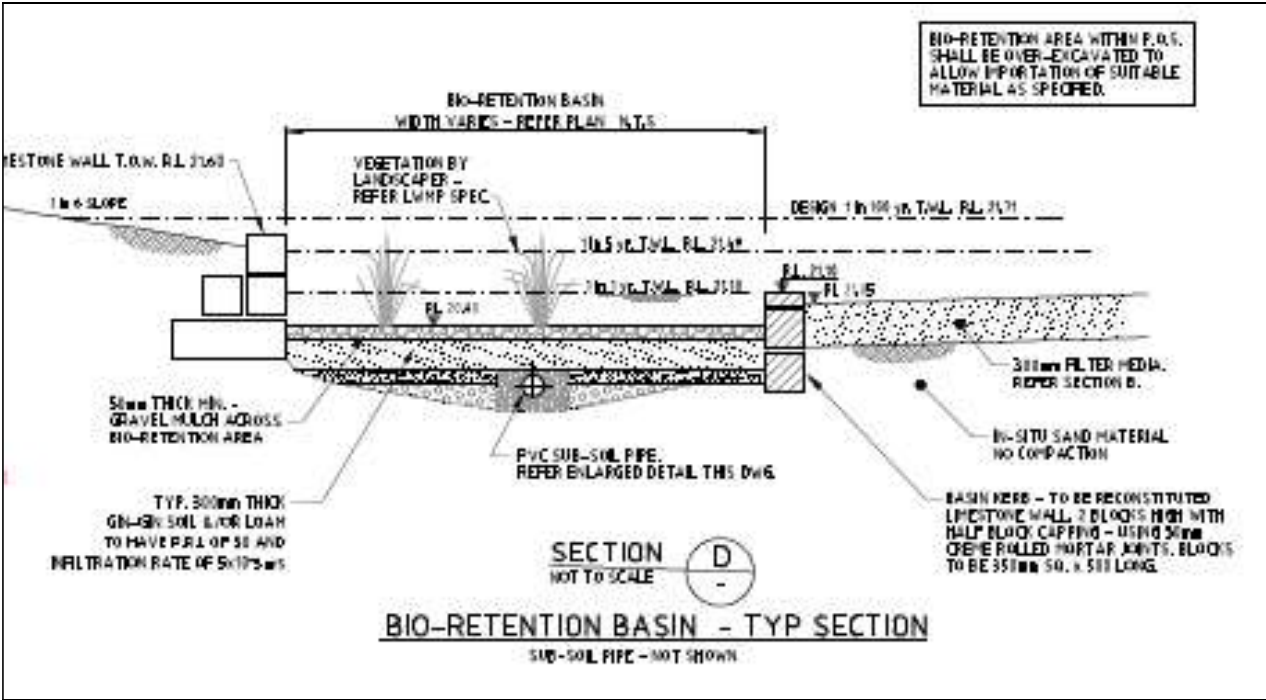


Plate 1: Indicative Rainwater Garden design



Plate 2: Example Rainwater garden in verge



Plate 3: Roadside biofilter with split guttering

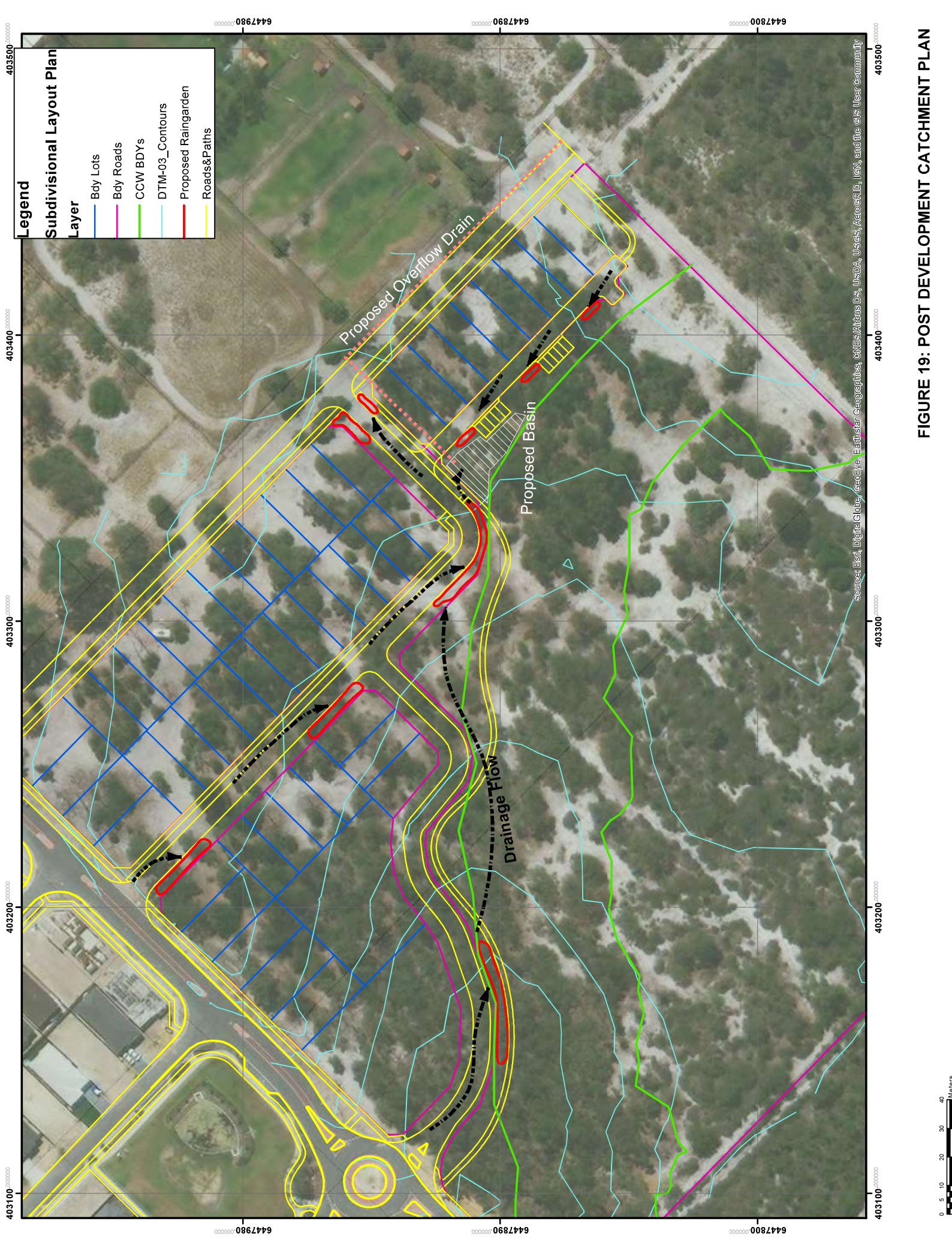


FIGURE 19: POST DEVELOPMENT CATCHMENT PLAN



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Table 14: Details of Indicative Raingarden Systems.

Post-Development Catchment:	Raingarden Preliminary Details					
	A	B	C	D	E	F
Detention Storage Data						
Floor Level (mAHD)	21.9	21.5	20.7	20.9	20.5	20.5
Catchment Area	530	330	330	675	930	580
Floor Area (m ²)	10.6	6.6	6.6	13.5	18.6	11.6
Side Slopes (v:h)	1:4	1:4	1:4	1:4	1:4	1:4
Flood Storage (m ³)	3.18	1.98	1.98	4.05	5.58	3.48
Top Water Level (mAHD)	22.2	21.8	21.0	21.2	20.8	20.8

6.6 Surface Water Quality Management

6.6.1 Water Quality Objectives

The following pollutant reduction targets are to be achieved, as compared with a development that does not actively manage stormwater quality, as specified in The Stormwater Management Manual for Western Australia (DoW, 2004-2007), Better Urban Water Management (WAPC, 2008), and the Southern River Integrated Land and Water Management Plan:

- Rain garden structures sized for 2% of the connected constructed impervious areas.

The requirement of the Southern River Integrated Land and Water Management Plan is to provide either 2% of the connected impervious area of the site as bio-retention or size the amount of Bio-retention for the site based on load reduction requirements. The 2% rule gives no detail of Extended Detention Depth (EDD) or depth of media requirements. Consultation with the City of Gosnells has advised an optimum depth of 300mm for the rainwater gardens.

6.6.2 Confirmation of drainage criteria

Sizing of the volumes of the bio-retention pockets was based on the volume of expected runoff from the catchments discharging to each treatment device. The invert of the outlet structures of the bio-pockets/raingardens were then set at this level which achieved the determined volume of runoff. This volume was calculated using the 63% AEP rainfall intensity of the subject site (Gosnells = 17mm) and multiplied this by the contributing connected impervious areas. A summary of the results is shown in Table 15.

Table 15: 2% Connected Impervious Areas

Raingarden Catchment	Contributing Connected Impervious Catchment Area (m ²)	2% of Contributing Connected Impervious Area (m ²) Required	Floor Area Provided (m ²) of Bio-Garden/ Raingarden
A	530	10.6	25
B	330	6.6	25
C	330	6.6	38
D	675	13.5	220
E	930	18.6	270
F	580	11.6	180
Totals		67.5	758

Note: the retention volumes stated above do not consider any infiltration losses from the bio-retention beds.

6.6.3 XP-STORM modelling outputs

Post-development model layout is provided as Figure 20. The model was developed on a conservative basis to include any potential overland flow from the CCW, as well as a modelled treatment train. Table 16 provides a summary of the pre- and post-development results for the site, and shows the following:

- Although the peak discharge will not increase, the volume required to be managed will increase.
- To service the increased flow rates, the raingardens have been structured to accommodate the storage of the 63% AEP.
- A 450 diameter pipe or culvert would be required to be installed from the lowest point of the rain gardens through to the Woongan St, to allow conveyance of additional flow.

Table 16: Comparison of Pre- and Post-Development Results

Peak Flow Results					
AEP	ARI	Flow (m³/sec)			
		Pre	Post		
63%	1	0.03	0.06		
10%	10	0.34	0.14		
1%	100	0.66	0.19		
Total Volume					
AEP	ARI	Volume (m³)		Detention volume required, m³	Water Management Infrastructure
		Pre	Post		
63%	1	1.7	10.3	8.6	Rainwater Gardens have a total available capacity of 20.25m³
10%	10	22.7	35.3	12.6	Rainwater Gardens have a total available capacity of 20.25m³
1%	100	34.2	61.0	26.8	Rainwater Gardens + Small Basin (76m³); basin to have overflow to manage larger flow events

6.6.4 63% AEP Water Management

Raingarden pockets will capture stormwater near source. Table 15 shows a suitable floor area to allow for localised treatment and infiltration of water.

Raingardens located adjoining the CCW wetland buffer will be designed as vegetated swales. The road network will connect as flushed kerb to allow suitable conveyance of flow. This will allow for the overflow of larger storm events away from infrastructure, towards the CCW.

The swale design is provided in Table 17 below.

Table 17: Swale Design Input Parameters

	Length (m)	Width (m)	Area (m ²)	Depth (m)	Volume (m ³)	K (sand) (m/day)	Infiltration Rate (m ³ /sec)
Total Swale	33	4	132	0.35	46.34	5	0.012

6.6.5 10% AEP Water Management

Raingardens shall be connected to a drainage system that conveys water south to the edge of the CCW wetland buffer. The water will follow the natural contours eastwards, where a small basin will be constructed. The basin shall be located within a low point on the site.

The basin location is shown in Figure 20. The basin area has been designed within the current contours whilst not encroaching on the CCW wetland buffer. The basin has a depth of 0.25m. The proposed basin would provide 75m³ of water storage, which allows for sufficient storage for the 10% and 1% AEP design volume.

The base RL of the basin would be 19.75m AHD, which would be slightly higher than the proposed maximum groundwater level, and 0.6m higher than the September 2018 peak groundwater level in Bore 3. Further refinement will be required at the UWMP stage, once the groundwater monitoring has been finalised, to determine if there is sufficient depth to install subsoil drainage below the basin. The subsoil would be connected to the overflow structure and allow for free-draining of the basin post-stormwater event.

6.6.6 1% AEP Water Management

Water shall be conveyed towards the CCW and basin. As outlined above, the basin would provide sufficient storage for the 1% AEP design volume. As the subdivision is raised in this location, a minimum freeboard of 300mm can be achieved.

An overflow structure is proposed for this site to allow for conveyance of large storm events and reduce the risk of impacts to property. A 450mm culvert, connecting to Woongan Rd, would allow for the safe conveyance of larger storm events offsite, towards the Forrestdale Main Drain.

A review of the drainage levels on the site shows that the infrastructure is above the 10% and 1% AEP levels as dictated at node FMD0002 in the FMD ADS.

6.6.7 Comparison of drainage design against objectives

Table 18 provides a comparison of the drainage design against the design objectives.

Table 18: Modelling outputs against design objectives

Aspect	Objective	Modelling Output
Ecological Protection	Retain all flows up to and including the 1-yr ARI event.	The modelling shows an increase in total flow by 68%. During detailed design, the ARI flows shall be reviewed to increase total swale volume to retain all flows from the subdivision area onsite.
Ecological Protection	Achieve pollutant load reduction in the average annual load by adopting a treatment train approach including non-structural measures, on-site retention of the 1-yr 1-hour ARI event and bio-retention structures/systems sized at either 2% of the connected constructed impervious areas (WAPC 2008)).	Infrastructure shall be designed for 2% of the connected constructed impervious area.
Flood Management	Compensate peak flow in the 100-yr ARI event to pre-development peak flow rates; all water to be retained onsite.	Flood modelling shows that the peak flows in the 1% AEP event post-development event are 71% of the pre-development scenario.
Flood Management	Maintain a minimum of 300mm freeboard between the local 1% AEP flood level and finished lot levels and 500mm between the regional 1% AEP flood level and finished lot levels.	During detailed design, the ARI flows shall be reviewed to increase total swale volume to retain all flows from the subdivision area onsite.



Figure 20: XP-Storm node delineation



Figure 21: Post-development model layout

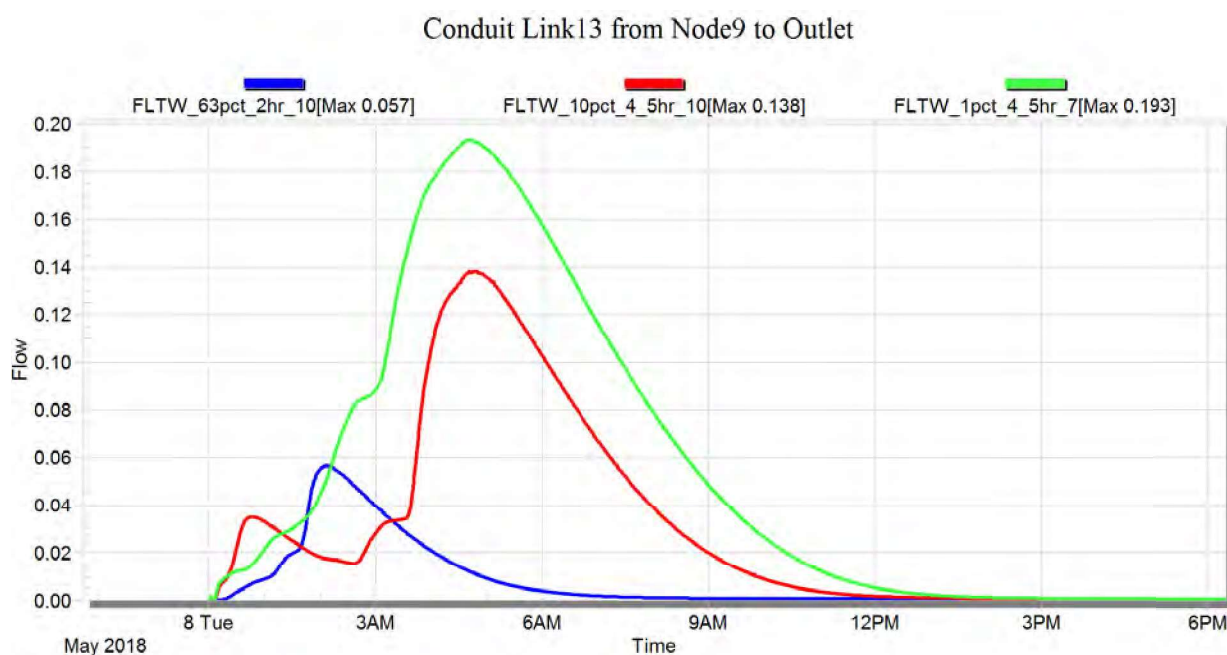


Figure 22: Post-Development Peak Flows

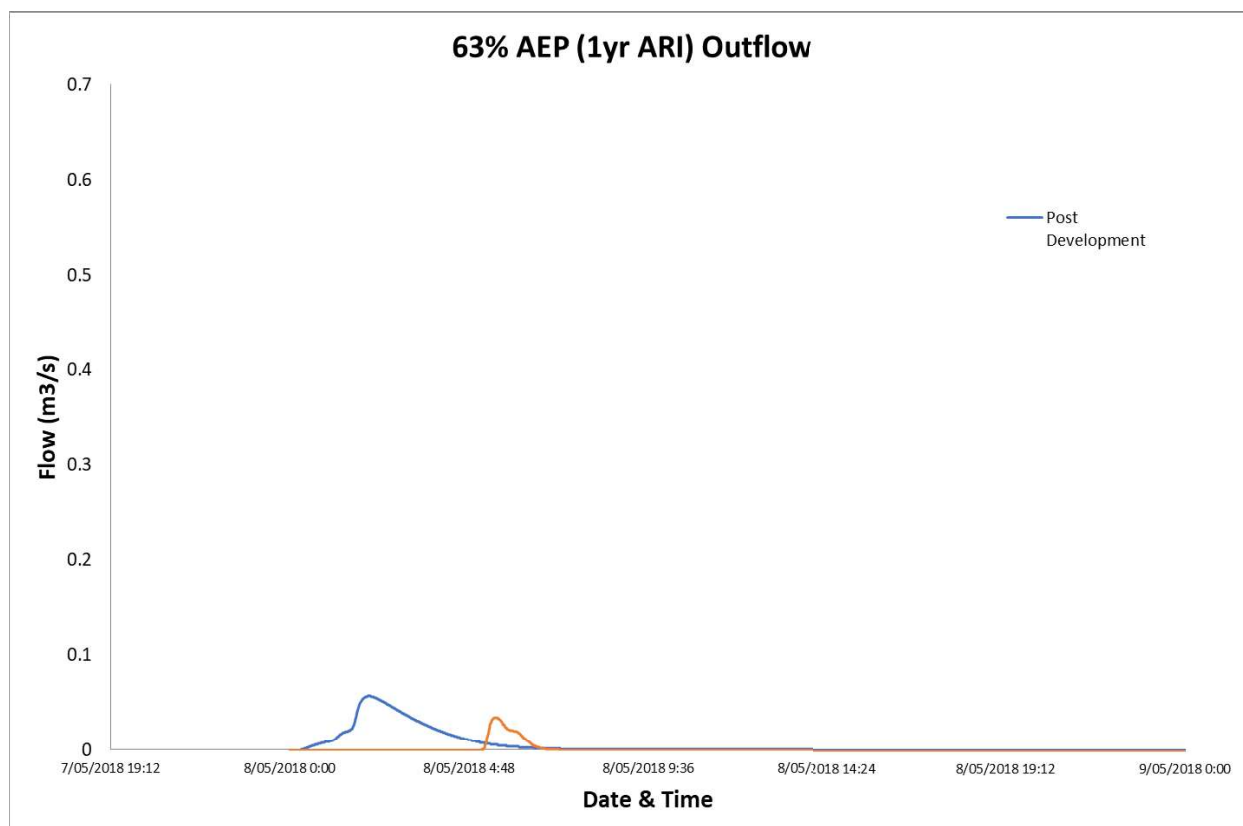


Figure 23: Comparison of Pre- and Post- development, 63% AEP scenario

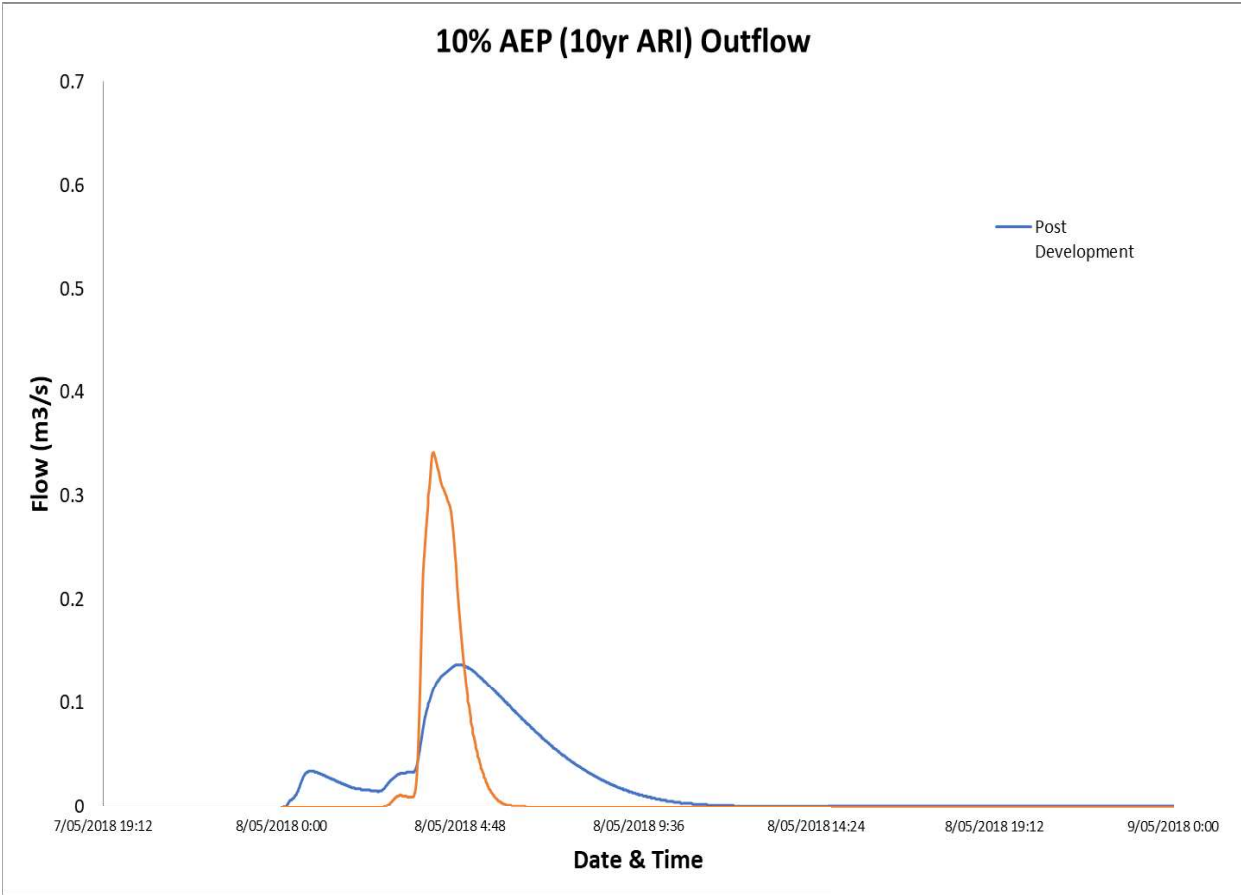


Figure 24: Comparison of Pre- and Post- development, 10% AEP scenario

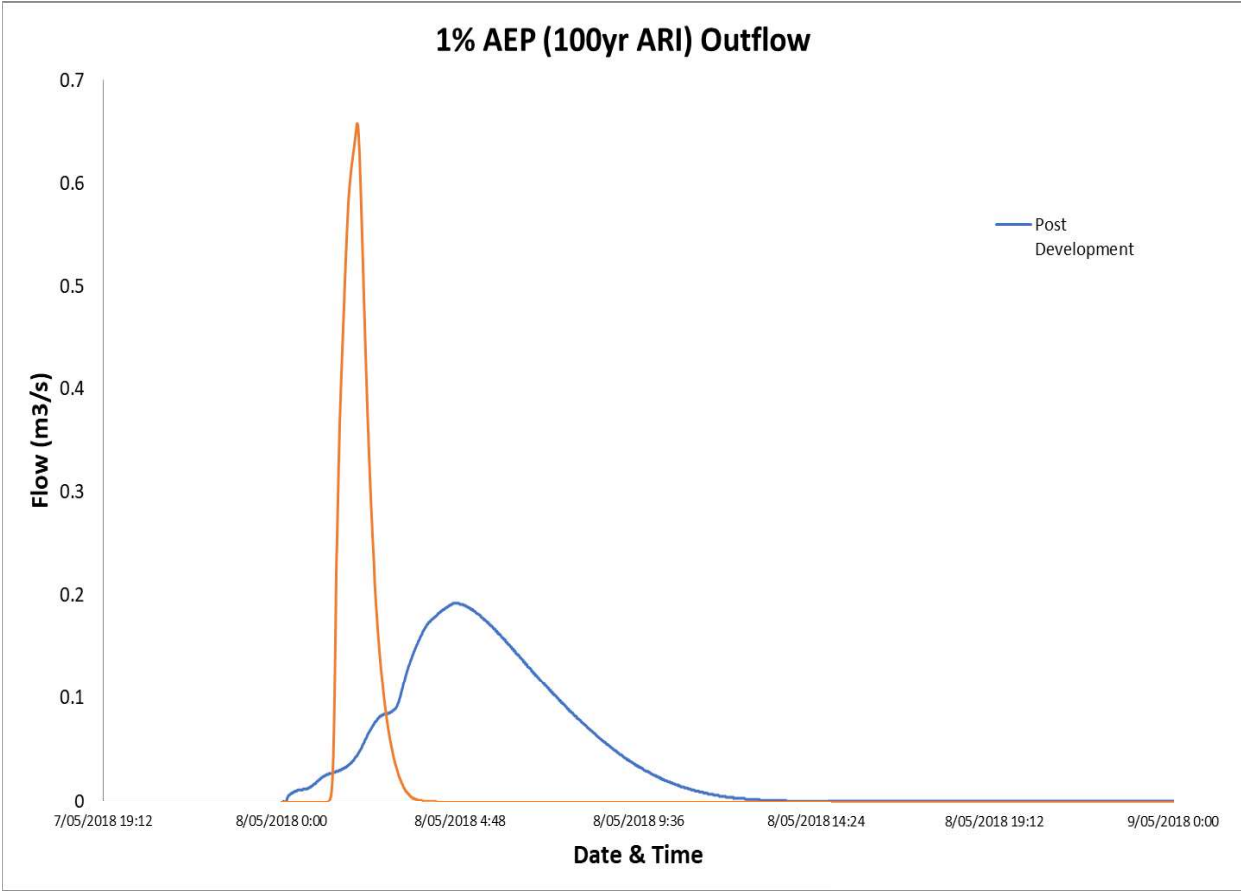


Figure 25: Comparison of Pre- and Post- development, 1% AEP scenario

7. Groundwater Management Strategy

Groundwater management design criteria includes:

- Management of groundwater levels to protect infrastructure and assets.
- Maintaining groundwater regimes at pre-development conditions for the protection of the CCW.
- Protection of groundwater resources.
- Water quality testing of groundwater supply for irrigation.
- Adoption of nutrient load reduction design objectives for discharges to groundwater

The MGL for the site shall be delineated as part of the UWMP for the project.

7.1 Post-Development groundwater levels

The groundwater levels over the site shall be a minimum of 1.2m separation between the groundwater and the finished lot level. Clean fill, as per the geotechnical considerations, will be used to backfill the site and provide sufficient separation to groundwater. Finished Lot levels are shown in Figure 18.

7.2 Outlet Controls

A 450-diameter pipe or culvert is proposed to connect the site to Woongan St, which will then flow through to the FMD. This will allow for the management of surface water effectively and minimise any groundwater discharge.

8. Implementation Plan

8.1 Commitments

Pacelin Pty Ltd is committed to implement this DWMS and construct the development in accordance with the detailed engineering design in consultation with the City of Gosnells and DWER.

8.2 Roles/Responsibilities and Funding

The key stakeholders are:

- Paceline Pty Ltd
- City of Gosnells.
- Department of Water.
- Lot owners/residents.

Their roles, responsibilities and funding are summarised below.

Table 19: Summary of Roles and Responsibilities.

Organization	Role/Responsibility	Funding
Pacelin Pty Ltd	Satisfy WAPC conditions pertaining drainage and stormwater management. Implement the stormwater management detailed in this DWMS in consultation with and to the satisfaction of the City of Gosnells and DWER. Demonstrate that the proposed subdivision designs are supportive of the DWMS and that water quantity and quality objectives and criteria set by this document can be achieved. Design, establish, construct, maintain and manage the stormwater management system and control measures, including the provision of a central storage/detention basin, raingardens and outfall structures, together with landscaping, until handover to the City of Gosnells: ▪ 12 months maintenance for roads and drainage; and ▪ 24 months for landscaping including raingardens. Undertakes post-development monitoring activities, reporting and rectification of the stormwater management system, if required, until handover to the City of Gosnells two years after completion of development. Transfer ground water licence to City of Gosnells at handover. Provides guidance to landowners/residences for the development of lots in accordance with the DWMS. Designs and constructs the potable water supply and sewer to Water Corporation standards.	Developer

Organization	Role/Responsibility	Funding
	Provision and implementation of a Wetland Management Plan, including a 24-month maintenance period.	
Lot Owner	Construction and management consistent with DWMS inclusive of meeting the requirements of the City of Gosnells, relevant building codes including construction and management of soakwells for onsite disposal of stormwater and compliance with waterwise programs in using water efficient fittings and household appliances.	Lot Owner
City of Gosnells	Assumes responsibility for roads and stormwater drainage infrastructure, including POS and irrigation, including the ongoing operation, maintenance and monitoring thereof subsequent to handover by the developer: ▪ 12 months maintenance for roads and drainage; and ▪ 24 months for landscaping including raingardens. Enforce construction and management of Lot Level BMP's by building licences.	Rates
Water Corporation	Assumes responsibility for the potable water supply and sewerage infrastructure including the ongoing operations and maintenance thereof.	Rates

8.3 Review

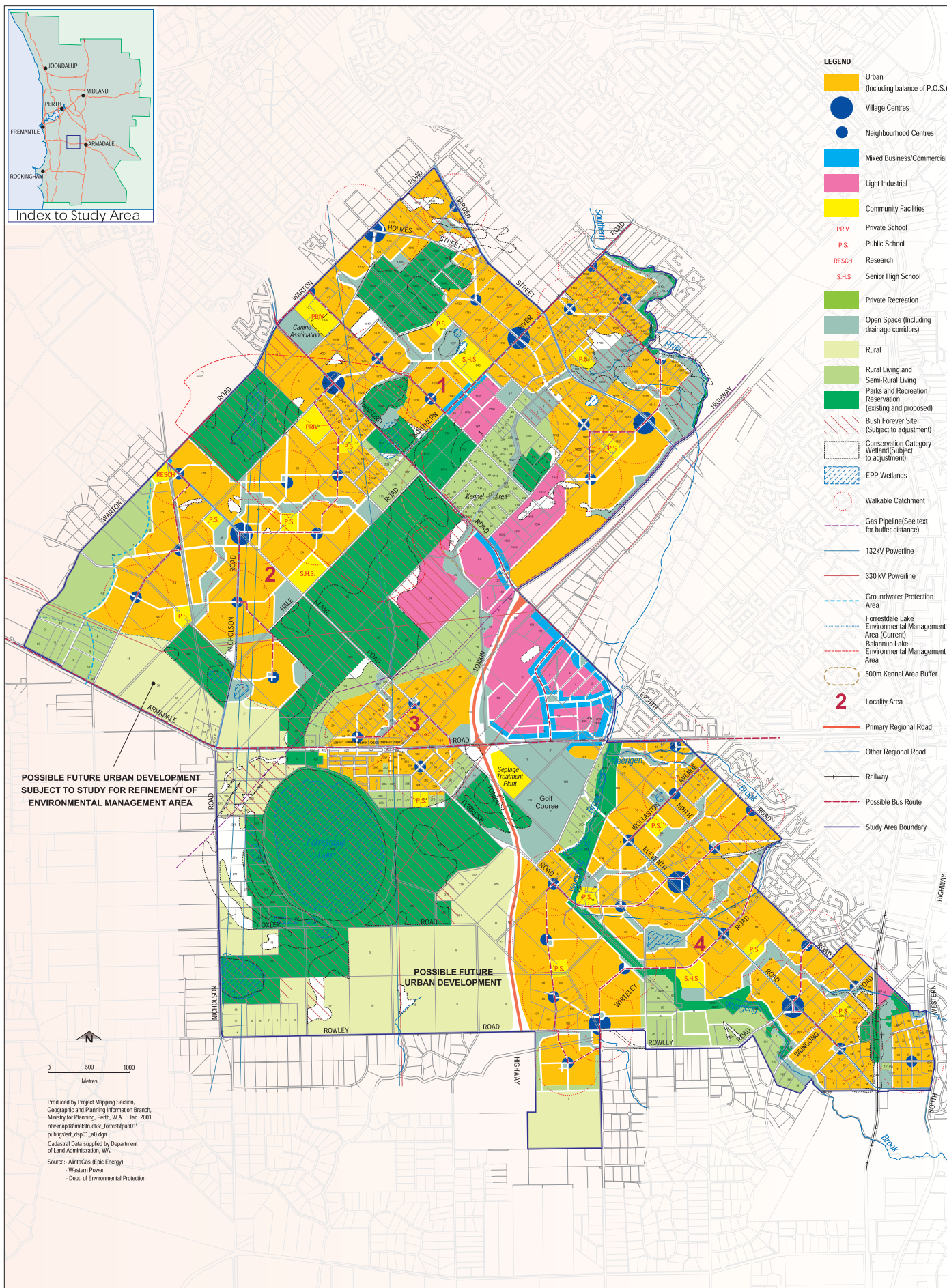
Subsequent stages of storm water management entail construction and monitoring of the stormwater management system. As such this document has been reviewed upon comment from the City of Gosnells and the Department of Water prior to commencing with construction. Monitoring is an essential component of stormwater management and is to be undertaken in strict accordance with this document. Monitoring reports, to be submitted to the City of Gosnells and DWER, are to be utilised to assess whether the stormwater management system performs in accordance with the engineering objectives and design criteria and are to form the basis for continual review and rectification/improvement, if required.

9. References

- Aurora Environmental 2018: Lots 1796 – 1798 Matison Street, Southern River, Environmental Assessment.
- ANZECC, 2000: Australian Water Quality Guidelines for Fresh and Marine Waters, National Water Quality Management Strategy, Australia and New Zealand Environment and Conservation Council (ANZECC).
- AS/NZS 5667, 1998: Series on Water Quality Sampling Guidelines.
- Department of Environment Conservation, 2009: Contaminated Sites Register.
- Department of Environment Conservation, 2008: A Guideline for the Development and Implementation of a Dust Management Program.
- Department of Environment Conservation, 2003: Contaminated Sites Management Series Assessment Levels for Soil, Sediment and Water.
- Department of Health, 2007: Chironomid Midge and Mosquito Risk Assessment Guide for Constructed Water Bodies.
- Department of Health: Contaminated Sites Reporting Guideline for Chemicals in Ground Water.
- Department Housing and Works (DHW), 2007: The Water Use in House Code (5 Star Plus).
- Department of Water, 2009: Southern River Integrated Land and Water Management Plan.
- Department of Water, 2009: Forrestdale Main Drain – Arterial Drainage Strategy
- Department of Water, 2008: Urban Water Management Plans Guidelines for Preparing Plans for Complying with Subdivision Conditions.
- Department of Water, 2004-2007: Stormwater Management Manual for Western Australia.
- Engineers Australia, 2016: Australian Rainfall Runoff (ARR) A Guide to Flood Estimation.
- Engineers Australia, 2006: Australian Runoff Quality (ARQ).
- Francesco Lombardo Engineering, 2018, Engineering Report.
- Government of Western Australia, Department of the Premier and Cabinet, 2007: State Water Plan 2007.
- Swan River Trust (SRT), 2008: Healthy Rivers Action Plan.
- Water Corporation, 2008a: Waterwise Land Development Criteria.
- Water Corporation, 2008b: H2O A Guide for Considering Alternative Water Supplies.
- Water Corporation, 2006: http://www.watercorporation.com.au/W/ waterwise_display_villages.cfm
- Water Corporation, 2003: Domestic Water Use Study in Perth, Western Australia 1998-2001.
- Water and Rivers Commission, 1997 and 2004: Perth Ground Water Atlas (1st and 2nd Editions).
- Western Australian Planning Commission (WAPC), 2008: Better Urban Water Management.
- Western Australian Planning Commission (WAPC), 2009a: Planning Bulletin 64/2009 Acid Sulfate Soils.
- Western Australian Planning Commission (WAPC), 2009b: Liveable Neighbourhoods.

Appendix 1: District Structure Plan

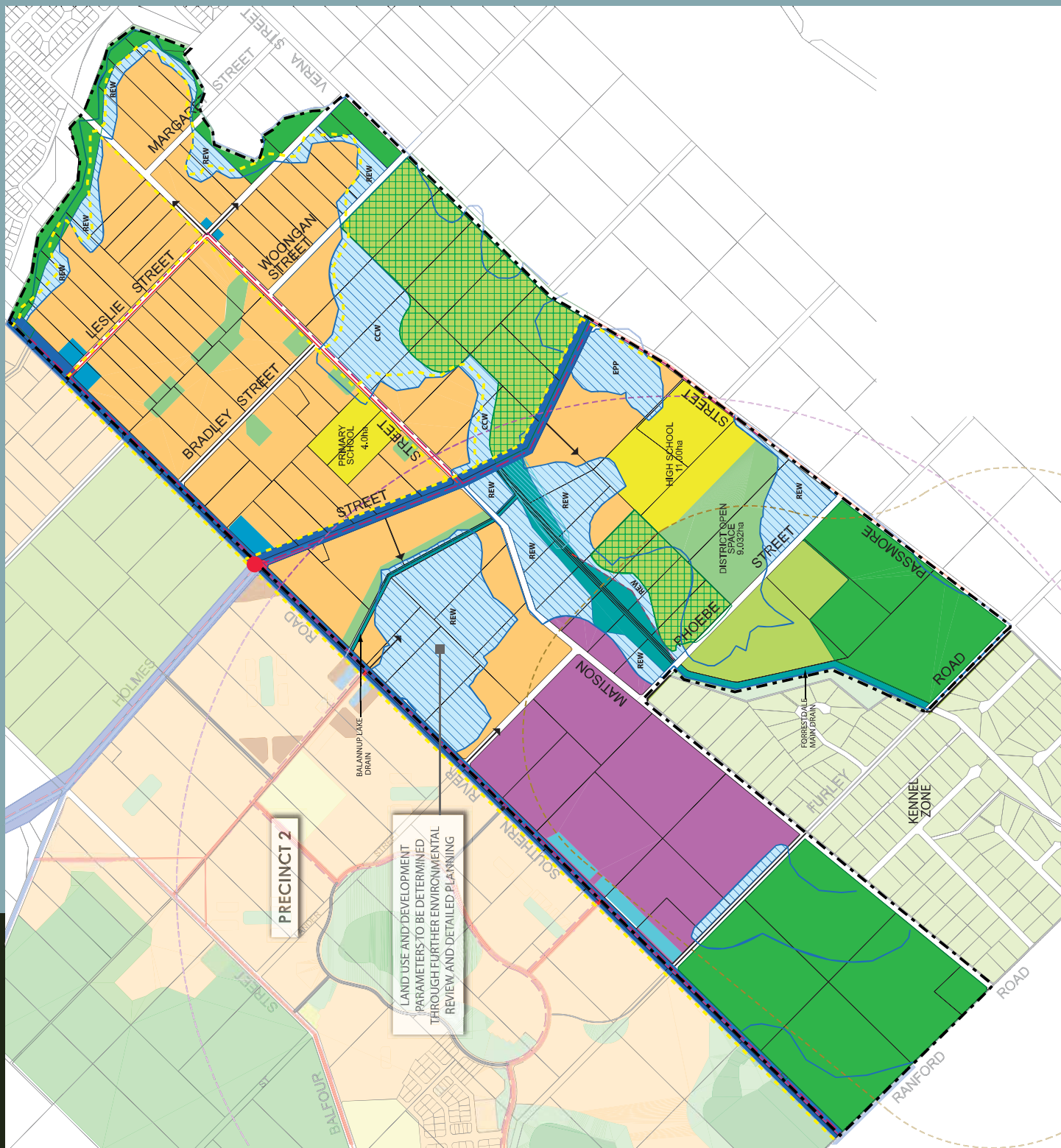
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Southern River/Forrestdale/Brookdale/Wungong District Structure Plan - 2001

Appendix 2: Southern River Precinct Stage 3 Structure Plan

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- | | |
|---|---|
|  | Residential |
|  | Local Centre |
|  | Mixed Business |
|  | Light Industry |
|  | Community Purpose (as marked) |
|  | General Rural |
|  | Bush Forever Protection Area |
|  | Open Space (Local Open Space and District Open Space) |
|  | Parks and Recreation Reservation |
|  | Widening Required For Forrestdale Main Drain |
|  | Forrestdale Main Drain / Balannup Lake Drain |
|  | 500m Kennel Buffer
(Subject to further acoustic study) |
|  | 1500m Liquid Waste Site Buffer |
|  | Other Regional Road |
|  | Neighbourhood Connector |
|  | Local Connector |
|  | Traffic Signals |
|  | Wetland (Including Buffers) denoted as follows:
EPP - Environmental Protection Policy Wetland
CCW - Conservation Category Wetland
REW - Resource Enhancement Wetland |
|  | Proposed Bus Route |
|  | Overland Flow Path |
|  | 1:100 Event Extent (50m - 100m) |
|  | Shared Paths |
|  | Precinct 3 Boundary |

- Further Local Open Space to be provided in accordance with Council and Drainage requirements.
- Extent of wetlands required for conservation to be determined through further environmental review and detailed planning.
- Medium residential densities to be provided in accordance with City of Gosnells Local Housing Strategy criteria.
- A Place of Worship is constructed on Lot 16 Southern River Road. Additional development of the site will be subject to resolution of wetland and other environmentally sensitive area protection requirements.
- Planning of the Light Industrial Area will be subject to resolution of wetland and other environmentally sensitive area protection requirements.
- A review of the existing road network will need to be considered as part of further detailed planning. This review will need to consider those roads to be retained, local intersection treatments and road upgrades required.
- The primary function of the Forrestdale Main Drain is to convey the 1:100 year flood path. The intention is for the drain to be widened and operate as a living stream. The widening of the drain will also assist in wetland protection. The interface between development and the Forrestdale Main Drain will need to be carefully considered as part of future detailed planning.

SOUTHERN RIVER PRECINCT 3 STRUCTURE PLAN

Adopted by Council: 4 June 2009 (OCM 12 May 2009)
Noted by WAPC: 15 September 2009

Appendix 3: Geotechnical Assessment (GGC, 2019)

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Geotechnical and Geological Consultants



Geotechnical Investigation Report

Proposed Residential Development Lot 1797 and 1798 Matison Street Southern River WA

GGC181715

February 2019



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Proposed Residential Development, Lot 1797 and Lot 1798 Matison Street, Southern River
Geotechnical Investigation Report

Our ref: GGC181715-R01-Rev1

Prepared for
Green Values Australia Pty Ltd

Prepared by
Geotechnical and Geological Consultants Pty Ltd
439 Vincent Street West
Leederville WA 6007

5 February 2019

Document authorisation

For and on behalf of Geotechnical and Geological Consultants Pty Ltd

James Campbell

Senior Engineering Geologist

Quality information

Revision history

Revision	Description	Date	Author	Reviewer	Signatory
Rev0	Issued to Client	1 February 2019	JC	RM	JC
Rev1	Issued to Client	5 February 2019	JC	RM	JC

Distribution

Report Status	No. of copies	Format	Distributed to	Date
Rev0	1	PDF	Green Values Australia Pty Ltd	1 February 2019
Rev0	1	PDF	Geotechnical and Geological Consultants Pty Ltd Report Library	1 February 2019
Rev1	1	PDF	Green Values Australia Pty Ltd	5 February 2019
Rev1	1	PDF	Geotechnical and Geological Consultants Pty Ltd Report Library	5 February 2019

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IMPORTANT INFORMATION SHEETS

“Your Geotechnical Report”

FIGURES

FIGURE 1 SITE INVESTIGATION PLAN

APPENDICES

APPENDIX A SUBDIVISION CONCEPT PLANS

APPENDIX B TEST PIT LOGS

APPENDIX C LABORATORY TEST RESULTS

1 Introduction

This report presents the results of a geotechnical investigation carried out by Geotechnical and Geological Consultants Pty Ltd (GGC) for Green Values Australia Pty Ltd (Green Values) on the proposed residential development located at Lot 1797 and Lot 1798 Matison Street, Southern River WA (“the site”).

This work was commissioned by Rhys Houlihan via a confirmation email dated 9 January 2019.

This report, and the information presented and herein, must be read together with the important notes included on the “*Your Geotechnical Report*” information sheets included after the main report text.

2 Site description

The site comprises a rectangular shaped parcel of land and covers a total area of about 8.3ha including a wetland area. The proposed residential lots occupy the northern portion of the site whilst the wetland area occupies the southern portion of the site.

The existing ground surface at the site undulates. Based on the topographic information, the existing ground surface levels range from about 22.4 m AHD on the north western boundary of the site to about 19.6 m AHD on the north eastern boundary.

Low-level vegetation and mature trees cover the site and number of existing access tracks are present across the site.

The extent of the proposed site is shown on the proposed concept plans included in **Appendix A**.

3 Proposed development

The proposed residential subdivision development will include the construction of 50 residential lots, associated access roads and public open space. The wetland area will be retained and incorporated into the development.

The concept plan indicates future bulk earthworks will typically require fill earthworks of up to about 2m across the site.

The proposed concept plans indicating the overall proposed subdivision layout are included as **Appendix A**.

4 Project objectives

The objectives of the geotechnical investigation were to:

- ▶ Assess subsurface soil and groundwater conditions across the site;
- ▶ Provide a preliminary site classification(s) in accordance with AS 2870-2011 “*Residential Slabs and Footings*”;
- ▶ Provide pavement design parameters for flexible pavement design (by others);
- ▶ Assess the potential to use soak wells for stormwater disposal as part of the development;
- ▶ Assess the suitability of the existing near surface soils for re-use as fill material; and
- ▶ Provide recommendations for site preparation and earthworks.

5 Available information

5.1 Client supplied information

The following information was provided and used in the compiling of this report:

- ▶ Concept Earthworks Plan, Drawing C200 Rev A, Francesco Lombardo Consulting Pty Ltd, March 2018;
- ▶ Groundwater Monitoring Sheet/Information, Lots 1797 and 1798 Matison Street, Southern River, Green Values Australia; and
- ▶ Concept Layout (Ver. 3. 1) Lots 1797 and 1798 Matison Street, Southern River Structure Plan Urbanism, 26 February 2018.

5.2 Published information

The following published information has been used in the preparation of this report:

- ▶ The 1:50 000 Environment Geology sheet (Armadale) Geological Survey of WA; and
- ▶ Department of Water Perth Groundwater Atlas (<https://maps.water.wa.gov.au/#/webmap/gwm>).

6 Fieldwork

6.1 General

Fieldwork was carried out between 14 January 2019 and comprised:

- ▶ Site walkover by a Senior Engineering Geologist from GGC;
- ▶ Eight test pits (TP1 to TP8) advanced using a rubber tyred backhoe to depths of between 2.6 m and 3.0 m below existing ground level;
- ▶ Recovery of samples for geotechnical laboratory testing;
- ▶ Perth Sand Penetrometer (PSP) Testing adjacent to each test pit to depths of 1.05m below ground level;
- ▶ Hand auger boreholes and infiltration testing at four locations across the site; and
- ▶ On-site logging by a Senior Engineering Geologist from GGC.

The investigation locations were measured during the fieldwork by hand-held GPS relative to Geocentric Datum of Australia (GDA).

Surface elevations were not recorded by GGC, all depths referenced are in metres below existing ground level.

Approximate investigation locations are shown on the Site Investigation Plan, **Figure 1**, attached to this report.

6.2 Test Pitting

A total of eight test pits (TP1 to TP8) were excavated to depths of between about 2.6 m to 3.0 m below existing ground surface using a backhoe operated by Allwest Plant Hire Pty Ltd. Disturbed samples of the encountered soils were recovered from the test pits for laboratory testing.

On completion, each test pit was backfilled with spoil to the existing ground level.

The test pit logs showing the major strata intersected, together with explanatory notes and the depths at which samples were recovered are included together with explanatory notes in **Appendix B**.

6.3 Penetrometer Testing

Perth Sand Penetrometer (PSP) testing was carried out at eight locations adjacent to TP1 to TP8. PSP tests were undertaken to depths of 1.05 m below the existing ground surface. The PSP tests were completed in general accordance with AS 1289.6.3.3.

The tabulated results for the PSP testing are included with the test pit logs in **Appendix B**.

6.4 Infiltration Testing

Four infiltration tests (I1 to I4) were completed in hand augured boreholes adjacent to TP1, TP2, TP4 and TP8. The locations were selected to provide infiltration rates which are generally considered representative of the site as a whole. The infiltration tests were completed using the “*Inverse Auger Hole Method*” described by Cocks (2007). The results of the infiltration testing are summarised in Table 1.

Table 1 – Summary of Falling Head Infiltration Tests

Test Reference and Location	Stratigraphy	Depth to base of test (m) [#]	Minimum Unsaturated Permeability, k (m/day) [*]
I1 (TP1)	SAND	0.89	>10 [@]
I2 (TP2)	SAND	0.80	7
I3 (TP4)	SAND	0.80	5
I4 (TP8)	SAND	0.87	10

Notes: [#] All depths are relative to existing ground surface. Hand auger boreholes were completed to about 1.0m depth, however upon infiltration testing material washed into the base of the borehole resulting in a depth to base of test less than 1.0m as shown in the table above.

^{*} Minimum unsaturated permeability estimates shown were recorded at the end of the test when head pressure lowest.

[@] Permeabilities in excess of 10m/day are not reported due to inaccuracy of the test method at very high permeability.

7 Description of laboratory testing

Geotechnical laboratory testing was carried out in accordance with the general requirements of AS 1289 by Material Consultants at their NATA registered soils laboratory in Perth.

A summary of the testing completed for this study is presented in Table 2 and the laboratory test certificates are included in **Appendix C**.

Table 2 – Extent of Laboratory Testing

Type of Test	Test Method Reference	Number of Tests Completed
Particle Size Distribution	AS1289.3.6.1	6
Atterberg Consistency Limits (Liquid Limit, Plastic Limit, Plasticity Index, and Linear Shrinkage)	AS1289.3.1.1-3.4.1	1
Modified Compaction (MMDD)	AS1289.5.2.1	1
California Bearing Ratio (Soaked)	AS 1289.6.1.1	1

8 Site conditions

8.1 Published Geological Information

The 1:50,000 Environmental Geology Series map (Armadale) indicates that the site is expected to be underlain by the following:

- ▶ S₈ – Sand: White to pale grey at the surface, yellow at depth, fine to medium grained, moderately sorted, subangular to subrounded, minor heavy minerals of eolian origin. Bassendean Sand; and
- ▶ S₁₀ – Sand, – As S₈ (above) overlying Clayey Sand of the Guildford Formation Sand.

8.2 Published and Client Supplied Groundwater Information

Historic maximum groundwater contours included on the Perth Groundwater Map indicate that the highest groundwater levels at the site were RL 20m AHD. This is at, or up to about 2m below current ground levels across the site.

Client supplied groundwater information indicates groundwater levels range from between about 18m AHD to 20m AHD across the site.

8.3 Encountered subsurface conditions

8.3.1 General site

The subsurface conditions encountered during the GGC investigation fieldwork were generally consistent with the published information and client supplied information and are as follows:

- ▶ A thin Topsoil layer was encountered from the ground surface to depths of between 0.1 m and 0.4m below ground level within the test pit completed across the site;
- ▶ Bassendean Sand (SW), typically fine to coarse grained, moist to wet, to depths of between 1.2 m and the maximum depth of the test pits (2.8m) was encountered directly beneath the Topsoil layer within all test pits across the site;
- ▶ The Bassendean Sand was typically underlain by Clayey Sand (SC) of the Guildford Formation typically comprising fine to coarse grained Sand and low plasticity Clay, moist to wet; and
- ▶ Ferricrete Rock (Coffee Rock) typically comprising, fine to coarse grained, iron cemented sand, very low to medium strength rock was generally encountered at the Bassendean Sand/ Guildford Formation interface or within the Bassendean Sand within all test pits at depths of between 1.2m to 2.6m.

8.3.2 Groundwater Levels

Groundwater was encountered within several test pits across the site as outlined in the **Table 3** below.

Table 3 – Groundwater Levels

Location	Depth to water (m) *	Date Recorded
TP1	2.2	14 January 2019
TP2	Not Encountered	14 January 2019
TP3	2.8	14 January 2019
TP4	2.8	14 January 2019
TP5	Not Encountered	14 January 2019
TP6	Not Encountered	14 January 2019
TP7	2.6	14 January 2019
TP8	2.6	14 January 2019

Notes: * All depths recorded relative to existing ground level at time of investigation

It should be noted that groundwater levels will vary over time in response to environmental factors, including rainfall, temperature, and other factors.

8.4 Results of Laboratory Testing

The results of the laboratory testing completed on samples recovered from test pits during the investigation fieldwork are summarised in **Table 4**

Table 4 – Summary of Laboratory Test Results

Location Reference	Depth from (m)*	Depth to (m)*	Particle Size Distribution			Consistency Limit Atterberg				CBR (%)	OMC (%)	MMDD (t/m ³)
			% Gravel	% Sand	% Fines	Liquid Limit %	Plastic Limit %	Plasticity Index %	Linear Shrinkage %			
TP1	0.2	1.5	0	95	5	-	-	-	-	19	12.5	1.75
TP2	0.3	1.0	0	97	3	-	-	-	-	-	-	-
TP4	0.5	1.0	0	96	4	-	-	-	-	-	-	-
TP6	2	2.8	0	76	24	29	15	14	1.5	-	-	-
TP7	1.5	2.0	4	89	7	-	-	-	-	-	-	-
TP8	0.4	1.0	0	96	4	-	-	-	-	-	-	-

Notes: * All depths measured relative to existing surface level
California Bearing Ratio (CBR) are soaked and remoulded to a dry density ratio of 95% MMDD, 4.5kg surcharge
OMC – Modified Optimum Moisture Content
MMDD –Modified Maximum Dry Density

9 Geotechnical assessment

9.1 Site classification

The site classification system included in AS2870-2011 is applicable only to one and two storey residential buildings, or structures of similar size, structural articulation and loading. The footing details and inferred soil movement associated with AS2870-2011 are not applicable to larger structures, taller structures or structures with heavier loading to than found in single residential buildings.

“A-Class” site classifications typically require a minimum thickness of the 1.8 m of inert granular material below finished subdivision design levels. This inert granular material can comprise natural soils (such as clean sands) or approved imported inert granular material.

Based on current site conditions and following topsoil strip we consider the site comprises an “A-Class” site classification, in accordance with AS2870-2011.

In order to achieve the required site classification, the site preparation works detailed in the following sections must be completed as part of the proposed development and that recommendations for the selection, placement and compaction of approved engineered fill be adopted.

9.2 Recommended Site Preparation Measures

The following site preparation measures are aimed at achieving the required site classification for future residential lots. Recommended site preparation works include:

- ▶ Remove any uncontrolled fill, deleterious materials from across the site;
- ▶ Strip all topsoil and grub out all vegetation from proposed development areas, including removal of roots and stumps, to expose the underlying subgrade and natural sand soils;
- ▶ Stockpile excavated materials for possible re-use (subject to approval by a geotechnical engineer), or arrange for disposal of unsuitable/ deleterious materials to a suitably licensed facility; and
- ▶ Proof compact the exposed natural sand/cut surface to a Dry Density Ratio (DDR) of 95% Maximum Modified Dry Density (MMDD) to a depth of at least 1 m. Where proof compaction reveals ‘soft spots’ or ‘loose zones’ these must be excavated and backfilled with granular fill and compacted to 95% MMDD.

Where fill is required to build up site levels, place approved structural fill in accordance with Section 9.4.

It should be noted that compaction within 1 m of groundwater table is likely to be difficult. We recommend that earthworks be undertaken during summer months to avoid potential problems achieving compaction close to the groundwater table.

9.3 Assessment of Excavated Sand Materials of Re-use as Structural Fill

The natural occurring in situ clean Sand material is considered suitable for reuse as structural fill.

Any sand used for structural filling should be clean, cohesionless, free draining and free of all silty, organic or any other deleterious inclusions.

9.4 Imported Granular Fill and Site-Won Clean Sand (Structural Fill)

Imported granular fill (Approved Structural Fill) and site-won clean Sand used to build up levels across the site must be compacted using suitable plant and equipment to a dry density ratio of at least 95% MMDD as determined in accordance with AS1289.5.2.1.

Where sand with less than 5% fines is used, and the Perth Sand Penetrometer can be used for compaction control, the following minimum blow counts may be assumed to correlate approximately to a dry density ratio of 95% MMDD:

- ▶ Depth Range 0.0-0.15 m: SET;
- ▶ Depth Range 0.15-0.45 m: 8 blows;
- ▶ Depth Range 0.45 - 0.75 m: 10 blows; and
- ▶ Depth Range 0.75 - 1.05 m: 12 blows.

Whilst the above can be used as a general guide for naturally occurring Perth sands with less than 5% fines, experience indicates that correlation variations do occur. It is therefore recommended that a site-specific PSP/ dry density correlation is undertaken for each material source used on this project.

Over excavation and replacement with approved granular fill may be required where the minimum dry density cannot be achieved. If compaction difficulties are noted, the advice of an experienced geotechnical engineer should be sought.

After compaction, verification testing is required to confirm the level of compaction that has been achieved by testing to a minimum depth of 1.05 m:

- ▶ On each lift of fill on a 10 m grid;
- ▶ At each spread footing location;
- ▶ At 5 m centres along gravity retaining wall footings and all strip footings (where present); and
- ▶ At 10 m centres below on-ground slabs and pavements.

Fill must be placed in horizontal layers not exceeding 300 mm loose lift thickness (depending on the compaction plant adopted). Each layer must be compacted by suitable compaction equipment, and carefully controlled to ensure even compaction over the full area and depth of each layer.

9.5 Approved Imported Fill

Imported granular fill must be placed and compacted to achieve a minimum dry density ratio of 95% MMDD and must comply with the material requirements of AS3798-2007 *“Guidelines on Earthworks for Commercial and Residential Developments”*. Sand fill must comprise clean-sand that is free of organic matter and must have a fines content of less than 5%.

9.6 Flexible Pavements

We recommend the CBR for pavement thickness design for naturally occurring Sand compacted to 95% MMDD is 12%.

The recommended CBR value assumes that the subgrade will be prepared and compacted in accordance with the recommendations noted above to a depth of at least 0.5 m below top of subgrade level.

9.7 Stormwater Disposal

Soak wells are traditionally used in suitable free draining sands where the ground surface is at least 1.5m above the Average Annual Maximum Groundwater Level (AAMGL). Drainage design will therefore need to consider the depth to groundwater across the site, as soakwells typically become less efficient where groundwater is within 1m of the base of the soakwell. Should the base of any soakwells be within 1 m of the groundwater, permeability rates should be expected to reduce (possibly significantly) during and following storm events and in winter months.

We consider, provided finished ground levels at the site are greater than 1.5 m above the Average Annual Maximum Groundwater Level (AAMGL) and the base of the soakwells are at least 1.0m above groundwater design level, the site is generally suitable for on-site disposal of stormwater by infiltration using soakwells.

Based on assessment of site infiltration rates, we recommend a design permeability value (k) for in-situ sand soils of no greater than 5m/day to allow for the variability in materials and reduced permeability's as a consequence of:

- ▶ Densification of sand during site preparation works;
- ▶ Natural variability in the Sands; and
- ▶ Clogging of the sand around soakwells over time with fines.

Soakwells should be positioned a minimum distance of 2 m from footings and ground bearing slabs (subject to council regulations). Discharge from soak wells can cause local densification of loose sandy soils, leading to settlement of footings and slabs overtime.

If soakwells are positioned closer than 2 m to building footings and slabs, consideration can be given to wrapping the soak well with a non-woven separation geotextile, but the specification for the geotextile must be provided by an experienced geotechnical engineer.

We also recommend a minimum separation spacing of at least 10 m between individual soak wells at this site. This minimum distance is intended to reduce the potential for reducing the local permeability and interaction between the soak wells that may reduce the effectiveness of soakage.

9.7.1 Cemented materials and Ferricrete (coffee rock)

It is important to note that cemented materials and ferricrete (coffee rock) were identified in test locations across the site. These materials are considered relatively impermeable and unsuitable for soakwell installation.

It is recommended that a depth of at least 1 m of Sand with less than 5% fines be present beneath the base of all soak wells and that the base of soak wells are at least 1 m above the groundwater table. Where cemented materials and ferricrete (Coffee Rock) material is present above this depth, it should be over-excavated to the full depth of influence and replaced with approved free draining granular fill prior to installation of soak wells.

9.7.2 Imported Sand Soils

We recommend a required design permeability value (k) for imported sand soils be least of 10 m/day.

9.7.3 General

We recommend that further in situ infiltration testing be conducted following bulk earthwork operations and prior to soak well installation to assess the soak well suitability at the site.

10 Important information about your GGC geotechnical report

The reader's attention is drawn to the important information about this report which follows the main text.

11 References

The following published information sources have been reviewed by GGC in compiling this report:

- ▶ Standards Australia (2017) “Geotechnical Site Investigations” Australian Standard AS1726-2017.
- ▶ Standards Australia (2011) “Residential Slabs and Footings” Australian Standard AS2870 – 2011.
- ▶ Standards Australia (2007) “Guidelines on Earthworks for Commercial and Residential Developments” Australian Standard AS3798 – 2007.
- ▶ Cocks, G (2007), Journal and News of Australian Geomechanics Society, Volume 42 No. 3 pp 101-114 “Disposal of Stormwater Runoff by Soakage in Perth Western Australia.
- ▶ Armadale (1986), Sheet SH 2033 I and part of SH 2133 IV. (1:50,000 scale) Environmental Geological Series, Geological Survey of Western Australia.
- ▶ Department of Water, online Perth Groundwater Maps, (<http://maps.water.wa.gov.au/#/webmap/gwm>).

FIGURE 1

SITE INVESTIGATION PLAN



APPENDIX A

SUBDIVISION CONCEPT PLANS



APPENDIX B

TEST PIT LOGS

EXPLANATORY NOTES - SOIL DESCRIPTION

	FILL		SAND (SP OR SW)		CLAY (CL, CI OR CH)		COBBLES OR BOULDERS
	GRAVEL (GP OR GW)		SILT (ML OR MH)		ORGANIC SOILS (OL, OH OR PT)		

Combinations of these basic symbols can be used to indicate mixed materials (eg. Clayey Gravel)

GP	Poorly Graded Gravel	SM	Silty Sand	CH	High Plasticity Clay
GW	Well Graded Gravel	SC	Clayey Sand	OL	Organic Soils (LP)
GM	Silty Gravel	ML	Low Plasticity Silt	OH	Organic Soils (HP)
GC	Clayey Gravel	MH	High Plasticity Silt	PT	Peat
SP	Poorly Graded Sand	CL	Low Plasticity Clay	Describe	Cobbles and Boulders
SW	Well Graded Sand	CI	Medium Plasticity Clay	Fill	Fill

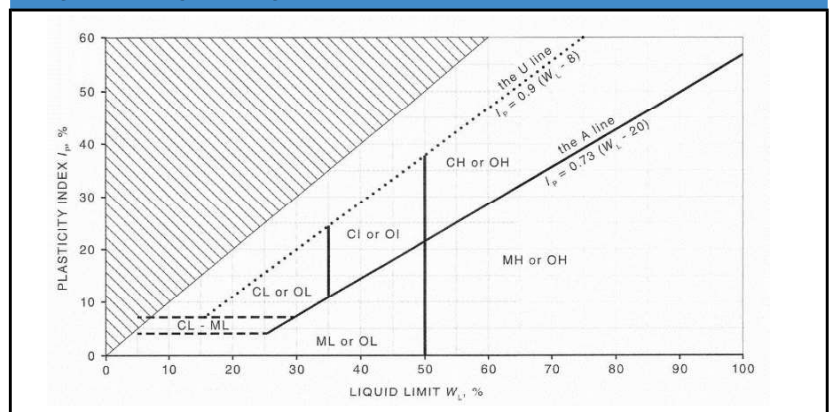
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726:2017, Section 6.2. Material properties are assessed in the field by visual/tactile methods in combination with field testing techniques (where used).

PARTICLE SIZE

Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	20 to 63
	Medium	6 to 20
	Fine	2 to 6
SAND	Coarse	0.6 to 2.0
	Medium	0.2 to 0.6
	Fine	0.075 to 0.2
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY PROPERTIES



MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties if primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

RESISTANCE TO EXCAVATION

Symbol	Term	Description
VE	Very easy	All resistances are relative to the selected method of excavation.
E	Easy	
F	Firm	
H	Hard	
VH	Very hard	

MOISTURE CONDITION

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays and silts may be brittle or friable and powdery
M	Moist	Soils are darker than in the dry condition and may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY

Symbol	Term	Undrained Shear Strength (kPa)	SPT "N"	DCP blows per 100mm	Symbol	Term	Density Index (%)	SPT "N"	DCP blows per 100mm	PSP blows per 300mm
VS	Very soft	0 to 12	0 to 2	<1	VL	Very Loose	<15	0 to 4	<1	0 to 2
S	Soft	12 to 25	2 to 4	<1	L	Loose	15 to 35	4 to 10	1 to 2	2 to 6
F	Firm	25 to 50	4 to 8	1 to 2	MD	Medium Dense	35 to 65	10 to 30	2 to 3	6 to 8
St	Stiff	50 to 100	8 to 15	3 to 4	D	Dense	65 to 85	30 to 50	4 to 8	8 to 15
VSt	Very Stiff	100 to 200	15 to 30	5 to 10	VD	Very Dense	>85	>50	>8	>15
H	Hard	>200	>30	>10	Note: PSP correlations only valid 450mm depth					

Consistency and density may also be inferred from excavation performance and material behaviour.

Explanatory Notes - Rock Description

Rock Substance

Rock Name: Common rock names are used in preference to more detailed geological descriptions used in the mining industry.

Particle Size (generalised)

	Sedimentary (Sandstone)	Igneous and Metamorphic
Coarse Grained	0.6mm to 2mm	2mm to >20mm
Medium Grained	0.2mm to 0.6mm	0.06mm to 2mm
Fine Grained	0.06mm to 0.2mm	0.002mm to 0.06mm

Fabric (Terms for layering of the rock mass)

Massive	No layering (homogeneous and isotropic)
Indistinct	Layering is just visible (does not affect rock properties)
Distinct	Layering readily visible (rock breaks parallel to layering)

Weathering Classification

Term	Symbol	Definition
Residual Soil	RS	Soil derived from extremely weathered rock; the mass structure and fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered	XW	Material is weathered to such an extent that it has soil properties, ie. disintegrates or can be remoulded. Original rock fabric is evident.
Highly Weathered*	HW	Rock strength is typically changed by weathering. The rock is discoloured by staining or bleaching. Some minerals are decomposed to clays. Porosity may be increased by leaching or may be increased by the depositing of minerals in pores.
Moderately Weathered*	MW	Rock strength is typically changed by weathering. The rock is discoloured by staining or bleaching such that the colour of the fresh rock is no longer recognisable.
Slightly Weathered	SW	The rock is slightly discoloured but shows little to no change in strength from that of the fresh rock
Fresh	FR	Rock shows no sign of decomposition or staining.

Note: The term Distinctly Weathered (DW) may be used where it is not possible to delineate between the weathering conditions of HW and MW.

Strength of Rock Materials

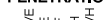
Term	Symbol	Point Load Index (MPa) Is_{50}	Field Guide
Very Low	VL	$>0.03 \leq 0.1$	Material crumbles under firm blows with the sharp end of a pick; can be peeled with knife; pieces up to 3cm thick can be broken by finger pressure.
Low	L	$>0.1 \leq 0.3$	Easily scored with a knife; indentations 1mm to 3mm show with firm blows of a pick point; has dull sound under hammer. A piece 150mm long by 50mm diameter. May be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	M	$>0.3 \leq 1.0$	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	H	$>1.0 \leq 3$	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rings under a hammer.
Very High	VH	$>3 \leq 10$	Hand specimen breaks with many blow of a pick to break intact material; rings under a hammer.
Extremely High	EH	>10	Hand specimen breaks with more than one blow of a pick; rings under a hammer.

PAGE: 1 OF 1

PROJECT LOCATION: **Southern River, WA**



CHECKED BY: **RAM**

METHOD	PENETRATION	SAMPLES & FIELD TESTS	CLASSIFICATION SYMBOLS & SOIL DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY
N Natural Exposure		U - Undisturbed Sample	Based on Unified Classification System	VS - Very Soft
X Existing Excavation		D - Disturbed Sample		S - Soft
BH Backhoe Bucket		B - Bulk Disturbed Sample		F - Firm
B Bulldozer Blade		MC - Moisture Content		St - Stiff
R Ripper		HP - Hand Penetrometer (UCS kPa)	MOISTURE D - Dry M - Moist W - Wet	VSt - Very Stiff
		VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)		H - Hard
		PBT - Plate Bearing Test		Fr - Friable
				VL - Very Loose
				L - Loose
				MD - Medium Dense
				D - Dense
				VD - Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

TEST PIT NUMBER: TP02

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PROJECT NUMBER: GGC181715

PROJECT NAME: Lot 1797 & 1798 Matison St

PROJECT LOCATION: Southern River, WA



Geotechnical and Geological Consultants

DATUM: MGA94 Zone 50

EQUIPMENT: 590R Backhoe

DATE STARTED: 14/01/2019

ELEVATION:

EXCAVATION LENGTH: 2.5 m

DATE COMPLETED: 14/01/2019

EASTING (m): 403252

EXCAVATION WIDTH: 1 m

LOGGED BY: JC

NORTHING (m): 6447947

EXCAVATION ORIENTATION:

CHECKED BY: RAM

EXCAVATION								MATERIAL						
PENETRATION		SUPPORT	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	Elevation (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations		
VE	F												H	
					0.0				TOPSOIL: Fine to coarse grained sand, sub-angular to sub-rounded, dark grey, trace of organic fines, non-plastic	D		0.00: Occasional rootlet up to 20mm in diameter between 0.0m - 0.75m.		
				0.30m					SAND: Fine to coarse grained, sub-angular to sub-rounded, grey, trace fines, non-plastic					
				B	0.5			SW			MD			
				1.00m	1.0				 Becoming dark grey at 1.1m.					
					1.5				FERRICRETE: Low to medium strength, fine to coarse grained iron cemented sand in sand matrix, trace of fines, non-plastic, dark orange brown and dark brown mottled.	M		1.20: Ferricrete recovered as mixture of sand, gravel, cobbles and boulders.		
					2.0									
				2.10m	2.0				CLAYEY SAND: Fine to coarse grained sand, sub-angular to sub-rounded, pale grey/pale orange and brown mottled, clay low plasticity, trace of fine to medium grained gravel, sub-angular to sub-rounded.					
				B	2.5			SC						
				2.80m	2.80m				Hole Terminated at 2.80 m Target depth					
					3.0									
					3.5									
METHOD				PENETRATION			SAMPLES & FIELD TESTS			CLASSIFICATION SYMBOLS & SOIL DESCRIPTION		CONSISTENCY/ RELATIVE DENSITY		
N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper				 No Resistance			U - Undisturbed Sample D - Disturbed Sample B - Bulk Disturbed Sample MC - Moisture Content HP - Hand Penetrometer (UCS kPa) VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa) PBT - Plate Bearing Test			Based on Unified Classification System				
SUPPORT				WATER						MOISTURE				
T Timbering				 10 Oct, 73 Water Level on Date shown water inflow water outflow						D - Dry M - Moist W - Wet		VS - Very Soft S - Soft F - Firm St - Stiff VSt - Very Stiff H - Hard Fr - Friable VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense		

METHOD N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper SUPPORT T Timbering		PENETRATION WATER 10 Oct, 73 Water Level on Date shown water inflow water outflow		SAMPLES & FIELD TESTS U - Undisturbed Sample D - Disturbed Sample B - Bulk Disturbed Sample MC - Moisture Content HP - Hand Penetrometer (UCS kPa) VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa) PBT - Plate Bearing Test		CLASSIFICATION SYMBOLS & SOIL DESCRIPTION Based on Unified Classification System MOISTURE D - Dry M - Moist W - Wet		CONSISTENCY/ RELATIVE DENSITY VS - Very Soft S - Soft F - Firm St - Stiff VSt - Very Stiff H - Hard Fr - Friable VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense	
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See Explanatory Notes for details of abbreviations & basis of descriptions.

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TEST PIT NUMBER: TP03

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PROJECT NUMBER: GGC181715

PROJECT NAME: Lot 1797 & 1798 Matison St

PROJECT LOCATION: Southern River, WA



Geotechnical and Geological Consultants

DATUM: MGA94 Zone 50

EQUIPMENT: 590R Backhoe

DATE STARTED: 14/01/2019

ELEVATION:

EXCAVATION LENGTH: 2.5 m

DATE COMPLETED: 14/01/2019

EASTING (m): 403216

EXCAVATION WIDTH: 1 m

LOGGED BY: JC

NORTHING (m): 6447987

EXCAVATION ORIENTATION:

CHECKED BY: RAM

EXCAVATION					MATERIAL				
VE E F H	SUPPORT	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m) Elevation (m AHD)	GRAPHIC LOG CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY/ RELATIVE DENSITY	STRUCTURE & Other Observations
				0.0		TOPSOIL: Fine to coarse grained sand, sub-angular to sub-rounded, dark grey, trace of non-plastic organic fines.	D		0.00: Abundant roots ranging from 10mm to 60mm diameter present between 0.0m - 0.5m.
				0.50m		SAND: Fine to coarse grained, sub-angular to sub-rounded, grey, trace fines non-plastic.			
			B	1.0	SW	 Becoming dark grey at 1.3m.			
				1.20m		FERRICRETE: Low to medium strength, patchy fine to coarse grained iron cemented sand in sand matrix, dark orange brown and dark brown mottled.	M		1.40: Water observed seeping in at base of Ferricrete layer.
				1.5					
				2.0					
				2.5	SC	SANDY CLAY: Low plasticity, fine to coarse grained sand, sub-angular to sub-rounded, pale grey and pale orange mottled, trace of fine grained gravel, sub-angular to sub-rounded.			
				3.0		Hole Terminated at 3.00 m Target depth	W		
				3.5					

METHOD	PENETRATION	SAMPLES & FIELD TESTS	CLASSIFICATION SYMBOLS & SOIL DESCRIPTION Based on Unified Classification System	CONSISTENCY/ RELATIVE DENSITY
N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper		U - Undisturbed Sample D - Disturbed Sample B - Bulk Disturbed Sample MC - Moisture Content HP - Hand Penetrometer (UCS kPa) VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa) PBT - Plate Bearing Test	D - Dry M - Moist W - Wet	VS - Very Soft S - Soft F - Firm St - Stiff VSt - Very Stiff H - Hard Fr - Friable VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense
SUPPORT T Timbering				

See Explanatory Notes for details of abbreviations & basis of descriptions.

JDS181715.GPJ 01/02/2019 15:16 10.0.000 Digged Lab and In Situ Test - DGD [Lib: JDS1 1.00 2015-12-09] JDS1 1.00 2015-12-09

TEST PIT NUMBER: TP04

PAGE: 1 OF 1

PROJECT NUMBER: GGC181715

PROJECT NAME: Lot 1797 & 1798 Matison St

PROJECT LOCATION: Southern River, WA



Geotechnical and Geological Consultants

DATUM: MGA94 Zone 50

EQUIPMENT: 590R Backhoe

DATE STARTED: 14/01/2019

ELEVATION:

EXCAVATION LENGTH: 2.5 m

DATE COMPLETED: 14/01/2019

EASTING (m): 403170

EXCAVATION WIDTH: 1 m

LOGGED BY: JC

NORTHING (m): 6447950

EXCAVATION ORIENTATION:

CHECKED BY: RAM

EXCAVATION					MATERIAL				
VE E F H	SUPPORT	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY/ RELATIVE DENSITY
				0.0			TOPSOIL: Fine to coarse grained sand, sub-angular to sub-rounded, dark grey, trace of non-plastic organic fines.	D	Occasional roots/rootlets ranging from 1mm to 20mm in diameter between 0.0m - 0.5m.
				0.15m			SAND: Fine to coarse grained, sub-angular to sub-rounded, grey, trace fines, non-plastic.		0.00: Occasional roots/rootlets ranging from 1mm to 20mm in diameter between 0.0m - 0.5m.
				0.50m					
				0.5					
				1.0					
				1.50m					
				1.5					
				2.0					
				2.5					
				2.80m					
				3.0					
				3.5					

METHOD	PENETRATION	SAMPLES & FIELD TESTS	CLASSIFICATION SYMBOLS & SOIL DESCRIPTION	CONSISTENCY/RELATIVE DENSITY
N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper		U - Undisturbed Sample D - Disturbed Sample B - Bulk Disturbed Sample MC - Moisture Content HP - Hand Penetrometer (UCS kPa) VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa) PBT - Plate Bearing Test	Based on Unified Classification System MOISTURE D - Dry M - Moist W - Wet	VS - Very Soft S - Soft F - Firm St - Stiff VSt - Very Stiff H - Hard Fr - Friable VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

JDS1 LIBRARY REV 2.0 CLB Log JDS1 TEST PIT JDS181715.GPJ --Drawing File--> 01/02/2019 15:16 10.0.000 Dated Lab and In Situ Test - DGD [Lib: JDS1 1.00 2015-12-09 Proj: JDS1 1.00 2015-12-09]

TEST PIT NUMBER: TP05

PAGE: 1 OF 1

PROJECT NUMBER: GGC181715

PROJECT NAME: Lot 1797 & 1798 Matison St

PROJECT LOCATION: Southern River, WA



Geotechnical and Geological Consultants

DATUM: MGA94 Zone 50

EQUIPMENT: 590R Backhoe

DATE STARTED: 14/01/2019

ELEVATION:

EXCAVATION LENGTH: 2.5 m

DATE COMPLETED: 14/01/2019

EASTING (m): 403302

EXCAVATION WIDTH: 1 m

LOGGED BY: JC

NORTHING (m): 6447988

EXCAVATION ORIENTATION:

CHECKED BY: RAM

EXCAVATION					MATERIAL				
VE E F H	SUPPORT	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m) Elevation (m AHD)	GRAPHIC LOG CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY/ RELATIVE DENSITY	STRUCTURE & Other Observations
	Not Encountered		B	0.0		TOPSOIL: Fine to coarse grained sand, sub-angular to sub-rounded, dark grey, trace of non-plastic organic fines.	D		0.00: Roots and rootlet ranging from 1mm to 30mm diameter present from 0.0m - 0.5m.
				0.5		SAND: Fine to coarse grained, sub-angular to sub-rounded, grey, trace fines, non-plastic		D to MD	
				1.00m					
				1.5		FERRICRETE: Very low strength, patchy, fine to coarse grained iron cemented sand in sand matrix, orange and brown mottled. SAND: Fine to coarse grained, sub-angular to sub-rounded, grey, trace fines, non-plastic Becoming brown at 1.5m.	M		
				2.00m		CLAYEY SAND: Fine to coarse grained sand, sub-angular to sub-rounded, pale grey/green grey and brown mottled. Clay, low plasticity.			2.00: Water observed seeping from top of clayey sand layer.
				2.5					
				3.0					
				3.5		Hole Terminated at 2.60 m Target depth			

METHOD N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper SUPPORT T Timbering		PENETRATION WATER 10 Oct., 73 Water Level on Date shown water inflow water outflow		SAMPLES & FIELD TESTS U - Undisturbed Sample D - Disturbed Sample B - Bulk Disturbed Sample MC - Moisture Content HP - Hand Penetrometer (UCS kPa) VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa) PBT - Plate Bearing Test		CLASSIFICATION SYMBOLS & SOIL DESCRIPTION Based on Unified Classification System MOISTURE D - Dry M - Moist W - Wet		CONSISTENCY/ RELATIVE DENSITY VS - Very Soft S - Soft F - Firm St - Stiff VSt - Very Stiff H - Hard Fr - Friable VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense	
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See Explanatory Notes for details of abbreviations & basis of descriptions.

JDS1 LIBRARY (REV 2.0) Log JDS1 TEST PIT JDS181715.GPJ - Drawing File -> 01/02/2019 15:18 10.0.000 Digitized Lab and In Situ Test - DGD [Lib: JDS1 1.00 2015-12-09 Proj: JDS1 1.00 2015-12-09]

TEST PIT NUMBER: TP06

PAGE: 1 OF 1

PROJECT NUMBER: GGC181715

PROJECT NAME: Lot 1797 & 1798 Matison St

PROJECT LOCATION: Southern River, WA



Geotechnical and Geological Consultants

DATUM: MGA94 Zone 50

EQUIPMENT: 590R Backhoe

DATE STARTED: 14/01/2019

ELEVATION:

EXCAVATION LENGTH: 2.5 m

DATE COMPLETED: 14/01/2019

EASTING (m): 403349

EXCAVATION WIDTH: 1 m

LOGGED BY: JC

NORTHING (m): 6447946

EXCAVATION ORIENTATION:

CHECKED BY: RAM

EXCAVATION					MATERIAL							
VE E F H		SUPPORT	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	Elevation (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
		Not Encountered		0.0			0.15m	TOPSOIL: Fine to coarse grained sand, sub-angular to sub-rounded, dark grey, trace of non-plastic organic fines.	D	MD to D	0.00: Roots and rootlets up to 90mm diameter observed between 0.0m - 0.4m.	
				0.50m	0.5		SW		SAND: Fine to coarse grained, sub-angular to sub-rounded, grey, trace fines, non-plastic.			M
				1.00m	1.0							
				1.50m	1.5			1.40m	 Becoming dark grey at 1.3m.			
								1.70m	FERRICRETE: Very low strength, patchy, fine to coarse grained iron cemented sand in sand matrix.			
				2.00m	2.0		SW		SAND: Fine to coarse grained, sub-angular to sub-rounded, grey and brown, trace of fines, non-plastic.			
								2.00m				
				2.50m	2.5		SC		CLAYEY SAND: Fine to coarse grained sand, sub-angular to sub-rounded, pale grey/green grey and brown mottled. Clay, low plasticity			
				2.80m				2.80m				
				3.0				Hole Terminated at 2.80 m Target depth			2.30: Water observed seeping in side wall at 2.3m.	
				3.5								

METHOD N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper SUPPORT T Timbering		PENETRATION No Resistance WATER 10 Oct., 73 Water Level on Date shown water inflow water outflow		SAMPLES & FIELD TESTS U - Undisturbed Sample D - Disturbed Sample B - Bulk Disturbed Sample MC - Moisture Content HP - Hand Penetrometer (UCS kPa) VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa) PBT - Plate Bearing Test		CLASSIFICATION SYMBOLS & SOIL DESCRIPTION Based on Unified Classification System MOISTURE D - Dry M - Moist W - Wet		CONSISTENCY/ RELATIVE DENSITY VS - Very Soft S - Soft F - Firm St - Stiff VSt - Very Stiff H - Hard Fr - Friable VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense	
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See Explanatory Notes for details of abbreviations & basis of descriptions.

JDS181715.GPJ Log JDS1 TEST PIT JDS181715.GPJ --Drawing File-- 01/02/2019 15:18 10.000 Dated Lab and In Situ Test - DGD [Lib: JDS1 1.00 2015-12-09]

TEST PIT NUMBER: TP07

PAGE: 1 OF 1

PROJECT NUMBER: GGC181715

PROJECT NAME: Lot 1797 & 1798 Matison St

PROJECT LOCATION: Southern River, WA



Geotechnical and Geological Consultants

DATUM: MGA94 Zone 50

EQUIPMENT: 590R Backhoe

DATE STARTED: 14/01/2019

ELEVATION:

EXCAVATION LENGTH: 2.5 m

DATE COMPLETED: 14/01/2019

EASTING (m): 403396

EXCAVATION WIDTH: 1 m

LOGGED BY: JC

NORTHING (m): 6447914

EXCAVATION ORIENTATION:

CHECKED BY: RAM

EXCAVATION					MATERIAL				
VE E F H	SUPPORT	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m) Elevation (m AHD)	GRAPHIC LOG CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
	At 2.50m		B	0.0		TOPSOIL: Fine to coarse grained sand, sub-angular to sub-rounded, dark grey, trace of non-plastic organic fines.	D to MD		0.00: Abundant roots and rootlet up to 20mm diameter between 0.0m - 0.5m.
				0.40m		SAND: Fine to coarse grained, sub-angular to sub-rounded, grey, trace fines, non-plastic			
				0.5					
				1.00m		 Becoming dark grey at 1.1m.			
				1.20m		FERRICRETE: Very low strength, patchy, fine to coarse grained iron cemented sand and fines in sand matrix.			
				1.30m		SAND: Fine to coarse grained, sub-angular to sub-rounded, orange brown, with fines, non-plastic, trace gravel, fine to medium grained, sub-angular to angular, weakly iron-cemented in part.			
			B	1.50m			M		
				2.00m					
				2.5		CLAYEY SAND: Fine to coarse grained sand, pale grey/green grey and mottled brown. Clay, low plasticity.			
				2.70m			W		
				2.70m		Hole Terminated at 2.70 m Target depth			
				3.0					
				3.5					

METHOD	PENETRATION	SAMPLES & FIELD TESTS	CLASSIFICATION SYMBOLS & SOIL DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY
N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper SUPPORT T Timbering	 No Resistance WATER 10 Oct., 73 Water Level on Date shown water inflow water outflow	U - Undisturbed Sample D - Disturbed Sample B - Bulk Disturbed Sample MC - Moisture Content HP - Hand Penetrometer (UCS kPa) VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa) PBT - Plate Bearing Test	Based on Unified Classification System MOISTURE D - Dry M - Moist W - Wet	VS - Very Soft S - Soft F - Firm St - Stiff VSt - Very Stiff H - Hard Fr - Friable VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

JDS1 LIBRARY (REV 2.0) Log JDS1 TEST PIT JDS181715.GPJ -> Drawing File -> 01/02/2019 15:18 10.0.000 D:\git\Lab and In Situ Test - DGD [Lib: JDS1] 2015-12-29 Proj: JDS1 2015-12-29

TEST PIT NUMBER: TP08

PAGE: 1 OF 1

PROJECT NUMBER: GGC181715

PROJECT NAME: Lot 1797 & 1798 Matison St

PROJECT LOCATION: Southern River, WA



Geotechnical and Geological Consultants

DATUM: MGA94 Zone 50

EQUIPMENT: 590R Backhoe

DATE STARTED: 14/01/2019

ELEVATION:

EXCAVATION LENGTH: 2.5 m

DATE COMPLETED: 14/01/2019

EASTING (m): 403441

EXCAVATION WIDTH: 1 m

LOGGED BY: JC

NORTHING (m): 6447864

EXCAVATION ORIENTATION:

CHECKED BY: RAM

EXCAVATION								MATERIAL																							
VE		E		PENETRATION		F		H		SUPPORT		GROUND WATER LEVELS		SAMPLES & FIELD TESTS		DEPTH (m)		Elevation (m AHD)		GRAPHIC LOG		CLASSIFICATION SYMBOL		MATERIAL DESCRIPTION Soil Name, Plasticity or Particle Characteristic, Colour, Secondary Soil Components, Minor Components and Origin		MOISTURE CONDITION		CONSISTENCY RELATIVE DENSITY		STRUCTURE & Other Observations	
																0.0										D				0.00: Occasional roots and rootlets ranging from 1mm to 50mm diameter present between 0.0m - 0.5m.	
																0.40m															
																0.5															
																1.00m															
																1.0															
																1.5															
																2.0															
																2.5															
																2.40m															
																2.50m															
																2.70m															
																3.0															
																3.5															

METHOD	PENETRATION	SAMPLES & FIELD TESTS	CLASSIFICATION SYMBOLS & SOIL DESCRIPTION	CONSISTENCY/ RELATIVE DENSITY
N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper SUPPORT T Timbering	 No Resistance WATER 10 Oct, 73 Water Level on Date shown water inflow water outflow	U - Undisturbed Sample D - Disturbed Sample B - Bulk Disturbed Sample MC - Moisture Content HP - Hand Penetrometer (UCS kPa) VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa) PBT - Plate Bearing Test	Based on Unified Classification System MOISTURE D - Dry M - Moist W - Wet	VS - Very Soft S - Soft F - Firm St - Stiff VSt - Very Stiff H - Hard Fr - Friable VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense

See Explanatory Notes for details of abbreviations & basis of descriptions.

JDS1 LIBRARY (REV 2.0) Log JDS1 TEST PIT JDS181715.GPJ -> Drawing File -> 01/02/2019 15:18 10.0.000 DwgLab and In Situ Test - GGC Lib JDS1 1.00 2015-12-09 Pj1 JDS1 1.00 2015-12-09

CLIENT: Green Values Australia	DATE: 14/01/2019
PROJECT: Lot 1797 and 1798 Matison Street	TESTED BY: JC
LOCATION: Southern River	HAMMER MASS: 9kg
SOIL TYPE: Sand	HAMMER DROP HEIGHT: 600mm

Test Location	TP1	TP2	TP3	TP4	TP5	TP6
Test Depth mm	Blows/150mm					
0-150	SET	SET	SET	SET	SET	SET
150-300	3	1	3	2	4	3
300-450	3	3	5	3	4	4
450-600	3	3	6	4	6	6
600-750	4	3	8	3	5	7
750-900	5	4	7	4	4	8
900-1050	5	5	9	4	5	10

Test Location	TP7	TP8				
Test Depth mm	Blows/150mm					
0-150	SET	SET	SET	SET	SET	SET
150-300	4	3				
300-450	4	3				
450-600	5	3				
600-750	6	4				
750-900	5	4				
900-1050	7	5				

Test Location						
Test Depth mm	Blows/150mm					
0-150	SET	SET	SET	SET	SET	SET
150-300						
300-450						
450-600						
600-750						
750-900						
900-1050						

Test Location						
Test Depth mm	Blows/150mm					
0-150	SET	SET	SET	SET	SET	SET
150-300						
300-450						
450-600						
600-750						
750-900						
900-1050						

APPENDIX C

LABORATORY TEST RESULTS

TEST CERTIFICATE
CALIFORNIA BEARING RATIO : AS 1289.6.1.1

CLIENT:	GGC Pty Ltd, 439 Vincent Street West, Leederville
JOB NO.:	15_1
SAMPLE NO.:	1
CLIENT REFERENCE:	TP1, 0.20m to 1.50m
DATE SAMPLED:	Unknown
DATE TESTED:	21.01.2019
SAMPLE DESCRIPTION:	Sand
FEATURE:	-
PROJECT:	Quality Control - Job No. GGC181715 - Southern River

TEST CONDITIONS OF SPECIMEN

PERIOD OF SOAKING	4 days
SURCHARGING OF SPECIMEN	4.50 kg
COMPACTIVE EFFORT USED IN MOULDING SPECIMEN:	9 blows, 5 layers using a modified hammer

TEST RESULTS

MAXIMUM DRY DENSITY	1.75 t/m ³
OPTIMUM MOISTURE CONTENT	12.7 %
% Retained on the 19mm sieve	0%
OVERSIZE MATERIAL	Excluded
<u>DRY DENSITY</u>	
SPECIMEN BEFORE SOAKING	1.66 t/m ³
SPECIMEN AFTER SOAKING	1.65 t/m ³
<u>DRY DENSITY RATIO</u>	
SPECIMEN BEFORE SOAKING	95.0 %
SPECIMEN AFTER SOAKING	94.0 %
<u>MOISTURE CONTENT (AS 1289.2.1.1)</u>	
SPECIMEN AT COMPACTION	12.6 %
SPECIMEN AFTER SOAKING	16.5 %
TOP 30 mm LAYER OF SPECIMEN AFTER PENETRATION	14.8 %
REMAINING DEPTH OF SPECIMEN AFTER PENETRATION	16.0 %
<u>MOISTURE RATIO</u>	
SPECIMEN AT COMPACTION	99.5 %
SPECIMEN AFTER SOAKING	130.0 %
TOP 30 mm LAYER OF SPECIMEN AFTER PENETRATION	117.0 %
REMAINING DEPTH OF SPECIMEN AFTER PENETRATION	126.0 %
SPECIMEN SWELL	0.5 %

CALIFORNIA BEARING RATIO
19 % AT 2.50mm PENETRATION

SAMPLING PROCEDURES: Tested as received
 REMARKS:



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 ISO/IEC 17025 -
TESTING

Report No:	MC 15_1_1
Issue No:	1
Doc Name:	1289611S Rev 010 Date 24.03.2018
File name:	15_1cbr.xlsm

APPROVED : 
 L Greaves, Signatory
 DATE : 22.01.2019

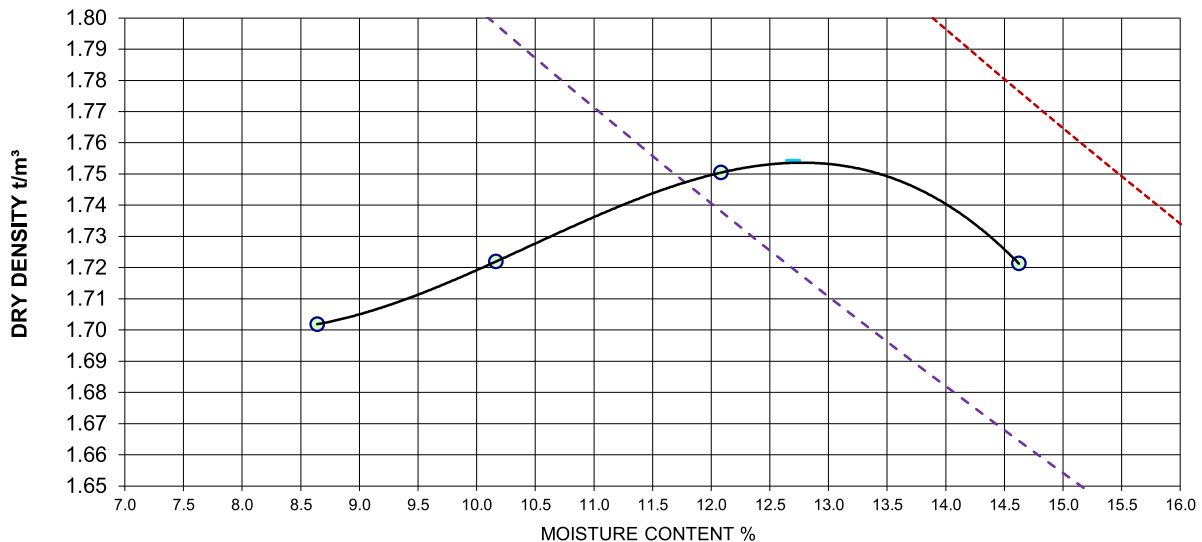
300 Collier Road, Bassendean, WA 6054 | PO Box 3090, Bassendean DC, WA 6942

T: 08 6278 3755 | F: 08 6278 4411 | E: admin@matcons.com.au | www.matcons.com.au

INDEPENDENT TESTING LABORATORIES NATA ACCREDITATION NUMBER 1763 ABN: 67 126 947 386

TEST CERTIFICATE
DETERMINATION OF THE DRY DENSITY/MOISTURE CONTENT RELATIONSHIP
OF A SOIL USING MODIFIED COMPACTIVE EFFORT : AS1289.5.2.1

CLIENT:	GGC Pty Ltd, 439 Vincent Street West, Leederville
JOB NO.:	15_1
SAMPLE NO.:	1
CLIENT REFERENCE:	TP1, 0.20m to 1.50m
DATE SAMPLED	Unknown
DATE TESTED:	16.01.2019
SAMPLE DESCRIPTION:	Sand
FEATURE:	-
PROJECT:	Quality Control - Job No. GGC181715 - Southern River



MODIFIED MAXIMUM DRY DENSITY	1.75 t/m³
MODIFIED OPTIMUM MOISTURE CONTENT	12.5 %
RETAINED 19.0 mm SIEVE	0 %
RETAINED 37.5 mm SIEVE	0 %

SAMPLING PROCEDURES: Tested as received

REMARKS: Type A Mould (1 litre) used for this test.
 Estimated Liquid Limit
 Curing Time: 2.00 hrs



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TESTING

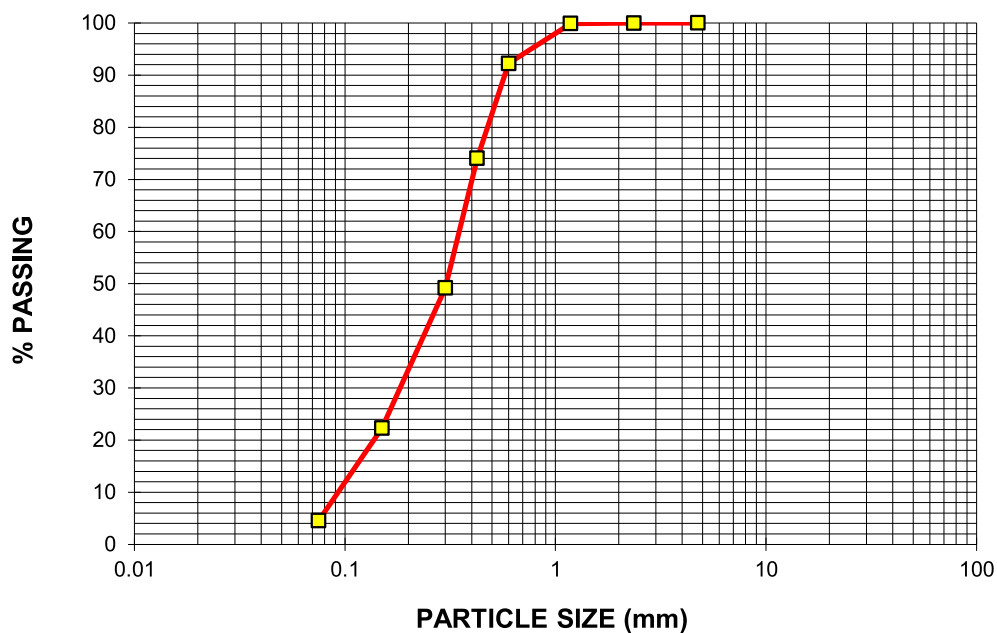
Report No: MC 15_1_2
 Issue No: 1
 Doc Name: MDDAS5 Rev 007 Date 01.12.2017
 File name: 15_1mdd.xlsm

APPROVED: 
 L Greaves, Signatory
 DATE: 22.01.2019

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION
STANDARD METHOD OF ANALYSIS BY SIEVING : AS 1289.3.6.1

CLIENT: GGC Pty Ltd, 439 Vincent Street West, Leederville
 JOB NO. : 15_1
 SAMPLE NO. : 1
 CLIENT REFERENCE : TP1, 0.20m to 1.50m
 DATE SAMPLED: Unknown
 DATE TESTED : 16.01.2019 & 19.01.2019
 SAMPLE DESCRIPTION : Sand
 FEATURE: -
 PROJECT : Quality Control - Job No. GGC181715 - Southern River

Particle Size Distribution - Graphical Representation



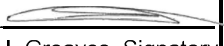
SIEVE SIZE (mm)	% PASSING
4.75	100
2.36	100
1.18	100
0.600	92
0.425	74
0.300	49
0.150	22
0.075	5

SAMPLING PROCEDURES: Tested as received
 REMARKS: Wet Sieved.



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ISO/IEC 17025 -
TESTING

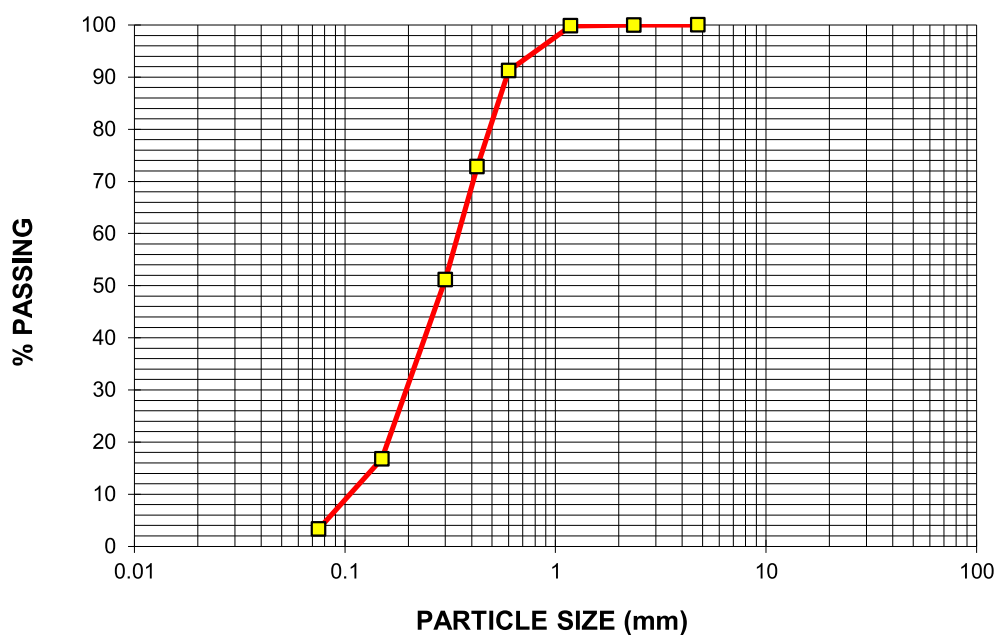
Report No: MC 15_1_3
 Issue No: 1
 Doc Name: 1289361 Rev 003 Date 28.11.2018
 File name: 15_1psd.xlsm

APPROVED : 
 L Greaves, Signatory
 DATE : 22.01.2019

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION
STANDARD METHOD OF ANALYSIS BY SIEVING : AS 1289.3.6.1

CLIENT: GGC Pty Ltd, 439 Vincent Street West, Leederville
 JOB NO. : 15_2
 SAMPLE NO. : 2
 CLIENT REFERENCE : TP2, 0.30m to 1.00m
 DATE SAMPLED: Unknown
 DATE TESTED : 16.01.2018 & 17.01.2019
 SAMPLE DESCRIPTION : Sand
 FEATURE: -
 PROJECT : Quality Control - Job No. GGC181715 - Southern River

Particle Size Distribution - Graphical Representation



SIEVE SIZE (mm)	% PASSING
4.75	100
2.36	100
1.18	100
0.600	91
0.425	73
0.300	51
0.150	17
0.075	3

SAMPLING PROCEDURES: Tested as received
 REMARKS: Wet Sieved.



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COMPLIANCE WITH
ISO/IEC 17025 -
TESTING

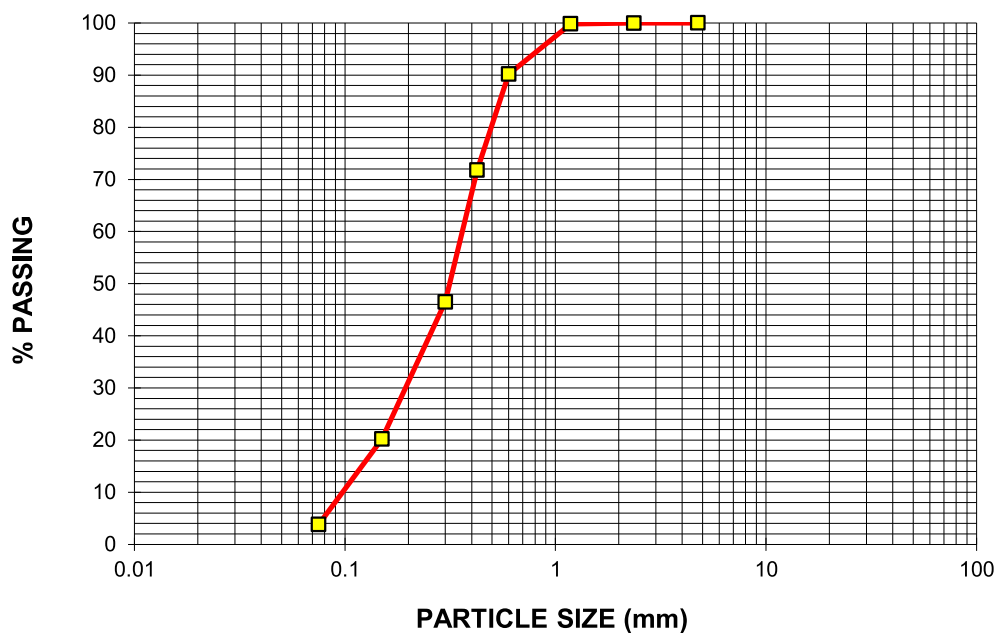
Report No: MC 15_2_1
 Issue No: 1
 Doc Name: 1289361 Rev 003 Date 28.11.2018
 File name: 15_2psd.xlsm

APPROVED : 
 L Greaves, Signatory
 DATE : 18.01.2019

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION
STANDARD METHOD OF ANALYSIS BY SIEVING : AS 1289.3.6.1

CLIENT: GGC Pty Ltd, 439 Vincent Street West, Leederville
 JOB NO. : 15_3
 SAMPLE NO. : 3
 CLIENT REFERENCE : TP4, 0.50m to 1.50m
 DATE SAMPLED: Unknown
 DATE TESTED : 16.01.2019 & 19.01.2019
 SAMPLE DESCRIPTION : Sand
 FEATURE: -
 PROJECT : Quality Control - Job No. GGC181715 - Southern River

Particle Size Distribution - Graphical Representation



SIEVE SIZE (mm)	% PASSING
4.75	100
2.36	100
1.18	100
0.600	90
0.425	72
0.300	46
0.150	20
0.075	4

SAMPLING PROCEDURES: Tested as received
 REMARKS: Wet Sieved.



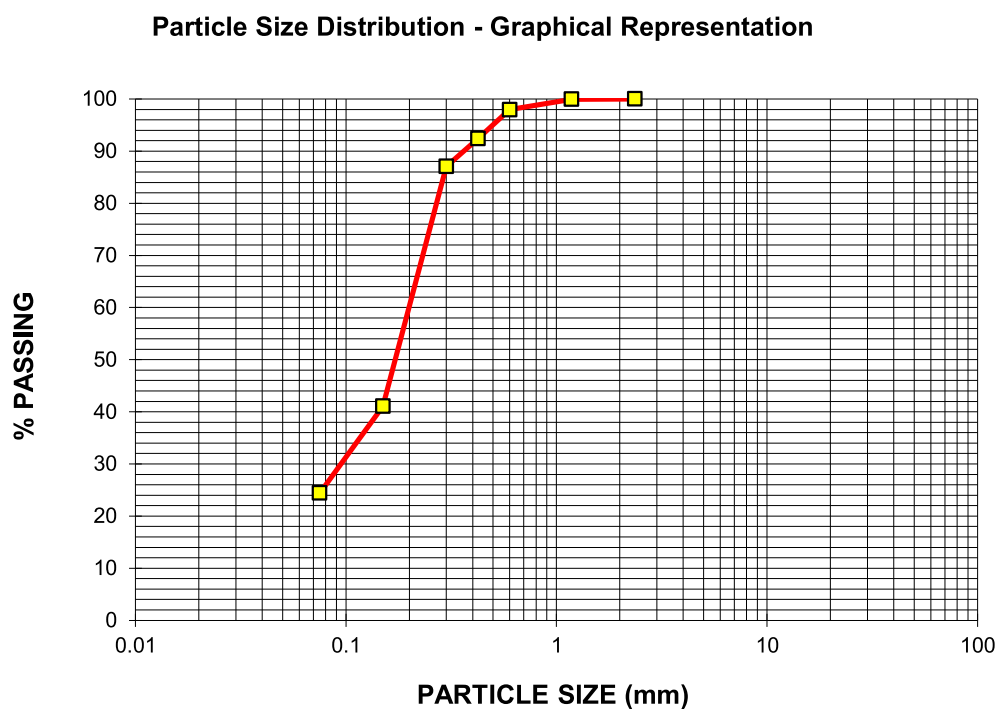
ACCREDITED FOR
COMPLIANCE WITH
ISO/IEC 17025 -
TESTING

Report No: MC 15_3_1
 Issue No: 1
 Doc Name: 1289361 Rev 003 Date 28.11.2018
 File name: 15_3psd.xlsm

APPROVED: 
 L Greaves, Signatory
 DATE : 21.01.2019

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION
STANDARD METHOD OF ANALYSIS BY SIEVING : AS 1289.3.6.1

CLIENT:	GGC Pty Ltd, 439 Vincent Street West, Leederville
JOB NO. :	15_4
SAMPLE NO. :	4
CLIENT REFERENCE :	TP6, 2.00m to 2.80m
DATE SAMPLED:	Unknown
DATE TESTED :	16.01.2019 & 24.01.2019
SAMPLE DESCRIPTION :	Sandy Clay
FEATURE:	-
PROJECT :	Quality Control - Job No. GGC181715 - Southern River

[illegible]

SAMPLING PROCEDURES:	Tested as received
REMARKS:	Wet Sieved.



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TESTING

Report No:	MC 15_4_1
Issue No:	1
Doc Name:	1289361 Rev 003 Date 28.11.2018
File name:	15_4psd.xlsm

APPROVED : _____
L Greaves, Signatory
DATE : 24.01.2019

TEST CERTIFICATE
CONSISTENCY LIMIT - ATTERBERG

**TEST METHODS: AS 1289.3.1.1, AS 1289.3.2.1, AS 1289.3.3.1,
 AS 1289.3.4.1, MOISTURE CONTENT : AS 1289.2.1.1**

CLIENT: GGC Pty Ltd, 439 Vincent Street West, Leederville
 JOB NO.: 15_4
 SAMPLE NO.: 4
 CLIENT REFERENCE: TP6, 2.00m to 2.80m
 DATE SAMPLED: Unknown
 DATE TESTED: 22.01.2019
 SAMPLE DESCRIPTION: Sandy Clay
 FEATURE: -
 PROJECT: Quality Control - Job No. GGC181715 - Southern River

LIQUID LIMIT	29 %
PLASTIC LIMIT	15 %
PLASTICITY INDEX	14 %
LINEAR SHRINKAGE	1.5 %

SAMPLING PROCEDURES: Tested as received
 REMARKS: Oven dried (50° C) Dry sieved.



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TESTING

Report No: MC 15_4_2
 Issue No: 1
 Doc Name: PI_ATTER Rev 005 Date 19.04.2018
 File name: 15_4pi.xlsm

APPROVED : 
 L Greaves, Signatory
 DATE : 24/01/2019

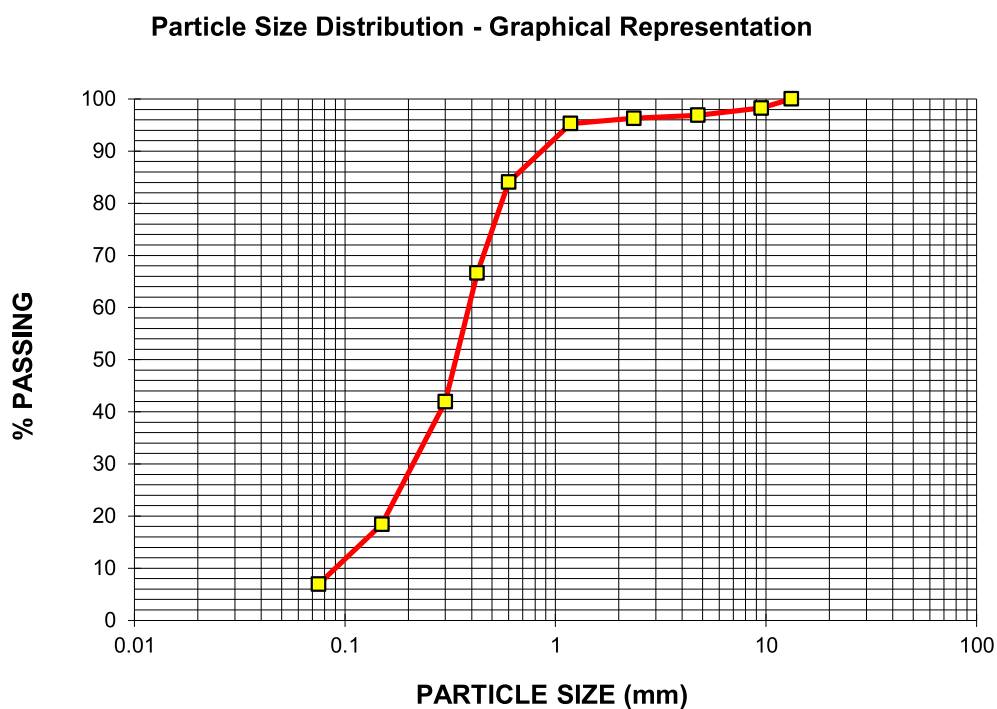
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INDEPENDENT TESTING LABORATORIES NATA ACCREDITATION NUMBER 1763 ABN: 67 126 947 386

TEST CERTIFICATE
PARTICLE SIZE DISTRIBUTION
STANDARD METHOD OF ANALYSIS BY SIEVING : AS 1289.3.6.1

CLIENT:	GGC Pty Ltd, 439 Vincent Street West, Leederville
JOB NO. :	15_5
SAMPLE NO. :	5
CLIENT REFERENCE :	TP7, 1.50m to 2.00m
DATE SAMPLED:	Unknown
DATE TESTED :	16.01.2019 & 19.01.2019
SAMPLE DESCRIPTION :	Gravelly Sand
FEATURE:	-
PROJECT :	Quality Control - Job No. GGC181715 - Southern River



SIEVE SIZE (mm)	% PASSING
13.2	100
9.5	98
4.75	97
2.36	96
1.18	95
0.600	84
0.425	67
0.300	42
0.150	18
0.075	7

SAMPLING PROCEDURES:	Tested as received
REMARKS:	Wet Sieved.



ACCREDITED FOR
COMPLIANCE WITH
ISO/IEC 17025 -
TESTING

Report No:	MC 15_5_1
Issue No:	1
Doc Name:	1289361 Rev 003 Date 28.11.2018
File name:	15_5psd.xlsm

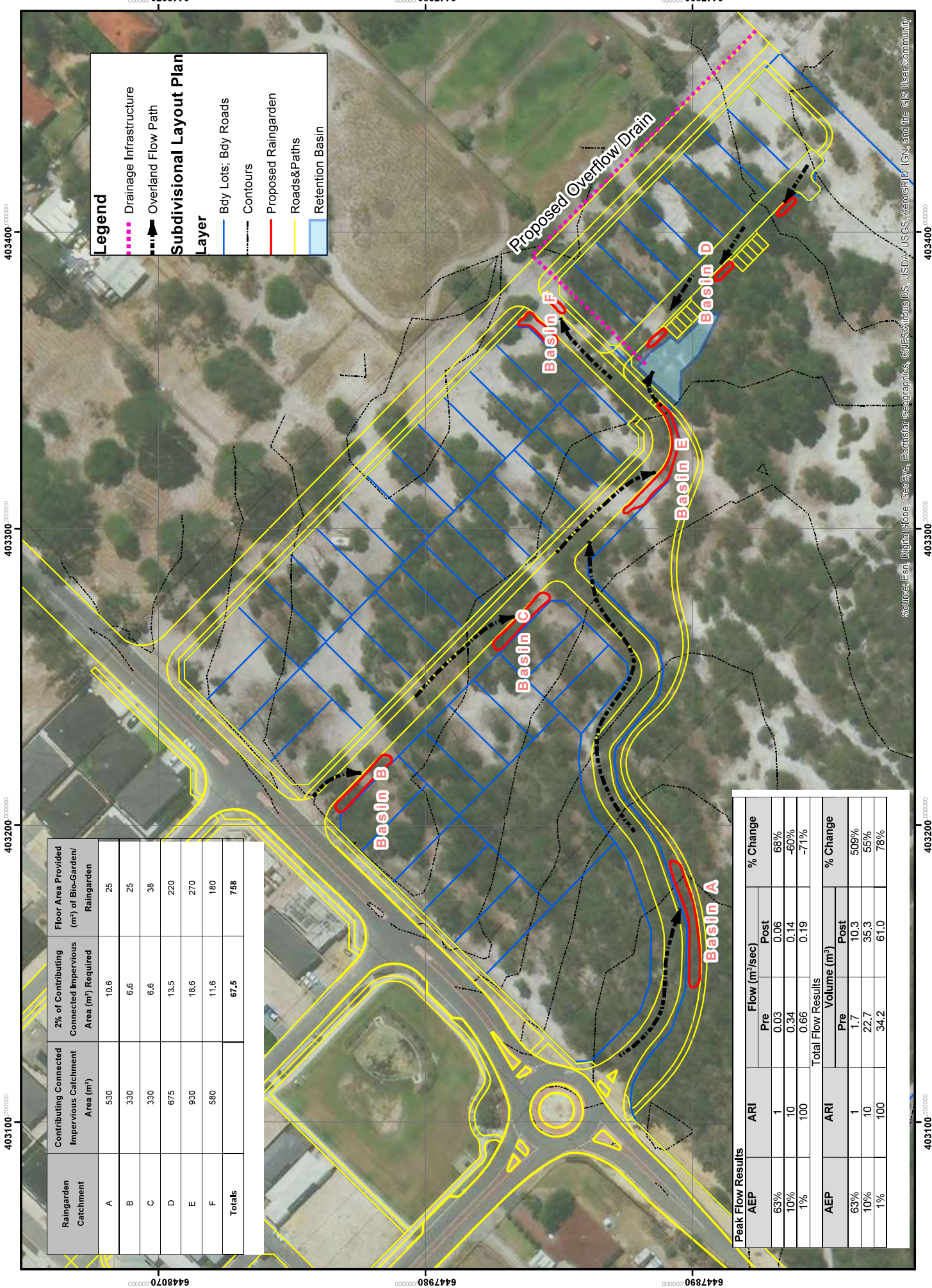
APPROVED : 
L Greaves, Signatory
DATE : 22.01.2019

Appendix 4: Stormwater Management Strategies

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1797 & 1798 Matisson St Southern River



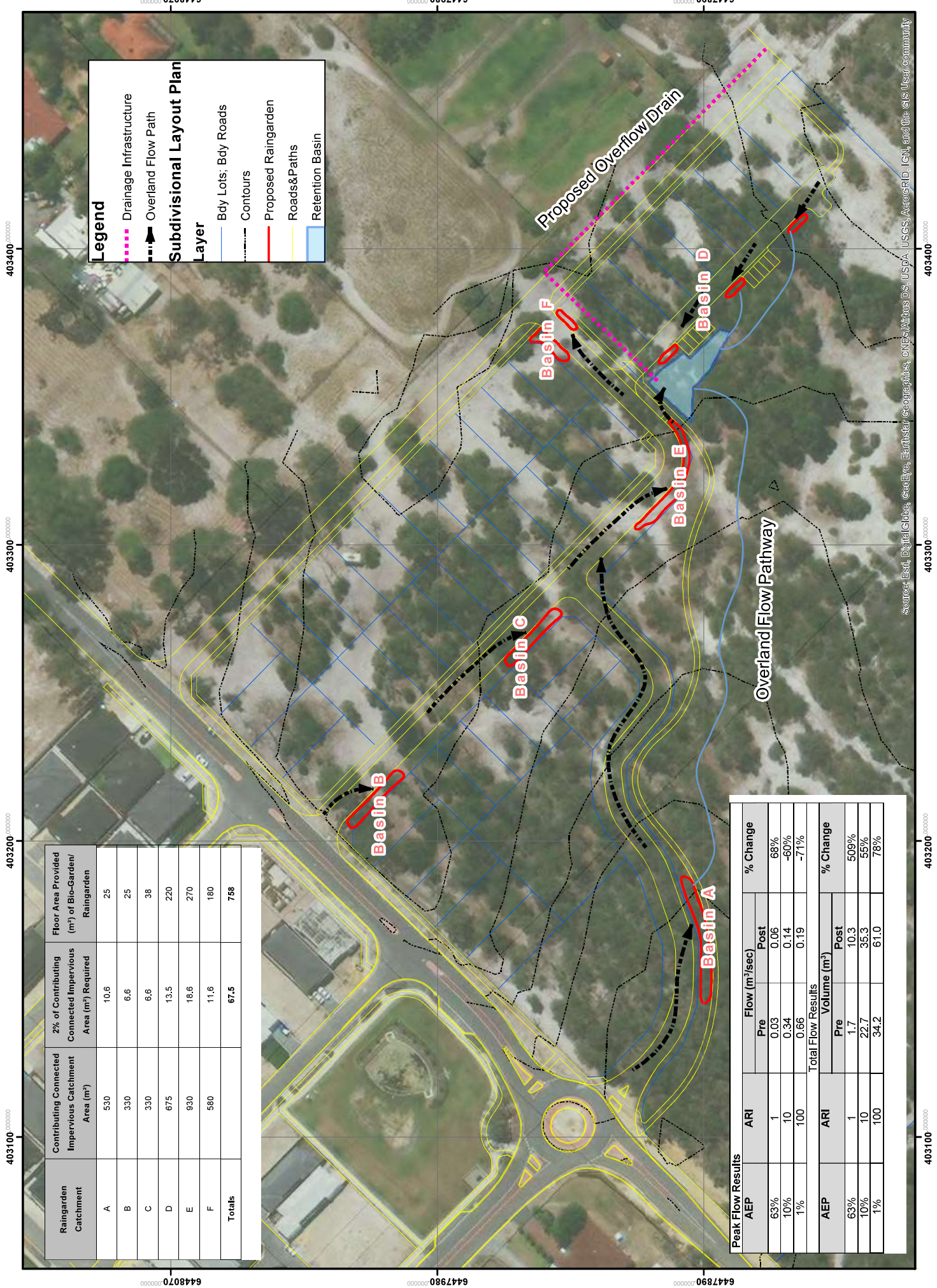
63% AEP STORM MANAGEMENT PLAN



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



1797 & 1798 Matisson St Southern River



10% AEP STORM MANAGEMENT PLAN





Appendix 5: Environmental Review (Aurora, 2018)

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11 July 2018

Urbanism
corey@urbanism.com.au

Attention: Corey Verwey

Dear Corey,

RE: LOTS 1797 & 1798 MATISON STREET, SOUTHERN RIVER

The following provides a summary of key findings from site investigations conducted on Lots 1797 and 1798 Matison Street, Southern River in relation to flora, vegetation and black cockatoo issues raised by the Department of Biodiversity, Conservation and Attractions (DBCA) and the City of Gosnells.

OVERVIEW

The proponents for the development of Lots 1797 and 1798 have requested the initiation of a scheme amendment to the Metropolitan Region Scheme (MRS). In parallel with this process, the proponents commissioned the preparation of a Local Structure Plan (LSP) for the site depicting the proposed land use and road layout for the site demonstrating how the site may be developed. Aurora Environmental prepared a high level environmental assessment report in support of the scheme amendment and LSP. This work was based on the environmental report prepared by ENV (2006) to underpin the original Southern River structure plan for Precinct 3.

Following review of the LSP, the City of Gosnells provided comment to the proponents indicating that further investigation of the site's environmental values was needed. DBCA provided advice to the Western Australian Planning Commission in relation to the scheme amendment. Similar to the City's comments on the LSP, DBCA advised that additional site investigations were recommended.

The key issues highlighted by DBCA and the City were as follows:

- The original flora and vegetation survey completed by ENV (2006) is old and therefore an updated flora and vegetation survey consistent with relevant EPA technical guidance is recommended.
- The retention of a mapped conservation category wetland (CCW) is supported and that a Wetland Management Plan is required.
- Appropriate interface setback and treatments for land adjacent to the Bush Forever site is required.

- Some vegetation on the site may be consistent with Banksia Woodlands of the Swan Coastal Plain threatened ecological community (TEC) which is protected under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*.
- Some of the vegetation on the site may provide habitat for the three black cockatoo species which are protected under the *Wildlife Conservation Act 1950* and the *EPBC Act 1999*.

PROPOSED APPROACH

Following a meeting with the City and consultation with DBCA, the following approach has been adopted to address the key issues for Lots 1797 and 1798:

- A review of the ENV (2006) flora and vegetation mapping along with an updated site assessment to verify:
 - The vegetation units on the site;
 - Re-map vegetation condition;
 - Identify the presence and extent of vegetation consistent with Banksia Woodland of the Swan Coastal Plain TEC; and
 - Comment on the likely presence/absence of conservation significant flora species and TECs based on site observations.
- Conduct a targeted black cockatoo habitat assessment which involved:
 - Assessing all trees (alive and dead specimens) over 50cm at DBH noting the GPS coordinates, species and whether there were any hollows or signs of use by Black Cockatoos;
 - Recording the location and nature of black cockatoo foraging evidence (e.g. chewed fruits around base of trees) as well as the nature and extent of foraging resources; and
 - Identifying black cockatoo roosting locations via direct and indirect evidence including branch clippings, droppings or moulted feathers.

The flora and vegetation assessment of the site was conducted by Dr Paul van der Moezel, a very experienced botanist with extensive survey experience throughout Western Australia. The Black Cockatoo habitat assessment was conducted by Mr Greg Harewood, a highly experienced zoologist who has conducted numerous black cockatoo surveys throughout the south-west of Western Australia.

SUMMARY OF RESULTS

Flora and Vegetation Assessment

The key findings from the flora and vegetation assessment (Attachment 1) were as follows:

- Seven vegetation types were observed on the site. The higher number of vegetation types than recorded by ENV (2006) was not unexpected given that ENV (2006) survey was conducted at a much broader scale. The seven vegetation types recorded by Dr Paul van der Moezel were:

Dryland Vegetation Types

- EtKg – *Eucalyptus tottiana* Low Open Woodland over *Kunzea glabrescens* Tall Open Scrub
- CcEtKg – *Corymbia calophylla* (Marri) *Eucalyptus tottiana* Low Open Woodland over *Kunzea glabrescens* Tall Open Scrub

Transitional Vegetation Types

- CcMp - *Corymbia calophylla* (Marri) Low Woodland to Woodland over *Melaleuca preissiana* Low Open Woodland
- AfCc – *Allocasuarina fraseriana* (Sheoak)/*Corymbia calophylla* (Marri) Low Woodland

Wetland Vegetation Types

- MpKgRc – *Melaleuca preissiana* Low Open Woodland over *Kunzea glabrescens* Tall Open Shrubland over *Regelia ciliata* Open to Closed Low Heath
- EtRc – *Eucalyptus tottiana* Low Open Woodland over *Regelia ciliata* Open to Closed Low Heath
- HaAa – *Hypocalymma angustifolium*/*Astartea affinis* Open Heath
- The vegetation types were mapped and are presented in Figure 1 of Attachment 1.
- The vegetation condition was assessed across both Lots and mapped (Figure 1 in Attachment 1). The area mapped as Degraded by ENV (2006) was not as extensive, with the main area of disagreement being the area mapped as a CCW which was assessed as mostly being Very Good with some bare sandy areas that were rated as Good. However, the transitional vegetation types were assessed as Degraded due to a depleted understorey resulting from clearing. The dryland vegetation types were mostly considered to be rated in Good condition with small areas of intact understorey in the EtKg vegetation type rated as Very Good.
- Vegetation type EtKg was identified as potentially being representative of the *Banksia* Woodland of the Swan Coastal Plain TEC. However, the vegetation type does not meet two of the key diagnostic criteria i.e. the canopy is not dominated or co-dominated by any of the three *Banksia* species (*B. attenuata*, *B. ilicifolia* or *B. menziesii*) and the understorey does not contain a high to very high floristic diversity of shrub and herb species as stated in the key diagnostic criteria. The EtKg vegetation type is rated as mostly Good with patches of Very Good and therefore meets the condition criteria. However, it does not meet the minimum patch size as the vegetation in question covers an area of 0.70 ha as mapped using a handheld GPS unit. Therefore, it was concluded that there are no vegetation types on site which have a significant *Banksia* component of the woodland canopy.
- ENV (2006) did not record any conservation significant flora on the site. Dr Paul van der Moezel reviewed the species list in ENV (2006) and considered recent updates to the threatened species list. He considered that there is potential for *Verticordia lindleyi* subsp. *lindleyi* (Priority 4 species) to be found in the area mapped as CCW. However, it was

concluded that no other conservation significant flora are likely to be found in the proposed developable portion of the site due to the degraded condition.

- The transitional vegetation types are in too poor condition to be able to be assigned to a floristic community type if a spring flora and vegetation survey were to be undertaken. Therefore, there is little merit in undertaking a spring flora and vegetation survey.

Black Cockatoo Habitat Assessment

The key findings from the black cockatoo habitat assessment (Attachment 2) were as follows:

- The vegetation remaining on Lots 1797 and 1798 was assessed as degraded/highly degraded condition with large areas of bare sand or sparse grass separating individual trees or groves of trees and shrubs including a number of planted exotic and non-endemic tree and shrubs.
- Tree species considered potentially suitable for black cockatoo nesting included: Marri (*Corymbia calophylla*), Coastal Blackbutt (*Eucalyptus tottiana*), Jarrah (*Eucalyptus marginata*), Flooded Gum (*Eucalyptus rudis*) and various planted non-endemic Eucalypts.
- Sheoaks (*Allocasuarina fraseriana*) and Paperbarks (*Melaleuca preissiana*) with a DBH greater than 50cm are not considered viable breeding habitat as these species generally do not form hollows.
- The site contained 51 potential habitat trees, with 38 having no hollows observed and the remaining 13 specimens containing hollows not suitable for use by Black Cockatoos (due to size of hollow entrance, inappropriate orientation of hollow, shallow depth of the hollow or the presence of bees). The location of the potential habitat trees was captured using a GPS.
- The 51 trees included 27 Marri, 15 Coastal Blackbutt, 4 Jarrah, 1 Flooded Gum and 1 planted non-endemic Eucalypt.
- The Coastal Blackbutt specimens were all stunted and as such would unlikely be used by black cockatoos for breeding even if they contained suitable hollows.
- Foraging habitat was recorded on the site and evidence of foraging on the site was recorded in the form of chewed Marri, Coastal Blackbutt and Sheoak fruit and pine cones. This evidence was attributed to Forest Red-tailed black cockatoo species (Marri, Coastal Blackbutt and Sheoak fruits) and Carnaby's Cockatoo (pine cones).
- It was difficult to determine the extent of foraging habitat due to the fragmentation of vegetation on the site and the density of foraging species varies greatly, but Harewood (2018) assessed the area of foraging habitat to be between one and two hectares.
- Some of the larger Eucalypt species appear suitable for roosting habitat; however, no evidence of night roosting was observed on the site.

CONCLUSION

Further assessment of Lots 1797 and 1798 Matison Street have been undertaken to review and update findings in relation to flora, vegetation and black cockatoo issues. Copies of the assessment reports are provided as Attachments 1 and 2.

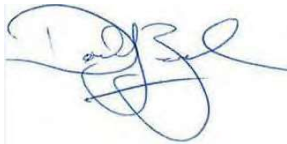
The flora and vegetation assessment has provided updated mapping of vegetation types and condition for the site. The developable portion of the site was assessed as being mostly Degraded with a small area being rated in Good condition. The vegetation in the developable area was not considered to be representative of *Banksia* Woodland TEC as it did not meet two of the key

diagnostic criteria and was too small to meet the condition threshold. The likelihood of conservation significant flora in the developable portion of the site is considered low due to previous clearing. However, there is potential for a Priority 4 species (*Verticordia lindleyi* subsp. *lindleyi*) to be found in the area mapped as CCW. If present, this species would not be impacted by the proposed development due to the retention of the CCW.

The Black Cockatoo habitat assessment recorded 51 potential habitat trees on the site. However, there was no evidence of breeding or roosting activity on the site. Of the 51 potential habitat trees, 38 did not contain hollows and the remaining 13 specimens had hollows but were not suitable for black cockatoo breeding. Evidence of black cockatoo foraging (by Forest Red-tailed black cockatoo and Carnaby's Black Cockatoo) was recorded on the site. Harewood (2018) estimated that the site contained between one and two hectares of foraging habitat, noting that it is difficult to calculate a precise area due to the variation in density of foraging resources.

As discussed with the City, matters protected under the *EPBC Act 1999* and referral obligations will be considered by the proponent at an appropriate time.

For and on behalf of Aurora Environmental,



Paul Zuvela
Manager – Environmental Impact Assessment

Attachments:

1. Flora and Vegetation Assessment
2. Black Cockatoo Habitat Assessment

Attachment 1

Flora and Vegetation Assessment



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Knightside Nominees Pty Ltd

6 July 2018

Paul Zuvela

Aurora Environmental

2 Bulwer Street

Perth WA 6000

Dear Paul,

RE: Lots 1797 & 1798 Matison St, Southern River – Flora and Vegetation Advice

Following is our advice regarding the vegetation on Lots 1797 and 1798 Matison Street, Southern River.

1 Scope of Work

The scope of work required for this advice was to:

1. Confirm the vegetation types identified by ENV (2006);
2. Map vegetation condition across the site;
3. Map the extent of Banksia woodland of the Swan Coastal Plain TEC on the site;
4. Check the Flora List against current Schedule and Priority rankings;
5. Provide comment on the likely presence/absence of conservation significant flora species and TECs based on site observations.

2 Vegetation Types

2.1 ENV

Lots 1797 and 1798 Matison Street are within the City of Gosnells Southern River Precinct 3 planning area. The vegetation of Precinct 3 was mapped by ENV in 2006. On the study site ENV mapped two native vegetation communities on most of the site with the balance being mapped as cleared. The two vegetation communities were:

Community 3 – MpRc

Low Open Woodland of *Melaleuca preissiana*, *Eucalyptus todtiana* and *Corymbia calophylla* over *Regelia ciliata*, *Astartea affinis*, *Xanthorrhoea preissii*, *Schoenus efolius*, *Patersonia occidentalis*, *Phlebocarya ciliata* and *Euchilopsis linearis*.

This vegetation community was the dominant vegetation type, occurring over about 80% of the site.

Community 16 – EtCc

Open Woodland of *Eucalyptus todtiana*, *Corymbia calophylla*, *Melaleuca preissiana* over *Jacksonia sternbergiana*, *Regelia ciliata*, *Xanthorrhoea preissii*, *Phlebocarya ciliata*, *Hibbertia hypericoides*, *Hybanthus calycinus* and *Dasypogon bromeliifolius*.

This vegetation community occurred in a small area at the western end of the site adjacent to Matison Street.

2.2 PGV Environmental

Dr Paul van der Moezel of PGV Environmental undertook a site inspection on 2 July 2018 to address the above scope of work. The inspection included a walk through the site to assess the ENV vegetation community and condition mapping and to map the potential extent of the Banksia Woodland of the Swan Coastal Plain TEC, if it occurs on the site.

PGV Environmental recorded seven vegetation types on the property compared to the two mapped by ENV (see Figure 1 attached). The large difference in mapping units is likely to be due to the scale of mapping used by ENV for the whole Southern River Precinct that required a broader unit of mapping than the vegetation type mapped by PGV Environmental. The use of the term 'vegetation community' by ENV supports this assumption when 'vegetation type' or 'vegetation unit' are more commonly used for vegetation mapping.

The vegetation types mapped by PGV Environmental are determined on the basis of their relationship to the different hydrological and soil type characteristics of the site. The southern part of the site is a dampland wetland (conservation category) which grades gradually through a transition zone to drier upland areas in the western and northern parts of the site.

At the level of vegetation type PGV Environmental recorded the following vegetation types on the site:

Dryland Vegetation Types

EtKg – *Eucalyptus todtiana* Low Open Woodland over *Kunzea glabrescens* Tall Open Scrub

This vegetation type occurred at the western end of the site and is roughly equivalent to the ENV EtCc vegetation community 16. However, the wetland species *Regelia ciliata* recorded by ENV in this area was not present. *Kunzea glabrescens* which was dominant in the mid-storey was not used in the ENV description of community 16.

Banksia menziesii, *B. attenuata* and *B. ilicifolia* were present as scattered trees throughout this vegetation type at a density less than 5%. *Jacksonia sternbergiana* was present as a tall shrub in small patches close to Matison Street.

The understorey was mostly absent or scarce. Some patches at the highest part of the site contained an open shrub understorey with common species being *Hibbertia hypericoides* and *Mesomelaena pseudostygia*.

CcEtKg – *Corymbia calophylla* (Marri) *Eucalyptus todtiana* Low Open Woodland over *Kunzea glabrescens* Tall Open Scrub

This vegetation type occurs adjacent to the EtKg vegetation type on slightly less elevated land but still considered to be dryland soils. Marri was the dominant tree with *Eucalyptus todtiana* and Sheoak (*Allocasuarina fraseriana*) also present. The understorey was largely absent.

Transitional Vegetation Types

CcMp - *Corymbia calophylla* (Marri) Low Woodland to Woodland over *Melaleuca preissiana* Low Open Woodland

This vegetation type is the main vegetation type in the northeastern part of the site, considered to occur on a transitional soil type. The Marri trees ranged from 6-12m in height with *Melaleuca preissiana* trees to 4m. The understorey was mostly cleared although some patches of *Regelia ciliata* occurred within this area.

AfCc – *Allocasuarina fraseriana* (Sheoak)/*Corymbia calophylla* (Marri) Low Woodland

This vegetation type occurred in the northern part of the site with the tree species, Sheoak and Marri, the main species present 6-10m high over a mostly cleared understorey.

Wetland Vegetation Types

MpKgRc – *Melaleuca preissiana* Low Open Woodland over *Kunzea glabrescens* Tall Open Shrubland over *Regelia ciliata* Open to Closed Low Heath

This is the main vegetation type in the mapped wetland area and includes a low density of *Melaleuca preissiana* trees and *Kunzea glabrescens* shrubs over a shrub layer of *Regelia ciliata* that ranges from mid-dense to very dense. Overall the *Regelia ciliata* coverage is around 60-70%,

EtRc – *Eucalyptus todtiana* Low Open Woodland over *Regelia ciliata* Open to Closed Low Heath

Similar to the MpKgRc vegetation type except the dominant tree species is *Eucalyptus todtiana* trees rather than *Melaleuca preissiana*. The *Regelia ciliata* dense shrub layer also contains *Acacia pulchella* as a common species. This vegetation type is probably slightly drier than the MpKgRc vegetation type and occurs in a small area near the south-west boundary of the site.

HaAa – *Hypocalymma angustifolium*/*Astartea affinis* Open Heath

A small stand of this vegetation type occurred within the MpKgRc vegetation type and contained dense cover of *Hypocalymma angustifolium* and *Astartea affinis* shrubs.

The vegetation types are mapped on Figure 1 (attached)

3 Vegetation Condition

ENV mapped most of the site as Degraded with a small area at the western end rated as Good. The location of the Good vegetation was very similar to the location of their EtCc Community 16 although the boundary of the areas mapped are not exactly the same.

PGV Environmental considers the area mapped by ENV as Degraded is not as extensive as shown on their map. The main area of disagreement is the Conservation Category Wetland which PGV Environmental rates as mostly being in Very Good condition with some bare sandy areas that could be rated as Good (Figure 1).

The areas considered Degraded by PGV Environmental include all of the transitional vegetation types which have had the understorey largely cleared. The small areas of transitional vegetation containing stands of *Regelia ciliata* within the Marri woodland could be considered Good although these are difficult to map due to the patchiness of the *Regelia* shrubs.

The dryland vegetation types are mostly considered to be rated in Good condition with small areas of intact understorey in the EtKg vegetation type rated as Very Good.

The vegetation condition is shown in Figure 1.

4 Banksia Woodland of the Swan Coastal Plain TEC

The 'Banksia Woodlands of the Swan Coastal Plain' ecological community was listed as a Threatened Ecological Community under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* in September 2016.

The Conservation Advice for the Banksia Woodland TEC contains a number of steps used to determine the presence of the Banksia Woodland TEC. The vegetation on the site was assessed against these steps as follows:

Step 1 – Key diagnostic characteristics

The vegetation on the site meets the following key diagnostic characteristics for the Banksia Woodland TEC

- the site is on the Swan Coastal Plain
- The dryland parts of the site occur on a well-drained sandplain landform
- the dryland parts of the site contain low woodland to woodland vegetation structure
- The EtKg vegetation type contains three of the diagnostic tree *Banksia* species, being *B. attenuata*, *B. ilicifolia* and *B. menziesii*

The EtKg vegetation type therefore could be representative of the Banksia Woodland TEC. However, the EtKg vegetation type does not meet two of the key diagnostic characteristics in Step 1. The first of these is the EtKg vegetation type does not have a canopy dominated or co-dominated by any or all of the three *Banksia* species. The density of *Banksia* trees is far less than the density of *Eucalyptus todtiana* trees.

Secondly, the understorey does not contain a high to very high diversity of shrub and herb species as is stated in the key diagnostic characteristics in Step 1.

Step 2 – Condition Thresholds

For an area of Banksia woodland to meet the definition of the Banksia Woodland TEC the condition of the vegetation needs to be at least in Good condition.

The EtKg vegetation type is rated as mostly Good with patches of Very Good and therefore meets the minimum condition threshold.

Step 3 – Minimum Patch Size

Minimum patch sizes apply for different condition classes of Banksia woodland vegetation in order to meet the definition of the Banksia Woodland TEC. The minimum patch sizes are:

- Pristine – no minimum patch size
- Excellent – 0.5ha
- Very Good – 1ha
- Good 2ha

The area of the EtKg vegetation type was measured on site using Waypoints on a hand-held GPS unit. The co-ordinates were used to map the EtKg and CcEtKg vegetation types in Figure 1.

The area of the EtKg vegetation type was calculated by PGV Environmental as 0.70ha. This is below the minimum threshold for vegetation in Good or Very Good condition to be the Banksia Woodland TEC. The EtKg vegetation type, therefore, would not be considered the Banksia Woodland TEC on the basis of its size and condition.

Step 4 – Further Information

The site does not contain any other characteristics listed in the Conservation Advice as potentially contributing to the vegetation being considered the Banksia Woodland TEC.

Conclusion

There are no vegetation types on the site which have a significant *Banksia* component of the woodland canopy. The vegetation type that does contain some *Banksia* trees is too small to be defined as the Banksia Woodland of the Swan Coastal Plain TEC either with a Good condition rating or a Very Good condition rating.

5 Flora List

The ENV survey report for the Southern River Precinct 3 area contains in Appendix H a species list for each of the vegetation communities recorded, however there is no list of species sampled from individual plots. Therefore, it is not possible to determine which of the species in ENV's species list occurred on each site. Nevertheless, Figure 9 of the ENV report shows that no flora of conservation significance were recorded on Lots 1797 or 1798.

There have been changes to the lists of Threatened and Priority flora at a State and Commonwealth level since the ENV survey was completed, both in terms of additions and deletions to the list as well as name changes. PGV Environmental reviewed the flora list for ENV vegetation communities 3 and 16 to determine whether any of the changes may impact on the potential presence of conservation significant species on the site.

ENV recorded no Declared Rare Flora and two Priority listed flora in their survey. The Priority species were *Aponogeton hexatepalus* and *Verticordia lindleyi* subsp. *lindleyi*. ENV also considered *Evandra pauciflora* as a significant species although it is not listed as a Declared Rare or Priority flora.

PGV Environmental's review of the ENV species list for communities 3 and 16 against the current list of Threatened and Priority species revealed that the list contains three current Priority species in these vegetation communities as follows:

- *Jacksonia gracillima* (P3)
- *Jacksonia sericea* (P4); and
- *Verticordia lindleyi* subsp. *lindleyi* (P4).

Jacksonia sericea was listed as Priority species in 2006 at the time of the ENV survey and appears to have been overlooked in the report. However, *J. sericea* occurs on calcareous sandy soils closer to the coast and is unlikely to occur in the Southern River area. A swamp form of *J. sericea* from the eastern side of the Swan Coastal Plain was recognised in 2006. That species has since been described in 2007 as *J. gracilis* which is not a Priority species.

Jacksonia gracillima occurs on transitional wetland/dryland soil types on the eastern side of the Swan Coastal Plain. Therefore, it could potentially occur on the site. However, *Jacksonia gracillima* was recorded in the ENV survey in the Southern River Precinct 3 but not on the site. Given the Degraded nature of the transitional vegetation types on the site and the results of the ENV survey, PGV Environmental considers the Priority 3 species *Jacksonia gracillima* is highly unlikely to occur on the site.

Verticordia lindleyi subsp. *lindleyi* (P4) occurs on sand and sandy clay winter-wet depressions and was recorded by ENV in vegetation community 3 but not on the site. Given that ENV mapped the wetland vegetation on the site as Degraded whereas PGV Environmental considers the condition as Very Good, there is potential that ENV may have not undertaken a thorough survey of the wetland area. Therefore, given the condition of the wetland on the site PGV Environmental considers it is possible that *Verticordia lindleyi* subsp. *lindleyi* could occur in the wetland area.

6 Conservation Significant Flora and Vegetation

As discussed above, PGV Environmental considers that the Priority 4 species *Verticordia lindleyi* subsp. *lindleyi* could occur in the wetland area but not in the transitional area due to the hydrology and Degraded understorey and not in the dryland area as the species is wetland dependent. No other Threatened or Priority flora species are likely to occur on the site based on the ENV survey results.

PGV Environmental considers the Commonwealth listed Banksia Woodlands of the Swan Coastal Plain TEC does not occur on the site due to the absence of a dominant Banksia overstorey and the size of the area that does contain Banksia trees being under the minimum requirement to be the TEC.

PGV Environmental considers the Very Good condition wetland vegetation on the site is not one of the State listed wetland TECs. In addition, the Degraded areas of vegetation are in too poor condition to be assigned to a Floristic Community Type. Therefore, these areas are not a State listed TEC.

There is some potential for the very small area of upland vegetation type EtKg to be a State listed TEC, however this would need to be determined by analysing quadrat data which were not presented in the ENV report.

Please contact me if you would like to discuss this advice further.

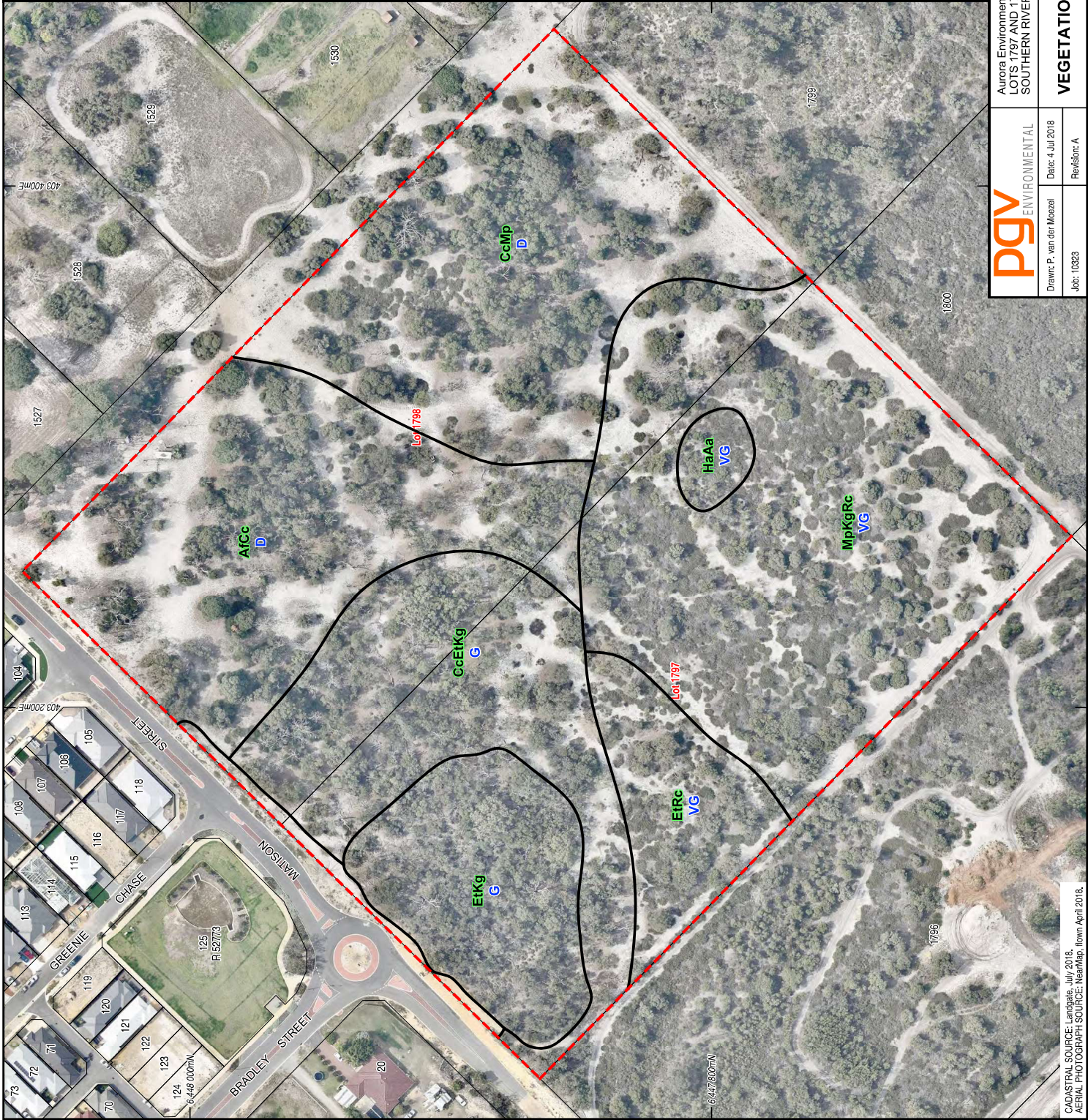
Yours sincerely

A handwritten signature in blue ink, appearing to read 'pvdml', is written over a faint, light blue circular stamp.

Paul van der Moezel
Managing Director

Attachments

Figure 1: Vegetation Type and Condition



Legend

- Site Boundary
- Cadastral Boundary
- Vegetation Type Boundary
- Vegetation Type
- Vegetation Condition

Vegetation Types

- EtKg** - *Eucalyptus totillana* Low Open Woodland over *Kurzea glabrescens* Tall Open Scrub.
- CcEIKg** - *Corymbia calophylla* (Marri) *Eucalyptus totillana* Low Open Woodland over *Kurzea glabrescens* Tall Open Scrub.
- CcMp** - *Corymbia calophylla* (Marri) Low Woodland to Woodland over *Melaleuca preissiana* Low Open Woodland
- AfCc** - *Allocasuarina fraseriana* (Sheoak)*Corymbia calophylla* (Marri) Low Woodland
- MpKgRc** - *Melaleuca preissiana* Low Open Woodland over *Kurzea glabrescens* Tall Open Scrubland over *Regelia ciliata* Open to Closed Low Heath
- EtRc** - *Eucalyptus totillana* Low Open Woodland over *Regelia ciliata* Open to Closed Low Heath
- HaAa** - *Hypocalymma angustifolium**Astarea affinis* Open Heath

Vegetation Condition

(SOURCE: Bush Forever, Govt. of W.A., 2000)

- P - Pristine**
Pristine or nearly so, no obvious signs of disturbance.
- Ex - Excellent**
Vegetation structure intact, disturbance affecting individual species and weeds are non aggressive species.
- VG - Very Good**
Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
- G - Good**
Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
- D - Degraded**
Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
- CD - Completely Degraded**
The structure of the vegetation is no longer intact and the areas is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora composing weed or crop species with isolated native trees or shrubs.
- Cl - Cleared**
No native vegetation remaining.



Aurora Environmental
LOTS 1797 AND 1798 MATISON STREET
SOUTHERN RIVER

Drawn: P. van der Meezel	Date: 4 Jul 2018
Job: 10323	Revision: A

VEGETATION TYPES AND CONDITION

Figure 1

Attachment 2

Black Cockatoo Habitat Assessment

Black Cockatoo Habitat Assessment



Lots 1797 and 1798 Matison Street Southern River

JULY 2018

Version 1

On behalf of:

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FIGURES

FIGURE 1: Habitat Trees (DBH $\geq$ 50cm)

APPENDICES

APPENDIX A: Tree Details

1. INTRODUCTION

This report details the results of a black cockatoo habitat assessment of areas of Lots 1797 and 1798 Matison Street, Southern River (subject site). The subject site has a total area of about 8.1 hectares.

2. SCOPE OF WORKS

The scope of works was to conduct a:

1. Targeted survey for black cockatoo habitat/site use (habitat trees, existing and potential nest hollows, foraging and roosting habitat). The assessment is to be conducted in accordance with relevant EPA and EPBC guidelines, noting that the information derived from the investigations will be used for referrals and will be made publicly available; and
2. Supply of Data for incorporation into report being prepared by Aurora.

Note: For the purposes of this report the term black cockatoo is in reference to Baudin's black cockatoo *Calyptorhynchus baudinii*, Carnaby's black cockatoo *Calyptorhynchus latirostris* and the forest red-tailed black cockatoo *Calyptorhynchus banksii naso*.

3. METHODS

3.1 VEGETATION UNITS

The nature of the vegetation units present within the subject site was recorded during the field survey and a summary of observations provided.

3.2 BLACK COCKATOO HABITAT ASSESSMENT

The following methods will be employed to comply with the defined scope of works and are based on guidelines published by the federal Department of the Environment and Energy (DotEE) (Commonwealth of Australia 2012) which states that surveys for Carnaby's, Baudin's and forest red-tailed black cockatoo habitat should:

- be done by a suitably qualified person with experience in vegetation or cockatoo surveys, depending on the type of survey being undertaken;
- maximise the chance of detecting the species' habitat and/or signs of use;

- determine the context of the site within the broader landscape—for example, the amount and quality of habitat nearby and in the local region (for example, within 10 km);
- account for uncertainty and error (false presence and absences); and
- include collation of existing data on known locations of breeding and feeding birds and night roost locations.

Habitat used by black cockatoos have been placed into three categories by the DotEE (Commonwealth of Australia 2012) these being:

- Breeding Habitat;
- Foraging Habitat; and
- Night Roosting Habitat.

To comply with the requested scope of works and in line with the published guidelines the following will be carried out.

3.2.1 Breeding Habitat

The black cockatoo breeding habitat assessment involved the identification of all suitable breeding trees species within the survey area that have a Diameter at Breast Height (DBH) of equal to or over 50cm. The DBH of each tree will be estimated using a pre-made 50 cm “caliper”.

Trees within the subject site have been previously assessed for size by a surveyor (Phil Jones – MNG) in late 2017. All live trees (irrespective of species) with a DBH of over 50cm were marked with numbered tags and their location recorded with a GPS. These trees were examined as part of this more recent assessment along with any additional unsurveyed specimens (e.g. dead trees).

Target tree species included marri, jarrah, tuart and flooded gum or any other *Corymbia/Eucalyptus* species of a suitable size that may have been present. Peppermints, banksia, sheoak and melaleuca tree species (for example) were not assessed as they typically do not develop hollows that are used by black cockatoos.

The location of each tree identified as being over the threshold DBH was recorded with a GPS and details on tree species, number and size of hollows (if any) noted. Trees observed to contain hollows (of any size/type) were marked with “H” using spray paint.

Potential hollows were placed into one of four categories, based on the size of the apparent hollow entrance, these being:

- Small = ~<5cm diameter (i.e. entrance too small for a black cockatoo);

- Medium = ~5cm-10cm diameter (i.e. entrance too small for a black cockatoo);
- Large = ~>10cm diameter (entrance large enough for a black cockatoo but possible hollow appears to be unsuitable for nesting i.e. wrong orientation, too small, too low or too shallow); or
- Large (cockatoo) = ~>10cm diameter (entrance appears big enough to provide access to a possible hollow that maybe suitable for a black cockatoo to use for nesting).

Based on this assessment trees present within the subject site were then placed into one of four categories:

- Tree < 50cm DBH or an unsuitable species;
- Tree $\geq$ 50cm DBH, no hollows seen;
- Tree >50cm DBH, one or more hollows seen, none of which were considered suitable for black cockatoos to use for nesting; or
- Tree >50cm DBH, one or more hollows seen, with at least one considered potentially suitable for black cockatoos to use for nesting.

For the purposes of this assessment a tree containing a potential cockatoo nest hollow was defined as:

Generally, any tree which is alive or dead that contains one or more visible hollows (cavities within the trunk or branches) suitable for occupation by black cockatoo for the purpose of nesting/breeding. Hollows that had an entrance greater than about 10cm in diameter and would allow the entry of a black cockatoo into a suitably orientated and sized branch/trunk, was recorded as a "potential nest hollow".

Identified hollows were examined using binoculars for evidence of actual use by black cockatoos (e.g. chewing around hollow entrance, scarring and scratch marks on trunks and branches).

The health status of each tree was also assessed and placed into one of three categories:

- Healthy;
- Declining; or
- Dead.

3.2.2 Foraging Habitat

The location and nature of black cockatoo foraging evidence (e.g. chewed fruits around base of trees) observed during the field survey was recorded. The nature and extent of potential foraging habitat present was also documented irrespective of the presence of any actual foraging evidence.

3.2.3 Night Roosting Habitat

Direct and indirect evidence of black cockatoos roosting within trees on site was noted if observed (e.g. branch clippings, droppings or moulted feathers).

4. SURVEY CONSTRAINTS

No seasonal sampling has been carried out as part of this fauna assessment. The conclusions presented are based upon field data and the environmental monitoring and/or testing carried out over a limited period of time and are therefore merely indicative of the environmental condition of the site at the time of the field assessments. It should also be recognised that site conditions can change with time.

During the black cockatoo habitat survey trees with hollows were searched for. It should be noted that identifying hollows suitable for fauna species from ground level has limitations. Generally, the full characteristics of any hollow seen are not fully evident (e.g. internal dimensions). It is also difficult to locate all hollows within all trees as some are not observable from ground level.

5. RESULTS

5.1 VEGETATION UNITS

It is understood that the subject site has historically been partly cleared and used for livestock grazing (primarily horses) for many years. As a consequence, the native vegetation remaining is largely in a degraded/highly degraded condition with large areas of bare sand or sparse grass separating individual trees or groves of trees and shrubs. A number of planted exotic and non-endemic trees and shrubs have also been planted in some areas.

Prior to disturbance raised upland areas would have been comprised of a mosaic of open woodlands containing various densities of coastal blackbutt, jarrah, marri, *banksia*, *Nuytsia floribunda* and sheoak. Lower lying areas (damplands) would have been dominated by open woodlands of marri over low woodlands of *melaleuca* and heaths/shrublands. Within the subject site upland vegetation would have occupied much of the northern half of the area with the southern half likely to contain vegetation more typical of lower lying dampland areas.

Table 1 provides some example images of the vegetation remaining within the subject site

Table 1: Vegetation - Example Images

Description	Example Image
Cleared areas with planted pines over paperbark and regrowth marri – north west corner of Lot 1798.	
Grove of marri trees – central/eastern section of Lot 1798.	
Low open woodland of coastal blackbutt, jarrah, <i>banksia</i> , <i>Nuytsia floribunda</i> and sheoak - near western boundary of Lot 1797.	

Description	Example Image
Open heath/shrubland (dampland) – near southern boundary of Lot 1797.	

5.2 BLACK COCKATOO HABITAT ASSESSMENT

5.2.1 Breeding Habitat

Trees considered potentially suitable for black cockatoos to use as nesting habitat (based on DotEE criteria (i.e. tree with a DBH >50cm) though ultimately subject to a suitable hollow being present or forming and a range of other factors) which were found within the subject site are comprised of the following species:

- Marri – *Corymbia calophylla*;
- Coastal Blackbutt – *Eucalyptus tottiana*;
- Jarrah – *Eucalyptus marginata*;
- Flooded Gum - *Eucalyptus rudis*; and
- Planted non-endemic eucalypts (unknown species);

Most of the trees were previously recorded by MNG in 2017, however some additional specimens have been included (mainly dead trees not previously assessed).

Sheoak, paperbark and other tree species recorded by MNG as having a DBH >50cm have not been included in the breeding habitat assessment as they are not documented as forming hollows that are then used by black cockatoos.

It should also be noted that the coastal blackbutt trees present on site are all relatively small stunted specimens and as such would seem unlikely to be used by black cockatoos for breeding even if a suitably sized hollow was to form. They have however been included in the assessment for completeness.

A summary of the potential black cockatoo breeding trees (using DotEE criteria i.e. any suitable tree species with a DBH $\geq$ 50cm (Commonwealth of Australian 2012)) observed within the subject site is provided in Table 2 and their location shown in Figure 1.

Table 2: Summary of potential cockatoo breeding habitat trees (DBH $\geq$ 50cm)

Total Number of Habitat Trees	Number of Trees with <u>No Hollows</u> Observed	Number of Trees with Hollows Considered <u>Unsuitable</u> for Nesting Black Cockatoos	Number of Trees with Hollows Considered <u>Possibly</u> Suitable for Nesting Black Cockatoos	Tree Species				
				Marri	Coastal Blackbutt	Jarrah	Flooded Gum	Planted Non-endemic Eucalypt
51	38	13	0	27	15	4	1	1

The assessment identified a total of 51 trees with a DBH of $\geq$ 50cms within the subject site. The majority (38, ~74.5%) of the trees were not observed to contain hollows of any size. Thirteen trees (13, ~25.5%) were observed to contain possible hollows with various sized entrances but none were considered by the Author as being potentially suitable for black cockatoos to use for nesting purposes. This conclusion was in most cases based on entrances to possible hollows being too small, branches being of an unfavourable orientation and/or hollows being too low or shallow. One tree was also occupied by bees which eliminated the potential for it to be used by black cockatoos even if a suitable hollow was present.

The majority of the trees with a DBH $>$ 50cm were in a healthy condition (~88%) with the balance being in decline (~6%) or dead (6%).

Additional details on each tree recorded (including all trees identified by MNG) can be found in Appendix A.

Based on available mapping there is about 8,760 ha of remnant native vegetation within 10 kilometres of the subject site. Much of this this is likely to also contain “potential” breeding habitat. Nearly half of this vegetation (~4,191 ha) is contained within bush forever sites.

5.2.2 Foraging Habitat

Following is a list of the flora species recorded within the subject site during the fauna survey that are known to be or potentially used as a direct food source (i.e. seeds or flowers) by one or more species of black cockatoo:

- Marri – *Corymbia calophylla*;
- Coastal Blackbutt – *Eucalyptus tottiana*;
- Jarrah – *Eucalyptus marginata*;
- Flooded Gum - *Eucalyptus rudis*;
- Banksia – *B. attenuata*, *B. menziesii* and *B. ilicifolia*;
- Sheoak – *Allocasuarina fraseriana*;
- Pine – *Pinus* spp.; and
- Planted non-endemic eucalypts (unknown species).

It should be noted that some of the above-mentioned species (e.g. Planted non-endemic eucalypts, flooded gum) while foraged upon on occasions are only likely to make up a small proportion of any one birds diet relative to more favoured plant species such as marri. Some tree species are also only represented by a small number of specimens (pine, jarrah, flooded gum and banksia) and therefore do not contribute to the overall foraging resource to a significant degree.

Evidence of black cockatoos foraging was observed during the field survey in the form of chewed marri, coastal blackbutt and sheoak fruits and pine cones. This evidence was attributed to the forest red-tailed black-cockatoo in the case of the marri, coastal blackbutt and sheoak fruits and Carnaby's black-cockatoo in the case of the pine cones (Table 3).

It is difficult to quantify the extent of quality foraging habitat within the subject site as the vegetation is fragmented and the density of foraging species within each area varies greatly but is only likely to total between one or two hectares.

Table 3: Foraging Evidence Examples

Foraging Evidence Description	Example Image
Marri Fruits – foraging activity attributed to the forest red-tailed black-cockatoo.	
Coastal Blackbutt Fruits – foraging activity attributed to the forest red-tailed black-cockatoo.	
Sheoak Fruits – foraging activity attributed to the forest red-tailed black-cockatoo.	

Foraging Evidence Description	Example Image
Pine Cones – foraging activity attributed to Carnaby's black-cockatoo.	

Based on available mapping there is about 8,760 hectares of remnant native vegetation within 10 kilometres of the subject site. Much of this this is likely to also represent black cockatoo foraging habitat of some type. Nearly half of this vegetation (~4,191 ha) is contained within bush forever sites.

5.3 Night Roosting Habitat

Some of the larger eucalyptus trees appear to be suitable for use as night roosting however no evidence of black cockatoo using them for this purpose was observed within the subject site during survey period.

A review of the 2017 Great Cocky Count database shows no documented roost sites within the subject site, the closest active roost (2017) being about 500m north east. This site was in use by 32 red-tailed black cockatoos during the 2017 Great Cocky Count. Another forty documented roost sites (but not necessarily in current use) occur within 10 km of the subject site.

6. SUMMARY

The black cockatoo habitat tree survey identified the presence of 51 trees fulfilling DotEE (2012) criteria as potential breeding habitat. The majority (38, ~74.5%) of the trees were not observed to contain hollows of any size. Thirteen trees (13, ~25.5%) were observed to contain possible hollows with various sized entrances but none were considered by the Author as being potentially suitable for black cockatoos to use for nesting purposes.

The majority of the trees with a DBH $\geq$ 50cm were in a healthy condition (~88%) with the balance being in decline (~6%) or dead (6%).

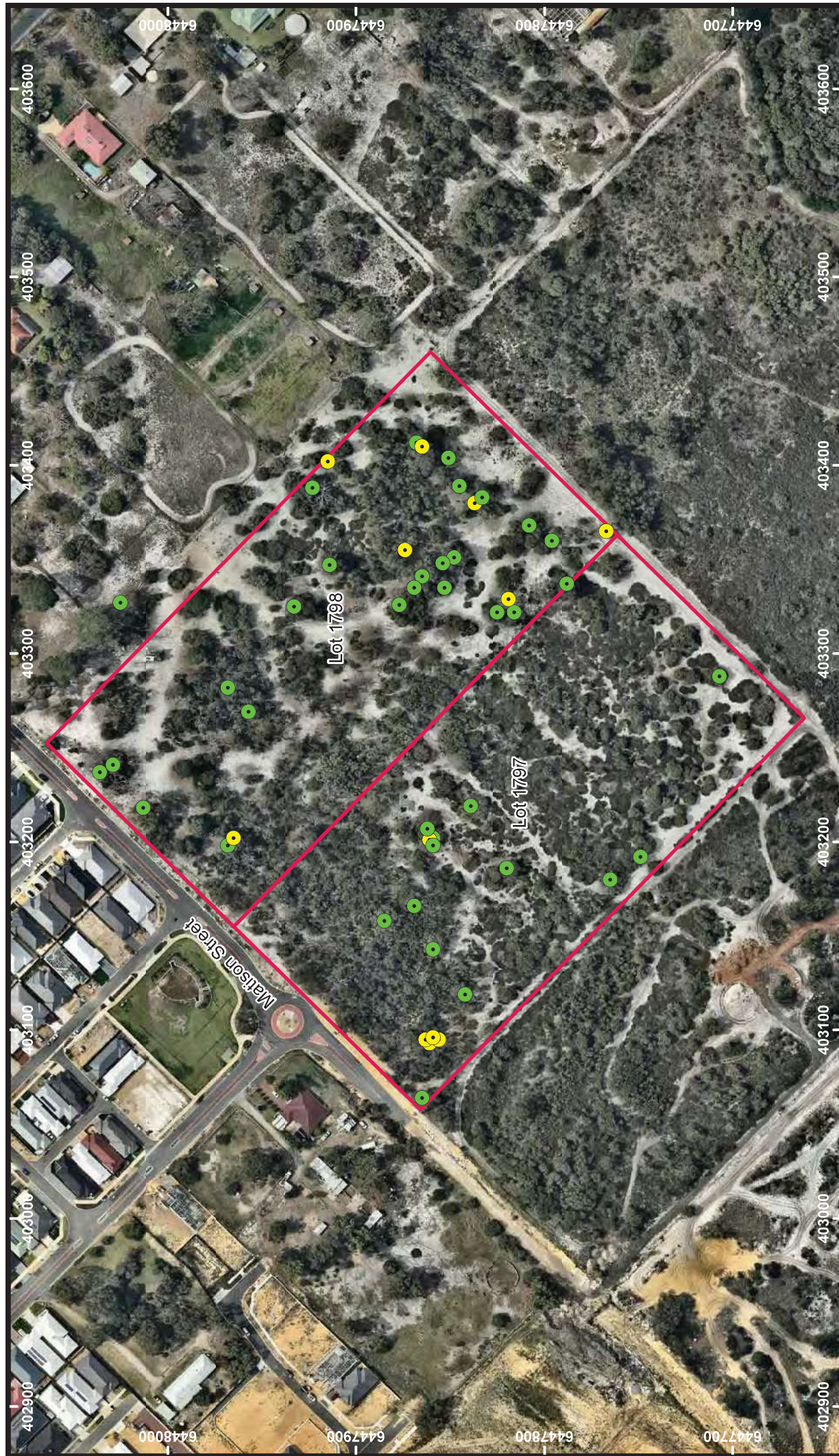
The vegetation present within the subject site contains some quality foraging habitat for black cockatoos given the presence of favoured plant species. It is however difficult to quantify the extent of this habitat as the vegetation is fragmented and the density of foraging species within each area varies greatly but is only likely to total between one or two hectares.

No black cockatoo roosting activity was observed.

7. REFERENCES

Commonwealth of Australia (2012). *EPBC Act Referral guidelines for three threatened black cockatoo species: Carnaby's cockatoo (endangered) *Calyptorhynchus latirostris*, Baudin's cockatoo (vulnerable) *Calyptorhynchus baudinii*, Forest red-tailed black cockatoo (vulnerable) *Calyptorhynchus banksii naso*.*

FIGURES



Legend

 Subject Site

-  Tree >50cm DBH, no hollows seen
-  Tree >50cm DBH, one or more hollows seen
-  None appear suitable for black cockatoos.



(Unsuitable tree species excluded)



Drawn: G Harewood
Date: 5/07/2018
Scale: 1:2,750

Lots 1797 and 1798
Matison Street
Southern River
Habitat Trees
(DBH >50cm)

APPENDIX A

TREE DETAILS

Trees - All species
DBH >50cm
Datum - GDA94
Entrance Size Ranges - Small = >5cm, Medium = 5 to 10cm, Large = >10cm

Waypoint Number	MING Tag Number	Zone	mE	mN	Tree Species	Tree Height (m)	DBH (cm)	Number of Hollows	Estimated Hollow Entrance Size Range (cm)	Occupancy	Chew Marks	Potential Cockatoo Nest Hollow	Comments
wpt001		50H	403237	6448036	Dead Marri	15-20	>50	0					Dead
wpt002		50H	403241	6448029	Dead Marri	15-20	>50	0					Dead
wpt003	T 2	50H	403218	6448013	Unknown Eucalypt	15-20	>50	0					Healthy (planted)
wpt004	T 1	50H	403242	6447990	Pine	20+	>50	0					Healthy
wpt005	T 45	50H	403198	6447968	Marri	15-20	>50	0					Healthy
wpt006		50H	403202	6447965	Dead Unknown	0-5	>50	1	Large	No Signs	No Signs	No	Dead - hollow too low and shallow
wpt007	T 3	50H	403172	6447975	Paperbark	10-15	>50	0					Healthy
wpt008	T 4	50H	403169	6447961	Sheoak	10-15	>50	0					Healthy
wpt009	T 44	50H	403191	6447928	Sheoak	10-15	>50	0					Healthy
wpt010	T 58	50H	403327	6448025	Marri	15-20	>50	0					Healthy
wpt011	T 59	50H	403327	6447984	Pine	20+	>50	0					Healthy
wpt012	T 67	50H	403342	6447953	Paperbark	10-15	>50	0					Healthy
wpt013	T 61	50H	403399	6447939	Paperbark	10-15	>50	0					Healthy
wpt014	T 60	50H	403388	6447923	Marri	15-20	>50	0					Healthy, Foraging debris
wpt015		50H	403402	6447915	Dead Marri	20+	>50	2+	Small-Medium	No Signs	No Signs	No	Dead
wpt016	T 12	50H	403416	6447876	Paperbark	10-15	>50	0					Healthy
wpt017	T 66	50H	403418	6447891	Paperbark	10-15	>50	0					Healthy
wpt018	T 11	50H	403412	6447868	Marri	15-20	>50	0					Healthy
wpt019	T 10	50H	403410	6447865	Marri	15-20	>50	2+	Small	No Signs	No Signs	No	Healthy
wpt020	T 9	50H	403404	6447851	Marri	15-20	>50	0					Declining
wpt021	T 13	50H	403389	6447845	Marri	15-20	>50	0					Healthy
wpt022		50H	403380	6447837	Dead Unknown	0-5	>50	2+	Small-Large	No Signs	No Signs	No	Dead - hollow too low
wpt023	T 14	50H	403383	6447833	Marri	15-20	>50	0					Healthy
wpt024	T 15	50H	403379	6447833	Paperbark	10-15	>50	0					Healthy
wpt025	T 16	50H	403383	6447810	Nuytsia	10-15	>50	0					Healthy
wpt026	T 19	50H	403368	6447808	Marri	15-20	>50	0					Healthy
wpt027	T 18	50H	403360	6447796	Marri	15-20	>50	0					Healthy
wpt028	T 17	50H	403365	6447767	Marri	15-20	>50	1	Large	No Signs	No Signs	No	Declining - Hollow to low and shallow
wpt029	T 65	50H	403347	6447765	Paperbark	10-15	>50	0					Healthy
wpt030	T 35	50H	403323	6447751	Paperbark	10-15	>50	0					Healthy
wpt031	T 36	50H	403288	6447707	Coastal Blackbutt	10-15	>50	0					Healthy, Foraging debris
wpt032	T 37	50H	403192	6447749	Coastal Blackbutt	10-15	>50	0					Healthy, Foraging debris
wpt033	T 38	50H	403180	6447765	Coastal Blackbutt	10-15	>50	0					Healthy, Foraging debris
wpt034	T 39	50H	403117	6447821	Sheoak	10-15	>50	0					Healthy

Waypoint Number	MNG Tag Number	Zone	mE	mN	Tree Species	Tree Height (m)	DBH (cm)	Number of Hollows	Estimated Hollow Entrance Size Range (cm)	Occupancy	Chew Marks	Potential Cockatoo Nest Hollow	Comments
wpt035	T 41	50H	403088	6447843	Sheoak	10-15	>50	0					Healthy
wpt036	T 5	50H	403064	6447865	Coastal Blackbutt	10-15	>50	0					Healthy, Foraging debris
wpt037	T 6	50H	403093	6447861	Jarrah	15-20	>50	2+	Small	No Signs	No Signs	No	Declining
wpt038	T 7	50H	403095	6447863	Jarrah	15-20	>50	2+	Small	No Signs	No Signs	No	Declining
wpt039	T 8	50H	403095	6447856	Jarrah	15-20	>50	2+	Small	No Signs	No Signs	No	Declining
wpt040		50H	403096	6447859	Dead Jarrah	10-15	>50	2+	Small-Medium	No Signs	No Signs	No	Healthy
wpt041	T 40	50H	403119	6447842	Coastal Blackbutt	10-15	>50	0					Healthy, Foraging debris
wpt042	T 42	50H	403143	6447859	Coastal Blackbutt	10-15	>50	0					Healthy, Foraging debris
wpt043	T 43	50H	403158	6447885	Coastal Blackbutt	10-15	>50	0					Healthy, Foraging debris
wpt044		50H	403166	6447869	Coastal Blackbutt	10-15	>50	0	Small	No Signs	No Signs	No	Healthy
wpt045	T 49	50H	403202	6447859	Coastal Blackbutt	10-15	>50	1	Small	No Signs	No Signs	No	Healthy
wpt045A	T 51	50H	403202	6447859	Coastal Blackbutt	10-15	>50	0					Healthy
wpt046	T 49	50H	403201	6447861	Coastal Blackbutt	10-15	>50	2+	Small	No Signs	No Signs	No	Healthy
wpt047		50H	403198	6447859	Coastal Blackbutt	10-15	>50	0					Healthy
wpt048		50H	403207	6447862	Coastal Blackbutt	10-15	>50	0					Healthy
wpt049	T 48	50H	403214	6447858	Sheoak	10-15	>50	0					Healthy
wpt050	T 50	50H	403219	6447839	Coastal Blackbutt	10-15	>50	0					Healthy
wpt051	T 73	50H	403186	6447820	Coastal Blackbutt	10-15	>50	0					Healthy
wpt052	T 46	50H	403216	6447890	Sheoak	10-15	>50	0					Healthy
wpt053	T 47	50H	403230	6447879	Sheoak	10-15	>50	0					Healthy
wpt054	T 72	50H	403199	6447901	Sheoak	10-15	>50	0					Healthy
wpt055	T 54	50H	403276	6447903	Sheoak	10-15	>50	0					Healthy
wpt056	T 52	50H	403273	6447918	Sheoak	10-15	>50	0					Healthy
wpt057	T 53	50H	403266	6447911	Sheoak	10-15	>50	0					Healthy
wpt058	T 28	50H	403299	6447877	Sheoak	10-15	>50	0					Healthy
wpt059	T 29	50H	403299	6447857	Sheoak	10-15	>50	0					Healthy
wpt060	T 74	50H	403268	6447854	Sheoak	10-15	>50	0					Healthy
wpt061	T 31	50H	403322	6447816	Marri	15-20	>50	0					Healthy
wpt062	T 32	50H	403327	6447813	Paperbark	10-15	>50	0					Healthy
wpt063		50H	403329	6447819	Dead Marri	15-20	>50	2+	Small-Medium	No Signs	No Signs	No	Healthy
wpt064	T 30	50H	403322	6447825	Marri	15-20	>50	0					Healthy
wpt065	T 34	50H	403337	6447788	Flooded Gum	15-20	>50	0					Healthy
wpt066	T 33	50H	403336	6447795	Paperbark	10-15	>50	0					Healthy
wpt067	T 20	50H	403351	6447848	Marri	15-20	>50	0					Healthy
wpt068	T 21	50H	403348	6447854	Marri	15-20	>50	0					Healthy, Foraging debris
wpt069	T 23	50H	403341	6447865	Marri	15-20	>50	0					Healthy
wpt070	T 24	50H	403335	6447869	Marri	15-20	>50	0					Healthy

Waypoint Number	MNG Tag Number	Zone	mE	mN	Tree Species	Tree Height (m)	DBH (cm)	Number of Hollows	Estimated Hollow Entrance Size Range (cm)	Occupancy	Chew Marks	Potential Cockatoo Nest Hollow	Comments
wpt071	T 22	50H	403335	6447853	Marri	15-20	>50	0					Healthy
wpt072		50H	403355	6447874	Dead Unknown	15-20	>50	2+	Small-Large	Bees	No Signs	No	Healthy - occupied by bees
wpt073	T 25	50H	403326	6447877	Marri	15-20	>50	0					Healthy
wpt074	T 26	50H	403322	6447869	Sheoak	10-15	>50	0					Healthy
wpt075	T 27	50H	403315	6447866	Sheoak	10-15	>50	0					Healthy
wpt076	T 62	50H	403347	6447914	Marri	15-20	>50	0					Healthy
wpt077	T 55	50H	403325	6447933	Marri	15-20	>50	0					Healthy, Foraging debris
wpt078	T 64	50H	403296	6447928	Sheoak	10-15	>50	0					Healthy
wpt079	T 69	50H	403255	6447956	Paperbark	10-15	>50	0					Healthy
wpt080	T 71	50H	403215	6447931	Sheoak	10-15	>50	0					Healthy
wpt081	T 70	50H	403227	6447935	Sheoak	10-15	>50	0					Healthy
wpt082	T 56	50H	403282	6447968	Marri	15-20	>50	0					Healthy
wpt083	T 68	50H	403269	6447957	Marri	15-20	>50	0					Healthy
wpt084	T 57	50H	403301	6447992	Pine	20+	>50	0					Healthy, Foraging debris

DISCLAIMER

This fauna assessment report (“the report”) has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Greg Harewood (“the Author”). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints. In accordance with the scope of services, the Author has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

The conclusions are based upon field data and the environmental monitoring and/or testing carried out over a limited period of time and are therefore merely indicative of the environmental condition of the site at the time of preparing the report. Also it should be recognised that site conditions, can change with time.

Within the limitations imposed by the scope of services, the field assessment and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

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